Understanding the Baseline Level of Efficiency in London

Prepared for UK Power Networks, Thames Water, Scotia Gas Networks and Cadent Gas

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CONFIDENTIALITY

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Executive Summary

Our Assignment

NERA Economic Consulting (NERA) and Arcadis have been commissioned by UK Power Networks, Cadent Gas, Scotia Gas Networks and Thames Water to perform a study that identifies the key factors affecting the cost of performing utility services in London, as compared to other parts of the country, and quantifies the effect of these differences.

In the British energy and water sectors, the sector regulators (Ofgem and Ofwat) typically assess the baseline efficient costs for each company when setting their price controls using top-down econometric benchmarking models. Ofwat and Ofgem use these statistical models to predict average company costs as a function of a pre-defined set of cost drivers. Sometimes these top-down models are supplemented with bottom-up engineering or more disaggregated econometric analyses, but the modelling still relies on a limited set of drivers contained in industry datasets. Some of the outcome targets, such as in relation to customer service, are also set through comparisons of company performance.

However, a well-known limitation of these comparative models for setting cost and performance targets is their limited ability to capture all the factors that affect cost and performance, for reasons other than differences between companies' relative efficiency. The limited availability of data on cost and outcome drivers constrains regulators' ability to control for the factors driving London-specific costs, such as congestion charges, tunnel access charges, and local permitting costs. Similarly, regional wage indices may not fully reflect differences in sector-specific contractor prices.

For all these reasons, both Ofwat and Ofgem give companies the opportunity to submit special cost factor evidence to quantify any additional cost effects not captured by their models. These submissions need to provide robust evidence that the effects are collectively material, outside of management control and not accounted for in the regulators' econometric models.

This project intends to understand the baseline level of efficiency for London utilities, to contribute to the basis of knowledge on why and how London utilities' costs differ from those in other parts of the country, and provide insights that can be used either in the development of comparative models or to substantiate special cost factor claims.

Our Approach

Given these limitations of regulators' comparisons of companies' costs and outputs, we have sought to identify and quantify the effect of the factors affecting London utilities' cost conditions. As a starting point, we drew on our own experience and worked with the Consortium to "brainstorm" potential cost drivers affecting London utilities' baseline level of efficiency. We also drew on publicly available documents from previous price controls and the experience of our team. This process led to us identifying a number of hypotheses about the reasons why London utilities might differ from those utilities serving other parts of the country.

For each of these hypotheses we have sought data and information to assess why the identified factor affects London utilities' costs differently from those operating in other parts of the country. We then assessed whether the factor in question was within the control of the management, and sought to quantify its effect, relying on data and information from the Consortium companies and other published sources to perform this quantification.

The next step in our approach is to appraise the extent to which the current top-down econometric benchmarking models used to compare costs and outputs in the energy and water sectors accounts for these factors, and to identify ways in which these models could be enhanced.

To inform this assessment, we review the econometric benchmarking models recently used and/or under consultation for each sector. In the electricity and gas sectors, we review the models Ofgem used at RIIO-GD1 and RIIO-ED1 and consider the (very limited) indications of its proposed approach for RIIO-2 in its recently published framework documents. In the water sector, we focus our review on the models Ofwat proposed for PR19 in mid-2018, as the models published subsequently by Ofwat in its Initial Assessment of companies' business plans pre-dates the time when the analysis to inform this report was carried out.

We then quantify the extent to which the factors we identify based on our bottom-up assessment of the specific factors affecting London utilities' costs differently from those in other parts of the country is controlled for in existing comparative benchmarking models.

The outcome from this process is an indicative estimate of the amount by which London utilities' baseline costs and performance metrics would need to be adjusted for comparability with those utilities operating in other parts of the country when regulators make comparative assessments of their costs and performance.

Identifying Potential London Factors

Through discussions with the utilities and our review of regulatory precedent, we identified a long list of potential sources of difference, which we grouped according to the following themes:

- Factors which related to the physical make-up of the network surroundings (such as more expensive footpath materials which drive reinstatement costs):
  - Roads are classified based on the expected volume of traffic they are designed for. Roads which are expected to be used more intensively have deeper “bound layers” of asphalt and concrete. London may have a higher proportion of “high use” road types than other regions, making streetworks more complex and costly. For instance, utility assets may be located deeper underground, and there may be a greater prevalence of concrete surfaces and “road-on-road” construction.
  - Utility assets may be more likely to be located under carriageways rather than the footway or verge due to the prevalence of coal cellars.
  - Road surfaces are more likely to require specialised colouring, greater “anti-skid” properties, and have more raised road crossings with printed concrete. This reflects the specific Highway Authority requirements in London. Similarly, the prevalence of specialized footway surfaces (e.g. York stone, resin bound tiles) is greater in London. These surfaces are more expensive and increase the complexity of reinstatement works.

  - Utility works in London are more likely to be disrupted by special engineering conditions and/or archaeology, and the sub-surface may be more congested due to the effects of utility congestion and buried tram lines.
- Factors related to traffic management and road access, including permitting:
  - All of London is covered by permitting schemes for streetworks, while outside of London there is a mix of noticing (which only requires companies to notify Highways Authorities that they are carrying out work) and permitting (which requires a permit from the Highways Authority before non-emergency work can begin).
  - Parking bay suspensions may be more complex and costly to obtain in London, for instance, due to the charges levied and procedures adopted by Transport for London relative to Highways Authorities elsewhere in the country.
  - Utilities may also be more likely to require costly traffic management measures like manned lights during peak hours, and provision of alternative pedestrian walkways during streetworks.
  - Lane rental charges are higher and more prevalent in London than elsewhere, and the process of obtaining permission for works is complicated by the greater prevalence of bus routes, cycle lanes, the frequency of major events in London, the density of Critical National Infrastructure, and special locations.
  - London utilities are unique in facing congestion charging for their vehicles.
  - Permits for lane rental and bay suspensions may be more likely to contain working hour restrictions, they are more complex to administer than elsewhere, and more jobs may need to be aborted because of cars parked in suspended bays.
  - Temporary Traffic Regulation Notices are substantially more expensive to obtain in London than they are in the rest of the South East of England.
  - London has a high density of Highways Authorities, with utility jobs crossing their boundaries, which creates a need to consult both TfL and the local HA on many jobs.
  - The density of railway crossings may be greater in London.
- Factors affecting utilities’ transport and logistics operations:
  - The cost and scarcity of land in central London means that distances to depots and tips is greater, increasing transport costs.
  - Scarcity of space for streetworks activities by utilities may also necessitate daily removal of spoil from sites, overnight plant delivery. Similarly, utilities’ delivery hours to central depot sites may be restricted.
  - Staff and contractors may spend longer driving into London to work sites or depots than in other parts of the country, as London property costs drive them to live further away.
  - Parking costs may be higher than elsewhere at work sites, depots, and offices, and utilities are more likely to incur parking fines.
  - Vehicle servicing costs may be higher in London.

  - Challenges with access may lead to inefficiency through the use of a greater number of smaller vehicles making more journeys to depots and work sites, and the limited ability to store materials at sites.
- Specificities associated with utilities' network configuration in London:
  - Confined spaces cause utilities to incur relatively high costs, such as in respect of underground governor and substation maintenance, tunnel rental costs and higher costs of inspection, maintenance and repair inside tunnels.
  - The prevalence of multi-occupancy buildings may create additional costs related to gas risers and electricity rising and lateral mains.
  - For electricity, a number of characteristics of the LPN network may also increase costs relative to utilities serving less densely populated areas including higher costs associated with substation ventilation, substation flooding, pipe cutting, link box inspections, substation trip testing, excessive HV and EHV fault costs, substation access and underground primaries.
  - In the water sector, cost efficiency may also be affected by the large size of raw water and wastewater treatment works.
- Relatively high labour costs in London:
  - Wages are relatively high in London compared to other parts of the country, which can affect utilities' costs through the compensation paid to their staff, contractor rates and in some cases fleet costs and payments for commuting time.
  - Due to a low number of employees living in London and a high proportion of emergencies and streetworks overnight, some utilities use a central London shift system, which requires payment of a premium on wages compared to those staff who in other regions would simply be on call at home.
  - Due to working hours restrictions, staff in London work more "unsocial" hours.
- Relatively high operational property costs in London:
  - Similar to labour, property costs prices in London are also higher than in the rest of the country, affecting rents, rates, etc. for London-based operational property.
  - London utilities may face higher terrorism insurance premia and other insurance costs, such as for buildings.
- Specific requirements and expectations of the customer base in London:
  - The demographic make-up of London differs from other parts of the country, such as having a proportion of customers in higher income brackets.
  - The value of economic output in central London is also exceptionally high, which may result in commercial customers placing higher demands on utilities.

Bottom-up Estimates of the Impact of London Factors

For each of the potential London factors identified above, we conducted an assessment drawing on data from the Consortium to assess whether each factor was unique to London, whether it was within management control (a key determinant of whether it warrants special treatment by the regulators in setting price controls), and to quantify its effect on utilities' costs.

While we concluded that many of the factors identified in our initial "long list" were not material or quantifiable, we also concluded that many of the factors listed above were unique to London and could be estimated. We conducted a detailed bottom-up estimation of the impact each factor would have on London utilities' costs, relative to the average cost across all networks.[1] We tailored our estimates to each company participating in this study. The table below shows the resulting estimates of the extra costs faced by London companies.

Table 1: Summary of Bottom-up Estimate of the London-Specific Costs Faced by London Utilities (£m / annum, 17/18 real)

£ million pa. (17/18 real)	**Cadent**	**SGN**	**UKPN LPN**	**UKPN EPN**	**UKPN SPN**	**Thames Water** (drinking water)	**Thames Water** (waste-water)
Nature of Streets	15.67	11.49	8.14	1.28	1.22	31.74	16.46
Permitting and Traffic Management	5.37	4.02	2.81	0.00	0.00	6.49	1.22
Transport and Logistics	0.78	0.05	0.38	0.00	0.00	0.05	0.05
Network-specific Factors	8.39	12.10	16.06	0.17	7.75	0.00	0.00
Labour Costs	25.31	18.23	23.77	4.74	6.37	7.80	11.12
Property Costs	0.64	0.00	0.00	0.00	0.00	0.00	0.00
Total	**56.15**	**45.90**	**51.16**	**6.19**	**15.34**	**46.08**	**28.86**

Source: Summary of NERA and Arcadis analysis

Controlling for London Factors in Comparative Assessments

To some extent the regulators' existing comparative models may control for some of the factors that make London utilities different from those in other parts of the country. In particular, some benchmarking models used at past price control reviews control for variation in regional labour costs, factors that reflect the volume/value of assets required by London utilities, and factors associated with density in central London. However, we assess that none of these models fully controls for the specific conditions facing London utilities.

Indeed, we have quantified in Table 2 the extent to which the benchmarking models used at the GD1 and ED1 price control reviews control for London-specific factors we have identified, as well as those proposed by Ofwat for the PR19 price control review in March 2018. As part of this, we have also assessed whether each element of the bottom-up estimates of London-specific factors discussed above requires a special factor adjustment. Hence, we have limited our analysis to factors which are not already excluded from benchmarking models, and in respect of Ofgem's benchmarking models, costs which would have been anticipated in companies' business plan forecasts at the last price control reviews.

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[1] Note that we have not quantified the extent to which costs in other parts of the country are lower than average due to the offsetting effect of these London specific costs.

Table 2: Proportion of London-Specific Costs Allowed for Implicitly by Existing Benchmarking Models (£m, annual average)

	Original Models			Models excluding London-specific Costs				Implicit Allowance	
Model	Modelled costs	Actual costs	Efficiency Score	Modelled costs	Actual costs	Efficiency Score	Ldn-specifc costs	(£m)	(%)
TW water	449.57	529.91	-18%	436.32	501.22	-15%	28.69	**13.25**	**46%**
TW wastewater	603.90	598.24	1%	590.85	578.73	2%	19.51	**13.05**	**67%**
Cadent London	187.11	199.19	-6%	184.37	184.75	0%	14.45	**2.74**	**19%**
SGN Southern	321.08	329.90	-3%	317.41	320.82	-1%	9.08	**3.67**	**40%**
LPN	207.73	203.73	2%	205.60	196.11	5%	7.62	**2.13**	**28%**
EPN	228.74	229.66	0%	227.50	228.52	0%	1.13	**1.24**	**109%**
SPN	343.89	253.91	26%	343.27	252.82	26%	1.09	**0.62**	**57%**

Note: Efficiency Score is calculated as the difference between modelled costs and actual costs, divided by modelled costs. Costs reported in benchmarking model price-base.
Source: NERA and Arcadis Analysis.

For most companies, the share of the special factor for London-specific costs that is allowed for implicitly by the benchmarking models ranges between 19% and 67%, and the benchmarking models find London companies appear more efficient when models are re-estimated with London-specific costs excluded (demonstrated by the higher efficiency scores in models which exclude London-specific costs). For EPN, a UKPN DNO which partly serves London (but predominantly serves the East of England), the re-estimated benchmarking models find the company to be less efficient when London-specific costs are excluded, reflecting the reduction in modelled costs for non-London areas when London-specific costs are excluded.

We have also reviewed the extent to which London-specific factors affect output incentive mechanisms and other cross-company comparisons of outputs, in particular, measures of customer service. We find strong evidence that London customers have different expectations and requirements to customers in other parts of the country, which may, in part, be explained by higher average incomes in London. Cross-company performance benchmarks (e.g. customer satisfaction measures used in customer service incentives) will therefore tend not to be appropriate for London companies, since they fail to take account of London customers' characteristics. Regulators could account for these differences in customers' expectations and requirements by allowing London companies to invest more (to reflect London customers' requirements), or by setting company-specific targets, e.g. based on companies' historical performance, or based on models which take account of customer characteristics in different parts of the country.

1. Introduction

1.1. Objectives of the UBLE Project

NERA Economic Consulting (NERA) and Arcadis have been commissioned to perform a study that identifies the key factors affecting the cost of performing utility services in London, as compared to other parts of the country, and quantifies the effect of these differences.

In the British energy and water sectors, the sector regulators (Ofgem and Ofwat) typically assess the baseline efficient costs for each company when setting their price controls using top-down econometric benchmarking models. Ofwat and Ofgem use these statistical models to predict average company costs as a function of a pre-defined set of cost drivers. Sometimes these top-down models are supplemented with bottom-up engineering or more disaggregated econometric analyses, but the modelling still relies on a limited set of drivers contained in industry datasets. Some of the outcome targets, such as in relation to customer service, are also set through comparisons of company performance.

However, a well-known limitation of these comparative models for setting cost and performance targets is their limited ability to capture all the factors that affect cost and performance, for reasons other than differences between companies' relative efficiency. The limited availability of data on cost and outcome drivers constrains regulators' ability to control for the factors driving London-specific costs, such as congestion charges, tunnel access charges, and local permitting costs. Similarly, regional wage indices may not fully reflect differences in sector-specific contractor prices.

For all these reasons, both Ofwat and Ofgem give companies the opportunity to submit special cost factor evidence to quantify any additional cost effects not captured by their models. These submissions need to provide robust evidence that the effects are material, outside of management control and not accounted for in the regulators' econometric models.

This project intends to understand the baseline level of efficiency for London utilities, to contribute to the basis of knowledge on why and how London utilities' costs differ from those in other parts of the country, and provide insights that can be used either in the development of comparative models or to substantiate special cost factor claims.

1.2. Structure of this Report

The remainder of this report is structured as follows:

- Section 2 describes our approach to evaluating the baseline efficiency for London utilities, in relation to cost and output comparisons conducted by regulators at price reviews;
- Section 3 describes the approaches used by energy and water regulators to compare companies' efficiency and performance, and how regulators have addressed London factors;
- Section 4 identifies and quantifies specific factors affecting London utilities, referencing more detailed descriptions of our approach and calculations in appendices covering:
  - The nature of streets and the impact on streetworks costs;

  - Permitting and traffic management costs;
  - Transport and logistics costs;
  - Specific factors affecting the electricity, gas and water sectors individually;
  - Labour costs; and
  - Property costs;
- Section 5 sets out our assessment of the effect of the factors identified in Section 4 on regulators’ assessment of London utilities’ baseline efficiency; and
- Section 6 concludes.

2. Our Approach to Evaluating the Baseline Efficiency for London Utilities

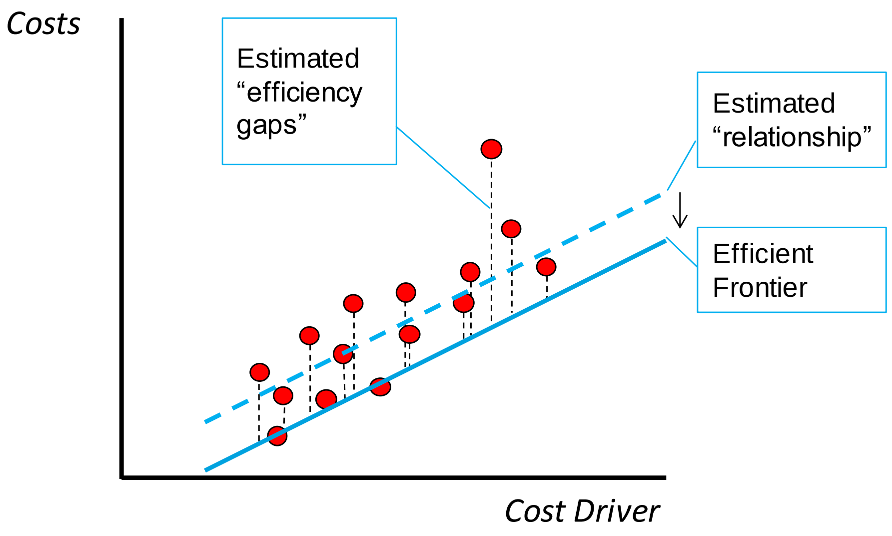
2.1. Cost and Output Comparisons in British Energy and Water Regulation

Ofgem and Ofwat set prices for energy and water network companies using incentive regulation, imposing ex-ante revenue allowances which provide an incentive to companies to increase profits by achieving required outputs at the lowest possible cost. These ex-ante price controls require the regulators to forecast companies' "efficient costs" over the upcoming control periods, reflecting a level of expenditure that will be sufficient for companies to finance the delivery of the outputs agreed as part of the regulatory settlement.

At recent price controls, regulators have used comparative benchmarking models of companies' costs relative to forecast companies' efficient costs. These models define a quantitative relationship between the costs incurred by regulated companies and one or more cost drivers. Cost drivers are variables that are intended to explain variation in comparator companies' costs that arises for reasons besides technical inefficiency. The relationship between costs and cost drivers can be estimated using different methods, for instance econometric regression models, or through alternative, non-econometric methods, such as unit cost adjustments. Regulators have conducted benchmarking on aggregate costs ("totex") or more disaggregated cost items, e.g. operating costs and capital enhancement costs separately, or even costs related to specific activities, such as tree-cutting and fault repairs in electricity distribution).

Figure 2.1 below provides a simplified example of a comparative benchmarking model. The dashed "estimated relationship" line is the line that best fits the available data. This line represents a regulator's modelled cost estimates for all values that the cost driver may take. However, regulators commonly shift this line downwards, reflecting an assumption that some proportion of the variation around the line (the error terms in the regression) is attributable to technical inefficiency, and not just data noise.

Figure 2.1: Regulators' approach to comparative benchmarking



In Figure 2.1, the efficient frontier (the solid blue line) is then used to set companies' allowances, with the difference between companies' actual and estimated efficient costs deemed by the regulator to be due to technical inefficiency and (largely) excluded from companies' allowances. We describe Ofgem and Ofwat's approaches to benchmarking in more detail in Section 3 below.

Regulators also use comparative assessments to set the target level for some non-cost outputs which companies' are required to deliver, for example customer satisfaction scores. Regulators may associate outputs with financial incentive mechanisms, that allow companies' to earn rewards or pay penalties based on their performance relative to targets. Up to now, regulators have set these output benchmarks using simple methods, rather than more sophisticated econometric models. We discuss financial output incentive mechanisms which are currently set with reference to output performance comparisons in Sections 3.1.3, 3.2.3 and 3.3.3 below, for the electricity, gas and water sectors respectively.

2.2. Distortions Created by Omitted Factors

Econometric modelling (and other advanced statistical techniques)[2] allow regulators to develop models which control for more than one cost driver, and therefore estimate the combined effect of different factors on companies' costs and outputs. However, the number of cost drivers that can be included in an econometric model is limited by the data on utilities' costs/outputs and drivers: there are a relatively small number of regulated companies in each industry and data may not exist (or be sufficiently reliable) to capture every driver of differences in their costs or outputs.

Since benchmarking models only consider a limited number of cost drivers, they are limited in their ability to disentangle genuine inefficiency from factors that influence costs for other reasons. Such factors may include data noise, differences in cost allocation amongst the comparator set, or characteristics of companies' networks, businesses, or service areas not controlled for by the model, which are often termed "omitted factors".

Due to the presence of omitted factors, estimated efficiency gaps may under- or overstate the true inefficiency in companies' costs and output targets, therefore unduly influencing allowances emerging from the cost assessment, and, in the case of output comparisons, output incentive mechanisms.

Setting allowances based on models which understate companies' true efficiency costs contravenes UK regulators' obligations to ensure that companies can finance their activities,[3] and can deter network owners from investing in their networks, to the detriment of future customers, since they will be unwilling to incur costs which the regulator will not allow them to recover. Similarly, setting output targets without taking account of differences between companies and regions risks imposing/awarding penalties/rewards for performance which is

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[2] For example, Data Envelopment Analysis, a more complex statistical technique which UK regulators have considered using, but not yet employed in a price control.

[3] See, for example, the 1989 Electricity Act which obliges Ofgem to "protect the interest of current and future consumers" by, amongst other things, secure that network owners are able to finance their activities.

Electricity Act 1989, s 3A.

outside of companies' control, which may distort incentives to invest in improving outputs such as customer service.

To limit the effect of these potential biases, UK regulators attempt to control for differences between companies by including data on the characteristics of each comparator in benchmarking models. However, where they cannot do so, regulators have tended to provide companies with the opportunity to submit special factor claims against the regulators' proposed cost benchmarking models. There is less regulatory precedent for company-specific adjustments to output targets, where regulators' methods for setting targets have tended to be less sophisticated. We describe in more detail the different approaches that can be applied to benchmarking models to improve their ability to control for omitted variables in Section 5.1 below.

2.3. Gathering Evidence on the Effect of Conditions in London on Utilities' Costs and Outputs

Given these limitations of regulators' comparisons of companies' costs and outputs, we have sought to identify and quantify the effect of the factors affecting London utilities' cost conditions. As a starting point, we drew on our own experience and worked with the Consortium to "brainstorm" potential cost drivers affecting London's utilities baseline level of efficiency. We also drew on publicly available documents from previous price controls and the experience of our team. This process led to us identifying a number of hypotheses about the reasons why London utilities might differ from those of utilities serving other parts of the country.

For each of these hypotheses we have sought data and information to assess why the identified factor affects London utilities' costs differently from those operating in other parts of the country. We then assessed whether the factor in question was within the control of the management, and sought to quantify its effect, relying on data and information from the Consortium companies and other published sources to perform this quantification.

2.4. Assessing the Impact of the Factors on London Utilities Performance in Comparative Modelling

The next step in our approach is to appraise the extent to which the current top-down econometric benchmarking models used to compare costs and outputs in the energy and water sectors accounts for these factors, and to identify ways in which these models could be enhanced.

To inform this assessment, Chapter 3 reviews the econometric benchmarking models recently used and/or under consultation for each sector. In the electricity and gas sectors, we review the models Ofgem used at RIIO-GD1 and RIIO-ED1 and consider the (very limited) indications of its proposed approach for RIIO-2 in its recently published framework documents. In the water sector, we focus our review on the models Ofwat proposed for PR19 during mid-2018, as the models published subsequently by Ofwat in its Initial Assessment of companies' business plans pre-dates the time when the analysis to inform this report was carried out.

We then quantify the extent to which the factors we identify based on our bottom-up assessment of the specific factors affecting London utilities' costs differently from those in other parts of the country is controlled for in existing comparative benchmarking models.

The outcome from this process is an indicative estimate of the amount by which London utilities' baseline costs and performance metrics would need to be adjusted for comparability with those utilities operating in other parts of the country when regulators make comparative assessments of their costs and performance.

3. Ofwat and Ofgem's Comparative Efficiency Assessments at their Latest Price Control Reviews

As background to our work to identify differences in the cost conditions facing London utilities relative to those elsewhere in the country and assessing different ways of quantifying their effect, we have reviewed the comparative benchmarking methods Ofwat and Ofgem have used in recent price reviews, and the allowances made (if any) for the specific conditions facing London companies.

3.1. Electricity Distribution

3.1.1. Comparative cost assessment at RIIO-ED1

At RIIO-ED1, Ofgem set Distribution Network Operators' (DNOs') allowed revenues using both top-down and bottom-up comparative benchmarking models, as well as placing weight on DNOs' own forecasts of their efficient costs. Figure 3.1 provides an overview of Ofgem's approach. Ofgem performed three efficiency assessments:

- **"Activity Based" or "Disaggregated" analysis**, in which Ofgem estimated efficient expenditure for each activity separately using a range of approaches (some econometric benchmarking analysis, some ratio or unit cost analysis, and some qualitative "expert" assessments);
- **A "top-down totex" model**, in which Ofgem estimated efficient total expenditure across all cost categories using a regression equation that defines totex as a function of a Composite Scale Variable (CSV) comprising two high level measures of companies' scale: Modern Equivalent Asset Value (MEAV)[4] and customer numbers; and
- **A "bottom-up totex" model**, in which Ofgem estimated efficient total expenditure across all cost categories using a regression equation, as in the top-down model, but using more cost drivers. Specifically, it used the drivers from the disaggregated analysis, but weighted them together into a single CSV.

Ofgem weighted the two totex models at 25 per cent each and the disaggregated model at 50 per cent,[5] made corrections for inflation and productivity, and benchmarked efficient costs at the upper quartile level. Finally, it combined its view of efficient costs with the DNOs' own view, weighting the former at 75 per cent and the latter at 25 per cent. The DNOs' view was incorporated via the Information Quality Incentive (IQI), a mechanism to encourage DNOs to create business plans that reflect the best available information about their future efficient expenditure requirements.[6] The cost categories and underlying cost drivers which Ofgem used for the disaggregated models are listed in Table 3.1.

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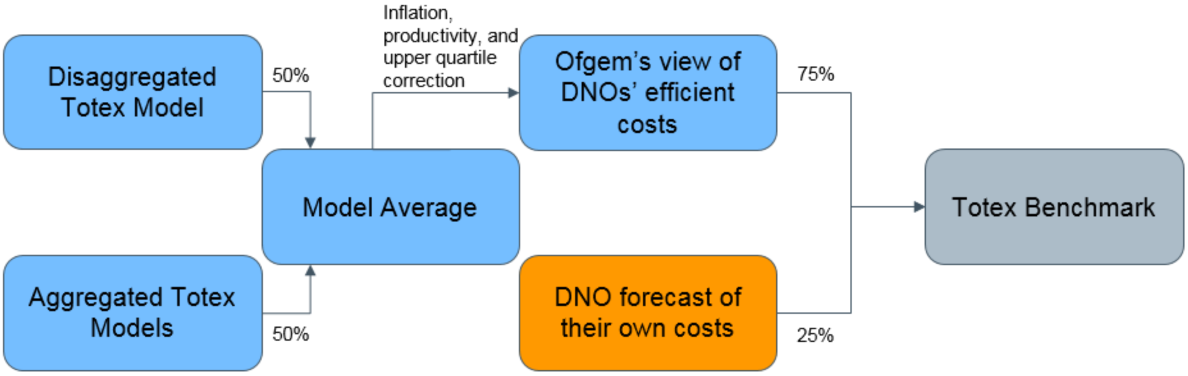
[4] The cost of replacing the existing network at current replacement cost. Ofgem calculated MEAV by multiplying the number of assets owned by the company, multiplied by unit costs for each type of asset, calculated by Ofgem's consultants.

[5] Ofgem (2014), RIIO-ED1: Final determinations for the slow-track electricity distribution companies – Expenditure Assessment, p. 32.

[6] Ofgem (2014), RIIO-ED1: Final determinations for the slow-track electricity distribution companies – Overview, p. 37.

Figure 3.1: Ofgem's Approach to Benchmarking at RIIO-ED1



Source: NERA.

Table 3.1: Cost Drivers for RIIO-ED1 Activity-Level Benchmarking of Opex and Non-operational Capex Costs

Cost Category	Cost Driver	Ofgem RIIO-ED1 Disaggregated Benchmarking Approach
Business Support, non-ITT	Modern Equivalent Asset Value ("MEAV")	Unit cost benchmark to group-level median, using 13 years of data
Business Support, ITT	MEAV	50% weight on quantitative benchmarking (unit cost benchmark to group-level median, using 13 years of data); and 50% weight on expert qualitative assessment of costs
CAI, vehicles and transport	MEAV	Assessed together with vehicles and transport costs within non-operational capex; unit cost benchmark to industry median using 13 years of data
CAI, operational training	Number of retirement and non-retirement leavers of full-time equivalent ("FTE") employees	Assessed separately for workforce-renewal (WFR) and non-workforce-renewal associated operational training costs; unit cost benchmark to group-level median using RIIO-ED1 data, with normalised leaver numbers as the driver for WFR costs, and FTEs as the driver for non-WFR costs
CAI, wayleaves	Number of towers and poles (on high voltage levels and above)	Unit cost benchmark to industry median using 13 years of data
CAI, other (regressed cost categories)	MEAV and the value of asset additions (based on Ofgem view of efficient unit costs)	Log-log regression using 8 years of forecast data (regression technique: pooled OLS with cluster-robust standard errors)
Inspection and Maintenance	Weighted average of (1) MEAV specific to overhead lines; and (2) MEAV specific to switchgears and transformers	Unit cost benchmark to industry median using 8 years of forecast data

Cost Category	Cost Driver	Ofgem RIIO-ED1 Disaggregated Benchmarking Approach
Tree cutting (ENATS 32-8)	Spans cut and spans inspected	Log-log regression using 8 years of forecast data (regression technique: pooled OLS with cluster-robust standard errors)
ONIs	Number of occurrences	Bespoke analysis for each type of occurrence, in general: unit cost benchmark, where the unit cost is set equal to the average of the DNO's own unit cost and industry median unit cost over RIIO-ED1, with qualitative adjustments for some categories of ONI costs. Efficient volumes assessed as the lower of DPCR5 actual and RIIO-ED1 forecast ONI volumes.
Trouble call, LV and HV OHL faults	Number of LV and HV OHL faults	Log-log regression using 4 years of historical data (regression technique: pooled OLS with cluster-robust standard errors)
Trouble call	Number of faults (at each voltage level and fault category)	Separate assessment for each fault type, in general: unit cost benchmarking to industry median (based on 8 years of forecast data); volumes assessed by taking the lower of DPCR5 actual and RIIO-ED1 forecast annual fault volumes, with qualitative adjustments for some categories of trouble call costs. Efficient volumes assessed as the lower of DPCR5 actual and RIIO-ED1 forecast fault volumes.
Non-op capex, ITT	MEAV	75% weight on qualitative expert view; 25% on quantitative unit cost benchmark to median (using 13 years of data)
Non-op capex, vehicles and transport	MEAV	Assessed together with vehicles and transport costs within CAI; unit cost benchmark to industry median using 13 years of data
Non-op capex, property	MEAV	Unit cost benchmark to industry median using 13 years of data
Non-op capex, STEs, plant and machinery		Allow each DNO their submitted costs

Source: Ofgem/NERA[7]

To account for differences in labour costs faced by DNOs in different parts of the country, Ofgem applied a "Regional Labour Adjustment" to costs, prior to running its models. Ofgem normalised labour costs using ONS data on wages in different parts of the country to adjust a portion of DNOs' costs upwards or downwards to reflect differences in labour costs in each DNOs' operating area compared to the national average. Ofgem calculated the share of costs attributable to labour as the average of all GB DNOs' labour cost shares, then applied its adjustment to the "local" share of labour, i.e. Ofgem assumed that some labour can be located outside a DNO's region, meaning that low-cost regions do not have a cost advantage for those labour costs (since it may be efficient for a DNO in a high-wage area to outsource some activities, e.g. call centre staff, to a low-wage area).

Some of the cost drivers Ofgem used correspond to areas in which London's operational environment differs. For example, Ofgem's model for workforce renewal (benchmarked against the total number of leavers) and non-workforce renewal (benchmarked against the total current workforce) controls for the amount of worker turnover, which may vary by geographical region for reasons outside of DNOs control.

Also, a number of Ofgem's aggregate and disaggregated models use MEAV as a driver, which is calculated by multiplying every asset on the DNO's asset register by Ofgem's view

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[7] (1) Ofgem (November 2014), "RIIO-ED1: Final determination for the slow-track electricity distribution companies – Business plan expenditure assessment: Final decision"; (2) NERA analysis of Ofgem modelling files.

of the unit cost of installing that asset.[8] In this way, it is a proxy for the scale and composition of each DNO's network.[9] However, MEAV does not account for differences in the unit cost of installing, accessing and maintaining similar assets located in different places.

3.1.2. Ofgem's use of special factor claims to control for the specificities of the London networks

At RIIO-ED1, four of the six DNO groups (SSEPD, UKPN, SPEN and ENWL) proposed company-specific factors in their revised business plans, submitted in March 2014 after Ofgem's decision to fast-track WPD's four DNOs.[10] In addition to Ofgem's proposed adjustments for regional labour costs, UKPN also claimed special factors associated with the cost of working in London, for its LPN and SPN networks. UKPN's regional factor claim was divided into the following categories: [11]

- **Transport and Travel** – Additional costs associated with London congestion charging, parking fines, delivery, vehicle servicing, and the need to move plant overnight to avoid heavy traffic;
- **Excavation** – Additional costs due to the higher cost of excavation permission and the need to inform local residents;
- **Operations** – The extra cost of maintaining and repairing assets in London;
- **Security** – Higher security costs associated with preparation of major events
- **Properties** – UKPN identified higher insurance premiums on high value London properties that are especially at risk of terrorism;
- **Resourcing and Contracting** – UKPN suggested there are additional costs of working in the London area associated with different transport costs, standby charges, and labour rates;
- **Tunnels** – Inspection, maintenance and defect repair cost more in London, as do charges from local authorities for accessing tunnels; and
- **Central London Network Strategy** – Additional costs of providing the enhanced service demanded by customers in Central London.

Excluding labour costs, Ofgem accepted 41 per cent of UKPN's claims for LPN. In its final decision, Ofgem accepted its consultants' assessment that LPN did not provide sufficient justification for the remainder of its claims.[12] Notably, in its expenditure assessment, Ofgem only acknowledges UKPN's claims in relation to LPN, and made no comment on its decision

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[8] It excludes: rising and lateral mains (RLM), LV service associated with RLM, batteries at ground mounted HV substations, 3kV substations, 66kV substations, and 132kV substations, pilot wire overhead, pilot wire underground, cable tunnels (DNO owned), cable bridges (DNO owned), electrical energy storage.

[9] Ofgem (2012), RIIO-ED1: Final determinations for the slow-track electricity distribution companies Business plan expenditure assessment, p. 39.

[10] Ofgem (2012), RIIO-ED1: Final determinations for the slow-track electricity distribution companies Business plan expenditure assessment, p. 4.

[11] UK Power Networks (March 2014), Business Plan (2015 to 2023), Annex 13a: Regional Cost Justification, p. 10.

[12] Ofgem (2012), RIIO-ED1: Final determinations for the slow-track electricity distribution companies Business plan expenditure assessment, p. 48.

not to apply special factors to SPN's costs. Outside of London, Ofgem also accepted company-specific cost adjustments for two other DNOs:

- **SSEH** (in Northern Scotland) related to the high cost of operating in remote, sparsely populated areas in the highlands and islands of Scotland; and
- **SPMW** (in North Wales and North West England) related to its unique network configuration (due to its historical, pre-privatisation design), which increased maintenance costs. Unlike most distribution network assets in Britain, SPMW has an interconnected rather than a radial network design which the company claimed (and Ofgem accepted) increases costs.

Hence, Ofgem's special factor adjustments related factors for which its models did not control in relation to either rurality or urbanity or differences in legacy network design.

3.1.3. Use of outcome performance comparisons to determine DNOs' allowed revenues

In RIIO-ED1, Ofgem operates two financial incentives which rely upon comparative assessment.

Firstly, each DNO is incentivised to reach certain standards of customer service via the Broad Measure of Customer Service (BMCS). The BMCS has three components:[13]

- *The annual customer satisfaction survey* covers three categories of customer: customers that require a new connection, customers experiencing an interruption, and customers making a general enquiry. All DNOs have the same penalty and reward thresholds, across all categories of customer. These thresholds are set against a benchmark based on the customer service achieved across a range of different industries, including retail, banking and other utility services. The thresholds include one for the maximum penalty, maximum reward and a mid-range target.
- *The complaints metric* measures performance against four key indicators to assess the quality of the DNOs' complaints handling procedures. These indicators are then weighted to calculate an overall complaints metric score. The target and maximum penalty threshold for this score are based on the average-performing and worst-performing DNO during the 2012-13 period respectively.[14]
- *The stakeholder engagement and consumer vulnerability incentive* obliges DNOs to submit a report on both stakeholder engagement and consumer vulnerability. These reports are then measured against a set of minimum criteria to assess whether each DNO is eligible for a reward.

Therefore, the first two components of the BMCS directly rely upon comparative assessment, while the third does not, except to the extent that Ofgem's subjective assessment reflects

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[13] Ofgem (2014), Guide to RIIO-ED1, p. 34.

[14] Ofgem (2014), Guide to RIIO-ED1, p. 35.

differences between companies' performance. Overall, the range of penalties and rewards is -1.5 to 1.5 per cent as a proportion of base allowed revenue.[15]

Each DNO is also incentivised to provide a reliable supply through the **Interruptions Incentive Scheme** (IIS).[16] Specifically, DNOs are incentivised on the number and duration of planned and unplanned network supply interruptions; the unpanned interruptions incentive is set against a target derived from benchmark industry performance.[17] Most recently, Ofgem set the targets during the RIIO-ED1 price control, which will remain in place until the next periodic review.[18]

3.1.4. Performance of London companies in comparative assessment

Table 3.2 summarises the results of Ofgem's cost assessment before IQI interpolation, i.e. the process by which Ofgem accounted for DNOs' own cost forecasts (see Section 3.1.1).

Table 3.2: Ofgem's Cost Assessment by DNO for RIIO-ED1

DNO	Slow-track Final Submitted Totex	Modelled Efficiency Gaps		Rank
	£m	£m	%	
ENWL	1,876	17	0.9%	2
NPgN	1,368	-57	-4.2%	5
NPgY	1,805	-46	-2.5%	4
LPN	1,970	-164	-8.3%	9
SPN	1,872	-105	-5.6%	6
EPN	2,775	-160	-5.7%	8
SPD	1,563	60	3.9%	1
SPMW	1,924	-200	-10.4%	10
SSEH	1,210	-68	-5.6%	6
SSES	2,425	-6	-0.2%	3
Total	18,788	-728	-3.9%	

Note: The four WPD DNOs, while included in the comparative benchmarking, were not subject to the efficiency assessment according to Ofgem's models, since they were "fast-tracked".
Source: Ofgem[19]

At the aggregate level, Ofgem made downwards adjustments to the DNOs' costs worth 3.9 per cent of submitted costs.[20] LPN was given a downwards adjustment of 8.3 percent based on this initial cost assessment. By Ofgem's estimate, this placed LPN as second-least efficient out of the ten slow-track DNOs. SPN and EPN, the only other DNOs with some

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[15] Ofgem (2014), Guide to RIIO-ED1, p. 34.

[16] Ofgem (2014), RIIO-ED1: Final Overview, p. 17.

[17] Ofgem (2013), RIIO-ED1: Strategy decision for the RIIO-ED1 electricity distribution price control – Outputs, incentives and innovation, p. 32.

[18] Ofgem (2017), Guide to the RIIO-ED1 electricity distribution price control, p. 48.

[19] Ofgem (November 2014) RIIO-ED1: Final determinations for the slow-track electricity distribution companies – Overview, p. 21.

[20] Ofgem made further adjustments to companies' costs to account for smart grid benefits (Ofgem's 'off-model' assessment of additional savings companies should make over RIIO-ED1 due to the roll out of 'smart' technology) and Real Price Effects (RPEs – i.e. Ofgem's assessment of real input price inflation).

operations in London, performed slightly better , ranked 6th and 8th with efficiency gaps of 5.6 per cent and 5.7 per cent respectively. Slow-track DNOs were generally given downward adjustments at the cost assessment stage; only ENWL and SPD were given uplifts of 0.9 per cent and 3.9 per cent respectively.

Table 3.3 summarises industry performance in the BMCS in 2016-17. All companies exceeded the industry-wide customer satisfaction and complaints targets, although LPN was ranked 10 out of the 14 DNOs by customer satisfaction, and 13th by the complaints metric. Under the IIS, LPN recorded the fewest customer interruptions and the lowest average customer minutes lost, meaning LPN received the highest reward of any company.[21]

Table 3.3: DNO 2016-17 BMCS Performance

DNO	**Customer Satisfaction**		**Complaints**	
	Score	Rank	Score	Rank
ENWL	8.32	14	3.45	9
NPgN	8.68	8	7.08	14
NPgY	8.59	12	5.40	12
WMID	8.86	4	1.43	1
EMID	8.96	1	1.74	2
SWALES	8.89	3	2.61	5
SWEST	8.91	2	2.29	4
LPN	8.63	10	5.71	13
SPN	8.69	7	5.29	11
EPN	8.61	11	5.06	10
SPD	8.65	9	2.85	7
SPMW	8.82	6	2.83	6
SSEH	8.82	5	2.18	3
SSES	8.37	13	3.33	8
Target	8.2		8.33	

Note: The third component of the BMCS, stakeholder engagement, is assessed qualitatively.
Source: Ofgem.[22]

3.2. Gas Distribution

3.2.1. Comparative cost assessment at RIIO-GD1

At RIIO-GD1, Ofgem used four sets of models to benchmark Gas Distribution Networks' (GDNs') costs. As in RIIO-GD1 (see 3.1.1), Ofgem relied on a combination of top-down models and disaggregated bottom-up models: a four-year historical totex estimate, a four-year historical bottom-up estimate, two-year forecast totex estimate and two-year forecast bottom-up estimate.[23] Ofgem's view of efficient costs was formed of the straight-line average of these four models with an upper-quartile adjustment; and Ofgem finally placed 75 per cent

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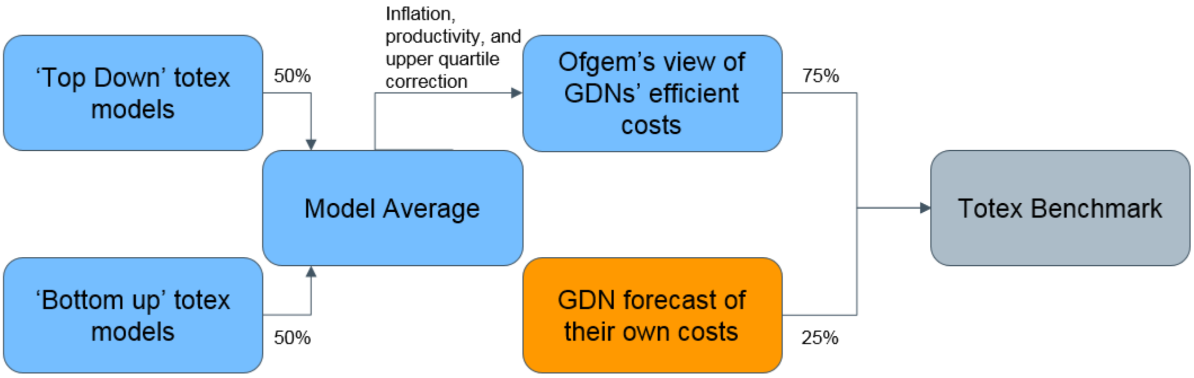
[21] Ofgem (2017), RIIO-ED1 Annual Report 2016-17, Table A2.1 p. 26.

[22] Ofgem (2017), RIIO-ED1 Annual Report 2016-17, Table A2.7 p. 37.

[23] Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, p. 11.

weight on its assessment and 25 per cent on GDN's own forecast to form companies' final allowances.[24] An overview of this process is given in Figure 3.2.

Figure 3.2: Ofgem's Approach to Benchmarking at RIIO-GD1



Ofgem used a single driver in each of its two 'top-down' models, a CSV which combined network scale based on MEAV with workload drivers based on Ofgem's bottom-up regressions.[25] The bottom-up assessment used different cost drivers for different activities:

- **Work management,** measured by MEAV;
- **Emergency,** measured by a CSV of external condition reports (20 per cent) and number of customers (80 per cent);
- **Repairs,** measured by external condition reports;
- **Maintenance,** measured by Maintenance MEAV;
- **Mains reinforcement,** measured by mains reinforcement workload;
- **Connections,** measured by connections workload; and
- **Repex,** measured by workload related to reducing iron-mains risk.

In its bottom-up assessment, Ofgem also used non-regression methods, such as "qualitative and technical assessment", for other cost activities.[26] For example, for gas holder decommissioning costs, Ofgem calculated an average unit cost which it applied across the GDNs, and for vehicle costs, Ofgem relied upon historical average vehicle spend.[27]

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[24] Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, p. 11.

[25] Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, p. 22.

[26] Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, p. 27.

[27] Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, p. 22.

For each non-regressed cost activity, Ofgem applied its view of real price effects, but did not apply additional adjustments for ongoing efficiencies, as the analysis was based on the GDN's forecast costs.

3.2.2. Ofgem's use of special factor claims to control for the specificities of the London networks

In its Initial Proposals, Ofgem proposed two types of regional adjustment to ensure it only benchmarked costs which were comparable across GDNs: company-specific effects and regional labour costs.[28] Ofgem considered the following company-specific factors:[29]

- **Urbanity,** i.e. the different level of productivity associated with working in an urban environment. Ofgem recognised the reduced labour productivity associated with working inside the M25, and applied a productivity adjustment of 15 per cent to the labour cost element of repex and capex mains reinforcement and connections work carried out within the M25.
- **Sparsity,** i.e. the differences in costs associated with working in relatively sparse areas for the emergency and repair cost activities. It calculated sparsity indices based on district level area and population data and then adjusted the GDNs' cost data. This decreased the cost allowances for London GDNs.
- **Salt cavity costs,** a company-specific special factor for NW's cost associated with maintaining a salt cavity storage facility.

Ofgem's urbanity adjustment was based on evidence submitted by SGN, which found that congestion, depth of infrastructure and access issues reduced labour productivity by 15 to 20 per cent.[30] Ofgem also recognised lower labour productivity associated with reinstatement costs within the M25 by assuming that reinstatement costs were 100 per cent labour, meaning that Ofgem applied the London labour cost adjustment to all costs associated with reinstatement.[31]

The GDNs broadly supported Ofgem's urbanity adjustments, but NGGD and SGN expressed concerns about the scale of the adjustment in response to the draft determination, which they considered did not fully consider the effect of lower productivity in inner London on their costs. NGGD requested that Ofgem consider a 20 per cent productivity uplift for London GDNs' repex, emergency and repair activities.[32] Ofgem re-examined SGN's evidence but decided to retain the urbanity productivity factor at the initially proposed level of 15 per cent. It believed that additional productivity costs were captured by Ofgem's regional labour adjustment, which reflected differences in overtime and shift premium pay.[33]

Ofgem recognised labour cost differentials between London, the South East and other parts of Great Britain by making a pre-modelling adjustment to companies' costs. It calculated labour indices using the Office of National Statistics' (ONS) Annual Survey of Hourly Earnings

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[28] Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, p. 13.

[29] Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, p. 13.

[30] Ofgem concluded that the lower bound, 15 per cent, was appropriate, because "an efficient company minimises its productivity impact.

Ofgem (2012), RIIO-GD1: Initial Proposals - Supporting document - Cost efficiency, p. 100.

[31] Ofgem (2012), RIIO-GD1: Initial Proposals - Supporting document - Cost efficiency, p. 100.

[32] Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, p. 14.

[33] Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, p. 14.

(ASHE) data.[34] Apart from SGN, all GDNs supported Ofgem's approach to accounting for regional differences in labour costs. SGN proposed using average instead of year-specific direct labour indices to reflect the effects of direct labour pay settlements which last longer than one year.[35]

Table 3.4 shows the labour indices Ofgem used by GDN region.

Table 3.4: RIIO-GD1 Labour Indices 2009 to 2021

	Contract Labour			Direct Labour		
GDN	2009	2010	2011-21	2009	2010	2011-21
EoE	0.97	0.97	0.97	0.98	0.98	0.98
Lon	1.18	1.16	1.18	1.15	1.14	1.16
NW	0.96	0.96	0.96	0.96	0.97	0.97
WM	0.96	0.96	0.96	0.96	0.97	0.97
NGN	0.96	0.96	0.96	0.96	0.97	0.97
Sc	0.96	0.96	0.96	0.96	0.97	0.97
So	1.1	1.09	1.09	1.1	1.08	1.07
WWU	0.96	0.96	0.96	0.96	0.97	0.97

Source: Ofgem[36]

3.2.3. Use of outcome performance comparisons to determine GDNs' allowed revenues

During RIIO-GD1, GDNs are incentivised to provide customers with a good level of service through a BMCS incentive similar to that applied to DNOs under the ED1 price control (see Section 3.1.3). As in ED1, the incentive comprises a customer satisfaction survey, a complaints metric and a stakeholder engagement component:

- The customer survey score is calculated as the simple mean of satisfaction as reported by three types of customer: those who experienced planned interruptions, those who experienced unplanned interruptions and those requesting new connections.[37] The target and maximum reward/penalty scores are based on data from a trial survey administered in the 2011-12 period.[38] The target is specifically calculated as the upper quartile performance across companies from that survey, while the upper and lower thresholds are 'broadly based' upon 1.5-1.75 standard deviations from the trial's mean score.
- The complaints metric is the weighted average of the following indicators: percentage of complaints unresolved after one working day (10 per cent), percentage of complaints unresolved after 31 working days (30 per cent), percentage of repeat complaints (50 per cent), the number of Energy Ombudsman (EO) decisions that go against the GDN as a percentage of total complaints received (10 per cent). The fixed target is calculated based on upper quartile performance during 2011-12 and the maximum penalty score is

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[34] Ofgem (2012), RIIO-GD1: Final Proposals – Supporting document – Cost efficiency, p. 13.

[35] Ofgem (2012), RIIO-GD1: Final Proposals – Supporting document – Cost efficiency, p. 14.

[36] Ofgem (2012), RIIO-GD1: Final Proposals – Supporting Document – Cost Efficiency, Table 2.1, p. 15.

[37] Ofgem (2012), RIIO-GD1: Final Proposals – Supporting Document – Outputs, Incentives and Innovation, p. 23.

[38] Ofgem (2012), RIIO-GD1: Final Proposals – Supporting Document – Outputs, Incentives and Innovation, p. 20.

calculated based on 1.75 standard deviations from the mean level of performance in 2011-12.[39]

- In the stakeholder engagement scheme, companies which meet certain minimum requirements qualify to attend an independent panel assessment. The panel assesses the submissions through a Q&A session and with the aid of a scorecard. Based on the company's score the panel then decides whether the company is eligible for a financial reward.

As at ED1, the first two components of the GD1 BMCS directly rely upon comparative assessment, while the third (stakeholder engagement) does not, except to the extent that Ofgem's subjective assessment reviews differences between companies' performance. Overall, the possible range of penalties/rewards resulting from the three components of the BCMS is a 1 per cent reduction to a 1 per cent increase in the GDN's allowed revenue.[40]

3.2.4. Performance of London companies in comparative assessment

As explained in Section 3.2.1, to arrive at final cost allowances, Ofgem first calculated baseline costs using a straight-line average of four cost assessment models and then took account of companies' own forecasts using the IQI.[41] For opex and capex, Ofgem reports the gap between GDN-submitted costs (after Ofgem adjustment) and the 'Ofgem baseline' (see Table 3.5 and Table 3.6 respectively).

At the totex level and after adjustments for IQI allowance, Cadent London ("Lon" in the tables below) was ranked least efficient across all GDNs, with an estimated efficiency gap of 11 per cent. SGN Southern ("So") which partly operates in London was ranked joint second with an efficiency gap of 5 per cent. Considering opex and capex performance separately, SGN Southern was found to be relatively efficient for opex, but less efficient for capex, whereas Ofgem's analysis found Cadent London was relatively inefficient in both categories.

For opex,[42] Cadent London had an efficiency gap between 14 per cent and 16 per cent, depending on Ofgem's model (before IQI adjustment).[43] This placed it jointly second-to-last across the eight GDNs. SGN Southern performed better with efficiency gaps between 7 per cent and 9 per cent, ranking second most efficient.

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[39] Ofgem (2012), RIIO-GD1: Final Proposals – Supporting Document – Outputs, Incentives and Innovation, p. 24.

[40] Ofgem (2012), RIIO-GD1: Final Proposals – Supporting Document – Outputs, Incentives and Innovation, p. 26.

[41] Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, p. 12.

[42] The two categories of Ofgem's definition of operating expenditure (opex) were direct activities (work management, emergency, repairs, maintenance and 'other') or indirect activities (business support, training and apprentices).

[43] Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, p. 46.

Table 3.5: Opex Efficiency Gaps by GDN for RIIO-GD1

	EoE	Lon	NW	WM	NGN	Sc	So	WWU	Total
Submitted costs	1,018.1	755.3	762.1	533.4	708.3	635.1	1,088.9	817.5	6,318.6
Ofgem adjusted costs	1,013.8	742.7	749.5	534.5	734.9	652.9	1,060.6	754.1	6,242.9
Ofgem cost baseline (historical model)	862.7	639.8	642.4	492.1	643.8	542.1	962.2	639.5	5,424.5
Gap to Ofgem adjusted cost	-15%	-14%	-14%	-8%	-12%	-17%	-9%	-15%	-13%
Ofgem cost baseline (forecast model)	880.0	627.1	636.2	479.9	636.7	530.5	983.6	644.9	5,418.8
Gap to Ofgem adjusted costs	-13%	-16%	-15%	-10%	-13%	-19%	-7%	-14%	-13%

Note: Ofgem cost baselines are pre-IQI adjustment.
Source: Ofgem[44]

For capex,[45] Cadent London had the second-largest efficiency gap at 23 per cent according to the historical model, and the largest efficiency gap (27 per cent) according to the forecast model. SGN Southern, had the largest gap in the historical model (25 per cent) and the second-largest gap according to the forecast model (23 per cent).

Table 3.6: Capex Efficiency Gaps for RIIO-GD1

	EoE	Lon	NW	WM	NGN	Sc	So	WWU	Total
Submitted costs	384.0	217.3	240.3	188.5	374.8	419.5	586.0	445.8	2,856.2
Ofgem adjusted costs	354.6	212.2	232.1	180.8	349.3	345.0	520.8	398.8	2,593.5
Ofgem cost baseline (historical model)	292.1	162.4	206.3	159.2	329.4	282.0	390.9	355.7	2,178.1
Gap to Ofgem adjusted cost	-18%	-23%	-11%	-12%	-6%	18%	-25%	-11%	-16%
Ofgem cost baseline (forecast model)	290.9	154.6	199.3	151.0	333.6	284.7	399.4	370.3	2,184.0
Gap to Ofgem adjusted costs	-18%	-27%	-14%	-16%	-4%	17%	-23%	-7%	-16%

Note: Ofgem cost baselines are pre-IQI adjustment.
Source: Ofgem[46]

All GDNs met their annual output targets in 2016-17 except three of the four Cadent networks which did not meet all of their customer satisfaction targets.[47] Table 3.7 summarises GDN performance in the BMCS in 2016-17. Cadent London were ranked last according to both measures, while SGN Southern ranked 4th out of 8; both Cadent London and SGN Southern have consistently ranked lowest for both measures within their ownership groups.

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[44] Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, Table 6.7, p. 43.

[45] The five categories of capital expenditure (capex) were LTS and storage, reinforcement, connections, governor replacement and 'other'. Source: Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, p. 46.

[46] Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, Table 7.2, p. 48.

[47] Ofgem (2017), RIIO-GD1 Annual Report 2016-17, Table 2.1 p. 4.

Table 3.7: GDN 2016-17 BMCS Performance

DNO	Customer Satisfaction		Complaints	
	Score	Rank	Score	Rank
EoE	8.69	5	9.32	5
Lon	8.12	8	11.03	8
NW	8.49	6	9.39	6
WM	8.25	7	10.20	7
NGN	9.17	2	2.65	2
Sc	9.25	1	2.64	1
So	9.01	4	3.67	4
WWU	9.11	3	2.83	3
Target	8.31		11.57	

Note: The third component of the BMCS, stakeholder engagement, is assessed qualitatively.
Source: Ofgem.[48]

3.3. Water and Wastewater

3.3.1. Comparative cost assessment at PR14 and PR19

3.3.1.1. Ofwat's cost assessment at PR14

In Ofwat's 2014 price review (PR14), it set allowances for the 2015 to 2020 period on each of the following activities separately: wholesale water, wholesale wastewater, household retail and non-household retail. [49,50]

Ofwat's consultants, CEPA, constructed 'basic cost threshold' (BCT) projections of the efficient level of wholesale totex (for water and wastewater separately) over AMP6 (2015 to 2020). Ofwat derived the BCT using forecast driver data fed into a set of regression and unit cost models for the wholesale water and wastewater services. Ofwat used the thresholds to assess each regulated company's efficiency according to their proposed level of wholesale water and wastewater expenditure as set out in their business plans. The water totex BCT was constructed using results from the following three models:

- A **refined water top-down totex model**, which is composed of an unweighted average of 'thresholds' obtained from two models: the first uses the random effects (RE) econometric technique and the other uses corrected ordinary least squares (COLS). These two refined models include only explanatory variables that are statistically significant or variables that are important from a theoretical point of view;

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[48] Ofgem (2017), RIIO-GD1 Annual Report 2016-17, Table 2.26O and Table 28O.

[49] Ofwat, 2016 non-household retail price review, URL: https://www.ofwat.gov.uk/regulated-companies/price-review/2016-non-household-retail-price-review/.

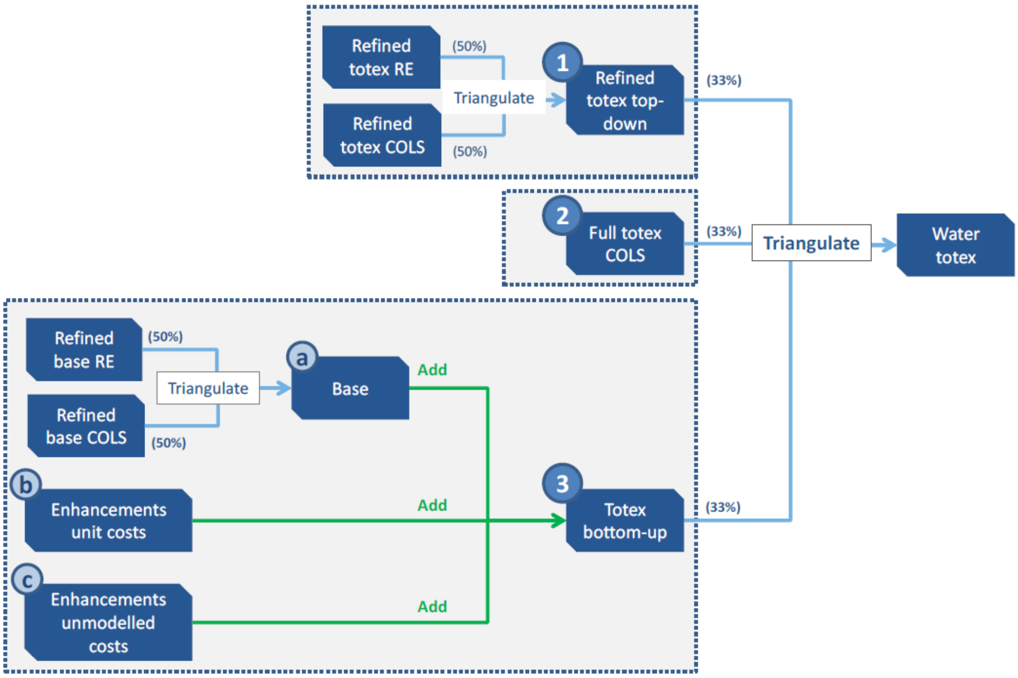
[50] The Water Act 2014 allowed certain businesses and other non-household customers of providers wholly or mainly in England to choose their supplier of water and wastewater retail services. These services included billing, meter reading and other customer services. The non-household retail price controls at PR14 were therefore designed to apply for only two years.

Source: Ofwat, 2016 non-household retail price review, URL: https://www.ofwat.gov.uk/regulated-companies/price-review/2016-non-household-retail-price-review/.

- A **full totex COLS model**, which is a top down model which includes all explanatory variables, including those which may not be statistically significant or theoretically important;
- A **totex bottom-up model**. It begins with two refined base models which estimate total opex and capital maintenance (botex) expenditure, but unlike totex models they do not include capital enhancement expenditure. One of these uses RE and the other uses COLS.

Ofwat's approach to combining the results of different models (at different levels of aggregation) is set out in Figure 3.3 and Figure 3.4 below for water and wastewater respectively.

Figure 3.3: Ofwat's Approach to Combining Water Models at PR14



Source: Ofwat.[51]

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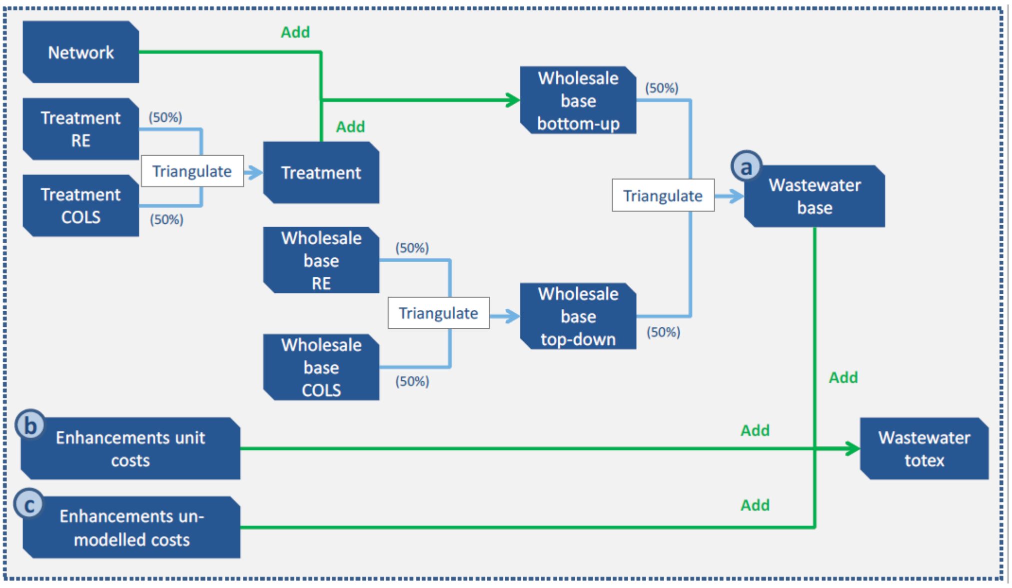
[51] CEPA (20 March 2014), Ofwat Cost Assessment – Advanced Econometric Models, Figure 5.1.

Figure 3.4: Ofwat's Approach to Combining Wastewater Models at PR14



Source: Ofwat.[52]

Ofwat's wholesale water models used explanatory variables which fell under the following (cost driver) categories, which CEPA described as follows:[53]

- **A time trend,** which was expected to capture a combination of Real Price Effects (RPE) changes in efficiency and changes in quality which are not explained by other explanatory variables;
- **Input prices,** such as regional wages and construction prices;
- **Network characteristics,** including population density (used to measure 'occupancy'), the prevalence of metered properties (as metered properties were expected to have lower water consumption than non-metered and hence generate lower costs) and proportions of usage by metered and non-metered household properties respectively;
- **Treatment and sources characteristics,** in terms of the number of sources, pumping head (a proxy of energy consumption used in pumping), water input from river abstractions and reservoirs;
- **Level of activity,** in terms of the prevalence of new meters, new mains and mains relined or renewed as basic driver of costs; and
- **Quality,** referring to the prevalence of properties with inadequate water pressure, leakage, planned and unplanned interruptions.

The approach to controlling for sewerage cost drivers was very similar, using proxies for scale and treatment costs related to sewerage.[54]

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[52] CEPA (20 March 2014), Ofwat Cost Assessment – Advanced Econometric Models, Figure 5.2.

[53] CEPA (20 March 2014), Ofwat Cost Assessment – Advanced Econometric Models, p. 22.

[54] CEPA (20 March 2014), Ofwat Cost Assessment – Advanced Econometric Models, p. 22.

Before running its models, Ofwat smoothed capital maintenance and capital enhancement costs, to account for the "lumpiness" of capex from year-to-year, meaning that the dependent variable in Ofwat's totex (and botex) models consisted of [opex in given year] + [capex (or capital maintenance) 5-year moving average]. This smoothing lessens the effect of abnormally higher investment in one year, by spreading it over a five-year period.

CEPA considered two model specifications for cost benchmarking at PR14: Cobb-Douglas and 'translog'.[55] Under the Cobb-Douglas model specification, the coefficients on cost drivers can be interpreted as the elasticity of cost with respect to the corresponding driver; as per the models estimated by Ofgem at GD1 and ED1. In contrast, the translog specification includes higher-order (i.e. squared variables (e.g. $[\text{population}]^2$) and interaction (cross) terms (e.g. [network length]×[density]), which allows the returns-to-scale factor to vary. Ultimately, Ofwat chose to rely upon models using the translog functional form at PR14, finding that translog models performed better according its model robustness criteria.

3.3.1.2. CMA's redetermination of Bristol Water's costs at PR14

Bristol Water sought a referral of Ofwat's PR14 final determination to the Competition and Markets Authority (CMA).[56] In its redetermination, the CMA decided to reassess Bristol's efficient wholesale expenditure using its own set of models, because it identified shortcomings in the Ofwat models' specification and design.[57] The CMA identified the following shortcomings with Ofwat's modelling approach:[58]

- **No disaggregation below wholesale water:** Ofwat's exclusive use of top-down analysis precluded the benefits of more disaggregated modelling;
- **Timing of investment needs:** While Ofwat used a smoothed version of capex, it did not sufficiently account for the timing of investment needs;
- **Totex models that include enhancements:** Ofwat's water totex models did not sufficiently capture the heterogenous nature of enhancement which varies significantly over time and between companies;
- **Counter-intuitive coefficients:** The estimated coefficients of some models contradicted causality that would be explained by conventional engineering or economic logic;
- **Relationship between costs and cost drivers:** Furthermore, the way in which Ofwat included some of the explanatory variables in its models contradicted either engineering or economic intuition;
- **Number of explanatory variables relative to sample size:** The large ratio of variables to sample size, particularly for the totex model, posed a risk of inaccuracies in the results;
- **Translog models:** The inclusion of higher-order (squared) terms and interaction (cross) terms in Ofwat's models complicated interpretation of the models' results. Furthermore, Ofwat did not strictly follow convention in the translog functional form by only applying higher-order and cross-terms to a subset of the identified cost drivers; and

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[55] CEPA (20 March 2014), Ofwat Cost Assessment – Advanced Econometric Models, p. 16.

[56] CMA (2018), Bristol Water plc: A reference under section 12(3)(a) of the Water Industry Act 1991, p. 1.

[57] CMA (2018), Bristol Water plc: A reference under section 12(3)(a) of the Water Industry Act 1991, p. 7.

[58] CMA (2018), Bristol Water plc: A reference under section 12(3)(a) of the Water Industry Act 1991, 72-73.

- **Endogeneity:** Some variables were likely to be correlated with the error term, resulting in 'endogeneity' in the model which would cause bias in model estimates. That is, long-run average of the estimates from repeated sampling was not equal to the underlying subject of the estimate.

The CMA's alternative models were, in some respects, a refinement of Ofwat's, since they used the same dataset of costs and explanatory variables with minor adjustments. However, in contrast to Ofwat, the CMA did not use totex models, but limited its econometric modelling to botex (opex and capital maintenance). The CMA developed 18 initial models, six sets of explanatory variables with three different specification types:[59]

- **Logarithmic unit cost models,** in which the dependent variable was the natural logarithm of the measure of expenditure per connected property;
- **Linear unit cost models,** in which the dependent variable was expenditure per connected property, without taking the logarithm; and
- **Logarithmic aggregate cost models,** in which the dependent variable was a measure of aggregate wholesale (base) expenditure.

- From the initial set of 18 models, the CMA took a simple average of seven preferred models for its Final Determination.[60] The CMA used both smoothed and unsmoothed botex as dependent variables for their regressions, and in its unsmoothed models, the CMA was able to use a longer (7 year) time period.[61] For the smoothed botex models, the CMA used explanatory variables in explanatory variable groups 'EV2' and 'EV3' for both the log unit cost and linear unit cost specifications. For the unsmoothed botex models it used both variable groups for the linear unit cost, but only EV2 for log unit cost. (See Table 3.8 and Table 3.9 respectively).

Table 3.8: Explanatory Variables by Cost Driver for Log Unit Cost Models

Explanatory Variable	CEPA PR14 Driver Category	EV2	EV3
Water delivered per property	Scale (Core)	Yes	Yes
Regional wage measure	Input prices	Yes	Yes
Mains length per property	Scale (Core)	Yes	Yes
Proportion of distribution input from rivers	Treatment and source characteristics	Yes	Yes
Proportion of distribution input from reservoirs	Treatment and source characteristics	Yes	Yes
Average pumping head	Treatment and source characteristics	Yes	Yes

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[59] CMA (2018), Bristol Water plc: A reference under section 12(3)(a) of the Water Industry Act 1991, p. 84.

[60] The other models were dropped owing to their output of counterintuitive coefficients on key variables.

CMA (October 2015), "Bristol Water plc – A reference under section 12(3)(a) of the Water Industry Act 1991: Report", paras. 4.148 – 4.152.

[61] CMA (October 2015), "Bristol Water plc – A reference under section 12(3)(a) of the Water Industry Act 1991: Report", p. 84.

Explanatory Variable	CEPA PR14 Driver Category	EV2	EV3
Proportion of water consumption by metered non-household customers	Network characteristics	No	Yes
Proportion of distribution input subject to W3 or W4 treatment	Quality	No	Yes

Source: CMA / Ofwat[62]

Table 3.9: Explanatory Variables by Cost Driver for Linear Unit Cost Models

Explanatory Variable	CEPA PR14 Driver Category	EV2	EV3
Water delivered per property	Scale (Core)	Yes	Yes
Regional wage measure	Input prices	Yes	Yes
Mains length per property	Scale (Core)	Yes	Yes
Proportion of distribution input from rivers x water delivered per property	Treatment and source characteristics	Yes	Yes
Proportion of distribution input from reservoirs x water delivered per property	Treatment and source characteristics	Yes	Yes
Average pumping head x water delivered per property	Treatment and source characteristics	Yes	Yes
Proportion of water consumption by metered non-household customers	Network characteristics	No	Yes
Proportion of distribution input subject to W3 or W4 treatment x water delivered per property	Quality	No	Yes

Source: CMA / Ofwat[63]

Since Bristol Water is a water-only company, the CMA's redetermination did not consider Ofwat's PR14 wastewater models; however, the CMA's critique equally applies to Ofwat's wastewater models, which were similar to its water models, but relied upon an even smaller number of observations.

3.3.1.3. Ofwat's draft models at PR19

At PR19, Ofwat will develop a new suite of benchmarking models for assessing the efficiency of water and wastewater companies. Ofwat has indicated that it will consider the CMA's concerns and critiques in the Bristol Water appeal at PR14.

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[62] CMA Redetermination for Bristol Water, p. 85 and Ofwat PR14 Cost Assessment, p. 20.

[63] CMA Redetermination for Bristol Water, p. 85 and Ofwat PR14 Cost Assessment, p. 20.

In response to the CMA's arguments, Ofwat included both aggregated and more disaggregated benchmarking models in its PR19 methodology and excluded areas of enhancement expenditure it considered unsuitable for its analysis. To conduct more disaggregated modelling, Ofwat has separated water and wastewater costs according to its "value chain":[64]

- For wholesale water:
    - Water resources,
    - Raw water distribution,
    - Water treatment, and
    - Treated Water Distribution.
- For wholesale wastewater:
    - Wastewater collection,
    - Wastewater treatment, and
    - Bioresources.

Ofwat also set out to ensure that coefficients on variables consistently aligned with prior expectations and excluded translog functional form models altogether.[65] CEPA and Ofwat's approach to selecting cost drivers at PR19 was similar to PR14. However, at PR19 Ofwat has expanded its pool of explanatory variables to reflect each level of disaggregation. CEPA has proposed categories of cost drivers as follows:[66]

- **Scale,** referring to the overall scale of the company's activities as a driver of costs, also allowing an initial evaluation of whether economies of scale exist;
- **Density,** either driving costs up in densely populated areas due to additional costs such as increased expenditure for traffic management or driving costs down as a result of more efficient use of resources, e.g. reducing travelling distances for maintenance (we discuss the PR19 density drivers in more detail in Appendix H, Section H.1.1);
- **System characteristics,** referring to the characteristics or the assets and systems operated by the company insofar as they affect costs of providing services;
- **Quality,** either driving costs up as a result of additional investment required to provide higher quality services, or driving costs down as a result of greater efficiency; and
- **Level of activity,** encompassing the differences in costs that resulted in a higher (but efficient) amount of activity being undertaken by the company to deliver specific outputs.

As of December 2018, Ofwat has published 382 econometric models, all as part of its March 2018 consultation; including 151 models concerning wholesale water botex, and 161 concerning wholesale wastewater botex.[67] Ofwat's own models range from aggregated

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[64] Ofwat (March 2018), Cost assessment for PR19: a consultation on econometric cost modelling, Appendix 1, Table 3 and Table 4.

[65] CEPA (March 2018), PR19 Econometric Benchmarking Models, p. 10.

[66] CEPA(March 2018), PR19 Econometric Benchmarking Models, p. 15.

[67] Ofwat (March 2018), Cost assessment for PR19: a consultation on econometric cost modelling, p. 5.

models (concerning total wholesale water/wastewater botex) to more disaggregated models (concerning one or more component of the water value chain).[68] As of January, 2019, Ofwat has not disclosed its proposed approach for combining the results of different models, or its proposed efficiency target (upper quartile or otherwise).

Notably, Ofwat's initial models fail to control for differences in labour costs between different regions, with neither a pre-modelling adjustment or a regional wage variable included in Ofwat's proposed models.

3.3.2. Ofwat's use of special factor claims to control for the specificities of the London networks

Ofwat applied special cost factors far more extensively at PR14 than Ofgem applied at GD1 and ED1. In net terms, Ofwat granted special cost factors for all but four of the eighteen water companies at PR14; Southern Water, Thames Water, Yorkshire Water and Affinity Water received downwards adjustments of £2 million, £388 million, £47 million and £8 million respectively.[69] Thames Water proposed several London-specific cost adjustments. Among them were:

- **Scheme Specific Factors,** some of which Ofwat allowed;
- **Bad Debts,** totalling £93.2 million owing to the additional costs incurred from the transient nature of customers that reside in Thames Water's London service area; and
- **London Special Factors,** including higher sludge transport costs, energy costs, capital maintenance costs, distribution costs, insurance costs, business rates (rent) and costs associated with road congestion, affecting wholesale water and wholesale wastewater.

Ofwat did not accept Thames Water's £93.2 million claim owing to bad debt. The draft and final determinations do not make clear the regulator's decision on Thames Water's wholesale water and wastewater special cost factors.

In its PR19 methodology, Ofwat has indicated that it will maintain a role for special cost factors at PR19, but that it will make the process more symmetrical, meaning that special cost factor adjustments should reflect the extent to which Ofwat's models overstate, as well as understate, companies costs relative to their peers.[70] Ofwat invited companies to submit proposed special factor adjustments as part of their September 2018 business plan submissions, although companies will also be able to submit special cost factors in response to Ofwat's draft determinations, at which point Ofwat's draft benchmarking models will be published.[71]

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[68] Ofwat (March 2018), Cost assessment for PR19: a consultation on econometric cost modelling, p. 14.

[69] Ofwat (2014), Setting Price Controls for 2015-20 - Final Price Control Determination Notice: Policy Chapter A3 – Wholesale Water and Wastewater Costs and Revenues, p. 35.

[70] Ofwat (December 2017), Delivering Water 2020: Our final methodology for the 2019 price review Appendix 11: Securing cost efficiency, p 11.

[71] Ofwat (December 2017), Delivering Water 2020: Our final methodology for the 2019 price review Appendix 11: Securing cost efficiency, p 13.

As part of its business plan submission in September 2018, Thames Water submitted the following wholesale special factors (or "cost assessment claims"):[72]

- Higher costs for Thames Water (and lower costs for other companies) due to the productivity impacts of working in exceptionally dense urban environments, affecting water network plus and wastewater network plus. This claim concerned higher costs associated with traffic permits, travel disruption and regional wages.
- Higher costs for Thames Water (and lower costs for other companies) due to the age and condition of Thames Water's network and ground conditions in London, affecting water network plus costs.
- "Enhancement" cost assessment claims related to Thames Water's proposed improvements in service:
  - Additional water resources costs to balance water supply and demand as a result of regional water stress, and
  - Additional water resources costs related to improving the resilience of water supply in North East London from climate change and demand growth.

3.3.3. Use of outcome performance comparisons to determine companies' allowed revenues

In the water sector, output regulation consists of "Performance Commitments" (PCs), a target level for some output, and 'Outcome Delivery Incentives' (ODIs) which may consist of financial penalties (or rewards) companies would pay (receive) for underperformance (overperformance) against Performance Commitments.[73]

Ofwat designed ODIs to reflect the value customers place in delivered outcomes, and follows a more bespoke approach than Ofgem's output incentive schemes. At both PR14 and PR19, companies were invited to submit proposed PCs and ODIs against which they would be assessed over the following price control.[74]

At PR14, Ofwat required all companies to deliver certain outcomes, either because the incentive mechanism was based on comparative assessment, or because it deemed the outcome to be universally important to customers or the environment.[75] Ofwat required all companies to target leakage performance and, via the Service Incentive Mechanism (SIM)

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[72] Thames Water's Cost Assessment Claims are summarised in its PR19 Business Plan:

Thames Water (September 2018), Our Business Plan 2020–2025, Appendix 7 – Efficiency, p 65.

[73] Ofwat (January 2018), Service Delivery Report, p. 2, URL: https://www.ofwat.gov.uk/wp-content/uploads/2018/01/Service-Delivery-Report-2016-17-final.pdf.

[74] Each company must also report their performance in an Annual Performance Report (APR). Ofwat (January 2018), Service Delivery Report, p. 2, URL: https://www.ofwat.gov.uk/wp-content/uploads/2018/01/Service-Delivery-Report-2016-17-final.pdf.

[75] Ofwat (July 2013), Setting price controls for 2015-20 – final methodology and expectations for companies' business plans, p. 63. URL: https://webarchive.nationalarchives.gov.uk/20150604030339/http://www.ofwat.gov.uk/pricereview/pr14/pap_pos201307finalapproach.pdf.

customer service.[76] Of these two outcomes, only the SIM target was directly set based on comparative assessment.

The SIM consists of two metrics. First, a Customer Satisfaction (CSAT) score, which contributes 75 per cent of the overall SIM score. Over the year, Ofwat contacts each water company on four occasions unannounced to ask it for details of the household customers in the preceding week. Customers are asked to rate the overall service they received from their water company with a score between 1 (very dissatisfied) and 5 (very satisfied).[77] The second metric, worth the remaining 25 per cent of the SIM score, is a measure of the number of written complaints and unwanted telephone calls that the water company receives from household customers throughout the year. [78] Through direct comparison of companies' overall SIM performance, Ofwat then gives each company a financial penalty or reward.[79]

At PR19, Ofgem proposes to extend comparative assessment to a larger number of "common" performance targets, including leakage, water supply interruptions, sewer flooding and pollution incidents.[80] Ofwat also proposed to replace the SIM with two measures of companies' performance in customer service: the Customer Measure of Experience (C-MeX) and the Developer Services Measure of Experience (D-MeX).[81] The C-MeX covers service provision to residential customers across both the retail and wholesale business, while the D-Mex relates to developer services (i.e. new connections customers).[82]

Ofwat intends C-MeX to address several perceived shortcomings in C-MeX's PR14 predecessor, the SIM.[83] Firstly, Ofwat was concerned with the convergence in SIM scores with diminishing improvements at the upper end; which it suggested demonstrated ineffectiveness in encouraging leading companies to improve the customer service frontier. Secondly, Ofwat suggested that because the SIM was limited to comparisons within the water sector, the mechanism would not incentivise companies to reach the higher levels of customer

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[76] Ofwat (December 2014), Setting price controls for 2015-20 Final price control determination notice: policy chapter A2 – outcomes, p. 10, URL: https://www.ofwat.gov.uk/wp-content/uploads/2015/10/det_pr20141212outcomes.pdf.

[77] Thames Water (30 June 2017), Annual Performance Report 2016/17 ,p. 15. URL: https://corporate.thameswater.co.uk/-/media/Site-Content/Thames-Water/Corporate/AboutUs/Investors/Annual-report/2018/Previous-reports/Annual-performance-report-2016-17-combined.pdf.

[78] Thames Water (30 June 2017), Annual Performance Report 2016/17 ,p. 15. URL: https://corporate.thameswater.co.uk/-/media/Site-Content/Thames-Water/Corporate/AboutUs/Investors/Annual-report/2018/Previous-reports/Annual-performance-report-2016-17-combined.pdf.

[79] Ofwat (2018), Customer Service, URL: www.ofwat.gov.uk/regulated-companies/company-obligations/customer-service/. Visited on 10 December 2018.

[80] Ofwat (13 December 2017), Delivering Water 2020: Our methodology for the 2019 price review Appendix 2: Delivering Outcomes for Customers, p. 8 – p. 22.

[81] Ofwat (13 December 2017), Delivering Water 2020: Our methodology for the 2019 price review Appendix 3: C-MeX and D-MeX, p. 2. URL: https://www.ofwat.gov.uk/wp-content/uploads/2017/12/Appendix-3-C-MeX-and-D-MeX-FM.pdf.

[82] Developer services customers include small and large property developers, self-lay providers (SLPs), and those with new appointments and variations (NAVs).

[83] Ofwat (13 December 2017), Delivering Water 2020: Our methodology for the 2019 price review Appendix 3: C-MeX and D-MeX, p. 5. URL: https://www.ofwat.gov.uk/wp-content/uploads/2017/12/Appendix-3-C-MeX-and-D-MeX-FM.pdf.

service achieved in most other sectors.[84] Thirdly, Ofwat suggested that the SIM failed to reflect changing communications technology, how customers interact with retailers and the customer service experience of developer services (new connections) customers.

To this end, Ofwat has proposed that the C-MeX will take account of all customers who directly contact the water company (rather than the subset of included in the PR14 SIM), and include an experience, or 'non-contact', survey, based on a random satisfaction survey of customers.[85]

Ofwat will make final decisions on its proposed customer service incentive mechanisms' designs after pilots in 2018 and 2019.[86]

3.3.4. Performance of London companies in comparative assessment

At PR14, Ofwat combined the results of its different models, as described in Section 3.3.1, to draw a "triangulated" assessment of companies' efficiency for wholesale water and wholesale wastewater separately.

For wholesale water, Thames Water was ranked third-most efficient out of 18 companies.[87] Thames Water's submitted costs were 4.8 per cent lower than the final allowance granted by Ofwat. The implied efficiency of the three water-only companies which partly operate in London varied; Affinity Water was ranked second best, while South East Water and SES Water were ranked joint tenth (see Table 3.10).

For wholesale wastewater, Thames Water was ranked third of the 10 wastewater companies. Thames Water's submitted wastewater costs were 1.7 per cent lower than its final allowance (see Table 3.11).

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[84] Ofwat (13 December 2017), Delivering Water 2020: Our methodology for the 2019 price review Appendix 3: C-MeX and D-MeX, p. 5. URL: https://www.ofwat.gov.uk/wp-content/uploads/2017/12/Appendix-3-C-MeX-and-D-MeX-FM.pdf.

[85] Ofwat (13 December 2017), Delivering Water 2020: Our methodology for the 2019 price review Appendix 3: C-MeX and D-MeX, URL: https://www.ofwat.gov.uk/wp-content/uploads/2017/12/Appendix-3-C-MeX-and-D-MeX-FM.pdf.

[86] Ofwat (13 December 2017), Delivering Water 2020: Our methodology for the 2019 price review Appendix 3: C-MeX and D-MeX, URL: https://www.ofwat.gov.uk/wp-content/uploads/2017/12/Appendix-3-C-MeX-and-D-MeX-FM.pdf.

[87] According to the ratio of submitted business plan totex to Ofwat's cost threshold

Table 3.10: PR14 Final Determinations for Water

	BCT (£m)	Policy Items (£m)	Special Cost Factors (£m)	FD Cost Threshold (£m)	Business Plan Totex (£m)	Difference (%)
ANH	1,417	268	34	1,719	1,773	3.1%
WSH	1,091	127	18	1,236	1,240	0.3%
NES	1,198	154	1	1,353	1,362	0.7%
SVT	2,251	300	291	2,843	2,930	3.1%
SWT	591	132	18	741	684	-7.7%
SRN	696	75	-2	769	816	6.1%
TMS	3,483	316	-388	3,411	3,249	-4.8%
UU	1,949	338	107	2,395	2,404	0.4%
WSX	463	95	124	682	707	3.6%
YKY	1,370	238	-47	1,560	1,487	-4.7%
AFW	1,015	86	-9	1,091	1,034	-5.3%
BRL	315	30	64	409	541	32.2%
DVW	73	7	19	99	103	3.8%
PRT	128	13	1	142	137	-3.4%
SBW	111	18	4	133	134	1.2%
SEW	699	83	4	785	810	3.1%
SSC	357	41	1	399	411	3.1%
SES	185	19	23	227	234	3.1%
Total	**17,392**	**2,340**	**263**	**19,994**	**20,056**	**0.3%**

Source: Ofwat[88]

Table 3.11: PR14 Final Determinations of Wastewater

	BCT (£m)	Policy Items (£m)	Special Cost Factors (£m)	FD Cost Threshold (£m)	Business Plan Totex (£m)	Difference (%)
ANH	2,196	179	185	2,559	2,518	-1.6%
WSH	1,211	59	101	1,370	1,329	-3.0%
NES	948	75	3	1,026	1,011	-1.5%
SVT	2,634	164	-7	2,791	2,658	-4.8%
SWT	790	51	54	895	898	0.3%
SRN	1,522	106	262	1,890	1,929	2.1%
TMS	3,059	239	526	3,824	3,757	-1.7%
UU	2,275	167	491	2,933	3,112	6.1%
WSX	890	66	142	1,099	1,131	2.9%
YKY	1,643	127	201	1,971	1,976	0.3%
Total	17,167	1,234	1,957	20,358	20,319	

Source: Ofwat

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[88] Ofwat (December 2014), Final price control determination notice: policy chapter A3 – wholesale water and wastewater costs and revenues, p. 35.

As described in Section 3.3.3, Ofwat uses a comparative benchmark for one output incentive, the SIM. In 2016-17, bottom-ranked Thames Water, with a score of 77.3, performed more than ten percentage points worse than leader Portsmouth Water (see Table 3.12). Thames, Affinity and Southern, the three companies with supply areas covering London, constituted the bottom three, as they had in the previous year, albeit in a different order.[89] Despite being placed last in the rankings for 2016/17, Thames Water's SIM score of 77.3 was the highest it as achieved.[90]

Table 3.12: Service Incentive Mechanism Scores 2016-17 (Ordered by Rank)

Water Company	SIM Score
Portsmouth	87.7
Wessex	87.5
Northumbrian	87.5
Bournemouth	86.5
Dee Valley	86.0
Bristol	85.9
Anglian	85.6
United Utilities	85.4
South East	84.6
South Staffs Cambridge	84.4
Severn Trent	83.6
Yorkshire	83.4
Welsh Water	82.9
South West	81.6
SES	79.6
Affinity	78.6
Southern	78.1
Thames	77.3
Average	83.7

Source: Ofwat.[91]

As of January 2019, Ofwat has not published its proposed approach to calculating companies' efficient costs at PR19. Ofwat has not yet determined the relative weight it will place on different models, nor indicated how it will address special factor adjustments. However, based on the average efficiency score (i.e. the difference between modelled costs and actual costs) for each level of aggregation, we can observe where Ofwat's models tend to find the companies perform relative to one another.

Table 3.13 shows companies' average efficiency score by water value chain element; a negative score indicates relative inefficiency (where actual costs are higher than modelled

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[89] Ofwat (January 2018), Customer Service, URL: https://www.ofwat.gov.uk/regulated-companies/company-obligations/customer-service/.

[90] Thames Water (30 June 2017), Annual Performance Report 2016/17 ,p. 15. URL: https://corporate.thameswater.co.uk/-/media/Site-Content/Thames-Water/Corporate/AboutUs/Investors/Annual-report/2018/Previous-reports/Annual-performance-report-2016-17-combined.pdf.

[91] Ofwat (2017), Customer Service, URL: https://www.ofwat.gov.uk/regulated-companies/company-obligations/customer-service/.

costs) and a positive score indicates relative efficiency (actual costs are lower than modelled costs). In wholesale water, Thames Water's lowest and highest efficiency scores were from treated water distribution (-37 per cent) and water treatment (7.1 per cent) respectively. Ofwat's aggregate "wholesale water" models, estimated Thames Water's efficiency score at 18.3 per cent.

Table 3.14 shows, analogously to Table 3.13, companies' average efficiency score by element of the wastewater value chain. Thames Water's lowest and highest efficiency scores were from sewage collection (-9.2 per cent) and sewage treatment (14.6 per cent). Thames' efficiency score for aggregated wholesale wastewater was higher than wholesale water, at 0.7 per cent, compared -18.3 per cent.

Table 3.13: PR19 Preliminary Efficiency Scores by Water Value Chain Element

	Water Resources	Water Treatment	Treated Water Distribution	Network Plus	Water Resources Plus	Wholesale Water
AFW	16.2%	36.0%	-10.2%	-0.5%	17.4%	0.8%
ANH	-18.4%	-4.1%	5.0%	4.9%	5.2%	10.9%
BRL	-121.9%	-9.8%	-3.4%	-3.5%	-21.9%	-9.1%
DVW	0.5%	-6.6%	-7.4%	-10.4%	5.7%	-6.6%
NES	-36.0%	27.3%	4.7%	13.5%	17.1%	8.6%
NWT	13.8%	-41.5%	-0.9%	-19.3%	-26.7%	-27.6%
PRT	35.7%	17.5%	8.1%	10.2%	12.7%	11.1%
SES	-10.8%	-36.6%	2.9%	-5.7%	-44.6%	-5.2%
SEW	7.0%	-26.7%	-2.5%	-0.9%	6.3%	2.9%
SRN	33.5%	-26.6%	15.8%	11.9%	-11.2%	11.4%
SSC	-0.7%	31.6%	-5.9%	4.9%	31.5%	8.7%
SVT	7.3%	-20.4%	7.9%	1.6%	-9.3%	3.5%
SWB	40.8%	-54.1%	11.6%	-6.5%	-16.0%	-2.4%
TMS	6.1%	7.1%	-37.0%	-28.5%	-6.7%	-18.3%
WSH	-23.9%	-23.6%	-7.9%	-11.4%	-24.5%	-11.9%
WSX	-16.4%	-22.2%	-23.6%	-13.1%	-19.9%	-17.5%
YKY	-18.6%	22.1%	14.6%	17.3%	16.2%	14.4%
Average	**-5.0%**	**-7.7%**	**-1.6%**	**-2.1%**	**-4.0%**	**-1.5%**

Source: NERA analysis of Ofwat models.

Table 3.14: PR19 Preliminary Efficiency Scores by Wastewater Value Chain Element

	Sewage collection models	Sewage treatment models	Network plus models	Bioresources models	Bioresources plus models	Wholesale wastewater models
ANH	0.4%	5.7%	-0.5%	-23.8%	-6.8%	-3.8%
NES	-2.0%	12.2%	18.9%	8.2%	11.3%	3.5%
NWT	-5.5%	-29.8%	-5.8%	2.3%	-6.4%	-6.0%
SRN	-11.3%	-27.6%	-13.5%	10.4%	-16.6%	-10.0%
SVT	2.2%	2.1%	-1.3%	-3.5%	1.8%	4.2%
SWT	-6.5%	-5.0%	-15.6%	-14.4%	-9.5%	-2.3%
TMS	-9.2%	14.6%	-8.1%	1.8%	6.6%	0.7%

	Sewage collection models	Sewage treatment models	Network plus models	Bioresources models	Bioresources plus models	Wholesale wastewater models
WSH	-7.2%	-3.6%	-7.8%	8.3%	3.4%	4.1%
WSX	14.6%	15.4%	6.1%	2.4%	13.3%	2.3%
YKY	14.6%	1.4%	17.2%	-8.8%	-7.1%	2.6%
Average	-1.0%	-1.5%	-1.0%	-1.7%	-1.0%	-0.5%

Source: NERA analysis of Ofwat models.

Table 3.15 and Table 3.16 below shows the efficiency ranking of each company according to Ofwat's different levels of aggregation. Thames Water generally performs better in wastewater models, ranked 6th out of 10 in aggregated wholesale wastewater, and ranking, second-to-last ranking in wholesale water. Notably, Thames Water's poorest performance relative to its peers is in the "network" segment of water and wastewater, Treated Water Distribution (ranked least efficient) and Sewage Collection (ranked second least efficient) respectively.

Table 3.15: PR19 Preliminary Efficiency Rankings by Water Value Chain Element

	Water Resources	Water Treatment	Treated Water Distribution	Network Plus	Water Resources Plus	Wholesale Water
AFW	4	1	15	8	2	9
ANH	13	7	6	6	8	4
BRL	17	9	11	10	14	13
DVW	9	8	13	13	7	12
NES	16	3	7	2	3	6
NWT	5	16	9	16	16	17
PRT	2	5	4	4	5	3
SES	11	15	8	11	17	11
SEW	7	14	10	9	6	8
SRN	3	13	1	3	11	2
SSC	10	2	12	5	1	5
SVT	6	10	5	7	10	7
SWB	1	17	3	12	12	10
TMS	8	6	17	17	9	16
WSH	15	12	14	14	15	14
WSX	12	11	16	15	13	15
YKY	14	4	2	1	4	1

Source: NERA analysis of Ofwat models.

Table 3.16: PR19 Preliminary Efficiency Ranking by Wastewater Value Chain Element

	Sewage collection models	Sewage treatment models	Network plus models	Bioresources models	Bioresources plus models	Wholesale wastewater models
ANH	4	4	4	10	7	8
NES	5	3	1	3	2	3
NWT	6	10	6	5	6	9
SRN	10	9	9	1	10	10
SVT	3	5	5	7	5	1
SWT	7	8	10	9	9	7
TMS	9	2	8	6	3	6
WSH	8	7	7	2	4	2
WSX	2	1	3	4	1	5
YKY	1	6	2	8	8	4

Source: NERA analysis of Ofwat models

3.4. Conclusions

As set out in this chapter, across the recent regulatory reviews of energy and water utilities' allowed revenues, there has been a tendency for London companies to perform relatively poorly in comparative efficiency modelling, as well as in comparative assessments of outputs. This tendency for poor performance of London utilities across sectors suggests there may be factors for which regulators' comparative benchmarking models do not control that drive London companies' costs. Indeed, some price control determinations have recognised the existence of London-related special factors. The remainder of this report therefore focuses on identifying the factors that may cause London utilities' costs to differ from the costs of utilities serving other parts of the country.

4. Specific Conditions Facing London Utilities

4.1. Identifying the Specific Conditions Facing London Utilities

To supplement our review of regulatory precedent, described in the previous chapter, we also conducted a series of workshops with operational staff from UKPN, SGN, Cadent and Thames Water. The purpose of these workshops was to understand the operating conditions facing their activities in London, and how these differed from comparable activities outside London.

These discussions with the utilities identified a long list of potential sources of difference, which we grouped according to the following themes:

- Factors which related to the physical make-up of the network surroundings (such as more expensive footpath materials which drive reinstatement costs):
  - Roads are classified based on the expected volume of traffic they are designed for. Roads which are expected to be used more intensively have deeper “bound layers” of asphalt and concrete. London may have a higher proportion of “high use” road types than other regions, making streetworks more complex and costly. For instance, utility assets may be located deeper underground, and there may be a greater prevalence of concrete surfaces and “road-on-road” construction.
  - Utility assets may be more likely to be located under carriageways rather than the footway or verge due to the prevalence of coal cellars.
  - Road surfaces are more likely to require specialised colouring, greater “anti-skid” properties, and have more raised road crossings with printed concrete. This reflects the specific Highway Authority requirements in London. Similarly, the prevalence of specialized footway surfaces (e.g. York stone, resin bound tiles) is greater in London. These surfaces are more expensive and increase the complexity of reinstatement works.
  - Utility works in London are more likely to be disrupted by special engineering conditions and/or archaeology, and the sub-surface may be more congested due to the effects of utility congestion and buried tram lines.
- Factors related to traffic management and road access, including permitting:
  - All of London is covered by permitting schemes for streetworks, while outside of London there is a mix of noticing (which only requires companies to notify Highways Authorities that they are carrying out work) and permitting (which requires a permit from the Highways Authority before non-emergency work can begin).
  - Parking bay suspensions may be more complex and costly to obtain in London due to the charges levied and procedures adopted by Transport for London relative to Highways Authorities elsewhere in the country.
  - Utilities may also be more likely to require costly traffic management measures like manned lights during peak hours, and provision of alternative pedestrian walkways during streetworks.
  - Lane rental charges are higher and more prevalent in London than elsewhere, and the process of obtaining permission for works is complicated by the greater prevalence of

  bus routes, cycle lanes, the frequency of major events in London, the density of Critical National Infrastructure, and special locations.

  - London utilities are unique in facing congestion charging for their vehicles.
  - Permits for lane rental and bay suspensions may be more likely to contain working hour restrictions, they are more complex to administer than elsewhere, and more jobs may need to be aborted because of cars parked in suspended bays.
  - Temporary Traffic Regulation Notices are substantially more expensive to obtain in London than they are in the rest of the South East of England.
  - London has a high density of Highways Authorities, with utility jobs crossing their boundaries, which creates a need to consult both TfL and the local HA on many jobs.
  - The density of railway crossings may be greater in London.
- Factors affecting utilities' transport and logistics operations:
  - The cost and scarcity of land in central London means that distances to depots and tips is greater, increasing transport costs.
  - Scarcity of space for streetworks activities by utilities may also necessitate daily removal of spoil from sites, overnight plant delivery. Similarly, utilities' delivery hours to central depot sites may be restricted.
  - Staff and contractors may spend longer driving into London to work sites or depots than in other parts of the country, as London property costs drive them to live further away.
  - Parking costs may be higher than elsewhere at work sites, depots, and offices, and utilities are more likely to incur parking fines.
  - Vehicle servicing costs may be higher in London.
  - Challenges with access may lead to inefficiency through the use of a greater number of smaller vehicles making more journeys to depots and work sites, and the limited ability to store materials at sites.
- Specificities associated with utilities' network configuration in London:
  - Confined spaces cause utilities to incur relatively high costs, such as in respect of underground governor and substation maintenance, tunnel rental costs and higher costs of inspection, maintenance and repair inside tunnels.
  - The prevalence of multi-occupancy buildings may create additional costs related to gas risers and electricity rising and lateral mains.
  - For electricity, a number of characteristics of the LPN network may also increase costs relative to utilities serving less densely populated areas including higher costs associated with substation ventilation, substation flooding, pipe cutting, link box inspections, substation trip testing, excessive HV and EHV fault costs, substation access and underground primaries.
  - In the water sector, cost efficiency may also be affected by the large size of raw water and wastewater treatment works.

- Relatively high labour costs in London:
  - Wages are relatively high in London compared to other parts of the country, which can affect utilities' costs through the compensation paid to their staff, contractor rates and in some cases fleet costs and payments for commuting time
  - Due to a low number of employees living in London, and a high proportion of emergencies and streetworks overnight, some utilities use a central London shift system, which requires payment of a premium on wages compared to those staff who in other regions would simply be on call at home.
  - Due to working hours restrictions, staff in London work more "unsocial" hours.
- Relatively high operational property costs in London:
  - Similar to labour, property costs prices in London are also higher than in the rest of the country, affecting rents, rates, etc for London-based operational property.
  - London utilities may face higher terrorism insurance premia and other insurance costs, such as for buildings.
- Specific requirements and expectations of the customer base in London:
  - The demographic make-up of London differs from other parts of the country, such as having a proportion of customers in higher income brackets.
  - The value of economic output in central London is also exceptionally high, which may result in commercial customers placing higher demands on utilities.

4.2. Evaluating and Quantifying the Effect of the Factors Identified

The purpose of this long list was to develop a range of hypotheses, as described above, that may explain why London utilities incur different levels of cost from those serving other parts of the country. The next stage of the process involved quantifying the impact of the factors on London utilities' costs. This work on quantification allowed us to assess the following:

- Is there a plausible technical explanation for why this would lead to a cost increase or difference in output?
- Can we show that it is different in London than elsewhere?
- Is it outside of management control?
- What evidence is there that it is having an impact, direct or indirect?
- What impact does it have on comparative performance and what is the most econometrically efficient way of correcting for it?

In performing this quantification, we used the following types of approaches:

- Where we were able to find specific costs which could be attributed to the factor, such as lane rental or congestion charges, we used those costs, adjusted as required to reflect the share of the cost item which is London-specific.
- In other cases, we found evidence for a London-specific productivity effect which we applied to the appropriate activities to determine the impact of the factor on company totex.

In some cases, it was useful to distinguish between the effects of a factor on utilities' inputs, considering whether each factor:

- Requires utilities to incur additional labour costs, which may also be more expensive in London due to higher wages;
- Requires utilities to incur additional materials costs;
- Requires utilities to incur additional equipment/fleet costs;
- Increases directly attributable overheads such as planning and works management costs, e.g. to hire staff to deal with lane rentals or parking suspensions;
- Increases other overheads; or
- Imposes cash costs payable directly to external parties such as Lane Rentals to Highways Authorities.

As part of this process, we investigated these factors further to assess the uniqueness of London and the quantum/materiality of their effect, also considering that some of the factors listed above may be interrelated. For instance, the location of London operational property is driven by the need to meet response time requirements, despite traffic issues. Also, some costs associated with long journey/commuting times is driven by high wage and property costs in central London. Where possible we have shown that the selected trade-off is an efficient one.

4.3. Quantifying the Impact of the Factors

We summarise below our work to quantify the potential sources of difference listed in Section 4.1. We provide significantly more detail on our methods in a series of appendices to this report.

4.3.1. Nature of streets

4.3.1.1. Differences between London and elsewhere

As discussed in Appendix A, a significant fraction of utilities' work requires the excavation and reinstatement of the street surface, using materials and methods that result in the street surface being returned to its original condition.

The cost and complexity of planning and executing excavation and reinstatement depends on the street structure. Streets, including carriageways, footpaths and cycleways, can be constructed in a variety of ways. We found that there were slightly more reinstatements of the category of road with the thickest/most complex structures within London than outside of it based on SGN's reinstatement data. (9% vs. 6%).

SGN reinstatement data also shows that the overlay-on-concrete roads are three times as common within the M25 than outside, which makes roads substantially more difficult to dig than more flexible roads made of bituminous material.

We investigated the use of three types of carriageway surface:

- Red tarmac (used for bus lanes);
- Green tarmac (used for cycle lanes); and

- Anti-skid coating (used near junctions and other high-risk areas).

Based on UKPN data, we found that red tarmac was used twice as often in London compared to elsewhere in the country. UKPN data also shows that anti-skid coating is also used 70% more often in London than elsewhere, while SGN data shows these coatings are used twice as often within the M25 as outside. Green tarmac appears to be used more often within London but rarely enough that we were not able to make a definitive conclusion.

The most common type of footway surface is a flexible asphalt, similar to that used on road surfaces. However, slabs, natural paving stones, and asphalt overlays on concrete surfaces are more common in London than elsewhere. York paving stones are also found more commonly in London than elsewhere. For instance, UKPN carries out almost ten times as many York Stone paving reinstatements in London than it does elsewhere and the unit rates for these London reinstatements are higher than elsewhere (by 75%+). SGN data also shows that areas within the M25 have a much higher percentage of footways that require reinstatement with stone slaps (22% inside London, 6% outside) and a higher frequency of overlay-on-concrete footpaths (7% vs 1.5% respectively).

The preferred location for utility assets (except sewers) is under grass verges or the footway, making them easier to access and less susceptible to vibration from passing traffic. Excavating and reinstating carriageways is more expensive than excavating and reinstating footways and verges. Based on data from Cadent, SGN, and UKPN, we found that:

- There was 8% - 11% more work carried out under the carriageway in London than elsewhere for GDN repair and repex; and
- There did not appear to be a similar effect based on UKPN’s excavation and reinstatement data.

During our workshops with operational experts from the consortium companies, we were told that the density of underground assets makes excavations and reinstatements slower and more resource-intensive in London than elsewhere. We tested this hypothesis using a variety of information on (1) the incidence of equipment damage by third parties; (2) the density of UKPN underground cables, overground lines and gas mains; and (3) SGN public liability insurance claims relating to utility strikes. Overall, we did not find sufficient evidence to support this hypothesis, either because there is no such effect or because the effect exists only in the most central parts of London and the data on cable and gas main lengths is not sufficiently granular to identify it:

- We found that there was no evidence in the data that third parties damage UKPN assets more frequently in the LPN area.
- By contrast, data from Cadent indicates that third party damage to mains is much more common in London than the GB average, and indeed, has been higher in London GDN than in every other network in each year of RIIO-1 to date.
- We found that there was more cable per length of available road in LPN than in EPN and SPN however the difference between SPN (1.06 km cable / km road) and EPN (2.05) was substantially larger than the difference between EPN and LPN (2.32), which may indicate that this is not a good measure of utility congestion. For SGN we found that the density of mains by available length of road was actually lower in London than outside London.

We also investigated a number of other factors but did not find sufficient evidence to demonstrate the uniqueness of London with the information available to us:

- Density of sensitive archaeological sites;
- Buried tram lines in the road;
- Coal cellars turned into basements; and
- The productivity effect and effect on management costs of the diversity of surfaces and road types.

4.3.1.2. Estimated effect on London utilities' costs

We analysed repex productivity data per area for Cadent and SGN. The repex programme is the largest programme across all utility sectors that requires work under the street surface. We have therefore used this data to estimate a London productivity effect for all sectors.

We present our results in Table 4.1 below. The estimate of 7.8% for SGN likely understates the true productivity effect, because SGN's depot-level data does not allow an exact separation of London and non-London areas.[92] For this reason, our combined productivity effect estimate of 15.5% for Cadent and SGN likely also understates the true London productivity effect.

For reference, we also show Thames Water's historical mains laying productivity in Table 4.1 below.

Table 4.1: London Productivity Effect

Company	Analysis	Effect
Cadent	Analysis of productivity by Local Authority	18.4% in Outer London 88.1% in Inner London 23.1% Weighted London
SGN	Analysis of productivity within vs outside the M25	7.8%
Thames	PR09 Productivity	42%
Combined	Average of Cadent weighted London and SGN	15.5%

Source: Summary of Arcadis analysis.
Note: A +10% productivity effect means that productivity in London is 10% lower than in the rest of the country on average.

In addition to the productivity measures discussed above, we have also quantified the London effect using alternative data sources, including data on contractor unit rates and relative unit costs (based on Ofgem's synthetic unit costs), as we discuss below.

For all the companies in the consortium, excavation and reinstatement are largely outsourced activities. The effects of London conditions on costs will therefore appear in contractor unit

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[92] Specifically, some of the work undertaken by SGN's outer-London depots is likely outside of London, reducing our estimate of the London productivity effect downwards.

rates and bundled rates,[93] so we have used evidence from the following sources to quantify their effect:

- Cadent repex contractor rates for excavating (where required), replacing or inserting a gas main, and carrying out any reinstatement required;
- SGN repex unit costs;
- Cadent repair unit costs;
- Thames Water reinstatement unit rate analysis; and
- UKPN reinstatement rate analysis.

In addition to this analysis of contractor rates, we also determined relative unit costs for repex per metre for both Cadent and SGN using Ofgem’s synthetic unit costs.

Table 4.2 below summarises the cost differences identified between London and the rest of the country, based on our analysis of contractor rates and Ofgem’s synthetic unit costs for repex.

Estimates based on contractor rates show a smaller London effect than those based on “top-down” calculations of cost per metre such as the Ofgem synthetic unit costs for repex, as these contractor rates will apply to routine work and fees for larger / more complex work will be separately negotiated.

Table 4.2: Nature of Streets: Summary of Unit Rate Results

Company	Analysis	Effect on London Utilities’ Costs Relative to GB average
Cadent	Repex regional rate premium and work mix difference	24%
Cadent	Repair costs per metre	21%
Cadent	Ofgem’s synthetic unit costs for repex	45%
SGN	Repex unit costs	7%
SGN	Ofgem’s synthetic unit costs for repex	32%
Thames Water	Reinstatement unit costs	31% to 143%
UKPN	Reinstatement unit costs	57%

Source: Summary of Arcadis analysis.

Since the data from Cadent and SGN is based on the largest volume of excavation and reinstatement work (due to the size of their repex programmes) we have used the average of the productivity effect figures for these two companies (from Table 4.1) to estimate a 15.5% productivity effect in London for all companies.

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[93] Since these contractors have been competitively procured, we can assume that they have incorporated their experience of factors which drive regional cost differences into their rate structure established through the procurement process. Note that these rates also incorporate effects due to travel, labour prices, and other factors on contractor input costs. To avoid double counting, we have excluded contractor labour from our labour price analysis; for the other factors there is no overlap.

Our "most likely" estimate of the London effect for excavation and reinstatement work is therefore 15.5%.[94]

We show our estimate of the cost impact the 'nature of streets' special cost factor in Table 4.3 below. These estimates are based on assumptions (described in more detail in Appendix A) on the scale of activity requiring the opening of streets.

Table 4.3: Impact of Nature of Streets on Companies' Costs

Company	Cost of activities which require opening of streets	Factor	Impact
Cadent	£809m	15.5%	£125.4m (GD1 total) £15.7m p.a.
SGN	£593m	15.5%	£91.9m (GD1 total) £11.5m pa.
UKPN LPN	£420m	15.5%	£65.1m (ED1 total) £8.1m pa.
UKPN EPN	£66m	15.5%	£10.2m (ED1 total) £1.3m pa.
UKPN SPN	£63m	15.5%	£9.8m (ED1 total) £1.2m pa.
Thames Water drinking water	£1024m	15.5%	£158.7m (AMP 7 total) £31.7 pa.
Thames Water wastewater	£531m	15.5%	£82.3m (AMP 7 total) £16.5m

Source: Summary of Appendix A

4.3.2. Permitting and traffic management costs

4.3.2.1. Differences between London and elsewhere

As we explain in Appendix B, the costs utilities incur to conduct and plan streetworks is also determined by prevailing local procedures and charges associated with lane rental, traffic management and parking bay suspensions.

We investigated both direct and indirect effects of permitting and traffic management and found that there were substantial regional differences in direct costs which could be attributed to specific schemes. We found that costs associated with permitting and traffic management were substantially higher in London than elsewhere, but that not all differences were necessarily London-specific and some regions may also see this category of cost rise over time as Highway Authorities (HAs) around the country change their policies on discretionary charging schemes (e.g. lane rental costs).

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[94] This estimate reflects (1) how much lower productivity is in London relative to the national average; and (2) the proportion of London utilities' relevant costs that is London-specific.

HAs can decide whether to operate a permit scheme (previously, all HAs had only a “notice” scheme which only required utilities to notify the HA after the work has started) and can charge for this. We have not considered permitting costs payable directly to councils as these are well understood and recent utility price controls have treated them at least partially as a pass-through cost. We did consider the following effects on utilities’ costs:

- Parking bay suspensions;
- Temporary traffic regulation orders (fees and contractor costs);
- Lane rental costs;
- Bus suspension costs;
- Indirect costs;
- Permit fees.

We also considered a number of other factors for which we were not able to assemble sufficient evidence to comment.

A parking bay suspension occurs when existing parking controls and rights to park are suspended by the HA and exclusive use of the parking bays is given to an undertaker for the duration of the suspension. Utilities require bay suspensions to carry out works under the carriageway. Local Authorities are permitted by the Local Authorities (Transport Charges) Regulations to charge for the suspension of parking places. London networks typically had significantly more of their population covered by parking bay suspension schemes than the 50% of the population covered by these suspensions in England & Wales, as Table 4.4 shows.

Table 4.4: Prevalence of Parking Bay Suspension Schemes by Network Area

	% Population Covered by Parking Bay Suspension Scheme
Cadent London	74%
SGN Southern	41%
SGN Southern (w/in M25)	72%
UKPN LPN	87%
Thames Water WW	77%
Thames Water W	78%
Thames Water WW (w/in M25)	85%
Thames Water W (w/in M25)	95%
England & Wales	50%

Source: Arcadis geospatial analysis of DfT parking suspension data by local authority, network shapefiles, and ONS population by MSOA, Thames Water whole network from Thames Water

We found that 96% of Cadent’s parking suspension costs were in excess of a non-London proxy, i.e. 96% of costs were due to a London-specific effect. For all of the other utilities, we used Cadent’s non-London parking bay suspension spend as a baseline for a non-London network.

HAs use Temporary Traffic Regulation Orders (TTROs) to temporarily close a road or vary the usual traffic conditions in a highway. HAs charge for TTROs and utility undertakers are responsible for putting in place any necessary traffic management solutions such as temporary traffic signals and temporary signage. We found that:

- UKPN data shows that TTROs were up to twice as expensive on a unit cost basis in Inner London than outside London (UKPN), but TTROs are not permit conditions more often in London than elsewhere. UKPN's spending on traffic management contractors was less in LPN than in the other two UKPN networks.

- Cadent's expenditure on TTRO fees was substantially higher in its London and East of England networks than the other two Cadent networks. Spending on combined TTRO fees and traffic management contractors is higher than the national average in Cadent's North London network, but is even higher in its East of England network. The East of England network contains urban areas, but even the East Anglia operational region, which is not heavily urbanized had substantial TTRO total costs, higher than the WM and NW regions which contain Greater Birmingham and Greater Manchester, respectively.

In light of the UKPN and Cadent data it is not clear that costs associated with TTROs are London-specific costs. We have therefore not calculated a London-specific cost adjustment for TTROs.

The New Roads and Street Works Act 1991 (NRSWA), as amended, and the Traffic Management Act 2004 (TMA) contain provision for two types of charges for occupying highways: Section 74 charges, for unreasonably prolonged works and Section 74A charges, determined by reference to duration of works, and commonly referred to as lane rental charges.

At present, two HAs are permitted to charge lane rental costs of up £2,500 a day for occupying the carriageway: Kent and TfL. TfL controls the busiest, most strategic roads in London and 56 per cent of the TfL road network has a lane rental scheme applied. Under the London scheme, lane rental charges apply whenever a street is designated as "traffic sensitive". Charges do not apply in the first 24 hours of emergency works. We found that:

- According to UKPN data, 8.2 per cent of all permits granted by TfL had lane rental as a permit condition as compared to 1.2 per cent for Kent, and none in other HAs;
- All of Cadent's lane rental costs are incurred in its North London network;
- Research conducted by Thames Water shows that 66.4 per cent of its wastewater population served is in TfL or Kent County Council areas, the next highest is Affinity at only 13.4 per cent;
- SGN spent £958,700 in 2017/18 on lane rental costs;
- Cadent's North London network spent £828,000 on lane rental costs;
- Thames Water forecast that they would spend £7.775m on lane rental for their water network business in AMP7 (£1.55m / year) and £2.035m in AMP7 for their wastewater business (£0.41m / year);
- UKPN spent £1.277m on lane rental in 2017/18 (of which it spent £1.15m with TfL and the rest with Kent County Council)

We therefore concluded that 100% of utilities' lane rental costs are specific to the London and Kent areas.

TfL also charges for bus lane suspensions in London, which we understand is not the case in other parts of the country. In 2018, UKPN spent £8,340 on bus lane suspensions, while Thames Water spent £99k in its wastewater business and £1m in its drinking water business. The GDNs did not have data on bus lane suspension costs.

Where HAs have introduced permit schemes, utilities must obtain streetworks permits from the HA before works can begin. HAs charge permit fees for this and utilities incur additional costs in preparing permit applications and complying with permit conditions imposed by HAs. Permit schemes are not unique to London but tend to be more prevalent in London than in the rest of Great Britain

We also investigated the effect of cycle routes, the density of special events/locations and Critical National Infrastructure (CNI) in London, but found no evidence of any material effect on utilities' costs.

4.3.2.2. Estimated effect on London utilities' costs

The table below shows the London-specific costs we identified. Other factors such as spend on TTROs vary by HA but do not appear to show a clear London pattern. We therefore do not show these factors in the table below.

Table 4.5: Impact of Permitting and Traffic Management on Companies' Costs

£17/18m annual	SGN Southern	Cadent NL	LPN	EPN	SPN	Thames W	Thames WW
Parking bay suspensions	0.45	3.65	1.03	0.00	0.00	1.22	0.25
Lane rental	0.96	0.83	1.28	0.00	0.00	1.55	0.41
Bus stop suspensions	0.00	0.00	0.008	0.00	0.00	1.00	0.10
Streetworks permits	2.61	0.89	0.49	0.00	0.00	2.72	0.46
Total	**4.02**	**5.37**	**2.81**	**0.00**	**0.00**	**6.49**	**1.22**

Source: Various data and analysis as described above.

4.3.3. Transport and logistics

4.3.3.1. The impact of slower traffic speeds

As explained in Appendix C, utilities and their contractors must move staff and equipment to and from their assets in order to maintain them. If traffic speed is persistently lower in London than elsewhere, or delays are consistently longer, staff will spend longer travelling for each hour of productive work. Contractors will incorporate this into their own cost calculations and this will therefore be reflected in contractor's rates as well.

For activities where there are either statutory or regulatory goals for response time such as emergency FCOs (First Call Operatives) for GDNs, actual response times are not materially higher in London but it takes a larger number of on-call staff at peak times to achieve those times, increasing companies' costs.

Data from the Department for Transport[95] shows that average speeds on A roads for 2015 – 2016 are lower in London than in the other statistical regions of the country (26.4km/h vs. an average for England of 40.7km/h). We used traffic speed data at the Local Authority level to determine the average speed for each of the network operating areas, as shown in Table 4.6. It shows that traffic speeds in these areas are substantially slower than the average for England and if the same distances had to be covered, this would lead to a cost increase due the time spent travelling by staff.

Table 4.6: Average Traffic Speed by Company

		Thames Water WW (M25)	**Thames Water DW (M25)**	**Cadent NL**	**Southern within M25**	**LPN**
By local authority	Population weighted average speed km/h	28.4	25.9	32.4	29.3	25.6
	% slower than England average	30%	36%	20%	28%	37%

Source: Arcadis calculation by ONS region and local authority

4.3.3.2. The impact of shorter journeys

However, the effect of longer journey times due to slower traffic speeds may be offset by shorter journeys in a denser environment. The trade-off between these depends on the type of work and travel patterns. Using population density alone to estimate the effect on driving distances is not sufficient as population density is a measure of just that, how close people live together. The distance of journeys undertaken by utility companies' staff are less clearly related to population density, so we have conducted a geo-spatial analysis of these journey types specifically.

Our analysis considers a range of different journey types undertaken by utility operatives: travel to/from sites from residence and depot locations and work sites, sequential travel between sites such as to make inspections, and travel in response to real-time events such as emergencies. We also considered different types of work: full day work, project-based work such as DNO reinforcement projects, sequential work such as routine inspections, and time-sensitive responses, such as GDNs' emergency FCOs.

We carried out an extensive analysis of the relative distances between assets and depots and how this effect might counteract the effect of slower traffic speeds. We were not able to reach a definitive verdict on the degree to which these effects offset each other. We have therefore not estimated a London-specific cost adjustment to account for slow traffic and shorter journey distances in London.

4.3.3.3. Other transport and logistics costs

We also investigated if companies' tipping costs were higher in London than elsewhere. We found that Cadent's tipping costs were 33% higher in London than elsewhere. We would expect this to reflect the London effect for the other companies' tipping costs as well.

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[95] Department for Transport, Average speed on local 'A' roads: monthly and annual averages, CGN0501B. See: https://www.gov.uk/government/statistical-data-sets/average-speed-delay-and-reliability-of-travel-times-cgn

However, we were not able to locate data on tipping costs for the other companies, and therefore assumed a London effect of zero (for tipping costs) for all companies except Cadent.

We calculated that expenditure on parking fines in London by Cadent is 1,200 per cent of the national average, due to substantially higher average fines as well as a much higher volume of fines. We found that SGN's London parking fines were 740 per cent of parking fine costs outside London. We have estimated Thames Water's London-specific parking fine costs based on the this evidence. We did not have data on UKPN's parking fines and have therefore not quantified a London effect (of parking fines) for LPN.

Congestion charging is a London-specific cost, though we would expect this to be primarily incurred by Cadent's North London network, Thames Water and LPN, as SGN's inner-most depot is in Kennington.

We investigated the following additional effects but did not quantify them separately:

- Need for daily muck-away - we account for the additional costs as part of our adjustment to tipping costs;
- Overnight plant delivery - we did not find London to be materially different from the rest of the country;
- Delivery hours restrictions to central depot sites - we did not find London to be materially different from the rest of the country;
- Vehicle servicing costs in London - as the location of vehicle servicing is within management control (within reason), we assume that the majority of vehicle servicing occurs outside the M25 and there is therefore no London-specific effect;
- Smaller vehicles - we did not find London to be materially different;
- Smaller sites - we did not find London to be materially different;
- Shorter permit lengths - we did not find London to be materially different.

4.3.3.4. Transport and logistics summary

The table below shows the total annual costs in £17/18 per year which we have identified for each company.

Our analysis of travel speeds and distances did not reach a definitive conclusion, i.e. we have not been able to show that the impact of slower travel speeds and shorter distances do not offset each other (or been able to quantify the extent to which they do). We have therefore assumed a zero combined London effect for travel speed and distance.

Table 4.7: Impact of Transport and Logistics on Companies' Costs

Company	Effect of travel speed and distance	Tipping costs	Parking costs and fines	Congestion charges	Total
Cadent NL	-	£0.54m	£0.08m	£0.147m	£0.78m
SGN Southern	-		£0.05m	N/A	£0.05m
UKPN LPN	-			£0.38m	£0.38m
Thames Water DW	-		£0.02m	£0.03m	£0.05m
Thames Water WW	-		£0.02m	£0.03m	£0.05m

Source: Summary of above

4.3.4. Network-specific factors

We examined in Appendix D a number of factors which are highly specific to each industry and which we have treated separately for that reason:

- GDN emergency spend (GDNs);
- Confined space and tunnel costs (UKPN, Cadent);
- Multiple occupancy buildings (GDNs);
- Compressed time windows (UKPN);
- GDN's Guaranteed Standard of Performance (GSOP) payments (GDNs);
- Cable pit costs (UKPN);
- Tunnel radio costs (UKPN); and
- Link box costs (UKPN).

We discuss each of these factors and their impact on costs in turn below.

4.3.4.1. GDN emergency spend

We performed bottom-up modelling to test whether the high number of concurrent emergency events, such as Publicly Reported Escapes (PREs) in London are the primary drivers of emergency costs. We took data on GDNs' expenditure on emergencies (adjusted for regional labour cost variation – see Appendix E), and established a correlation between emergency spend and the 97th percentile of the number of concurrent jobs on a winter's day, estimated through simulation modelling of the frequency and duration of each incident.

We compared the actual expenditure for each company with the average of the five networks and found that Cadent North London's expenditure was above the average and SGN Southern's expenditure was below it, however this is explained by the differences in peak numbers of concurrent jobs. Based on this evidence, we have not accounted for a London effect for GDNs' emergency spend in our summary tables.

Table 4.8: GDN Emergency Spend

£m 17/18	EoE	NW	WM	Lon	SGN	Average
Total emergency spend 2017/18	18.7	12.7	9	14.2	18.80	14.7
Total Emergency cost, adjusted for regional labour	18.7	12.7	9.0	12.8	18.0	
Concurrent winter daytime jobs	104	80	54	81	112	86.2
Additional expenditure relative to average	4.02	-1.98	-5.68	-1.91	3.32	
Model predicted	17.32	13.15	8.64	13.33	18.71	
Residual	-1.38	0.45	-0.36	0.56	0.72	

Source: Actuals from 2017/18 RRP tables, concurrent jobs from Arcadis analysis

However, at the last price control, Ofgem’s used a ‘workload’ CSV for its emergency costs disaggregated modelling, consisting of customer numbers and repair reports, meaning it did not account for the higher than average number of PREs per customer in Cadent’s London supply area, which may be driven by its high population density. Since Cadent London has around 14% more PREs per customer than the GB average over RIIO-GD1, Cadent London’s excess cost would be around £1.6m per year, based on Ofgem’s GD1 disaggregated modelling.

4.3.4.2. Confined spaces and tunnel costs

We found that UKPN spent an average of £335k / yr in the last two years on confined space training due to the high number of confined spaces in central London. Within LPN, more than 10% of substations in the HV Central area require confined space training.

Additional costs were also incurred by UKPN’s network such as to inspect and maintain tunnel assets and to pay rent on municipal subways. We estimate that these costs amount to approximately £2.46m per annum for LPN, £4.21m per annum for SPN, and £0.17m for EPN.

Cadent also incurs an annual tunnel rental cost of £156k in North London and does not incur this cost in any of its other networks.

4.3.4.3. Gas supply to Multiple Occupancy Buildings (MOBs)

Gas risers within Multiple Occupancy Buildings belong either to the GDNs or to the building management company / freeholder / local authority. For safety reasons, in cases where it is not clear who owns the gas riser, the GDN is assumed to do so and must maintain it.

Working on gas assets inside a building requires careful safety planning and many of these assets (including many that have not historically appeared on GDNs’ asset registers or been maintained by them) are now end of life and must be replaced for safety reasons. It is likely that in the wake of the accident at Grenfell tower there will be greater public attention paid to gas risers in MOBs.

Analysis of Cadent and SGN data show that the majority of MOBs (75%+) are in London.[96] There are three sources of additional costs due to a high number of MOBs for GDNs:

1. Reduced repair and emergency productivity due to access difficulties;
2. Routine survey costs to ensure that the risers are in a safe condition; and
3. Replacement costs for risers.

The first item is addressed in our analysis of Cadent and SGN repair and emergency productivity in London. For (2), we estimate that Cadent London and SGN each require an additional £0.93m / year to carry out riser surveys in MOBs. For (3); we assume that the three non-London Cadent networks are representative of the national average, and based on this data, estimate that Cadent requires £6.03m per year to replace risers in North London MOBs and SGN requires an additional £9.9m per year to replace risers in its Southern network.

4.3.4.4. Compressed time window working

Some work must be done when DNO networks are not at their peak loading, so that assets (which are designed with some measure of redundancy) can be de-energised without affecting the reliable operation of the network.

Each DNO is required to publish as part of their charging schedules the hours in which they are most loaded (their red time band) for their Low Voltage and High Voltage customers, and also to publish a super-red time band for their Extra High Voltage customers. These are important to customers because they affect the rates at which some customers are charged for their use of the distribution network.

Table 4.9: LPN's 2019 Time Bands (for Half-Hourly Metered Properties)

Time periods	Red and Super Red Time Bands	Amber Time Band	Green Time Band
Monday to Friday (Including Bank Holidays) All Year	11:00 - 14:00 16:00 - 19:00	07:00 - 11:00 14:00 - 16:00 19:00 - 23:00	00:00 - 07:00 23:00 - 24:00
Saturday and Sunday All Year			00:00 - 24:00

Source: 2019 distribution charging schedule

LPN, alone of all the distribution networks, has two red and two super red time bands, in both cases between 11:00-14:00 and 16:00-19:00. The other UKPN networks and other DNOs in GB have their red and super-red bands between 16:00-19:00 (a few have them between 16:30-19:30 and networks are free to set them otherwise if they can evidence their network loadings are different than this).

This means that maintenance tasks that require de-energising assets, which are required during red and super red times but not during the amber or green time band hours, must be

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[96] Note that Greater Manchester and Liverpool are in Cadent's North West network, Birmingham is in the West Midlands network and these are also major urban areas, so it is not the case that all major urban areas have high rise buildings with MOBs in equal numbers.

carried out in a much shorter period of time than for other DNOs. Any such tasks which might take more than two hours also cannot be started in the window between 14:00 to 16:00.

For 2017/2018, the total spend on out of hours working on EHV assets in central London was £92,675 for 945 hours of out of hours work.

4.3.4.5. GDN MOB GSOPs

GDNs make Guaranteed Standard of Performance (GSOP) payments when customers are off supply for extended periods of time. For safety reasons, leaking risers in MOBs must be shut off immediately and cannot be restored to service until fully repaired, whereas underground gas mains can often remain in service while leaks are temporarily controlled. For this reason, significant additional GSOP payments are made to customers off-supply in MOBs.

The average London excess is £1.27m for Cadent North London, based on data on actual GSOP payments for MOBs in Cadent's networks. We have assumed that the cost for SGN's Southern network is the same.

4.3.4.6. Cable pit costs

UKPN's London network is unique amongst DNOs in being entirely underground. As a result, there are more cable pits, where cables are joined or terminated, than in other parts of the country. Annual cable pit costs have been £0.75m per year for LPN in RIIO-ED1, compared to cable pit costs of zero in the EPN and SPN networks.

4.3.4.7. Tunnel radio costs

Due to its network of tunnels, LPN must operate a radio system for safety reasons, in order to work safely in those tunnels. UKPN estimates that LPN's spending on tunnel radio costs is about £0.3m per annum in RIIO-ED1.

4.3.4.8. Link box costs

Link boxes are used to connect segments of LV feeder. As London has a more extensively connected LV feeder network than other regions, it has more link boxes than other networks. Link box costs include spending on condition-based replacement, inspection & maintenance, and link box-related blanket replacement costs. We estimate a London effect based on UKPN link box cost data of £12.12m per annum.

4.3.4.9. Network-specific factors summary

The additional costs related to network-specific factors are summarised below in Table 4.10.

Table 4.10: Network-Specific Factors

£17/18m annual	**Southern**	**Cadent NL**	**LPN**	**EPN**	**SPN**	**Thames DW**	**Thames WW**
GDN emergency spend	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Confined space costs	0.00	0.00	0.34	0.00	0.00	0.00	0.00
GDN MOBs	10.83	6.96	0.00	0.00	0.00	0.00	0.00
GDN MOB GSOPs	1.27	1.27	0.00	0.00	0.00	0.00	0.00
Compressed time windows	0.00	0.00	0.09	0.00	0.00	0.00	0.00
Tunnel costs	0.00	0.16	2.46	0.17	4.21	0.00	0.00
Cable pit costs	0.00	0.00	0.75	0.00	0.00	0.00	0.00
Tunnel radio costs	0.00	0.00	0.30	0.00	0.00	0.00	0.00
Link box costs	0.00	0.00	12.12	0.00	3.54	0.00	0.00
Total	**12.10**	**8.39**	**16.06**	**0.17**	**7.75**	**0.00**	**0.00**

Source: Summary of above, Appendix D

4.3.5. Labour costs

A high proportion of utility costs are wages, either paid to their own staff or to contractors and their sub-contractors. The nature of the work done by utilities means that much of it must be done where the assets are located. Because wages are higher in London, as explained in Appendix E, and labour cannot be moved to lower wage locations, this factor increases costs for London utilities relative to those in other parts of the country.

Utilities are required to be able to respond to faults within fixed periods of time and must have staff in position to do this within their entire networks. In most networks, this is handled out-of-hours using a standby-model where employees go home and are available to respond from their homes if required to. Employees are paid for being “on standby”.

For utilities with short required response times, this is not possible in London because almost none of their staff live in London. Therefore, staff must be paid to be physically present in London and ready to respond if necessary.

To test whether London wages are higher, we have used the Annual Survey of Hours and Earning (ASHE) data collected by the Office for National Statistics (ONS). This data has been used by GB utility regulators in the past to understand and account for regional wage impacts. The data is available split by geography, occupation, industry and other variables.

We used the ONS data split by SOC (Standard Operational Classification) codes which identify a range of occupational classifications, with an increasing level of granularity as the number of digits in the SOC code increases.

The ONS assigns a confidence grade to its wage data, grading it as “precise”, “reasonably precise”, “acceptable”, or “unreliable for practical purposes”. We have tested a variety of approaches which included 4-digit SOC codes but found that these were often graded as “unreliable for practical purposes” or “acceptable”. For this reason, we have not used 4-digit

SOC data. Rather, we used 2- and 3-digit SOC codes to characterise the workforces employed by utilities in each industry. From this, we determined the wage premia by region, as shown in Table 4.11.

Table 4.11: Wage Premia By Company

	GDN SOC	TW WW SOC	TW DW SOC	DNO SOC
Average weighted wage for SOC	£15.54	£16.18	£16.14	£15.85
Cadent London	+12%			
SGN Southern	+5.2%			
SGN Southern (w/in M25)	+14.2%			
UKPN LPN				+14.6%
UKPN EPN				+2.8%
UKPN SPN				+5.2%
Thames Water WW		+£11.2%		
Thames Water W			+13.3%	

Source: Arcadis analysis

These wage premia apply to wages paid by the companies themselves and to wages paid by their contractors. We would expect to see these premia reflected in the rates and costs of contractors working in London, to the extent that those contractors' costs are made up of labour.

We applied this wage premium to total wages as follows:

- For Thames Water we applied it to its calculated wage costs for AMP7 using the local / non-local labour splits which Ofgem has used in past price controls. As an alternative, we have also shown the size of the effect if either 70% or 80% of overall wage costs were subject to the calculated effects.
  - 89% of labour costs on direct activities
  - 40% of labour costs on indirect activities
  - 0% on overheads
- For UKPN we have applied the regional wage premium to each cost category using the percentages which Ofgem used at ED1 to estimate regional wage effects:
  - 89% of labour costs on direct activities
  - 40% of labour costs on indirect activities
  - 0% on overheads
- For the GDNs
  - 100% of labour costs on direct activities
  - 60% of labour costs on indirect activities
  - 0% on overheads

We also assessed the additional costs incurred by UKPN and Cadent by operating shift systems rather than standby + call-out systems for out-of-hours response and for SGN for additional out-of-hours work due to a higher percentage of escapes occurring in London than elsewhere.

- Cadent incurred an additional £0.54m pa. for its shift system;
- UKPN incurred an additional £1.6m pa. for its shift system (part of its central London strategy);
- SGN incurred an additional £30k pa. for additional out-of-hours working in London

Table 4.12: Impact of Labour Costs of Companies' Costs

£17/18m annual	Southern	Cadent NL	LPN	EPN	SPN	Thames DW	Thames WW
Higher regional wages	18.20	24.77	22.17	4.74	6.37	7.80	11.12
Shift system	0.00	0.54	1.6	0.00	0.00	0.00	0.00
Out of hours working	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Total	**18.23**	**25.31**	**23.77**	**4.74**	**6.37**	**7.80**	**11.12**

Source: Summary of above, Appendix E

4.3.6. Property costs

As explained in Appendix F, rents are higher in London than elsewhere in the country. Business rates are based on rental value and are therefore also higher in London than elsewhere.

Insurance is more expensive for two reasons:

- Direct insurance premia are higher because of the higher risk exposure;
- Premia can be higher indirectly due to higher costs to operate in London (for instance buildings insurance which is linked to the reinstatement value of the property).

VOA data shows that London commercial property is between 83% and 106% more expensive than the England and Wales average. We found that:

- Cadent's rent costs were 97% higher in London than elsewhere;
- Cadent's rates costs were 64% higher in London than elsewhere; and
- Other companies indicated that their London property costs were not substantially higher than elsewhere or did not provide sufficient data to determine the relationship between their London and non-London rent costs.

Overall, our determination was that London property costs are substantially higher than elsewhere in England and Wales but that the effect of this will be highly company-specific.

Table 4.13: Property cost summary

£17/18m annual	Southern	Cadent NL	LPN	EPN	SPN	Thames DW	Thames WW
Rent	£0.00m	£0.64m	£0.00m	£0.00m	£0.00m	£0.00m	£0.00m
Rates	£0.00m	£1.95m[97]	£0.08m	£0.00m	£0.00m	£0.00m	£0.00m
Total	**£0.00m**	**£0.64m**	**£0.00m**	**£0.00m**	**£0.00m**	**£0.00m**	**£0.00m**

Source: Summary of above, Appendix F

4.4. Conclusions

Table 4.14 below summarises our bottom-up estimates of the additional costs utilities in London face, relative to those operating in other parts of the country. The next step in the process, as we explain in the next chapter, is to evaluate the extent to which these costs can be controlled for within comparative models, and the extent to which existing models already do so.

Table 4.14: Summary of Bottom-up Estimates of London-Specific Costs by Network

£17/18 pa.	Cadent	SGN	UKPN LPN	UKPN EPN	UKPN SPN	Thames Water (drinking water)	Thames Water (waste water)
Nature of Streets	15.67	11.49	8.14	1.28	1.22	31.74	16.46
Permitting and Traffic Management	5.37	4.02	2.81	0.00	0.00	6.49	1.22
Transport and Logistics	0.78	0.05	0.38	0.00	0.00	0.05	0.05
Network-specific Factors	8.39	12.10	16.06	0.17	7.75	0.00	0.00
Labour Costs	25.31	18.23	23.77	4.74	6.37	7.80	11.12
Property Costs	0.64	0.00	0.00	0.00	0.00	0.00	0.00
Total	**56.15**	**45.90**	**51.16**	**6.19**	**15.34**	**46.08**	**28.86**

Source: Summary of previous tables

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[97] Not included in the total as treated by regulators outside of the price control

5. Accounting for Conditions Facing London Utilities in Price Controls

5.1. Alternative Methods for Controlling for the Specific Conditions Facing London Utilities

As we set out in Chapter 3, Ofwat and Ofgem have used a range of different methods at recent price controls to capture the effect on efficient costs of the specific factors faced by London utilities.

5.1.1. Including drivers in econometric benchmarking models

To some extent, regulators have controlled for London factors "in model", i.e. using benchmarking models which capture London-specific factors by including drivers which reflect differences between London companies and those serving other regions. However, in practice regulators' aggregated (e.g. totex) models have included a relatively small number of cost drivers. While disaggregated modelling has allowed regulators to better capture the particular drivers of specific activities or business segments,[98] regulators are still constrained by data availability, restricting the extent to which their econometric models can control for company-specific factors for two reasons:

- Firstly, regulators are constrained in their choice of cost drivers, since there is not a large number of exogenous factors which are recorded for every company over time.
- Secondly, regulators are constrained in the number of cost drivers they can include in each model. Due to the limited number of regulated companies and the relatively short periods of time over which cost and driver data has been collected, including many variables tends not to generate statistically robust models.

It may be possible to add some variables to econometric benchmarking models to improve the extent to which they capture the London-specific factors we discuss in the appendices to this report. While it is not possible for an econometric model to control for every individual London-specific factor, 'proxy' drivers which capture the combined effect of London-specific effects can be appropriate in benchmarking models. As we discuss in Appendix H, density is one such driver which proxies for many of the London-specific factors, since it captures the extent to which costs are higher in urban areas, where population density is higher. Proxy drivers are, however, unable to capture the effect of factors which are unique to London (e.g. congestion charge costs) and London-specific factors which are not correlated with density (e.g. historical network configuration).

Therefore, even with the inclusion of some proxy cost drivers, data limitations mean that econometric benchmarking models, if used without other adjustments, might not capture the drivers of London utilities' efficient costs identified in Chapter 4, causing cost assessment modelling to incorrectly conflate inefficiency and London-specific factors.

5.1.2. Pre-modelling adjustments

A possible solution to this problem is for regulators to make off-model adjustments to account for company-specific factors, i.e. changes to companies' costs prior to running

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[98] Particularly in Ofgem's "bottom-up" models, see Section 3.1.1 and Section 3.2.1.

benchmarking models. A simple example is the exclusion of incomparable costs from benchmarking models, effectively treating such costs as "pass-through" items. However, since treating costs as pass-through items does not incentivise cost reduction, regulators tend to only allow pass-through of uncontrollable costs (e.g. Ofgem licence fees paid by DNOs and GDNs).

An alternative that does not weaken incentives for cost reduction is to base pre-modelling adjustments to companies' costs on data unrelated to the firm's own expenditure. A prominent example is Ofgem's previous "regional labour adjustments", which have attempted to standardise companies costs to account for different labour cost levels in different regions before running econometric benchmarking models.

5.1.3. Special factor adjustments

Finally, regulators can allow special-factor adjustments to companies' costs, either before or after running benchmarking models, to reflect differences in costs which are not controlled-for through other aspects of the cost assessment, but which cannot be attributed to inefficiency. As discussed in Section 3, there is regulatory precedent for allowing companies to make special factor claims in the electricity, gas and water sectors. In Chapter 4 above, we describe our quantification of the magnitude of each London-specific factor relative to the national average, which could be used as the basis for special factor claims.

When granting special factors, regulators can account for the implicit-allowance granted by benchmarking models for that special factor. For example, removing London-specific permitting costs from a benchmarking models would reduce the effect of a density driver on modelled costs (and other drivers correlated with urban areas); therefore the required special factor to control for permitting costs would be less that the total cost of permits. We describe our approach to addressing this "offset" element of special factor claims in Section 5.3.1 below.

Regulators can also take account of company-specific factors when setting output targets. Historically, regulators have tended to set company-specific output targets, often based on historic performance and a qualitative assessment of the scope to deliver outputs under management control. In more recent price control periods, regulators have set targets for some outputs based on comparative assessment between companies, especially those related to customer satisfaction (see Section 3 and Appendix G); but in doing so, regulators have used simple models to set output targets for all companies, expecting companies to achieve standardised levels of performance across the country.

However, company-specific factors affect both the cost and quality/quantity of outputs utilities deliver. Indeed, some company-specific factors related to customers' expectations can only be addressed using adjustments to output targets (see Section G.1.1). As such, regulators can control for the effect of London-specific factors by using models which control for London's characteristics, making an "expert assessment" to adjust target to account for biases caused by omitted regional factors, or by setting targets based on historical performance, since historical performance implicitly accounts for the difficulty of delivering certain outputs in different regions compared to one another.

5.2. Data Available to Control for London Factors in Comparative Econometric Modelling

While the quantification of London factors discussed in Chapter 4 relies on company-specific data for the London utilities, controlling for London factors within benchmarking models relies upon the availability of data for all companies including those in other regions.

Regulators' benchmarking models generally rely on data which regulators have required companies to report, collated into a single database. In assessing the extent to which existing models control for London-specific factors we have used the following data:

- Ofgem's RIIO-ED1 benchmarking dataset for electricity, which included cost and driver data for the 16 GB DNOs, with historical "out-turn" data between 2010-11 and 2014-15, and forecast data from 2015-16 to 2022-23;
- Ofgem RIIO-GD1 benchmarking dataset for gas, which included cost and driver data for the 8 GB GDNs, with historical data between 2008-09 and 2012-13, and forecast data from 2013-14 to 2020-21; and
- Ofwat's PR19 benchmarking dataset, published in March 2018, which includes historical cost and driver data for the 10 water and wastewater companies and 8 water only companies in England and Wales, between 2011-12 and 2016-17.

In the case of Ofgem, these datasets were used at the most recent price control, whereas, in the case of Ofwat, this dataset was used for estimating Ofwat's initial models for PR19.[99]

We have also reviewed other potential sources of industry-wide comparative data from which regulators may be able to draw additional variables which could be added to benchmarking models to better account for London-specific factors:

- Cost and driver data provided by DNOs and GDNs to Ofgem each year in RIGs submissions;
- PR19 Business Plan data collected by Ofwat but not included in Ofwat's published dataset, and other data used in companies in alternative models submitted to Ofwat's PR19 comparative modelling consultation;
- Comparative data published by third parties, such as Discover Water;[100] and the Health and Safety Executive (HSE); and
- Regional data published by third parties, which can be mapped onto companies' supply areas, such as regional labour cost data published by ONS (ASHE data).

In the following sections, we set out how each of these data sources could be used to control for the London-specific factors identified in Chapter 4 using the methods described in Section 5.1. In Section 5.3.1, we assess the extent to which existing models control for London-specific factors, and in Section 5.3.2 we assess whether there is currently sufficient information and data to better control for these factors in benchmarking models.

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[99] Ofwat's final PR19 benchmarking dataset is likely to also include forecast data collected in companies' business plan submissions in September 2018. However, this was not available at the time of performing the analysis described in this chapter.

[100] Website: discoverwater.co.uk

5.3. Controlling for the London Factors Identified in this Study

5.3.1. Assessing whether existing cost benchmarking models control for factors identified

5.3.1.1. Assessment of the extent to which London factors are controlled by models

For each of the factors identified in Chapter 4, we have reviewed the extent to which the cost drivers used in existing models control for differences between companies. In general, the "top down" models used to model aggregated categories of cost (such as Totex and Botex) do not control for London-specific factors, instead relying on broad drivers of scale, or measures of workload which assume similar unit costs (relative to network size) in different parts of the country.

However, models do include some cost drivers which may proxy the effect of operating in London to some extent, such as the population density and network density drivers which are used in some Ofwat models, and the MEAV driver which is used in Ofgem's models (which accounts for the higher value of assets used in densely populated areas compared to rural areas, but does not account for the higher unit cost of assets in densely populated areas).

We have described in detail the extent to which each factor is controlled-for by existing models in Appendix A to Appendix F below. In summary:

- Existing benchmarking models do not directly control for differences in the **nature of streets** (see Section A.6.1), although some models contain drivers which are likely to be correlated with differences in streets between companies and regions, notably density; therefore, we have calculated the extent to which existing models grant an 'implicit' allowance for this cost factor.
- Existing benchmarking models do not directly control for the differences in **permitting and Traffic Management Act** conditions (see Section B.6.1), although regulators have excluded the direct costs incurred under these regulations from benchmarking models due to their incomparability between regions;
- Existing benchmarking models do not directly control for differences in **transport and logistics costs** (see Section C.6.1), although some water models control for density, which is likely to be a key driver of congestion and thus why transport costs vary between companies;
- Existing electricity and gas models control for regional differences in **labour costs**, by conducting a pre-modelling adjustment to "normalise" labour costs between different regions (see Appendix E); Ofwat's March 2018 benchmarking models do not directly control for labour costs, although some of Ofwat's models include density drivers which may proxy the effect of higher wages in London; and
- Existing models do not control for differences in **property costs** within benchmarking models, although costs related to business rates, which are higher in London as a result of higher property values, are generally excluded from regulators' models.

5.3.1.2. Implicit allowance granted for London-specific factors

As described in Section 5.1, regulators can account for London-specific factors using special factor adjustments; however, simply adding the quantum of the special factor to a company's modelled costs will overstate the extent of the special factor if benchmarking models control for a special factor to some extent. For example, given the extent to which London companies operate in more densely populated areas the other companies, removing London-specific costs from benchmarking models would likely reduce the coefficient on a density driver, and thus reduce London companies' modelled costs to some extent in models using a density driver.

In order to estimate the size of this offsetting factor, or "implicit allowance", we have followed the following three steps for the gas, electricity and water models:

- Firstly, we have summarised annual average modelled and "actual" costs for London companies' in their respective benchmarking models.[101]
- We have removed London-specific costs from the dependent variable (i.e. "actual costs"), re-run the benchmarking models, and re-estimated annual average modelled costs, which are estimated based on the updated regression coefficients.
- We have calculated the implicit allowance as the difference between modelled costs in the model which includes and excludes the special factor.

For each of the factors we have identified and quantified in Section 4 above, we have assessed whether it appropriate to quantify an implicit allowance for these costs relative to existing aggregated benchmarking models, based on whether the existing models include these costs, and whether existing models control for these factors already.[102]

Specifically, we have only excluded costs related to special factors which are included in the "actual costs" used to estimate benchmarking models. Therefore, we have not quantified an implicit allowance for factors which are already excluded from or normalised in existing benchmarking models. Similarly, since we are re-estimating models developed at previous-price control decisions which rely on business plan forecasts of costs, we have not included costs which are not included in business-plan forecasts, such as lane rental costs for permit schemes which have begun since the price control decision.

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[101] "Actual costs" are the input costs used to calculate the model, i.e. normalised according to the regulators' different approaches.

[102] We have limited our quantification of the implicit allowance to aggregate cost models, since it is not possible to robustly allocate these special factors to the disaggregated cost categories used by regulators, which vary from one price control to another. In Appendix A to Appendix F below, we discuss the extent to which existing disaggregated models contain cost drivers which account for each London-specific factor.

Table 5.1: London-specific Costs Removed from Aggregated Cost Models

	Costs Removed from Aggregated Costs
Nature of Streets	We have removed costs associated with this factor from London companies' costs in all benchmarking models.
Permitting and Traffic Management	We have not excluded this factor from Ofwat's models, because Ofwat excludes costs associated with permitting and traffic management. We have not excluded this factor in Ofgem's models, because Ofgem's models excluded permit costs for known schemes, and because business plan forecasts would not have included permitting and traffic management costs related to new schemes.
Transport and Logistics	We have removed costs related to London traffic speeds, tipping costs and parking costs and fines; we have not excluded congestion charge costs in Ofgem's models, since forecasts of these costs were already excluded from Ofgem's models.
Network-specific Factors	We have excluded Cadent's MOBs survey costs from benchmarking models, and costs related to confined space training and compressed peak-demand periods from UKPN's costs.
Labour Costs	Ofgem's RIIO benchmarking models include a regional labour adjustment, so we have not applied an additional London-labour cost adjustment in energy models; however, Ofwat's proposed models do no control for regional differences in labour costs, so we have removed London-excess labour costs.
Property Costs	All regulators exclude business rates from benchmarking models, so we have not estimated an implicit allowance for rates. We have included rent costs in our special factor for Cadent.

Table 5.2 summarises the costs we have excluded from "actual costs" in Ofgem and Ofwat's aggregate cost models.

Table 5.2: Special Factors Excluded from Aggregated Cost Models

(£m price base)	**Cadent**	**SGN**	**UKPN**	**Thames Water**	**Thames Wastewater**
Nature of Streets	12.30	9.02	9.46	22.69	12.67
Permitting and Traffic Management	-	-	-	-	-
Transport and Logistics	0.49	0.04	-	-	-
Network-specific Factors	0.73	-	0.38	-	-
Labour Costs	0.42	0.02	-	6.00	6.84
Property Costs	0.50	-	-	-	-
Total	**17.96**	**9.08**	**9.84**	**28.69**	**19.51**

Note: Costs standardised to price control price base. Source: Arcadis and NERA analysis.

We have re-estimated the following aggregated cost models:

- For Wholesale Water, we have re-estimated Ofwat's 12 botex models from its March 2018 consultation, which are estimated between 2011-12 and 2016-17;

- For Wholesale Wastewater, we have re-estimated Ofwat’s 8 botex models from its March 2018 consultation, which are estimated between 2011-12 and 2016-17;
- For Gas Distribution, we have re-estimated Ofgem’s final RIIO-GD1 totex models, specifically its 4-year historic model, and its 2-year forecasts model, both of which consisted of the same composite scale variable; and
- For Electricity Distribution, we have re-estimated Ofgem’s final RIIO-ED1 totex models, its “top-down” totex model and its “bottom-up” totex model, both of which were forecast over both historic and forecast years.

Table 5.3 summarises the results of our analysis for these models.

Table 5.3: Implicit Allowance in Aggregated Cost Models

	Original Models			**Models excluding London-specific Costs**					
Model	**Modelled costs**	**Actual costs**	**Efficiency Score**	**Modelled costs**	**Actual costs**	**Efficiency Score**	**Ldn-specifc costs**	**Implicit Allowance (£m)**	**Implicit Allowance (%)**
TW water	449.57	529.91	-18%	436.32	501.22	-15%	28.69	**13.25**	**46%**
TW wastewater	603.90	598.24	1%	590.85	578.73	2%	19.51	**13.05**	**67%**
Cadent London	187.11	199.19	-6%	184.37	184.75	0%	14.45	**2.74**	**19%**
SGN Southern	321.08	329.90	-3%	317.41	320.82	-1%	9.08	**3.67**	**40%**
LPN	207.73	203.73	2%	205.60	196.11	5%	7.62	**2.13**	**28%**
EPN	228.74	229.66	0%	227.50	228.52	0%	1.13	**1.24**	**109%**
SPN	343.89	253.91	26%	343.27	252.82	26%	1.09	**0.62**	**57%**

Note: Efficiency Score is calculated as the difference between modelled costs and actual costs, divided by modelled costs. Costs reported in benchmarking model price-base.
Source: NERA and Arcadis Analysis.

For most companies, the implicit allowance ranges between 19% and 67%, and the benchmarking models find London companies are more efficient when models are re-estimated with London-specific costs are excluded (demonstrated by the higher efficiency scores in models which exclude London-specific costs).

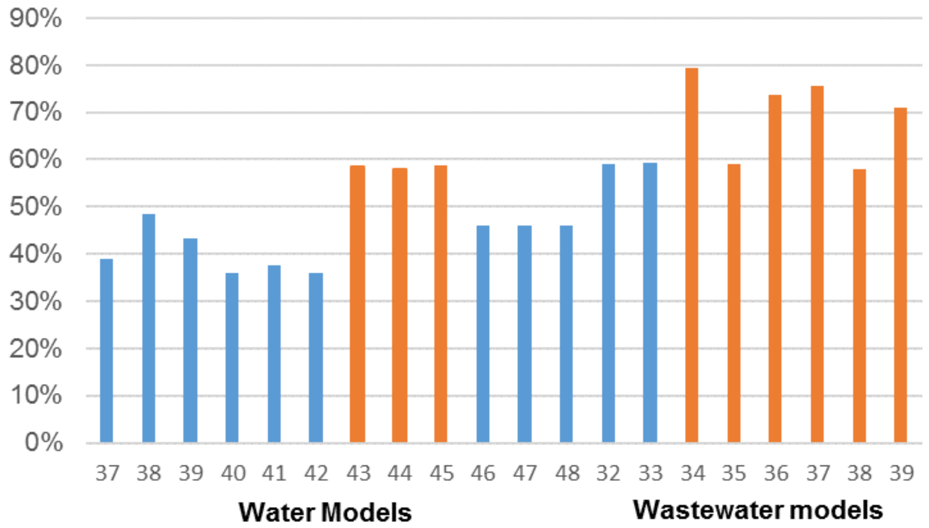
However, for EPN, a UKPN DNO which party serves London, but predominantly serves the East of England, the re-estimated benchmarking models find the company to be less efficient when London-specific costs are excluded. Given that the special factor for LPN is much larger than for EPN and SPN, this result likely reflects the extent to which the benchmarking models predict lower costs for non-London areas when London costs are excluded.

The magnitude of the implicit allowance differs between individual benchmarking models. For instance, Ofgem’s RIIO-ED1 “bottom-up” totex model, which uses a composite driver comprised of Ofgem’s disaggregated model drivers, includes a 9% implicit allowance for LPN’s additional special factors, whereas its “top-down” totex model, which uses a composite scale variable comprised of MEAV and customer numbers, grants a larger implicit allowance of 47%, leading to an average allowance of 37%.

Across Ofwat’s consultation models, Thames Water’s implicit allowance varies between 36% and 59% in water models, and 58% and 80% in wastewater models. In particular, Thames

Water's implicit allowance tends to be higher in models which include a density driver, such as population density or network density (models which are orange in Figure 5.1 below), than in models which do not control for density (coloured blue in the figure below). This finding reflects the tendency for Thames Water's modelled costs to be higher in models which control for density.

Figure 5.1: Thames Water's Implicit Allowance for London Factors in Ofwat's Aggregated Cost Benchmarking Models



Notes: Models 37-48 estimate "Wholesale Water Botex", whereas models 32 – 39 estimate "Wholesale Wastewater Botex". Models highlighted orange include a linear density driver. Source: NERA and Arcadis Analysis.

5.3.2. Using alternative cost drivers to control for the factors identified

As an alternative to allowing special factor adjustments for London companies' higher costs, regulators can improve their benchmarking models to better account for differences in conditions in London compared to other regions. Using the data identified in Section 5.2, existing benchmarking models could be improved to better-control for the factors which drive differences in efficient costs in London relative to the rest of the country.

For each of the factors in Chapter 4, we have considered the extent to which network density and population density are drivers of the underlying differences in costs (in Appendix A to Appendix F below). For some cost factors, such as transport and logistics costs, London's density is the underlying driver of higher costs compared to less congested, lower density, rural and urban areas. Other cost factors, which are not directly related to density may be correlated with density drivers to some extent. For instance, relatively high wages and density are related as high wages will tend to attract more people to a region, and high wages may be necessary to compensate workers for high property prices in densely populated areas.

Also, our analysis of the implicit allowances granted by different water and wastewater benchmarking models (in Section 5.3.1.2 above), suggests that models which control for density better control for differences in companies costs than models which do not control for density (see Figure 5.1 above).

In Appendix H, we discuss alternative approaches to controlling for density within benchmarking models, including the methods used by regulators at recent price controls. By better controlling for density, regulators may be able to better capture London-specific factors within econometric benchmarking models, without the need for special factors or other off-model adjustments.

There is no single, underlying relationship between density and companies' costs; instead density may affect companies' costs in either direction:

- Costs may increase with density due to factors related to road congestion and network congestion, and the constraints from working in densely populated areas, e.g. in finding land for depots, and carrying out construction work.
- Costs may decrease with density, due to factors related to travel distances, and the number of assets (both network assets and operational assets such as depots) needed to provide a given level of service, as well as other economies of scale.

The extent to which one factor dominates the other can be explained in an econometric benchmarking model which includes a linear measure of density.[103] Alternatively, a model which controls for a non-linear relationship between density and costs may better reflect the extent to which the opposing effects increase and decrease costs, particularly if the relationship between density and costs exhibits a "u-shape". Regulators could include non-linear measures, such as quadratic terms, or control for a density threshold (i.e. assuming that costs begin to increase with density only above a certain level of density).

However, ultimately, density is an imprecise proxy of London-factors, and including density drivers in a benchmarking model does not necessarily produce statistically reliable models. For this reason, we have also considered how regulators could add drivers which better control for each London-specific factors in benchmarking models:

- Regulators could better control for differences in cost which arise due to the **nature of streets** by controlling for differences in road type, differences in road surfaces, and differences in the location of assets (e.g. under carriageway or under footpath) between companies (see Section A.6.2);
- Regulators could control for differences in **permitting and Traffic Management Act** schemes between different parts of the country using the characteristics and prevalence of permit conditions (see Section B.6.2);
- Regulators could control for differences in **transport and logistics costs** by controlling for differences in traffic speeds or measures of the quality of road networks (see Section C.6.2);
- Regulators may be able to control for regional differences in **labour costs** by adding regional labour cost indices to benchmarking models, constructed using ONS data on regional differences in average wages in different parts of the country (see Appendix E). However this driver has not always performed well when used in previous benchmarking models, and Ofgem's latest price controls have used off-model adjustments for wage variation; and finally

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[103] For instance, Ofwat's water treatment models find that costs decrease as population density increase, whereas in Ofwat's treated water distribution model, costs increase as population density increases (see Section H.2.2).

- Regulators could control for differences in **property costs** by adding drivers related to economy-wide property costs, e.g. published indices on regional commercial and domestic property prices (see Section F.6.2).

5.3.3. Controlling for differing customer expectations or requirements in London

As well as differences between London utilities and utilities in other parts of the country related to operating conditions and network characteristics, there are differences between utilities' customers in different parts of the country. Differences in customer characteristics lead to material differences in companies' performance against output targets, in particular customer satisfaction scores, so can penalise companies against incentive mechanisms for reasons beyond their control.

For gas, electricity and water networks, London utilities rank poorly in customer satisfaction rankings (relative to other companies in their respective sectors). As well as differences in the objective quality of service provided to customers, there are a number of reasons why customer satisfaction may be lower.

Firstly, customers in London appear to have higher expectations than customers in other parts of the country, demonstrated, for example, by London customers' reporting lower satisfaction with the gas emergency call centre, a service which provides the same service to customers throughout the country. Also, Thames Water's analysis of its SIM has found a negative link between reported satisfaction and income (and London customers have the highest incomes in the UK, on average).

Performance benchmarks which are set comparatively can also be more challenging for utilities in London than utilities in other parts of the country, since investments with a net benefit according to cost benefit analyses in other parts of the country, would not be "cost beneficial" in London due to higher costs.

Measurements of output performance, which may be appropriate for utilities in other parts of the country, are not appropriate in London, for instance due to the large number of people indirectly affected by disruption to utilities services, e.g. in Central London, where large volumes of people visit, and there is very high value of economic output.

There are several ways regulators can take account of differences in customers' expectations and requirements:

Firstly, regulators can allow higher investment for London utilities to deliver higher levels of service than utilities in other parts of the country, such as UKPN's "Central London Strategy", which ensures higher resilience to asset failures in Central London, and provides faster responses after faults. Higher investment could be supported by evidence that London customers are willing to pay to deliver higher levels of service that customers in other parts of the country.

Secondly, regulators could set output targets against historical performance rather than comparative performance: while a comparative target (i.e. set relative to other companies performance at the same point in time) may to some extent reward companies who have performed well in the past, providing a long-run reward for good performance, a target relative to a company's own historical performance better reflects the extent to which underlying performance is outside of a company's control, while still incentivising year-on-year improvement in outputs.

Finally, regulators could set targets which take account of London factors. At present, most outcome incentives which are based on comparative performance use a simple unit-benchmark across the sector; alternatively, regulators could use company-specific benchmarks which reflect regional characteristics, calculated for instance using a model which controls for regional differences in the demographic or other characteristics of the customer base.

We discuss in more detail the effect of London customers specific requirements on London companies output performance, and the alternative approaches to addressing different customer expectations in London, in Appendix G.

5.4. Conclusions

There are a number of different approaches regulators can use to better control for the specific conditions facing London utilities: including drivers in benchmarking models which capture differences between companies which drive London-specific factors; making a "pre-modelling" adjustment to normalise costs which are not comparable between companies; or making "special factor" adjustments that exclude company-specific costs to conduct comparative benchmarking on comparable costs.

We have identified a number of sources of data which regulators could use to better control for the London-specific factors we have identified in Chapter 4, and we have considered alternative cost drivers regulators could consider. In particular, we have identified that density drivers may proxy differences in costs related to many of the London-specific factors. We have also identified additional data that regulators could collect from companies which would allow regulators to generate additional cost drivers in benchmarking models.

We have also tested the extent to which existing benchmarking models grant an "implicit allowance" for London-specific costs, finding that benchmarking models predict lower costs for London companies when special factors are removed from models. For the London-specific factors quantified in Chapter 4, we have evaluated whether it would be appropriate to make a special factor adjustment for that factor against existing benchmarking models. For the factors which are not sufficiently controlled for in existing models, we find that modelled costs generated by existing totex and botex benchmarking models provide implicit allowances between 19% and 67% of each company's total special factor, partly offsetting the extent to which failing to control for London-specific factors reduces London utilities' allowances.

Finally, we have reviewed the extent to which London-specific factors affect output incentive mechanisms and other cross-company comparisons of outputs, in particular, measures of customer service. We find strong evidence that London customers have different expectations and requirements to customers in other parts of the country, and that cross-company performance benchmarks tend not to be appropriate for London companies, since they fail to take account of London customers' characteristics. Regulators could account for these differences in customers' expectations and requirements by allowing London companies to invest more (to reflect London customers' requirements, which could potentially be measured by evidence on their "willingness to pay"), or by setting company-specific targets, e.g. based on companies' historical performance, or based on models which take account of customer characteristics in different parts of the country.

6. Conclusions

In this report, we have identified the key factors affecting the cost of performing utility services in London, as compared to other parts of the country, and quantified the effect of these differences.

Through discussions with the utilities participating in this study and our review of regulatory precedent, we identified a long list of potential sources of difference, which we grouped according to the following themes:

- Factors which related to the physical make-up of the network surroundings (such as more expensive footpath materials which drive reinstatement costs);
- Factors related to traffic management and road access, including permitting;
- Factors affecting utilities transport and logistics operations;
- Specificities associated with utilities network configuration in London;
- Relatively high labour costs in London;
- Relatively high operational property costs in London; and
- Specific requirements and expectations of the customer base in London.

For each of these potential London factors, we conducted an assessment drawing on data from the Consortium to assess whether each factor was unique to London and whether it was within management control. We then quantified each factor's effect on utilities' costs. We concluded that many of the factors listed above were unique to London and could be estimated. We conducted a detailed bottom-up estimation of the impact each factor would have on London utilities' costs, relative to the average cost across the rest of the country. We tailored or estimates to each company participating in this study. The tables below show the resulting estimates of the extra costs faced by London companies.

Table 6.1: Summary of Bottom-up Estimate of the London-Specific Costs Faced by London Utilities (£ / annum)

£17/18 pa.	**Cadent**	**SGN**	**UKPN LPN**	**UKPN EPN**	**UKPN SPN**	**Thames Water** (drinking water)	**Thames Water** (waste water)
Nature of Streets	15.67	11.49	8.14	1.28	1.22	31.74	16.46
Permitting and Traffic Management	5.37	4.02	2.81	0.00	0.00	6.49	1.22
Transport and Logistics	0.78	0.05	0.38	0.00	0.00	0.05	0.05
Network-specific Factors	8.39	12.10	16.06	0.17	7.75	0.00	0.00
Labour Costs	25.31	18.23	23.77	4.74	6.37	7.80	11.12
Property Costs	0.64	0.00	0.00	0.00	0.00	0.00	0.00
Total	**56.15**	**45.90**	**51.16**	**6.19**	**15.34**	**46.08**	**28.86**

Source: Summary of Arcadis analysis.

Based on the bottom-up estimates of London-specific factors discussed above, we have evaluated whether it would be appropriate to make a special factor adjustment for each factor against existing benchmarking models. We have therefore limited this stage of our analysis to factors which are not already excluded from benchmarking models, and in respect of Ofgem's benchmarking models, costs which would have been anticipated in companies' business plan forecasts at the most recent price reviews. For the companies which primarily operate in London, we find that modelled costs generated by existing totex and botex benchmarking models provide partial, implicit allowances between 19% and 67% of each company's total special factor, as shown in the table below.[104]

Table 6.2: Proportion of London-Specific Costs Allowed for Implicitly by Existing Benchmarking Models (£m, annual average)

	Original Models			**Models excluding London-specific Costs**				**Implicit Allowance**	
Model	**Modelled costs**	**Actual costs**	**Efficiency Score**	**Modelled costs**	**Actual costs**	**Efficiency Score**	**Ldn-specifc costs**	**(£m)**	**(%)**
TW water	449.57	529.91	-18%	436.32	501.22	-15%	28.69	**13.25**	**46%**
TW wastewater	603.90	598.24	1%	590.85	578.73	2%	19.51	**13.05**	**67%**
Cadent London	187.11	199.19	-6%	184.37	184.75	0%	14.45	**2.74**	**19%**
SGN Southern	321.08	329.90	-3%	317.41	320.82	-1%	9.08	**3.67**	**40%**
LPN	207.73	203.73	2%	205.60	196.11	5%	7.62	**2.13**	**28%**
EPN	228.74	229.66	0%	227.50	228.52	0%	1.13	**1.24**	**109%**
SPN	343.89	253.91	26%	343.27	252.82	26%	1.09	**0.62**	**57%**

Note: Efficiency Score is calculated as the difference between modelled costs and actual costs, divided by modelled costs. Costs reported in benchmarking model price-base.
Source: NERA and Arcadis Analysis.

We have also found strong evidence that London customers have different expectations and requirements to customers in other parts of the country, which may, in part, be explained by higher average incomes in London. Therefore, cross-company performance benchmarks (e.g. customer satisfaction measures used in customer service incentives) tend not to be appropriate for London companies, since they fail to take account of London customers' characteristics, and are thus harder to achieve for London companies. Regulators could account for these differences in customers' expectations and requirements by allowing London companies to invest more (to reflect London customers' higher willingness to pay), or by setting company-specific targets, e.g. based on companies' historical performance, or based on models which take account of customer characteristics in different parts of the country.

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[104] For EPN, a UKPN DNOs which only partly serves London, the re-estimated benchmarking models find the company to be less efficient when London-specific costs are excluded, which likely reflects the extent to which the benchmarking models predict lower costs for non-London areas when London-specific costs are excluded.

Appendix A. Nature of Streets

A.1. Overview

A significant fraction of utilities' work requires the excavation and reinstatement of the street surface. The nature of that surface and its surroundings drives costs in those areas and these are materially different in London than they are elsewhere in the country, for the reasons summarised in Table A.1.

We have reviewed the possible differences listed between the make-up of streets in London as compared to elsewhere in the country, which could affect London utilities' costs relative to those operating elsewhere, as described in the remainder of this appendix.

Table A.1: Possible Differences in the Nature of Streets in London vs. Elsewhere in Great Britain

		Impact on Utility Expenditure by Category					
Cost Driver	**Why London Differs from Elsewhere in Great Britain**	***Labour***	***Materials***	***Equipment/ fleet***	***Directly attributable overheads***	***Other overheads***	***Pass-through***
Depth of the bound layer of the roadway and depth of assets Roads are classified based on the expected volume of traffic they are designed for. Roads which are expected to be used more intensively have deeper "bound layers" of asphalt and concrete. These categories range from Type 4 (low use) to Type 0 (high use).	London has a higher % of heavily used roads than other parts of the country.	More labour due to time taken to excavate & reinstate	More materials required for reinstatement		May require more temporary works due to deep excavations		Muck-away costs increased
Type of road structure – presence of concrete layers or "road on road" construction	More highly trafficked roads and roads that have been pedestrianised	More labour due to time taken to excavate & reinstate		Equipment required to break through concrete layer			
Asset location under carriageway rather than footway or verge	Utility congestion drives assets under carriageway	Requires more time to excavate and reinstate	More material to be replaced		Planning of TM and applications for permits		Lane rental costs, bay suspensions, traffic management
Type of carriageway surface: coloured / anti-skid etc.	More common in London due to high	More labour time	Higher unit costs				

	density of bus and cycle lanes					
Type off footway surface: York stone, resin bound tiles etc.	Common in high amenity areas of central London	More labour time to remove and replace	Have to be replaced at conclusion – expensive materials			
Special Engineering Conditions and/or archaeology	High density in central London				Actual finds are rare but must be incorporated into planning	
Productivity effect of diversity of surfaces	Large number of different requirements require specialist teams				Overall productivity driver	
Raised road crossings with printed concrete	These may be more common in London			Specialist concrete printer		
Buried tram lines in road surface	Legacy of decommissioned tram systems	Increased excavation time		Equipment to remove		
Utility congestion	High density of utilities increase need for slow hand digs around other undertaker assets	Increased time due to hand digging				
Coal cellars	Presence of occupied former coal cellars in central London pushes utility assets into carriageway				Additional planning costs	

Source: Arcadis

A.2. Technical Background and Reason for Higher Costs in London

For work which requires excavating the road surface, carrying out work on buried assets, and reinstating that road surface, the majority of the cost is attributable to the planning and execution of the excavation and reinstatement steps (discussed in this section) and to meeting Highways Authority (HA) requirements (discussed in Appendix B).

In conducting excavation work, utilities or their contractors are required to break the surface with a road saw, corer or planer and store excavated material on-site or elsewhere, depending on the plans for the re-use of excavated material and the available space at the site. If required, utilities use a side support system to prevent collapse of the excavation. For deep excavations of more than 1.5 metres, a temporary works design may be required to ensure the trench is safe to work in.

A.2.1. Street structure

When a utility opens a road to install, repair, or replace an asset it is obligated to reinstate it in a suitable way. The Specification for the Reinstatement of Openings in Highways (SROH) guides undertakers on acceptable reinstatement methods. Broadly, the road surface must be restored to how it was before the excavation commenced.

The cost and complexity of planning and executing excavation and reinstatement depends on street structure and context, the type of surface used on the road, the depth of the layers of materials in the road, and any special engineering conditions (such as proximity to bridges or sensitive archaeology) These factors all drive reinstatement costs in a variety of ways noted in Table A.1.

The same types of factors apply to footways, footpaths, and cycle tracks as to carriageways.

Highways Authorities (HAs) are required to maintain a Local Street Gazetteer which records the type of all local roads and how they are to be reinstated, traffic sensitivity (which drives pressure to reinstate quickly) and additional information. These gazetteers are uploaded and combined to form the National Street Gazetteer.

Roads are categorised into traffic categories based on the expected volume of traffic as shown in Table A.2.

Table A.2: Definition of Road Types

Road category	Traffic capacity (millions of standard axles)
Type 0	Roads carrying 30 to 125 msa
Type 1	Roads carrying 10 to 30 msa
Type 2	Roads carrying 2.5 to 10 msa
Type 3	Roads carrying 0.5 to 2.5 msa
Type 4	Roads carrying up to 0.5 msa

Source: SROH

Reinstatement designs for roads carrying more than 125 msa are not specified and must be agreed on a case by case basis.

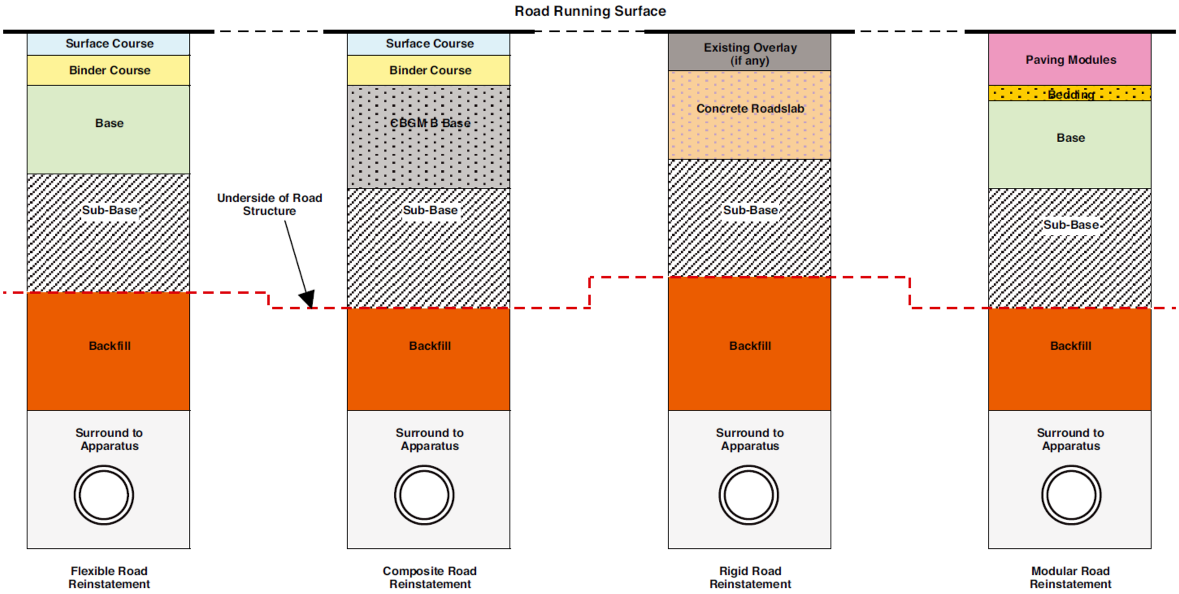
A.2.2. Flexible roads

Most roads in the UK are flexible roads with bituminous surfaces (i.e. asphalt). A flexible bituminous road is made up of a number of layers, the depth and composition of which must match SROH standards. As Figure A.1 illustrates:

- The lowest section has a layer of fine material which surrounds utility pipes, cables, or ducts. This is called the surround to apparatus.
- Above this layer are the backfill layers and above the backfill is the sub-base, which is a granular material. Backfill and sub-base materials can be either graded or granular material.
- Above the sub-base is sometimes the base / road-base layer, though this is optional and used for carriageways but not footways. This is followed by the binder course made of bituminous material.
- The top layer is the surface course, also made of bituminous material. This is the layer with which vehicles or pedestrians come into contact. The type of road, speed of traffic, and skid resistance requirements all play a role in selecting the material.
  - The top layer is usually laid hot (Hot Rolled Asphalt, HRA or Stone Mastic Asphalt SMA) but in some cases specialist permanent cold-lay surfacing materials can be used. HRA must be kept in an acceptable temperature range, as material that has cooled before laying will fail. The need to maintain the material at an acceptable temperature affects the distance and time it can travel from where it is produced.
  - The skid resistance of the surface course depends on the material used. This is measured using the Polished Stone Value (PSV) which will be specified for each reinstatement. While the SROH specifies minimum PSVs for each Road Traffic Category, HAs may require higher PSVs.
  - Other material properties such as abrasion resistance are also required for higher traffic road types. In general, materials meeting these higher standards are more expensive.

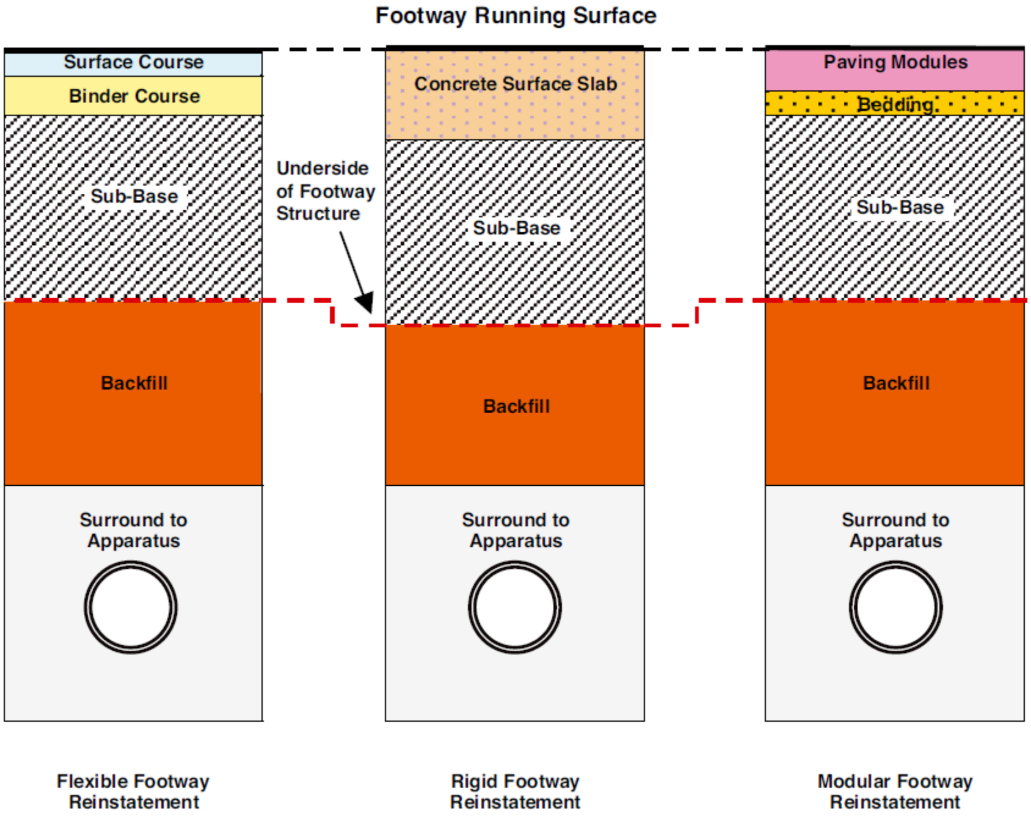
Road markings will then be applied to the surface before re-opening. However, in London more than elsewhere, this course may be required to have specific features for bus and cycle lane colourations and coatings. Many footways, particularly in London, have a surface course of cut stone, as illustrated in Figure A.2.

Figure A.1: Typical Carriageway Reinstatement Structure



Source: Specification for the Reinstatement of Openings in Highways

Figure A.2: Typical Footway Reinstatement Structure



Source: Specification for the Reinstatement of Openings in Highways

The cost and complexity of planning and executing excavation and reinstatement works also depends on the nature of the site. In general, sites are classified as either high or low risk. High risk sites are those with one or more of the following factors:

- Sites encompassing (or within 50 metres of an approach to) traffic signals, pedestrian crossings or roundabouts;
- Gradients of more than 10 per cent (i.e. steep roads); and/or
- Sharp bends with speed limits of more than 40 miles per hour.

While London has relatively few roads with bends with speed limits of more than 40 miles per hour and only a limited number of steep roads, much of the London road network is within 50 metres of a traffic signal or pedestrian crossing, making them high risk. Whether or not a road is classified as high risk affects requirements such as minimum PSV, as illustrated in Table A.3. Table A.3 shows the SROH's PSV requirements by road type for high risk and other roads, with high risk roads having more stringent requirements across most road types.

Table A.3: Minimum PSV by Road Type

Road Traffic Category	Minimum PSV for High-Risk Roads	Minimum PSV for Other Roads
0	68	68
1	68	65
2	65	60
3	65	55
4	65	55

Source: Specification for the Reinstatement of Openings in Highways

The SROH also sets out a number of acceptable reinstatement methods. The methods which can be used and the depth of the layers depend on the class of the road.

- *Method A – All Permanent Reinstatement:* The entire excavation is reinstated to a permanent standard at the first visit.
- *Method B – Permanent Binder Course Reinstatement:* The backfill, sub-base, base, and binder course are reinstated to a permanent standard at the first visit. A temporary surface course is used which is removed at a later date to allow laying of the permanent surface course.
- *Method C – Permanent Base Reinstatement:* The backfill, sub-base, and base are reinstated to a permanent standard at the first visit. An interim binder and surface course is used which is later removed to allow laying of permanent binder and surface courses.
- *Method D – Permanent Sub-Base Reinstatement:* As above but only the backfill and sub-base are permanently installed on the first visit.

As Table A.4 shows, the depth of bound material (combining the binder course and surface source) depends on the Road Traffic Category. We discuss the prevalence of different road types in London as compared to elsewhere in Great Britain below.

Table A.4: Reinstatement Requirements by Road Type

Road Traffic Category	Depth of Binder Course	Depth of Surface Course	Total Bound Material
4	110mm	40mm	150mm
3	150mm	40mm	190mm
2	245mm	40mm	285mm
1	280mm	40mm	320mm
0	305mm	40mm	345mm

Source: SROH

In summary, excavating and reinstating flexible roads of a higher traffic category is more expensive due to differences in material specifications and volume. In Section A.3 we show that such road categories are more common in London than elsewhere.

A.2.3. Rigid concrete roads

Excavating through concrete, or through composite roads that contain a concrete layer is substantially more difficult than through flexible roads made of bituminous material and requires mini-diggers.

In addition, some flexible roads have concrete layers embedded in them either as a historical legacy or as a choice made for strength, making excavations through these roads substantially more difficult.

A.2.4. Footways and cycle tracks

Footways generally have a much simpler sub-structure than carriageways (compare Figure A.1 and Figure A.2). The surface of a footway is usually of asphalt or of cut stone. The latter is substantially more expensive and more common in London as we show below.

The surface of London cycle tracks is often coloured, most of these are part of the carriageway and therefore are otherwise reinstated to carriageway standards.

High duty and high amenity footways, footpaths, and cycleways are recorded by the HA which will also identify a source of appropriate reinstatement materials.

A.2.5. Special engineering conditions

Some parts of central London have a high density of bridges, roads with shallow tunnels underneath, and/or require archaeological survey work before excavation. This may increase planning costs even if the work to be carried out is identical to that required in less congested areas. And in some cases, the work must be adjusted to adopt more expensive or complicated approaches due to the prevailing engineering conditions or the need for/findings from archaeological surveys.

A.2.6. Productivity effect of diverse surfaces

Apart from the higher unit costs for the materials, which we address below, having a large number of different surface types and finishes may reduce productivity. This is because it is costly to keep reinstatement crews fully utilised if they are not fully interchangeable due to the need for specialist equipment and training. This may also drive up stores costs for utilities and their contractors.

A.2.7. Raised road crossings with printed concrete

While the presence of road crossings made of printed concrete and the cost of the associated machinery was discussed in our workshops, we have not been able to find any evidence for a material cost associated with this.

A.2.8. Buried tram lines in the road surface

In some areas, tram lines decommissioned in the 1950s to 1970s were left in place and covered with a layer of asphalt. When these rails are uncovered during an excavation, they must be cut and removed, which we understand adds to the difficulty of carrying out an excavation according to our discussions. However, we have not been able to find any quantitative evidence that this is a material factor.

A.2.9. Utility congestion

The view of participants in our workshops was that utility congestion is greater in London and that this leads to lower work productivity and a greater number of third-party damage events.

If it is the case that utility congestion is greater in London, then this may lead to a greater number of third-party damage events and a need for more hand digging to avoid damage to other utility assets. Density of fibre optic installations, which are often laid in conduit directly over pre-existing electricity distribution mains or other assets may also contribute to access complications.

A.2.10. Coal cellars turned into basements

Central London has a high density of coal cellars which are now used for office or shop space. Not only does this contribute to utility congestion and force utility assets under the carriageway but it also creates unique problems when installing gas and water services.

A.3. Evidence for Uniqueness of London

A.3.1. Class of roads / depth of bound layer

As Table A.5 shows, based on data from SGN, there are slightly more reinstatements of category 1 roads within the M25. This is based on an analysis of more than 16,000 SGN reinstatement work orders (29% of which were within the M25).

Table A.5: SGN Reinstatement Type by Road Category

Reinstatement work type	% of all SGN Southern reinstatements inside and outside the M25	% of all reinstatements within M25 only
Reinstatement of road categories 3 or 4 with flexible material	81%	78%
Reinstatement of road category 2 with flexible material	13%	13%
Reinstatement of road category 1 with flexible material	6%	9%

Source: Arcadis analysis of SGN reinstatement data

We also analysed Department for Transport (DfT) data on road length per region and found that London had a lower percentage of B roads and more C and Unclassified roads, as demonstrated by Table A.6. However, there is not a direct link between reinstatement category and road class.

Table A.6: Roads by type London vs Great Britain

	Motorways	A roads	B roads	C and U roads	All roads
London (km)	60	1,718	508	12,556	14,842
London (% of total)	0.4%	11.6%	3.4%	84.6%	100.0%
Great Britain (km)	3,688	46,896	30,323	316,131	397,039
Great Britain (% of total)	0.9%	11.8%	7.6%	79.6%	100.0%

Source: DfT dataset RDL02 (Road length in kilometres)

A.3.2. Location of assets

The preferred location for utility assets (except sewers) is under the footway. Placing them under the footway makes them easier to access and subjects them to less vibration from passing traffic. Some utility assets are located under grassed verges, these are even cheaper to replace and repair than those under the footway.

The density of utility assets under London's streets and the presence of coal cellars and other basement structures under many London streets leads to a greater percentage of assets in London being under the carriageway, which is expected to affect excavation, traffic management, and other costs.

The evidence we have examined to test this hypothesis is:

- Repair and repex work volumes from Cadent;
- Reinstatement data from SGN; and
- Streetworks noticing and permit data from UKPN.

As Table A.7 and Table A.8 show, Cadent's repair and repex work is more likely to be under the carriageway in London as compared to elsewhere, and less likely to be under the footway or the verge. Given the incentives the company has to minimise the unit cost of its repex work and to locate assets in the footway when possible, we would expect this difference between London and other network areas to be caused by the environmental factors the utility faces in central London.

Table A.7: Cadent Repair Work Volume by Surface

Gas repair (Cadent)	Carriageway	Footway	Verge
National average[105]	31%	58%	12%
London	39%	54%	7%
London excess	8%	-3%	-4%

Source: Arcadis analysis of Cadent repair and contractor data 2017/18 – 2018/19

Table A.8: Cadent Repex Work Volume by Surface

Gas repex (Cadent)	Carriageway	Footway	Verge	Other
East	34%	47%	16%	3%
Northwest	36%	47%	16%	1%
West Midlands	30%	50%	17%	3%
London	48%	38%	12%	2%
Average	37%	46%	15%	2%
London excess	11%	-8%	-3%	0%

Source: Arcadis analysis of Cadent contractor rates 2017/18 – 2018/19

Reinstatement data from SGN also reflects this higher proportion of assets in the carriageway. A substantially higher proportion of SGN's work is in the public highway than in footpaths in London, as shown in Table A.9.

Table A.9: SGN Reinstatements by Location

Reinstatements (SGN)	Public Highway	Public Footpath
Southern overall %	61%	30%
London within M25 %	81%	9%
London excess	20%	-21%

Source: Arcadis analysis of SGN reinstatement activity

However, analysis of UKPN permitting data shows that this does not appear to be the case for UKPN. As illustrated by Table A.10, 72% of UKPN's permits and notices cover work carried out on footways. The proportion is higher at over 80% for both inner and outer London. The volume of work carried out under verges in London is minimal.

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[105] Based on London, East Anglia and East Midlands, using the latter two as a proxy for the six non-London GDNs

Table A.10: UKPN Permits and Notices by Cover Type

All networks	Carriageway	Footway	Verge	Area fraction
Inner London	17%	82%	0%	23%
Other	22%	62%	16%	52%
Outer London	12%	84%	4%	22%
TfL	7%	91%	2%	3%
All	19%	72%	9%	100%

Source: UKPN permits and noticing 2015/16 – 2017/18

A.3.3. Type of road structure

Data from SGN (see Table A.11 below) shows that London has more composite road structures which contain a layer of concrete under an HRA or other flexible surface. Work done for the GD1 price control by Cadent found that 27% of all repair jobs done over a 5-month period in Hammersmith and Fulham involved concrete. However, the proportion varies substantially by HA.

Table A.11: Frequency of Overlay on Concrete Roads in London

Reinstatements (SGN)	Overlay on Concrete
Southern overall %	4%
London within M25 %	12%
London excess	8%

Source: SGN reinstatement data

A.3.4. Type of carriageway surface

We have investigated the use of the following types of carriageway surfaces:

- Red tarmac (used for bus lanes);
- Green tarmac (used for cycle lanes); and
- Anti-skid coating (used near junctions and other high-risk areas).

Red tarmac is used to mark London bus lanes, among other things, and it is therefore not surprising that it is used more by LPN than in the other two UKPN networks, on average more than twice as often in the LPN network as compared to the SPN and EPN networks (see Table A.12).

Table A.12: Number of Red Tarmac Reinstatements by UKPN Networks

	EPN	LPN	SPN
2015	N/A	259	110
2016	29	256	164
2017	215	351	224
2018	270	265	143
Average	171	283	160

Source: UKPN

As well as being used more often in London, the unit cost of red tarmac reinstatement is also higher in LPN, as Table A.13 shows.

Table A.13: Average Cost of Red Tarmac by UKPN Network

	Average unit cost
LPN	£48
EPN & SPN average	£39
	+22%

Source: UKPN

SGN does not record the frequency with which red tarmac is used within the M25. However, data from both UKPN and SGN shows that green tarmac is used more frequently within the M25, but that the amounts involved are not material.

We also analysed the use of anti-skid coatings as shown in Table A.14 and Table A.15 for UKPN and SGN respectively. We find that the use of this material is more common in London than elsewhere. For instance, SGN applies anti-skid coating twice as often inside the M25 compared to outside it.

Table A.14: Number of Anti-skid Coating Applications by UKPN Network

	EPN	LPN	SPN
2015		259	110
2016	29	256	164
2017	215	351	224
2018	270	265	143
Average	171	283	160

Source: UKPN

Table A.15: Frequency of Application of Anti-skid Coating for SGN Reinstatements

	Southern ex M25	London (in M25)
Frequency of application of Anti-skid coating	215	260
% of all work orders	0.7%	1.5%

Source: SGN Reinstatement data

Data on the use of anti-skid coating was not available from Cadent and Thames. However, it seems reasonable to assume that they must also apply anti-skid coating more often within the M25 than outside it, based on the data shown above for the other companies covered by this study.

A.3.5. Type of footway surface

The most common type of footway surface is a flexible asphalt, similar to that used on road surfaces. However, slabs, natural paving stones, and asphalt overlays on concrete surfaces are more common in London than elsewhere. York paving stones are also more commonly found in London than elsewhere.

As Table A.16 shows, UKPN uses almost ten times as many York stone paving installations in LPN than in its other two networks.

Table A.16: Number of York Paving Stone Installations by UKPN Network

	EPN	LPN	SPN
2015	N/A	1598	247
2016	17	2019	222
2017	320	3072	264
2018	503	2386	477
Average	280	2269	321

Source: UKPN

Installing York stone was also more expensive in London than elsewhere over this period, with the unit cost of installation 76% higher than EPN and SPN, as Table A.17 shows.

Table A.17: Average Cost of York Paving Stone by Network

	Average Unit Cost
LPN	£317
EPN & SPN average	£180
	+76%

Source: UKPN

Data from SGN displayed in Table A.18 also shows that London (defined to be within the M25) has a much greater percentage of footways that require reinstatement with stone slabs or which require a flexible overlay on a concrete surface.

Table A.18: SGN Footway Reinstatements

Footway reinstatements (SGN)	Flexible	Slabs	Overlay on concrete
Southern outside M25	39%	6%	1.5%
Southern within M25 %	25%	22%	7%
London excess	-14%	16%	5.5%

Source: SGN reinstatement data

A.3.6. Special engineering conditions and/or archaeology

We have not been able to find any evidence to demonstrate this conclusively.

A.3.7. Productivity effect of diversity of surfaces

We were not able to determine whether the diversity of surfaces led to a productivity difference specifically attributable to that factor.

A.3.8. Raised road crossings with printed concrete

We have not been able to find any evidence to demonstrate the uniqueness of London in relation to this cost category.

A.3.9. Buried tram lines

We have not been able to find any evidence to demonstrate the uniqueness of London in relation to this cost category.

A.3.10. Utility congestion

During our workshops with operational experts from the consortium companies, and from further discussions with contractors and others who have worked on excavation and reinstatement work in London, we were told that the density of underground assets makes these operations slower and more resource-intensive in London than elsewhere.

To test this quantitatively, we have examined the following datasets

A.3.10.1. UKPN incident types including equipment damage by third parties and overall cable damage to services and LV mains

We analysed four years (2015 – 2018) of UKPN damage call data, summarised in Table A.19, to determine if there were more incidents due to third-party damage to underground assets in LPN than in the other networks. We found that there was no evidence from this data that third-party damage to UKPN assets occurred more frequently in the LPN area than in UKPN's other networks.

Table A.19: UKPN Top Incident Types by Network 2015 - 2018

Type of incident	EPN	LPN	SPN
Cable Damage service	54.9%	44.8%	61.9%
Damaged Equipment LV incident	20.9%	24.5%	19.1%
Emergency Disconnection	5.5%	9.5%	1.6%
Smell of Burning SP incident (Customer Safety Check)	5.8%	9.9%	7.5%
Miscellaneous	2.6%	3.2%	1.0%
Damaged Equipment, 3rd party damage HVN incident	2.3%	0.7%	1.8%

Source: UKPN critical call data 2015 – 2018, % of total calls

A.3.10.2. The density of UKPN underground cables and overground lines per km^2 of network area

We estimated the length of road in each network using the DfT dataset (RDL0201) that shows the total length of road by ONS region. Our road length estimations are displayed in Table A.20. As these regions do not map exactly to network boundaries, we allocated the length of each region to UKPN networks based on population (shown in italics in the table).

Table A.20: Estimated Road Length by UKPN Network

Road length (km)	Total km road	EPN	LPN	SPN
ONS East	40,052	71%	2%	0%
ONS London	14,842	24%	96%	22%
ONS South East	48,179	4%	2%	78%
		100%	100%	100%
ONS East (km)		28,597	801	0
ONS London (km)		3,532	14,248	3,265
ONS South East (km)		2,072	964	37,580
Total by network (km)		**34,201**	**16,013**	**40,845**

Source: Arcadis analysis of DfT RDL0201 and Arcadis geospatial analysis estimate of population split between ONS regions and UKPN networks

A.3.10.3. The density of UKPN cables and lines per estimated km of road

We used these road length estimates to determine the length of cable per length of available road to estimate the density of underground cables, with the resulting estimates shown in Table A.21. Note that not all cable is laid under roads, especially in rural areas such as those serviced by EPN.

Table A.21: UKPN Linear Asset Density by Network

	EPN	LPN	SPN
Total overheads (km)	27,841	0	9,922
Total length cable (km)	69,977	37,160	43,092
Total length (km)	97,817	37,160	53,015
Total area (km^2)	20,114	666	8,012
Total length / area (km^{-1})	5	56	7
Total road length (km)	34,201	16,013	40,845
Cable / road length	2.05	2.32	1.06

Source: UKPN overhead line and cable lengths, Arcadis estimate of road length per network

While the data shows that the density of cable and overhead lines per square kilometre is much higher in LPN, it does not show conclusively that the density of cable per length of road is unusually high in LPN.

A.3.10.4. The density of SGN gas mains by km^2 and per estimated km of road

We carried out a similar road length analysis using SGN data and arrived at the estimates in Table A.22. We then used the road lengths from Table A.22 to calculate the density of mains by length of available road and by area. The resulting estimates of mains density are shown in Table A.23.

As with the UKPN data, we found that that the density of mains per square kilometre was higher in London than elsewhere. However, the density of mains by available length of road was actually lower in London than elsewhere.

Table A.22: Estimated Road Length by SGN Network Area

Road length (km)		**SGN all**	**SGN within M25**
ONS East	40,052		
ONS London	14,842	25%	87%
ONS South East	48,179	67%	13%
ONS South West	50,386	8%	
		100.0%	100.0%
ONS East (km)		3,711	12,913
ONS London (km)		32,280	6,263
ONS South East (km)		4,031	0
ONS South West (km)		40,021	19,176

Source: Arcadis analysis of DfT RDL0201 and Arcadis geospatial analysis estimate of population split between ONS regions and SGN areas networks

Table A.23: SGN Mains Density by Area

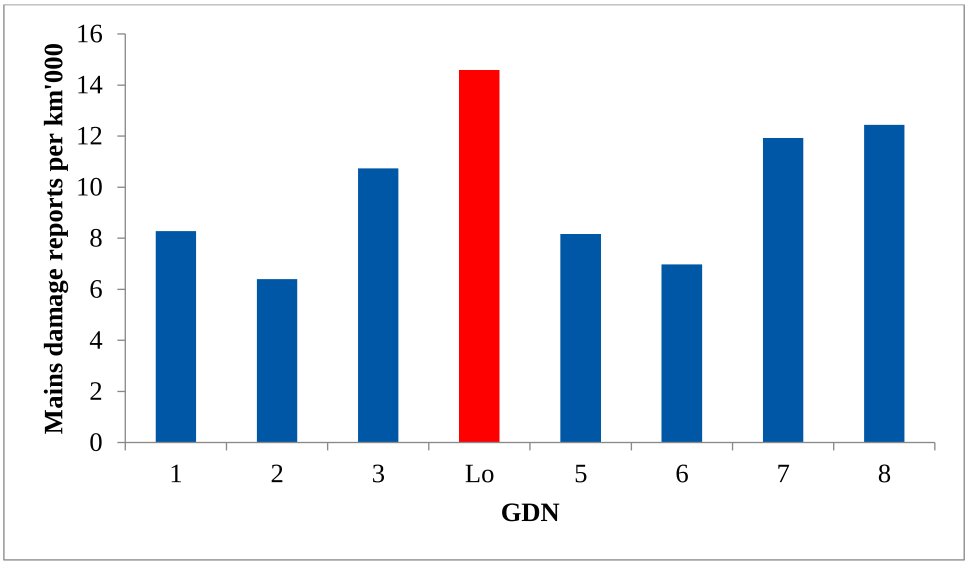
	SGN all	**SGN within M25**
Estimated road length (km)	40,021	19,176
Total mains (km)	48,094	13,298
Total area km^2	22,029	2,400
Mains / length of road	1.2017	0.6935
Km of mains / km^2	2.18	5.54

Source: SGN service and mains density data, Arcadis estimate of road length per network

A.3.10.5. Cadent mains damage reports

Data from Cadent indicates that third-party damage to mains is much more common in London than the GB average. Figure A.1 below shows the mains damage reports by length of mains for five years.

Figure A.1: Mains damage reports per km ‘000 (2013/14 to 2017/18) by GDN



Source: Arcadis analysis of Cadent data

Average mains damage for Cadent’s North London network is 57% higher than the other GB networks (including SGN’s Southern network which is also substantially in London).

A.3.10.6. SGN public liability insurance claims relating to utility strikes during excavation

We also examined claims against SGN’s public liability insurance relating to damage done to assets belonging to other utilities during excavations. This data did not have sufficient regional granularity to allow us to determine if this was more common in London than elsewhere on SGN’s networks.

A.3.10.7. Conclusions on the uniqueness of utility congestion to central London

Overall, we have not been able to demonstrate using the data available to us that the density of utility assets in London leads directly to a specific additional cost. However, we have shown from Cadent data that damage to underground assets is more frequent in London than elsewhere, and we would expect this more frequent damage to result in additional expenditure for all London utilities in emergency and fault response and in repair expenditures for underground assets. As gas, electrical, and water assets are in close proximity to each other in similar underground surroundings, we would expect this effect to apply not just to gas distribution to the other utility sectors as well.

A.3.11. Overall effect of the nature of streets on London utilities’ costs indicated by market rates for contractors

Many activities are carried out by contractors and therefore utilities may not have direct insight into the factors that drive cost increases. Since these contractors have been competitively procured, we can assume that they have incorporated their experience of factors which drive regional cost differences into their rate structure established through the procurement process.

Note that these rates also incorporate effects due to travel, labour prices, and other factors on contractor input costs.

A.3.11.1. Evidence from Cadent repex contractor rates

We have analysed the per metre rates charged to Cadent by its contractors to excavate, replace gas distribution pipes and reinstate the surface. The reported costs are unit rates to carry out these works. They do not include:

- The cost of materials;
- Indirect costs (closely associated or otherwise) incurred by the utility in planning the works and associated traffic management planning; and
- Costs payable directly to HAs for lane rentals, parking bay suspensions, etc.

Therefore, regional cost premia derived from these data can be added to such costs without double counting. However, adding them to cost premia determined for factors such as labour cost and logistics costs (such as the effects of traffic congestion) may double-count the effect on contractor rates from higher contractor labour costs in London.

Since materials are not included, we would expect the regional premia for London and the relative prices for digging in the verge, carriageway, and footway to be applicable to similar activities in the water and electricity industries.

The rates are split by the use of “no-dig” trenchless pipe replacement techniques or conventional trenching. No-dig techniques are also suited to water pipe replacement schemes.

Rates vary depending on whether the excavation is in the grassed verge, under a footpath, or under the carriageway. The rates are also split by diameter of the pipe to be replaced which drives required excavation size. Rates grow more slowly by diameter for no-dig techniques than for dig techniques which is to be expected as dig techniques require trenching.

We have aggregated the rates, weighted by diameter of activity to arrive at the below premia for the various regions of Cadent over the national average. The same contractor (tRIIO) carries out repex activity on behalf of Cadent in East Anglia, East Midlands, and North London. We have therefore used the difference in rates between the East of England network and the North London network to estimate the London effect on contractor rates.

We have also tested the effect against the rates for the North West and West Midlands networks which are covered by Balfour Beatty and found similar effects, however the tRIIO prices provide a more useful comparison as the same organisation is delivering across London and other regions.

As we do not have access to a full unit cost database that reflects costs across the whole of Great Britain, we have assumed that the average is composed of:

- 1/8 London rates; and
- 7/8 average rates for the two areas of the East of England network (EoE is a large network and split into two for historical reasons).

The West Midlands, East of England, and North West networks cover a mix of rural, suburban, and non-London urban areas across England and should represent a reasonable proxy for Great Britain outside of London. All below data is based on an average of rates agreed for 2017/18 and 2018/19.

Table A.24 and Table A.25 show the overall regional effect, with premia reported in percentage terms relative to average costs across all regions for each cover/excavation type.

Table A.24: Regional Effects on Overall Rates – No Dig

Surface type	East Anglia	East Midlands	London
Footway	4%	-12%	28%
Carriageway	4%	-13%	33%
Verge	7%	-10%	11%

Source: Arcadis analysis of Cadent contractor rates 2017/18 – 2018/19, weighted by diameter.

Table A.25: Regional Effects on Overall Rates – Dig

Surface type	East Anglia	East Midlands	London
Footway	5%	-12%	26%
Carriageway	4%	-13%	33%
Verge	3%	-13%	34%

Source: Arcadis analysis of Cadent contractor rates 2017/18 – 2018/19, weighted by diameter.

London rates are substantially more expensive than the average in every category. The East Midlands[106] region is less expensive than average. There is a substantial difference between the rates charged by surface type, as shown in Table A.26 and Table A.27.

Table A.26: Premium Over Footway Rate - No Dig

Surface type	East of England	London
Footway	0%	0%
Carriageway	14%	18%
Verge	-16%	-27%

Source: Arcadis analysis of Cadent contractor rates 2017/18 – 2018/19, weighted by diameter

Table A.27: Premium Over Footway Rate - Dig

Surface type	East of England	London
Footway	0%	0%
Carriageway	19%	26%
Verge	-36%	-31%

Source: Arcadis analysis of Cadent contractor rates 2017/18 – 2018/19, weighted by diameter

Inside and outside of London, there are substantial premia for operating in the carriageway over the footway and substantial discounts for operating in the verge. Table A.28 shows the

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[106] The East Midlands and East Anglia operational regions are both within the East of England network price control

combined effect of the regional rate difference and work mix difference for Cadent's London network. We derived from Table A.28 that, if Cadent were able to carry out its London repex work at the national average rates and with the same mix of surfaces, it would spend 24% less for the same output. Our derivation proceeds by:

- Taking the actual London and national average work mixes and the weighted national rate (indexed relative to the London carriageway) as inputs;
- Calculating the blended rate for London using London actual costs and London actual work mix;
- Calculating the blended rate of carrying out the national average work mix at London rates. This isolates the surface type effect and shows that this leads to a cost uplift of 3%;
- Calculating the blended rate of carrying out the London work mix at national average rates. This isolates the per surface rate uplift and shows that this leads to a cost uplift of 18%; and
- Finally, combining the two previous effects and calculating how much it would cost to carry out the national work mix at national average rates. This is 20% less than the London rate.

Table A.28: Combined Effect of Regional Rate Premium and Work Mix Difference on Cadent London Repex Costs

	Verge	Carriageway	Footway	Blended rate	London uplift
London work mix	13%	49%	39%		
National work mix (constructed average)	16%	36%	47%		
Diameter weighted rate (London)	0.62	1.00	0.84		
Diameter weighted rate national	0.56	0.75	0.66		
Cost per m, London	0.08	0.49	0.33	0.89	
Cost per m, national work mix @ London rates	0.10	0.36	0.40	0.86	3%
Cost per m, London work mix @ national average rates	0.07	0.37	0.26	0.69	22%
Cost per m, national work mix @ national average rates	0.09	0.27	0.31	0.67	24%

Source: Arcadis analysis of Cadent contractor rates 2017/18 – 2018/19

We also examined Cadent data comparing the cost per metre of repair work in the North London and East of England regions over a five-and-a-half-year period to December 2018 and found that repair work in North London cost on average 21% more than in the East of England network.

A.3.11.2. Evidence from SGN repex unit costs

We analysed SGN repex unit rates in three regions, weighted by the technique used to deliver the work (insertion vs. open cut) and grouped into three diameter bands.

- Inner South London;
- Outer London, Surrey, and the South Downs; and
- South: Thames Valley, Wessex, Oxford, and Poole.

Table A.29 shows unit costs relative to the average unit cost for that band in the South area.

Table A.29: SGN Repex Unit Costs

	Band 1: 40mm - 75mm	Band 2: 75mm - 125mm	Band 3: 125mm - 180mm
South	–	–	–
Outer	104%	78%	152%
Inner	105%	84%	144%

Source: SGN repex unit cost analysis

The conclusions from this analysis are mixed. For bands 1 and 3, there is a substantial London effect ranging from 4% to 52%. For band 2, the costs are highest in the South region, i.e. outside of the Inner and Outer London areas.[107]

Weighting these premia by the relative volume of work in each band, we find an overall effect of a 7% cost increase in London (inner and outer combined).

✂

A.3.11.3. Evidence from Cadent on repex productivity

We have also analysed repex productivity data (metres per time period) from Cadent's London and East of England networks. These two networks deliver their repex through the same delivery model, Cadent's GDSP delivery alliance.[108]

Figure A.2 below shows Cadent's repex productivity split into four regions:

- Inner London boroughs;
- Outer London boroughs (some of which are within the East of England licence area, but which are managed as part of London);
- Local Authorities which are within the London GDN network area but are not within London; and
- Local Authorities in the East of England network.

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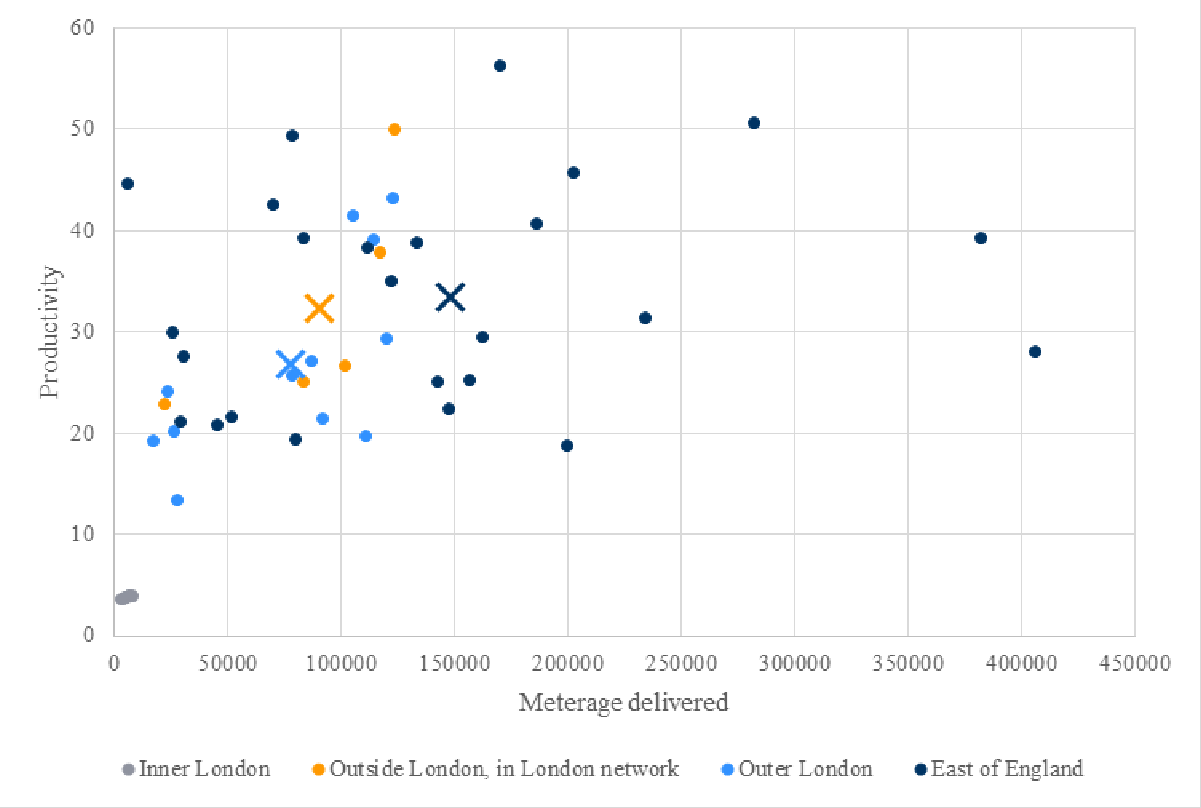
[107] We also considered whether this results from a small volume of work in band 2. However, band 2 repex work in Inner South London was 47% of all repex delivered.

[108] Note that since the team size, definition of productivity and other factors are very different, these productivity figures cannot be compared directly with SGN's which are below. We have not sought to reconcile these definitions.

The scatterplot shows that the productivity achieved for inner London is "clustered" in the bottom left-hand corner of the chart, indicating a lower average level of productivity in Inner London. The fact that this series is clustered below the series for other areas shown in the figure also suggests that the lower volume of metres replaced in inner London than in other areas is not solely responsible for this lower productivity; indeed, there is no apparent positive correlation between productivity and metres replaced.

Table A.30 shows average productivity for each of the series shown in Figure A.2. As the volume delivered in some Local Authorities was very small and we were less confident that the productivity of work delivered in these areas reflected underlying factors rather than very small programmes of work, we have discounted any Local Authority where less than a kilometre was delivered when calculating the averages shown in the table.

Figure A.2: Cadent Repex Productivity (metres/week) vs Meterage Delivered (metres)



Source: Cadent repex productivity data
Note: The crosses in the above chart represent averages for the respective regions.

Table A.30: Cadent Average Repex Productivity by Region (metres/week)

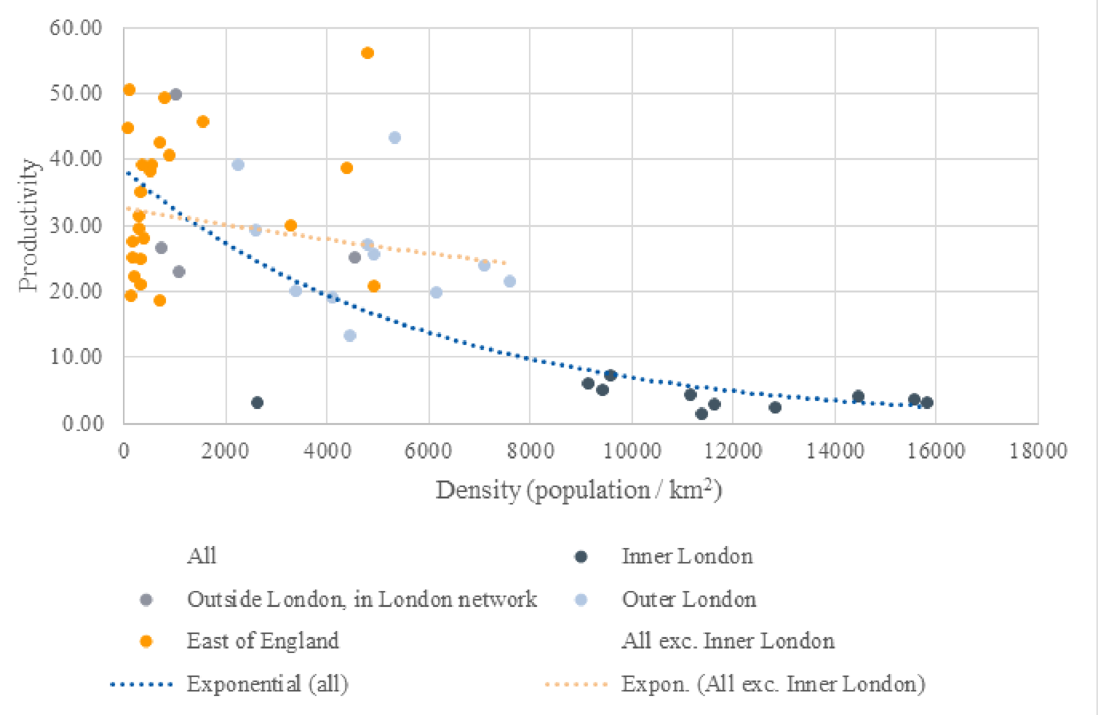
	Average, Discounting Lowest Meterage Local Authorities
East of England	33.57
Outside London, in London network	32.41
Outer London	26.92
Inner London	3.93
All of London	15.92

Source: Cadent repex productivity data

As set out elsewhere in this report, there are a number of factors that could contribute to this lower measured productivity of the repex programme in Inner London. As Figure A.3 shows, one possible explanation for this, and indeed a possible means of capturing this effect in benchmarking regressions as we discuss further in Section A.6, is the high density within central London.

However, the chart also seems to indicate a relatively weak correlation between productivity and density within regions outside London, suggesting this effect may be challenging to control for robustly within regression models. Including density drivers could, in effect, act as a dummy variable for the central London companies.

Figure A.3: Repex Productivity (metres/week) vs Density (population/km^2)



Source: Cadent repex productivity data

Taking data from Table A.30 above, and treating the repex productivity in the East of England network and in those parts of the London GDN which are not within London boroughs as the baseline, we obtain the differences in productivity in London shown in Table

A.31. Weighting the Inner and Outer London effects by the relative meterage delivered gives an overall effect on productivity of 23.1%**.** Note that if this data is used for assessing future programmes of work, then this will have to be re-balanced using forecast splits between Inner London and Outer London work volumes. The effect size for those areas outside London but part of the Cadent London network (the North bank of the Thames to the East of London) is shown for reference.

Table A.31: Repex Productivity for London vs. Other Areas

	Productivity Discount to Non-London
Outside London, in London network	-2.0%
Outer London	-18.4%
Inner London	-88.1%
Weighted average	-23.1%

Source: Cadent repex productivity data

A.3.11.4. Evidence from SGN on repex productivity

Overall data on repex productivity from SGN shows that on a unit output per head basis,[109] the London-based teams are able to abandon 7.8% fewer metres per week than the average, as Table A.32 shows.

Table A.32: SGN Repex Productivity

	Team productivity in metres / week 2016/17, 2017/18, 2018/19 to date average
Non-London based	32.0m
London based	29.5m

Source: SGN Repex output data

This is substantially lower than the effect seen in the Cadent data. Factors that may cause this difference are:

- The Cadent data is on a local authority basis, allowing exact comparison between London and non-London data, the SGN data compares depots and some of the work done from the SGN repex depots (in outer-London) may be outside of London;
- The densest parts of central London are covered by the North London network and the productivity effect is most pronounced in those areas.

A.3.11.5. Evidence from Thames Water on mains laying productivity

We have examined two sources of evidence from Thames Water relating to streetworks costs and productivity:

- Mains laying productivity in metres / gang / week collected to support the PR09 submission. Although this data is now around 8 years old, to the extent that London-

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[109] One of the London teams operated with a larger team and their productivity has been adjusted proportionately downwards.

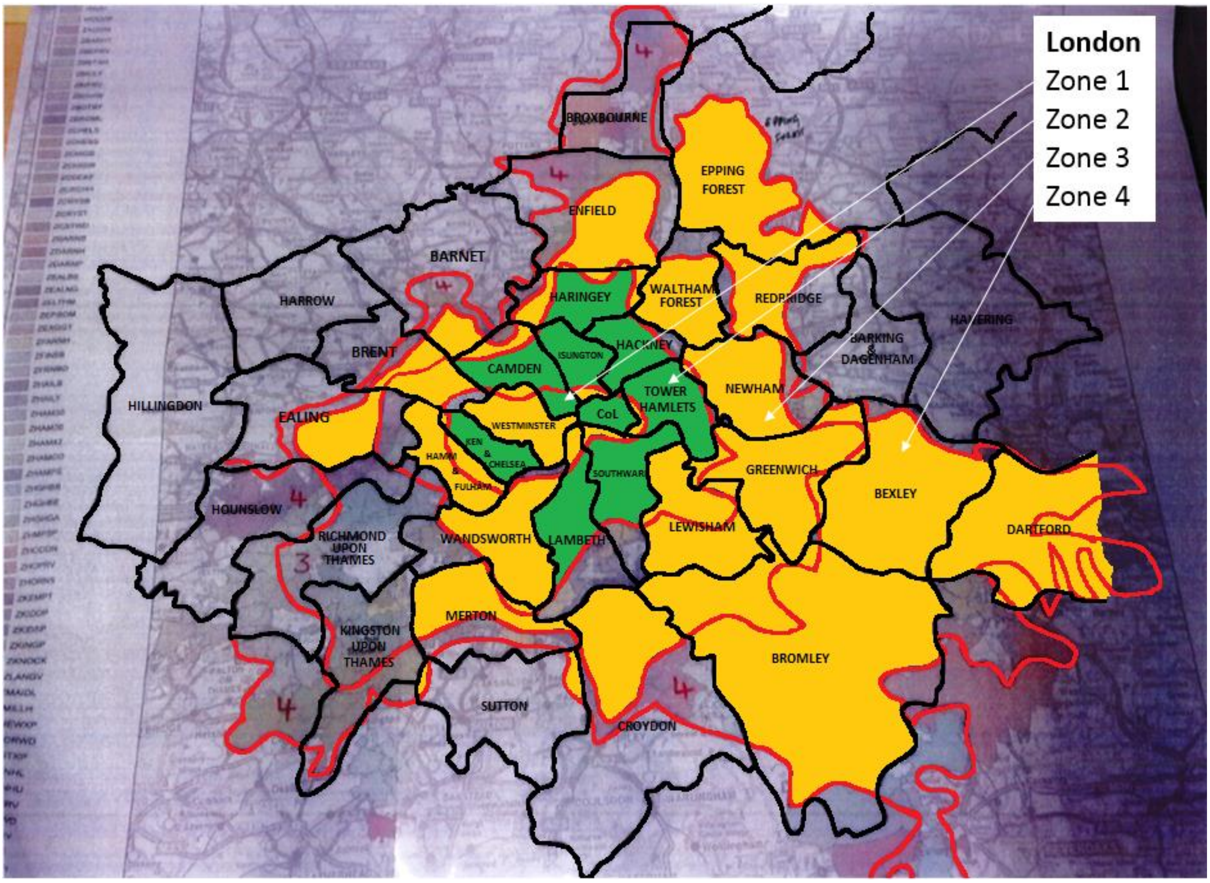
specific productivity factors are stable over time, it still gives some insight into those factors; and

- London reinstatement rates analysis based on current rate cards split by North London, South London, and the Thames Valley

At the time, mains laying rates were split into four zones.

- Zone 1 – Approximately City of London, Westminster, Kensington & Chelsea;
- Zone 2 – Most of the rest of Inner London;
- Zone 3 – The outer parts of Inner London and inner parts of Outer London; and
- Zone 4 – Other parts of Outer London.

Figure A.4: Thames Water Mains Laying Zones



Source: Thames Water

The productivity figures from 59 gangs working across zones 1-3 are shown in Table A.33.

Table A.33: Thames Water Mains Laying Productivity by London Zone

	Mean productivity (metres / gang / week)
Zone 1	31
Zone 2	33
Zone 3	57

Source: Thames Water mains laying productivity at PR09

Mean productivity in Zone 2 was 58% of that in Zone 3 which is consistent with lower repex productivity found in denser Inner London areas for Cadent and SGN. Water mains laying is a similar activity (replacement of old pipe with new HDPE pipe using a mixture of open-cut and insertion techniques.

A.3.11.6. Evidence from Thames Water on reinstatement unit rates

We analysed two elements of Thames Water's reinstatement costs:

- The relative prices per square metre of reinstating different types of carriageway, footway, and verges; and
- The regional unit rate differences across the North London, South London, and Thames Valley areas.

Our analysis shows similar reinstatement rate differences between types of carriageways (C/W), types of footways (F/W), and public verges. These relative reinstatement rates are shown in Table A.34.

Table A.34: Thames Water relative reinstatement rates (North London)

Surface type	Relative rates (North London)
C/W Type 1 Tarmac	100.0%
C/W Type 3/4 Tarmac	83.4%
F/W Tarmac	52.2%
F/W Slabs	44.2%
F/W Blocks	46.9%
Public Verge	27.0%

Source: Thames Water unit rates

The rates assume that specialist modular materials such as paving slabs or York Stone blocks are either reused or separately costed which explains why rates for the footway surface types follow a different pattern than those shown for UKPN and SGN.

We express reinstatement costs for North and South London as percentages of Thames Valley reinstatement costs in Table A.35.

Table A.35: Thames Water Regional Reinstatement Rates Relative to Thames Valley

Reinstatement work type	North London	South London
Reinstate Public Verge / Unmade	140%	109%
Reinstate F/W - DBM/HRA/SMA	165%	131%
Reinstate F/W - Slabs/Mods	83%	67%
Reinstate F/W - Blocks	97%	79%
Reinstate C/W Type 1 - DBM/HRA/SMA	113%	90%
Reinstate C/W Type 3/4 - DBM/HRA/SMA	243%	191%

Source: Thames Water unit rates

Premiums range from 9%, for verges in South London, to 143% for type 3&4 carriageway reinstatement in North London. Reinstatement of footways with slabs or blocks is cheaper in London than in the Thames Valley but this work type is relatively rarer outside of London based on analysis of SGN reinstatement data. Reinstatement of type 1 carriageways is also cheaper in South London than in the Thames Valley.

Based on the Cadent and SGN data analysed throughout this appendix, the most common work types in London are reinstatement of footways with flexible material (DBM/HRA/SMA) and the reinstatement of type 3&4 carriageways. For these items, reinstatement premiums range from 31% to 143%.

We were not able to analyse detailed data on the composition of Thames Water's mains relaying, sewer rehabilitation, and burst response programmes but these data are consistent with the evidence that overall productivity was worse central London for SGN and Cadent.

A.3.11.7. Evidence from UKPN

We also examined whether the unit costs from UKPN's reinstatement contractor, SQS, were higher in London. We calculated the unit cost, determined as the total spend / number of jobs, based on more than 70,000 jobs over three years in LPN and SPN. LPN's unit costs were found to be 57 per cent higher than SPN's. If SPN is representative of the national average, then overall blended reinstatement costs are 57 per cent higher in LPN than the national average.

A.3.11.8. Evidence from GDN repex comparative costs

As an additional check on relative repex costs, we used Ofgem's synthetic unit costs (i.e. a composite workload variable Ofgem used at RIIO-GD1), combined with the actual work mix for each GDN to determine relative repex and repair costs for 2017/18. We found that on a whole-network basis, these costs were 47% above the average of the six non-London networks for North London and 22% above that average for Southern.

Table A.36: GDN repex comparative costs

Network:	1	2	Lo	So	5	6	7	8	All	Non London
Cost per unit of synthetic	1.21	1.39	1.97	1.63	1.34	1.46	1.72	1.13	1.47	1.34
Relative to non-London average	91%	104%	147%	122%	100%	109%	129%	85%		
Relative to total average			134%	111%						
Assumed % in London			75%	35%						
Derived London effect			45%	32%						

Source: Cadent

Using the costs relative to the total average (including the London networks) and assuming that this effect is driven purely by the % of the network which is in London and that the costs in each network outside of London are at the national average, we have estimated a “pure” London effect for each network. This ranges from 32% to 45%. As expected, this is higher than the number from contractor rates as it also includes costs due to variations and separately negotiated large projects.

A.4. Management Control

All of the factors we have reviewed in this section relate to the design and specification of roads and their surrounding areas. They are therefore due to the external environment and are not within management control.

Much of the evidence relied upon is contractor unit rates. These are procured in a competitive market where contractors are highly incentivised to bid low rates for the most used rate items. Contractors in these areas must meet minimum technical hurdles to qualify and are evaluated on quality as well as price, but uncompetitive prices will not tend to win work through utilities’ tenders.

Moreover, in our experience, contractors have access to extensive internal experience of operating in London and have rich datasets on their own productivity, labour costs, transport and logistics costs, and other inputs. While any individual rate item may not fully reflect all of these, the overall rate package is likely to.

The fact that we have been able to use a combination of productivity and unit rate data from multiple companies who have different delivery models, different management teams, and in many cases different contractors delivering similar sorts of work and this data consistently shows a pronounced London cost uplift effect is strong evidence that this effect is real and that it is due to a mix of exogenous factors.

Hence, we would expect the contractor rates we have used to reflect the efficient, market price of utility work conducted in London relative to other areas.

A.5. Quantification

A.5.1. Class of roads

Due to the greater depth of the base course and other layers, contractors operating on behalf of utilities charge more for excavating and reinstating higher category roads than lower category roads. Table A.37 expresses SGN's unit reinstatement costs for road categories 1 and 2 as a percentage of SGN's unit reinstatement costs for road categories 3 or 4.

Table A.37: SGN Reinstatement Costs Relative to Road Category 3/4 (%)

Road category	Premium
Road category 2	130
Road category 1	164

Source: SGN reinstatement costs, costs per length

Combining these costs with the relative numbers of reinstatements in each category in Table A.38 shows that road class alone explains only a relatively small uplift in total spend as the majority of work is done on category 3 and 4 roads both within and outside the M25.

Table A.38: Impact of Road Class on Reinstatement Costs

	Cat 3/4	Cat 2	Cat 1	
% of all reinstatements outside M25	81%	13%	6%	
% of all reinstatements within M25 only	78%	13%	9%	
Unit rates	100%	130%	164%	
Notional cost	0.78	0.17	0.15	1.097
Notional cost (at outside M25 mix)	0.81	0.17	0.10	1.077
% difference				-1.8%

Source: SGN reinstatement costs

A.5.2. Location of assets

Data from Cadent show that working under the carriageway is substantially more expensive than under the footway and the verge. While the work splits shown in Section A.3.2 are GDN-specific, we expect that these location-specific premia will apply to all utilities needing to excavate and reinstate.

To quantify the effect of asset location on Cadent's costs, we have used Cadent's relative cost data which shows differences in contractor rates for work under the three surface types. We have applied the national average splits which we calculate in Table A.39 below. We have used the no-dig rates for repex as 96 per cent of London (and 94 per cent of Cadent total) over the last five years has been done using this technique. We have used the dig rates for repair.

We re-allocated the total work volume to reflect the national average split between surface types. All prices in Table A.39 are relative to the highest rate which is the rate for work under the carriageway in London.

Table A.39: Effect of Work Mix on GDN Repex

	Verge	Carriageway	Footway	Total
London work mix	13%	49%	39%	
National work	16%	36%	47%	
Diameter weighted rate (London)	0.62	1.00	0.84	
Cost per m, London	0.08	0.49	0.33	0.89
Cost per m, national work mix @ London rates	0.10	0.36	0.40	0.86
% cost uplift				3.5%

Source: Arcadis analysis of Cadent contractor rates 2017/18 – 2018/19

These data suggest that, if Cadent's work mix in London were the same as the national average it would spend 3.5% less on repex than its actual costs. This same adjustment applies to SGN's repex work within the M25.

To quantify the effect on repair work, we have repeated the same analysis using the dig technique rates[110] and displayed the results in Table A.40. We have used the work mixes for repair.

Table A.40: Effect of Work Mix on Cadent Repair

	Verge	Carriageway	Footway	Blended rate	London uplift
London work mix	7%	39%	54%		
National work mix	12%	31%	58%		
Diameter weighted rate (London)	0.55	1.00	0.79		
Cost per m, London	0.04	0.39	0.43	0.86	
Cost per m, rebalanced work mix @ London rates	0.07	0.31	0.46	0.84	2.4%

Source: Arcadis analysis of Cadent contractor rates 2017/18 – 2018/19

If repair work in London were carried out at the same proportions of verge, carriageway, and footway, it would cost 2.4% less.

To quantify the effect of asset location on UKPN's costs, we have combined:

- UKPN's data for the split of notices & permits between carriageway, footway, and verge; and
- Cadent's relative cost data which shows the costs of excavating and reinstating under those three surface types relative to the costs for footways. We have selected the "dig technique" premia as no-dig is a technique better suited to the replacement of pipes (as the new pipes can be inserted inside the old one).

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[110] Even if repair is not done by the same contractors or by contractors at all, there is a similar sequence of road opening, activity, and reinstatement that takes places.

We applied UKPN's non-London split to re-allocate the London work and applied the relative premia from Cadent's cost data. The results of our analysis are displayed in Table A.41, which shows UKPN's actual reinstatement costs, and the reinstatement costs that would prevail if reinstatement work were allocated as it is outside London.

Table A.41: UKPN Asset Location Effect on Reinstatement Costs (£)

	Carriageway	Footway	Verge	Total
London	12,381	61,726	1,049	£75,156
London, rebalanced at non-London split	19,440	45,522	8,067	£73,029
London excess cost	-7,059	16,204	-7,018	£2,127

Source: volumes from UKPN noticing & permitting, relative costs Arcadis analysis of Cadent rates

Due to location of assets, we would expect UKPN to spend 2.8% less in London on activities which require excavation and reinstatement if that work was taking place at the carriageway / footway / verge proportions seen outside of London.

A.5.3. Type of road structure

Analysis of SGN cost data indicates that it costs about 80% more to carry out a reinstatement on an overlay over a concrete structure than on other types of road. Combining this with the data on the relative occurrence of these types of road in Table A.42 shows that Southern would spend 5.3% less on this reinstatement work if overlay-on-concrete roads were as infrequent within the M25 as they are outside it.

Table A.42: Impact of Road Structure on Reinstatement Costs

Reinstatements (SGN)	Overlay on concrete	Other	Blended cost	London difference
Southern outside M25 %	4%	96%		
Southern within M25 %	12%	88%		
Notional rate	180%	100%		
Notional cost	0.22	0.88	1.10	
Rebalanced to outside M25	0.07	0.96	1.03	-5.3%

Source: SGN reinstatement data

A.5.4. Type of carriageway surface

Combining the higher frequency of use and higher average cost of red tarmac, UKPN spends £7,000 more in LPN than elsewhere on red tarmac.

Green tarmac, which is used to mark cycle lanes appears to be used more commonly in LPN's network than elsewhere. However, the data shows only a very small number of uses in the last several years and, given a total spend across all networks of a few hundred pounds a year it appears not to be a material factor.

LPN spends £47,500 more on anti-slip surfaces on average than UKPN's other two networks.

With an estimated unit cost of £250,[111] multiplied by about 130 additional applications (based on half of the actuals[112]), SGN has spent £31,250 more on anti-slip surfaces than it otherwise would have.

A.5.5. Type of footway surface

Footway surface types affect the cost of excavation and reinstatement. Relative to standard flexible asphalt surfaces, slab pavers were 5% more expensive to replace and overlay on a concrete base course was 35% more expensive based on SGN's relative costs for footway reinstatements. We have shown these costs relative to flexible reinstatements in . Table A.43.

Table A.43: SGN Relative Costs for Footway Reinstatement

Footway reinstatements costs / quantity (SGN)	Flexible	Slabs	Overlay on concrete	Blended cost	excess cost
Southern outside M25	39%	6%	1.5%		
Southern within M25	25%	22%	7%		
Notional unit rates	100%	105%	135%		
Notional cost	0.25	0.23	0.09	0.58	
Notional cost at outside M25 mix	0.39	0.06	0.02	0.47	-18%

Source: SGN Reinstatement costs

Therefore, based on the differences in unit costs, it would cost SGN 18 per cent less to carry out its London footway reinstatements if the surface mix was the same within the M25 as it was in SGN's operational area outside the M25. The same logic would hold for the footway expenditure of all four utilities.

Combining the far greater volume and the higher unit cost from Section A.3.5, LPN incurs an extra £736,660 per year replacing York paving stones.

A.5.6. Combining all the evidence

We have analysed repex productivity data per area for Cadent and SGN. The repex programme is the largest programme across any of the utility sectors that requires work under the street surface and we have therefore used this data to estimate a London productivity effect for all sectors. We have averaged the SGN and Cadent productivity effects to derive an overall London effect for all utilities. However, as the SGN calculation is based on a depot-level estimate and some of the work done by its outer-London depots is outside London, this is likely an underestimate.

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[111] Based on a combination of UKPN and SGN data

[112] The frequency of anti-skid application as a percentage of work orders within London is half the average fraction for the whole network.

For reference, we have also shown Thames Water historical mains laying productivity. Table A.44: below summarises the productivity data we have analysed.

Table A.44: Summary of Productivity Analysis

Company	Analysis	Effect
Cadent	Analysis of productivity by Local Authority	18.4% in Outer London 88.1% in Inner London 23.1% Weighted London
SGN	Analysis of productivity within vs outside the M25	7.8%
Thames	PR09 Productivity	42%
Combined	Average of Cadent London and SGN Southern	15.5%

Source: Summary of analysis above.

In addition to the productivity measures discussed above, we have also quantified the London effect using alternative data sources, including data on contractor unit rates and relative unit costs (based on Ofgem's synthetic unit costs), as we discuss below.

For all the companies in the consortium, excavation and reinstatement are largely outsourced activities. The effects of London conditions on costs will therefore appear in contractor unit rates and bundled rates,[113] so we have used evidence from the following sources to quantify their effect:

- Cadent repex contractor rates for excavating (where required), replacing or inserting a gas main, and carrying out any reinstatement required;
- SGN repex unit costs;
- Cadent repair unit costs;
- Thames Water reinstatement unit rate analysis; and
- UKPN reinstatement rate analysis.

In addition to this analysis of contractor rates, we also determined relative unit costs for repex per metre for both Cadent and SGN using Ofgem's synthetic unit costs.

Table A.45 below summarises the cost differences identified between London and the rest of the country, based on our analysis of contractor rates and Ofgem's synthetic unit costs for repex.

Estimates based on contractor rates show a smaller London effect than those based on "top-down" calculations of cost per metre such as the Ofgem synthetic unit costs for repex, as

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[113] Since these contractors have been competitively procured, we can assume that they have incorporated their experience of factors which drive regional cost differences into their rate structure established through the procurement process. Note that these rates also incorporate effects due to travel, labour prices, and other factors on contractor input costs. To avoid double counting, we have excluded contractor labour from our labour price analysis; for the other factors there is no overlap.

these contractor rates will apply to routine work and fees for larger / more complex work will be separately negotiated.

Table A.45: Summary of Unit Cost Analysis

Company	Analysis	Effect on London Utility Costs Relative to GB average
Cadent	Repex regional rate premium and work mix difference	24%
Cadent	Repair costs per metre	21%
SGN	Repex unit costs	7%
Thames Water	Reinstatement unit costs	31% to 143%
UKPN	Reinstatement unit costs	57%
Cadent and SGN	Repex synthetic unit costs	32% to 45%

Source: Various as shown above

Since the data from Cadent and SGN is based on the largest volume of excavation and reinstatement work (due to the size of their repex programmes) we have used the average of the productivity effect figures for these two companies (from Table A.44:) to estimate a 15.5% productivity effect in London for all companies.

A.5.7. The impact on each company

To determine the impact on each company, we first had to determine how much each company spent on excavating, carrying out work on buried assets, and reinstating the highway and how much of that cost was in London. Table A.46 shows the percentage of each network’s population served in the London ONS region.

Table A.46: Percentage of Population in London ONS region

Network	Percent of Population in London
Cadent London (ops)	73%
Cadent East (ops)	>1%
SGN Southern	25%
UKPN LPN	96%
UKPN EPN	24%
UKPN SPN	22%
Thames Water WW	60%
Thames Water W	72%

Source: Arcadis geospatial analysis

In the case of SGN, we have been informed that the population split does not represent the percentage of workload done within London. We have therefore used the share of workload done within London (of 35%) for SGN instead.

For both the GDNs, we have applied this adjustment to the following categories of GD1 expenditure:

- Repex;
- Reinforcement capex;
- Repair; and
- Connections.

For UKPN, we have applied it to:

- All reinstatement spend based on spending with its contractor SQS (UKPN's reinstatement contractor) in 2016 and 2017;
- Spending on underground cables in ED1 (including reinforcement, refurbishment, and replacement); and
- Fault spending relating to underground cable assets.

We estimated the latter two items from the expenditure in these categories to date in the relevant RRP lines and projected expenditure forward for the rest of the ED1 period. Table A.47: below summarises the spending in each of UKPN's network:

Table A.47: UKPN spending on underground assets

£17/18m	Faults	SQS	Cable replacement	Cable reinforcement	Cable refurbishment	HVPs	Total
LPN	203.8	154	20.8	51.4	3.5	3.7	437
EPN	271.9	0	2.2	-	0.0	-	274
SPN	193.7	69	22.9	-	0.5	-	286

Source: UKPN RRP tables

For Thames Water, we applied the adjustment to infrastructure capex and opex spend for AMP7 from Table 2B of its 17/18 annual report, multiplied by 5 (for the number of years in the price control).

Table A.48: Thames Water Applicable Expenditure (£17/18m)

Item	WR	WN+	WWN+	Sludge	DW / pa.	WW / pa.
Renewals expensed in year (Infra)		63.1	69		63.1	69
Maintaining long term capability (Infra)	6.3	139.3	70.8	0	145.6	70.8
Other capital expenditure (Infra)	2	65.2	29.8		67.2	29.8
Infra network reinforcement		8.3	7.3		8.3	7.3
Total					284.2	176.9
Total per AMP					1421	884.5

Source: Thames Water Annual Report 2017/18 Table 2B

We have applied the adjustment to the assumed percentage of the company spend which is within London which we have estimated based the proportion of their population served within the London ONS region.

Table A.49: Applicable London Expenditure

£m 17/18	Apply to	Base amount	% in London ONS region	Amount to apply factor to
Cadent North London	Repex; Reinforcement capex; Repair; and Connections	£1,180m	73%	£809m
SGN Southern		£1,675m	35%	£593m
LPN	Spend with SQS + underground faults + UG cable	£437m	96%	£420m
EPN		£274m	24%	£66m
SPN		£286m	22%	£63m
Thames Water drinking water	Infra renewals and investment	£1,421	72%	£1,023
Thames Water wastewater		£885	60%	£531

Source: various cited above

Table A.50 shows the impact of this factor on each company's programmes of work.

Table A.50: Impact of the Nature of Streets on Individual Companies

Applicable cost categories by utility	Activities which require opening of streets	Factor	Impact
Cadent	£809m	15.5%	£125.4m (GD1 total) £15.7m p.a.
SGN	£593m	15.5%	£91.9m (GD1 total) £11.5m pa.
UKPN LPN	£420m	15.5%	£65.1m (ED1 total) £8.1m pa.
UKPN EPN	£66m	15.5%	£10.2m (ED1 total) £1.3m pa.
UKPN SPN	£63m	15.5%	£9.8m (ED1 total) £1.2m pa.
Thames Water drinking water	£1024m	15.5%	£158.7m (AMP 7 total) £31.7 pa.
Thames Water wastewater	£531m	15.5%	£82.3m (AMP 7 total) £16.5m

Source: various cited above

A.6. Impact on Comparative Performance

As described in Section A.2, the nature of streets in London affects companies' costs in all activities requiring emergency and planned excavations, as well as directly attribute overhead costs related to training, planning and managing work related to excavations.

A.6.1. Assessment of the extent to which existing models control for the nature of streets

In Ofgem's aggregate "top-down" totex models at ED1 and GD1, Ofgem's MEAV variables (which are calculated using unit-costs multiplied by the number of assets owned by a company in different sub-categories) may take some limited account of the effect of different road surfaces on costs, to the extent that road surfaces affect the type of asset a company must install. MEAV may also be correlated with density, as more densely populated areas require more use of underground cables, which have a higher unit cost than overhead lines.

However, MEAV variables take no account for the difference in works specifically due to the nature of streets, because MEAV assumes a pipe/cable buried under a road has the same unit costs as a pipe/cable buried under a verge. Also, Ofgem's models include the natural logarithm of MEAV as a linear term in its benchmarking equations. This means that the modelled relationship with expenditure will conflate the tendency for costs to be higher for larger networks, for some costs to be higher in more densely populated areas, and for some costs to be higher in sparsely populated areas.

At ED1, a number of Ofgem's disaggregated cost categories included costs associated with excavating streets including asset replacement, fault repairs ("trouble call") and connections. In its models for these cost categories, Ofgem does not directly control for the nature of streets, instead relying on proxies for the size of the network (MEAV) and workload drivers related to the number of faults. As in its aggregated model, Ofgem's MEAV driver may partly take account for differences in assets due to differences in the streets; however, Ofgem's workload driver for (number of faults) does not take account of differences in costs related to streets, only reflecting differences due to the proportion of faults on different parts of the network.[114]

In Ofgem's gas benchmarking models at RIIO-GD1, street excavations are required for work in the majority of the disaggregated cost models, including repex, repairs and mains reinforcement. In each of its disaggregated models, Ofgem used a single driver, related to workload or MEAV; none of these drivers account for the nature of the streets above where assets are buried.

Ofwat's draft PR19 aggregate models (for water and wastewater respectively) do not directly control for any cost driver related to the nature of streets. However, most of Ofwat's proposed models do control for density, which is likely to be positively correlated with costs related to the nature of streets, as discussed in Section A.6.2 below.

Water and sewerage companies' costs related to street excavations fall under disaggregated cost categories for water distribution and wastewater collection. Ofwat's disaggregated models do not control for the nature of streets, except for controls for population density and network density, which may partially capture the relationship between the nature of streets and higher costs. Ofwat's disaggregated water models include a workload variable measuring the proportion of mains refurbished and relined; this variable does not capture the differences in the unit costs of refurbishing and relining mains under different types of street.

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[114] Specifically, Ofgem calculated benchmark unit costs for cable faults at different voltage levels, see Section 3.1.1.

The nature of streets will affect directly attributable overhead costs, such as additional costs incurred in training staff to work with diverse road structures, and similar costs affecting the planning and managing of excavation work. For its disaggregated modelling at RIIO-ED1, Ofgem includes these costs in “closely associated indirects”, and at GD1 Ofgem included theses costs in “work management”. In these models, Ofgem’s relied on MEAV drivers which do not control for the relative complexity of the excavations that are required. In its PR19 models, Ofwat does not separate overheads (or indirect costs) from other, direct costs, instead allocating such costs between different parts of the business.

A.6.2. Controlling for the nature of streets in benchmarking models

We have not identified any drivers in benchmarking datasets which directly account for differences in the nature of streets between companies.

Many of the cost factors identified in this section are the consequences of operating in a densely populated urban area; and for this reason, a model which adequately controls for density is likely to better control for differences in costs due to the nature of streets. For example, London companies’ higher reinstatement costs (due to more road junctions and crossings, and deeper carriageway surfaces), are a consequence of high population density in London.

We discuss alternative approaches regulators could employ to control for density in Appendix H. Conversely, some factors are a consequence of London’s age, such as the prevalence of coal cellars. Some factors are related both to London’s age and its density; London’s narrow streets and its high population density contribute to utility congestion (due to the high density of different utilities’ pipes and cables underneath streets); for a given city of the same population density, but built with wider streets, utility congestion is less likely to affect companies’ costs.

Regulators may be able to directly control for differences in the nature of streets in benchmarking models using drivers related to street surfaces and the location of assets. However, regulators do not currently collect comparative data for these characteristics.

Disaggregated models are better able to take account of differences in characteristics between companies which only affect a particular category of costs, and statistical models are more likely to isolate relationships between drivers which capture these factors and disaggregated costs, than it is in more aggregated cost models.

Regulators could collect the following information from companies, which may be significant cost drivers in disaggregated benchmarking models related to excavations works:

- Proportion of assets buried under carriageway, footways and verges; and
- Proportion of assets buried under roads of different categories.

Finally, we discuss in Section C.6.3 the use of a cost driver which captures the density or length of roads of different classifications, to capture differences in road networks in different parts of the country, which may affect transport and logistics costs.

A.6.3. Conclusion on the impact of this cost factor on comparative performance

Existing benchmarking models do not directly control for the nature of streets, although some models contain drivers which are likely to be correlated with differences in streets between companies and regions, notably density, and thus will control for differences in companies costs to some extent.

We have not identified any existing cost drivers which can be added to benchmarking models to control for differences in the nature of streets, although if regulators collect comparative data, they would be able to test the inclusion of cost drivers related to differences between types of road in different regions, and differences regarding where assets are buried (i.e. carriageway or paths and verges).

Since this factor leads to material differences in costs between companies for reasons outside management control, we have included this cost factor in in our special factor quantification in Section 5.3.

Appendix B. Permitting and Traffic Management

B.1. Overview

The costs utilities incur to conduct and plan streetworks are also determined by prevailing local procedures and charges associated with lane rental, traffic management and parking bay suspensions. Table B.1 below summarises the differences in these permitting and traffic management costs we have identified, which we explain in the remainder of this appendix.

Table B.1: Possible Differences in Permitting and Traffic Management Costs in London vs. Elsewhere in Great Britain

Cost Driver	**Why London Differs from Elsewhere in Great Britain**	**Impact on Utility Expenditure by Category**				
		Labour	*Materials*	*Equipment/ fleet*	*Directly attributable overheads*	*Third Party Fees*
Parking bay suspensions	London has more Controlled Parking Zones (CPZs) than other areas of the country.				Increased complexity of planning	Payments to HAs for suspending parking bays
Traffic Management costs	TM more likely to be necessary in London. TM measures are specified in the permit.				Increased complexity of planning	Payments for TM services
Traffic Management costs - manned lights during peak hours	Some HAs require lights to be manned during peak hours, this is more common in London				Increased complexity of planning	Payments for TM services
Traffic Management costs - need for pedestrian walkway	In some cases, pedestrian walkways must be provided. This is more common in London				Increased complexity of planning	Payments for TM services
Lane rental	Some HAs (specifically Kent and TfL) are able to charge daily fees for lane closures. These costs do not exist elsewhere.				Increased complexity of planning	Payments for lane rental to TfL and to Kent
Bus routes & cycle lanes	Higher density of bus routes in London which may be marked with coloured surfaces and require diversion planning	Additional reinstatement labour for coloured surfaces	Materials for coloured surfaces		Increased complexity of planning	
London events density	London has a much higher density of large, sensitive events	Need to keep teams on standby within traffic "islands" during marathons etc. Temporary reinstatement due to events followed by revisit to permanently reinstate			Increased complexity of planning	
London CNI and special locations	London has a higher density of Critical National Infrastructure and other locations which require special authorisation				Increased complexity of planning	
Working hour restrictions on permits	Increased number of revisits may require additional wage premia due to night / weekend working					

Permit overall complexity	Higher number of permit conditions with more parties to consult due to high density of HAs	Increased complexity of planning	
Temporary Traffic Regulation Orders	These may be required more often on congested streets	Increased complexity of planning	Fees to HAs for TTROs
Permit costs	Only some areas operate permit schemes		Permit fees to HAs

B.2. Technical Background and Reason for Higher Costs in London

B.2.1. Permit overall complexity

When comparing costs for permits, it is not always the case that the total spent on streetwork permits in London is higher than in other regions of England for a given utility. However, the overall permit process in London is more complex due to the number of stakeholders, nature of HAs (both TfL and borough HAs), etc. This leads to a higher planning complexity in London – utilities have to expend greater effort per permit before it is issued and used.

Many HAs outside of London do not even operate permitting schemes, and instead use a notification process which is less complex for utilities.

B.2.2. Parking bay suspensions

A parking bay suspension occurs when existing parking controls and rights to park are suspended by the HA and exclusive use of the parking bays is given to an undertaker for the duration of the suspension. Utilities require bay suspensions to carry out works under the carriageway if there are parking bays present.

Local Authorities are permitted by the Local Authorities (Transport Charges) Regulations to charge for the suspension of parking places. While Local Authorities are not permitted to set charges calculated to produce a profit, charges for parking suspensions vary widely across different parts of the country.

When a suspension is granted and has been paid for, the Local Authority will mark the bays as suspended. Parking in a suspended bay can lead to a fixed penalty charge and the undertaker requesting the bay may legally have any vehicles parked there removed. However, it is at the Authority’s discretion whether they will remove any such vehicles and how promptly they will do so. In other words, a correctly obtained parking suspension is no guarantee that planned work can begin on time.

B.2.3. Temporary Traffic Regulation Orders (TTROs)

A TTRO is used by an HA to temporarily close a road, impose a waiting restriction, or otherwise vary the usual traffic conditions in a highway. HAs charge for TTROs but utility undertakers are also responsible for putting in place any necessary traffic management solutions such as temporary traffic signals and temporary signage.

B.2.4. Traffic management contractor costs

Where traffic management (i.e. a TTRO) is required by a permit, it will be necessary to plan and implement the appropriate traffic management solutions. This service is often provided by a specialist contractor and would need to be paid for by the utility undertaking the works.

B.2.5. Lane rental

The New Roads and Street Works Act 1991 (NRSWA), as amended, and the Traffic Management Act 2004 (TMA) contain provision for two types of charges for occupying the highway:

- Section 74 charges, for unreasonably prolonged works; and

- Section 74A charges, determined by reference to duration of works, and commonly referred to as lane rental charges.

At present, two HAs are permitted to charge lane rental costs of up £2,500 a day for occupying the carriageway: Kent and TfL. TfL controls the busiest, most strategic roads in London and 56 per cent of the TfL road network has a lane rental scheme applied.

Under the London scheme, lane rental charges apply whenever a street is designated as “traffic sensitive” They do not apply for the first 24 hours of emergency works.

B.2.6. Bus routes

Bus routes may complicate the process of carrying out works in the carriageway as they may have to be diverted and bus stops may have to be suspended or moved. Additionally, London bus lanes are often marked with coloured surfaces which have to be restored after excavation.

B.2.7. Cycle routes

Cycle routes / cycle superhighways have to be incorporated into planning for roadworks as they may have to be diverted and dismount / remount points planned in safe locations on either side of the works. Similar to bus lanes, they are often marked with specially coloured surfaces in London and these have to be restored as part of restatement works.

B.2.8. London events density

All major cities have events which require the suspension of road access to certain parts of the city. Such events include marathons, cycle races, and public events such as parades. London has a very high number of these, including state occasions which other cities in the UK do not have on the same scale.

B.2.9. London CNI and special locations

Certain locations are designated Critical National Infrastructure (CNI) or are otherwise special locations which require security clearance to enter or to work near, such as the sewers near Buckingham Palace. This increases costs for utilities which have to keep some staff security-cleared.

B.2.10. Congestion charging

London operates the only congestion charging scheme in the UK and utilities are not exempt from paying it.

B.2.11. Working hour restrictions

As a permit condition, HAs may enforce working hour restrictions which require work to take place during non-peak hours. This can lead to work taking longer to complete, being more complicated to plan, or to labour cost increases for shift or anti-social hours premia.

B.2.12. Permit fees

Before the Traffic Management Act (TMA) came into force, a notification scheme operated across the country. A notification scheme requires utility undertakers to notify local authorities whenever they carry out streetworks, whereas the TMA introduced the ability for

HAs to use a permit scheme instead. Where an HA introduces a permit scheme under the TMA, streetworks permits must be obtained from the HA before work can begin (with some exceptions for emergency work). HAs charge permit fees under these schemes and utilities incur additional costs in preparing permit applications and complying with permit conditions imposed by HAs.

B.3. Evidence for Uniqueness of London

B.3.1. Permit overall complexity

B.3.1.1. UKPN

As discussed above, as well as imposing more restrictions and costs on utilities, the permitting process in London is also more complex than in other areas. As a proxy for the overall complexity of the permitting process, we have computed the ratio of permit modification requests to total permits. This ratio is substantially higher in London than elsewhere, especially for TfL permits, as Table B.2 shows.

Table B.2: Permit Modification Requests

Location	Permit Modification Requests as a Percentage of Permits – 3-year Average, UKPN (%)
Inner London	35
Outer London	31
TfL	50
Outside London	12

Source: UKPN permit database

Permits are always issued for a particular duration, and sometimes the complexity of works means that utilities may need to make a request to the HA for their duration to be extended. This imposes costs on the utility because they are usually charged for this.

The proportion of duration-specific permits is also substantially higher in London than elsewhere, and these constraints can force utilities to carry out works in a compressed period of time. This restriction affects planning complexity and labour costs for night or shift working.

When a permit request is filed with a HA, the HA has the right to challenge it on a number of grounds including duration. The prevalence of challenges on the basis of duration is a proxy for the time pressure imposed by the HA on utilities.

As Table B.3 shows, TfL challenged 15 per cent of permits on the basis of duration, Outer and Inner London borough HAs also challenged on duration more often than boroughs outside London.

Table B.3: Duration Challenges

Location	Duration Challenges as a Percentage of Permits – 3-year Average, UKPN (%)

Inner London	6
Outer London	3
TfL	15
Outside London	1.6

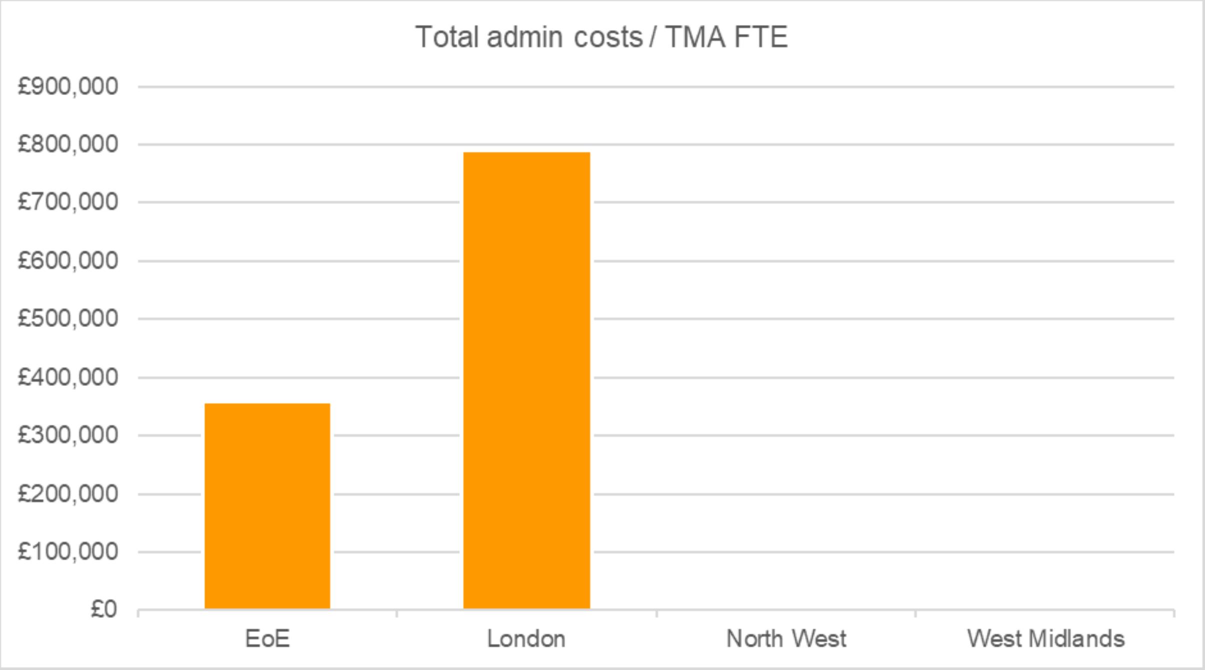
Source: UKPN permit database

B.3.1.2. Cadent Gas

Based on the data provided by Cadent Gas as part of their 2017/2018 Regulatory Reporting Pack (RRP), Figure B.1 shows that the complexity around applying for and obtaining permits for streetworks is greater in London than outside of London. The figure shows that the additional Traffic Management Act costs are only incurred in East of England and London, with London comprising the largest share. The administration costs include activities related to planning traffic management schemes, creating traffic management plans, conducting pre-site surveys to meet planning requirements and site meetings to ensure the requirements of Traffic Managers are met.

In contrast to London and East of England, the North West and West Midlands do not hire any employees directly for TMA activities and their only administration costs related to TMA include some standard back-office administration.

Figure B.1: Cadent Total Administration Costs per TMA Full Time Employee



Source: Cadent Gas RRP 2017/2018 Data

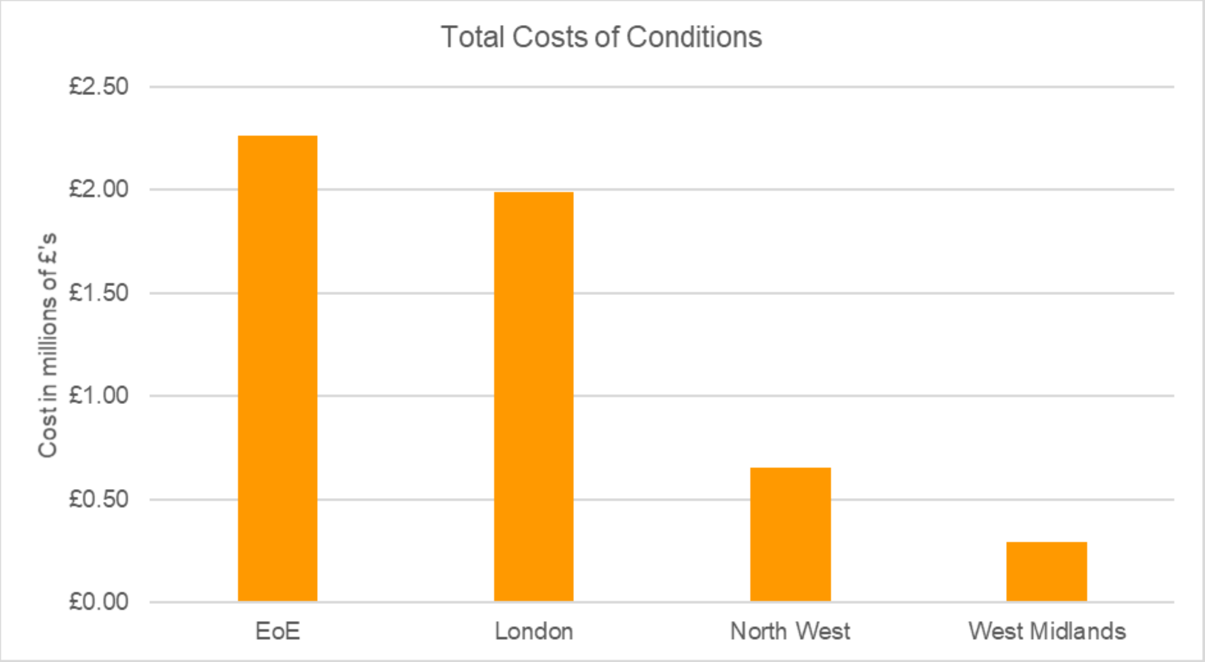
In terms of workload costs related to TMA permit conditions, which has an impact on productivity, London comes in second after the East of England. Figure B.2 shows the breakdown of the total cost of conditions per area. The TMA conditions considered in this data include:

- Timing and duration conditions;

- Road space conditions;
- Traffic management provisions;
- Methodology conditions;
- Consultation & publicity;
- Environmental conditions; and
- Local conditions.

Permit conditions are set by HAs in higher trafficked and more densely populated areas in order to keep traffic flowing. In common with our other analysis in this section, these costs were substantially higher in the East of England and North London networks.

Figure B.2: Cadent Total Costs of Conditions

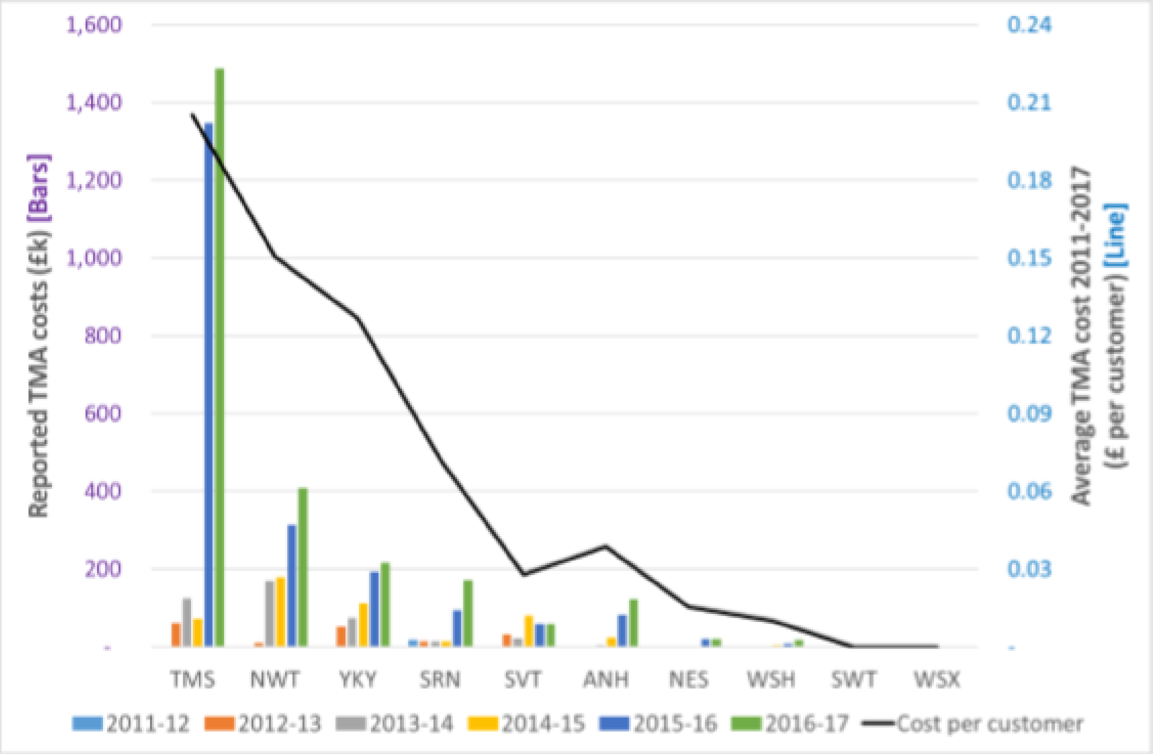


Source: Cadent Gas RRP 2017/2018 Data

B.3.1.3. Thames Water

Based on the report prepared by Thames Water for PR19 on the 'Productivity Impacts of Working Exceptionally Dense Environments', Thames Water pays significantly higher traffic management costs than other water utility companies.

Figure B.3: Analysis of reported TMA costs by wastewater company – Sewer Network



Source: Thames Water Report: CSD006-SNP-01b-PR19CA-FE, Productivity impacts of working in exceptionally dense environment

Figure B.3 shows that Thames Water has paid 36 per cent more per customer for costs associated with the TMA than the next highest company over the period of analysis and more than double the industry average. However, given the steady increase in TMA costs for other water companies over time, the magnitude of difference between Thames Water's costs in this area and those incurred by other companies may shrink in the future.

B.3.2. Parking bay suspensions

Parking bay suspensions are both more expensive and more frequently required in London than elsewhere. The cost that HAs can charge is fixed at covering their costs which include the administration and advertising of the suspension.

Highways Authorities must receive permission from the Department for Transport before they can operate a parking bay suspension scheme. As of January of 2019, the DfT had authorised 84 such schemes.[115] For each network, we analysed the % of its population which lived in an area covered by such a scheme.[116]

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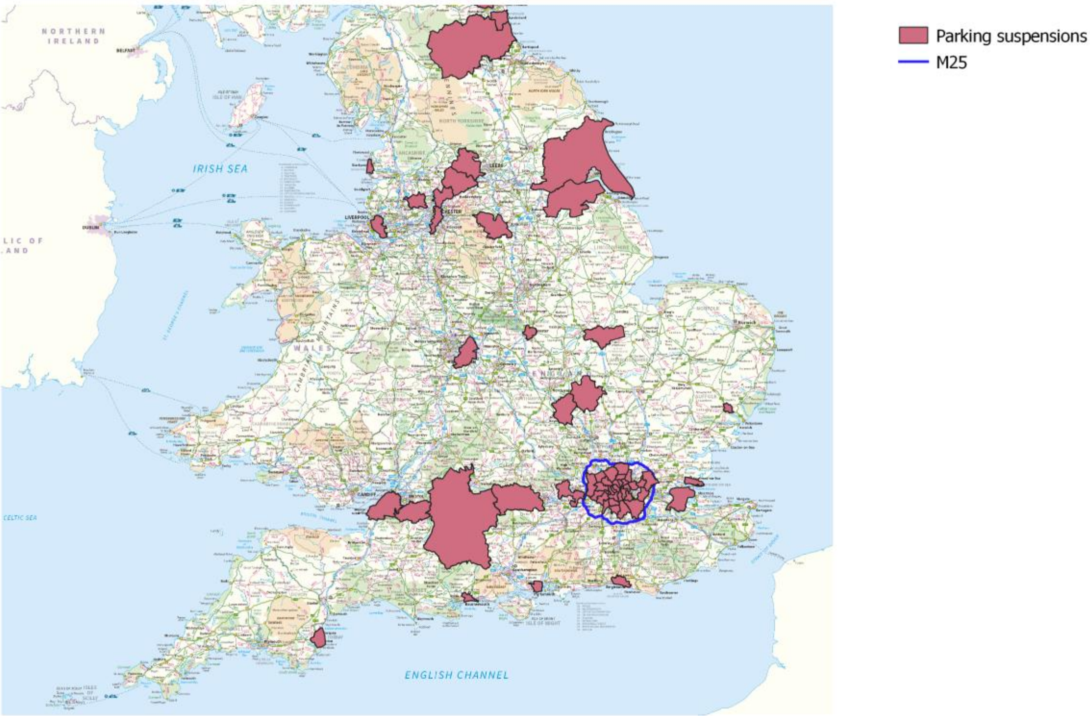
[115] Found on the DfT's traffic authorisation database at: http://www.dft.gov.uk/traffic-auths/

[116] Population of Medium Super Output Area (MSOA) intersected with the network boundaries and with the boundaries of the authorities operating these schemes.

Figure B.4: Active Parking Suspension Schemes in England and Wales (Jan 2019)



Contains OS data © Crown copyright and database right (2018)

Source: Arcadis geospatial analysis of DfT parking suspension schemes

Table B.4: Prevalence of Parking Bay Suspension Schemes in Network Areas

Operating Area	Percentage of Population Covered by parking bay suspension scheme (%)
Cadent London	74%
Cadent East	41%
SGN Southern	72%
SGN Southern (w/in M25)[117]	87%
UKPN LPN	77%
UKPN EPN	78%
UKPN SPN	85%
Thames Water WW	95%
Thames Water W	50%
England & Wales	50%

Source: Arcadis geospatial analysis of DfT parking suspension data by local authority, network shapefiles, and ONS population by MSOA

The London networks generally had significantly more of their population covered by parking bay suspensions schemes than the 50% of the population of England & Wales.

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[117] Calculated for comparison with contractor rates

B.3.2.1. UKPN

Of the streetworks undertaken by UKPN in Inner London, the table below shows that 17% required a parking suspension as a permit condition determined by the HA, as compared to only 9% in Outer London and 2% elsewhere in UKPN's service area. In some London boroughs such as Camden and Hammersmith & Fulham this is above 30%

Table B.5: The Need for Parking Bay Suspensions

	% Parking Suspensions (3-year Average, UKPN)
Inner London	17%
Outer London	9%
TfL	6%
Outside London	2%

Source: UKPN permit data

The daily cost of a parking bay suspension varies by HA, as does the charging structure for suspensions. Islington, for instance, charges £190 for the first day of a suspension but then only £29 per day afterwards. The City of London charges more for the first bay than for subsequent bays and also operates a banding system. In Table B.6 we have therefore used the average of the total cost per suspension by HA and region to compare costs.

Note that since the amount that HAs can charge for a parking bay suspension is fixed at their own costs, the variability of this will depend on HA input costs.

Table B.6: Cost per Parking Bay Suspension (UKPN)

	Average Cost per Suspension (2017-18, UKPN)
Inner London	£250
Outer London	£174
TfL	N/A
Outside London	N/A

Source: UKPN permit data

The detailed breakdown of costs for parking bay suspensions can be seen in Table B.7 below based on data provided by UKPN in their SPN network. Here, it can be clearly seen that Outer London parking suspensions are costlier than those not in the London area.

Table B.7 SPN Average Costs for Parking Bay Suspensions

Area	Average of 3 bays for 5 days (including admin fee)	Average of 1 bay for 5 days (including admin fee)	Average of Additional cost for 1 bay per day
Non-London	£417	£139	£32
Outer London	£742	£425	£48

Source: SPN spending on parking bay suspensions

UKPN data also indicates that the average cost of a parking suspension per bay is significantly higher for TfL as compared to outer London or outside London areas.

Table B.8 EPN Parking Bay Suspension Costs Average per Bay

Area	2017	2018	2019	Grand Total
Non-London	£ 91	£ 77	£ 45	£ 74
Outer London	£ -	£ 133	£ 141	£ 130
TFL	£ 175	£ 305	£ 181	£ 279
Grand Total	£ 63	£ 122	£ 107	£ 119

Source: EPN spending on parking bay suspensions

B.3.2.2. Cadent Gas

The cost of suspensions for GDNs is higher, likely because suspensions for gas distribution work tend to last longer, on average 5 days for Cadent in London as compared to 2-3 days in selected London boroughs for UKPN.

Table B.9: Cost of Road Closures and Parking Bay Suspensions

Network	Total Cost of Road Closures Including Parking Bay Suspensions (2017-18, Cadent)	Average Cost per Suspension
London	£375,641	£1,135
West Midlands	£56,475	£697

Source: Cadent spending on parking bay suspensions

The cost per closure is 63% higher in Cadent’s North London network than in its West Midlands network and the total spend is more than 6.5 times higher.

Hence, the cost data provided by UKPN and Cadent show that parking bay suspensions and road closures are more frequently required and more expensive on a unit cost basis than in other parts of the country.

B.3.3. Temporary Traffic Regulation Orders (TTROs)

TTROs, and TTRNs (Temporary Traffic Regulation Notices, a simpler mechanism which does not require the prior approvals that TTROs do), are substantially more expensive to obtain in London than they are in the rest of the South East of England.

Table B.10 below shows that these fees are substantially higher even in Outer London than in non-London boroughs, and TTRO fees are almost double non-London fees on TfL controlled highways. These data from UKPN cover London and the surrounding HAs in which UKPN operates.

Table B.10: TTRO and TTRN Average Fees

Operating Area	TTRO Average Fee (£)	TTRO Premium over Non-London (%)	TTRN Average Fee (£)	TTRN Premium over Non-London (%)
Inner London	2,105	72	1,013	98
Outer London	1,825	49	868	70
TfL	2,400	96	800	57
Outside London	1,222	0	510	0

Source: Arcadis analysis of UKPN TTRO spending

Overall, the data analysed in the sections below show that while there is a difference in both volume and unit costs between London (especially inner London and TfL-controlled roads) and some non-London areas, there are also non-London areas in the East of England and in the Midlands where both volumes and unit costs are higher than the national average. There is therefore evidence for regional variation but not necessarily for a London-specific effect. Hence, we have not calculated a London-specific adjustment for TTROs and recommend that these continue to be treated as separate costs by regulators.

B.3.3.1. UKPN

Analysis of UKPN data in Table B.11 did not show that traffic management was more likely to be required in London than in the areas surrounding it. In fact, the data seem to indicate the opposite.

Table B.11: The Need for Traffic Management

	% of permits for which Traffic Management Required – 3-year Average, UKPN (%)
Inner London	7
Outer London	10
TfL	12
Outside London	18

Source: Arcadis analysis of UKPN permitting data

B.3.3.2. Cadent Gas

Table B.12: below shows the TTROs data for all of Cadent, showing that there are more TTROs in North London than in the West Midlands and North West networks, however the East of England network (EA + EM) has the most.

Table B.12: Cadent number of TTROs by area 2017/18

Number of TTROs 2017/18	**EA**	**EM**	**NL**	**NW**	**WM**	**All areas**
Immediate (repair)	136	141	216	72	63	628
Major (replacement)	268	256	388	179	290	1381
Standard (new construction)	3	2	6	16	5	32
Total	**407**	**399**	**610**	**267**	**358**	**2,041**

Source: Cadent TTRO cost data

Table B.13 shows that HAs charge more for TTROs on average in London than elsewhere.

Table B.13: Cadent average cost of TTROs by area 2017/18

Average cost of TTROs 2017/18	EA	EM	NL	NW	WM	All areas	Non-London
Immediate (repair)	**1108**	**1291**	**1807**	**1075**	**1740**	**1472**	**1279**
Major (replacement)	1217	1228	1753	1065	1651	1428	1268
Standard (new construction)	959	1800	2063	903	1335	1316	1108

Source: Cadent TTRO cost data

Table B.14 shows that Cadent's North London network spends more on TTROs than any of its other networks.

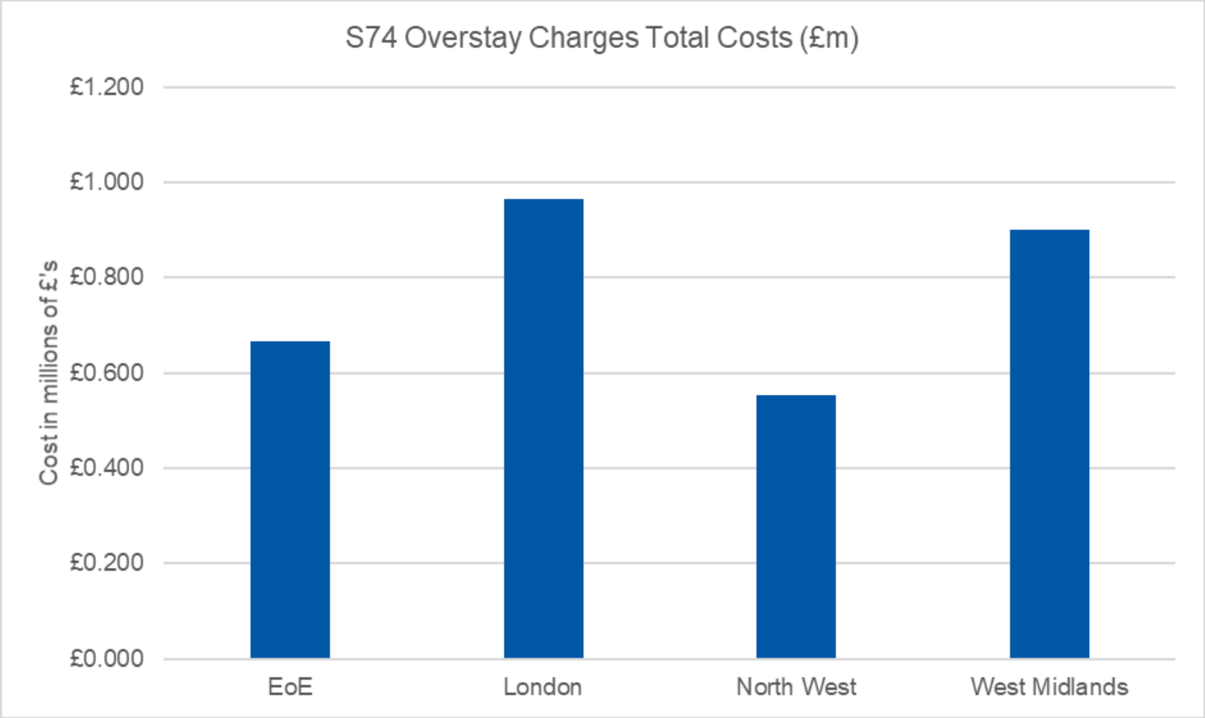
Table B.14: Cadent total spend on TTROs by area 2017/18

TTRO total spend 2017/18	EA	EM	NL	NW	WM	All areas
Immediate (repair)	136,600	176,653	405,609	70,618	99,894	889,374
Major (replacement)	272,870	300,158	625,001	221,896	460,411	1,880,336
Standard (new construction)	2,877	3,600	11,606	14,895	6,628	39,606
Total	**412,347**	**480,411**	**1,042,216**	**307,409**	**566,933**	**2,809,316**

Source: Cadent TTRO cost data

Further, Figure B.5 shows that the cost of S74 charges for prolonged works is also the highest in London which may be due to the complexity of the works and the working hour restrictions imposed within London.

Figure B.5: Cadent S74 Charges 2017/2018



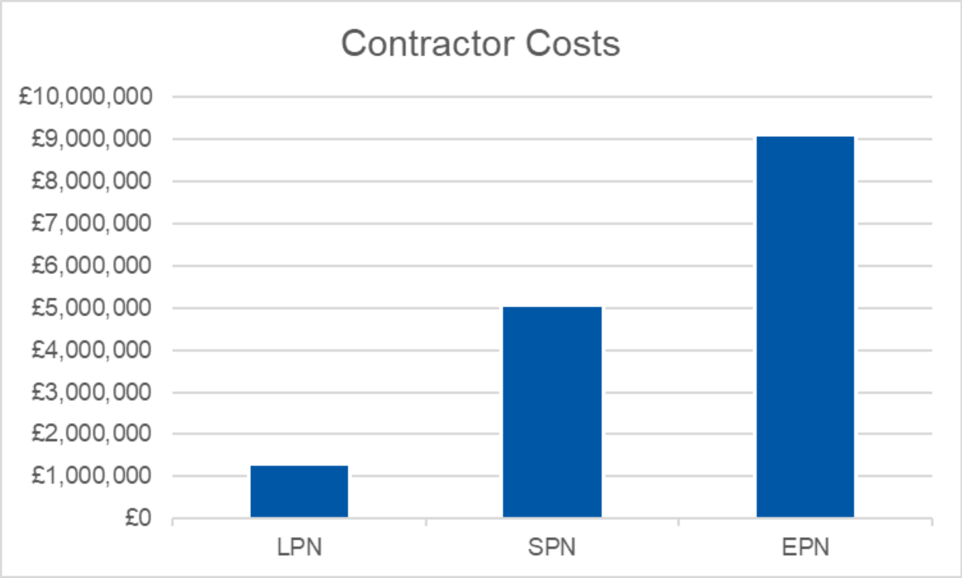
Source: Cadent Gas RRP 2017/2018 Data

B.3.4. Traffic management contractor costs

B.3.4.1. UKPN

Based on contractor spend data provided by UKPN and illustrated in Figure B.6, spending is highest in the EPN operating area. There is therefore no evidence of London-specific costs from these data.

Figure B.6: UKPN Contractor Cost Distribution

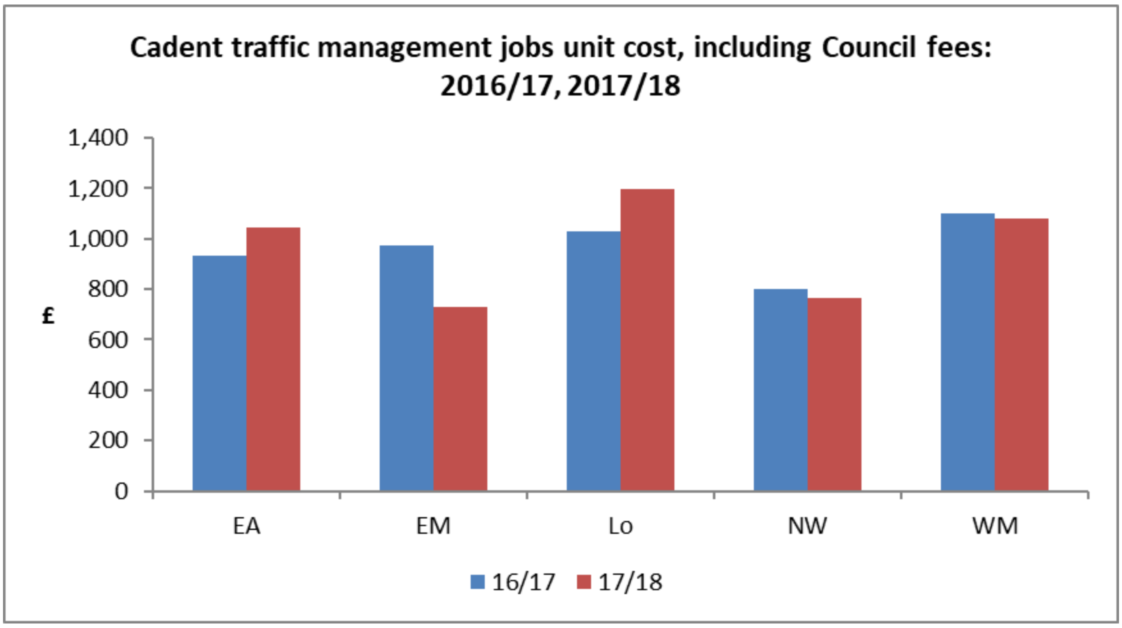


Source: UKPN Traffic Management Data

B.3.4.2. Cadent

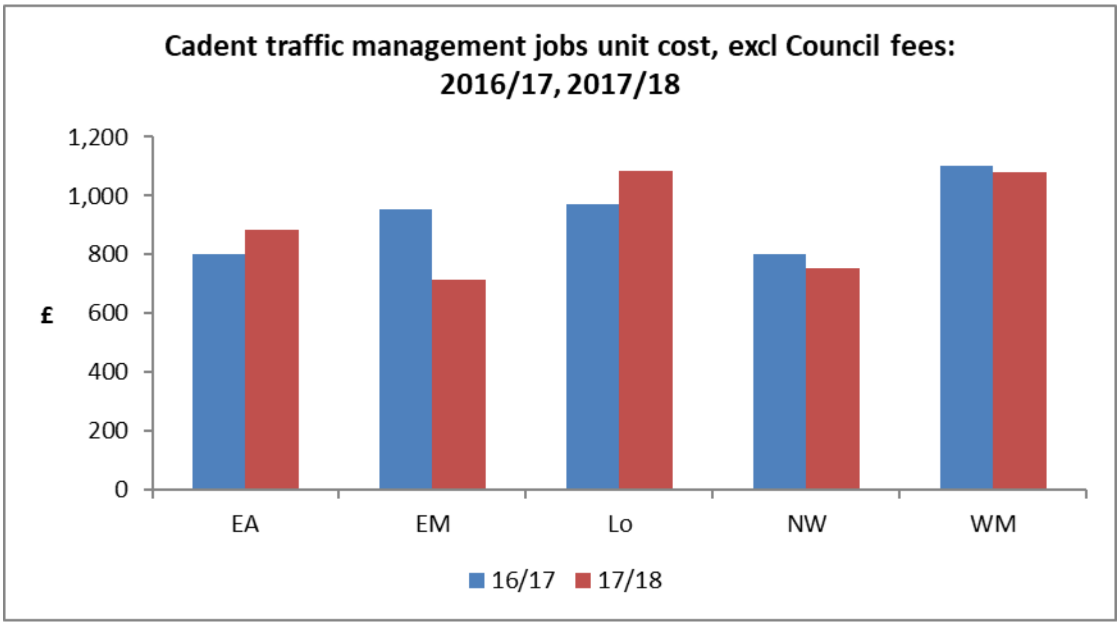
We analysed Cadent data for traffic management and found that there was no obvious London premium in the unit rates. Figure B.7 and Figure B.8 show that unit costs are highest in the West Midlands (and London). Conversations with Cadent have indicated that this is due to regional preferences for a high quality of service.

Figure B.7 Cadent TM Unit Costs Including Council Fees



Source: Cadent analysis of Cadent TM costs

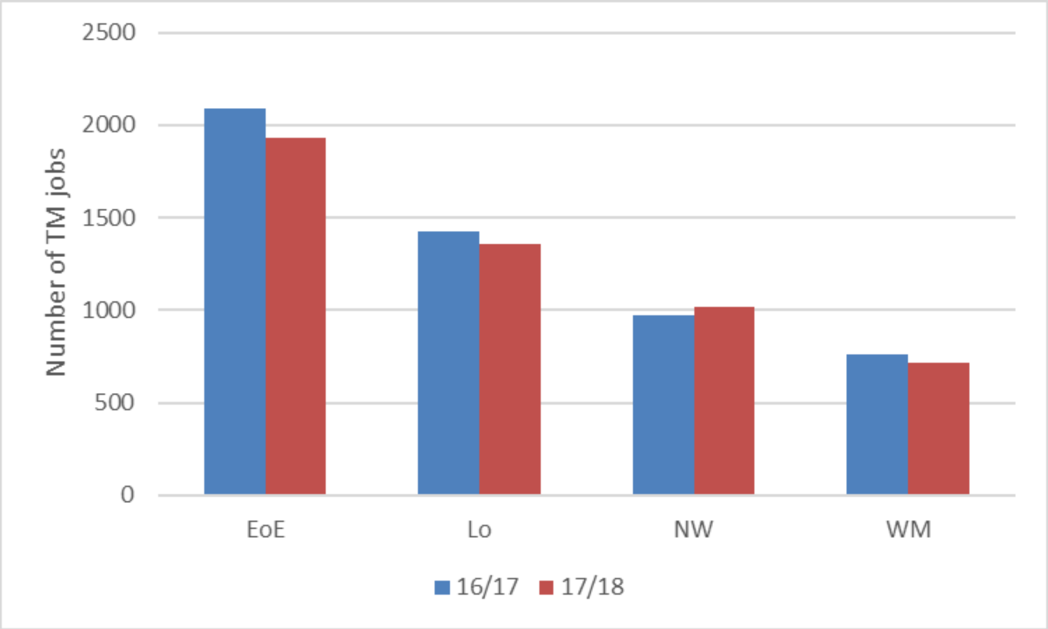
Figure B.8 Cadent TM Unit Costs Excluding Council Fees



Source: Cadent analysis of Cadent TM costs

Figure B.9 shows that there are more jobs that require traffic management in the East of England and London networks than in the other two networks, which is the same pattern that we have seen elsewhere in this section.

Figure B.9 Cadent's Number of TM Jobs per Network



Source: Arcadis analysis of Cadent data 2016/17 to 2017/18

While the evidence in this section indicates that there are substantial regional differences in traffic management costs, it does not indicate that this is a London-specific effect.

B.3.5. Lane rental

Only two HAs are currently charging lane rental costs: Tfl, which operates the major roads within London, and Kent. The lane rental charges in London are up to £2,500 per lane per day and up to £2,000 in Kent. A higher percentage of permits granted by TfL require lane rental than those granted by Kent.

B.3.5.1. UKPN

Table B.15 shows that UKPN's need for lane rental is almost 7 times higher for TfL than for Kent HA.

Table B.15: The Need for Lane Rental

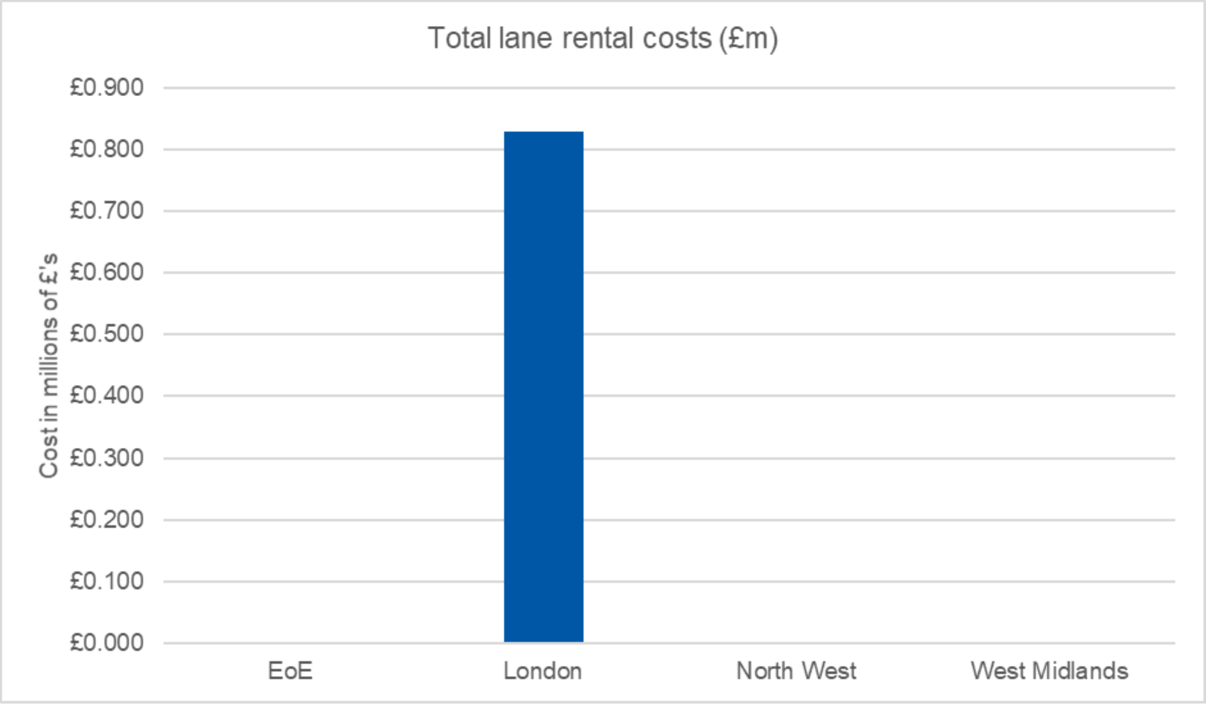
Highways Authority	**Percentage of permits Requiring Lane Rental – 3-year Average, UKPN (%)**
TfL	8.2
Kent	1.2

Source: UKPN permit data

B.3.5.2. Cadent Gas

Data provided in Table 3.13 of the RRP 2017/2018 for Cadent Gas and illustrated by Figure B.10 shows that all of Cadent's expenses due to lane rental fees are incurred in London.

Figure B.10: UKPN Cadent Total Lane Rental Costs (£m)

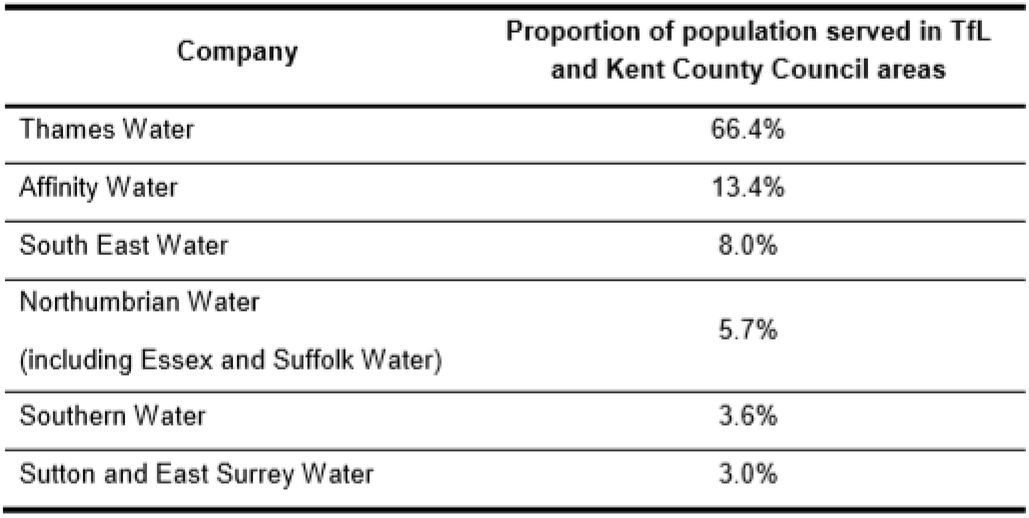


Source: Cadent Gas RRP 2017/2018 Data

B.3.5.3. Thames Water

In 2017, the population living in the TfL and Kent County Council areas totalled 10.4 million. Geo-spatial analysis shows that this population is served by six water companies, as shown in Table B.16. It shows that Thames Water has a significantly greater percentage of its operations affected by lane rental charges.

Table B.16 Proportion of Population in Lane Rental Charge Areas Served by Water Companies



Company	Proportion of population served in TfL and Kent County Council areas
Thames Water	66.4%
Affinity Water	13.4%
South East Water	8.0%
Northumbrian Water (including Essex and Suffolk Water)	5.7%
Southern Water	3.6%
Sutton and East Surrey Water	3.0%

Source: Thames Water Report: CSD006-SNP-01b-PR19CA-FE, Productivity impacts of working in exceptionally dense environment

B.3.6. Bus routes

B.3.6.1. UKPN

UKPN and Thames Water have provided data on fees paid to London Buses for bus lane suspensions. We show the UKPN data in Table B.17 below.

Table B.17 LPN Total Traffic Management Costs Paid to London Buses

Year	Total Cost
2018	£8,340

Source: UKPN Traffic Management data

Thames Water spent £99k in its wastewater business and £1m in its drinking water business on bus lane suspensions. The GDNs did not have data on spending on bus stop suspensions.

We have not found proof that that bus lane suspension schemes do not exist in other parts of the country, however the scheme in London is the only such scheme we were able to find.

B.3.7. Cycle routes

Apart from the cycle surface specific reinstatement costs covered in Appendix A, we have not been able to find any further costs specific to this factor.

B.3.8. London events density

We have not been able to identify any additional costs specific to this factor.

B.3.9. London CNI and special locations

We have not been able to identify any additional costs specific to this factor.

B.3.10. Working hour restrictions

B.3.10.1. UKPN

Table B.18 shows the percentage of UKPN permits with working hour restrictions in various operating areas. While a substantial percentage (more than 20 per cent) of permits granted by TfL have associated working hours restrictions, this is true of only 7 per cent of non-London permits. The percentage for Inner London is less than that for non-London HAs, possibly because the most traffic-sensitive roads in Inner London are managed by TfL.

Table B.18: Permits with Working Hour Restrictions

Operating Area	Percentage of Permits with Working Hour Restrictions – 3-year Average, UKPN (%)
Inner London	6
Outer London	10
TfL	21
Outside London	7

Source: UKPN permit database

B.3.11. Permit fees

Permit schemes are not unique to London, however there are wide variations across network areas in the prevalence of permit schemes and this is changing rapidly. In some network areas outside of London (such as the North West), permit scheme coverage has gone from minimal to almost universal in the last 4-5 years. We have determined a "non-London" baseline to allow for comparison with other costs but we recommend that regulators continue to assess these costs outside of the main cost assessment models, and, because schemes are constantly expanding over time, outside of the main price control.

B.4. Management Control

For the various reasons set out above, conducting excavations in London is more expensive than in other parts of the country. Because these extra costs of conducting works arise from differences in legislation and the practice of Local Authorities, these costs are beyond management control. Specifically, neither the rates paid to HAs, nor the conditions imposed by them are within management control.

While utilities have little discretion over the number, location and timing of emergency works, they have some discretion over the number and size of planned excavations. For instance, the extra costs associated with excavations may lead utilities to adopt more complex or costly techniques such as using "core and vac" machines (although these are not just used in London) that would not normally be least-cost, but that become economic when the utility considers the avoidance of permitting costs. In other words, even if some of the costs listed above can be avoided in relation to specific works, they are likely to increase other categories of costs. Utilities may also be able to reduce the number of works through more coordinated planning, albeit at some cost that is justified to reduce permitting expenditure.

However, utilities will still need to conduct a significant number of planned excavations in London, and the need for them is primarily driven by the need for investment to accommodate demand growth and to replace aging assets. As such, the extra costs utilities incur is within management control only to a very limited extent.

B.5. Quantification

B.5.1. Parking bay suspensions

Our overall assessment of parking bay suspension costs, shown by company below, is that since charging of these costs is at the discretion of the HA, it varies significantly between London and other areas assessed. However, HA decisions outside of London may change over time and these charges may well become more common in non-London areas.

B.5.1.1. UKPN

Table B.19 shows LPN's average fees and number of suspension in London Boroughs. Table B.20 summaries the parking bay suspension fees paid by UKPN over the specified periods, whereas Table B.21 details EPN's parking bay suspensions.

Table B.19: Average Fees and 2018 spend in LPN 2018

Borough	Inner/ Outer London	2018 suspensions	2018 cost (£)
Tower Hamlets	Inner	436	111,724
Southwark	Inner	287	N/A
Redbridge	Outer	131	28,259
Hackney	Inner	666	87,507
Kensington	Inner	1027	309,795
Westminster	Inner	1838	527,418
Greenwich	Outer	157	22,454
Hammersmith and Fulham	Inner	567	98,210
Total			**1,183,325**

Source: UKPN parking bay costs, LPN costs 2018

Table B.20 UKPN Parking Bay Suspensions over time

Borough	Category	Total Spent (£)				Average cost per Bay (£)			
		2015	2016	2017	2018	2015	2016	2017	2018
Hammersmith & Fulham	Inner London	12,798	127,134	111,194	98,210	89	107	153	175
Greenwich	Outer London	-	10,014	13,334	22,454	-	97	98	128

Source: UKPN Traffic Management data

Table B.21 UKPN Parking Bay Suspensions, EPN (£)

Area	2017	2018	Grand Total
Non-London	91	22,595	23,801
Outer London		47,465	53,463
TFL	350	11,300	12,375
Grand Total	441	81,360	89,639

Source: UKPN Traffic Management data

If EPN's non-London areas represents the typical non-London network, then the annual excess London spend is £1,093,686. This is a conservative view, as the majority of EPN's spend on parking bay suspensions is to outer London boroughs.

B.5.1.2. Cadent Gas

Table B.22 indicates the cost of parking bay suspensions and road closures for repair activity to Cadent Gas during the 2017/2018 RRP. Comparing Cadent's spending on parking bay suspensions, road closures, and TTMOs, we find that the London excess is £319k across all those categories.

Table B.22 Cadent Gas Parking Bay Suspensions & Road Closures (excluding repex) 2017/2018

Area	Type	Total cost (£)	Total number	Total days	Cost per suspension / closure (£)	Cost per day (£)
London	Parking suspensions	312,386	297	1457	1,051.80	214.40
London	Road closures & TTMOs	63,255	34	145	1,860.44	436.24
London	All	375,641	331	1602	1,134.87	234.48
WM	All	56,475	81		697.22	

Source: Cadent Gas RRP 2017/2018 Data

Table B.23: shows the total cost of parking suspensions for Cadent across two adjacent network areas, North London and East of England.

Table B.23: Cadent parking suspension costs

	2017/18 Costs (£)	London excess
North London	3,807,000	96%
East of England	153,943	

Source: Cadent cost data

If East of England represents a typical level for areas outside of London, 96% of London area parking suspension costs are excess and due to a London-specific effect.

B.5.1.3. Parking bay suspensions summary

For each of the other networks, we have used the Cadent East of England figure of £154k as a baseline for all companies as this is more conservative than the EPN non-London figure of £24k.

Table B.24: London excess parking bay suspensions

Network	% population covered by parking bay suspension scheme	Actual costs £17/18	Non-London baseline	Size of London excess
Cadent NL	74%	3,807,000	154,000	3,653,056
SGN Southern	41%	602,000	154,000	448,000
UKPN LPN	87%	1,183,325	154,000	1,029,325
Thames Water DW	77%	1,378,000	154,000	1,224,000
Thames Water WW	78%	407,000	154,000	253,000

Source: Arcadis geospatial analysis of DfT parking suspension data by local authority, network shapefiles, and ONS population by MSOA, Thames Water whole network from Thames Water

B.5.2. TTROs

B.5.2.1. UKPN

Table B.25 shows the fees paid by UKPN to contractors for their traffic management services. The data suggest that LPN does not spend more than the other two networks on traffic management costs. In fact, it spends significantly less.

Table B.25: LPN Total Traffic Management Costs to Contractors (£)

Year	LPN	SPN	EPN	Total
2015	-	626,820	416,392	1,043,212
2016	104,533	1,430,276	1,240,284	2,775,092
2017	625,292	1,461,375	3,597,037	5,683,703
2018	578,007	1,561,854	3,847,629	5,987,490
Total	1,307,832	5,080,324	9,101,341	15,489,497

Source: UKPN Traffic Management data

B.5.2.2. Cadent Gas

Table B.26 shows the costs related to TTROs incurred by Cadent Gas in the 2017/2018 RRP. As with other traffic management costs, Cadent spends significant amounts in the East of England and London on TTROs.

Table B.26: Cadent Gas TTROs 2017/2018

Area	Temporary traffic regulation orders (£m)
EoE	£0.89m
London	£1.04m
North West	£0.31m
West Midlands	£0.57m
Grand Total	£2.81m

Source: Cadent Gas RRP 2017/2018 Data

Table B.27 indicates the S74 work overrun charges incurred by Cadent Gas in the 2017/2018 RRP. Section 74 charges are higher in London but costs on surveys are lower in London.

Table B.27: Cadent S74 Charges 2017/2018

Area	S74 Daily Charge Rates / Overstay charges Total costs (£m)	S74 Other Streetworks Costs - Surveys Total costs (£m)
EoE	0.666	0.716
London	0.964	0.351
North West	0.553	0.750
West Midlands	0.899	0.467
Grand Total	3.083	2.284

Source: Cadent Gas RRP 2017/2018 Data

B.5.3. Traffic management costs

B.5.3.1. UKPN

Table B.28 through Table B.33 show the traffic management costs that have been reported by UKPN in its various operating areas. Table B.28 decomposes UKPN's traffic management costs by area and year.

The average traffic management costs incurred by UKPN over the last three years indicates that London is subject to almost double the traffic management costs compared to areas outside of London.

Table B.28: SPN Traffic Management Costs by Area (£)

Area	2015	2016	2017	2018	Total
Non-London	91,491	1,001,091	356,162	235,770	1,684,515
Outer London	10,226	59,421	158,696	72,970	301,313
Total	101,716	1,060,513	514,859	308,740	1,985,828

Source: UKPN Traffic Management data

Table B.29: SPN Traffic Management Costs Average per Council 2015-2018 (£)

Area	Average per Council
Non-London	280,752
Outer London	75,328

Source: UKPN Traffic Management data
Note: In interpreting per-council costs displayed in Table B.29, it is important to keep in mind that county councils outside of London (such as Essex) are far larger than London borough councils (such as Islington).

Table B.30: SPN Traffic Management Costs by Local Authority 2015-2018 (£)

Area	Total Cost
Non-London	
Kent County Council	1,100,200

Area	Total Cost
East Sussex County Council	58,605
Medway Council	66,888
Surrey County Council	152,707
West Sussex County Council	70,889
Brighton & Hove City Council	235,225
Outer London	
London Borough of Bromley	28,693
Bexley Council	59,746
Croydon Council	191,594
London Borough of Sutton	21,280

Source: UKPN Traffic Management data

Table B.31: LPN Total Traffic Management Costs to TfL (£)

Year	Total Cost
2018	39,323

Source: UKPN Traffic Management data

Table B.32: EPN Traffic Management Costs to TfL (£)

Year	Total
2015	88,160
2016	112,911
2017	116,350
2018	107,188
Grand Total	424,610

Source: UKPN Traffic Management data

Table B.33: UKPN Traffic Management Costs Average 2016-2018 (£)

Area	Average Cost
Non-London	531,008
London	970,121

Source: UKPN Traffic Management data

B.5.3.2. Cadent Gas

Table B.34 and Table B.35 report the TMA-related costs incurred by Cadent Gas over its 2017/2018 RRP. Table B.34 indicates that Cadent only incurs significant cost to employ people working on TMA in the East of England and London networks. Similarly, as Table B.35 shows, it only incurs TMA training costs in these areas, and TM scheme costs are higher in EoE and London.

Table B.34: Cadent Gas TMA Administration Costs 2017/2018 – 1 (£)

Area	Pre-site surveys to meet the planning requirements	Site meetings to ensure the requirements of the Traffic Managers are met	Total admin costs / TMA FTE (FTE directly employed for TMA activities)	Traffic management plans
EoE	97	46	358,700	177
London	114	52	789,737	183
North West	2	3	0	26
West Midlands	3	4	0	26
Grand Total	215	105	1,148,437	413

Source: Cadent Gas RRP 2017/2018 Data

Table B.35: Cadent Gas TMA Administration Costs 2017/2018 – 2 (£)

Area	Traffic management schemes including traffic control apparatus (special signage) and crew	Training costs / Number of FTEs trained for TMA activities	Training costs / Number of training hours (only relevant to TMA)
EoE	1,465	68	32
London	2,097	68	32
North West	918	0	0
West Midlands	290	0	0
Grand Total	4,770	135	65

Source: Cadent Gas RRP 2017/2018 Data

Table B.35 shows that there are more traffic management schemes and greater training costs related to traffic management in both the East of England and London networks.

B.5.3.3. SGN

Table B.36 displays the TMA costs SGN incurred over its 2017/2018 RRP. It shows that SGN spent more per council in London than elsewhere however these costs represent all TMA related costs and not just those for traffic management.

Table B.36: SGN TMA RRP 2017/2018 Costs

Area	Total TMA RRP Spend (£)	Count of Local Council	Avg per Council
Inner London	698,032	13	53,695
Non-London	2,262,813	80	28,285
Outer London	907,244	14	64,803

Source: SGN Traffic Management data

B.5.3.4. Thames Water

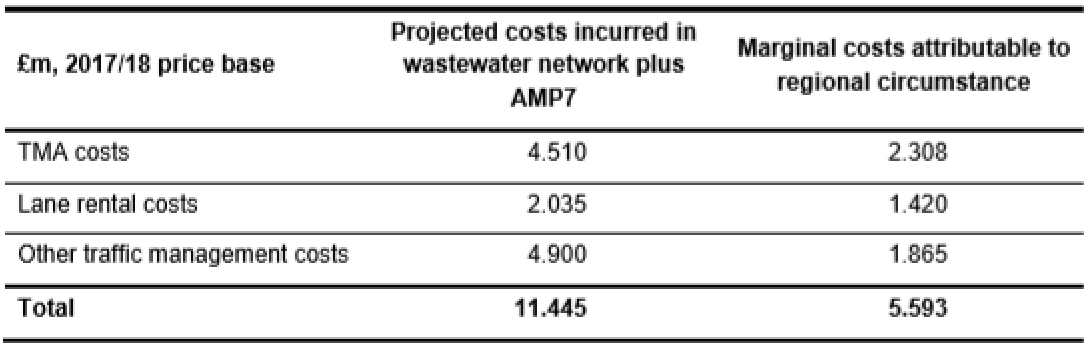
In its reports on productivity in dense areas, Thames Water indicated that it paid:

- £0.377m pa. on “other traffic management” and £0.096m pa. on “temporary traffic lights” in its wastewater business; and

- £0.421m pa. on “other traffic management” and £0.865m pa. on “temporary traffic lights” in its drinking water business.

For sewer and water networks respectively, Table B.36 and Table B.37 show Thames Water’s costs for TMA, lane rental, and other traffic management costs.

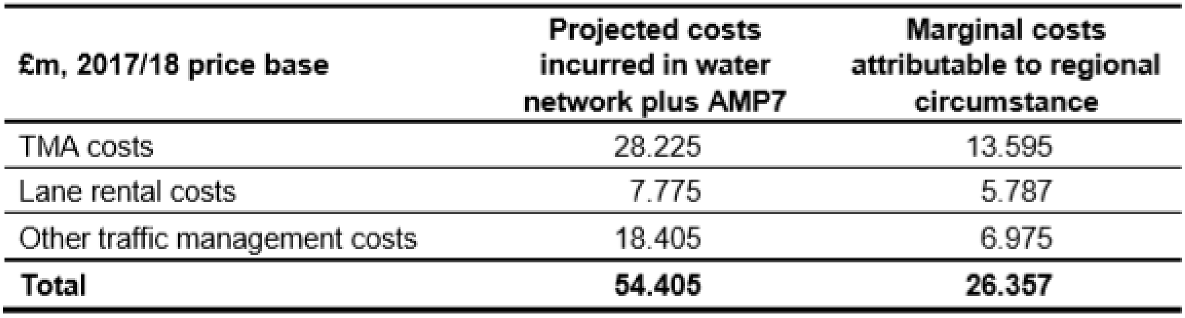
Table B.37: Thames Water projected and marginal costs in AMP7 by category, Sewer Networks



£m, 2017/18 price base	Projected costs incurred in wastewater network plus AMP7	Marginal costs attributable to regional circumstance
TMA costs	4.510	2.308
Lane rental costs	2.035	1.420
Other traffic management costs	4.900	1.865
Total	**11.445**	**5.593**

Source: Thames Water Report: CSD006-SNP-01b-PR19CA-FE, Productivity impacts of working in exceptionally dense environment

Table B.38: Thames Water Projected and Marginal Costs in AMP7 by Category, Water Networks



£m, 2017/18 price base	Projected costs incurred in water network plus AMP7	Marginal costs attributable to regional circumstance
TMA costs	28.225	13.595
Lane rental costs	7.775	5.787
Other traffic management costs	18.405	6.975
Total	**54.405**	**26.357**

Source: Thames Water Report: CSD006-WNP-01b-PR19CA-FE, Productivity impacts of working in exceptionally dense environment

B.5.3.5. Traffic management costs conclusion

Overall we have found substantial regional variation in the need for traffic management and some variation in unit costs to obtain the correct permits and pay contractors for managing it. These regional variations do not show a clear London-specific pattern, and we have therefore not quantified a London cost effect for traffic management costs.

B.5.4. Lane Rental

Table B.39 shows the lane rental costs incurred by Cadent Gas during its 2017/2018 RRP. This is a London (or rather London and Kent) specific cost and therefore the entire cost incurred is specific to London (and Kent).

Table B.39: Cadent Total Lane Rental Costs (£m) 2017/2018

Area	Total lane rental costs
EoE	0.000
London	0.828
North West	0.000
West Midlands	0.000
Grand Total	**0.828**

Source: Cadent Gas RRP 2017/2018 Data

Table B.40 indicates the total lane rental costs incurred by SGN between 2014 and 2015.

Table B.40: SGN Total Lane Rental Costs (£)

Area	2014	2015	2016	2017	2018
Kent CC (East)	0	0	0	0	0
Kent CC (Mid)	273,500	536,400	395,800	441,800	405,700
Kent CC (West)	0	0	0	0	0
LB Lewisham	0	0	0	0	0
LB Southwark	0	0	0	0	0
Transport for London	143,150	489,900	204,100	324,800	553,000
Grand Total	**416,650**	**1,026,300**	**599,900**	**766,600**	**958,700**

Source: SGN Traffic Management data

Thames Water forecast that it would spend £7.775m on lane rental for its water network business in AMP7 (£1.55m / year) and £2.035m in AMP7 for its wastewater business (£0.41m / year).

B.5.5. Bus routes

B.5.5.1. UKPN

Table B.41 shows the total fees paid to London Buses for Bus lane rentals in 2018 by UKPN.

Table B.41 LPN Total Traffic Management Costs Paid to London Buses (£)

Year	Total Cost
2018	8,340

Source: UKPN Traffic Management data

Thames Water also pays TfL for bus lane suspensions, Thames Water spent £99k in its wastewater business and £1m in its drinking water business. The GDNs did not have data on spending on bus stop suspensions.

B.5.6. Cycle routes

We have not identified any specific costs associated with traffic management of cycle routes.

B.5.7. London events density

We have not identified any specific costs associated with the density of events in London.

B.5.8. London CNI and special locations

We have not identified any specific costs associated with the presence of Critical National Infrastructure and other special locations in London.

B.5.9. Working hour restrictions

While we have not identified any specific costs due solely to working hours restrictions, we have found that there is more out of hours working in London, discussed further below.

B.5.10. Permit overall complexity

B.5.10.1. UKPN

While we have shown that a number of proxies for permit complexity are higher in London than elsewhere, we have not identified any specific costs associated for UKPN.

B.5.10.2. Cadent Gas

The traffic management permit conditions costs listed in Table B.42 were incurred by Cadent Gas as a result of the complexities of TMA permits during the 2017/2018 RRP. The data suggest Cadent incurs higher costs in the East of England and London networks, but these do not appear to be London-specific.

Table B.42 Cadent Gas Traffic Management Permit Conditions Costs 2017/2018

Area	Local Conditions (£m)	Methodology Conditions (£m)	Road Space Conditions (£m)	Timing and Duration Conditions (£m)	Total Costs of Conditions (£m)	Traffic Management Provisions (£m)
EoE	0.00	0.00	1.35	0.40	2.26	0.52
London	0.00	0.00	1.74	0.18	1.99	0.07
North West	0.00	0.01	0.00	0.04	0.66	0.60
West Midlands	0.04	0.00	0.00	0.01	0.29	0.24
Grand Total	0.04	0.01	3.09	0.63	5.20	1.43

Source: Cadent Gas RRP 2017/2018 Data

B.5.11. Permit fees

B.5.11.1. GDN permit fees

We compared the annual costs of paying permit fees to HAs for each of the Cadent networks and for SGN Southern. In each case, we considered permit fees related to repex, capex, and opex separately and assumed that differences in the levels of each were related to km of iron mains decommissioned, km of mains reinforced, and repairs carried out respectively. We used a separate method to the above to normalise each of the repex, capex, and opex costs.

To do this we:

- Normalised each of number of repairs within TMA boundary, mains decommissioned within TMA boundary, and mains reinforced within TMA boundary relative to the average for the five networks;
- Then we multiplied these normalised workload drivers by the average spend on TMA permits in each of the Opex, Repex, and Capex categories for the five networks;
- Finally we added these components together to estimate the annual cost of streetworks permits.

Table 43: GDN Permit Fees (£m/annum)

Network	Repairs, normalised	Iron mains abandoned, normalised	Reinforcement, normalised	Normalised cost of permits			
				Opex	Repex	Capex	Total
EoE	1.82	1.31	0.68	0.81	0.82	0.19	**1.82**
NL	0.75	0.79	0.23	0.34	0.49	0.06	**0.89**
NW	0.83	0.89	0.45	0.37	0.56	0.12	**1.05**
WM	0.16	0.27	0.45	0.07	0.17	0.12	**0.36**
SO	1.44	1.75	3.18	0.64	1.09	0.87	**2.61**
All	1.00	1.00	1.00	0.45	0.63	0.27	1.35

Source: Cadent, SGN RRP table 3.13

Permit schemes are not unique to London and establishing a non-London baseline for a cost which is highly workload dependant is challenging. We have nonetheless included these costs in our overall summary as they represent additional costs not fully accounted for at the time of the price control however it should be noted that not 100% of these costs are London specific and that models that use prevalence of permit schemes and workloads may be needed for regulators to estimate efficient levels of permit spending in the future.

B.5.11.2. UKPN permit fees

We compared total spend on permits inside and outside London for UKPN from 2015/16 to 2018/19 and compared the % of permit spend inside London with the % of MPANs in London. On this basis, we estimate a London excess for LPN of £0.5m per annum.

Table B.44: UKPN permit fees

	£17/18m
London permit fees	£1.9m
Non-London permit fees	£1.3m
% of permit spend in London	59%
% of MPANs in London	44%
% London permit spend excess	15%
London excess per annum	**£0.5m**

Source: UKPN data

B.5.11.3. Thames Water permit fees

Thames Water carried out analysis of TMA costs per customer from 2011/12 to 2016/17 showing that 51% of permit fees in its wastewater price control and 67% of permit fees in its drinking water price control are above the non-London baseline level.

Table B.45: Thames Water wastewater additional permit costs

	£17/18m
TMA permit costs	£0.902m
Estimated additional London costs	£0.462m

Source: Thames Water PR19 submission

Table B.46: Thames Water drinking water additional permit costs

	£17/18m
TMA permit costs	£4.029m
Estimated additional London costs	£2.719m

Source: Thames Water PR19 submission

B.5.12. Quantification summary

Table B.47 summarises the London premium for all companies across permitting and traffic management costs.

Table B.47: Permitting and Traffic Management Summary

£17/18m annual	Southern	Cadent NL	LPN	EPN	SPN	Thames DW	Thames WW
Parking bay suspensions	0.45	3.65	1.03	0.00	0.00	1.22	0.25
Lane rental	0.96	0.83	1.28	0.00	0.00	1.55	0.41
Bus stop suspensions	0.00	0.00	0.008	0.00	0.00	1.00	0.10
Streetworks permits	2.61	0.89	0.49	0.00	0.00	2.72	0.46
Total	**4.02**	**5.37**	**2.81**	**0.00**	**0.00**	**6.49**	**1.22**

Source: See analysis above

B.6. Impact on Comparative Performance

As described in this appendix, permitting and traffic management in London imposes costs on companies in all activities requiring emergency and planned excavations, as well as directly attributable overhead costs related to planning and managing work related to excavations.

B.6.1. Assessment of the extent to which existing models control for permitting and traffic management

At RIIO-ED1, Ofgem referred to most of the costs described in this section as “streetworks” costs. Ofgem’s “top-down” aggregate benchmarking model does not directly control for differences in permitting and traffic management costs from company-to-company. The MEAV driver controls for the different types of assets companies' own, including the mix of overhead lines vs. underground cables, but MEAV does not account for differences in the cost of accessing assets which are buried under different roads or roads which are subject to different permitting policies.

For its disaggregated modelling, Ofgem classified some of these costs as "existing streetworks", including costs associated with notification and inspection penalties and set-up costs, and included these costs as part of its disaggregated models for the categories asset replacement, fault repairs ("trouble call") and connections.[118] Ofgem classified other costs as "new streetwork costs", including permit costs and permit penalties, costs related to permit conditions and lane rental costs. Ofgem removed new streetworks costs from its disaggregated models, and assessed these costs qualitatively; for most categories, Ofgem allowed these costs, although Ofgem challenged some companies' forecast costs related to permit conditions (e.g. costs companies expected to incur for night-time work mandated in permit).[119]

At RIIO-GD1, Ofgem excluded streetworks costs from its econometric benchmarking models, and conducted a qualitative/technical assessment of companies' efficient streetworks costs. At GD1, Ofgem considered streetworks costs to include three types of costs, lane rental, "TMA" costs and S74 costs (see Section B.2.5).[120] Lane rental costs, which were relatively new when Ofgem made its decision in 2012, and therefore particularly uncertain at the time, were fully excluded from cost assessment. Instead, companies were remunerated for lane rental costs through an uncertainty mechanism (a price control re-opener in 2015).[121] Ofgem estimated efficient TMA and S74 costs based on a subjective assessment as to an efficient level of unit costs for administration, productivity effects and permit penalties.[122]

Ofwat's draft PR19 aggregate cost models do not directly control for any cost drivers related to differences in permitting conditions and traffic management costs. However, most of Ofwat's proposed models control for a linear measure of density, which finds a positive relationship between density and costs.[123] As we discuss in Section B.6.2 below, density is likely to be correlated with higher permitting and traffic management costs.

Water and wastewater companies' costs related to street excavations fall under disaggregated cost categories for water distribution and wastewater collection. Ofwat's disaggregated models fail to control for the nature of streets, except for controls for population density and network density, which may partially capture the relationship between the nature of streets and higher costs.

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[118] Ofgem (2014), RIIO-ED1: Final determinations for the slow-track electricity distribution companies – Expenditure Assessment, p. 129.

[119] Ofgem (2014), RIIO-ED1: Final determinations for the slow-track electricity distribution companies – Expenditure Assessment, Table 10.2 and p. 130.

[120] Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, p. 127.

[121] Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, p. 127.

[122] Ofgem (2012), RIIO-GD1: Initial Proposals - Supporting document - Cost efficiency, p. 26.

[123] Specifically, Ofwat uses either a population density or network density measure in 6 of its 12 wholesale water models, and controls for network density in 6 of its 8 wholesale wastewater models.

Permitting and traffic management also impose directly attributable overhead costs on companies, for example the additional planning and engagement required in order to obtain a permit in London compared to in other parts of Great Britain (see Section B.2.1). In Ofgem's ED1 benchmarking, these costs were included in "engineering management and clerical support" costs,[124] and benchmarked against MEAV and asset additions; these cost drivers do not account for differences in permitting policies in different regions. At GD1, Ofgem excluded administrative costs related to streetworks from its work management regressions and benchmarked them separately.

B.6.2. Controlling for permitting and traffic management in benchmarking models

Permitting costs are primarily driven by policy decisions by HAs in each area to impose charges (i.e. for parking bay suspensions and lane rental), and permit conditions which lead to other costs for companies (e.g. traffic management costs and working hour restrictions).

No cost driver is likely to directly account for differences in permitting policies from one HA to another, and there are significant differences in permitting policies between otherwise similar HAs.

Many of the specific factors related to permitting and traffic management costs are unique to London and surrounding areas, or are far more common in London than in other parts of the country.

However, differences in overall permitting costs are likely to be strongly correlated with measures of density, firstly since HAs in urban areas are more likely to face congestion and traffic issues which may encourage them to impose permit conditions, and secondly, since assets are more likely to be buried under roads in towns and cities than in rural areas (see Appendix A). Therefore, a model which adequately controls for density is likely to better control for differences in costs due to permitting and traffic management costs. We discuss alternative approaches regulators could employ to control for density in Appendix H.

By collecting new data from companies, regulators may be able to directly control for differences in permitting and traffic management costs using drivers related to different permitting policies in regions, for example the percentage of each company's supply area covered by HAs who impose lane rental and/or permit charges. This driver would also capture changes over time should more HAs choose to impose permit charges in the future. However, it would likely not be possible for a cost driver to capture particular characteristics of lane rental schemes, such as the cost per lane closure and the proportion of roads to which they apply.

B.6.3. Conclusion on the impact of this cost factor on comparative performance

Existing benchmarking models do not directly control for the differences in permitting and traffic management, although some regulators have excluded some of these costs from benchmarking models and assessed separately.

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[124] Ofgem (2014), RIIO-ED1: Final determinations for the slow-track electricity distribution companies – Expenditure Assessment, p. 129.

Since this factor leads to material differences in costs between companies for reasons outside management control, and since Ofwat’s draft models do not propose to exclude these costs from benchmarking models, we have included this cost factor in in our special factor quantification for Thames Water in Section 5.3

Appendix C. Transport and Logistics

C.1. Overview

Table C.1 below summarises a range of factors related to transport and logistics costs that may cause utilities to incur higher costs in London than in other parts of the country. These relate primarily to the speed of traffic and regulations around the movement of vehicles in central London, as well as the additional requirement for transport caused by cost conditions in central London, such as high labour, land and property costs.

Table C.1: Possible Differences in Transport and Logistics Costs in London vs. Elsewhere in Great Britain

Cost Driver	**Why London Differs from Elsewhere in Great Britain**	**Impact on Utility Expenditure by Category**				
		Labour	*Materials*	*Equipment/ fleet*	*Other overheads*	*Cash costs*
Traffic speed	Due to congestion	Driver time				
Distance to depots	Need to keep depot sites out of central London	Driver time		More vehicle time per job		
Distance to tips	Tip sites cannot be sited in central London	Driver time		More vehicle time per job		
Need for daily much-away	Permit condition imposed by HAs	Driver time		More vehicle time per job		Tipping costs per load per HA
Overnight plant delivery	Need to work through the night to deal with short permit lengths					Additional delivery charges
Delivery hours restrictions to central depot sites	Due to heavy traffic					Additional delivery charges
Accounting for staff driving time into and out of London	Most staff live outside of London and need to drive in before becoming operational	Staff time		Additional non-productive driving time		
Parking costs and fines	More restricted parking areas, higher parking fees, more parking fines					Parking fees and costs
Vehicle servicing costs in London	Due to higher labour costs of maintainers			Maintenance costs		
Smaller vehicles	Due to practicality of moving large vehicles through London traffic	Driver time		More vehicle movements / job		
Small sites	Permit condition which leads to more “Just in Time” delivery of supplies due to no storage on site	Driver time + Decreased productivity due to restricted working space		More vehicle movements / job		
Short permit lengths	Permit condition	More overnight working				

C.2. Technical Background and Reason for Cost Increase

C.2.1. Traffic speed

Utilities and their contractors must move staff and equipment to and from their assets in order to maintain them. If traffic speed is persistently lower / delays are consistently longer, then staff will spend longer travelling for each hour of productive work. Contractors will incorporate this into their own cost calculations and this will therefore be reflected in contractors' rates as well.

In the case of activities where there are either statutory or regulatory goals for response time such as emergency FCOs (First Call Operatives) for GDNs, or troublecall response for DNOs, we expect to find that actual response times are not materially higher in London but that it takes a larger number of on-call staff at peak times to achieve those response times. We note that Ofgem has historically made the opposite adjustment, based on the assumption that in dense urban environments, there are fewer FCOs required (but they are busier). Ofgem therefore provided additional allowance for more rural GDNs.

For most activities, we hypothesize that the average traffic speed (net of differences in distances driven) will be a driver of firms' relative efficiency. For time-sensitive response activities, such as FCOs, the driver of response workforce size (and associated vehicles and equipment) is likely to be peak traffic (i.e. traffic speed during peak hours). This is because the response capability must be sized to respond in time to incidents even at the most congested time.

Effects from slower journeys must be balanced against greater population density potentially leading to shorter journeys. Whether journeys are in fact shorter depends on the nature of the activity, which we discuss in greater detail in this appendix.

C.2.2. Distance to depots

For the fraction of journeys that begin or end in a depot, the average distance between the depot and the work location divided by the average speed will determine the length of the journey. It was hypothesised in our discussions with the Consortium that distances to depots were longer in London than elsewhere.

C.2.3. Distance to tips

Spoil from excavation must be taken to tipping sites where it can be disposed of or recycled. If this distance is larger in London due the location of tipping sites outside the M25, then this will lead to extra journeys.

C.2.4. Need for daily muck-away

As a condition of a streetworks permit, a Local Authority can require that spoil is removed from site daily rather than stored on site. For multi-day jobs, that leads to additional vehicle journeys (and associated costs) that would not otherwise be required.

C.2.5. Overnight plant delivery

In some cases, heavy plant must be delivered to central London sites overnight to avoid disrupting traffic. This may impose extra costs.

C.2.6. Delivery hours restrictions to central depot sites

If central depot sites are in busy areas, they may be restricted in the hours during which they can receive deliveries of large items.

C.2.7. Accounting for staff driving time into and out of London

London utilities' staff typically do not live in London. The time these staff spend driving into and out of London (for work) is longer than the time staff spend driving to work in other areas, affecting utilities' costs. If staff are not reimbursed for time spent driving into London, they will expect to receive a wage premium. This will show up in labour costs, which we discuss in Appendix E. If employers have to pay travel costs, which will depend on employee terms and conditions, then this is an additional labour cost.

C.2.8. Parking costs and fines

Utility vehicles have no special parking privileges and may incur parking fines. If the level of parking fines is higher in London than in the rest of the country, then this may lead to additional costs for London utilities.

C.2.9. Vehicle servicing costs in London

If vehicles' servicing costs are higher in London (due to labour and other inputs having a higher prices) then this may lead to higher fleet costs in London.

C.2.10. Smaller vehicles

The largest vehicles, articulated lorries, face restrictions in entering London and this may drive the use of smaller vehicles. If this leads to inefficient work division and if multiple small vehicles are more expensive than the equivalent lorry, then this may lead to higher fleet costs for London utilities.

C.2.11. Smaller sites

If sites need to be smaller in London due to HA pressure on permits, then this may require companies to deliver supplies such as pipes, cables, etc. on a "just-in-time" basis, delivering only the supplies needed on the given day at the site, rather than storing all supplies needed to complete the job on the work site. This may lead to more vehicle journeys for equivalent work than elsewhere, increasing costs.

C.2.12. Shorter permit lengths

If permits are shorter in London than elsewhere (due to shorter duration in HA permits), this may lead to more overnight work and additional costs.

C.3. Evidence for Uniqueness of London

C.3.1. Traffic speed and distances

We have used the DfT's data[125] on the average speeds on A roads for 2015 – 2016 to calculate average speeds for each ONS statistical region as shown in Table C.2.

Table C.2: Average Speed by Region

ONS region[126]	Average Speed (mph)	Average Speed (km/h)
London	16.4	26.4
Inner London	12.0	19.3
Outer London	19.6	31.5
South East	28.3	45.5
East of England	30.9	49.8
South West	28.7	46.2
East Midlands	29.5	47.5
West Midlands	26.1	42.0
All England	25.3	40.7

Source: ONS CGN0501b

Looking at traffic speed over a large network area can obscure local variations in traffic conditions. We have therefore estimated average traffic speed for each network by doing the following:

- Use the ONS CGN0501b dataset to determine average traffic speed by local authority;
- Use the relative share of each network's population that lives in each local authority to weight those traffic speeds;
- Calculate an weighted average traffic speed for each network area based on local authority population shares (see results in Table C.3).

As the table shows, we have calculated travel time effects for Cadent's North London network, UKPN's LPN network, and for Thames Water's drinking water and wastewater networks within the M25.

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[125] Department for Transport, Average speed on local 'A' roads: monthly and annual averages, CGN0501B. See: https://www.gov.uk/government/statistical-data-sets/average-speed-delay-and-reliability-of-travel-times-cgn

[126] Wales, North East, North West, Yorkshire and the Humber not shown

Table C.3:Average Traffic Speed by Company

	Thames Water WW (M25)	Thames Water DW (M25)	Cadent NL	Southern within M25	LPN
Population weighted average speed kmh	28.4	25.9	32.4	29.3	25.6
% slower than England average	30%	36%	20%	28%	37%

Source: Arcadis calculation by ONS region and local authority

C.3.2. Distance to depots

During our workshops with the Consortium, companies presented mixed views of whether depots in London were further away or closer to working sites than in the rest of the country.

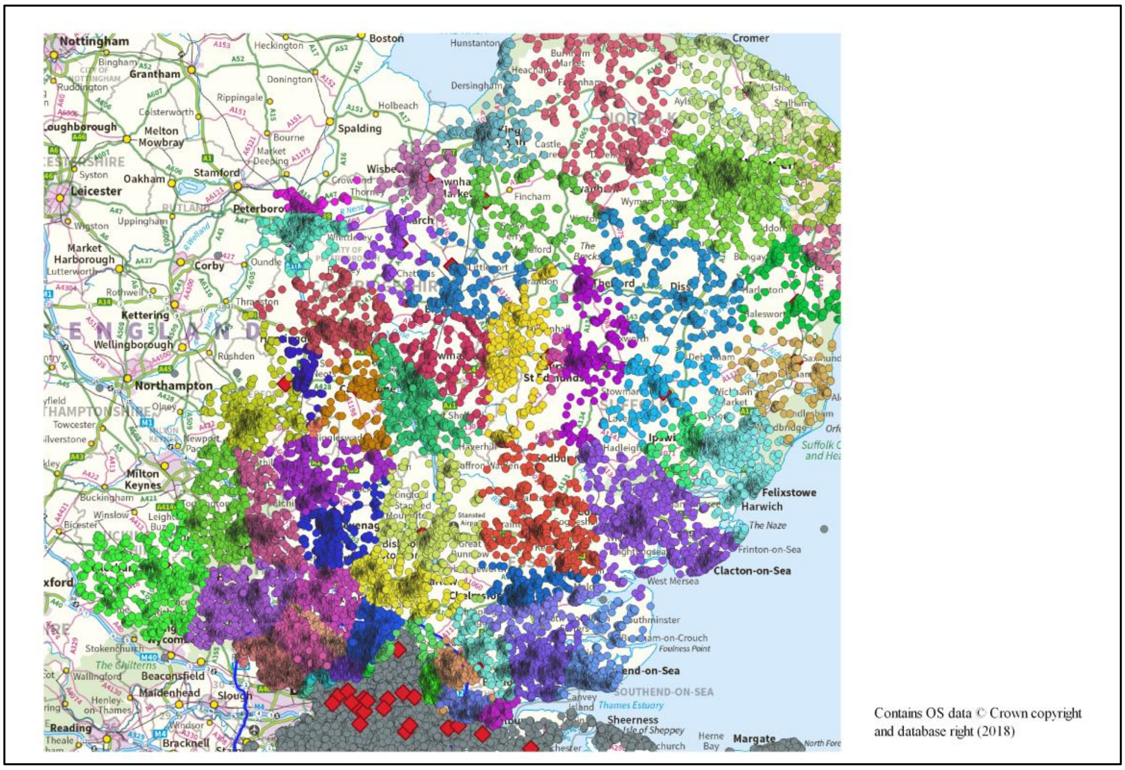
We have therefore obtained depot locations from several of the companies and carried out a geospatial analysis. We have done the following:

- For UKPN, we first assigned each substation to the nearest depot location, and then calculated for each depot the average distance of the nearby substations. We repeated this analysis for each UKPN network, as well as for areas within and outside the M25.
  - We also tested the effects on travel distance of removing all of UKPN’s depot and other locations inside the LPN footprint. This supplements our analysis of London property costs and shows that such costs are justified, because it would not reduce total costs to avoid them by moving all property outside of London.
- For SGN, we determined the average distance from the centre of each MSOA (MSOAs are census units containing up to 6,000 households) to the nearest depot. We repeated this analysis inside and outside the M25.
- We repeated the above for Cadent’s North London depots.
- For Thames Water, we have extrapolated from our results for the other companies.

C.3.2.1. UKPN

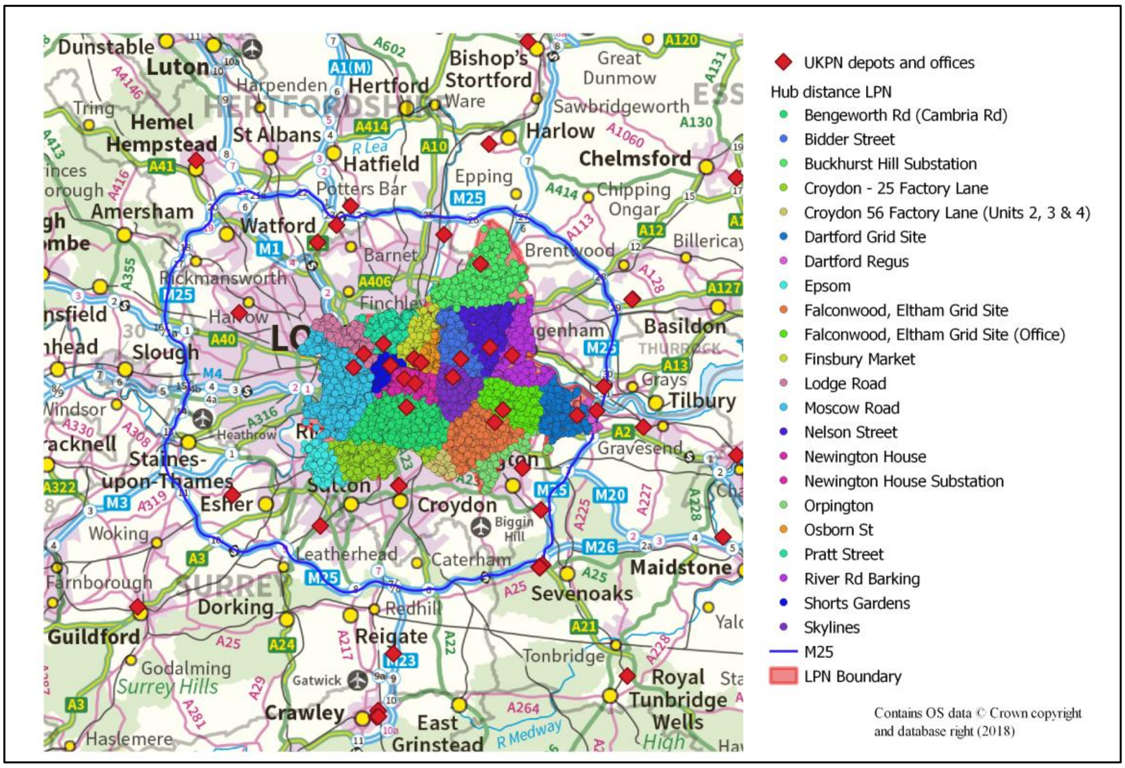
We used geospatial analysis to determine the average straight-line distance for each UKPN substation site to the nearest depot, office, or other manned site, as illustrated in Figure C.1 and Figure C.2, with the results shown in Table C.4.

Figure C.1: EPN Depots Categorised by Nearest Depot or Other Manned Site



Source: Arcadis geospatial analysis of UKPN depot and substation location data

Figure C.2: LPN Depots Categorised by Nearest Depot or Other Manned Site



Source: Arcadis geospatial analysis of UKPN depot and substation location data

Table C.4: UKPN Distance to Nearest Manned Site

Area	Average distance (m) to site from manned depot or office	Relative to EPN & SPN average (%)	Relative to distance outside M25 (%)
LPN	2826	40	
EPN	7249	103	
SPN	6859	97	
LPN (no central sites)	12054	171	
Outside M25	7442		100
Within M25	3820		51
All	6008		81

Source: Arcadis geospatial analysis of UKPN substation and depot/office location data

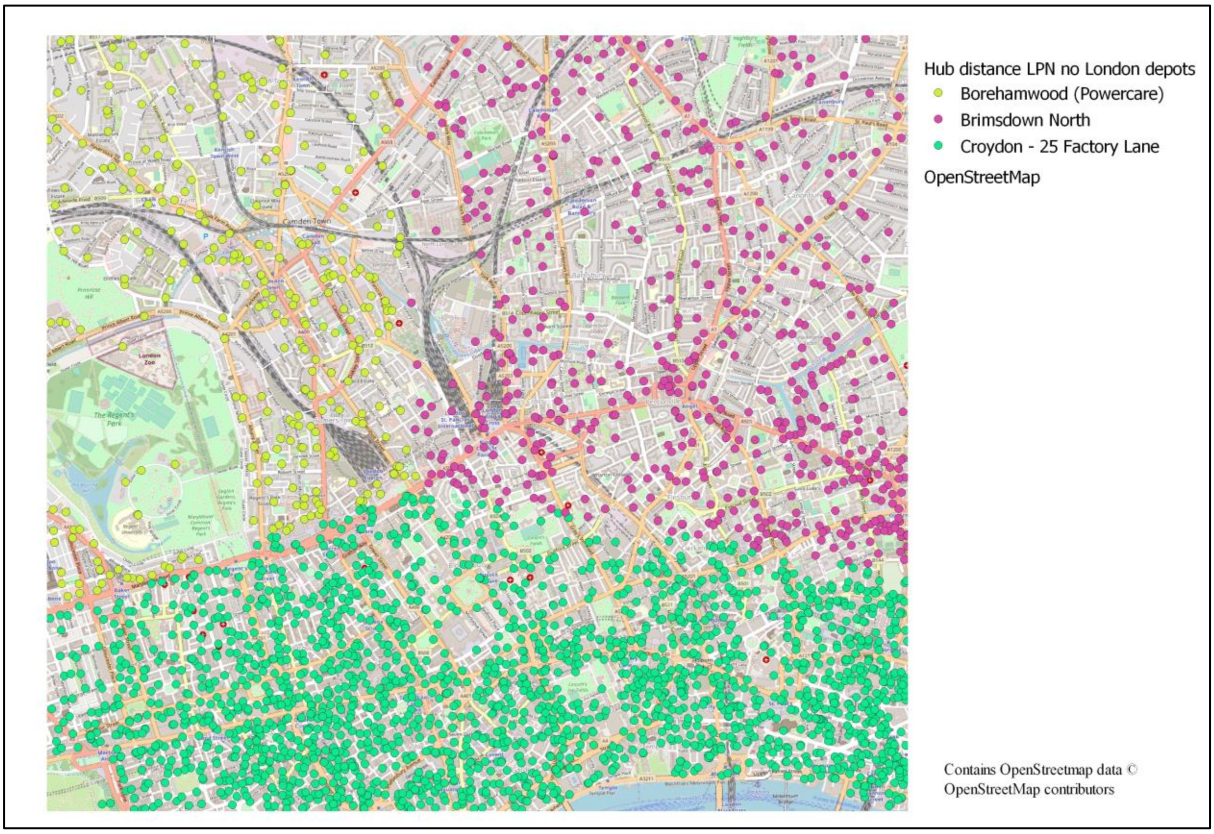
We found that substations in the LPN network were 40 per cent of the distance to the nearest manned depot or office than on average in the EPN and SPN networks. If we take EPN + SPN as a proxy for the GB average, then average driving distances to/from depots in LPN are only 40 per cent of the average GB network.

We found that substations inside the M25 were 51 per cent closer to the nearest manned site compared to those outside the M25. If the UKPN network footprint outside the M25 is representative of average GB networks, then driving distance to/from depots within the M25 are only 51 per cent of the average GB network.

We also reviewed property costs in London in Appendix F, in which we test the effect of removing UKPN's central London sites. Excluding the depots and offices within the LPN footprint, the average distance goes from 2.8km to more than 12km.

Figure C.3 shows a map we created, showing the nearest manned site to central London if the central London sites are removed.

Figure C.3: Nearest Manned Site to Central London - No LPN Depots



Source: Arcadis geospatial analysis of LPN substation and depot location data, LPN depots excluded

We used Google Maps to determine the driving time required to reach the point between Euston and St Pancras stations which is equidistant between three depots (all other non LPN-area depots were also included in the analysis but all the substations in the map frame are closest to one of these three). We tested driving time at 6pm as well as 2am. Table C.5 collates the results of our drive time tests.

Table C.5: Driving Times to Central London with No LPN Depots

Time to drive to Euston / St. Pancras	Drive time 6pm (mins)	Drive time 2am (mins)
Brimsdown North	80	40
Borehamwood	80	43
Croydon Factory Lane	110	61

Source: Google Maps driving time (Monday)

The table shows that at peak times, it can take more than an hour simply to reach central London from sites on the periphery of London. Even at 2am on a weekday when traffic is lighter it can take a substantial amount of time to drive to central London.

For comparison, this same point is reachable in 15 minutes from Pratt Street and 30 minutes from Shorts Gardens in peak 6pm traffic on a weekday.

C.3.2.2. SGN and Cadent

Figure C.4 shows the locations of SGN's operational depots.

Figure C.4: SGN Operational Depots

Source: SGN

We determined the average distance from the centres of Medium Super Output Areas (statistical areas with approximately equal populations) from SGN and Cadent depots and offices, displayed in Table C.6

Table C.6: Cadent and SGN Distance to Nearest Manned Site

Operator	Area	Average distance (m) to site from manned depot or office	Relative to distance outside M25 (%)
SGN	Outside M25	9774	100
SGN	Within M25	7143	73
SGN	All	9995	102
Cadent NL	Outside M25	10711	110
Cadent NL	Within M25	7317	75
Cadent NL	Within M25 without central depots	11827	121
Cadent NL	All	8081	83

Source: Arcadis geospatial analysis of Cadent depot locations, MSOA data from the ONS

We also tested how travel distances would change if the two most central depot sites, the two secondary depots at Imperial Road, Fulham and Islington Pear Street, were removed.

As only a small part of Cadent's North London network is outside of London, we used SGN's network outside the M25 as our comparator. If that comparator is similar to the rest of the British GDNs then the distances to SGN and Cadent depots within the M25 are only 73 per cent and 75 per cent respectively of average national distances.

We have applied the 73% adjustment to SGN distances within the M25 (as we determined SGN driving speed within the M25 and are only calculating a travel time adjustment for those distances).

We have applied the 83% adjustment to Cadent NL as we are calculating a travel time adjustment for all distance driven for that network.

C.3.2.3. Thames Water

We have assumed that Thames Water distances to depots within the M25 are 73 per cent of average national distances to water and wastewater distances. We have based this on the GDN data, on the grounds that the non-emergency activities of GDNs are a better proxy than those of DNOs (GDN emergency response is not exclusively depot-based to ensure that first responders can reach locations in a timely manner).

C.3.3. Distance to tips

As shown in Table C.7, we carried out a similar analysis to the previous section on average distance to tipping sites. We have used only UKPN data for this, as this dataset includes 347 sites spread across UKPN's licensed area, including on third party sites and is therefore likely to be relevant to the other companies as well.

Table C.7:Average Distance to Tip Sites UKPN

Area	Average distance (m) from tip site	Relative to EPN & SPN average (%)	Relative to distance outside M25 (%)
LPN	2972	48	
EPN	5316	86	
SPN	7078	114	
Outside M25	6970		100
Within M25	3521		51
All	5604		80

Source: UKPN

We found that substations in the LPN network were 48 per cent of the distance from the nearest tip site as they were in the average of EPN and SPN. If we take EPN and SPN as a proxy for the GB average, then average driving distances to/from tipping sites in LPN are only 48 per cent of those for the average GB network.

We found that substations inside the M25 were only 51 per cent of the distance from the nearest tipping site as ones outside the M25. If the UKPN network footprint outside the M25 is representative of average of other GB networks, then driving distance to/from tipping sites within the M25 are only 51 per cent of what they are in the average GB network.

We have adjusted driving distances to tipping sites by 50% for all companies

C.3.4. Need for daily muck-away

Requiring daily spoil removal is more common on permits in London than elsewhere. This requires more vehicle movements than would otherwise be required, as Table C.8 shows.

Table C.8: Permits Requiring Daily Spoil Removal

Operating Area	Permits Requiring Daily Spoil Removal – 3-year average, UKPN (%)
Inner London	8
Outer London	4
TfL	5
Outside London	2

Source: UKPN Permitting

C.3.5. Overnight plant delivery

After further investigation we determined that this was relatively rare and not likely to be material.

C.3.6. Delivery hours restrictions to central depot sites

Delivery sites are operated 24/7 and only a very small fraction of deliveries is too large for routine daytime delivery.

C.3.7. Accounting for staff driving time into and out of London

Staff driving time into and out of London can be split into two items:

1. Uncompensated time which is assumed to be priced-in to labour costs; and
2. Compensated driving time.

SGN has a policy of the first 30-45 minutes (depending on contract terms) of travel to and from site being on employee time. Any excess is considered part of the working day and either paid as overtime or accounted for through agreed earlier departure or later arrival at site. We have accounted for this time as part of our analysis of traffic speed.

C.3.8. Parking costs and fines

HAs do not allow utility companies any special powers or rights to park their operational vehicles, even if they are responding to emergencies. As a result, substantial parking fines can be incurred in the normal course of business. Although companies have strong incentives to challenge fines they believe to be unjustified, Table C.9 shows that parking fines are significantly higher for Cadent in London than elsewhere.

Table C.9: Parking Fines Cadent

Network (Cadent)	Fines Received	Paid Amount (£)	Percentage Cancelled (%)
East Anglia	37	1,536	22
East Midlands	59	2,257	14
London	3,110	261,118	18
North West	93	4,065	16
West Midlands	64	3,197	13
Total	3,363	272,173	17

Source: Cadent

Similar data from SGN, summarised in Table C.10, shows that it pays almost 12 times as much in parking fines per depot for its London depot as it does from its other depots.

Table C.10: Parking Fines SGN (£)

Operating Area	Parking Fines per Depot (2-year Average, SGN)
London	15,382
Non-London	1,304

Source: SGN analysis of four London and five non-London depots which together account for 96 per cent of all parking fines

C.3.9. Congestion charging

The congestion charge covers part of inner-London, utilities are not exempt from paying it. The Consortium’s congestion charge costs are shown in the tables below. Cadent provided us with congestion charge spend data by cost area (the table below shows cost areas covering 98% congestion charge costs between them).

Table C.11: Cadent Congestion Charges (excluding repex)

Operating area	£17/18 congestion charge spend
EA	£455
EM	£40
NL	£147,137
NW	£122
WM	£155

Source: Cadent finance data 17/18

Table C.12: UKPN Congestion Charges

Cost area	2017 congestion charge spend
Network Ops LPN	£301,342
Capital programmes	£33,226
Connections small services	£19,593
Network Ops & control	£8,014
Connections London	£6,703
Commercial	£5,393
Network Ops SPN	£4,259
…	
Total	£380,658

Source: UKPN finance data 2017

SGN's inner-most depot in Kennington is just outside the congestion charging zone and SGN has indicated that they do not pay a material amount of congestion charge.

Thames Water has informed us that it has spent £59k / year on congestion charges in the last two years.

C.3.10. Vehicle servicing costs in London

Labour prices, rents, and other input prices are higher in London than elsewhere in the country, suggesting that vehicle servicing costs could be higher as a result. However, vehicle servicing can also take place at depots outside of London.

We found that members of the Consortium had a range of contractual arrangements to service their vehicles, usually at a whole company level. A previous Cadent contract had a 20 per cent higher servicing cost per vehicle in London but the current contract is a national one with agreed average rates.

C.3.11. Smaller vehicles

We did not identify any evidence to support the hypothesis that operating in London requires a relatively large number of small operational vehicles, rather a smaller number of larger vehicles. Hence, this factor is only likely to influence utilities' costs in a small number of cases.

C.3.12. Smaller sites

We did not identify any evidence to support the hypothesis that operating in London requires a relatively large number of small operational sites, as opposed to fewer large sites in other areas.

C.3.13. Shorter permit lengths

There are more duration challenges in London. If this results in reductions in excavation productivity, this will be reflected in our analysis in Appendix A. We were not able to determine whether shorter permits lead to the need for more vehicle movements.

C.4. Management Control

Traffic speed and distances between employee homes and site, as well as distances between sites are not within management control, though companies do have some discretion as to whether they employ labour locally (and pay high wages) or employ people living further away (and pay for their travel time).

The distance to tips, which are operated by third parties is likewise outside of management control.

The location of depots, and therefore travel distances between depots and sites is within management control in the long term, although London-based depots are often co-located with sites which contain operating assets (such as UKPN’s Camden site or the larger GDN depots which are often on old gas-holder sites). Management must balance property costs and potential disposal value of central London sites with greater additional travel time incurred through the use of sites which are further outside of the city centre. We have shown that entirely abandoning central London sites leads to substantial increases in travel time between central London and the nearest depots.

In a very limited sense, parking fines are under management control: employees can simply be instructed not to park illegally. However, in practice this is not practical, as utilities must carry out their vital activities and be able to respond to emergencies and repair assets promptly. The fact that multiple utilities systematically incur substantially higher parking fines in London than in their operations elsewhere indicates that this is driven by exogenous factors.

C.5. Quantification

C.5.1. Traffic speed vs distance and fixed site locations

Quantifying the effect of traffic conditions requires the balancing of the slower travel speeds demonstrated above with the potential for shorter journeys in a denser environment.

However, the way these factors affect journeys in practice depends on the type of work and travel patterns. Population density is a measure of just that, how close people live together.

Some distances are related to population densities, the distance between any two randomly selected people in an area of uniform density for instance is clearly related to the population density. The distances that are important for utility companies are however are less clearly related to population density.

We have considered three types of travel patterns:

1. Travel to/from sites from fixed sites – distances depend on the average distance between fixed residence and depot locations and work sites. We have considered three such distances:
   A. Depots/offices;
   B. Tips; and
   C. Home.
2. Sequential travel between sites – distances depend on the average distance between sites requiring similar activity within the day. For instance, travel distances for substation/governor/pumping station inspections or gas repairs depend on the distance between the sites; and
3. Travel in response to real-time events – distances depend on location of nearest available resource at time of event.

We have considered three types of work which best match these travel patterns:

1. Full day, project-based work, such as DNO reinforcement projects, GDN repex, GDN repair, water mains replacement. In these cases, materials, equipment, and people move to site from a variety of fixed locations. Waste is taken away to tips/recycling plants, also at fixed locations. After finishing their work, people return to depots or directly home. Equipment is returned to company or contractor depots in fixed locations.
2. Sequential work, such as routine inspections, and various maintenance tasks. In these cases, staff and contractors carry travel to their work area, carry out a task and then travel to the next site to carry out the same or a similar task.
3. Time sensitive responses, such as GDN emergency FCOs, DNO fault response. Similar to (2) above, staff undertaking these activities finish responding to a call and are then available to respond to the next one. Unlike (2) there is no way of knowing where calls will come in advance and calls cannot be assigned to the closest operative: they must be assigned to the closest operative not already committed. Resource levels are set using experience supplemented by models to ensure adequate response times.

We have used vehicle tracker data, split using a combination of recorded data and judgement to determine how much of each type of travel was undertaken by employees of each company.

Based on the data available, we have not been able to definitively split travel distances into categories with sufficient granularity to determine whether the effect of slower traffic speeds or greater density dominates and therefore whether there is an additional cost or a reduction in cost. Further analysis of travel data in the future may determine which effect dominates. We have therefore not quantified the effect of travel.

C.5.1.1.1. Commutes to/from home

For this type of work, we assume that staff and contractors travel from/to depots or home at the beginning and end of the day, with most of the staff and contractors working for the utility not living in London. Average commutes of people living in London are the longest in the country, as shown in Table C.13.

Table C.13: Duration of Commute from Home to Work by Region of Workplace, October-December 2009, United Kingdom

	London	Rest of UK	All UK
1-15 min	18%	46%	42%
16-30 min	26%	34%	33%
31-45 min	20%	11%	12%
46-60 min	20%	6%	8%
60+ min	16%	3%	5%

Source: ONS Labour Force Survey 2009

Taking the mid-point of the ranges in the table, we find that the average commute in London is 36.3 minutes, the average commute in the rest of the UK is 23.1 minutes and the London commute is 157 per cent of the average commute for the UK.

Work carried out by Field Dynamics for Cadent into emergency engineer commutes to their start locations for Cadent is summarised below in Table C.14.

Table C.14: Cadent Commute to Work Distances

Region	Average Commute (miles)
EA	2.80
EM	2.90
LO	10.70
NW	3.30
WM	2.00

Source: Field Dynamics analysis of Cadent emergency engineer commute to work

If we use the average of the four non-London regions as representative of the 7 (out of 8) GDN networks which are not London, and average these with the distance for London, we find that the national average is 3.7 miles. The distance of the London commute is 286 per cent of that average.

Cadent’s repair engineers travel from a mix of depot and home locations. Table C.15 shows that London travel distances are not the shortest. Given that depots are closer together in London, we considered the hypothesis that repair teams and others dispatched from depot to site would need to travel a shorter distance and that this would offset the effect of slower traffic speeds.

Table C.15: Cadent Repair Travel Distances per Network Region

Region	Miles Per Job
EA	30.50
EM	26.83
LO	27.67
NW	19.65
WM	17.59

Source: Field Dynamics analysis of Cadent repair travel data

However, Table C.15 above, which analyses average travel distance for repair crews by network region, shows that this is not the case. In fact, if we use the same averaging method as above, we find that the distance travelled by repair crews in London is 15 per cent above the national average.

C.5.1.1.2. Travel to/from depots

Our analysis in Section C.3.2 found that distances to and from depots in London was 40 per cent of the national average for LPN, 83 per cent for Cadent North London, and 73 per cent for SGN's network within the M25. We further assumed that Thames Water would be most similar to the GDNs and applied a 73 per cent adjustment to their travel distances to and from depots.

C.5.1.1.3. Travel to/from tipping sites

Our analysis in Section C.5.2 found that distances to and from tipping sites in London was 48 per cent of the national average for LPN and 51 per cent for all locations within the M25. We have used 50% as an adjustment for all companies.

C.5.1.2. Sequential work

This work has two essential characteristics:

- It can be planned in advance; and
- It consists of the same, or very similar, operations carried out sequentially on a number of sites over the course of a working day.

Efficient planning of such work will minimise travel time by ordering the work geographically. We have considered the hypothesis that sequential travel distances would be shorter in London and that this would balance out the slower traffic speeds.

Examples of this work include the routine inspection and maintenance of substations, pumping stations, and gas governors.

To investigate this hypothesis, we have used geospatial analysis to determine the "nearest neighbour distance" for electricity substation sites and for water and wastewater sites.

The nearest neighbour distance is the distance between any one site and the closest neighbouring site. The average nearest neighbour distance is the average such distance within the area of analysis. We have used this distance as a proxy for the efficient distance to drive between sites.

We have used site data showing:

- UKPN substation sites;
- Thames Water wastewater sites; and
- Thames Water drinking water sites.

We have used UKPN data which shows the locations of all substations in the UKPN network to determine the relationship between the density of population and the average distance of each substation to its nearest neighbour substation.

In Table C.16, we show these distances for each of the three UKPN networks. For reference, we then also show the density of UKPN substations within the SGN and Cadent North London network operating areas.

Table C.16: Average Nearest Neighbour Distance Between UKPN Substations

Network area	Average Nearest Neighbour (metres)	Percentage of SPN-EPN Average (%)
UKPN LPN	87	41
UKPN SPN	209	98
UKPN EPN	218	102
SGN within M25	138	65
SGN all[127]	192	90
Cadent NL	115	54

Source: Arcadis geospatial analysis of UKPN substation locations

We find that distances between substations in LPN are only 41 per cent of the EPN and SPN average. If EPN and SPN are typical of GB DNO networks, then driving distances between substations in LPN are only 41 per cent of the national average.

However large parts of both networks (and EPN in particular) are especially sparse, therefore we also sought to determine whether there was a general relationship between population density and average nearest neighbour distance which we could use to estimate the average nearest neighbour distance for GB as a whole.

To understand the general relationship between population density and nearest neighbour distance of substations, we determined nearest neighbour distances for London boroughs, counties, and unified authorities (UTAs) and plotted them against the population density of those local authorities in Table C.17.

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[127] Limited overlap between SPN and SGN outside M25

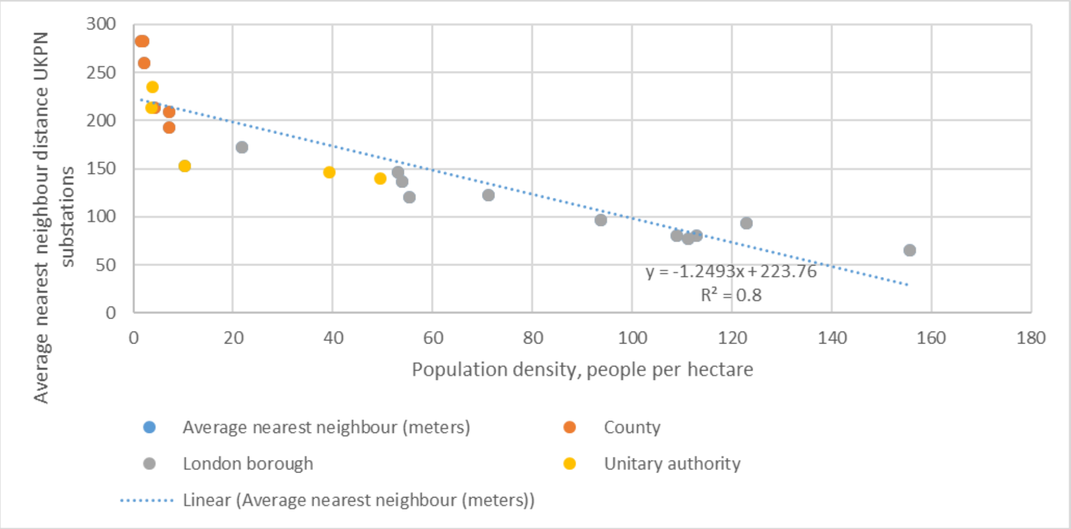
Table C.17: Average Nearest Neighbour UKPN Substation by Area

Area	Population Density, People / Hectare	Average Nearest Neighbour (metres)
Norfolk	1.66	283
Suffolk	1.99	283
Cambridgeshire	2.12	260
Essex	4.23	213
Surrey	7.12	209
Hertfordshire	7.18	193
Bromley	21.8	172
Southend on Sea	39.4	146
Brighton	53	146
Redbridge	53.9	137
Merton	55.3	120
Waltham Forest	71.2	123
Wandsworth	93.7	97
Southwark	108.9	80
Camden	111.3	77
Hammersmith and Fulham	113	80
Lambeth	123	93
Islington	155.6	65
Southend on Sea	39.4	146
Bedford	3.56	213
Central Bedfordshire	3.9	235
Luton	49.5	140

Source: Arcadis geospatial analysis of UKPN substation locations

As Figure C.5 shows, there appears to be a negative correlation between nearest neighbour distance and population density (R^2 of 0.8).

Figure C.5: Average Nearest Neighbour Distance vs Population Density



Source: Arcadis geospatial analysis of UKPN substation locations

As Table C.17 and Figure C.5 show, there does appear to be a relationship between population density by local authority and average nearest neighbour distance. We therefore use OLS to fit a linear relationship, which we have used in Table C.18 to estimate the average nearest neighbour distance for Great Britain as a whole based on local authority level population density data.

Table C.18: Calculated Distance Between Neighbouring Substations

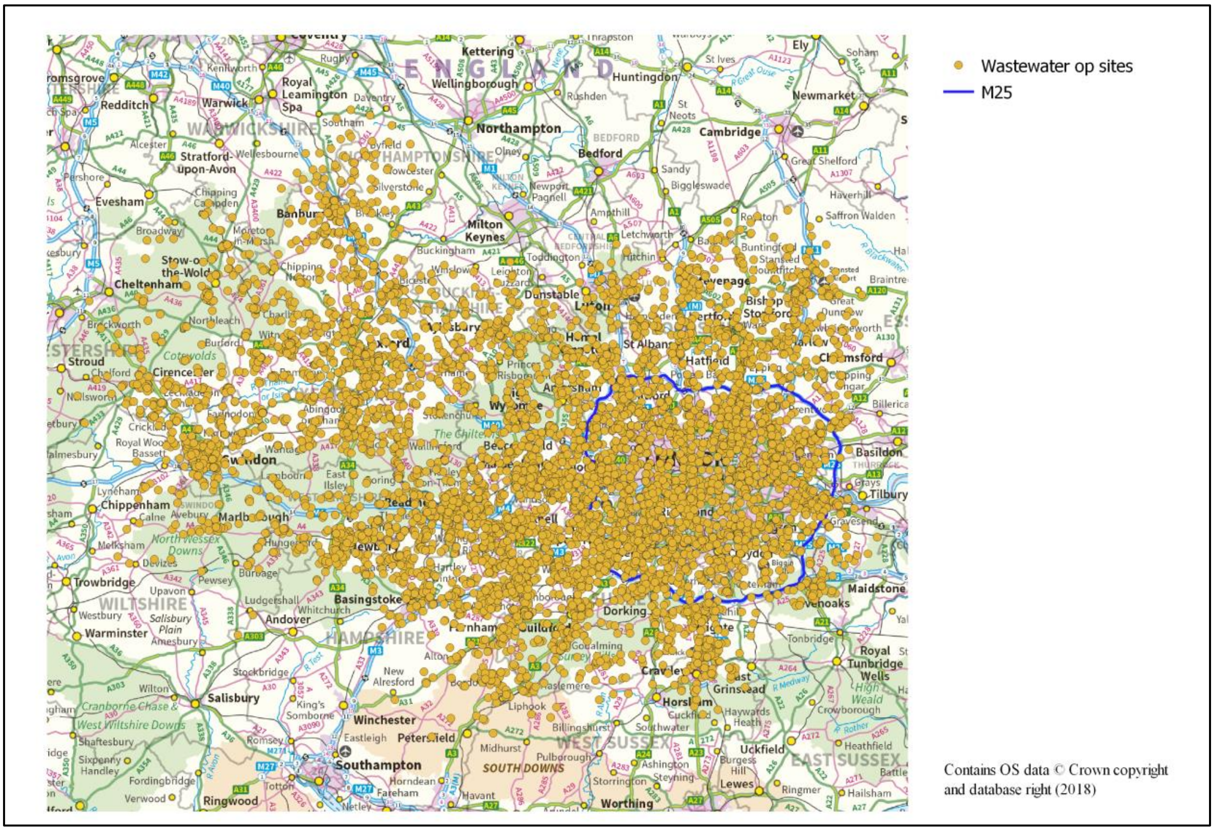
	Population Density (People / Hectare)	Calculated Nearest Neighbour
Great Britain	2.75	224
London (ONS region)	56	158
London / GB %		70%

Source: Arcadis analysis of UKPN substation data, ONS population density

For this category of travel, we thereore divide UKPN travel distances by 70% to convert them to distances for the equivalent journeys outside London, based on the results shown in Table C.18.

We carried out a similar analysis to the above using Thames Water’s wastewater sites. This dataset contains fewer features (only 7.6k vs 75k+ for UKPN) reflecting the different nature of the networks (see Figure C.6).

Figure C.6: Thames Water Wastewater Sites



Source: Arcadis geospatial analysis of Thames Water data

Figure C.6 shows Thames Water's wastewater sites. While it is visually apparent that they are densely clustered in London, it is also clear that sites outside of London are also likewise clustered together.

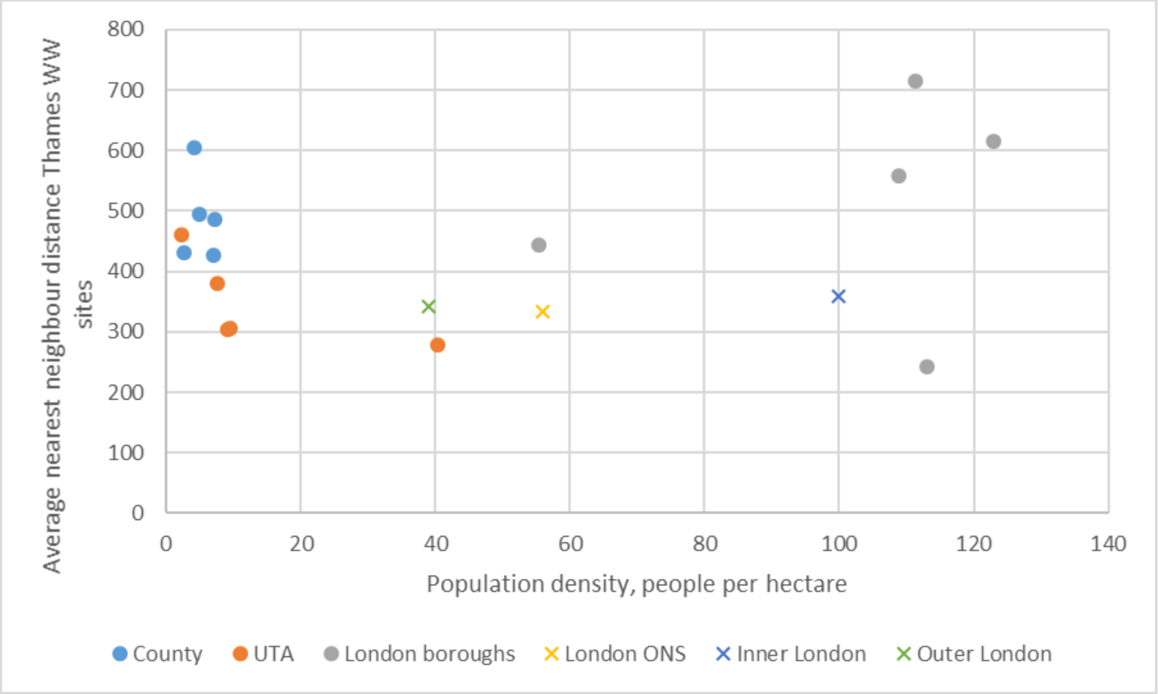
Table C.19 tabulates population density and average distance between Thames wastewater sites for various regions, and Figure C.7 plots this relationship. It is not clear from this analysis that there is any relationship between the distance between wastewater sites and population density.

Table C.19: Average Nearest Neighbour Thames Wastewater Sites by Area

Region	Population density, people / hectare	Average nearest neighbour (metres)
West Berkshire	2.3	460
Oxfordshire	2.61	431
Buckinghamshire	4.28	604
Hampshire (partial)	4.87	494
Surrey	7.12	426
Hertfordshire	7.18	486
Windsor and Maidenhead	7.6	381
Wokingham	9.2	304
Swindon	9.6	307
Outer London	39	342
Reading	40.3	278
Merton	55.3	444
London (ONS region)	56	333
Inner London	100	360
Southwark	108.9	559
Camden	111.3	714
Hammersmith and Fulham	113	243
Lambeth	123	616

Source: Arcadis geospatial analysis of Thames Water wastewater site data

Figure C.7: Wastewater Site: Nearest Neighbour Distance vs Population Density



Source: Arcadis geospatial analysis of Thames Water wastewater sites data

We were able to compare the nearest neighbour distance for all Thames wastewater sites (452 metres on average) with the average for London (ONS definition, 333 metres on average) and find that the distance in London was 74 per cent of the distance outside of London.

However, in the absence of a clear link to population density, we are not able to estimate an average distance for GB which makes this adjustment less robust than the one for UKPN.

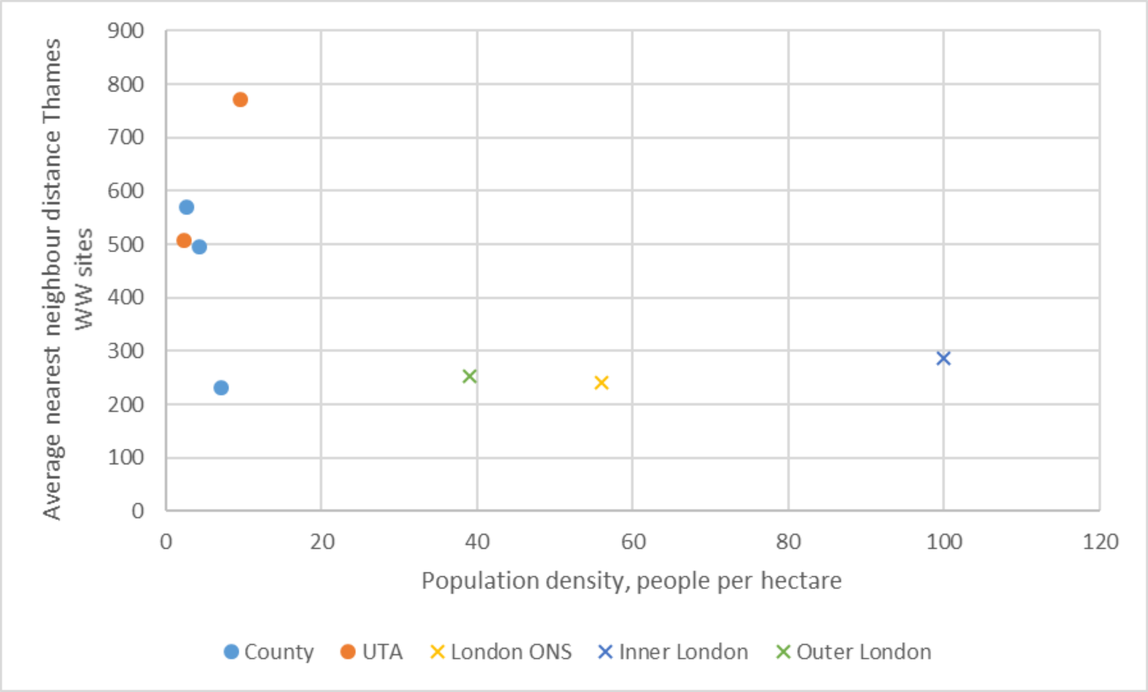
We repeated this analysis for 1,807 Thames Water drinking water sites (of which 507) are in London. Again, Table C.20 tabulates population density and distance between sites, and Figure C.8 plots the relationship.

Table C.20: Nearest Neighbour Distance Thames Water Drinking Water Sites

Region	Population density, people / hectare	Average nearest neighbour (metres)
London ONS	56	240
Inner London	100	286
Outer London	39	253
Oxfordshire	2.61	569
Surrey	7.12	231
Buckinghamshire	4.28	495
Swindon	9.6	770
West Berkshire	2.3	508

Source: Arcadis geospatial analysis of Thames Water drinking water site data

Figure C.8: Thames Water Drinking Water Sites Nearest Neighbour Distance vs Population Density



Source: Arcadis geospatial analysis of Thames Water drinking water site data

There are substantially fewer drinking water sites than wastewater sites, and as a result we have not included as many local authorities in our analysis, as geographic areas with only a small number of sites within their boundaries give unreliable results in average nearest neighbour distance data (because a small number of outliers can dominate the data).

As with wastewater sites, we were able to compare the nearest neighbour distance within London with the average distance for the whole company (240m and 366m respectively) and found that the London distance was 66 per cent of the distance outside of London.

As with wastewater, we were not able to find a clear relationship between population density and nearest neighbour distance.

C.5.1.3. The effect of parking on travel time

A study carried out by Opinium for the British Parking Association in 2016 found that it took 8 minutes on average to find a parking spot in London which is 36 per cent longer than the 5.9 minute national average.[128]

For a series of short journeys, the fixed time spent looking for parking each time becomes more relevant. Utilities have no special rights to park and staff must park legally the same way that any other motorist does.

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[128] https://www.britishparking.co.uk/News/motorists-spend-nearly-four-days-a-year-looking-for-a-parking-space

The materiality of the 2 minutes extra per destination required to park depends on the number of destinations per day. Even with as many as 10 destinations (which is a reasonable upper limit for sites visited in a day), this is only 20 minutes of additional time.

C.5.1.4. Urgent unplanned work

For all these analyses there are three inter-related variables: traffic speed, distance to travel, and time taken to travel. In the previous two sections we have looked at exogenous drivers for the first two and taken the excess travel time as the result.

For urgent work such as GDN emergency, this does not work. The time taken to travel is controlled by management by varying the number of first call operatives on duty. Specifically, GDNs organise their FCO workforce so that they are able to meet their obligation to arrive at a reported Public Reported Escape of Gas (PRE) within an hour 97 per cent or more of the time if the escape is controlled, or within two hours if it is uncontrolled.

From a travel cost perspective, we have reviewed the evidence for effects due to traffic speeds and distances for emergency travel.

Table C.21 shows Cadent's emergency travel patterns by region. It shows that London emergency travel distances are similar to Cadent's national average and that it is sparser regions such as East Anglia where outlier distances exist.

Table C.21: Cadent Emergency Jobs per Day and Miles per Job

Region	Jobs per day	Avg. Miles per Job	Total Miles
EA	3.82	15.28	58.4
EM	4.20	12.89	54.1
LO	4.04	11.72	47.3
NW	4.09	9.69	39.7
WM	3.59	10.92	39.2
Average	3.9	12.1	47.8

Source: Field Dynamics analysis of Cadent emergency travel data

We also reviewed actual time to job for SGN emergency FCOs, as shown in Table C.22. It shows that actual time to job for FCOs was less within the M25 than in the rest of Southern's operational area.

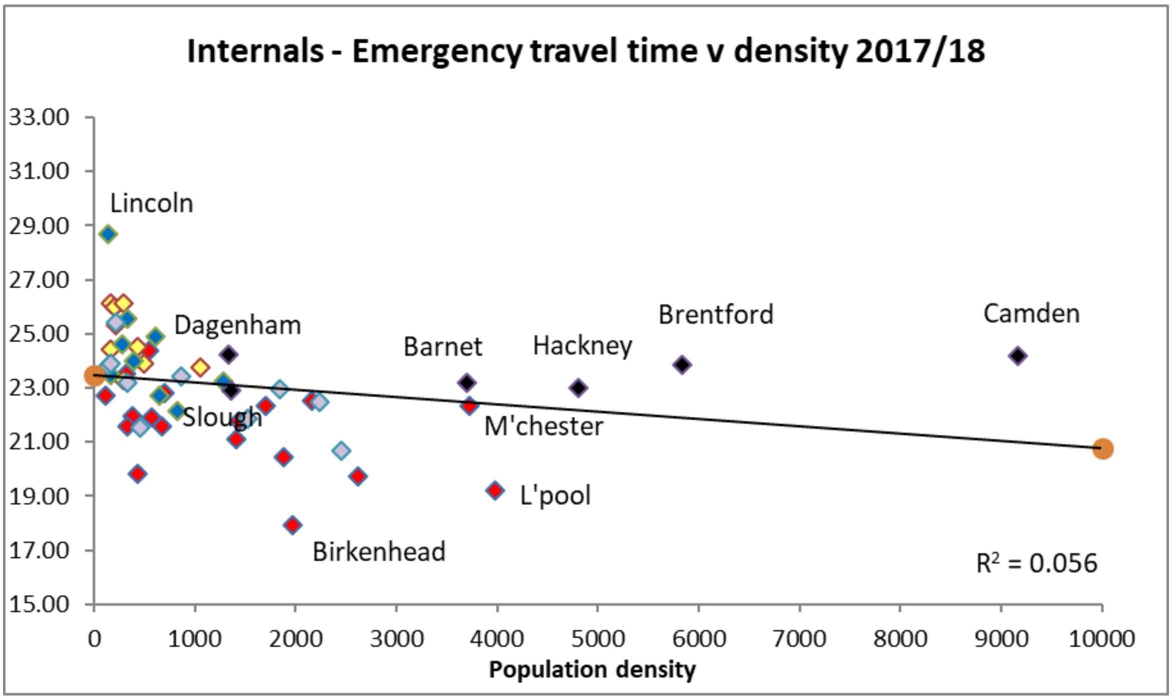
Table C.22: SGN Emergency Average Time to Job

Depot	Average Time to Job (mins)
London	17.41
West Kent	17.90
Surrey	18.11
Inner M25 depots	17.79
Southern ex M25	20.74

Source: SGN analysis of FCO travel time

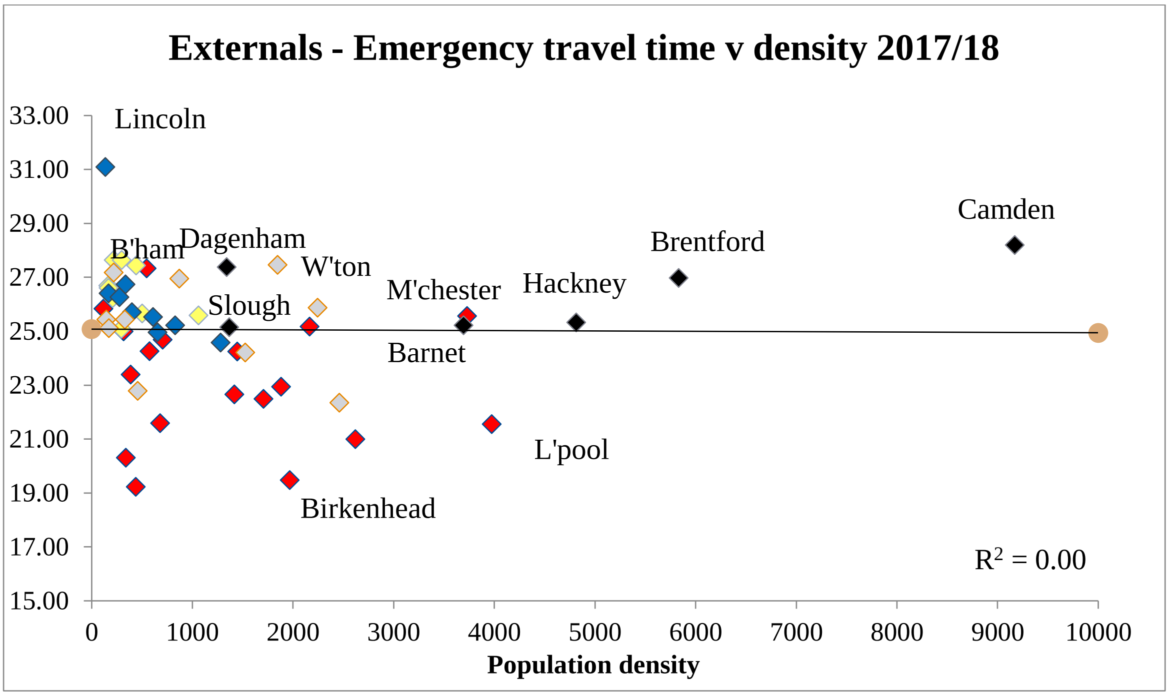
Cadent has conducted research on the link between population density and emergency travel time, as shown below in Figure C.9 and Figure C.10.

Figure C.9: Emergency (Internal) Travel Time vs Density



Source: Cadent analysis of 2017/18 emergency travel time vs HA population density

Figure C.10: Emergency (External) Travel Time vs Density



Source: Cadent analysis of 2017/18 emergency travel time vs HA population density

The data suggests an extremely weak correlation between emergency travel time and density which we expect. Travel time, travel distance, and FCO average job length must be considered together to understand differences in FCO resource level requirements. For more details, see the network-specific factor section.

C.5.1.5. Combining the effect of traffic speed and distance

We carried out an extensive analysis of the relative distances between assets and depots and how this effect might counteract the effect of slower traffic speeds. We were not able to reach a definitive verdict on the degree to which these effects offset each other. We have therefore not estimated a London-specific cost adjustment to account for effect of traffic speeds and travel distances in London.

C.5.2. Distance to tips and tipping costs

We discuss the effect of distance to tipping sites in Section C.5.1. We analysed the 2017/18 tipping cost for Cadent, shown in Table C.23, and found that the unit costs were 48 per cent higher in London than the national average.[129] We would expect that this will be reflected in the tipping costs of the other companies as well. We calculated that 33 per cent of London tipping costs were due to London-specific factors.

Table C.23: Cadent Tipping Costs by Region for 2017/18

Region	Quantity tipped (Tonnes)	Tipping total cost (£)	Unit cost (£ per tonne)
East of England	160,858	1,639,858	10.19
London	117,417	1,666,599	14.19
North West	120,540	1,166,630	9.68
West Midlands	85,116	586,253	6.89
Cadent	483,931	5,059,340	10.45
Average			9.58
London	117,417	1,124,782	9.58
London excess		**541,817**	
London excess % / London actual		33%	

Source: Cadent

We were not able to locate data on additional tipping costs for other companies, and therefore assumed a zero London effect (for tipping costs) for all companies except Cadent.

C.5.3. Need for daily muck-away

We account for the additional costs as part of our adjustment to tipping costs.

C.5.4. Overnight plant delivery

We have not quantified this effect, as we did not find London to be materially different.

C.5.5. Delivery hours restrictions to central depot sites

We have not quantified this effect, as we did not find London to be materially different.

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[129] As elsewhere, we have constructed this average assuming that the costs in three non-London Cadent networks are representative of the national average and can be used for the 7/8 of the cost which is not London

C.5.6. Accounting for staff driving time into and out of London

We have considered this factor as part of our analysis of average traffic speed, but have not estimated a London-specific cost adjustment for it.

C.5.7. Parking costs and fines

For Cadent, we have calculated that expenditure on parking fines in London is 1,200 per cent of the national average, as shown in Table C.24. This is due to substantially higher average fines as well as a much higher volume of fines.

Table C.24: Quantifying Cadent parking fines London effect

Network (Cadent)	Fines Received	Paid Amount (£)	Unit cost (£)	Percentage over London actual (%)
East Anglia	37	1,536	42	
East Midlands	59	2,257	38	
London	3,110	261,118	84	
North West	93	4,065	44	
West Midlands	64	3,197	50	
Total	3,363	272,173	81	
National average[130]	444	21,509	48	
London volume, national rates		150,626		42
National volume, London rates		37,286		86
National rates, National volume		21,509		92

Source: Arcadis analysis of Cadent parking fine data

There are two reasons why the total amount of "additional" parking fines could be viewed as less than wholly efficient: (1) there is a substantial discount for early payment, and (2) some fines are due to driver behaviour which we are not able to justify as being necessary to carry out the required tasks. Removing such items, including failure to pay and display and assuming that all fines are paid at the earliest possible date, reduces the London additional cost to £88k pa.

Table C.25 quantifies the difference between London and non-London parking fine costs. We found that SGN's London parking fines were 740 per cent of parking fine costs outside London.

Table C.25: Quantifying the London Effect for SGN's Parking Fines

London 2 year average parking fines	£62,542
Non-London 2 year average parking fines	£8,455
London excess	£54,087
London excess fines as percentage of London fines	86%

Source: Arcadis analysis of SGN parking fine expenditure

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[130] 7/8 non-London, 1/8 London

Over the last few three years, Thames Water has incurred an average of £57k / year in parking fines. The vast majority in London, the highest level of fines in a non-London authority was £1,395 in Reading (3 yr cumulative) vs £45k+ in Kensington & Chelsea alone over the same period. Applying the same 86% to the Thames Water fines, we calculate a £49k / year London excess of parking fines.

We did not have data on UKPN's parking fines and have therefore not quantified a London effect (of parking fines) for LPN.

C.5.8. Congestion charging

We have assumed that the entire congestion charging amount for each company is a London-specific cost.

C.5.9. Vehicle servicing costs in London

As the location of vehicle servicing is within management control (within reason), we assume that the majority of vehicle service occurs outside the M25 and there is therefore no London-specific effect.

C.5.10. Smaller vehicles

We have not quantified this effect, as we did not find London to be materially different.

C.5.11. Smaller sites

We have not quantified this effect, as we did not find London to be materially different.

C.5.12. Shorter permit lengths

We have not quantified this effect, as we did not find London to be materially different.

C.5.13. Quantification summary

Table C.26 below sets out our estimate of the London-specific costs related to travel and logistics.

Table C.26: Quantification Summary for Travel & Logistics Costs

Company	Effect of travel speed and distance	Tipping costs	Parking costs and fines	Congestion charges	Total
Cadent NL	-	£0.54m	£0.08m	£0.147m	£0.78m
SGN Southern	-		£0.05m	N/A	£0.05m
UKPN LPN	-			£0.38m	£0.38m
Thames Water[131] DW	-		£0.02m	£0.03m	£0.05m
Thames Water WW	-		£0.02m	£0.03m	£0.05m

Source: Summary of previous sections

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[131] We have split the total parking fines 50/50 between the drinking water and wastewater businesses

C.6. Impact on Comparative Performance

As described in Section C.2, companies incur transport and logistics costs across all parts of their business, ranging from travel to attend to incidents and emergencies, travel between depots and sites, and costs related to planning and managing transport and deliveries.

C.6.1. Assessment of the extent to which existing models control for transport and logistics

Ofgem's aggregate "top-down" totex models at ED1 and GD1 only control for differences in transport and logistics costs between companies to the extent that they control for the scale of companies' networks. Ofgem's scale drivers (primarily MEAV) take no account of higher *unit* costs associated with travel costs, and the associated productivity effect of work in London. For example, in gas models, Ofgem's MEAV driver will likely capture the number of journeys required to inspect the network, but it does not capture the extent to which journeys are slower in London. In electricity models, MEAV may be correlated with density, since more densely populated areas require more use of underground cables, which have a higher unit cost than overhead lines; as we discuss below, transport and logistics costs are likely to be correlated with density.

At ED1, Ofgem included transport and logistics costs in a number of its disaggregated models; Ofgem modelled indirect costs related to vehicles and transport ("Vehicles and Transport CAI" – including lease costs, vehicle insurance and maintenance), alongside vehicle purchases ("Vehicles Non-op Capex"), using MEAV as the only cost driver. However, Ofgem modelled other costs associated with increased transport costs discussed in this appendix as part of companies' direct activities or business support models; including IT and property costs associated with vehicle management, labour costs of staff driving vehicles, and costs associated with use of company cars.[132] For instance, wages paid for engineers travelling to faults would appear in faults models. While Ofgem controlled for MEAV in some of these models, Ofgem does not directly control for differences in costs due to factors such as traffic speeds.

At GD1, Ofgem modelled some costs associated with transport and logistics as part of direct cost activities, including work management, emergency, and repairs costs; these models used cost drivers related to workload and scale (e.g. number of gas escapes), which do not reflect higher unit costs due to transport and logistics. Delivery costs to and between depots and stores were included in "stores and logistics" costs, which was modelled as part of business support, using cost drivers related to broad measures of scale (such as customers and total MEAV).

Ofwat's draft aggregate cost models at PR19 do not control for any cost drivers directly related to transport costs. However, most of Ofwat's proposed models control for a linear measure of density, which finds a positive relationship between density and costs.[133] As we discuss in C.6.2 below, higher transport costs in London are largely driven by traffic

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[132] Ofgem (2015), RIIO-ED1 regulatory instructions and guidance: Annex A – Glossary, p. 188.

[133] Specifically, Ofwat uses either a population density or network density measure in 6 of its 12 wholesale water models, and controls for network density in 6 of its 8 wholesale wastewater models.

congestion, therefore density drivers are likely to be an appropriate proxy of higher transport and logistics costs.

Costs associated with travelling to water/sewerage leaks and network repairs and enhancement make up a significant proportion of water distribution and wastewater collection costs. Ofwat's disaggregated water distribution and wastewater collection models each control for population density or network density, and these drivers are likely to capture some differences in transport and logistics costs between companies.

The geographical spread of operational assets across London at other parts of the water and wastewater value chain, may mean that other, non-network cost categories are affected by higher transport and logistics costs to some extent (in contrast with the factors discussed in Appendix A), for example, higher costs due to delivery restrictions and parking costs. Apart from water distribution and wastewater collection models, most of Ofwat's disaggregated models do not control for density, or any other measure correlated with congestion and traffic costs.

C.6.2. Controlling for transport and logistics in benchmarking models

We have not identified any drivers in benchmarking datasets which directly account for differences in transport and logistics costs between companies.

However, many of the cost factors identified in this section are the consequences of operating in a densely populated urban area. For example, lower traffic speeds and time lost to finding parking space are a consequence of congestion, which is higher in densely populated areas. Therefore, a model which adequately controls for density is likely to better control for differences in costs due to the higher transport and logistics costs.

We discuss alternative approaches regulators could employ to control for density in Appendix H. While a measure of density is likely to be correlated with transport and logistics costs, there are a number of reasons why a density measure cannot capture the full effect of transport factors such as traffic congestion. Firstly, areas of the same density do not necessarily have the same level of traffic congestion as one another, since other factors, such as the age of the city (and the width of roads), and the quality of public transport, will affect traffic speeds. Secondly, measures of population density will understate density in areas with few residents but large numbers of commercial buildings, such as Central London, where traffic congestion is, in fact, higher than surrounding residential areas. At its PR14 re-determination, the CMA calculated a special factor against its benchmarking models for traffic congestion in Bristol, using evidence that the average traffic speed is lower in Bristol than in other local authorities of the same population density.[134]

Regulators may be able to directly control for differences in transport costs in benchmarking models using drivers related to traffic speeds and journey times, for example:

- Regulators could control for journey times of companies' vehicles. Utilities' vehicle tracking data records average journey duration (and average traffic speeds) for journeys made in operational vehicles; by controlling for average journey duration; alternatively

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[134] CMA (October 2015), "*Bristol Water plc – A reference under section 12(3)(a) of the Water Industry Act 1991: Report*", appendix 4.3, paragraphs 117-152.

- Regulators could use a variable calculated from published traffic speeds. The Department for Transport (DfT) publishes data on average traffic speeds on ‘A’ roads in England, reported by highway authority.[135] This data could be mapped onto utility companies’ supply areas, weighted according to population density or network density, to account for where jobs are most likely to occur.

Operational data, based on the journeys a utility company must make, may better capture traffic at the time of day companies’ make most of their journeys, and the balance between long-distance and short-distance journeys required for utilities, than independent data representing all journeys; whereas independent data, based on general travel speeds (by all vehicles on major roads), may better capture the extent to which management can take mitigating actions to reduce the effect of congestion, e.g. by travelling at quieter times of the day.

Regulators could also control for the density or length of roads of different classifications in a company’s supply area, to capture differences in road networks in different parts of the country. The balance between different types of roads (Motorways, ‘A’ roads, ‘B’ roads) etc. will affect travel costs as well as costs associated with streetworks, which are discussed in Appendix A). In areas with better networks of high-capacity roads, utilities are more able to serve a large area with a single depot, while minimising travel time.

A utility in London, which faces more traffic congestion than other regions, can take a number of mitigating actions to maintain required levels of service (see Section C.4); for instance, a company can minimise response times by ensuring they have more depots in areas with more traffic congestion. However, any such efforts to reduce the effect of traffic congestion will impose additional costs on other areas of the business, e.g. higher property costs due to locating depots in high-cost, inner-city areas. Therefore, it may also be appropriate to control for transport and logistics in disaggregated models concerning other cost categories.

C.6.3. Conclusion on the impact of this cost factor on comparative performance

Existing benchmarking models do not directly control for transport and logistics costs, although some models control for density, which is, to some extent, a driver of the underlying cause of differences in transport costs between companies. Many disaggregated cost categories are affected by the productivity effects of lower travel speeds and logistics difficulties, but few models contain cost drivers which account for the effect of this factor on higher unit costs.

Since this factor leads to material differences in costs between companies for reasons outside management control, we have included this cost factor in in our special factor quantification in Section 5.3.

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[135] Department for Transport (28 February 2018), Travel time measures for the Strategic Road Network and local 'A' roads: January to December 2017.

Appendix D. Network-Specific Factors

D.1. Overview

While the other appendices cover factors that affect the costs of all London utilities (at least to some extent), this appendix covers those cost items we have identified which only affect one of the electricity, gas or water industries. We summarise these factors in Table D.1 below.

Table D.1: Network-Specific Factors in London vs. Elsewhere in Great Britain

Cost Driver	**Why London Differs from Elsewhere in Great Britain**	**Impact on Utility Expenditure by Category**				
		Labour	***Materials***	***Equipment/ fleet***	***Other overheads***	***Cash costs***
GDN Emergency productivity	Multiple factors – high density, many multi-occupancy buildings, traffic, escapes at night	More night working, higher peaks				
DNO Confined space and tunnel costs	Higher density drives use of utility tunnels and underground substations	Specialist training required for confined space working		Breathing apparatus for some confined spaces		Some tunnels owned by local authorities and rent charged Specialist I&M costs
GDN Multiple Occupancy Buildings (MOB) costs	London has more MOBs than other areas	Additional labour	Riser replacement			
DNO compressed time period	LPN peak loading hours are longer (red and super-red bands) which leads to fewer available working hours for certain tasks	Out of hours work				
GDN MOB GSOP costs	Guaranteed Standards of Performance payments made due to customers In MOBs being off supply					Payment to customers
Cable pit costs	UKPN-specific costs due to the underground nature of the London network	Additional labour				
Tunnel radio costs				Additional equipment		
Link box costs		Additional labour		Additional equipment		

D.2. Technical Background and Reason for Cost Increase

D.2.1. GDN emergency (Cadent and SGN)

There are a number of factors that may explain differences in emergency productivity between regions including:

- Traffic speed;
- Distances between depots and work and distances between work sites; and
- Differences in how long it takes to control an emergency or effect a repair.

D.2.2. Confined space and tunnel costs (UKPN)

LPN has a network of deep tunnels containing EHV cables running between grid and primary substations. There are additional costs associated with this tunnel network such as:

- Ventilation;
- Confined Space regulation compliance;
- Additional Inspection & Maintenance costs for assets in tunnels;
- Flooding; and
- Paying local authorities for those tunnels which belong to them.

LPN also has a higher percentage of substations with access restrictions which require confined space training and equipment, when compared to DNOs operating in other parts of the country.

D.2.3. Gas supply to Multiple Occupancy Buildings (GDNs)

Gas risers within Multiple Occupancy Buildings belong either to the GDNs or to the building management company / freeholder / Local Authority. For safety reasons, in cases where it is not clear who owns the gas riser, the GDN is assumed to do so and must maintain it.

Working on gas assets inside a building requires careful safety planning and many of these assets (including many that have not historically appeared on GDN asset registers or been maintained by them) will require remediation and replacement following ongoing surveys. It is likely that in the wake of the accident at Grenfell tower there will be greater public attention paid to gas risers in MOBs.

Since London has more MOBs than other parts of the country, Cadent and SGN incur higher costs as a result.

D.2.4. Compressed time window (DNO)

Some work must be done when DNO networks are not at their peak loading, so that assets (which are designed with some measure of redundancy) can be de-energised without affecting the reliable operation of the network.

D.2.5. GDN MOB GSOP payments

GDNs are required to maintain a certain Guaranteed Standard of Performance (GSOP) which means that customers who are off supply longer than a certain period of time are entitled to compensation. When rising mains in MOBs require repair, this often leads to a substantial period with no supply for a large number of customers. This is because unlike outdoor underground mains which can be made safe and continue to operate in certain conditions with small controlled leaks while a permanent repair is carried out, mains in MOBs which are leaking must be shut off immediately and cannot be restored to service until fully repaired.

D.2.6. Cable pit costs

UKPN’s London network is unique amongst DNOs in being entirely underground. As a result, there are more cable pits, where cables are joined or terminated, than in other parts of the country.

D.2.7. Tunnel radio costs

Due to its network of tunnels, LPN must operate a radio system for security reasons, in order to work safely in those tunnels.

D.2.8. Link box costs

Link boxes are used to connect segments of LV feeder. London has a more extensively connected LV feeder network than other regions, and so it has more link boxes than other networks.

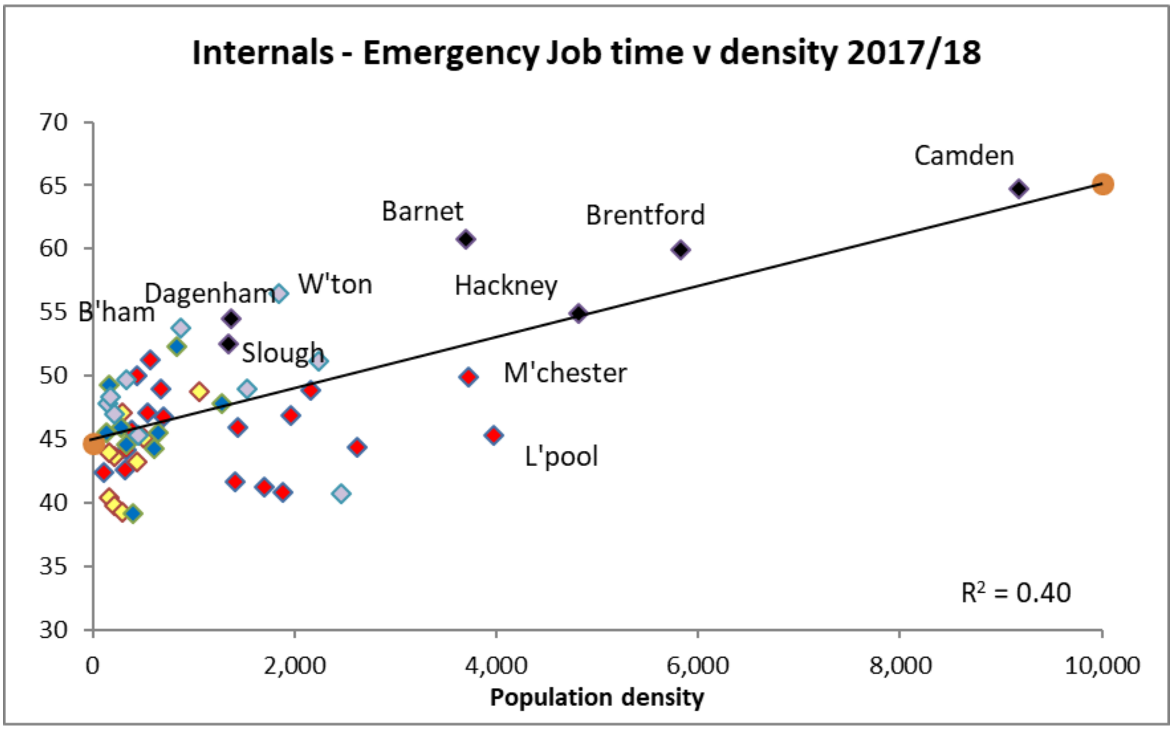
Link box costs include spending on condition-based replacement, inspection & maintenance, and link box related blanket replacement costs.

D.3. Evidence for Uniqueness of London

D.3.1. GDN emergency (Cadent and SGN)

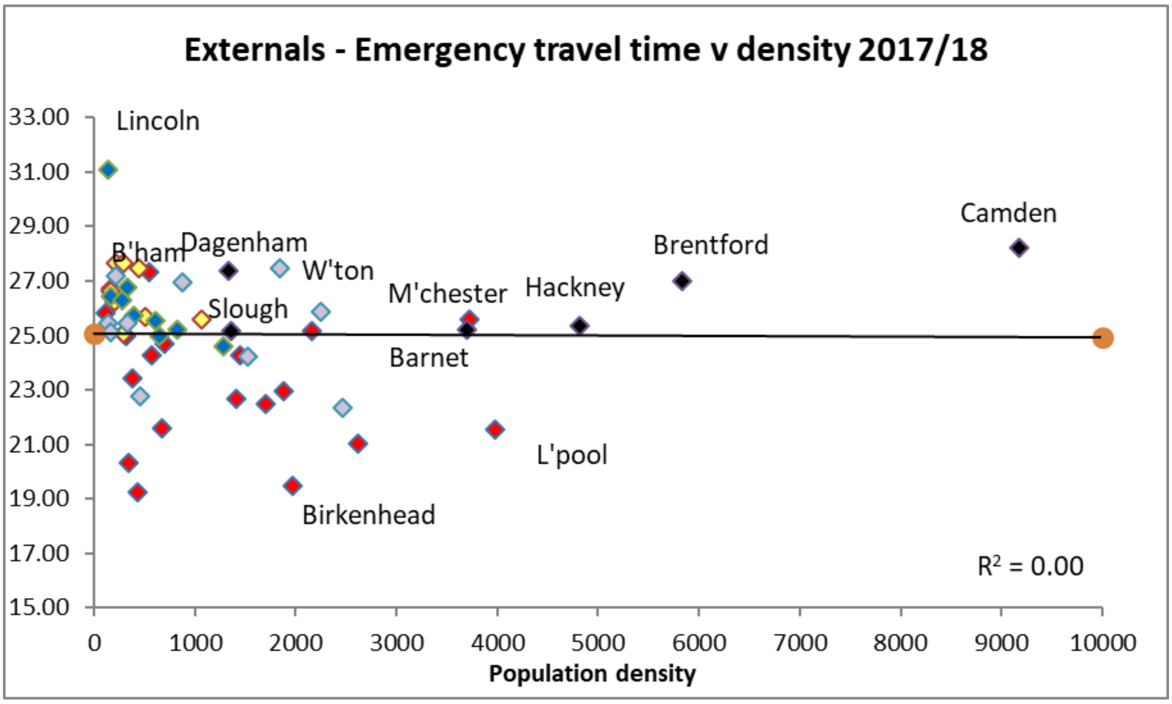
The comparisons between emergency job times and population density across all Cadent networks in Figure D.1 and Figure D.2 show that there is some positive correlation between the two factors. Both internal escapes (escapes inside properties) and external escapes (escapes outside properties) are shown.

Figure D.1: GDN Internal Expenditure – Emergency Job Time vs Density



Source: Cadent analysis of 2017/18 emergency times.

Figure D.2: GDN External Expenditure – Emergency Job Time vs Density



Source: Cadent analysis of 2017/18 emergency times

93 per cent of the total cost for this response capability is labour cost, as a substantial number of FCOs (First Call Operatives) are needed to ensure adequate response times. Overall costs for emergency are not driven directly by the actual number of escapes but by:

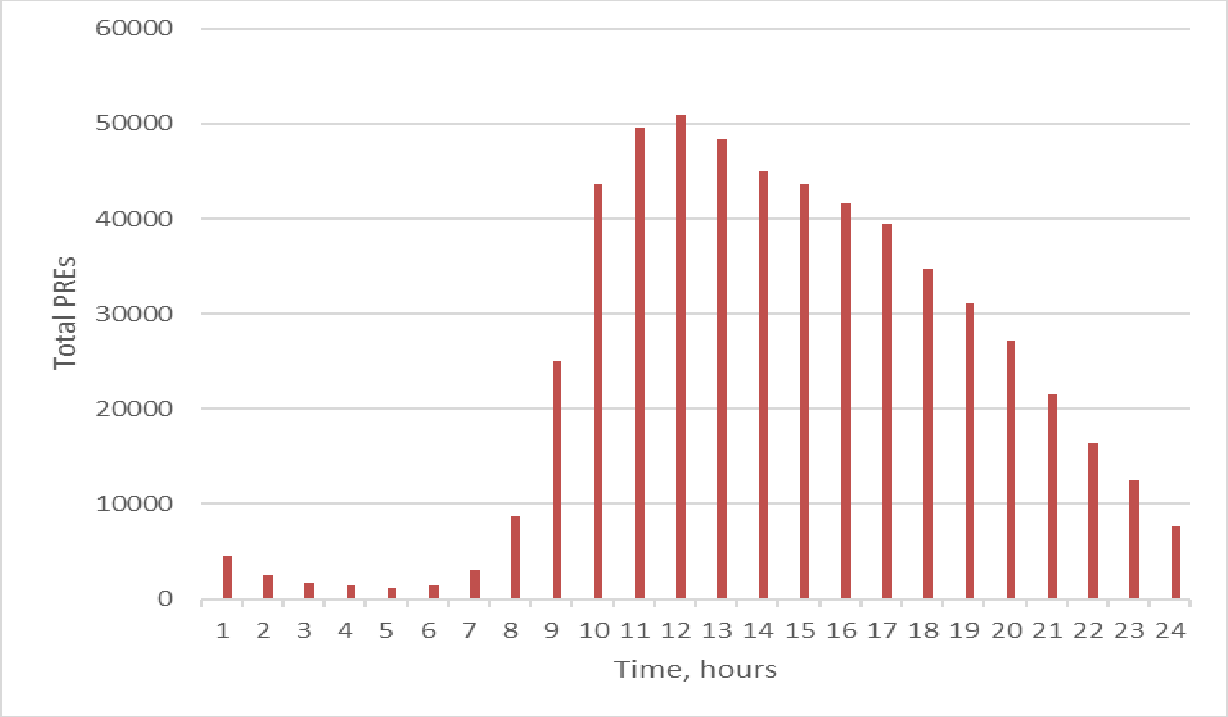
- The number of FCOs who are simultaneously required at peak times;
- How many FCOs are required at off-peak times;
- How off-peak (night-time) provision is organised (i.e. based on an on-call model or night shift model); and
- The average wages of those FCOs.

The number of FCOs required is dependent on the number of simultaneous emergency incidents. Emergency incidents are random events, the frequency of which depends on:

- The time of day – peaking in the early afternoon;
- The time of year – peaking in the winter; and
- The population.

Figure D.3 shows that PREs (Public Reported Escapes – reported gas leaks by the public) peak around noon.

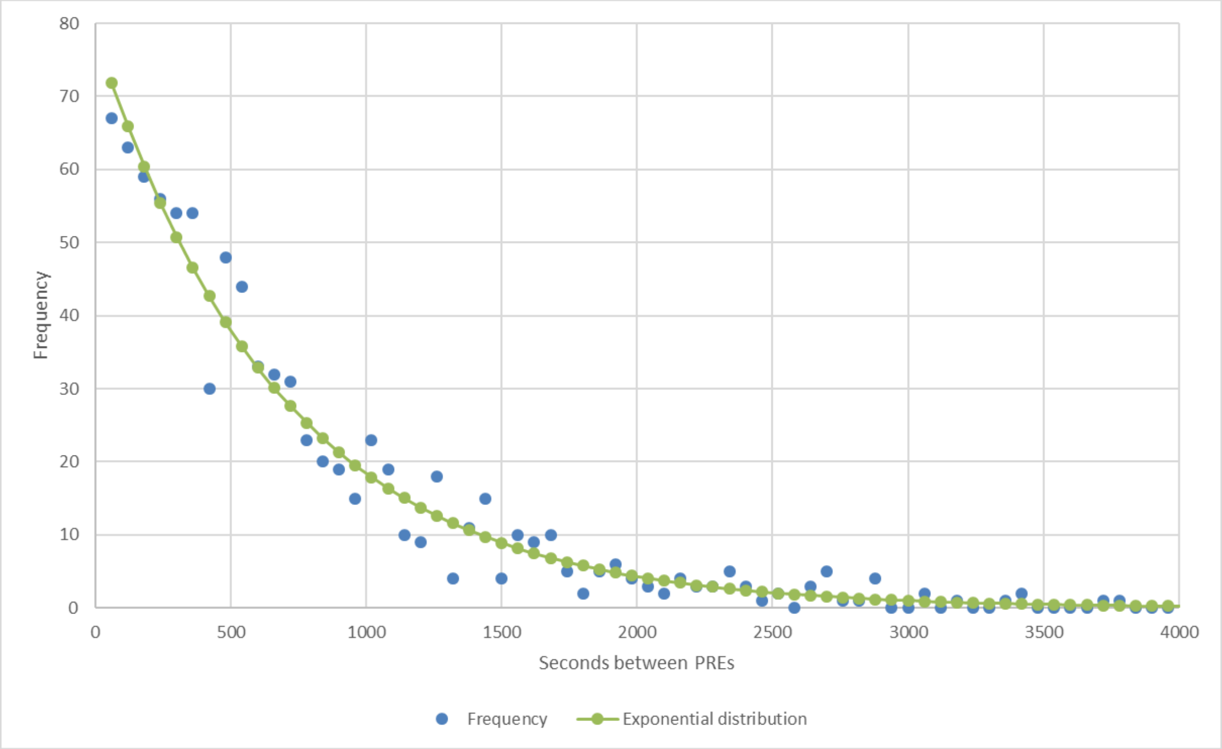
Figure D.3: Cadent Frequency of Publicly Reported Escapes of Gas



Source: Cadent, six years of PRE data for London.

The time between sequential escape events can be modelled using an exponential distribution characterised only by its mean as shown in Figure D.4, which shows a probability distribution of the seconds between events for Cadent’s North London network at 1pm for each day of April 2017.

Figure D.4: Seconds Between PREs, Histogram and Modelled Fit, April at 1pm



Source: Cadent emergency data

The number of required FCOs does not depend purely on the occurrence of PREs. Once an escape has been reported, an FCO must:

- Drive to the site;
- Park; and
- Find and control the escape.

If a repair team is required, the FCO must wait until they have arrived.

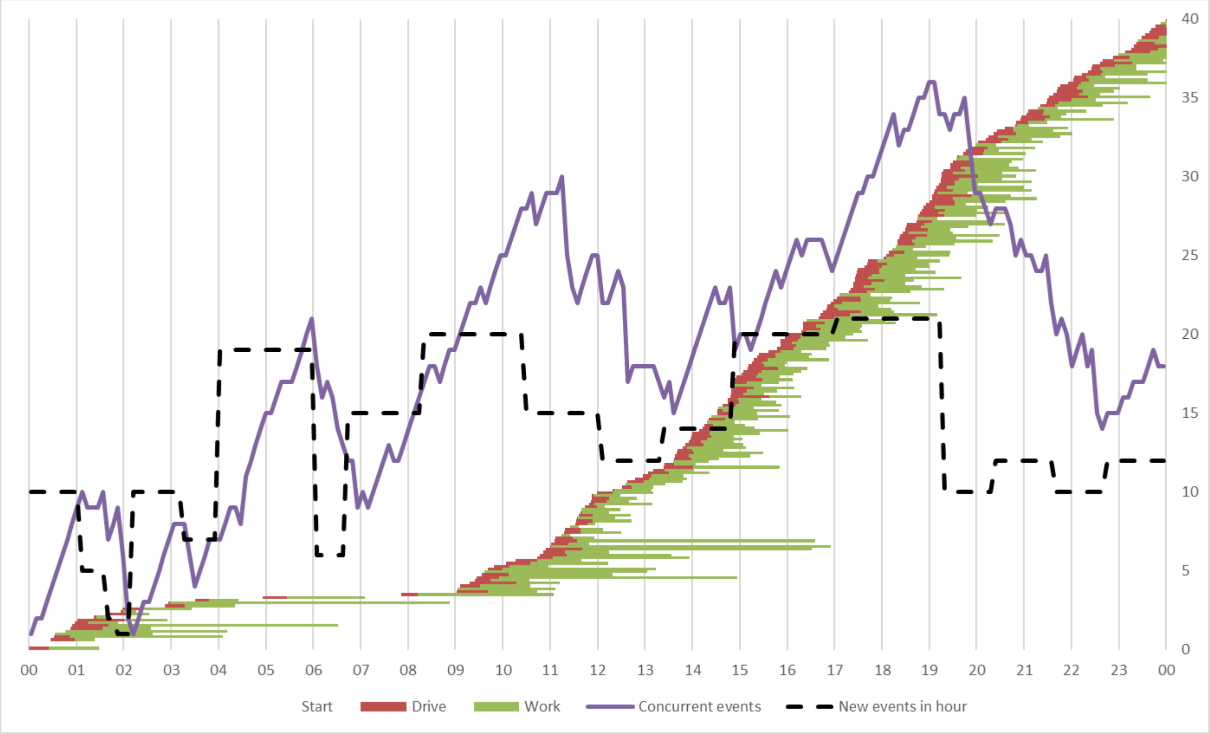
Each one of the three steps above can be affected by the location of the escape. Driving time depends on average traffic speeds and average distances. In turn, average distance depends on the number of FCOs and how highly utilised they are since only an available FCO can respond to a new incident. Their ability to find and control the escape also depends on the surroundings of the reported escape.

To estimate a time series for each network, covering the whole of 2017/18, of the number of simultaneous incidents at each time, we performed the following for each of the Cadent networks and for SGN’s Southern Network using 2017/18 emergency data:

- We assume that an incident starts with a PRE, incrementing the number of simultaneous incidents by 1;
- Travel time and time to complete are then added to the start time to get the end time;
- At the end time, the number of simultaneous incidents is decremented by 1; and
- At each time step, we determined the number of concurrent incidents.

Figure D.5 shows a 24-hour period in London on 1 April, 2017 including the number of simultaneous incidents at each time and the number of new PREs by hour. Each bar represents a single incident and the response to it. Note that as this graph covers a single day, the trend over the course of the day is different from the average trend shown in Figure D.3.

Figure D.5: Simulated Number of Gas Emergencies in a 24-Hour Period



Source: Arcadis analysis of Cadent 2017/18 Emergency data

Since this represents only one day, the pattern of incidents over time is "noisier" than the chart above. What is clearly visible is that the peak of simultaneous incidents, and therefore of FCO utilisation happens an hour or more after the peak in PREs.

To determine required resource levels to respond to all incidents we then do the following:

- For each day in 2017/18 we determined for each network the maximum number of simultaneous incidents.
  - During the day: 8am to 10pm.
  - During the night: 10pm to 8am.
- We divided the year into a summer season (April – September) and a winter season (October – March).
- For each, time of day, season, and network we then determined the 97th percentile of simultaneous incidents as a proxy for a reasonable level of FCO resource for that network, season, and time of day, as shown in Table D.2.

The table shows that in Cadent's North London network, there is more work done at night relative to the amount done during the day than elsewhere.

Table D.2: SGN and Cadent 97th Percentile Maximum Simultaneous Incidents

Network	Winter day	Summer day	Winter night	Summer night	Winter night / winter day
NW	80	56	42	27	53%
London	81	63	60	40	74%
WM	54	41	28	18	52%
EA	46	32	26	13	57%
EM	58	41	30	16	52%
EoE total	104	73	56	29	54%
SGN total	112	79	45	21	40%

Source: Arcadis analysis of SGN and Cadent emergency data

Analysis carried out by Cadent on its last six years of data also supports our finding from Table D.2 that there are more incidents at night than during the day. Cadent's analysis in Table D.3 indicates that more of London's PREs are out of hours than elsewhere.

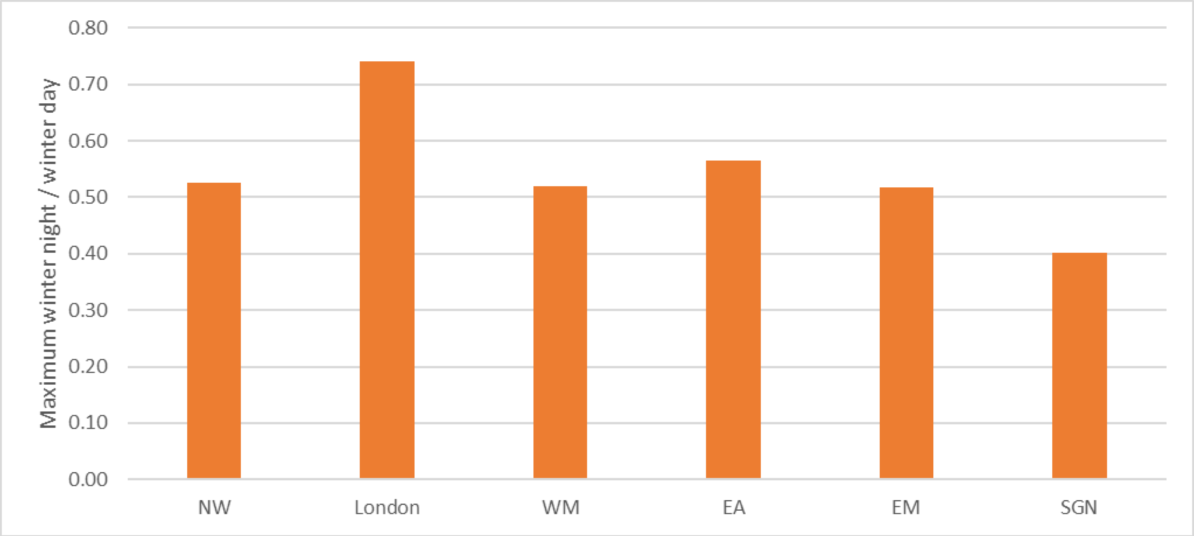
Table D.3: Cadent PREs Occurring Out-of-hours

	PRE 10pm to 8am	
East of England	41876	6.64%
London	**44480**	**7.91%**
North West	33733	6.54%
West Midlands	23081	6.32%
All networks	143170	6.90%
All except London	98690	6.53%

Source: Cadent analysis of six year PRE data

Figure D.6 shows this effect graphically.

Figure D.6: Maximum Concurrent Jobs on 97th Percentile Day Night / Day



Source: Arcadis analysis of Cadent emergency data

Note that we analysed the whole of SGN's Southern network, only about a third of which is in London. This data does not show an effect for SGN Southern as a whole.

As noted above, jobs lag PREs. SGN found in an analysis of its 2018/19 year-to-date emergency data that slightly more than half of its emergency jobs were out-of-hours[136] both within the M25 and in the rest of its network, as shown in Table D.4. While this contradicts evidence from Cadent, the SGN definition of out-of-hours is before 8am and after 4:30pm.

Table D.4: Out of Hours Emergency Jobs SGN

	Average Job Time (mins)	% Out of hours
Inner M25 depots	69.85	53%
Southern ex M25	70.17	52%

Source: SGN analysis of 2018/19 year-to-date emergency data

D.3.2. Confined space and tunnel costs

The use of tunnels by DNOs outside of central London is very uncommon to our knowledge. While we have not been able to confirm that there are no tunnels used by DNOs outside of central London, we have not found any DNO except for UKPN which has ever publicly stated that they have any. Confined spaces are categorised into types as shown in Table D.5.

Table D.5: UKPN confined spaces by type

Type	Access & Egress	Typical locations
A	▪ Stairway ▪ Straightforward egress	▪ Underground substations
B	▪ Vertical ladders or step irons ▪ Recovery of injured casualty likely to be difficult	▪ Underground substations, cable pits ▪ Areas with height restrictions
C	▪ Number of access / egress points ▪ Work may be some distance from egress point and at depth where communication is difficult ▪ Recovery of an injured casualty likely to be difficult	▪ Tunnels ▪ Ducts

Source: UKPN ED1 Regional cost justification

As Table D.6 shows, there are more substations in the HV Central region which have access restrictions (B1 or above) than in the other regions. Only a third of the substations in this region have no access restriction.

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[136] Out of hours in this case is before 8am or after 4:30pm.

Table D.6: LPN Substations by Access Type

Area	No access restriction	A	B1	B2	C
HV CENTRAL	33.8%	53.1%	3.8%	9.0%	0.1%
HV NORTH EAST	95.0%	4.3%	0.3%	0.4%	0.1%
HV NORTH WEST	67.3%	25.3%	3.6%	3.6%	0.2%
HV SOUTH EAST	79.6%	19.9%	0.0%	0.3%	0.1%
HV SOUTH WEST	78.7%	19.5%	0.1%	1.7%	–

Source: LPN substation access information

There is no central registry of substation access type nor of underground power tunnels (whether shared municipal or sole use) so it is not possible to say for certain how much of this cost is London-specific. UKPN covers a wide area with its three networks and does not incur tunnel related costs outside of London, which is evidence that these are London-specific costs. There are more substations in the most central part of LPN that have access restrictions than in other parts of the network which is evidence that this kind of cost is characteristic of only the densest urban areas.

D.3.3. Multiple Occupancy Buildings (MOBs)

Data on MOBs for Cadent (see Table D.7) shows that the majority of high-rise buildings, which are the most likely to have GDN-maintained risers are in London.

Table D.7: MOBs by Network, Cadent

Network	Total number of high-rise buildings	MOBs x stories
East Anglia	112	1211
East Midlands	65	587
North London	2105	18780
North West	207	2595
West Midlands	253	2791
Total	2742	25964

Source: Cadent MOBs database

Note that Greater Manchester and Liverpool are in Cadent's North West network, Birmingham is in the West Midlands network and these are also major urban areas, so it is not the case that all major urban areas have high rise buildings with MOBs in equal numbers.

Similar analysis of SGN MOB data by postcode (see Table D.8), which also includes data on non-high rise MOBs, also shows that the majority of MOBs are in London (see SE and SW postcodes in the table below).

Table D.8: SGN: MOBs by Postcode

Postcodes	Number of MOBs	Location
SE	4506	London
SW	2092	London
BN	1296	Brighton
PO	368	Portsmouth
DA	289	Dartford
BH	285	Bournemouth
CR	272	Croydon
TN	237	Tunbridge Wells
SO	217	Southampton

Source: SGN MOB data by postcode

D.3.4. Compressed time window (DNO)

Each DNO is required to publish as part of its charging schedules the hours at which they are most loaded (their red time band) for their Low Voltage and High Voltage customers. They also publish a super-red time band for their Extra High Voltage customers. These are important because they affect the rates at which some customers are charged for their use of the distribution network.

Table D.9: LPN's 2019 Time Bands for Half-Hourly Metered Properties

Time periods	Red and Super Red Time Bands	Amber Time Band	Green Time Band
Monday to Friday (Including Bank Holidays) All Year	11:00 - 14:00 16:00 - 19:00	07:00 - 11:00 14:00 - 16:00 19:00 - 23:00	00:00 - 07:00 23:00 - 24:00
Saturday and Sunday All Year			00:00 - 24:00

Note: All times are in UK clock times. Source: 2019 distribution charging schedule

LPN, alone of all the distribution networks, has two red and two super red time bands, in both cases between 11:00-14:00 and 16:00-19:00. The other UKPN networks and other DNOs in GB have their red and super-red bands between 16:00-19:00 (a few have them between 16:30-19:30 and networks are free to set them otherwise if they can evidence their network loadings are different than this).

This means that maintenance tasks that require de-energising assets, which are required during red and super red times but not during the amber or green time band hours, must be carried out in a much shorter period of time than for other DNOs. Any such tasks which might take more than two hours also cannot be started in the window between 14:00 to 16:00.

D.3.5. GDN MOB GSOP payments

As we describe in Section D.5.3, London has significantly more MOBs than other parts of the country. Table D.10 below shows actual GSOP payments for MOBs for each of the Cadent networks for the last three years.

Table D.10: Cadent MOB GSOP payments

£17/18m	2017/18	2016/17	2015/16	Average
EoE	90,576	48,215	60,747	
NL	1,473,024	1,033,137	1,307,960	
NW	36,797	30,967	25,638	
WM	62,958	19,639	20,698	
Average non-London	63,444	32,940	35,964	
London excess	1,409,580	1,000,197	1,272,266	1,272,348

Source: Cadent

The average London excess is £1.27m for Cadent.

We have not received data on MOB GSOP payments from SGN but have estimated that the cost will be the same as that for Cadent’s North London network.

D.3.6. Cable pit costs

Table D.11 below shows cable pit cost projections for all UKPN networks for the RIIO-ED1 price control period, based on spending to date. These costs are incurred only by LPN.

Table D.11: Cable pit costs

£17/18m	ED1 estimated	Per annum
LPN	6.0	0.75
EPN	0.0	
SPN	0.0.	

Source: UKPN RRP tables

D.3.7. Tunnel radio costs

Table D.12 below shows tunnel radio cost projections for all UKPN networks for the RIIO-ED1 price control period, based on spending to date. These costs are incurred only by LPN.

Table D.12: Tunnel radio costs

£17/18m	ED1 estimated	Per annum
LPN	2.4	0.30
EPN	0.0	
SPN	0.0.	

Source: UKPN RRP tables

D.3.8. Link box costs

Table D.13 below shows link box-related cost projections for all UKPN networks for the RIIO-ED1 price control period, based on spending to date. To estimate the expenditure which is excess for London, we:

- Calculated a cost per MPAN for non-London (based on EPN);
- Determined how much would have been spent in LPN and SPN based on the EPN cost per MPAN; and
- Subtracted that figure from the actual spend to determine a "London excess" in the SPN and LPN networks.

Table D.13: UKPN Link Box Costs (RIIO-ED1)

	MPANS	**Condition based replacement**	**Inspection, repair, & maint.**	**Link box related fire blanket replacement**	**Total link box related**	**Expenditure / MPAN**	**Expenditure at EPN £ / MPAN**	**London excess**	
	#	£12/13m	£12/13m	£12/13m	£12/13m	£ / MPAN	£12/13m	£12/13m	£17/18m
LPN	2,376,820	93.9	9.9	8.8	**112.5**	47.35	26.2	86.3	**96.9**
EPN	3,670,695	30.1	1.9	8.5	**40.5**	11.04	40.5	0.0	**0.0**
SPN	2,136,975	36.5	2.4	9.9	**48.8**	22.84	23.6	25.2	**28.3**

Source: UKPN RRP tables

D.4. Management Control

The company-specific factors we consider in this appendix are outside of management control:

- The factors driving emergency productivity are outside the control of Cadent and SGN. These factors are:
  - Traffic speed (net of any savings from shorter driving distances)
  - Physical factors such as a higher share of impermeable surfaces and more multi-occupancy buildings which are expected to reduce emergency productivity and increase job time.
- Confined space and tunnel costs are likewise driven by the physical environment of London, and are therefore outside of management control.
- It is not within the control of utility companies whether people live in MOBs.
- DNOs can set their red and super-red time bands but they do so based on network peak timings which are not within their control.

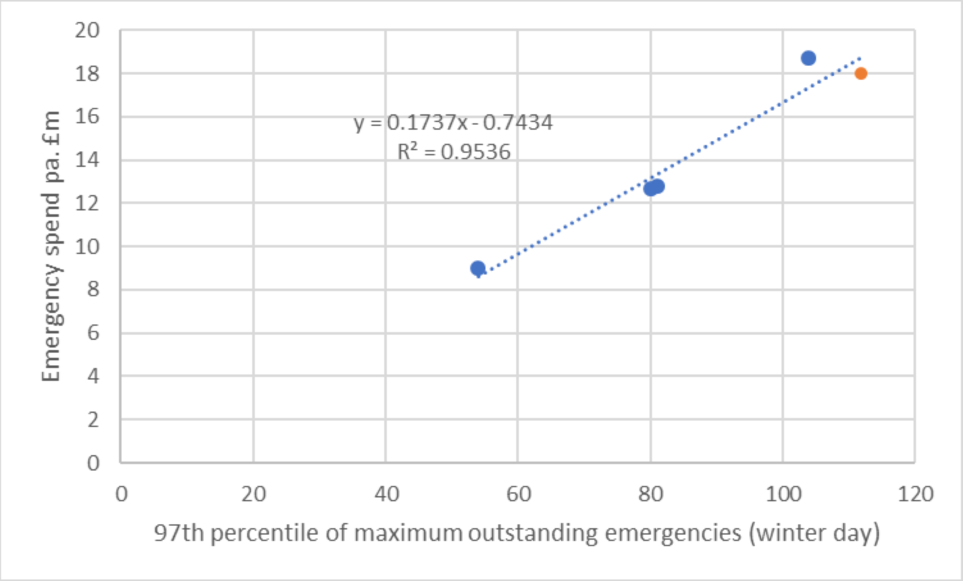
D.5. Quantification

D.5.1. GDN Emergency (Cadent and SGN)

To test whether it is in fact the case that concurrent emergency events are a material driver of emergency costs, we:

- Obtained forecast total GD1 spend on GDN emergencies as reported in the 2017/18 RRPs;
- Adjusted the labour component (93% on average) of emergency spending by the appropriate labour price adjustment factor from Appendix E.
- Plotted the adjusted emergency spend against the 97th percentile of the number of concurrent jobs on a winter's day, as shown in Figure D.7.

Figure D.7: Labour Price Adjusted Emergency Spend pa. vs 97th Percentile of Concurrent Emergencies



Source: Arcadis analysis of Cadent and SGN emergency data, 2017/18 RRPs

Fitting a linear relationship to this data for SGN and the four Cadent networks we find a strong positive correlation (R-squared of 0.9536), suggesting that the 97th percentile of maximum concurrent emergencies can be used to predict total emergency spend once adjusted for regional labour costs.

We compared the actual expenditure for each company with the average of the five networks and found that Cadent North London's expenditure was above the average and SGN Southern's expenditure was below it, however this is explained by the differences in peak numbers of concurrent jobs. Based on this evidence, we have not accounted for a London effect for GDNs' emergency spend in the summary section below.

Table D.14: GDN Emergency Spend

£m 17/18	EoE	NW	WM	Lon	SGN	Average
Total emergency spend 2017/18	18.7	12.7	9	14.2	18.80	14.7
	18.7	12.7	9.0	12.8	18.0	
Concurrent winter daytime jobs	104	80	54	81	112	86.2
Additional expenditure relative to average	4.02	-1.98	-5.68	-1.91	3.32	
Model predicted	17.32	13.15	8.64	13.33	18.71	
Residual	-1.38	0.45	-0.36	0.56	0.72	

Source: Actuals from 2017/18 RRP tables, concurrent jobs from Arcadis analysis

However, at RIIO-GD1, Ofgem's used a 'workload' CSV for its emergency costs disaggregated modelling, which consisted of customer numbers and repair reports.[137] This approach does not account for the higher than average number of PREs per customer in Cadent's London supply area, which may be driven by its high population density (see Section D.3.1 above). In Cadent London's supply area, the forecast number of PREs per customer was around 14% higher than the GB average, over RIIO-GD1.[138] Therefore, based on Ofgem's GD1 disaggregated modelling, Cadent London's excess cost would be around £1.6m per year.

D.5.2. Confined space and tunnel costs

Confined space training is necessary for many LPN staff and must be refreshed every three years. The table below shows the costs of the course for six delegates.

Table D.15: UKPN Confined Space Training Costs

Type of training	Course length	Training cost	Person-days	Labour cost	Combined cost
Confined Space A,B,C	3 days	£2,850	18 days	£2,674	£5,524
Confined Space A,B	2 days	£1,900	12 days	£1,783	£3,683

Source: UKPN training costs

Assuming an 8- hour training day, we have applied the calculated hourly wage for LPN of £18.57/hr to estimate the cost of the time of the UKPN employees as well.

The result of this calculation suggests that UKPN has spent an average of £335k/yr in the last two years on confined space training.

However, we have not considered the offsetting saving UKPN realises (if any) because it does not need to train staff to work on overhead lines in LPN.

UKPN indicated that it incurred the following additional costs due to its London tunnel system:

- Annual rental costs for placing its assets in shared municipal subways;

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[137] Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, p. 64-65.

[138] According to Ofgem's GD1 forecast workload adjusted cost-drivers.

- Annual inspection costs of assets in such subways and repair of any defects; and
- Civils costs related to tunnels.

We set out the estimated London effect for these additional tunnel costs in Table D.16 below.

Table D.16: UKPN tunnel costs

£17/18m	LPN	SPN	EPN	Total
Annual rental of London Subway	£1.14m	-		£1.14m
Annual inspection & maintenance of assets in subway and tunnels (CV30)	£13.28m	£32.95m	£0.18m	£46.41m
Civil costs relating to tunnels (CV10)	£6.37m	£0.75m	£1.16m	£8.28m
Total ED1	£19.65m	£33.71m	£1.34m	£54.70m
Total pa.	£2.46m	£4.21m	£0.17m	£6.84m

Source: UKPN ED1 submission

D.5.2.1. Tunnel costs for GDNs

In addition to electricity distribution assets, there are also gas distribution assets in tunnels. Cadent pays an annual tunnel rental cost of £156k in North London and does not incur this cost is any other regions.

Since all repair team leaders, all apprentices in the emergency and repair teams, and many other technicians complete confined space training as part of their standard gas safety qualifications, there are no additional costs for this.

D.5.3. Multiple Occupancy Buildings (MOBs)

There are three sources of additional costs due to the high number of MOBs for London GDNs:

- Reduced repair and emergency productivity due to access difficulties;
- Routine survey costs to ensure that the risers are in a safe condition; and
- Replacement costs for risers.

The first item is addressed in our analysis of Cadent and SGN repair and emergency productivity in London. Survey costs for Cadent are shown in Table D.17 below.

Table D.17: Cadent: Riser Survey Costs

2017/18	EoE	Lon	NW	WM
	£m	£m	£m	£m
MOBS survey costs	0.25	1.20	0.21	0.36
Non-London average	0.28			
London excess	0.93			

Source: Cadent

If the three non-London GDN networks are typical of the national average, then Cadent requires an additional £0.93m / year to carry out riser surveys. We also assume SGN would incur £0.93m / year in survey costs; since SGN has more risers than Cadent London, this likely represents a conservative estimate.

Table D.18: Cadent and SGN: Riser Replacement Expenditure

	no. of risers	no. of Supply Points	Gross Costs £m	Average pa. £m
EoE	365	2,217	6.4	1.28
Lon	1640	12985	34.6	6.92
NW	284	893	2.5	0.49
WM	256	1090	4.5	0.91
Southern	9783	N/A	N/A	10.74
Average non-London:			4.5	0.89
Cadent London excess:			30.2	**6.03**
Southern London excess:			N/A	**9.9**

Cadent and SGN MOB repex 2013/14 – 2017/18

If the three non-London networks are representative of the national average, then Cadent required £6.03m per year to replace risers in North London MOBs and SGN requires an additional £9.9m per year to replace risers in its Southern network.

D.5.4. Compressed time window (DNO)

For 2018, the total spend on out of hours working on EHV assets in central London was £92,675 for 945 hours of out of hours work.

D.5.5. GDN MOB GSOP payments

The London excess is £1.27m for Cadent North London as calculated above.

D.5.6. Cable pit costs

The London excess is £0.75m per year in LPN as calculated above.

D.5.7. Tunnel radio costs

The London excess is £0.30m per annum for LPN as calculated above.

D.5.8. Link box costs

We estimate the London excess for link box costs for LPN and SPN in Section D.3.8 above for the RIIO-ED1 period as a whole. We divide the figures presented in that section by eight (the number of years in the RIIO-ED1 price control) to estimate an annual London effect.

D.5.9. Quantification summary

Table D.19 below present a summary of the estimated London effect of the network-specific factors.

Table D.19: Network-specific factors summary

£17/18m annual	Southern	Cadent NL	LPN	EPN	SPN	Thames DW	Thames WW
GDN emergency spend	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Confined space costs	0.00	0.00	0.34	0.00	0.00	0.00	0.00
GDN MOBs	10.83	6.96	0.00	0.00	0.00	0.00	0.00
GDN MOB GSOPs	1.27	1.27	0.00	0.00	0.00	0.00	0.00
Compressed time windows	0.00	0.00	0.09	0.00	0.00	0.00	0.00
Tunnel costs	0.00	0.16	2.46	0.17	4.21	0.00	0.00
Cable pit costs	0.00	0.00	0.75	0.00	0.00	0.00	0.00
Tunnel radio costs	0.00	0.00	0.30	0.00	0.00	0.00	0.00
Link box costs	0.00	0.00	12.12	0.00	3.54	0.00	0.00
Total	**12.10**	**8.39**	**16.06**	**0.17**	**7.75**	**0.00**	**0.00**

Sources: various as above

D.6. Impact on Comparative Performance

D.6.1. Assessment of the extent to which existing models control for network-specific factors

In Ofgem's aggregate "top-down" totex models at ED1 and GD1, Ofgem's MEAV variables (which are calculated using unit-costs multiplied by the number of assets owned by a company in different sub-categories) may take some limited account of the effect of network-specific costs which relate to differences in companies' assets. In disaggregated models, Ofgem uses drivers which may take some limited account of cost differences related to network-specific factors:

- Ofgem's RIIO-ED1 models may partially control for tunnel and confined space costs, since MEAV variables (used in aggregate and disaggregated models) take account of differences in the types of assets used in tunnels compared to those buried under roads. Ofgem's benchmarking models excluded LPN's costs associated with tunnel (and cable subway) repairs and maintenance, but did not exclude costs associated with confined space training.
- While a "MEAV" driver may, in principal take some account of differences in costs associated with MOBs however at GD1 Ofgem excluded MOBs from MEAV, Ofgem has excluded MOBs repex costs from its GD1 benchmarking models.[139] Additional inspections and maintenance costs associated with surveying MOBs are not accounted for in benchmarking models, except to the extent that Ofgem's models contain variables which are correlated with density, since MOBs are more prevalent in densely populated areas (see Section D.6.2). Disaggregated models for repairs costs, which use a cost driver

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[139] Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, p. 112-113.

related to the number of gas escapes (see A.6.2), do not account for the higher unit-cost of gas escapes in or near to MOBs.

- Additional labour costs associated with the compressed maintenance time window in which UKPN can de-energise assets are not controlled for in benchmarking models, since Ofgem’s labour cost adjustment only relates to differences in regional labour costs (i.e. across all hours of the day).

D.6.2. Controlling for network-specific factors in benchmarking models

Since the factors discussed in this appendix relate to costs which are unique to London companies, a model which adequately controls for density is likely to better control for differences in costs than one which does not. We discuss alternative approaches to controlling for density in Appendix H below

Differences in MOBs costs are likely to be highly correlated with population density measures; the number of multi-occupancy buildings in an area is likely to be strongly correlated with population density measure (e.g. occupants per square kilometre), since mutli-storey, multi-occupancy buildings accommodate more people per square kilometre.

Since tunnels and cable subways are likely to be unique to London utilities (see Section D.2), no cost driver can adequately capture the extent to which these network features drive differences in costs between companies.

In theory, Ofgem’s electricity benchmarking models may be able to account for higher costs associated with compressed maintenance time windows by controlling for the length of “red” peak loading bands per day (see Section D.3.2). However, because there is very limited variation in peak loading bands for DNOs outside London, this driver is unlikely to perform well in an econometric benchmarking model.

D.6.3. Conclusion on the impact of this cost factor on comparative performance

Existing benchmarking models do not directly control the network-specific factors discussed in this appendix, although some models control for density, which is, to some extent, a driver of the underlying cause of these features.

Some of the factors discussed in this section have been removed from existing benchmarking models; however some costs, such as MOBs survey costs, and confined space training, were not previously excluded. Since these factor leads to material differences in costs between companies for reasons outside management control, we have included these cost factor in in our special factor quantification in Section 5.3.

Appendix E. Labour Costs

E.1. Overview

A high proportion of utility company costs are wages, either paid to their own staff or to contractors and their sub-contractors. The nature of the work done by utilities means that much of it must be done where the assets are located and cannot be moved to a lower wage location.

There may also be additional costs faced by companies from differences in shift and/or standby arrangements required to provide a 24/7 response capability in London when their staff live outside London.

Table E.1: Labour Costs in London vs. Elsewhere in Great Britain

Cost Driver	Why London Differs from Elsewhere in Great Britain	Impact on Utility Expenditure by Category				
		Labour	*Materials*	*Equipment/ fleet*	*Other overheads*	*Cash costs*
Higher regional wages	Wages in London are higher than elsewhere in GB	Labour / hr				
Shift or standby staff Utilities are required to be able to respond to faults within fixed periods of time and must have staff in position to do this within their entire networks.	Due to low numbers of employees living in London – need a central London shift system for 24/7 coverage within required response times	Labour / hr				

E.2. Technical Background and Reason for Cost Increase

E.2.1. Higher regional wages

A high proportion of utility company costs are wages, either paid to their own staff or to contractors and their sub-contractors. The nature of the work done by utilities means that much of it must be done where the assets are located and cannot be moved to a lower wage location.

E.2.2. Shift or standby staff

Utilities are required to be able to respond to faults within fixed periods of time and must have staff in position to do this within their entire networks. In most networks, this is handled out-of-hours using a standby-model where employees go home and are available to respond from their homes if required to. Employees are paid for being “on-standby”.

For utilities with short required response times, this is not possible in London because almost none of their staff live in London. Therefore, staff must be paid to be physically present in London and ready to respond if necessary.

E.3. Evidence for Uniqueness of London

E.3.1. Higher regional wages

To test whether London wages are higher, we have used the Annual Survey of Hours and Earning (ASHE) data collected by the Office for National Statistics (ONS). This data has been used by GB utility regulators in the past to understand and account for regional wage impacts. The data is available split by geography, occupation, industry and other variables.

E.3.1.1. Definition of wages

It is appropriate to consider differences in overtime patterns when computing the differences in labour costs utilities face in different parts of the country, as overtime pay forms part of market wages for some occupations and/or companies. For instance, a particular position may be more attractive to an employee if the prospects of receiving overtime pay are greater.

ASHE data suggests there is some variation in overtime pay between different regions of the UK, and in particular, that London employees are paid more in overtime than workers in other parts of the country. However, in this report we address working patterns separately, as discussed below. We have therefore, conservatively, used reported hourly wages excluding overtime, although this means our quantification may underestimate the true effect of London labour costs.

At RIIO-ED1, Ofgem used data on gross hourly pay to control for regional wage variation. Ofwat’s PR14 and the Northern Ireland Utility Regulator’s PC15 decision both used data on gross hourly pay excluding overtime. Supporting this approach, Ofwat’s consultants (CEPA) argued that “[w]eekly pay may be capturing differences in company policies and in efficiency. For example, if employees in one company work 40 hours a week while employees in another company work 35 hours a week, doing the same job, this would mean that the weekly wages would allow for that inefficiency”.[140]

In its 2012 decision on NIE’s price control, the Competition Commission (the predecessor to the CMA) used *weekly* data, which it asserted “were more relevant to the type of salaried occupations that are relevant to the workforce of NIE and NIE Powerteam”[141]. However, we consider this is a less appropriate approach than using hourly data, as weekly data would not control for regional differences in the hours worked.

The same task would take the same number of hours across all regions of the UK if we assume labour productivity is the same. Therefore, a company in a region with shorter working hours would need either more weeks or more employees to complete the task, offsetting the lower weekly salary it pays due to shorter working hours. Alternatively, it may be that utilities have similar working practices around the UK, such that engineers employed by all utilities work similar hours across the country, even if there is regional variation in the hours worked by engineers in other industries. In any case, using weekly rather than hourly wages risks understating the wages earned by those utilities operating in regions where working hours tend to be lower, and vice versa.

E.3.1.2. Industrial and occupational classifications

The ONS classifies types of workers in the ASHE dataset using an index of Standard Operational Classifications, or “SOC codes”. SOC codes identify a range of occupational classifications, with an increasing level of granularity as the number of “digits” in the SOC code increases. For instance:

- The 1-digit SOC codes group workers by the level of responsibility and skill, ranging from SOC Code 1 “Managers and Senior Officials” to SOC Code 9 “Elementary Occupations”, with no differentiation by industrial sector;
- Adding digits to the SOC code makes the classification (and hence the associated estimates of average wages) progressively more specific to a particular type of worker. For example:
    - The “2-digit” SOC Code 52 corresponds with “Skilled metal, electrical and electronic trades”, and is a subset of the “1-digit” SOC Code 5, “Skilled trades occupations”;
    - The “3-digit” SOC Code 524 (a subset of the “2-digit” SOC Code 52) corresponds with “Electrical and electronic trades”; and
    - The “4-digit” SOC Code 5241 (a sub-set of the “3-digit” SOC Code 524) corresponds with “Electricians and electrical fitters”.

At previous price control reviews, there has been substantial debate around the granularity of data used in calculating regional labour cost differences, as the more granular codes more directly measure labour costs associated with particular roles or occupations in individual industries, but are more susceptible to data issues as the sample sizes are smaller.

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[140] CEPA (2014): *Cost Assessment – Advanced Econometric Models*, 20 March 2014, page 56

[141] CC (2014): *Northern Ireland Electricity Ltd Price Determination, Final Determination*, 26 March 2014, para 8.72.

At RIIO-ED1, Ofgem based its regional labour cost adjustment on 2-digit SOC codes, without providing any justification for this approach. Not all DNOs agreed with this approach, however, and Northern Powergrid (NPg) appealed this aspect of Ofgem's RIIO-ED1 decision to the CMA (as we ll as on two other grounds).

NPg argued that "[t]hese broad categories will not isolate differences in labour costs faced by DNOs between regions, because of compositional bias or mix issues".[142] NPg argued instead for the use of 4-digit codes. Ofgem then justified its approach by clarifying that it used 2-digit SOC codes "in order to strike a balance between using data which contained relevant occupations on the one hand and avoiding small sample sizes on the other. [Ofgem] did not use 4-digit SOC codes because that would have given rise to problems deriving from data with small sample sizes and industry bias (i.e. samples which contain a disproportionately high ratio of DNOs' own employees)".[143]

Ultimately, the CMA dismissed NPG's appeal on this ground. In doing so, it noted that "analysis of the four-digit ASHE data demonstrates that it is also at risk of error and is unstable, which suggests it may not be reliable for estimating RLAs over RIIO-ED1".[144] Although the CMA did not endorse 2-digit SOC codes as the "correct" method, it did find that "NPg did not demonstrate that [Ofgem]'s approach was wrong by reference to any of the grounds of appeal advanced by NPg".[145]

Ofwat also used 2-digit SOC codes in PR14. In particular, it used just two SOC codes: SOC code 21 (Science, research, engineering and technology professionals) and SOC code 53 (Skilled construction and building trades), with a 40% weight on the former and a 60% weight on the former, drawing on precedent from Ofgem's DPCR5.[146] In selecting the use of 2-digit codes, Ofwat chose not to use 1-digit codes because they include "occupations that are not applicable to the water and sewerage industry", and did not use 3- and 4-digit codes as they "are less robust because they rely on smaller sample sizes and may also create industry bias".[147]

The most granular approach in the decisions we have reviewed was adopted by the CC in the 2014 NIE decision. The CC used two different wage adjustments: one based on 3-digit codes and one based on 4-digit codes. The CC stated that the 3-digit adjustment "strikes a balance between including occupational categories that are relevant to the activities of NIE and GB DNOs and avoiding the risks of data error from a small sample size". On the other hand, the 4-digit adjustment "is more closely aligned than [the 3-digit adjustment] with the occupations relevant to NIE's activities, even if it does suffer from a smaller sample size".[148] At the time,

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[142] NPg (2015): *Notice of Appeal Energy Licence Modification – Sensitive Information Redacted*, para. 8.18

[143] Ofgem (2015): *Response to Notice of Appeal – Energy License Modification,* 22 April 2015, para. 207(c)

[144] CMA (2015): *Northern Powergrid (Northeast) Limited and Northern Powergrid (Yorkshire) plc v the Gas and Electricity Markets Authority—Final determination*, 19 September 2015, para. 6.73

[145] CMA (2015): *Northern Powergrid (Northeast) Limited and Northern Powergrid (Yorkshire) plc v the Gas and Electricity Markets Authority—Final determination*, 19 September 2015, para. 6.77

[146] CEPA (2014): *Cost Assessment – Advanced Econometric Models*, 20 March 2014, page 57

[147] CEPA (2014): *Cost Assessment – Advanced Econometric Models*, 20 March 2014, page 57

[148] CC (2014): *Northern Ireland Electricity Ltd Price Determination, Final Determination*, 26 March 2014, para 8.203.

NIE argued for the use of 4-digit codes, stating that the 3-digit approach is "based on an analysis of types of labour that are completely irrelevant to NIE and the GB DNOs".[149]

The Office of National Statistics (ONS) assigns a confidence grade to its wage data, grading it as "precise", "reasonably precise", "acceptable", or "unreliable for practical purposes". We have tested a variety of approaches which included four-digit SOC codes but found that these were often graded as "unreliable for practical purposes" or "acceptable". For this reason, we have not used four-digit SOC data.

The data we have used is:

- For UKPN we have used a mix of two and three-digit SOC codes, the weights of the two-digit SOC codes have been adjusted to remove any three digit SOC codes underneath them in the hierarchy that we have also used. Two-digit SOC weights should therefore be read as all other jobs not captured by the more specific three-digit codes. For instance, we have weighted "52 – electrical trades" as 7.3% of the DNO workforce and "524 – Electricians, electrical fitters" as 34.1%. Therefore 7.3% of the workforce are in the electrical trades but not classed as electricians or electrical fitters. This data is based on DNO data from ED1 and is shown in Table E.2 below.
- For Cadent and SGN we have used three-digit SOC code data collected by SGN for its Southern network at GD-1. These are shown in Table E.3 below. We have carried out sensitivity testing using the Ofgem's aggregate weights from GD1, which showed a difference of less than 0.1% in the regional labour factors for both GDNs.
- For Thames Water we have used two digit SOC codes used by Thames Water in preparing its PR19 submission which were those agreed by the Cost Assessment Working Group and which are shown in Table E.4 and Table E.5 below.

Table E.2: UKPN 2- and 3-digit SOC Weights

Description	SOC	Weight
Corporate managers and directors	11	2.0%
Other managers and proprietors	12	0.9%
Science, research, engineering and technology professionals	21	2.9%
Engineering Professionals	212	10.6%
Business, media and public service professionals	24	3.8%
Science, engineering and technology associate professionals	31	4.9%
Science And Engineering Technicians	311	5.7%
Business and public service associate professionals	35	2.5%
Administrative occupations	41	10.9%
Secretarial and related occupations	42	0.5%
Skilled agricultural and related trades	51	0.3%
Skilled metal, electrical and electronic trades	52	7.3%
Electrical Trades	524	34.1%

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[149] CC (2014): *Northern Ireland Electricity Ltd Price Determination, Final Determination*, 26 March 2014, para 8.214.

Description	SOC	Weight
Skilled construction and building trades	53	1.3%
Sales occupations	71	0.1%
Customer service occupations	72	3.0%
Process, plant and machine operatives	81	2.0%
Transport and mobile machine drivers and operatives	82	0.9%
Elementary trades and related occupations	91	6.1%
Elementary administration and service occupations	92	0.2%

Source: NERA analysis of ED1 DNO data

Table E.3 Cadent and SGN SOC Code Weights

Description	SOC	Weight
Corporate Managers And Senior Officials	111	0.5%
Production Managers	112	0.3%
Functional Managers	113	3.4%
Quality And Customer Care Managers	114	0.2%
Financial Institution And Office Managers	115	0.1%
Managers And Proprietors In Other Service Industries	123	0.1%
Engineering Professionals	212	10.8%
Information And Communication Technology Professionals	213	0.6%
Legal Professionals	241	0.2%
Business And Statistical Professionals	242	1.4%
Science And Engineering Technicians	311	17.6%
Draughtspersons And Building Inspectors	312	0.9%
IT Service Delivery Occupations	313	0.8%
Media Associate Professionals	343	0.1%
Transport Associate Professionals	351	0.1%
Legal Associate Professionals	352	0.1%
Business And Finance Associate Professionals	353	1.8%
Sales And Related Associate Professionals	354	0.2%
Public Service And Other Associate Professionals	356	1.8%
Administrative Occupations: Finance	412	0.3%
Administrative Occupations: Records	413	2.6%
Administrative Occupations: Communications	414	0.0%
Administrative Occupations: General	415	1.1%
Metal Machining, Fitting And Instrument Making Trades	522	2.5%
Vehicle Trades	523	0.0%
Electrical Trades	524	0.2%
Construction Trades	531	46.9%
Customer Service Occupations	721	0.2%
Transport Operatives And Drivers	821	0.3%

Elementary Construction Occupations	912	5.2%

Source: SGN

Table E.4 Thames Water Drinking Water Two Digit SOC Code Weights

Description	SOC	Weight
Corporate managers and directors	11	5.0%
Other managers and proprietors	12	5.0%
Science, research, engineering and technology professionals	21	14.0%
Business, media and public service professionals	24	3.0%
Science, engineering and technology associate professionals	31	19.0%
Business and public service associate professionals	35	4.0%
Administrative occupations	41	12.0%
Skilled metal, electrical and electronic trades	52	5.0%
Skilled construction and building trades	53	5.0%
Customer service occupations	72	8.0%
Process, plant and machine operatives	81	20.0%

Source: Thames Water

Table E.5 Thames Water Wastewater Two Digit SOC Code Weights

Description	SOC	Weight
Corporate managers and directors	11	5.0%
Other managers and proprietors	12	5.0%
Science, research, engineering and technology professionals	21	14.0%
Health professionals	22	–
Teaching and educational professionals	23	–
Business, media and public service professionals	24	3.0%
Science, engineering and technology associate professionals	31	17.0%
Health and social care associate professionals	32	–
Protective service occupations	33	–
Culture, media and sports occupations	34	–
Business and public service associate professionals	35	5.0%
Administrative occupations	41	12.0%
Secretarial and related occupations	42	–
Skilled agricultural and related trades	51	–
Skilled metal, electrical and electronic trades	52	8.0%
Skilled construction and building trades	53	2.0%
Textiles, printing and other skilled trades	54	–
Caring personal service occupations	61	–
Leisure, travel and related personal service occupations	62	–
Sales occupations	71	–
Customer service occupations	72	5.0%
Process, plant and machine operatives	81	21.0%
Transport and mobile machine drivers and operatives	82	3.0%
Elementary trades and related occupations	91	–
Elementary administration and service occupations	92	–

Source: Thames Water

The ASHE wage data split by SOC code is available at the regional level, though wage data at the local authority level (not split by SOC code) is also available. On balance, we have not used Local Authority-level wage data as we felt that the granularity available from the SOC data was more important than fine grained geospatial detail.

To illustrate the method, we have shown data at the SOC 1 digit level below.

Table E.6: Mean hourly wage by region and SOC

SOC Code	East	EM	London	NE	NW	Scotland	SE	SW	UK	Wales	WM	Yorkshire
1	24.4	22.0	37.9	21.6	23.3	23.5	25.3	22.4	26.6	20.1	23.7	22.7
2	22.5	21.4	26.5	21.5	21.4	21.8	22.5	21.2	22.7	21.1	21.7	21.0
3	17.8	16.7	22.7	16.3	16.8	18.3	19.4	16.8	18.6	15.8	18.3	16.7
4	12.6	11.6	16.4	11.7	12.1	13.0	13.2	12.0	12.9	12.0	12.0	11.8
5	13.0	12.8	14.4	13.0	12.9	13.2	13.5	12.6	13.1	12.7	12.9	12.8
6	9.9	9.7	11.1	9.9	9.9	11.1	10.1	9.9	10.2	9.8	9.9	9.8
7	10.3	9.8	12.1	9.8	10.4	10.3	10.5	9.9	10.4	9.8	9.9	10.0
8	11.7	11.1	14.5	11.4	11.8	11.4	12.1	11.4	11.7	10.9	11.9	11.1
9	9.6	9.5	10.2	9.6	9.6	9.6	9.9	9.6	9.6	9.4	9.5	9.4

Source: Arcadis analysis of ASHE table 3.6a (Hourly pay exc. overtime) 2018 provisional

The hourly wage premia by SOC code for the relevant regions are shown below in Table E.7.

Table E.7: Wage Premium by SOC Code and Region

SOC code	London	South East	East
1	42%	-5%	-8%
2	17%	-1%	-1%
3	22%	4%	-4%
4	26%	2%	-2%
5	10%	3%	0%
6	10%	-1%	-3%
7	17%	1%	0%
8	24%	3%	0%
9	6%	2%	0%

Source: Arcadis analysis of ASHE table 3.6a (Hourly pay exc. overtime) 2018 provisional

To understand the regional impact, we have analysed the total average wage premium, weighted by the industry appropriate SOC codes of the London, South East, and East ONS regions above the average for the UK.

Table E.8: Hourly Wage Premium over UK Average

Premium over average	Average Wage Premium, GDN weights	Average Wage Premium, UKPN weights	Average Wage Premium, Thames WW weights	Average Wage Premium, Thames DW weights
London	+18.8%	+17.8%	+21%	+21.1%
South East	+1.87%	+2%	+1.8%	+1.71%
East	-2.3%	-2.4%	-1.4%	-1.26%

Source: Arcadis analysis of ASHE table 3.6a (Hourly pay exc. overtime) 2018 provisional

In the following section on quantification, we determine the impact that these wage premia are likely to have on each company's labour costs.

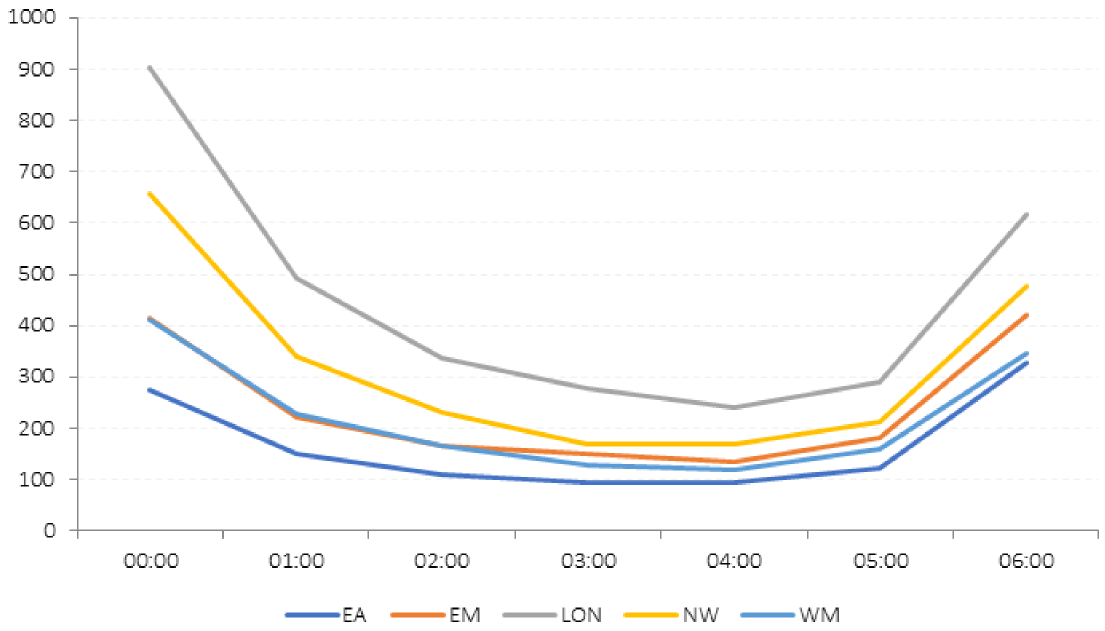
E.3.2. Shift or standby staff

UKPN operates a 24-hour response capability overall all its networks. Most areas use a standby arrangement where staff work their normal day shift and then respond to faults if required on an overtime basis. Most areas operate from 7AM to 11PM with first responders on shift and then standby / overtime basis outside those hours.

Central London operates a 24-hour staffed response and repair capability. Covering one role on a 24-hour shift pattern required 6 people (including allowances for weekends, holiday etc.) The central London team has 6 field staff on shift at all times who manage the network, interact with customers, and respond to faults. They receive a 27% basic salary uplift for working on a shift system. This has improved LPN response time from an average 120 minutes to get to site to about 40 minutes.

Cadent's London network has a greater relative volume of Publicly Reported Escapes (PREs) during the night than its other networks as shown in Figure E.8. This drives a greater volume of work into night-time hours for which Cadent must pay, either through a shift system with overall salary uplift or through over-time rates for staff working at night.

Figure E.8: Average Escapes per Hour, 2012 - 2017



Source: Cadent PRE data

Over the course of a typical year, Cadent has calculated that it requires 3,306 hours more emergency labour between the hours of 10pm and 8am in its North London network due to increased out of hours escapes as Table E.9 shows.

Cadent runs a shift system in its North London network, in its other networks and in other GDNs' emergency work at night is handled through a standby and call-out system where engineers are paid to be on standby and paid additionally if they come out to a call.

SGN pays 2x on weekend nights and 1.5x on other nights work working unsocial hours, across both it's networks.

In a previous section on traffic management, we show that a higher percentage of permits in London than elsewhere had working hours restrictions and that a higher percentage was subject to duration challenges. Both of these indicate that there are greater pressures to work overnight in London which would lead to greater overnight shift payments.

Table E.9: Excess Night-time Emergency Hours - Cadent

PRE 10pm to 8 AM		**% of total**	**London number at non-London rate**	**Excess London pa.**	**Internal**	**External**	**Excess night-time hours**
East of England	41876	6.64%					
London	44480	7.91%	36732	1550			
North West	33733	6.54%					

PRE 10pm to 8 AM		% of total	London number at non-London rate	Excess London pa.	Internal	External	Excess night-time hours
West Midlands	23081	6.32%					
All networks	143170	6.90%					
All except London	98690	6.53%					
Internal / external split					83%	17%	
London excess				1550	1286	263	
Average time to resolve (minutes)					58.7	142.2	
Excess time (hrs)					1258	624	1883

Source: Cadent PRE data

To calculate the number of excess night-time hours in London we:

- Determined the actual average number of PREs at night for each of Cadent's networks and the % of total PREs this represented over five years to 2016/17;
- Determined the number of night-time PREs that there would have been in London over that time had they only represented 6.53% (average of non-London) rather than 7.91% of all PREs;
- Subtracted this number from the actual number of night-time PREs (44,480 – 36,732 = 7,748) and divided by five to estimate the number of "excess" night-time PREs a year in London; and
- Split these PREs into internal and external PREs and apply the average time to resolve to estimate the additional time.

We found the total excess time to 1,883 hours a year

E.4. Management Control

While regional wages are not within management control, there may be a range of management strategies that utilities can deploy to manage them. This might involve factors such as those described above, including employing staff located further away and paying for their travel, or managing any inefficiency that comes with having staff located away from the region served by their network assets. For instance, whether to adopt a shift system or run a standby & call-out system for emergency response is a management decision that needs to be made in response to high London wages.

In relation to direct work, it is the nature of much of the work conducted by utilities that it must take place where the network assets are located. Reflecting this, the regional wage adjustments used by Ofgem at RIIO-ED1 assumed that 89% of the labour costs directly on the network would need to be employed locally. However, it assumed that some indirect labour could be located elsewhere. It assumed that:

- 40% of the labour costs for certain indirect activities such which are closely linked to the management of such work or for items such as depot labour costs which cannot be too far from the assets are considered to be incurred locally; and
- 0% of overhead costs are considered to be incurred locally.

Other regulators have adopted different approaches. Ofwat's methodology in PR14 involved including a regional labour variable in its benchmarking regression models. In essence, Ofwat let a statistical model decide the scale of adjustment that should be made across the companies for variation in regional labour costs. However, the coefficients it estimated on regional labour were, at least in certain models, counterintuitively negative suggesting companies in regions with higher wages have lower costs as a result.

The Utility Regulator of Northern Ireland (UR), in its determination of NIE Network's costs at RP6, in 2017, assumed that all labour must be co-located with the network, and rejected making any assumption that some labour can be outsourced to lower wage regions.[150] In particular, UR cited political pressure to "keep jobs in their area", and the need for companies' to retain control over the provision of services, as a reason why companies cannot, in practice, outsource business support and CAI activities to other regions.[151] The UR also cited evidence that every GB DNO locates its customer service centres in the region in which they operate, and that DNO groups which operate two geographically separate regions (such as SSEN and SPEN) operate call centers in both regions in which they operate.[152]

E.5. Quantification

E.5.1. Higher regional wages

In the below section on quantification, we use geospatial analysis to determine the effect of the London and South East regional wage uplifts on each relevant network.

We believe that population is the best overall proxy for work allocation however if particular material programmes of works exist with different work allocations then those could reasonably be used instead.

We determined the intersection between the Medium Super Output Areas (MSOAs) used by the ONS and the footprints of the networks, MSOAs are census units containing up to 6,000 households. The population of any MSOAs which were on boundaries were proportionately allocated based on the % of their area falling within the network boundary. We then allocated these intersected populations to the ONS regions.

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[150] UR (30 June 2017), Transmission & Distribution 6th Price Control (RP6), Final Determination, p. 114-118.

[151] UR (30 June 2017), Transmission & Distribution 6th Price Control (RP6), Final Determination, p. 115.

[152] UR (30 June 2017), Transmission & Distribution 6th Price Control (RP6), Final Determination, p. 116.

The below table shows the percentage of each network's population which is contained in each of the regions.

Table E.10: Network Population by ONS Region

	London	South East	East	Other
Cadent London (ops)	73%	12%	15%	0%
Cadent East (ops)	>1%	2%	42%	56%
SGN Southern	25%	67%	0%	8%
UKPN LPN	96%	2%	2%	0%
UKPN EPN	24%	4%	71%	1%
UKPN SPN	22%	78%	0%	0%
Thames Water WW	60%	26%	11%	3%
Thames Water W	72%	22%	4%	2%

Source: Arcadis Geospatial analysis of network operational boundaries against ONS regions and MSOA population, Thames data from Thames + Atkins analysis

The split between Cadent's London and East of England network above reflects the operational rather than the licence area boundaries. This is because parts of outer metropolitan North London are within the East of England network but are managed operationally by the London network.

Historically, 9% of the London network costs for opex are recharged to the East of England and we have therefore applied the London adjustment to 9% of the East of England wages as well.

SGN informed us that a larger percentage of work is carried out in London than indicated by population alone. We have therefore used a London regional weight of 35% for SGN.

Some portion of the total labour employed can take place anywhere and should therefore not be subject to any regional wage premium adjustment. In the past, regulators have adopted the following positions:

- At ED1, Ofgem took the position that 89% of direct costs, 40% of indirect costs, and no business support costs should be subject to regional adjustments
- Ofwat's analysis to support PR19 has assumed that 70% of all company labour costs is subject to a regional effect, although Thames Water's bottom-up analysis by SOC categories indicates that this is closer to 80%.
- For GD1, Ofgem applied an adjustment to 100% of most direct costs, 40% to work management, and 0% to business support functions.

We have adopted the Ofgem approach as it better reflects options open to management to trade-off between on-site and off-site costs.

For each company, we have adopted the same approach used by its regulator at the last price control, except that we have made an adjustment to GDN work management. Our analysis shows that 64% to 68% of work management costs are operations management costs, and we have applied regional adjustments to 60% of GDN work management costs.

We have therefore calculated regional wage premia by determining the average hourly wage for each company's regional and SOC split and comparing this to the average UK wage for that same SOC split.

Table E.11: Wage Premia

	Calculated wage premium to UK average for…			
	GDN SOC	TW WW SOC	TW DW SOC	DNO SOC
Average weighted wage for SOC	£15.54	£16.18	£16.14	£15.85
Cadent London	+12%			
SGN Southern	+6.8%			
SGN Southern (w/in M25)	+14.2%			
UKPN LPN				+14.6%
UKPN EPN				+2.8%
UKPN SPN				+5.2%
Thames Water WW		+£11.2%		
Thames Water W			+13.3%	

Source: Arcadis analysis

These wage premia apply to wages paid by the companies themselves and to wages paid by their contractors. We would expect to see these premia reflected in the rates and costs of contractors working in London, to the extent that those contractors' costs are made up of labour.

We then applied this wage premium to total wages as follows:

- For Thames Water we applied it to its calculated wage costs for AMP7 using the local / non-local labour splits which Ofgem has used in past price controls. As an alternative, we have also shown the size of the effect if either 70% or 80% of overall wage costs were subject to the calculated effects.
  - 89% of labour costs on direct activities
  - 40% of labour costs on indirect activities
  - 0% on overheads
- For UKPN we have applied the regional wage premium to each cost category using the percentages which Ofgem used at ED1 to estimate regional wage effects:
  - 89% of labour costs on direct activities
  - 40% of labour costs on indirect activities
  - 0% on overheads
- For the GDNs
  - 100%% of labour costs on direct activities

- 60% of labour costs on work management
- 0% on overheads

The table below shows Thames Water's Wastewater and Drinking Water businesses and the effect that wage premia have on overall wage spend

Table E.12: Thames Water Additional Labour Costs vs UK average (AMP7 total)

			% local labour		% local labour	
	£17/18m	*Regional premium:*		*13.3%*	*Regional premium:*	*13.3%*
Wastewater	Direct Labour	338.0	89%	40.0	80%	36.0
	Indirect Labour	293.2	40%	15.6	80%	31.2
				55.6		67.2
		Regional premium:		*11.2%*	*Regional premium:*	*11.2%%*
Drinking Water	Direct Labour	192.1	89%	19.1	80%	17.2
	Indirect Labour	444.0	40%	19.9	80%	39.8
				39.0		**57.0**

Source: Arcadis analysis of Thames Water AMP7 wage data

The below table shows a three year average of UKPN labour costs on a per annum basis and the effect that wage premia have on overall wage spend.

Table E.13: UKPN Additional Labour Costs vs UK average (per annum)

	Three year average 2017/18price base	**EPN**	**LPN**	**SPN**	**% local labour**	**EPN**	**LPN**	**SPN**
	Regional wage premium:					*2.80%*	*14.60%*	*5.20%*
Load related	Connections within the price control	8.2	10.9	4.5	89%	0.20	1.41	0.21
	Reinforcement (Primary Network)	9.0	7.4	4.0	89%	0.23	0.97	0.18
	Reinforcement (Secondary Network)	3.6	4.3	2.2	89%	0.09	0.55	0.10
	Fault Level Reinforcement	0.9	0.0	0.0	89%	0.02	0.00	0.00
	New Transmission Capacity Charges	0.0	0.0	0.0	89%	0.00	0.00	0.00
	Total load related costs	**21.7**	**22.6**	**10.7**				
Non-load capex (excluding non-op capex)	Diversions (Excluding Rail Electrification)	4.3	1.2	5.1	89%	0.11	0.16	0.23
	Diversions (Rail Electrification)	0.0	0.0	0.0	89%	0.00	0.00	0.00
	Asset Replacement	20.0	17.7	18.1	89%	0.50	2.31	0.84
	Refurbishment no SDI	0.3	0.6	0.2	89%	0.01	0.07	0.01
	Refurbishment SDI	1.6	1.7	1.4	89%	0.04	0.22	0.06
	Civil Works Condition Driven	2.4	2.7	1.1	89%	0.06	0.35	0.05
	Operational IT and telecoms	4.5	3.6	3.9	89%	0.11	0.47	0.18
	Blackstart	0.3	0.3	0.4	89%	0.01	0.04	0.02
	BT21CN	1.3	0.0	3.5	89%	0.03	0.00	0.16
	Legal & Safety	2.8	3.2	2.4	89%	0.07	0.41	0.11

	Three year average 2017/18price base	**EPN**	**LPN**	**SPN**	**% local labour**	**EPN**	**LPN**	**SPN**
	QoS & North of Scotland Resilience	0.5	0.2	0.6	89%	0.01	0.03	0.03
	Flood Mitigation	0.1	0.1	0.1	N/A	0.00	0.00	0.00
	Physical Security	0.0	0.0	0.0	N/A	0.00	0.00	0.00
	Rising and Lateral Mains	0.0	0.0	1.0	89%	0.00	0.00	0.04
	Overhead Line Clearances	3.1	0.0	2.0	89%	0.08	0.00	0.09
	Worst Served Customers	0.0	0.0	0.1	89%	0.00	0.00	0.01
	Visual Amenity	0.0	0.0	0.2	89%	0.00	0.00	0.01
	Losses	0.1	0.2	0.1	89%	0.00	0.02	0.00
	Environmental Reporting	0.4	0.3	0.3	0%	0.00	0.00	0.00
	Total non-load capex (excluding Non-op capex)	**42.0**	**31.8**	**40.4**				
Non-op Capex	IT and Telecoms (Non-Op)	8.8	6.8	6.9	40%	0.10	0.39	0.14
	Property (Non-Op)	1.3	1.4	0.5	40%	0.02	0.08	0.01
	Vehicles and Transport (Non-Op)	0.0	0.0	0.0	40%	0.00	0.00	0.00
	Small Tools and Equipment	0.0	0.0	0.0	40%	0.00	0.00	0.00
	Total non-op capex	**10.2**	**8.1**	**7.4**				
HVP	**Total high value projects**	**11.3**	**15.6**	**0.0**	**89%**	0.28	2.02	0.00
Network Operating Costs	Faults	30.3	22.8	29.1	89%	0.76	2.96	1.35
	Severe Weather 1 in 20	0.0	0.0	0.0	89%	0.00	0.00	0.00
	ONIs	11.2	8.8	11.2	89%	0.28	1.14	0.52
	Tree Cutting	3.6	0.0	5.1	89%	0.09	0.00	0.23
	Inspections	3.8	4.1	2.6	89%	0.09	0.53	0.12
	Repair and Maintenance	8.5	8.2	6.8	89%	0.21	1.07	0.32
	Dismantlement	0.1	0.0	0.0	89%	0.00	0.01	0.00
	Remote Generation Opex	0.0	0.0	0.0	89%	0.00	0.00	0.00
	Substation Electricity	0.0	0.0	0.0	89%	0.00	0.00	0.00
	Smart Metering Roll Out	2.1	1.1	1.4	89%	0.05	0.14	0.07
	Network Operating Costs	**59.5**	**45.1**	**56.2**				
Closely associated Indirects	Core CAI	81.5	75.5	52.7	40%	0.91	4.41	1.10
	Wayleaves	0.8	0.3	1.4	40%	0.01	0.02	0.03
	Operational Training (CAI)	4.7	4.0	4.3	40%	0.05	0.23	0.09
	Vehicles and Transport (CAI)	2.9	2.0	2.8	40%	0.03	0.12	0.06
	Closely Associated Indirects	**90.0**	**81.9**	**61.2**				
Business Support Costs	**Total Business Support Costs**	**30.9**	**26.8**	**21.7**	**0%**			
Other costs within Price Control	**Other costs within Price Control**	7.8	7.4	7.4	**N/A**			
Costs outside Price Control	Directly remunerated services (excluding connections, other consented activities, legacy meters and de minimis)	51.7	48.6	29.8				

Three year average 2017/18price base	EPN	LPN	SPN	% local labour	EPN	LPN	SPN
Total DNO					**4.74**	**22.17**	**6.37**
% London excess of total wages					1.7%	9.3%	3.1%

Source: Arcadis analysis of three years UKPN wage data

The tables on the following pages shows the impact on Cadent’s North London and SGN’s Southern networks based on the most recent three years of wage data.

9% of Cadent’s London network’s additional opex costs are attributable to the East of England network and should be accounted for there in efficiency assessments. The relevant items are highlighted in the table.

Table E.14: Cadent North London Additional Labour Costs vs UK Average (per annum)

			Three year average labour	% local labour	London excess
	£17/18m	*Regional wage premium:*	*12%*		
opex	Direct costs	Work Management	17.9	60%	1.29
		Work Execution	40.2	100%	4.82
	Business support costs	Excluding stores & logistics	18.4	0%	-
		Stores & logistics	0.2	100%	0.02
	Training & Apprentices	Trainees & Apprentices	3.9	100%	0.47
capex	LTS, storage and entry		10.4	100%	1.25
	Reinforcement		7.1	100%	0.85
	Governors (Replacement)		0.5	100%	0.06
	Connections		10.5	100%	1.26
	Other Capex		5.6	100%	0.68
repex	repex Iron mains Mandatory Tier 1 + <=2" steel		70.2	100%	8.42
	repex Iron mains Mandatory Tier 2A		0.5	100%	0.07
	Other: non-mandatory Mains		13.1	100%	1.57
	Other repex services		15.6	100%	1.87
	Other Services		9.2	100%	1.10
	Diversions		8.8	100%	1.05
	Sub-deducts		0.0	100%	0.00
Total			231.9		**24.77**
% of wages excess					**9.8%**

Source: Arcadis analysis of three years Cadent North London labour costs

Note: Expenditure areas we have not included in our regional labour premium analysis to avoid double counting the productivity and rate effects from Appendix A are shaded.

Table E.15: SGN Southern Additional Labour Costs vs UK Average (per annum)

			Three year average labour	**% local labour**	**London excess**
	£17/18m	*Regional wage premium:*	*6.8%*		
opex	Direct costs	Work Management	30.5	60%	1.25
		Work Execution	46.3	100%	3.15
	Business support costs	Excluding stores & logistics	18.6	0%	-
		Stores & logistics	0.3	100%	0.01
	Training & Apprentices	Trainees & Apprentices	4.3	100%	0.29
capex	LTS, storage and entry		9.9	100%	0.67
	Reinforcement		4.8	100%	0.33
	Governors (Replacement)		2.9	100%	0.20
	Connections		22.9	100%	1.56
	Other Capex		4.5	100%	0.31
repex	repex Iron mains Mandatory Tier 1 + <=2" steel		113.2	100%	7.70
	repex Iron mains Mandatory Tier 2A		1.8	100%	0.12
	Other: non-mandatory Mains		11.9	100%	0.81
	Other repex services		13.8	100%	0.94
	Other Services		9.7	100%	0.66
	Diversions		3.3	100%	0.22
	Sub-deducts		0.1	100%	0.01
Total			298.9		**18.2**
% of wages excess					

Source: Arcadis analysis of three years SGN Southern labour costs

Note: Expenditure areas we have not included in our regional labour premium analysis to avoid double counting the productivity and rate effects from Appendix A are shaded.

E.5.2. Shift or standby staff

At GD1 Ofgem disallowed additional costs due to night-time working for GDNs on the basis that it was using a regional pay adjustment based on gross wages including overtime and that this captured an element of the differential caused by requiring work in unsocial hours in London. We have made a separate adjustment for two reasons:

- We used hourly pay excluding overtime in our calculations and therefore did not capture any London-specific shift working adjustment; and
- Unsocial hours working requirements placed on GDNs are not typical of the economy as a whole: Other organisations captured in the ONS data may need to work in London using a shift or standby system but this is typical to cover planned work, for GDNs and DNOs most of the additional labour cost is due to unplanned work.

We estimated that Cadent incurs an extra 1,883 hours a year in night-time working due to the higher percentage of public reported escapes (PREs).

At the estimated uplifted regional wage of £17.41/hr, and assuming that out of hours work is remunerated at time and a half, the annual cost would be £55kif it were possible to use standby staff for this work.

Cadent has indicated to us that its actual additional costs from operating a shift scheme are 4% of total FCO labour expenditure (additional costs, after subtracting costs saved from not using call-out staff), we have calculated the effects as £0.54m pa. While this expensive per additional hour, it is important to note the following points:

- As we show in Appendix D, actual hours worked lag PRE hours. A large number of PREs occur in the early evening just before unsociable hours start and work on these will continue into unsociable hours. Our estimate of out-of-hours work is therefore conservative.
- It is not appropriate to assess FCO productivity on a cost per hour basis because companies do not schedule their work. The costs incurred reflect the statutory duty of responding to escapes on time when they happen. If there were a (hypothetical) 24 hour period with no PREs, GDNs would still be necessary to maintain a full response capability even if FCOs were less intensively utilised.

As Southern has 57% as much population within the M25 as Cadent’s North London network, we assume the same amount of emergency labour on a pro-rated basis, implying that it requires 1,073 hours of extra labour.

✂

GDN additional emergency costs due to the higher percentage of public reported escapes (PREs) are shown below.

Table E.16: GDN costs due to overnight emergencies

£17/18	Additional FCO due to higher overnight emergency volume (shifts)	Additional FCO hours at night	Cost per hour	FCO labour expenditure	Additional costs pa.
Cadent London	4%			£13.4m	£0.5400m
SGN Southern		1,073	£29.16		£0.031m

Source: Cadent additional %, FCO costs from £17/18 RRP, %FCO labour from Cadent and SGN wage data

UKPN likewise runs a shift system in central London and has a team of eight people on-call 24 hours a day. Staff receive a salary uplift of 27% for working shifts. It takes six people per on-call position to run the shift system.

On the basis that all 48 people (eight roles and six people per role) receive a 27% uplift of their wages, and that our calculation of LPN wages is an average of £18.16, the adjusted wage for these staff is £23.06 and the total pay they receive (assuming an 8 hour shift, 5 days a week, 48 weeks working in a year) is 48 x 5 x 8 x 48 x £23.06 = £2.125m.

Covering those same eight positions only during daytime hours would cost 48 x 5 x 8 x 8 x £18.16 = £278,938. If we assume that each one of the eight is called out once a week from standby and paid double-time, this will cost £13,947.

Subtracting, this means that LPN’s shift system costs approximately £1.832m per annum.

Over the last three years, UKPN has spent an average of £1.6m per year on shift allowances for its staff working at LPN which is similar to our estimate.

E.5.3. Quantification summary

Table E.17: Labour costs summary

£17/18m annual	Southern	Cadent NL	LPN	EPN	SPN	Thames DW	Thames WW
Higher regional wages	18.20	24.77	22.17	4.74	6.37	7.80	11.12
Shift system	0.00	0.54	1.6	0.00	0.00	0.00	0.00
Out of hours working	0.03	0.00	0	0.00	0.00	0.00	0.00
Total	**18.23**	**25.31**	**23.77**	**4.74**	**6.37**	**7.80**	**11.12**

Source: various as above

E.6. Impact on Comparative Performance

UK regulators generally control for differences in labour costs between regions. At its last price control decisions for Gas and Electricity, Ofgem used an pre-modelling adjustment to account for higher regional wages in London (see Section E.3.1 above); at its PR14 price control decision, Ofwat used regional wages as a cost driver in benchmarking models.

In its proposed models for PR19, Ofwat does not propose to control for differences in labour costs directly, rejecting the use of a pre-modelling adjustment or including regional wages in benchmarking models. However, Ofwat controls for density in some of its models, and since both density and regional labour are higher in London than in the rest of the country,

As an alternative to directly controlling for regulators, regulators may be able to control for differences in labour costs to some extent using density drivers; while labour costs are not directly related to density may be correlated with density drivers; because high wages will tend to attract more people to a region, and high wages may be necessary to compensate workers for high property prices in densely populated areas. However, density is not directly correlated with labour costs, since some low density rural areas experience high regional labour costs.

Since this factor leads to material differences in costs between companies for reasons outside management control, and because Ofwat's models do not control for differences in labour costs, we have included this cost factor in in our special factor quantification for Thames Water in Section 5.3.

Appendix F. Property Costs

F.1. Overview

Rents are higher in London than elsewhere, this also affects rates payable at freehold sites or sites rented at lower than market rents. Property insurance costs are linked to property rebuilding cost which is higher in London

Table F.1: Property Costs in London vs. Elsewhere in Great Britain

Cost Driver	**Why London Differs from Elsewhere in Great Britain**	**Impact on Utility Expenditure by Category**				
		Labour	*Materials*	*Equipment/ fleet*	*Other overheads*	*Cash costs*
Rent and rates of London property		Facilities management costs				Rent Rates
Insurance in London						Higher costs for terrorism cover and buildings insurance

F.2. Technical Background and Reason for Cost Increase

F.2.1. Rent and rates

Rents are higher in London than elsewhere and business rates are based on rental value and are therefore also higher than elsewhere. Properties used by utilities for operational purposes will mostly be in the following categories for rating purposes:

- CO – Offices & Premises;
- CP – Car parking within specialist property; and
- CW3 – Stores within specialist property.

F.2.2. Insurance

Insurance in London tends to be more expensive for two reasons:

- First, direct insurance premiums are higher because of the risk exposure; and
- Second, premiums can be higher indirectly due to higher costs to operate in London (for instance buildings insurance which is linked to the reinstatement value of the property.

F.3. Evidence for Uniqueness of London

F.3.1. Rent and rates

The Valuation Office Agency (VOA) collects data on rents of commercial premises for all of England and Wales. Business rates are set by multiplying the rateable value (the amount the property could be rented out for if it was on the market) by the National Don-domestic multiplier of 49.3%.

The VOA classifies properties as follows, with London rateable value premiums shown below in Table F.2:

- Offices & Premises: “Office”
- Car parking within specialist property: “Other”
- Stores within specialist property, workshops, yards: “Industrial”

Table F.2: London Rateable Value Premium 2016

Property category	London / m2	England & Wales / m2	London premium
Offices	280	153	83%
Industrial	37	68	84%
Other	78	161	106%

Source: VOA Table FS3.4, FS4.4, FS5.4 2015/16

Based on this, and depending on the balance of a particular company’s estate between offices, industrial, and other area, market rents payable for property in London will be between 83% and 106% above the England and Wales average.

Payable rates reflect prevailing market rents, even if some utility premises are on long leases.

Note that since rates are based on prevailing market rents and not rents payable, rates payable by London utilities for their premises will be 84% - 100% higher than elsewhere, regardless of whether the rents are lagging market rises.

For reference, we also reviewed the London premium going back to 2000.

Table F.3: London Rateable Value Premium 2000

Property category	London / m2	England & Wales / m2	London premium
Offices	192	116	66%
Industrial	48	29	66%
Other	113	55	106%

Source: VOA Table FS3.4, FS4.4, FS5.4 2015/16

This shows that the London property premium is longstanding and that even premises on long-running leases would be expected to be more expensive in London than elsewhere.

F.3.1.1. Cadent data

Data provided to us by Cadent for their larger depot sites shows that London costs for offices, stores, workshops and other property is much higher than for the rest of the country which is in-line with public data sources on rents and other property costs by region.

Table F.4 shows the unit costs of rent per square foot for the various categories of property relative to the average unit cost (including London).

Table F.4: Property Unit Cost by Region vs Average

	Offices	Store	Workshop	Yard Area	Land
East Anglia	-2%	235%		-65%	-24%
East Midlands	-34%	110%		18%	-34%
London	**51%**	**272%**	**76%**	**62%**	**208%**
North West	-26%	-63%	-30%		-37%
West Midlands	-32%	236%	9%	54%	
Average unit cost	0%	0%	0%	0%	0%
Excluding London	-27%	-13%	-9%	-25%	-27%
% of total estate by sq ft.	5%	11%	2%	47%	35%

Source: Cadent property costs

The data show that rents in London are substantially more expensive than other regions in every category.

For the purposes of establishing an efficient baseline cost, comparing to the average unit cost *including London* will overestimate the efficient baseline (since ¼ of the networks used to determine it is London vs 1/8 in the total national average). Comparing to the average *excluding London* will underestimate the efficient baseline as the national average does include London. We have therefore constructed an average as follows:

- 1/8 London average unit rates
- 7/8 Cadent non-London average unit rates (this assumes that the three Cadent non-London GDNs have costs broadly representative of the other four GDNs which is reasonable)

Relative to this constructed average, London's average unit rates are as below:

Table F.5: London Property Unit Rates vs National Average

	Offices	Store	Workshop	Yard area	Land
London vs. constructed average	+82%	+204%	+73%	+88%	+200%
London vs. non-London average	+106%	+329%	+93%	+115%	+320%
% of total estate by sq ft.	5%	11%	2%	47%	35%

Source: Cadent property costs

We have also shown unit rates vs the non-London average for comparison.

Cadent's London rental premium data appears to be in line with what the VOA data shows about London rents vs those in the rest of the country.

F.3.2. Insurance

Insurance costs for buildings is driven by the reinstatement value of the buildings which may be higher in London due to the costs incurred during (re)construction being higher such as access and cost of labour. Additional insurance costs also arise due to increased terrorism risk.

London postal districts have a regional factor (used for estimating the rebuilding cost of property) of 13% above the national average according to BCIS (Building Cost Information Service).

Brokers and insurance professionals have indicated that the overall cost of insurance in London is typically 20%-25% higher than elsewhere but have not been able to evidence this further.

Terrorism risk rates are determined by Pool Re (the UK's government backed terrorism re-insurance pool) by geographical zones A through D:

- Zone A relates to Central London (postcodes: E1, E14, EC1, EC2, EC3, EC4, SE1, SW1, W1, WC1 and WC2);
- Zone B relates to the rest of Inner London and to the Central Business Districts in other major cities;
- Zone C relates to the rest of England (excluding Devon & Cornwall); and

- Zone D covers Devon, Cornwall and the other countries in Great Britain.

Zones A and B attract a higher premium rate of 0.033% per £m of insured property assets vs 0.006% per £m of insured property for Zones C and D.

At this time, UKPN and Cadent buy bundled insurance through their brokers who have not been able to separately quantify these costs.

Public liability insurance is also more expensive in London due to (among other factors):

- Higher property values leading to higher “damage to property” claims;
- Density of population and property leads to greater frequency of claims arising from one incident; and
- Higher potential for financial loss claims following damage due to the very high turnover of businesses in the area – City of London.

Thames Water and SGN have likewise indicated that their insurance costs are higher in London for the above reasons.

We have adopted the 13% BCIS adjustment (which is the one for which we have the strongest evidence) this is a conservative adjustment as it only applies one of the above factors.

F.4. Management Control

Management can make choices that reduces its Central London estate but the degree to which this is possible is limited by the need to be close to the assets being maintained. We investigate whether it is realistic for management to move their depots further out in Section C.3.2.1.

The GDNs carry out some emergency response using mobile units but still require London depots for storing larger equipment and materials.

Fundamentally there is a trade-off to be made between logistical costs due to long journeys, response times, and property costs.

While utilities can conduct competitive tendering and can in some respects choose between insuring themselves against risks or self-insuring, the cost of bearing certain risks such as terrorism, as reflected in market insurance premia, is largely outside of management control.

F.5. Quantification

F.5.1. Rent and rates

We have quantified the additional rent and rates paid by Cadent below. UKPN has a limited London rented footprint, most of its London property is freehold and co-located with operational assets at large substations. Its largest rented premises in London is its headquarters in Elephant and Castle (historically a low cost part of London). We are not including this in our analysis as headquarters functions could in principle be located in lower cost areas.

To quantify Cadent's additional rent, we have done the following:

- Determined the actual rent costs per year paid for its four largest London depots (Fulham, Islington, New Barnet, and Slough) and the square foot size in each category of property;
- Repriced those costs using the average costs per square foot, determined by weighting the average of the non-London property by 7/8ths and the London property costs by 1/8 to reflect the composition of the all-GDN average;
- Determined the difference between those to calculate the London additional costs; and
- Determined the percentage uplift for the London costs.

This percentage uplift can then be used to determine London rent premiums for other utilities, if desired.

Table F.6: Cadent Additional Property Costs per Annum

Additional London costs	Offices	Store	Workshop	Yard area	Parking	Land	Total
London actual costs	658,653	77,690	38,513	302,188	22,515	200,250	1,299,809
London cost @ national average	362,086	25,540	22,283	160,547	22,515	66,704	659,675
London additional cost	296,567	52,151	16,230	141,640	0	133,546	640,134
% London additional	82%	204%	73%	88%	0%	200%	97%

Source: Cadent property costs

These costs can be scaled up appropriately to cover a price control period. For an eight-year period such as GD1 this totals £5.12m.

As above, London excess rates are calculated by applying the national average rates to the London estate and comparing with the costs payable based on the London rates. Based on the location of Cadent's London depots, 75% are in the London VOA region, 12% in the South East region and 15% elsewhere. These splits are therefore used to calculate the rates payable.

Table F.7: Excess Rates Cadent North London

	sqft	London / £ per sqft	South East / £ per sqft	Rest of England & Wales / £ per sqft	Total cost (actual)	Cost at England & Wales average	London excess
Offices	57,548	26.0	10.5	8.7	1,259,783	817,182	442,601
Industrial	597,881	6.3	4.6	3.0	3,388,192	2,032,795	1,355,397
Other business	27,000	15.0	7.2	5.9	347,787	194,400	153,387
	682,429				4,995,762	3,044,377	1,951,385
Property split		75%	12%	13%		London excess %	64%

Source: Cadent property data, VOA property rates

This shows an annual excess of £1.95m (64%) pounds for Cadent on London rates (£15.6m over an 8 year period), which can also indicate the excess London rates for other utilities as well.

UKPN spends a total of £211,955 on rates on its London properties per annum. If London costs are 64% higher than the England & Wales average then the equivalent cost based on the England & Wales average is £129,241 and the London excess is £82,714.

F.5.2. Insurance

There are Zone B properties in many networks in GB as the centres of other major cities are also covered within Zone B. UKPN and Cadent's insurance is bought on the open market or bundled and therefore the Pool RE rates cannot be applied directly although they still reflect the underlying risks.

We have adopted the 13% BCIS adjustment (which is the one for which we have the strongest evidence) this is a conservative adjustment as it only applies one of the above factors.

Table F.8 shows the calculated percentage cost uplifts over national averages and the totals in pounds where available.

F.5.3. Summary

We have summarised the additional costs due to rent and rates for Cadent and our estimate of the additional rates cost for UKPN.

Table F.8: Property Summary

£17/18m annual	Southern	Cadent NL	LPN	EPN	SPN	Thames DW	Thames WW
Rent	£0.00m	£0.64m	£0.00m	£0.00m	£0.00m	£0.00m	£0.00m
Rates	£0.00m	£1.95m[153]	£0.08m	£0.00m	£0.00m	£0.00m	£0.00m
Total	**£0.00m**	**£0.64m**	**£0.08m**	**£0.00m**	**£0.00m**	**£0.00m**	**£0.00m**

Source: Summary of above information

F.6. Impact on Comparative Performance

F.6.1. Assessment of the extent to which existing models control for operational property costs

In Ofgem's aggregate "top-down" totex models at ED1 and GD1, Ofgem controlled for MEAV (a measure of the size of the network) and in the case of ED1, customer numbers. Ofgem's aggregate models therefore only account for differences in the scale of the operation property portfolio required by different companies because of differences in the size of their network. These drivers take no account of higher unit costs for property, such as higher rents and insurance costs.

In its disaggregated modelling at ED1, Ofgem included costs related to stores, depots and offices in its "property management" category, which it assessed as part of "business support" costs. Ofgem benchmarked these costs against MEAV at the ownership group

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[153] Not included in the total as treated by regulators outside of the price control

level;[154] Ofgem's MEAV driver takes no account for differences in property costs in different regions. Ofgem excluded business rates for operational property (including depots) form its benchmarking models.

At GD1, Ofgem included property costs such as rent and rates in "property management", which it assessed as part of "business support". Ofgem benchmarked business support costs for RIIO-T1 and RIIO-GD1 jointly, at the level of ownership group.[155] Ofgem's analysis used four cost drivers related to the scale of the network, and did not distinguish between differences in property costs in different regions; Ofgem argued that differences could be avoided by an efficient company since non-operational property is not tied to a particular region.[156] Ofgem excluded insurance costs from this efficiency assessment and allowed each company's baseline insurance costs.[157]

Ofwat's draft PR19 aggregate cost models do not directly control for any cost drivers related to differences in property costs, other than differences in property costs as a result of the size of the network. However, most of Ofwat's proposed models control for a linear measure of density, which finds a positive relationship between density and costs. As we discuss in Section F.6.2 below, density is likely to be correlated with higher property costs, although may not capture London-specific insurance premia costs.

In Ofwat's PR19 disaggregated models, companies incur property costs for all elements of the value chain. Ofgem does not directly control for property costs in these models, although it does control for measures of population or network density. However, while this variable is positive (indicating costs increase with density) for most value chain elements, it is negative for others, for instance Ofwat's models find water treatment costs decrease as population density increase – see Section H.2.2); therefore this variable fails to fully capture the extent to which property costs are higher in denser areas.

F.6.2. Controlling for property costs in benchmarking models

We have not identified any drivers in benchmarking datasets which directly account for differences in property costs between companies. However, property costs are likely to be correlated with density, which may therefore be a suitable proxy of the effect of operating in a densely populated urban area such as London on companies' property costs:

- Rental costs and property values tend to be higher in urban areas, and particularly in more densely populated urban areas, such as inner-city areas. Since business rates are correlated with rental prices, business rates are also higher in more densely populated, urban areas. However, property prices in London are higher than other urban areas of comparable density, so a density driver may understate the extent to which London costs are higher.
- Insurance costs are higher in densely populated urban areas since an incident has greater probability of affecting multiple properties in a densely populated area (see Section

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[154] Ofgem (2014), RIIO-ED1: Final determinations for the slow-track electricity distribution companies – Expenditure Assessment, p. 38.

[155] Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, p. 134.

[156] Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, p. 138.

[157] Ofgem (2012), RIIO-GD1: Final Proposals - Supporting document - Cost efficiency, p. 116.

F.5.2), and are also higher in areas with higher property values. However, insurance costs associated with terrorism are likely to be higher in London than other cities of similar density, since inner-London is deemed to face higher terrorism risks that other cities.

We discuss alternative approaches to controlling for density in more detail in Appendix H.

It is possible that regulators could obtain time-series indices of non-domestic property costs or rental prices by region. The UK Ministry of Housing, Communities & Local Government has also periodically published data on land values by Local Authority since 2014, which estimates regional land values for industrial use, and for commercial use in CBDs and Out of Town locations (such as business parks).[158] An index (calculated by mapping utility companies to local authorities) would capture differences in underlying non-domestic property costs in different companies supply areas. More granular, regional, time-series data is available for domestic property costs (i.e. house prices) in different parts of the country.[159] An index of domestic property costs could be a reasonable proxy for the relationship between rental prices faced by utilities and costs, since domestic and non-domestic property prices are likely to be correlated with one another.

Empirically, property costs are also likely to be correlated with labour costs, since higher housing costs lead to higher wages, and vice versa. Therefore, a model which contains an index of labour costs as a cost driver (such as Ofwat’s PR14 totex water regression, see Section 3.3.1.1) may capture some of the difference between property costs in different regions; a pre-modelling adjustment to account for differences in labour costs would not capture differences in property costs if the share of costs to which it is applied is based on the proportion of labour in the company’s cost base..

As described in Section F.4, utility companies face a trade-off when choosing where to locate operational property: in more expensive locations closer to assets (allowing faster response times or lower travel costs), or in cheaper locations, further away from operational assets and high density urban areas (leading to slower response times or higher travel costs). Therefore, to model efficient trade-offs between level of service and costs, any model which controls for differences in property costs should also control for any differences in relevant output measures (such as response time) if there is significant variation between companies.

F.6.3. Conclusion on the impact of this cost factor on comparative performance

Existing benchmarking models do not directly control for the differences in property costs between regions, although some models contain drivers which are likely to be correlated with differences in streets between companies and regions, notably density, and thus will control for differences in companies costs to some extent. Regulators have also excluded costs related to business rates from benchmarking models.

We have not identified any existing cost drivers which can be added to benchmarking models to better control for differences in property costs, but if regulators collected an index of

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[158] Ministry of Housing, Communities and Local Government (May 2018), Land value estimates, link: https://www.gov.uk/government/collections/land-value-estimates

[159] For example, residential land prices published by the Ministry of Housing for each GB Local Authority.

regional property prices or values and mapped this onto companies’ supply areas, this variable may capture differences in property costs in different parts of the country.

Since this factor leads to material differences in costs between companies for reasons outside management control, we have included components of this cost factor which are not excluded from benchmarking models in our special factor quantification in Section 5.3.

Appendix G. The Effect of London Customers' Specific Requirements

G.1. The Effect of London Customers' Specific Requirements on Output Incentives

As we described in Section 3, customer service and customer satisfaction scores for London utilities tend to be lower than the national averages:

- In electricity, LPN reports the lowest BMCS score of all GB companies (see Section 3.1.4) while other companies in the South East of England consistently appear in the lower quartile;
- In gas, Cadent (London) reports the lowest BCMS score (see Section 3.2.4), while SGN (South) appears in the lower quartile; and
- In water, Thames Water reported the lowest SIM score in England and Wales in 2017/18, (see Section 3.3.4) while two other water companies which serve Greater London (Affinity Water and SES Water) also received scores in the lower quartile.

G.1.1. Customers in London appear to have higher 'base-level' expectations

There are two, broad reasons why customers may report lower satisfaction with their electricity, gas and water company in one part of the country than in another.

Firstly, there may be differences in the level of service or performance delivered by different companies, or by the same company in different areas. For instance, customers on LPN's interconnected Central London network are likely to experience fewer supply interruptions than customers on LPN's (and other companies') radial networks. Secondly, customers may report different customer satisfaction scores due to differences in their preferences and expectations, and not due to differences in the level of service.

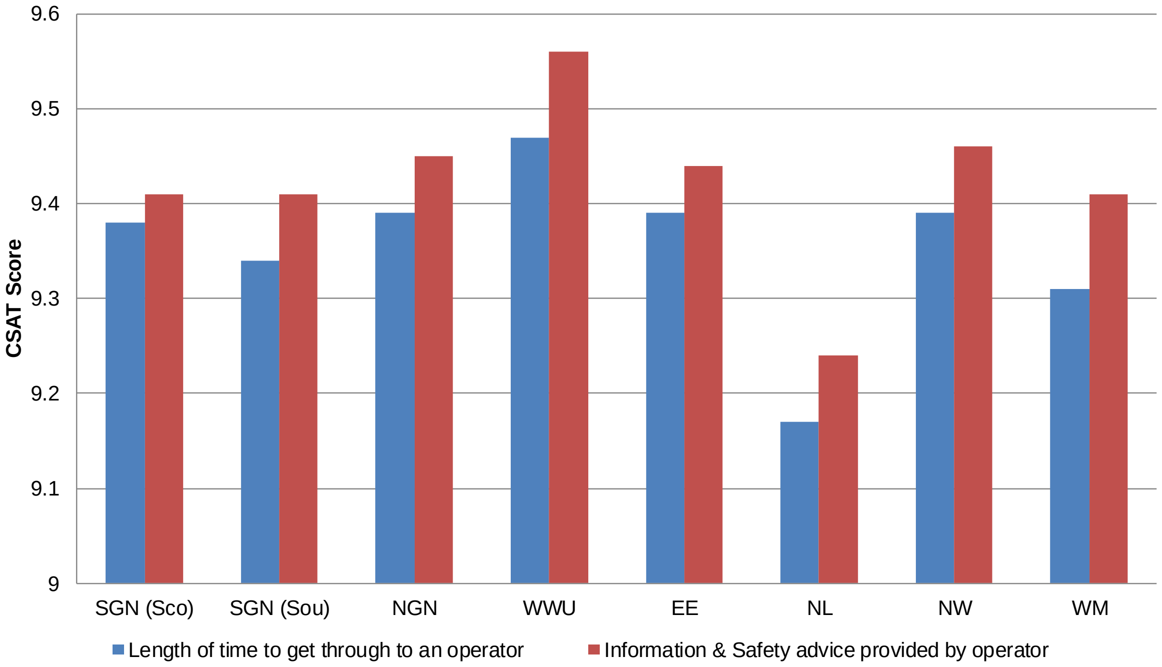
While differences in the level of service are, at least to some extent, within the control of companies, differences in customers' expectations are not under the control of companies. As a result, incentive mechanisms based on customers' reported satisfaction may be biased by differences between the expectations and preferences of their customers which are outside of companies' control.

There is evidence that customers in London and the surrounding area have higher expectations that customers in other parts of the country. Since companies cannot control customers' expectations, incentive mechanisms which are set according to national target levels may grant rewards and penalties to companies due to the characteristics of their customers and not due to the quality of service that companies provide.

As described above, Ofgem and Ofwat use customer satisfaction incentive mechanism to incentivise companies to deliver a high quality of customer service. In gas, electricity and water, customer satisfaction scores according to the BMCS and SIM measures, used by Ofgem and Ofwat respectively, are consistently amongst the lowest for London companies, and other companies operating in the South East of England tend to perform below the national average.

Strong evidence that customers in London have higher expectations than customers in other parts of the country comes from customers' reported satisfaction with the single National Gas Emergency Service, which operates a national call centre. As this is a single, national service, the same service is provided to customers in all GDN regions. Despite receiving the same service, Cadent (North London – or 'NL') customers report a lower satisfaction with the length of time to get through to an operator and the quality of information provided by the operator, than customers in other GDN regions.

Figure G.1: Gas Emergency Call Centre Satisfaction by GDN (2017/18)



Source: Cadent.

In 2016, Thames Water commissioned Deloitte to investigate Ofwat's statistical methodology in its SIM measure (see Section 3.3.3).[160] Deloitte conducted an econometric analysis of the CSAT component of the SIM, using a dataset of cross-company average CSAT scores, and a dataset of individual respondents from Thames Water's region. Deloitte found that higher income and higher wages are consistently associated with lower CSAT scores; other socio-economic characteristics which are correlated with income, such as home-ownership and socio-economic group, also tend to be associated with lower CSAT scores.[161] Deloitte therefore concluded that the PR14 SIM may award or penalise companies not only for the level of service they provide to their customers, but also for factors which are outside their control.[162]

The Deloitte study suggests that, since London has the highest average income and wages of any UK region, London customers' appear to have higher expectations on average than customers in other regions. Hence, London customers report lower scores in customer

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[160] Deloitte LLP (27 May 2016), Customer Service Incentives: statistical exploration of the water industry SIM.

[161] Deloitte LLP (27 May 2016), Customer Service Incentives: statistical exploration of the water industry SIM, p. 9.

[162] Deloitte LLP (27 May 2016), Customer Service Incentives: statistical exploration of the water industry SIM, p. 4.

satisfaction surveys for reasons beyond the control of the companies. Customer satisfaction incentive mechanisms which are based on customers' subjective response to satisfaction surveys, are biased downwards by factors outside of companies' control.

G.1.2. Performance benchmarks can be more challenging for utilities in London than utilities in other parts of the country

When utilities face investment decisions, they conduct cost benefit analysis (CBA) to determine whether an investment delivers a net present value benefit relative to the costs of carry out the investment. Since costs are higher in London (for the reasons discussed in Chapter 4), CBA is likely to support lower levels of investment in networks in London relative to other parts of the country, for a given level of benefit.

Therefore, London companies can only expect to achieve the same level of service as utilities outside London, if an investment in London is associated with a higher per-customer benefit than an investment in lower cost areas.

For example, in the water industry, companies' CBA and ODIs incorporate customer willingness to pay for changes in service; however, willingness to pay is calculated on a company-wide basis, and, in the case of ODIs, Ofwat proposes to challenge companies' on cross-company differences in their marginal benefit estimates.[163]

G.1.3. Performance metrics which may be appropriate for other utilities are not appropriate in London

As described in Section 3, Ofgem and Ofwat both operate output incentive mechanisms related to particular outputs which companies are committed to delivering, e.g. Ofgem's gas transport losses incentive, or Ofwat's ODIs for leakage or sewer flooding.

Where regulators apply financial incentives to an output, companies are incentivised to maximise reward (and avoid penalties) by ensuring they maximise performance according to the metric used to measure the output.

The units of performance measures are generally proxies of the ultimate output received by customers; for example, in the RIIO-ED1 Interruptions Incentive Scheme, the societal disruption due to a supply interruption is measured using customer interruptions and customer minutes lost. Due to company-specific factors, the extent to which the performance measure captures the true disruption faced by customers varies from company to company. Therefore, the regulators choice of performance measure may bias the level of output incentives awarded to different companies.

In London, disruption (e.g. due to supply interruptions or planned maintenance) is more likely to affect individuals who are not interrupted customers themselves.[164] This is due to the density of commercial properties, tourist attractions and transport infrastructure. Proxies of disruption (such as customer minutes lost) fail to take account of other customers affected by an interruption, and an incentive mechanism relying on this metric will fail to reward

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[163] Ofwat (2019), Initial Asessment of Business Plans, Delivering Outcomes for Customers, p 10.

[164] This is one reason why UKPN ensures a faster response to supply interruptions in Central London, as described in Section 4.

companies for the societal benefits of preventing or rectifying a supply interruption in Central London compared to other parts of the country.

G.2. Evaluation of Potential Changes to Regulators Approach to Setting Output Targets for London Utilities

In light of our findings in Section G.1, there are a number of ways regulators could change their output incentives to better take-account of London customers' requirements.

G.2.1. Allowing higher investment to provide customers in London with a higher level of service

In order to achieve higher levels of customer satisfaction, London companies could be allowed to invest more in order to provide higher levels of service.

Customers' lower levels of satisfaction compared to other regions suggests that customers in London have a higher willingness to pay for a higher quality of service. For example, in gas, London customers' lower satisfaction with emergency call centre wait times suggests London customers might be willing to pay higher bills in order to receive faster response times, unlike customers in other regions, who are more satisfied with current response times.

Similarly, since GVA per capita is higher in London,[165] the economic effect of supply interruptions (e.g. Value of Lost Load in electricity) may be larger in London than in other regions, leading to a higher willingness to pay to avoid supply interruptions, particularly amongst non-household customers, where the value of bossiness lost is likely to be higher in higher income areas.

At RIIO-ED1, Ofgem partially granted LPN a special factor to fund the cost of its Central London Strategy (see Section 3.1.2), which allows LPN to provide a faster response-time to faults in Central London. LPN's Central London Strategy addresses the particularly high Value of Lost Load for Central London customers, where supply interruptions are liable to cause particularly high economic disruption.

Where London companies are granted additional allowances to fund higher levels of service, it may be necessary to remove costs associated with this higher level of service from cost benchmarking models. This is because costs for delivering unique levels of service are not comparable between companies, and so non-workload cost-drivers will fail to take account of the additional costs a company incurs in maintaining a higher service.

G.2.2. Setting targets against historical performance rather than comparative performance

Rather than setting output targets based on comparative performance (i.e. across companies), regulators could rely on the historical performance of individual companies when setting company-specific targets. While a comparative target rewards companies who have performed well in the past, providing a long-run reward for good performance, a target relative to a company's own historical performance better reflects the extent to which underlying performance is outside of a company's control.

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[165] ONS (12 December 2018), Regional economic activity by gross value added (balanced), UK: 1998 to 2017.

Many output incentives would be suited to targets relative to historical performance. For example, Ofgem and Ofwat uses a customer satisfaction incentive to encourage improved customer service. A target set based on companies' own historical levels and rates of improvement in customer satisfaction would still provide an incentive for companies to improve performance within the price control period, with improvements reflected in updated targets set at the start of the following control period.

At PR19, Ofwat proposes to rely both on comparative targets and historical targets in its Performance Commitment guidance, for example, asking companies to target upper quartile performance for water supply interruptions and pollution incidents (a comparative target), but achieve a 15% reduction in leakage (a historical target).[166] Ofwat's ability to choose between comparative and historical performance targets when setting Performance Commitment shows that regulators can tailor their design of incentives based on the particular characteristics of the output, and thus the extent to which performance are affected by regional factors outside of companies control.

G.2.3. Setting targets which take account of London factors

Alternatively, regulators could set performance targets which take account of the effect of London customers' characteristics. In gas, electricity and water, customer satisfaction incentive targets are set according to a simple unit benchmark of companies' performance relative to one another. This method assumes that all differences in performance between companies are under the company's control, whereas an approach which takes account of regional characteristics recognises other factors which may influence performance.

For customer satisfaction incentives, regulators could improve their targets to take account of London customers' requirements by:

- Using an off-model adjustment to customer satisfaction scores to account for the extent to which "London customer characteristics" bias customer satisfaction scores; or
- Using models which control for London factors, for instance controlling for regional demographic characteristics which are expected to correlate with underlying customer expectations, e.g. income or wage.

As with special cost factors, there are tradeoffs between a simple off-model adjustment approach and a more sophisticated econometric modelling approach; while an off-model adjustment may be difficult to quantify objectively, a modelling approach may not be practical for statistical or data availability reasons.

G.3. Conclusions

As well as performing poorly in cost benchmarking models, London utilities tend to perform poorly in measures of customer service and according to customer satisfaction scores compared to utilities in other parts of the country.

Customers in London appear to have higher expectations than customers in other parts of the country, which may be driven by London customers' higher average income. Performance benchmarks which are set comparatively can be more challenging for utilities in London than

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[166] Ofwat (December 2017), Delivering Water 2020: Our final methodology for the 2019 price review, p. 54.

utilities in other parts of the country, since higher costs mean investments which are "cost beneficial" in other parts of the country are not "cost beneficial" in London. Performance metrics, which may be appropriate for utilities in other parts of the country, are not always appropriate in London, e.g. due to the large number of people indirectly affected by disruption to utilities services in Central London.

In light of these findings, regulators could better account for differences in customers' expectations and requirements in a number of ways.

Regulators could allow higher investment for London utilities to deliver higher levels of service than utilities in other parts of the country, reflecting London customers' willingness to pay for better levels of service. Regulators could set output targets against historical performance rather than comparative performance, since historical performance levels will implicitly account for differences in customers preferences. Regulators could set targets which take account of London factors, calculated, for instance, using a model which controls for regional differences in demographic characteristics.

Appendix H. Controlling for Density in Benchmarking Models

At a number of the costs assessments performed for the price control reviews surveyed in Chapter 3, Ofwat and Ofgem have recognised that the density of utilities' networks and the areas in which they operate is a driver of companies' efficient costs. Regulators' approach to controlling for density is relevant to London factors, since London is an outlier in terms of population density and network density. Indeed, many of the unique characteristics of London companies' operating conditions we have identified are related to the density of population, traffic, and urban development in London.

The vast majority of UK DNOs and GDNs operate in both rural and urban areas, and most UK cities are significantly smaller than London; for instance, London is 4-times larger than any other UK urban area. As a result, whether a benchmarking model controls for density or not, has a greater impact on the modelled costs for London companies than for most other companies.

In our evaluation of the operational factors we have descried in the sections above, we have discussed the relationship between population density and each factor, and the extent to which that factor can be controlled-for within benchmarking models by controlling for density.

In this section we discuss alternative approaches to controlling for density within benchmarking models, including the methods used by regulators at recent price controls. By better controlling for density, regulators may be able to better capture London-specific factors within econometric benchmarking models, without the need for special factors or other off-model adjustments.

There is no single, underlying relationship between density and companies' costs; instead density may affect companies' costs in either direction. Firstly, costs may increase with density due to factors related to road congestion and network congestion, and the constraints from working in densely populated areas, e.g. in finding land for depots, and carrying out construction work. Secondly, costs may decrease with density, due to factors related to travel distances, and the number of assets (both network assets and operational assets such as depots) needed to provide a given level of service, as well as other economies of scale. And as density decreases further, utilities may start to incur higher costs related to serving very dispersed population centres. Indeed, just as regulators have recognised the costs associated with serving urban areas, they have also controlled for the effect of serving remote, sparely populated areas on utilities' efficient costs.

In this section, we discuss alternative approaches regulators could use to control for density in econometric benchmarking models. While density is a relevant driver of costs in both energy and water networks, there is widest regulatory precedent for controlling for density in benchmarking models in Ofwat's models than in models developed by Ofgem. Since we have access to more recent comparative data in Ofwat's PR19 dataset, than in Ofgem's RIIO datasets, the analysis in this section is primary based on evidence from the water sector.

H.1. Controlling for Density in Existing Benchmarking Models

H.1.1. PR19 water and wastewater models

In developing benchmarking models for Ofwat at PR19, CEPA considered that there are arguments for the effect of density on costs to run in either direction.[167] CEPA tested seven different measures of population and network density:[168]

- **Total connections divided by total length of mains:** This measure of network density was used at PR14 in wholesale water models.
- **Total properties divided by total length of sewers:** This measure of network density was used at PR14 in wholesale wastewater models.
- **Ofwat weighted average density variable:** For PR19, Ofwat developed a new measure of population density using ONS data on the population density of each Local Authority District (LAD) served by a water (or wastewater) company, weighted by the number of customers in each LAD. According to Ofwat, “for two companies of the same overall density (people/km2) this measure will tend to be larger for the company that has denser LSOAs” (i.e. Lower Super Output Areas, a granular level of geographic data reporting).[169]
- **Ofwat high density explanatory variable:** This variable reflects the percentage of a company’s customers living in densely populated areas. It is also constructed using population density data at the LAD level. A given LAD is considered ‘highly dense’ if people per square kilometer is in excess of 2,000.
- **Annual urban runoff:** This wastewater explanatory variable was developed by Arup and Vivid Economics[170] to explain the variation in drainage costs, according to the hypothesis that higher level of urban runoff would lead to higher drainage costs.
- **Percentage of urban customers:** This second explanatory variable developed by Arup and Vivid Economics was constructed using ONS data on the rural-urban split of the distribution of populations and settlements.
- **Percentage of urban assets:** Arup and Vivid Economics included this third variable on the basis that assets in urban areas cost more to operate and maintain for reasons of access to networks for maintenance, the need for permissions for road/highway closures and slow traffic speeds. They specifically argued that in urban areas, treatment assets may also be constricted by land footprints and by more stringent permits on odour.

In its draft benchmarking models, Ofwat (and CEPA) rely exclusively on the first three cost drivers above, customers per length of main/sewer and “weighted average” population density.[171] Not all of Ofwat’s draft models include a density driver, and no model controls for network density and population density simultaneously.

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[167] CEPA (March 2018), PR19 Econometric Benchmarking Models, p. 122.

[168] CEPA (March 2018), PR19 Econometric Benchmarking Models, p. 122-123.

[169] Ofwat (March 2018), Cost assessment for PR19: a consultation on econometric cost modelling, p. 17.

[170] Vivid Economics and Arup. (2017), Understanding the exogenous driver of wholesale wastewater costs in England & Wales.

[171] Ofwat (March 2018), Cost assessment for PR19: a consultation on econometric cost modelling, p. 17 and p. 20.

H.1.2. Controlling for density in Ofgem's benchmarking models

In contrast with Ofwat's models, Ofgem did not directly control for density in either its aggregated or disaggregated models at RIIO-ED1 (see Section 3.1.1) and RIIO-GD1 (see Section 3.2.1).

Some of the cost drivers that Ofgem did include in its comparative benchmarking models may also capture some of the effects of density. In particular, an important driver in Ofgem's benchmarking models has been MEAV. This variable would capture the need that network companies may have for more assets or more costly assets to serve urban areas. For example, a kilometer of underground cables is more costly to install (so contributes more to MEAV) than a kilometer of overhead lines. The inclusion of this variable may therefore partially control for the effect of companies in more densely populated areas incurring higher costs.

However, the extent to which Ofgem's inclusion of MEAV in its econometric benchmarking models controls for density is extremely limited. In particular, companies serving very sparsely populated areas will also tend to have a relatively high MEAV because they require longer overhead lines to reach dispersed communities. Ofgem's assumption of a linear relationship between MEAV and expenditure therefore captures the tendency for companies with larger networks to incur higher costs, but not the specific impacts of density and sparsity on cost.

Therefore, as we describe in Sections 3.1.2 and 3.2.2, it does recognise the underlying effects of differences in density between companies and its effect on costs, by allowing special factors related to sparsity and urbanity. There is also some regulatory precedent for the use of density drivers in energy benchmarking models from the Northern Ireland Utility Regulator's recent RP6 determination for NIE Networks in 2017. The UR used two measures of network density (*properties per km of main* and *km of main per property*) in its opex models, benchmarking NIE against the GB electricity DNOs using RIIO cost and driver data for GB DNOs.[172]

H.1.3. Density drivers do not necessarily improve the robustness of benchmarking models

Despite the importance of factors related to density in determining utilities' costs, controlling for density in econometric benchmarking models does not necessarily improve the robustness or fit of models when appraised using standard measures of statistical performance, like testing whether coefficients on density drivers are statistically significant.

There are a number of reasons why density drivers may not be appropriate in a particular benchmarking model, even where there are strong grounds to expect a relationship between density and costs.

- Firstly, density measures may be correlated with other cost drivers, such as scale variables. For instance, Thames Water has the most densely populated operating area and is the largest company, as measured by connected properties and distribution input. In this case, true relationships between density and cost may be difficult identify reliably (due to a statistical phenomenon known as "multicollinearity").

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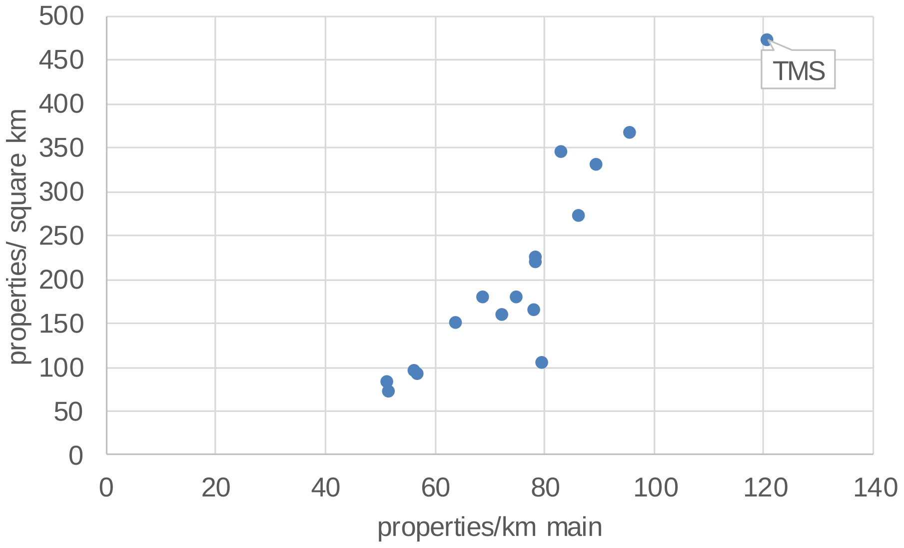
[172] UR (June 2017), Transmission & Distribution 6th Price Control (RP6) – Final Determination, p. 83.

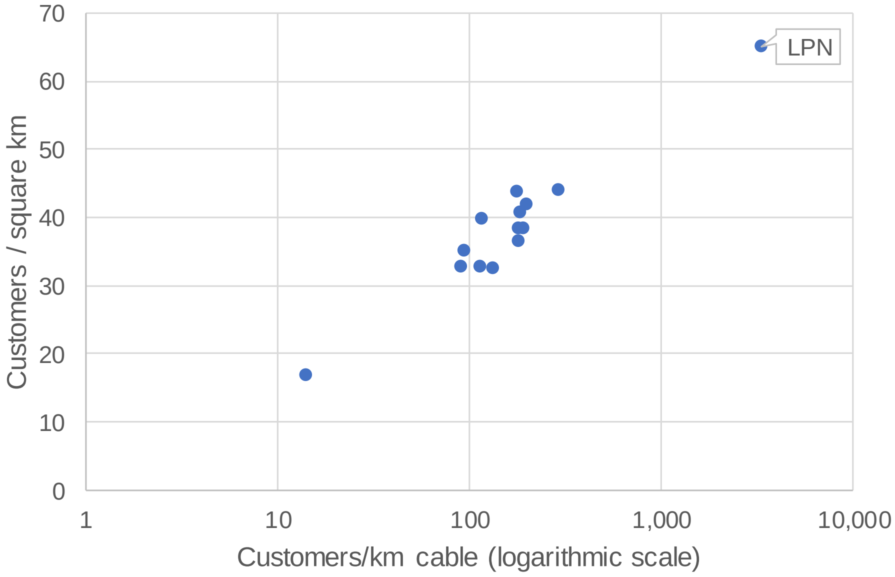
- Secondly, London companies tend to be outliers in terms of density compared to other companies (see Figure H.1 and Figure H.2, for example). London has a much higher population density than other UK regions, and most non-London utilities operate in smaller cities as well as the surrounding rural areas, so they do not operate in exclusively urban areas. There is relatively little variation in population density amongst other companies compared to London utilities, and an econometric model may be unable to separate a true relationship from statistical noise (such as variation in costs from one year to the next). Given London utilities may be outliers in density, including density drivers in models may not allow the regulatory to identify inefficiency in London companies' expenditure from the increase in costs caused by density.
- Moreover, as noted above in Section H.1.1, there are a wide range of measures of density that could possibly be included in econometric models. Given the limited cross-sectional variation in utility cost datasets (i.e. there are only 17 water companies, 10 wastewater companies, 8 GDNs and 14 DNOs), traditional econometric model selection procedures may not reliably identify the most relevant measures due to the limited number of "degrees of freedom" that would allow for the inclusion of multiple density drivers together in a single econometric model.

Figure H.1: England and Wales Water Companies by Network Density and Population Density (2017/18)



Source: NERA analysis of Ofwat data.

Figure H.2: Great British DNOs by Network Density and Population Density (2013)



Source: NERA analysis of Ofgem data.

Therefore, while density may explain much of the impact on utilities' costs from the London-specific factors identified in this report, controlling for density in benchmarking models may still not adequately capture the effect of density on companies' costs.

H.2. Alternative Methods for Controlling for Density

H.2.1. Use of alternative measures of density

The measures of density listed above in sections H.1.1 and H.1.2 capture population density (i.e. the number of people per unit of area) or network density (i.e. a measure of the size of network such as length of pipes or cables per unit of area or customer).

There are advantages and disadvantages of using both types of density measure. Population density measures are fully outside the control of companies, whereas network density measures are theoretically under the control of a utility, which can choose the capacity of network to build in a given area. However, network density measures may better capture the rate at which more densely populated areas require additional assets and capacity as population density increases. Population density measures also fail to capture high building density in non-residential areas, such as in Central London, and may not accurately capture the cost conditions facing more rural companies, if the definition of area served includes large amounts of empty countryside.

By controlling simultaneously for population density and network density, regulators may, in theory, be able fully capture the net effect of density on costs; i.e. that the compactness of the network reduces the length of pipes/cables required per customer, thus reducing costs; but that a high-density area is more likely to suffer from traffic and building congestion, increasing costs. However, these two measures are highly correlated in practice (see Section H.1.3), which may mean it is not appropriate to use both measures in the same model due to multicollinearity.

If a model controls for network density or population density alone, the driver will act as a proxy which captures the net effect of economies of scale due to network density (such as reduced travel distances), and diseconomies of scale due to congestion of people. However, a model controlling for these factors simultaneously may capture the relationships between cost and density only very approximately. For this reason, if network or population density measures are excluded from econometric models, special factor adjustments may be required to control for the costs of serving highly built-up and/or primarily non-residential areas.

H.2.2. Use of density drivers in disaggregated models

By controlling for density in disaggregated cost models, regulators can control for the extent to which the relationship between costs and density is different for different categories of cost.

Ofwat's draft PR19 models demonstrate the different effect of density on costs at different elements of the wholesale water value chain. Ofwat's water treatment models find that costs decrease as population density increase,[173] whereas in Ofwat's treated water distribution model, costs increase as population density increases.[174] This may reflect economies of scale in water treatment through high density allowing companies to have fewer, larger sites. By contrast, urbanity and congestion would tend to increase distribution network costs.

At a more disaggregated level still, the magnitude (and direction) of the relationship between density and costs may vary across different activities. For instance, in wholesale water distribution, density may be expected to reduce the cost of water pumping, since companies can use larger diameter pipes and water can travel smaller distances to reach customers, however, the cost of repairing burst pipes are higher than average in densely populated areas, due to higher costs associated with working in congested streets.[175]

H.2.3. Model a non-linear relationship between density and costs

Most regulatory benchmarking models used at recent energy and water price controls use a "log-log" model specification and a Cobb Douglas cost function,[176] where the cost relationship is estimated between the natural logarithm of costs *and* drivers. Coefficients in a log-log benchmarking model approximately estimate the percentage change in cost as a result of a percentage change in a driver, thus assuming that the relationship between costs and density is the same at each density level.

If, however, the true relationship between costs and density is not linear, i.e. if the relationship varies at different levels of density, then an alternative approach to modelling density may be appropriate.

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[173] Ofwat (March 2018), Cost assessment for PR19: a consultation on econometric cost modelling, Appendix 1 – Modelling results, p. 10.

[174] Ofwat (March 2018), Cost assessment for PR19: a consultation on econometric cost modelling, Appendix 1 – Modelling results, p. 13.

[175] Ofwat has not collected disaggregated activity-level cost data in its PR19 benchmarking dataset, preventing analysis of this relationship.

[176] See Section 3.3.1.1 for a more detailed description of the returns to scale in a Cobb-Douglas log-log model.

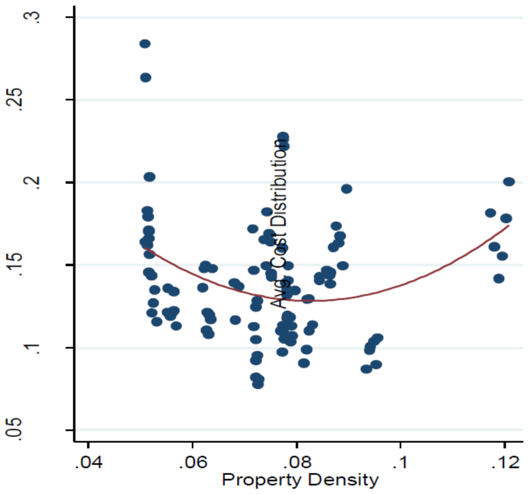
H.2.3.1. Controlling for quadratic and interaction terms

An alternative would be to model a non-linear relationship between density and costs, by adding higher order variables (e.g. quadratic variables) such as density-squared, thus estimating a U-shaped relationship. The U-shaped relationship reflects how costs initially decrease with density (since costs are high in sparse areas) and increase again as costs increase above a turning point, at which congestion begins to increase costs.

At PR14, Ofwat included squared density terms alongside other quadratic and interaction terms, according to a "translog" functional form (See Section 3.3.1.1), however Ofwat's choice of the translog model was criticised by the CMA at the Bristol Water appeal (see Section 3.3.1.2). The challenges of estimating translog models include the loss of degrees of freedom from including cross-product and higher-order terms, and multicollinearity between different cross-product and higher-order terms making coefficients hard to identify precisely, and potentially counterintuitive relationships between drivers and expenditure.

A number of GB water companies proposed squared density terms in models submitted to Ofwat's March 2018 consultation.[177] Figure H.3 below shows the relationship between unit costs (costs per million litres distributed) and property density for water distribution networks; the figure shows that at low levels of density, costs decrease with density (indicating *economies* of scale) while at higher levels of density, costs increase with density (indicating *diseconomies* of scale).

Figure H.3: Thames Water Analysis of the Relationship Between Distribution Unit Costs and Density Finds a U-Shaped Relationship



Note: Vertical Axis shows Water Distribution Base Totex per Million Litres Distributed.
Source: Thames Water.[178]

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[177] See for example, models proposed by Welsh Water, Yorkshire Water and Southern Water.

Ofwat (March 2018), Cost assessment for PR19: a consultation on econometric cost modelling, Appendix 1 – Modelling results, p. 18, 24 and 25.

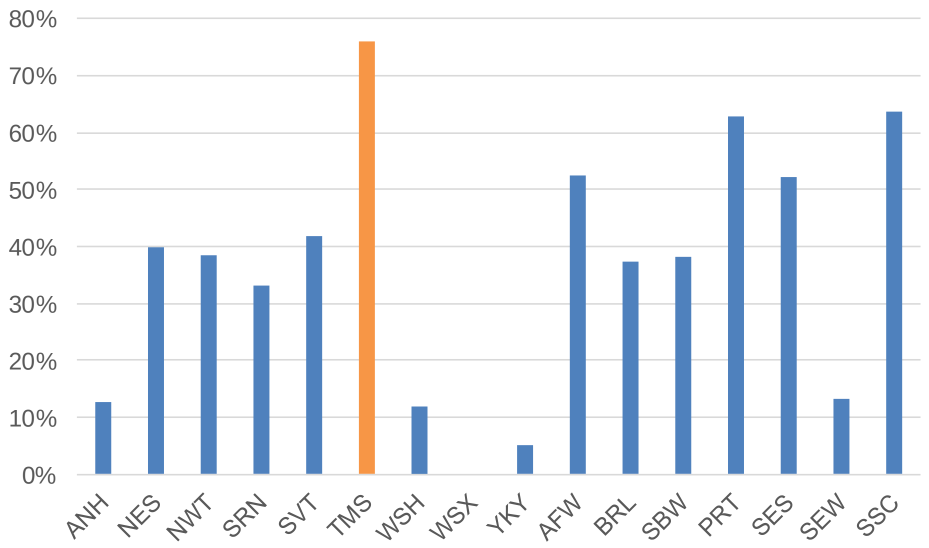
[178] Thames Water (4 May 2018), Letter to Ofwat RE *Cost assessment for PR19: a consultation on econometric cost modelling*, p. 3.

H.2.3.2. Controlling for a density "threshold"

One reason density drivers can perform poorly in econometric models is that there is limited variation in density from one company to another, when averaging out across each companies' total supply area. As Figure H.1 shows, Thames Water is an outlier in terms of network density and population density compared to all other water companies. Therefore, linear or quadratic density variables may perform poorly in econometric models, and appear statistically significant, because there is only significant variation from the mean for one of 18 companies.

An alternative to controlling for a linear density variable is to control for the proportion of a company's area which is above a certain density threshold. At PR19, Ofwat estimated the proportion of companies' areas with a population density greater than 2000 people per km^2. As Figure H.4 shows, there is more variation between the proportion of high density areas (between 0% and 75% of the companies' supply area) than there is in terms of company-wide population density shown in Figure H.1.

Figure H.4: Proportion of Population in 'High Density' Areas by Water Company



Note: 2016-17 data, "high density" defined as more than 2000 people per km^2.
Source: Ofwat PR19 data.

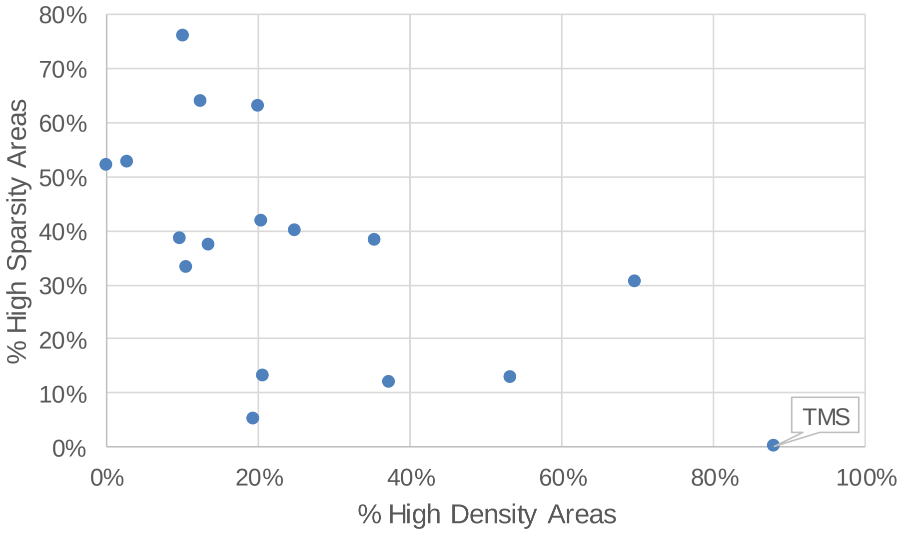
This approach to controlling for density may be attractive to regulators because it is simpler than including quadratic terms, and produces coefficients which are easier to interpret. However, this approach relies upon a subjective judgement of the level of the density "threshold" and may fail to account for differences in costs between companies with different levels of urbanity away from the 'threshold'. For instance, this driver fails to account for the different level of density in Central London and Outer London.

H.2.3.3. Controlling separately for density and sparsity

Rather than assuming a functional form for a non-linear relationship between density and costs, a model which controls simultaneously for density and sparsity may capture the extent to which both factors affect utilities' costs.

Ofwat's PR19 dataset includes variables which estimate a) the proportion of companies' area which are 'high density' and b) the proportion of companies' area which are 'low density', at a LSOA level. Figure H.5 shows the relationship between these two measures; while companies with more high-density areas tend to have fewer high sparsity areas, some companies serve regions which contain a relatively high proportion of high density and high sparsity areas, whereas others serve areas which are predominantly "medium" density.[179]

Figure H.5: Proportion of Population in 'High Density' and 'High Sparsity' by Water Company



Note: 2016-17 data.
Source: Ofwat PR19 data.

Like the approach described in Section H.2.3.2, this approach relies upon subjective judgement as to the thresholds at which costs are significantly higher than average due to sparsity and density. However, by controlling for sparsity alongside density, a model may better capture the "U-shaped" relationship between density and costs than by controlling for high density areas alone.

H.3. Conclusions

Regulators have tended to recognised that the density of utilities' networks and the areas in which they operate is a driver of companies' efficient costs, and regulators have sometimes included cost drivers which capture differences in network and population density between different companies. Regulators' approach to controlling for density is relevant to London factors, since London is an outlier in terms of population density and network density. While all regulators have considered using density drivers at recent price controls, the extent to

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[179] For example, 66% of South West Water and 76% of Yorkshire Water are classified as neither high-density or low-density.

which regulators' final models control for density has varied, in part because including density drivers does not necessarily improve the robustness of a benchmarking model.

There is no single, underlying relationship between density and costs, since some costs increase with density, while others decrease with density.; and the extent to which one factor dominates the other can be explained by the coefficient on an linear measure of density in an econometric benchmarking model.[180] Alternatively, a model which controls for a non-linear relationship between density and costs may better reflect the extent to which the opposing effects increase and decrease costs, particularly if the relationship between density and costs exhibits a "u-shape". Regulators could include non-linear measures, such as quadratic terms, or control for a density threshold (i.e. assuming that costs begin to increase with density only above a certain level of density).

However, ultimately, density is an imprecise proxy of London-factors, and including density drivers in a benchmarking model does not necessarily produce statistically reliable models.

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[180] For instance, Ofwat's water treatment models find that costs decrease as population density increase, whereas in Ofwat's treated water distribution model, costs increase as population density increases (see Section H.2.2).

Appendix I. Defining London

Throughout this report, London premia are stated as a percentage increment relative to the national average including London. This is to facilitate the use of these premia in benchmarking models. Where we have stated separately adjustments for Inner and Outer London, these are also premia over the national average including Inner and Outer London unless stated otherwise.

The following table shows the London boroughs that we have classified as Outer and Inner London.

Table I.1: ONS Definitions of Inner and Outer London Boroughs

Borough	Inner / Outer London
Barking and Dagenham	Outer
Barnet	Outer
Bexley	Outer
Brent	Outer
Bromley	Outer
Camden	Inner
City of London	Inner
Croydon	Outer
Ealing	Outer
Enfield	Outer
Greenwich	Outer
Hackney	Inner
Hammersmith and Fulham	Inner
Haringey	Inner
Harrow	Outer
Havering	Outer
Hillingdon	Outer
Hounslow	Outer
Islington	Inner
Kensington and Chelsea	Inner
Kingston-upon-Thames	Outer
Lambeth	Inner
Lewisham	Inner
Merton	Outer
Newham	Inner
Redbridge	Outer
Richmond upon Thames	Outer
Southwark	Inner
Sutton	Outer
Tower Hamlets	Inner
Transport for London	Inner & Outer

Borough	Inner / Outer London
Waltham Forest	Outer
Wandsworth	Inner
Westminster	Inner

We have captured all input data using the greatest available geographic granularity and then aggregated it back up to estimate effects for all of London and, where possible, on Inner London. Where a premium is stated for ‘London’ without qualification, this should be read to refer to the whole of London, including both Inner and Outer London.

Different data sources generally provide data at different levels of geographic granularity, and we try throughout to calculate London factors based on the most granular possible level of data and aggregate up to determine the effect on each network.

Specifically, and as explained in more detail in the preceding appendices:

- Contractor rates are usually reported per network by UKPN and Cadent. SGN records whether work is done within or outside the M25. Thames Water splits some of its contractor rates by regions. Since network boundaries do not match our definition of Inner/Outer London, we have:
  - We have taken the LPN premium over the UKPN average as an “All London” premium, as LPN extends as far North East as Theydon Bois and as far South as Bromley.
  - We have taken Cadent’s North London network premium over the group average as an All London premium.
    - Since three of Cadent’s four networks are non-London and these networks cover a wide range of areas (including the sparse East Anglia operational area but also greater Birmingham and Manchester) we have constructed an assumed national average cost in a number of cases by weighting the average of the three non-London by 7/8 and the London network by 1/8.
  - We have taken SGN’s data inside the M25 as an All London measure since this includes both inner South London and suburban outer South London.
- Where granular contractor invoices or work-order data is available, we have mapped these to Ordnance Survey co-ordinates using postcodes or other geo-data.
- Costs related to traffic management, lane rental, parking bay suspension, and similar factors are captured at the level of Highways Authorities. Each London borough has been assigned to either Inner or Outer London (see above), TfL costs are assigned to London as a whole except where they are available at a more granular resolution in which cases we have assigned them to corresponding boroughs.

Where boundaries of the data gathered do not match either of our definitions of London, we have estimated corrections based on the percentage overlap.

In many cases we have estimated the percentage of network activity and costs which take place in an area, such as at the level of counties, London boroughs, Unitary Local Authority Areas, and ONS regions (such as London, South East, East), where publicly available data we have used (e.g. traffic speeds, regional labour costs) is only available at that level. We have done this by:

- Breaking each network down to census Medium Super Output Areas (MSOAs) which are census units typically covering about 5,000 households using geospatial analysis of network boundaries;
- Using the population of these MSOAs to determine total population within the network and how it was distributed;
- Using the intersection of these MSOAs with other areas (such as Local Authorities or ONS regions) to allocate the network's population served to those areas; and
- Assuming that this population split was the best proxy for activity split in cases where we did not have more specific information

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