nationalgrid

Background

As part of our engagement in building our business plans for RIIO-T2, the four transmission network companies – National Grid Electricity Transmission, National Grid Gas, SP Transmission and SSEN Transmission – commissioned an independent consumer willingness to pay study in early 2019.

Willingness to pay research is an established way of finding out what consumers are willing to pay for changes to the services they receive. It is used widely to work out values for services that are not traded in markets, for example the value of environmental improvements. Regulators, academics and companies have been using willingness to pay in regulated utilities for over a decade, and we commissioned the study as a way of helping to establish consumers' views on a range of options which could then inform our plans.

We agreed to run one study with the other Transmission Owners so that we were all using a common methodology and all working from one set of results.

- The nature of willingness to pay methodology means that some topics are not appropriate for this type of research (for example, where there is already an established value, such as carbon pricing).
- We are publishing the results of this study in this report as part of our commitment to being open and transparent about how we have developed our business plan for our stakeholders, customers and consumers.

How we've used the results at National Grid

Willingness to pay data is useful in providing an upper limit of consumer values for service improvements, showing whether or not there is (at a high level) consumer support for options, or helping to prioritise areas of focus within our business plans.

We have used the willingness to pay results as one source of independent, robust data, which we are triangulating with the output of other consumer research, to check the appropriateness of our plan.

However, willingness to pay research has its limitations, as any research method does, and therefore we have not used the results as a direct input to cost benefit analysis or to set exact levels of spend.

We have not increased (or decreased) the size of our plan on the basis the willingness to pay findings alone.

NERA ECONOMIC CONSULTING

explain market research

Estimating Electricity and Gas Transmission Consumers' Willingness to Pay for Changes in Service during RIIO2

Prepared for National Grid Gas Transmission, National Grid Electricity Transmission, SP Transmission and Scottish Hydro Electricity Transmission

19 June 2019

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Peer Review

During this study, we were grateful to receive peer review and advice from Professor Elisabetta Cherchi of Newcastle University. We made various changes to our survey instruments and report in light of her feedback and advice. However, the content of this report is the sole responsibility of the authors from NERA Economic Consulting and Explain Market Research.

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Contents

Executive Summary

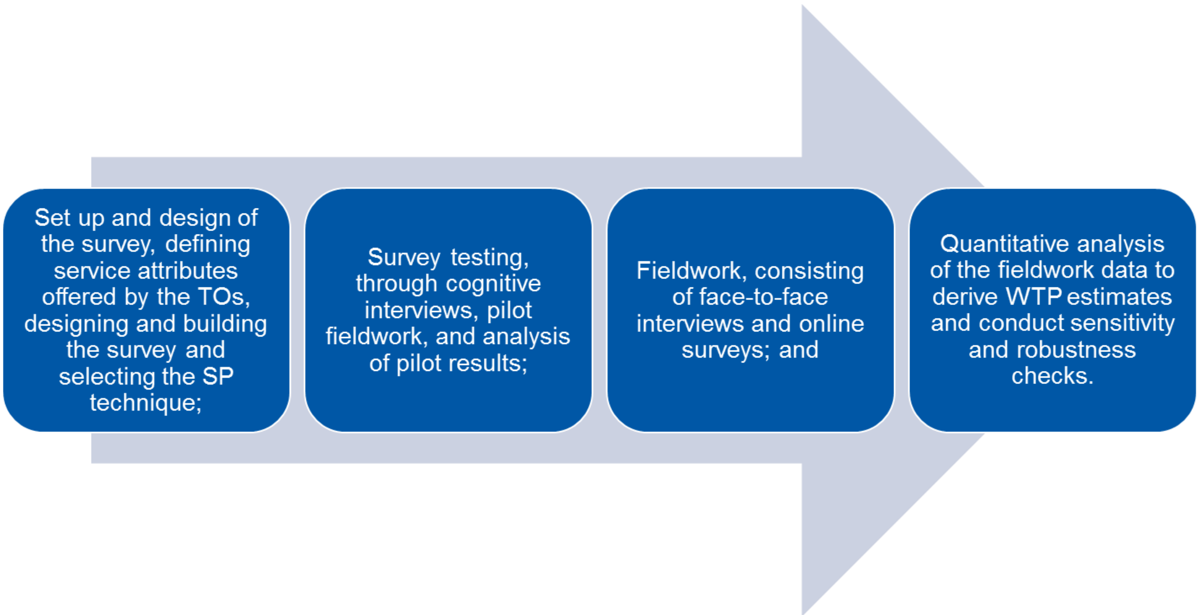
Our Assignment

NERA Economic Consulting (NERA) and Explain Market Research (Explain) were commissioned by a consortium of the four Transmission Operators (TOs) in Great Britain (National Grid Gas Transmission, National Grid Electricity Transmission, SP Transmission and Scottish Hydro Electricity Transmission) to estimate consumers' willingness to pay (WTP) for improvements in the service provided by the TOs, domestic and non-domestic gas and electricity consumers. To achieve this, we have designed, implemented and analysed the results from a series of stated preference (SP) surveys, which derive valuations from consumers' stated choices about trade-offs between changes in services provided by the TOs and changes in their energy bills.

We chose to use a stated preference approach to enable us to consider a broad spectrum of service attributes, which would not have been feasible using other techniques such as revealed preference which requires data on consumers' choices about the levels of service they demand for similar services; such data is often not available. Stated preference also has the advantage of allowing us to value the private value consumers derive from using services, as well as the altruistic or existence value they place on services provided by the TOs that bring environmental or societal benefits.

The project consisted of four main stages, summarised in Figure 1.

Figure 1: Overview of Project Process



We conducted four SP surveys, one each for domestic and non-domestic electricity and gas end users. The surveys used a mix of face-to-face and online methods, adhering to best practice in the conduct of WTP surveys. We conducted fieldwork only after a thorough process of defining attributes and testing the survey instrument.

The two electricity surveys consisted of nine attributes related to the service provided by the electricity TOs:

- Risk of power cuts;
- Time taken to recover from blackouts;
- Undergrounding of overhead lines (OHLs);
- Improving visual amenity of OHLs;
- Improving environment around transmission sites;
- Investing in innovation projects;
- Supporting local communities;
- Investing to make sure the network is ready for electric vehicle charging; and
- Investing to make sure the network is ready to connect renewable generation.

The two gas surveys consisted of five attributes related to the service provided by the gas TO, National Grid Gas:

- Risk of Supply Interruptions;
- Improving the environment around transmission sites;
- Supporting local communities;
- Investing in innovation projects to create future benefits for consumers; and
- Supporting consumers in fuel poverty.

Finally, the domestic gas surveys also tested consumers' relative preferences for five alternative heating technologies:

- Gas boilers;
- Air source heat pumps;
- Ground source heat pumps;
- District heating systems; and
- Hybrid heat pumps.

Research Method

Table 1 summarises our approach to developing the survey.

Table 1: Overview of our Survey Development Process

Robust process of iterative testing to ensure respondent understanding ↓ *Testing to ensure respondents make anticipated trade-offs when completing the survey*	▪ NERA and Explain developed an initial version of the survey instruments drawing extensively on industry best practice and our prior experience of designing stated preference studies ▪ We obtained comments on the draft survey instruments from the TOs, and, following discussion of these comments, we adjusted our initial draft to create a draft survey instrument for use in cognitive testing ▪ Based on the feedback we received from participants in cognitive interviews, we made revisions to the survey instrument before final internal testing; ▪ We obtained feedback from the peer reviewer and reflected these in revisions to our model and ▪ We then conducted a final test version of the survey instrument through pilot surveys, and again made minor changes to the instrument before proceeding to the main survey

Source: Explain and NERA.

We designed the stated preference surveys to conform with best practice in relation to stated preference research. In relation to the design of the questionnaire itself, we provided respondents with background information and context to improve the validity of their responses (e.g. the reason for conducting the research, the role of the TOs in the energy industry). We also provided detailed descriptions of service attributes through videos and other explanatory information, the content and phrasing of which was informed by focus groups conducted with consumers. Also, before asking consumers to make trade-offs between bill changes and service changes, we also reminded consumers about changes in their bill affecting the money they have available to spend on other things, and that their bills may change due to other factors. The questionnaire contained both choice experiments and a contingent valuation exercise, enabling us to understand how valuations stated for subsets of attributes change when consumers were presented with a full set of attributes in the contingent valuations.

Having designed the four surveys, we also tested them thoroughly. First, the draft survey was reviewed by the TOs and the NERA/Explain teams. We then performed cognitive testing to ensure the survey instrument was understandable and engaging to consumers. We also performed a pilot survey to validate the design of the stated preference questions.

Having conducted the survey, we also conducted a number of checks to ensure the validity of the survey data and the statistical robustness of our results. Overall, we concluded that the survey instrument performed well, providing a base estimate for the TOs' societal valuations at RIIO-T2. The evidence suggested that respondents engaged well with the instrument, and that a large majority reported that they were able to understand the attributes and make choices between packages. Only 3% of the gas respondents and 2% of the electricity respondents stated that they did not understand the services offered, and 2% of the gas respondents and 2% of the electricity respondents were not able to make comparison between services offered. These favourable performance indicators suggest our statistical analysis is unlikely to be affected by respondents' failing to understand the choices.

Our Results

As set out in Table 2 below, we then followed an econometric model estimation process to estimate "logit" models from which we derived consumers' willingness to pay for changes in the service provided by the TOs. We subjected these tests to a number of checks to examine the drivers of consumers' choices (e.g. demographic characteristics).

Table 2: Method for Econometric Model Estimation and Deriving Valuations from the Choice Experiment and Contingent Valuation Results

General-to-specific model selection procedure	▪ We started by estimating a basic model, which only controlled for service levels and bill effects. ▪ We then expanded it, following a "general to specific" modelling process, estimating multiple conditional logit models to test for the effect of respondents' demographic characteristics and other factors: – Gender, Socio-Economic Group (SEG), age, income, region, household size, family status – Research method (face-to-face vs. online), prior experience of interruptions, understanding of the services – Non-linearity in consumers' preferences ▪ We estimated a final "mixed logit" models using statistically significant factors. Where we control for consumer demographics, we estimate WTP for the population mean.
Standard procedure to avoid overstating WTP	▪ We also follow two steps to test if WTP from choice experiments is overstated by only covering some attributes of service: – We found that WTP does not depend on the statement in the survey about the "bill change for other reasons" – We compare consumers' WTP for each attribute in the Choice Experiments (CEs) to their overall WTP in the Contingent Valuation (CV) Exercise, and scale down the CE WTP results.

Source: NERA

Domestic Surveys

Using these econometric models, we find that domestic gas and electricity consumers are, on average, willing to pay for improvements in all attributes which were presented to them. We also find that the estimates of willingness to pay we obtain are statistically significant.

As is usually the case from this type of survey, we found that electricity consumers give lower valuations when they valued the whole package at once (in a contingent valuation, "CV" exercise) than when they valued trade-offs between individual attributes (in "choice experiments", or CEs). The CV exercise also suggested consumers are willing to pay less for improvements to the highest service levels. Therefore, we recommend the TOs rely upon the scaled WTP estimates presented in the Table 3below. By relying on scaled results from the CV exercises, we have followed a conservative approach to estimating willingness to pay.[1]

Table 3: Recommended Domestic Electricity Willingness to Pay Values (£/consumer/year)

Attributes	WTP (£)
Risk of powercuts	
2 hours decrease in the hours of powercuts at a 1.5% probability	7.70
4 hours decrease in the hours of powercuts at a 1.5% probability	9.70
Every fewer day to recover from a blackout	3.58
Undergrounding Overhead Transmission Lines	
20 miles additional underground in National Parks etc.	6.87
20 miles additional underground in other areas	6.46
Improving visual amenity of Overhead Transmission Lines	
Additional visual impact work in National Parks etc.	4.14
Additional visual impact work in National Parks and other areas	4.81
Additional transmission site environment improved	
25 additional sites	8.92
45 additional sites	10.78
Investing in innovation projects	
Medium Scale Projects compared to Small Scale Projects	2.38
Large Scale Projects compared to Small Scale Projects	3.11
Supporting local communities	
Current level of community activities	8.26
Current level of community activities and additional funding to charities	8.46
Investing in EV Charging Infrastructure	
Invest before definite need	9.55
Investing in infrastructure to connect to renewable generation	
Invest before definite need	11.78

Source: NERA Analysis.

We find positive WTP for all gas service attributes, shown in Table 4 below. We also find that our willingness to pay estimates are statistically significant (as in the electricity survey discussed above). In deriving these valuation estimates, we have also made methodological choices that result in relatively conservative (low) valuation results, to avoid overstating the value consumers place on service improvement.

1 We also made a number of other detailed modelling choices, described in more detail in the body of this report, and in doing so made choices that would tend to lead to relatively low valuation results. Our intention was to ensure the resulting willingness to pay estimates were conservative, and did not exaggerate the value that consumers place on service improvements.

Table 4: Recommended Domestic Gas Willingness to Pay values (£/consumer/year)

Attributes	WTP (£)
For a 1/10,000 reduction in the probability of a supply interruption.	6.71
Improving environment around transmission sites	
Additional 3 large sites and 10 small sites	3.61
Additional 11 large sites and 30 small sites	5.37
Supporting local communities	
Current level of community schemes compared to no support	4.79
Current level of community schemes and additional funding to charities and other organizations compared to no support	6.85
Investing in innovation projects	
Small scale projects compared to no innovation projects	6.05
Large scale projects compared to no innovation projects	9.40
Supporting consumers in fuel poverty	
Provide information to lower their energy bills compared to no information	1.41
Provide information to lower their energy bills and funding/financing compared to no support	5.06

Source: NERA Analysis

We also find domestic gas consumers would require, on average, alternative heating technologies to be materially cheaper than gas boilers for them to be willing, when replacing their existing boiler, to adopt an alternative technology. For instance, as Table 5 indicates, an average consumer would need an air source heat pump to be £8,966 cheaper than a gas boiler in order to switch away from a gas boiler.

Table 5: Recommended Domestic Alternative Heating Technology Willingness to Pay values (£/consumer/year)

Attributes	WTP (£)
Air Source Heat Pump instead of installing a Gas Boiler	-8965.90
Ground Source Heat Pump instead of installing a Gas Boiler	-13426.76
District Heating System instead of installing a Gas Boiler	-9099.76
Hybrid Heat Pump instead of installing a Gas Boiler	-19140.36

Source: NERA Analysis

Non-Domestic Surveys

We find non-domestic gas and electricity consumers are willing to pay for higher service across most attributes, although for some attributes (and, in some cases, for the highest service level for an attribute), non-domestic consumer's WTP is not statistically significantly different from 0, and in these cases we take a conservative approach by assuming zero WTP.

Since we conduct our non-domestic analysis in terms of percentage changes in consumers' bill (rather than absolute £ changes – as we use in the domestic survey), we monetise willingness to pay by multiplying by the median bill of respondents (see the final column of Table 6 and Table 7 below), which is conservative given the positive skew in the distribution of non-domestic consumers' bills. This approach was necessary due to the wide range of variation in non-domestic consumers' bills in monetary terms. We therefore performed the logit modelling using bill changes specified in percentage terms to reflect the survey design.

Table 6: Recommended Non-domestic Electricity Willingness to Pay values in Percentage (% bill/consumer/year) and Monetary Terms (£/consumer/year)

Attributes	WTP (%)	WTP (£)
Risk of powercuts		
2 hours decrease in the hours of powercuts at a 1.5% probability	1.20%	**43.30**
4 hours decrease in the hours of powercuts at a 1.5% probability	1.86%	**66.95**
Days to recover from a blackout		
2 fewer days to recover form a blackout	0.67%	**24.15**
Undergrounding Overhead Transmission Lines		
20 miles additional underground in National Parks etc.	1.25%	**45.02**
20 miles additional underground in other areas	1.27%	**45.90**
Improving visual amenity of Overhead Transmission Lines		
Additional visual impact work in National Parks etc.	0.76%	**27.36**
Additional visual impact work in National Parks and other areas	0.94%	**33.68**
Every additional transmission site environment improved	0.05%	**1.68**
Investing in innovation projects		
Medium Scale Projects	0.29%	**10.56**
Large Scale Projects	0.29%	**10.56**
Supporting local communities		
Current level of community activities	0.53%	**19.23**
Current level of community activities and additional funding to charities	0.53%	**19.23**
Investing in EV Charging Infrastructure		
Invest before definite need	0.90%	**32.38**
Investing in infrastructure to connect to renewable generation		
Invest before definite need	1.08%	**38.89**

Source: NERA Analysis.

Table 7: Recommended Non-domestic Gas Willingness to Pay values in Percentage and Monetary Terms

Attributes	WTP (%)	WTP (£)
For a 1/10,000 reduction in the probability of a supply interruption.	1.53%	**49.08**
Improving environment around transmission sites		
Additional 3 large sites and 10 small sites	0.31%	**9.91**
Additional 11 large sites and 30 small sites	1.13%	**36.35**
Supporting local communities		
Current level of community schemes compared to no support	1.45%	**46.65**
Current level of community schemes and additional funding to charities and other organizations compared to no support	1.70%	**54.73**
Investing in innovation projects		
Small scale projects compared to no innovation projects	1.36%	**43.74**
Large scale projects compared to no innovation projects	2.25%	**72.27**
Supporting consumers in fuel poverty		
Provide information to lower their energy bills compared to no information	0	**0**
Provide information to lower their energy bills and funding/financing compared to no support	0	**0**

Source: NERA Analysis.

Conclusions

For all four surveys, we find that consumers express a statistically significant willingness to pay for a range of service changes considered by our survey. Our WTP estimates are robust to a range of different assumptions in our modelling, for example controlling for respondent characteristics (such as demographic characteristics and firm size), as well as alternative econometric assumptions (since we use both the mixed logit and conditional logit modelling techniques).

Also, for the reasons described in this report, we have made recommendations using the stated preference research that make a very conservative assessment of the statistical evidence when estimating consumers' WTP for service improvement, particularly with regards to our assumptions about consumers' WTP for the highest levels of service.

Despite this conservative approach, we understand from our discussions from the TOs that the level of willingness to pay identified through this research exceeds the likely costs of provision by the TOs. On the face of it, this provides good evidence of an economic case for the TOs providing the services considered by the survey. However, this finding comes with a number of caveats that the TOs will need to consider during the business planning process.

- First, as further validation of the willingness to pay results, when used in business planning these WTP estimates would also benefit from being triangulated alongside other sources of valuation evidence, as well as other evidence of consumer preferences, such as qualitative research and analysis of consumers' support for business plan proposals. This reflects, for instance, cautionary guidance offered by Ofwat regarding potential overreliance on stated preference methodology.
- Even if the willingness to pay values we obtain are relatively high when compared to the costs of changing service levels, and if these findings are supported by other forms of

quantitative or qualitative engagement evidence, it would not be appropriate for the TOs to use this study as evidence that consumers support the provision of service levels that go beyond the ranges considered in this report. Hence, our valuation results should not be applied outside the ranges of service we presented to respondents on the survey instruments.

- The valuations we have estimated do not (in isolation) provide sufficient evidence to justify the TOs carrying out any particular investment or scheme. They would need to feed into more detailed cost-benefit analysis (CBA) to justify particular initiatives or investments. For instance, even if consumers are willing to pay for the TOs to invest to accommodate renewable generation or electric vehicles ahead of a definite need, the valuation we obtain could only be interpreted as an approximate budget that consumers might be willing to contribute to such investments, and does not support any particular investment project. Further technical and economic analysis would be needed to demonstrate the value of particular investments, with this willingness to pay evidence providing a cross-check and/or an input into CBA modelling.
- Finally, while our results demonstrate consumers value the service attributes covered in this research against the context of attribute descriptions that explain these services could be provided by the TOs, our analysis does not prove definitively which industry bodies should provide such support. For instance, while we have found evidence that domestic consumers are willing to pay for the TOs to provide additional support to fuel-poor consumers during RIIO-T2, our analysis does not prove conclusively that the TOs are best placed to provide additional support, or that consumers would not be equally willing to pay for other parties to deliver the same service.

For these reasons, willingness to pay studies of this sort should not be relied upon as the sole determinant of the levels of service provided by the TOs through their RIIO2 business plans. However, it does indicate whether and by how much consumers are willing to see their bill go up to fund a certain change in service, even in light of the fact they have budget constraints, and they face trade-offs with other attributes.

1. Introduction

NERA Economic Consulting (NERA) and Explain Market Research (Explain) were commissioned by a consortium of the four Transmission Operators (TOs) in Great Britain (National Grid Gas Transmission, National Grid Electricity Transmission, SP Transmission and Scottish Hydro Electricity Transmission) to estimate consumers' willingness to pay (WTP) for improvements in the service provided by the TOs, domestic and non-domestic gas and electricity consumers. To achieve this, we have designed, implemented and analysed the results from a series of stated preference (SP) surveys, which derive valuations from consumers' stated choices about trade-offs between changes in services provided by the TOs and changes in their energy bills.

We chose to use a stated preference approach to enable us to consider a broad spectrum of service attributes, which would not have been feasible using other techniques such as revealed preference which requires data on consumers' choices about the levels of service they demand for similar services; such data is often not available. Stated preference also has the advantage of allowing us to value the private value consumers derive from using services, as well as the altruistic or existence value they place on services provided by the TOs that bring environmental or societal benefits.

The project consisted of four main parts:

1. Set up and design of the survey, defining service attributes, designing and building the survey and selecting the SP technique;
2. Survey testing, through cognitive interviews, pilot fieldwork, and analysis of pilot results;
3. Fieldwork, consisting of face-to-face interviews and online surveys; and
4. Quantitative analysis of the fieldwork data to derive WTP estimates and conduct sensitivity and robustness checks and reporting.

This report proceeds as follows:

- Section 2 sets out how the TOs, Explain and NERA developed and tested a suite of attributes for gas and electricity transmission;
- Section 3 describes our approach to developing the four survey instruments,
- Section 4 describes the performance of the surveys in practice;
- Section 5 presents our quantitative analysis of the survey and our estimation of WTP; and
- Section 6 concludes.

2. Selection of Attributes for Valuation

2.1. Process for Defining the Scope of the Stated Preference Study

As set out above, the TOs commissioned us to perform a WTP study, and so the first stage of this assignment was to select the attributes of service for valuation. While the stated preference technique has a number of advantages, including its wide applicability and ability to capture the value associated with services enjoyed by both individuals and wider society, we needed to go through a process to ensure that the attributes included in the study:

- Would be useful for the TOs as part of their business planning process for RIIO-T2[2] and beyond; and
- Were likely to be successfully obtained using stated preference techniques. We decided it would be possible to value most of the attributes identified by the TOs using stated preference. However, for example, we did not value carbon emissions reductions as government guidance is available on how this should be valued.

From NERA and Explain's initial discussions with the TOs at the project inception meeting in Autumn 2018, we developed a short-list of gas and electricity attributes which were of interest to the TOs, which we subsequently refined to select those which could be valued in a stated preference survey. While some attributes were common across both electricity and gas, some were specific to the respective industries.

Based on these discussions, we developed an initial list of attributes, which Explain presented to consumers at a series of focus groups in November 2018, in order to indicate whether the attributes made sense to consumers, to assess in which units consumers would find the service attributes most understandable (while also ensuring that the results remained useful for business planning purposes), and whether consumers considered that the attributes covered the aspects of the TOs' activities which were most important to them.

Based on the findings from the focus groups, NERA, Explain and the TOs iteratively developed the shortlist of attributes for valuation into a final set of attributes: nine related to the service provided by the TOs for electricity consumers, five related to the service provided by National Grid Gas, and four related to the characteristics of heating technologies that households can use instead of gas central heating, which was also of interest to National Grid Gas. The final attributes and service levels are set out in Table 2.1 to Table 2.3 below.

For the final set of attributes, the TOs also provided us with between two and three service levels that could be achieved through decisions they are considering as part of the business planning process. In some cases, such as for reliability, these service levels spanned a range between a deterioration compared to current service and an improvement that could be achieved as part of the RIIO2 business plan. However, in some cases, attributes could either be provided by the TOs or not. The service levels either involve the TOs continuing not to provide the service, or providing service improvements (i.e. no deterioration). Table 2.1, Table 2.2 and Table 2.3 below also summarise the levels of service provided by the TOs.

[2] I.e. the price control period from 2021-2026.

Table 2.1: Electricity Service Attributes

	Risk of power cuts	**Recovering from blackouts**	**Undergrounding OHLs**	**Improving visual amenity of OHLs**	**Improving environment around transmission sites**	**Investing in innovation projects to create future benefits for consumers**	**Supporting local communities**	**Investing to make sure the network is ready for electric vehicle charging**	**Investing to make sure the network is ready to connect renewable generation**
Level 1 (low service)	Longer power cuts (1.5% chance of a 6 hour power cut each year)	Same level as now (7 days to restore power to everyone)	No additional undergrounding	No additional visual impact works	No sites improved	Small scale innovation projects focused on improving the way we do things	No community activities	Do not invest before there is a definite need for electric vehicle charging connections	Do not invest before there is a definite need for new renewable generation connections
Level 2 (mid service)	Same duration of power cuts as today (1.5% chance of a 4 hour power cut each year)	Faster restoration of power (5 days to restore power to everyone)	Up to 20 miles of additional undergrounding in National Parks, AONBs and NSAs	Additional visual impact works in National Parks, AONBs and NSAs	25 sites improved between 2021 and 2026	Medium scale innovation projects which aim to deliver benefit in up to 10 years but which come with a level of uncertainty and risk	Maintain current level of community activities	Invest before there is a definite need for electric vehicle charging connections	Invest before there is a definite need for new renewable generation connections
Level 3 (high service)	Shorter power cuts (1.5% chance of a 2 hour power cut each year)	N/A	Up to 20 miles of additional undergrounding in other areas (i.e. areas which are not National Parks, AONBs and NSAs)	Additional visual impact works in National Parks, AONBs and NSAs, as well as other rural and urban areas	45 sites improved between 2021 and 2026	Large scale, longer-term innovation projects which are more transformational and focus on creating benefit for the broader energy industry and/or wider community, but also carry a level of uncertainty and risk	Maintain current level of community activities and provide additional funding to charities and other organisations to support consumers	N/A	N/A

Table 2.2: Gas Service Attributes

Attribute	Risk of Supply Interruptions	Improving the environment around transmission sites	Supporting local communities	Investing in innovation projects to create future benefits for consumers	Supporting consumers in fuel poverty
Level 1 (low service)	Higher probability than today (1 in 5,750 households per year)	4 Large sites	No community schemes	No innovation projects	Continue as is - no proactive support
Level 2 (mid service)	Same probability as today (1 in 12,500 households per year)	7 large sites and 10 smaller sites	Maintain current level of community schemes	Small scale innovation projects focused on making our operations more efficient	Provide information, advice to achieve lower energy bills
Level 3 (high service)	Lower probability than today (1 in 13,750 households per year)	15 large sites and 30 smaller sites	Maintain current level of community schemes and provide additional funding to charities and other organisations to support consumers	Large scale innovation projects focused on benefits for third parties and consumers	Provide information, advice to achieve lower energy, funding for consumers in fuel poverty and / or low cost financing for consumers to deploy energy measures in their homes to reduce energy usage

Table 2.3: Gas Alternative Heating Technology Attributes

Name of heating technology	Ongoing running costs (£/year)	Carbon dioxide emissions	Level of disruption	Installati on costs*
Gas boiler	500	High	None	2000
Air source heat pump	700	Low	Need to replace radiators.	8000
Ground source heat pump	600	Low	In house disruption to alter radiators, and requires land and excavations to install.	14000
District heating System	850	Medium	Minimal	3500
Hybrid heat pump	700	Medium	Some. No need to replace radiators. Boiler can be retrofitted, however pipework will need to be replaced with steel.	26000

2.2. Testing of Service Attributes with Consumers

Explain conducted five focus groups with a total of 46 participants, in various locations across Great Britain, covering each of the TO operating areas.[3] The main objectives of the groups were to measure understanding of the proposed attributes, the descriptions of these attributes, and the measurements used for the attributes, and to ascertain whether there were any missing attributes that consumers identified as priorities but the TOs had not.

This initial testing of attributes with respondents supported the process of developing the survey instrument, allowing us to ensure it would be understandable to respondents, asking them to make meaningful trade-offs between bill impacts and service changes.

2.2.1. Common attributes to both gas and electricity

Two of the attributes and attribute descriptions (improving the environment around transmission sites and giving back to local communities) provided by the TOs were the same for gas and electricity, therefore we only tested these once as the outcome would have been the same regardless of whether we were talking about gas or electricity.

We drew the following conclusions in relation to the attribute “improving the environment around transmission sites”:

- 77% of participants thought it was clear what this attribute meant, suggesting it was relatively well-understood, but we did identify some specific improvements.
- 74% said they preferred the measurement by number of projects invested in rather than amount of money spent;
- It would help understanding to provide specific details on projects with before and after examples, so we added descriptions and photographs of schemes which the TOs have previously implemented; and
- While some respondents believed that measurement of this attribute would be better if shown as a percentage of sites invested in, we decided to refer to the absolute number of sites (provided in context) since the TOs proposed service levels were more easily communicable in absolute terms than in percentage terms.

In relation to the attribute “giving back to local communities”, we found that:

- 89% of participants thought it was clear what this attribute meant; and
- More detailed explanations were needed and that we needed to use simpler terms, so we elaborated with examples, and simplified the language in our description of what TOs can do to give back to local communities.

We then tested the survey instruments in a series of cognitive interviews, and sent the draft survey instrument to our academic peer reviewer for comment.

[3] Focus groups were held in Perth, Edinburgh, Manchester, Wrexham and London.

2.2.2. Electricity-specific attributes

For the attributes related to the "reliability of the electricity transmission network", which represents the risk of a transmission failure causing a wide-spread blackout that would last for several hours, we found the following from the focus groups:

- 78% of participants thought it was clear what this attribute meant, though many found the presentation of risk difficult to understand;
- 95% said they preferred the measurement of reliability to be shown as the chance per consumer of experiencing a problem, rather than chance per number of years of an event happening, so we adopted this approach in the survey design. Participants tended to prefer this risk to be shown as a percentage rather than a number, so we adopted this approach; and

We concluded that examples of what could cause a transmission power failure should be provided to aid understanding, and that the term 'household' would be more understandable than 'consumers '.

Closely related to the reliability attribute, we also tested an attribute representing how long it would take the TOs to recover from a long black-out, which could potentially last several days after an extreme event like a cyber attack:

- 91% of participants thought it was clear what this attribute meant;
- Some participants felt that the timeframe presented to them (between one and seven days) was too long, but given this reflects the type of incident on which the TOs needed to understand consumers' preferences, we retained this duration in the main survey; and
- Some participants suggested that more specific information and detailed examples should be provided, so we added information to the attribute descriptions giving real-life examples of multi-day blackouts in other countries.

We also tested two attributes related to undergrounding overhead transmission lines, which we ultimately merged into a single "undergrounding" attribute in the final survey. The first was "putting overhead lines underground in National Parks, Areas of Outstanding Natural Beauty and National Scenic Areas":

- 96% of participants thought it was clear what this attribute meant;
- Many said they would prefer the use of miles rather than kilometres, so we used miles in the survey; and
- Participants felt the use of pictures and illustrations for examples was important, so we added photographs to our attribute descriptions.

The second, "putting overhead lines underground in Sites of Special Scientific Interest and other areas":

- 64% of participants thought it was clear what this attribute meant, much less than the previous attribute on undergrounding in National Parks, Areas of Outstanding Natural Beauty and National Scenic Areas;
- Participants felt that more explanation of 'other areas', was needed, and an explanation of how sites being disturbed by undergrounding would be tackled, so we clarified that 'other

areas' meant areas which are not National Parks, Areas of Outstanding Natural Beauty and National Scenic Areas; and

- Participants felt this was too similar to the previous attribute, so we merged this into a single "undergrounding" attribute, as noted above.

Aside from undergrounding overhead lines, we also covered the alternative that the TOs can "lessen the visual impact of overhead lines in National Parks, Areas of Outstanding Natural Beauty and National Scenic Areas":

- 89% of participants thought it was clear what this attribute meant;
- When presented with alternative representations of this attribute, participants' preferred measurements were either 'number of trees planted, footpaths diverted etc' (38%), or the 'number of projects' invested in (35%). We used the 'number of projects' representation in the survey because the information about the first choice was not available;
- Participants felt that the explanations used in the focus groups would benefit from being more detailed regarding how trees could hide power lines or how public footpaths could be diverted;
- Some participants suggested that images and pictures should be used, so we added pictures of examples of visual amenity works; and
- Participants thought this attribute was repetitive following the previous two undergrounding attributes, however, the TOs required a separate valuation for alternative visual mitigation measures,[4] so in the final survey we used a single undergrounding attribute instead, minimising the repetition.

As for undergrounding, we also covered the work the TOs could do to "lessen the visual impact of overhead lines in Sites of Special Scientific Interest and other areas":

- 80% of participants thought it was clear what this attribute meant;
- Participants' preferred measurements were 'number of trees planted, footpaths diverted etc.' (38%) and 'number of projects invested in (35%). We used the 'number of projects' representation in the survey;
- As with the previous attribute, participants felt the explanation used in the focus group would benefit from being more detailed regarding how trees could hide power lines or how public footpaths could be diverted, and suggested that images and pictures should be used; and
- Again, participants thought this attribute was repetitive following the previous three attributes, but the TOs required this valuation information so we retained it.

The TOs could also "invest in innovation projects to create future benefits for consumers";

- 70% of participants thought it was clear what this attribute meant;

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4 For instance, in its critique of companies' RIIO-ED1 WTP studies for Ofgem, London Economics argued that National Grid's WTP study, which focussed on removing transmission lines, should have considered alternative measures.

London Economics (30 September 2011), Review of company surveys on consumers' willingness to pay to reduce the impacts of existing transmission infrastructure on visual amenity in designated landscapes, p. 37.

- Participants felt the examples used during the focus groups contained too much technical jargon and needed to be simpler, so we revised our language and provided more accessible examples of innovation projects; and
- Related to this, participants thought that examples of specific projects would help understanding.

The focus groups also covered potential "investments now to enable adoption of electric vehicles and renewable energy." The consequence of not making these investments is that adoption of electric vehicles and renewable generation could be slower than if the TOs do make these investments:

- 67% of participants thought it was clear what this attribute meant;
- Participants felt the description needed to be simpler;
- Participants found the description of the risk taken if the investment does not take place difficult to understand, so we revised our explanation; and
- They also suggested that more context around electric vehicles, why they are important and why investment is required would be useful.

2.2.3. Gas-specific attributes

Similar to electricity, we tested an attribute related to "reducing the risk of interruptions to the gas supply":

- 89% of participants thought it was clear what this attribute meant;
- 93% of participants preferred the measurement to be per number of consumers rather than per number of years. Hence, in the survey we used a probabilistic representation (1-in-X) representing the chance of the respondent experiencing the incident;
- Participants found the use of percentages to be the most understandable presentation of risk, but the low levels of probability of these events happening (currently 0.008%) led us to use a 1-in-X (1 in 12,500) representation as a percentage would require respondents to be comfortable with low percentages, which were zero to several decimal places; and
- Participants felt an explanation of the current level of risk was needed, which we included in the survey.

National Grid Gas could also "invest in innovation projects to create future benefits for consumers":

- 89% of participants thought it was clear what this attribute meant;
- Participants felt the description needed to be more concise and use less technical jargon, so we revised our language; and
- Participants suggested that images should be used to illustrate examples, so we added images and provided more accessible examples of innovation projects.

National Grid Gas could also "support those in fuel poverty":

- 88% of participants thought it was clear what this attribute meant;

- Some participants suggested that some of the terminology used should be explained further, so we provided additional definitions of terms such as “fuel poverty” and “green solutions”; and
- Some participants asked why this service was not currently provided, so we provided an explanation of how this service is currently only provided by other firms and organisations which interact directly with domestic end-users.

We then asked participants to think about heating methods and whether they would consider switching from a gas boiler to other methods. We described each alternative method, and then asked questions around whether each option was something the participants would consider using. Key findings were:

- The majority of participants had not considered switching to an alternative heat source;
- More information was needed before consumers could make decisions, particularly on the cost of installation and the savings achievable, as there was little prior knowledge of the options available; and
- Cost of installation and disruption were the key reasons for reluctance to switch.

Due to the lack of knowledge amongst participants, they were unable to give a lot of feedback on the different options. This demonstrated the importance of explaining the different heating technologies and the benefits of these thoroughly in the survey, which we strengthened by providing full descriptions up front, and allowing respondents to revist the descriptions once the exercises began.

2.2.4. Other consumer priorities identified through the focus groups

Aside from testing participants’ understanding and views on the attributes identified by the TOs, we also asked respondents if they thought there were any attributes missing that the TOs should consider as part of their planning process. In essence, we gave participants the opportunity to suggest other services that the TOs could provide. Participants made the following suggestions:

- Some participants suggested that the TOs should reduce costs. As this is not an attribute of service that can be valued, we did not cover it in the focus groups or in the stated preference survey. However, as we discuss in Section 3.4, consumers’ preference for lower bills can be accounted for, as the WTP instrument asks consumers to make trade-offs between service attributes and the bill they will pay over RIIO-T2. Consumers preferring lower bills to higher levels of service can express this preference through their responses to the questionnaire, and these responses will feed into our estimated WTP. Furthermore, as part of the RIIO-T2 price control review process, Ofgem will scrutinise the TOs’ cost efficiency.[5]
- Some participants suggested that the TOs should invest in greener solutions. It is not the responsibility of the TOs to invest in green sources of energy directly due to the conditions of the transmission licences, though they can influence through their activities the emissions of greenhouse gases. We recommended that the TOs use government guidance on the value of reducing greenhouse gas emissions rather than include it in this

[5] Ofgem (18 December 2018), RIIO-2 Sector Specific Methodology, p. 65-85.

stated preference study.[6] Also, the survey does cover other environmental benefits the TOs can deliver through their business planning process, such as improving the environment around transmission sites, and investing to support the uptake of renewables and electric vehicles.

- Some participants suggested that the TOs should consider health and safety for local communities. We considered that including safety attributes in a stated preference survey would not yield useful valuation information. In particular, including safety attributes might cause consumers to focus on them at the cost of ignoring other factors, and government guidance is available on the value of human life which the TOs could use to value safety attributes in any CBA related to this topic.
- Finally, some participants suggested that National Grid Gas should invest to ensure the supply of gas does not run out. We discussed this possibility with National Grid Gas, which advised the gas running out was not a credible possibility, so we did not cover it in the valuation survey.

6 BEIS (Dec 2017), Valuation of Energy Use and Greenhouse Gas: Supplementary guidance to the HM Treasury Green Book on Appraisal and Evaluation in Central Government.

3. Development of Survey Instrument

3.1. Process

Our process for developing the survey instrument relied on the guidance available from industry publications, our experience of developing survey instruments in the past, and input from the TOs. The process of developing the survey instrument followed the following stages:

1. NERA and Explain developed an initial version of the survey instruments drawing extensively on industry best practice and our prior experience of designing stated preference studies;
2. We obtained comments on the draft survey instruments from the TOs, and, following discussion of these comments, we adjusted our initial draft to create a draft survey instrument for use in cognitive testing;
3. Based on the feedback we received from participants in cognitive interviews, we made revisions to the survey instrument before final internal testing;
4. We then conducted a final test version of the survey instrument through pilot interviews with domestic gas and electricity consumers, and again made minor changes to the instrument before proceeding to the main survey;
5. We obtained and accounted for feedback from the peer reviewer at both the survey design stage, as well as on the draft version of this report, which we have accounted for in this version of the document.

In developing and implementing the surveys and valuation research, we sought to identify and conform with best practice in performing this type of research. There is no single definition of what constitutes best practice in performing stated preference research, so we have drawn on our experience of performing this type of research in the past, and in particular on the extensive track record of valuation research in the UK water industry, where the regulatory framework is similar to that applicable to energy networks. However, we have also reviewed guidance on survey design and WTP methods prepared in other industries and contexts.[7]

However, while we have sought to follow best practice in the design of survey instruments, it is also important to recognise that recent surveys of best practice also stress that prescriptive rules are not appropriate for SP research,[8] and indeed water companies' attempts to follow guidance narrowly and inflexibly at PR14 (the 2014 water price review) led to unreliable valuation research outcomes.[9] We have therefore interpreted good practice identified in other settings with caution, recognising this specific context.

In the rest of this section, we describe the survey instrument in more detail.

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7 For example: Department for Transport (DfT) (2016). Understanding and Valuing Impacts of Transport Investment; *and* HM Treasury / DWP (2011), Valuation Techniques for Social Cost-Benefit Analysis: Stated Preference, Revealed Preference and Subjective Well-Being Approaches.

8 ICF Consulting for CCWater (7 June 2017), Improving willingness-to-pay research in the water sector, p. 41.

9 UKWIR (2014) Post-PR14 Customer Engagement, Communications and Education.

3.2. Structure of Surveys

The four surveys were each structured in a similar way in order to conform to good practice on stated preference survey design, although the questions (and information and instruction presented to respondents) differed according to gas and electricity consumers, and domestic and non-domestic consumers. Our final surveys (included in Appendix F) consisted of the following sections:

1. Screener questions to establish whether the participant was eligible to take part.

We first ensured that the respondent was responsible for paying the energy bill (or, in the case of businesses, was responsible for making decisions related to the energy bill). We did this to minimise the hypothetical bias associated with the trade-offs consumers make when responding to choice experiment and contingent valuation questions.

2. Demographics used to meet quotas

Secondly, we asked for demographic characteristics (e.g. age and gender) which we could use to track quotas and close surveys with respondents from over-represented groups (see Section 4.2). Targeting a representative survey in this way ensures our valuation results are representative of the population served by the TOs.

3. Introduction to the TOs and their role

We described the electricity/gas TOs and described their role in the energy system, thus ensuring that respondent understood that they are "customers" of the TOs (in the sense that they pay an energy bill which – in part – funds services provided by the TOs) despite paying their bills to their electricity suppliers. This aspect of the questionnaire is important for providing context and ensuring respondents make meaningful choices in response to our survey questions.

4. Background to how energy is used in the home and how much is spent on energy bills

To provide further context, we asked respondents whether they had experienced supply interruptions and about how they use energy in the home/business (e.g. heating and cooking), providing us with data which we could test sensitivities around average WTP; followed by questions about a respondent's typical bill, which we used in the choice experiments themselves, as we explain in Section 3.4 below.

5. Explanation of where bill goes and projected changes to cost of bills on an individual level based on participants' current bill costs

We also described how an energy bill is attributable to different parts of the energy supply chain, and the proportion of consumers' bills which are paid to the TOs. We then described to consumers how energy bills are likely to increase over RIIO-T2 (see Section 3.7 below).

6. Exercises

Each survey consisted of between one and three types of exercise: electricity surveys consisted of three exercises, the gas domestic survey consisted of two exercises, and the gas non-domestic survey consisted of one exercise. Each exercise consisted of the following three sections:

A. Videos explaining attributes

We began by describing the attributes to respondents. Rather than providing traditional "show cards" to describe the attributes, we provided descriptions using videos with photographs, diagrams and a voice-over explaining the attribute, as we summarise in Section 3.5.2 below. This approach was an attempt to make the survey more engaging than the alternative of asking respondents to read a significant amount of material.

B. Instructions for exercises

Before the choice experiments, in accordance with good practice in order to ensure respondents' choices respect their budget constraints and trade-offs with other goods and services on which they could spend their income, we provided instructions explaining that respondents should select their preferred package. We reminded respondents that they should make their decisions while taking account of their overall financial situation, e.g. reminding them that other bills may increase, that money paid in energy bills cannot be spent on other goods and services, and that energy bills will increase by inflation irrespective of their choices. In providing these reminders, we reduce the extent of "hypothetical bias" which may cause respondents to overstate their WTP because, for example, they may not believe they would actually pay higher bills.

C. Choice cards

Each respondent was asked to repeat each exercise five times with different choice cards each time. We describe our choice cards in Section 3.5.3 below. We selected this number of repetitions of the exercise as a compromise between maximising the data gleaned from the survey against the cognitive burden placed on respondents from answering a large number of questions.

7. Validation questions on understanding of attributes/exercises

After all exercises, we asked respondents a series of validation questions to understand how respondents understood the attributes and the exercises, for instance, we ask respondents if they had experienced supply interruptions, if they understood the attributes, and if they believed the low probability events could 'actually' happen. We summarise respondents' responses in Section 4.3 below.

In the cognitive stage of testing, by going through the survey more slowly and face-to-face, we were able to ask questions to evaluate respondents' comprehension and identify scope for improvement (see Appendix G). We implemented a number of improvements in light of this. However, it was not practical to ask these open-ended comprehension questions throughout the survey, as it would have interrupted respondents' focus on the choice exercises, extended the length of the survey and increased cognitive burden.

8. Further demographics not used for quotas

We collected final demographic characteristics at the end of the survey. With the exception of data required to "filter out" respondents according to quotas, we placed most demographic questions at the end of the survey, when respondents level of engagement and attention may be lower.

3.3. Stated Preference Technique

3.3.1. We rely primarily on choice experiment and contingent valuation methods

There are two main techniques for Stated Preference (SP) valuation, Contingent Valuation (CV) and Choice Experiments (CE- also known as discrete choice experiments).[10] Both techniques are well established in the academic literature, to value various market and non-market benefits, and in policy applications, e.g. to value improvements in utilities' service. The objective of CV and CE methods is to estimate consumers' maximum WTP for improvements in service relative to some baseline. The maximum that people are willing to pay provides an economic measure of its value.

CE questions value marginal changes in specific aspects of service, as well as (by summation) valuing whole packages of service. By contrast, the CV technique is focused on valuing one particular scenario so is suited primarily to situations where estimates of total benefits of a package of service improvements are needed.

A CE question asks respondents to make a choice between a number (2 or more) of packages of service. One of the attributes of each package is always the cost or bill (referred to as the 'payment vehicle' – see below), and because of this the implicit monetary valuation respondents place on the attributes that make up the packages can be established. CV analysis values the whole set of attributes together. It can only be used to derive estimates for the whole package of service attributes rather than for individual service attributes.

The CE and CV methods are extremely well-established means of valuing non-market goods, including in the context of utilities.[11] Hence, our surveys draw primarily on the CE methodology. In the electricity survey where we have a larger number of attributes to value, we also conduct a CV experiment to test whether consumers value the whole package of attributes differently from the individual attributes valued through the CEs.

In the electricity surveys we employ a hybrid form of CV analysis which has been commonly used in the UK water sector to elicit valuations for a large number of related attributes. It is a hybrid approach because, while it does offer the respondent the choice between alternative packages of service levels covering all the attributes in the survey, it does so using a choice card with two packages of service levels to choose from which is more typical of CEs. Therefore, strictly speaking, our "CV" exercise is different from the usual CV exercise and in certain respects is closer to a CE exercise. Nevertheless, we refer to it as a "CV" exercise throughout as a means of distinguishing it from the CE exercises.

Including the CV exercise provides reassurance that our final recommendations are based on a conservative approach, that accounts for the lower stated valuation obtained when

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10 ICF Consulting for CCWater (7 June 2017), Improving willingness-to-pay research in the water sector, p. 17.

11 UKWIR (2011) Carrying-out Willingness-to-pay Surveys, Report 11/RG/07/22, p. 1.

respondents consider all attributes together as we explain below.[12] In the gas survey we do not conduct a CV experiment, due to the small number of attributes we needed to value.

3.3.2. We considered alternative methods

As part of recent price control reviews, some UK utilities have implemented more innovative stated preference techniques that seek to address some of the practical challenges they have faced in the past when implementing stated preference research to inform their business planning decisions. For instance, a known limitation of both CE and CV SP methods is that results tend to vary depending on the respondent's recent experiences (e.g. if the survey is undertaken immediately after supply interruptions), as well as on the type of questions posed to consumers and the background information provided (e.g. about the nature of disruption caused by a supply interruption).[13] Similarly, evaluation of the WTP programmes of England and Wales water companies at Ofwat's PR14 price control review, indicated that many companies' research experienced the same pitfalls, leading to significant variation in companies' WTP estimates for reasons beyond differences in consumer preferences.[14] Drawing from the experience from PR14, a UKWIR study in 2014 found that one of the main problems with traditional stated preference was the use of scenarios which were "too complex, not real-world and too abstract".[15]

As part of developing our stated preference instrument, we considered but did not implement the following alternative forms of CV:

- 'Payment Card Contingent Valuation' (PCCV), in which respondents are asked to choose an amount from a 'payment card' for a package of all the service attributes. However, this approach tends to understate willingness to pay, because it forces respondents to focus on the bill and draws attention away from the attribute and service levels. For this reason, we decided not to use it.
- 'Dichotomous Choice Contingent Valuation' (DCCV), where respondents are presented with a bill amount and asked if they would be willing to pay that much for a package of service interruptions (i.e. rather than choosing between two, alternative packages). While simpler for respondents, the disadvantage here is that only one piece of data (one yes/no answer) is obtained from each respondent.

We also considered using some of the more innovative techniques being deployed by other utilities, but chose not to do so on this occasion. The main reason for this is that, we were asked to conduct a single WTP study on which the TOs planned to rely for business planning. While there is a large body of existing valuation evidence upon which water companies can rely should more innovative methods prove unreliable or inconsistent, such a body of existing work does not exist in the electricity and gas sectors. Hence, we applied "tried and tested" techniques that have their foundations in established literature with a track record of practical application. Hence, we considered but did not use:

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12 UKWIR (2011) Carrying-out Willingness-to-pay Surveys, Report 11/RG/07/22, p. 53-55.

13 HM Treasury / DWP (2011) "Valuation Techniques for Social Cost-Benefit Analysis: Stated Preference, Revealed Preference and Subjective Well-Being Approaches", p.35

14 See, for example, United Utilities (2016), Improving Customer Research and Engagement, p. 8.

15 UKWIR (2014) "Post-PR14 Customer Engagement, Communications and Education".

- The "max-diff" method, or "best-worst" scaling, which involves presenting consumers with a range of possible options (such as a series of changes in service and a change in the bill); they are then invited to select their "most favoured" and "least favoured" option from the list. However, given the limited track record of its implementation, and the TOs' need for valuations that are estimated using methods grounded in "best practice" indicated by established literature, we did not use this.
- Similarly, some utilities have developed a CE stated preference tools that rely on sliders, through which consumers can select their desired levels of service for each attribute from a range, making a trade-off between higher levels of service and bill impacts. However, these tools have typically only been implemented in as experimental projects, and (in our experience) only relied on by UK utilities as a cross check to other more established methods.
- Adaptive Choice-Based Conjoint Analysis (ACBC), an approach similar to traditional CE (i.e. conjoint analysis), but which differs in that it generates a *personalised* multi-stage survey for each respondent, such that the conjoint analysis each respondent participates in is tailored to the responses and preferences of the individual.[16] The benefit of this approach is that the trade-offs presented are adjusted to the choices made by individual respondents. This may reduce cognitive burden, and allow better tailoring of each experiment around the real WTP of each respondent. However, the problem is that this kind of design generates "endogeneity", an econometric model that needs to be corrected when estimating the discrete choice models from which we calculate willingness to pay.

As a result of the criticisms of the SP methods used in UK regulatory contexts, we carried out robust testing of our survey instrument and attribute descriptions to ensure that respondents were able to understand the attributes and engaged fully with the survey. As described above, based on cognitive testing and focus group feedback, we used videos to introduce the attributes, and, in the choice experiments themselves, we improved the design of the choice cards to help respondents make their choices based on the differences between packages, as we discuss in Section 3.5.3 below. We also simplified language wherever possible and robustly tested that respondents were able to understand the attributes and the choices that they were asked to make in the CE and CV exercises.

3.4. Defining the Payment Vehicle

To obtain reliable valuations, it is important that the manner by which respondents are told they will pay for service improvements (the payment vehicle) is something respondents think they would actually have to pay and could not avoid. Otherwise, respondents may not reveal their true valuations.[17] Additionally, respondents must be aware and able to see that others,

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[16] The ACBC approach has been applied to pharmaceuticals research, where it consisted of a multistage process, beginning with a "build your own" exercise, where respondents choose their preferred level across all attributes individually, followed by a screener section, where the tool must identify attribute service levels which respondents always chose and those which respondents never chose, followed by a "choice tournament", with a format similar to traditional SP, but with packages tailored based on the respondents' own "must-haves" and "have-nots".

Cunningham, C. et. al. (2010), "Adaptive Choice-Based Conjoint Analysis A New Patient-Centered Approach to the Assessment of Health Service Preferences", The Patient: Patient-Centred Approach to the Assessment of Heath Service Preferences, 3(4), p. 260.

[17] ICF Consulting for CCWater (7 June 2017), Improving willingness-to-pay research in the water sector, p. 41.

in this case other electricity/gas consumers, will also pay for service improvements, so that they do not base their answers on concerns about fairness instead of their own benefit values.

In the case of improvements in the TOs' service, the most plausible payment vehicle is the electricity/gas bill.[18] Paying for improvements in the TOs' service would clearly be credible to a respondent and would minimise fairness issues because the payment would be collected from the constituency that would benefit from the improvements – although, for some attributes, there will be some difference in the level of benefits from improvements received by different consumers.

In the second gas exercise, which relates to alternative heating technologies, we use installation costs as the payment vehicle. The upfront cost of installing a heating technology is a credible cost that would typically be paid by a gas consumer when changing their boiler.[19]

For economic valuation of service changes, we require that respondents state values that they would actually be willing to pay. Therefore, as described above, our survey reminds respondents that higher energy bills (and more expensive heating technologies) mean they will have less money to spend on other things. To ensure respondents are in this mindset, the survey asks respondents to make their choices taking into account all the other things they could do with the money.

3.5. Experimental Design

3.5.1. The structure of our stated preference exercises

We describe the selection of packages to be included in the survey's choice cards as the 'experimental design'. In each CE and CV exercise, we showed respondents two packages, as described above. Neither package necessarily related to the current status quo, even if the bill level is "no change", thus avoiding a 'status quo bias', where respondents systematically choose the 'status quo' bill and service levels to avoid making a choice, rather than making trade-offs between costs and service levels.

Each attribute had between two and three possible service levels, and there are therefore many possible combinations of these service levels and the bill effect presented on the choice cards. The combinations of levels assigned to packages A and B appearing on each choice card were generated by random sampling from a full factorial design. A full factorial design makes use of every single possible package that could be put on the choice cards as package A or B i.e. every possible permutation of service levels for each of the attributes.

To increase the information recovered during the survey, all combinations of packages A and B which would lead to the inclusion of a 'dominated' option on a choice card (be that package A or B) were removed from the list of all possible combinations. A package is

[18] Specifically, changes in TOs service will affect the network charges end-users pay via their bills with their electricity suppliers.

[19] Best practice guidance in the water sector also sets out how bill level may not be an appropriate payment vehicle when considering large, specific impacts on individual customers. See UKWIR (2011) Carrying-out Willingness-to-pay Surveys, Report 11/RG/07/22, p. 22.

'dominated' if the other package shown on the choice card has an equal or better level of service for all attributes, and the bill is lower.

For the second exercise in the gas survey, which asked consumers to compare alternative heating technologies, we did not randomise the levels of specific attributes of the heating technology (e.g. the ongoing running costs, the level of disruption), but instead randomised which two alternative heating technologies consumers considered on any single choice card (i.e. the service levels per heating technology were fixed, with the exception of installation costs, the payment vehicle – see Section 3.4). Compared to the other questions, where we randomise all service levels, without creating 'dominated options' as explained above, we randomise only installation costs subject to the installation costs shown to the respondent being no greater than actual estimated installation costs, and no less than the estimated cost of a gas boiler. For instance, the estimated installation cost of an air source heat pump (provided to us by National Grid Gas) is £8,000, and we randomised this so it could take values between £2,000 and £8,000.

For the final electricity exercise, the CV exercise, we constrained the options from each of the previous exercises such that they moved in-parallel with one another (i.e. all first-exercise attributes would be set to the same service level (1, 2 or 3), and all second-exercise attributes would be set to the same service level).[20]

3.5.2. Introduction to attributes and service levels

The attributes were presented through a series of videos, describing each of the attributes using images and photographs throughout. The videos contained text describing the attributes alongside a voiceover reading out the text on the screen, and the language used throughout was simple, avoiding technical terms and jargon wherever possible. This method was chosen as the most effective way to describe the attributes following focus group testing, from which one of the key findings was that picture and images should be used wherever possible to illustrate examples, and that explanations needed to be thorough yet easy to understand without being technical. A copy of the script used was available to read after each video was shown, and these are included below in Appendix F.

3.5.3. Design and presentation of choice cards

Participants were presented with a number of choice cards with two options, package A and package B. We also allowed respondents to select "don't know", reducing the noise in the sample (e.g. for respondents who randomise their choice when they could not decide between two options). Each package contained different service levels for each attribute with a different impact on the consumer bill.

Each choice card was presented in a table containing a different attribute on each row, with two columns containing different possible service levels for each attribute. Participants could watch the videos again from the choice card if they needed a reminder of the definitions. Any row which contained differences for that attribute was shaded so the participants could focus on the attributes that had differences, as some attributes had the same service level in each column. During cognitive testing, we considered and tested different versions of shading and

[20] In effect, the CV exercise therefore effectively consisted of three attributes, a "first set" attribute, a "second set" attribute, and the bill.

colour coding, for instance highlighting which column showed the higher service level. However, we found that participants sometimes chose the package which had the most coloured cells, rather than reading through and making a considered decision which weighed up the extent of improvements between packages.

Examples of our final choice cards are presented in the figures below. As well as shading rows which change between packages, we also boldened key figures and words, to help respondents to weigh-up all attributes simultaneously. Respondents could replay the service description videos by clicking on the attribute names on the left-hand side of the choice card.

Figure 3.1: Example of Choice Card from Non-domestic Gas Survey

Which of the following packages do you prefer?

Down the left hand side of each table you will see all of the service areas that were explained in the videos you have watched. You can click on each of these to see a short description or to watch the videos again.

Colour coding has been used to help you compare Package A and B. If a row has shading it means there are changes to the service, if there is no shading it means Package A and Package B are the same for that service. The last row in each table will always be shaded, this row is in relation to the impact on your business' bill.

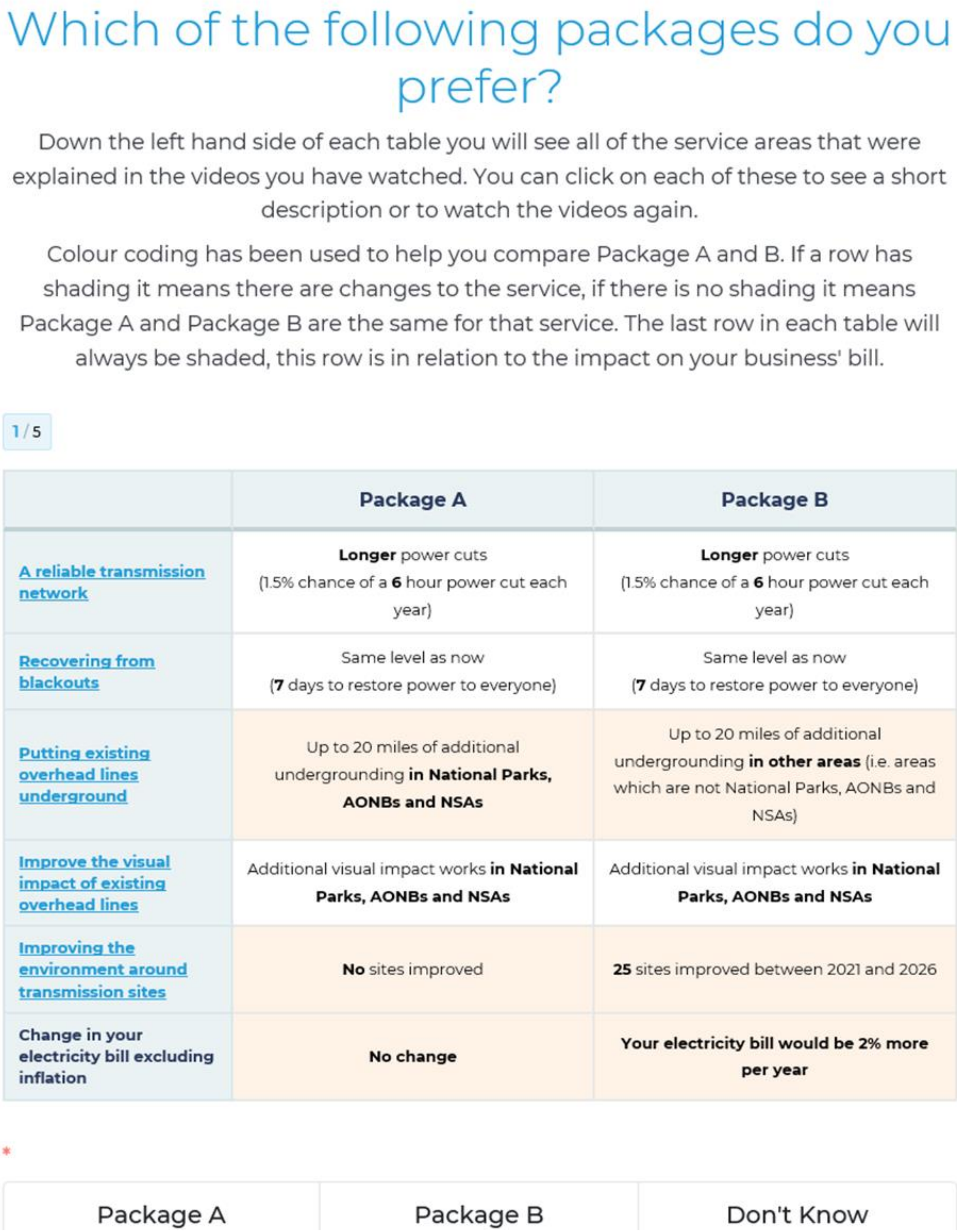
1 / 5

	Package A	Package B
Reducing the risk of a transmission interruption to the gas supply	**Same** probability as today (1 in **12,500** properties per year)	**Same** probability as today (1 in **12,500** properties per year)
Improving the environment around transmission sites	4 Large sites	7 large sites and 10 smaller sites
Supporting local communities	**No** community schemes	**No** community schemes
Investing in innovation projects to create future benefits for consumers	**Large scale** innovation projects focused on benefits for third parties and consumers	**Small scale** innovation projects focused on making our operations more efficient
Supporting those in fuel poverty	Provide information, advice to achieve lower energy bills	Continue as is - no proactive support
Change in your gas bill excluding inflation	**Your gas bill would be 1% less per year**	**No change**

*

Package A	Package B	Don't Know

Figure 3.2: Example of Choice Card from Non-domestic Electricity Survey



Which of the following packages do you prefer?

Down the left hand side of each table you will see all of the service areas that were explained in the videos you have watched. You can click on each of these to see a short description or to watch the videos again.

Colour coding has been used to help you compare Package A and B. If a row has shading it means there are changes to the service, if there is no shading it means Package A and Package B are the same for that service. The last row in each table will always be shaded, this row is in relation to the impact on your business' bill.

1 / 5

	Package A	Package B
A reliable transmission network	**Longer** power cuts (1.5% chance of a **6** hour power cut each year)	**Longer** power cuts (1.5% chance of a **6** hour power cut each year)
Recovering from blackouts	Same level as now (**7** days to restore power to everyone)	Same level as now (**7** days to restore power to everyone)
Putting existing overhead lines underground	Up to 20 miles of additional undergrounding **in National Parks, AONBs and NSAs**	Up to 20 miles of additional undergrounding **in other areas** (i.e. areas which are not National Parks, AONBs and NSAs)
Improve the visual impact of existing overhead lines	Additional visual impact works **in National Parks, AONBs and NSAs**	Additional visual impact works **in National Parks, AONBs and NSAs**
Improving the environment around transmission sites	**No** sites improved	**25** sites improved between 2021 and 2026
Change in your electricity bill excluding inflation	**No change**	**Your electricity bill would be 2% more per year**

*

Package A	Package B	Don't Know

3.6. Testing of Instrument

Following the build of the online tools, these were thoroughly tested internally by Explain and NERA using mock run-throughs and slide-by-slide cognitive testing, and shared with the

TOs for feedback. Explain then tested the survey fully via 20 focused cognitive interviews with members of the general public, which explored how respondents were answering individual questions they were looking at, understanding of specific terms, retrieval of relevant information, the decision-making processes, and overall understanding of the information and exercises within the tools. At the end of the survey, interviewers conducted a qualitative interrogation to explore how respondents felt, which elements they struggled with, what they understood the questions were asking them to do and ways to make it more user-friendly. We collated the results of these interviews and suggested changes to the tools based on the findings. All changes and recommendations we concluded as a result of the cognitive testing interviews are shown in Appendix G.

After implementing the changes to the survey, we ran a pilot of the survey via an online panel, collecting 100 responses for each of the surveys. We did not use these results in our final analysis; instead, conducting this relatively short test allowed us to verify that the stated preference elements of the survey were working as expected, with consumers making the theoretically-anticipated trade-offs between changes in the bill and changes in service quality. As a result of the pilot survey, we made a single edit to the instrument, increasing the range of bill changes in the third electricity exercise from
-£10 to +£10 to *-£20 to +£20*, since our analysis of the pilot suggested we may have been constraining respondents WTP for the changes that the exercise included to too narrow a range.

3.7. Calculating Current and Future Bills

Before the WTP exercise itself, respondents were asked how much their current electricity or gas bill is. Where respondents knew their bill, the stated preference exercises asked them about their WTP to accept changes in service and changes in bill relative to this stated level. The initial WTP results emerging from the pilot survey are shown in Appendix H.

For respondents who are unable to recall their bill, we asked for their dual-fuel bill and estimated a typical gas/electricity bill from this on the assumption that 50% per cent of a typical dual fuel bill corresponds to gas and 50% per cent to electricity; where respondents did not know their bill at all, we presented them with the average domestic gas/electricity bill, based on data published by Ofgem.[21]

We allowed respondents to report their bill in a number of different formats based on different billing options (i.e. per week, per month, per quarter and per year), which the survey then standardised into an annual bill. We also included an “are you sure?” validator, to ask respondents to check their entry if they told us their bill was very large or very small.

After providing this information, respondents are reminded that energy prices are likely to change over RIIO-T2 (2021-2026), irrespective of changes in the level of investment carried out by the TOs. To avoid any systematic bias on consumers’ valuations caused by their expectations about future price, we randomly present respondents with different information about future price changes, according to three scenarios in government energy price forecasts.

[21] Ofgem (July 2018), “Bills, prices and profits”.

The Department for Business, Energy and Industrial Strategy publishes retail electricity price projections as part of the UEEP (Updated Energy & Emissions Projections).[22] The most recent series, published in 2018, projects prices until 2035 for a series of scenarios, including a "baseline" scenario, based on central estimates of economic growth and fossil fuel prices and the government's expectation as to the effect of policy decisions "*which are sufficiently advanced to allow robust estimates of impact*". Other scenarios include "high price" and "low price" scenarios which forecast retail price projections for high and low wholesale fossil fuel prices respectively, and other scenarios related to different assumptions about future government policies.

For instance, in the baseline scenario, electricity prices are 15% higher on average between 2021 and 2025 (in real terms) than between 2014 and 2018 (i.e. the last five years). Alongside the baseline scenario, we use the "high prices" and "low prices" scenarios, rounded up and down respectively (i.e. away from the baseline scenario). We then randomly assign respondents to one of these three groups, meaning they see either a 5%, 15% or 25% increase in electricity bills during RIIO-T2. For domestic gas, our baseline and "low prices" scenarios are negative, reflecting that the government expects domestic gas prices may decrease on average (in real terms) over the next six years.

Table 3.1 below summarises the three bill change amounts used in the four different surveys. As a sensitivity of our valuation results, we compare valuations for consumers from the three different groups, as described in Section B.3.

Table 3.1: Random Bill Change Amounts In Each Survey

Electricity	Gas
Domestic	
5%	-15%
15%	-5%
25%	10%
Non-Domestic	
5%	0%
20%	25%
30%	50%

Source: NERA Analysis of BEIS data.
Note, while these figures are based on BEIS projections, the basis for which we have not examined in detail as part of this survey, the differences between bill increases for domestic and non-domestic consumers may reflect the different drivers of bill changes. For instance, network charges would tend to comprise a higher proportion of a domestic gas consumer's gas bill than a non-domestic gas consumer.

3.8. Sampling and Recruitment Methodology

For both gas and electricity, we targeted 1,000 surveys with bill payers across England, Wales and Scotland, plus 600 of each of the surveys with non-household consumers. We track quotas and close surveys if quotas from certain demographic characteristics were reached. Therefore, our sample of over 1,000 surveys gives a robust representation of TOs'

22 BEIS (2 January 2018), "Updated Energy and Emissions Projections: 2017".

consumers.[23] We conducted the household surveys using a mix of online and face-to-face methodologies.

Table 3.2: Number of Completed Surveys by Recruitment Method

Survey	Audience Type	Sample Size	Method	Avg. Interview Length (minutes)
Pilot Survey Gas	Domestic	138	Online	29
Main Survey Gas	Domestic	777	Online	30
Main Survey Gas	Domestic	249	Face-to-face	33
Main Survey Gas	Non-Domestic	622	Online	21
Pilot Survey Electricity	Domestic	128	Online	32
Main Survey Electricity	Domestic	786	Online	37
Main Survey Electricity	Domestic	267	Face-to-face	35
Main Survey Electricity	Non-Domestic	609	Online	33

Source: NERA and Explain Analysis.

There are a number of advantages and disadvantages associated with both online and face-to-face research methods. Face-to-face interviewing allows the interviewer to carefully explain the choices to respondents. Also, face-to-face allows to reach respondents who may not be accessible online (e.g. respondents without internet); if we rely upon online surveys alone, we risk failing to represent the preferences of disadvantaged groups of consumers who are likely to be underrepresented in online surveys. However, online surveying also has some advantages as it may also improve sampling of groups more comfortable with online surveying, it avoids biases from interview-effects, there is some evidence that respondents give higher valuations in face-to-face interviews, and online surveys are cheaper and faster to implement than face-to-face.

Reflecting these factors, HM Treasury guidance on valuation research[24] is not prescriptive about which survey mode is appropriate for an SP study. It considers a number of survey-related biases relating to online versus face-to-face techniques:

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23 Aside from representativeness, the question of whether 1,000 consumers is a sufficient sample size can also be assessed with reference to the confidence intervals around the coefficients in our logit models. We discuss the reliability and statistical significance of our parameter estimates below in Chapter 5.

24 Fujiwara, D. and Campbell, R. for HM Treasury / DWP (2011), *"Valuation Techniques for Social Cost-Benefit Analysis: Stated Preference, Revealed Preference and Subjective Well-Being Approaches"*

- Interviewer bias can arise from face-to-face and telephone surveys, but this effect can be mitigated by well-trained interviewers;
- Non-response bias can arise whenever individuals' propensity to take part is determined by the extent to which they have strong opinions on the subject. Postal and online surveys are most at risk of this problem, while face-to-face interviews with participation incentives are least likely to carry this bias; and
- Fatigue and frustration may arise in long survey formats, reducing the effort participants make to provide accurate answers. This problem is not specific to any survey methodology, but is easier to identify, and therefore potentially control for, with face-to-face interviews.

Additionally, in previous similar studies some companies have found statistically significant and lower valuations coming out of online surveys, suggesting face-to-face methods may result in slightly exaggerated valuations.

By using both methods, this allowed us to compare outcomes whilst also reducing the costs of this research: we conducted 75% of the household surveys online, with 25% conducted face-to-face. We continued face-to-face interviewing in the weeks after the online survey was complete, meaning we were able to ensure we recruited a sufficient sample from the demographic groups who had turned out to be under-represented in our online sample. As Table 3.2 above shows, respondents completed the online surveys at a similar pace to face-to-face interviews[25]. Due to the time pressures and constraints faced by relevant respondents within non-household consumers' organisations (e.g. a senior manager / decision maker in a firm), all non-domestic surveys were completed online.

To ensure representative and robust results, we set quotas for the household surveys to target a nationally representative sample by gender, age, region and socio-economic group (SEG) based on census data. We set quotas for both the online and face-to-face interviews.

We offered respondents an incentive of £15 to all face-to-face respondents to aid response rates.

[25] Non-domestic respondents, as shown in Table 3.2, have a shorter average interview length. This is because, in the non-domestic gas survey, respondents did not have to answer the questions about heating technologies.

4. Survey Performance

4.1. Overview of Fieldwork

Researchers from Explain's national fieldwork team, trained by the Market Research Society (MRS), conducted the face-to-face interviews. Each researcher was assigned a survey type (gas or electricity) and a region; ten regions were covered with an equal distribution across each of the TO areas. Researchers were briefed in full as to the project objectives to ensure the survey was administered correctly and all researchers conducted a test survey ahead of their first interview to ensure full understanding of the project. Researchers then went door to door to capture responses, ensuring their individual quotas were met.

All online interviews were conducted via an online panel. This ensured a guaranteed response rate, and also allowed quotas to be set for the household survey.

4.2. Representativeness of Sample

In the domestic surveys, Explain applied quotas to ensure we recruited a demographically representative sample of GB households. Explain's choice of quotas was based on census data. Since demographic characteristics were not available for households connected to the gas network, we relied on population-wide statistics for both the gas and electricity surveys. As Table 4.1 shows, the sample distribution is similar to the real population distribution for most attributes.

For a small number of regions, we find that the samples overrepresent some parts of the country; specifically Scottish consumers accounted for around 15% of our sample, compared to 8% of GB in total. As we describe in Section 5, we tested whether Scottish consumers have different preferences from those in the rest of GB, and we find that they do not. Since our sample remains representative in terms of other characteristics (gender, age and SEG), we decided not to apply weighting to our sample.

Table 4.1: Characteristics of Domestic Samples

	Quota (%)	Gas (%)	Electricity (%)
Gender			
Male	49	47	47
Female	51	53	53
Age			
18 - 24	12	12	10
25 - 34	17	14	15
35 - 44	18	18	20
45 - 54	18	19	20
55 - 64	15	18	18
65 +	20	20	18

	Quota (%)	Gas (%)	Electricity (%)
Region			
East Anglia	10	10	10
East Midlands	7	5	5
London	13	12	11
North East	4	5	6
North West	12	9	9
Scotland	8	15	16
South East	14	11	11
South West	9	9	12
Wales	5	6	6
West Midlands	9	7	7
Yorkshire & Humberside	9	10	9
SEG			
AB	22	24	25
C1	31	28	28
C2	21	21	21
DE	26	27	26

Source: NERA and Explain Analysis.

Table 4.2 summarises the characteristics of non-domestic respondents according to the number of employees, region and industry. In contrast with the domestic survey, where most households of similar characteristics (size, income etc.) are likely to consume a similar amount of electricity and gas, firms of similar size and industry are not especially homogeneous, and there are many unobservable characteristics which will affect the amount of electricity and gas they consume and how much it costs. Therefore, Explain used loose, minimum quotas to ensure that we contacted a broad mix of businesses, in terms of industry, size and geographic region. As the table shows, we successfully recruited a mix of non-domestic consumers from a wide range of industries, based on the 20 Standard Industrial Classification codes.

As we describe in Section 5.2 and Section 5.4, we conduct our WTP analysis based on percentage change in firms' energy bills, thus controlling for differences in the amount of energy they consume.

Table 4.2: Characteristics of Non-domestic Samples

	Gas (%)	Electricity (%)
Employees		
1 (self-employed)	4	5
2-9	14	12
10-49	18	20
50-249	31	30
>250	32	32
Region		
London	19	28

	Gas (%)	Electricity (%)
Yorkshire	17	10
North Scotland	8	4
South East	21	21
Wales	9	6
South Scotland	11	7
North East	10	5
North West	16	15
East Midlands	15	9
East England	17	12
South West	13	8
West Midlands	15	9
Industry		
Retail	10	9
Accommodation & food services	2	2
Manufacturing	15	15
Professional, scientific & technical	9	11
Education	9	6
Other	6	4
Construction	6	9
Transport & storage (inc postal)	5	5
Wholesale	2	4
Agriculture, forestry & fishing	1	2
Arts, entertainment, recreation & other services	2	2
Health	5	4
Motor trades	1	1
Property	1	2
Information & communication	6	8
Business administration & support services	3	4
Charity	1	1
Mining, quarrying & utilities	1	1
Financial & insurance	7	9
Public administration & defence	5	2

Source: NERA and Explain Analysis.

4.3. Survey Performance

As described in Section 3.2 above, at the end of the survey we asked respondents two questions to ascertain whether or not they understood the exercises they had just completed.

To obtain reliable results, it is important that respondents had a good understanding of the attributes and the questions themselves. We can therefore evaluate the performance of the survey instrument through examining how difficult it was to understand and compare choices. We asked respondents *"Did you feel able to make comparisons between the choices presented to you?"* and *"Did you feel you understood the services offered by the*

Transmission Companies and the levels of service included in your choices?" Figure 4.1 and Figure 4.2 report the responses to these questions for each survey.

Figure 4.1: Domestic Respondents' Reported Ability to Understand Attributes and Compare Packages

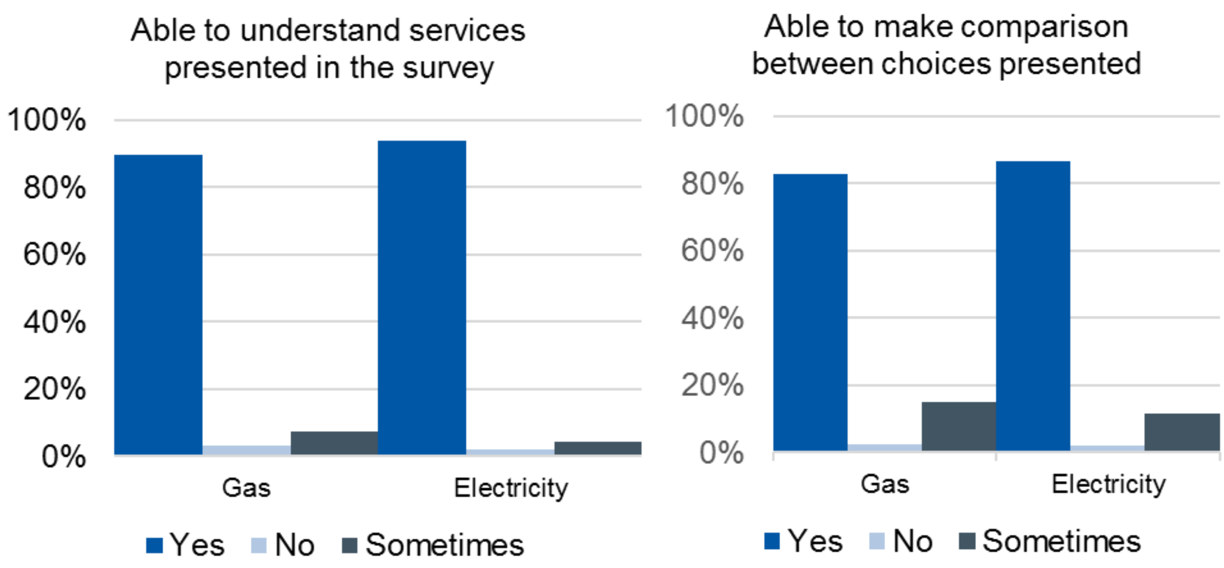
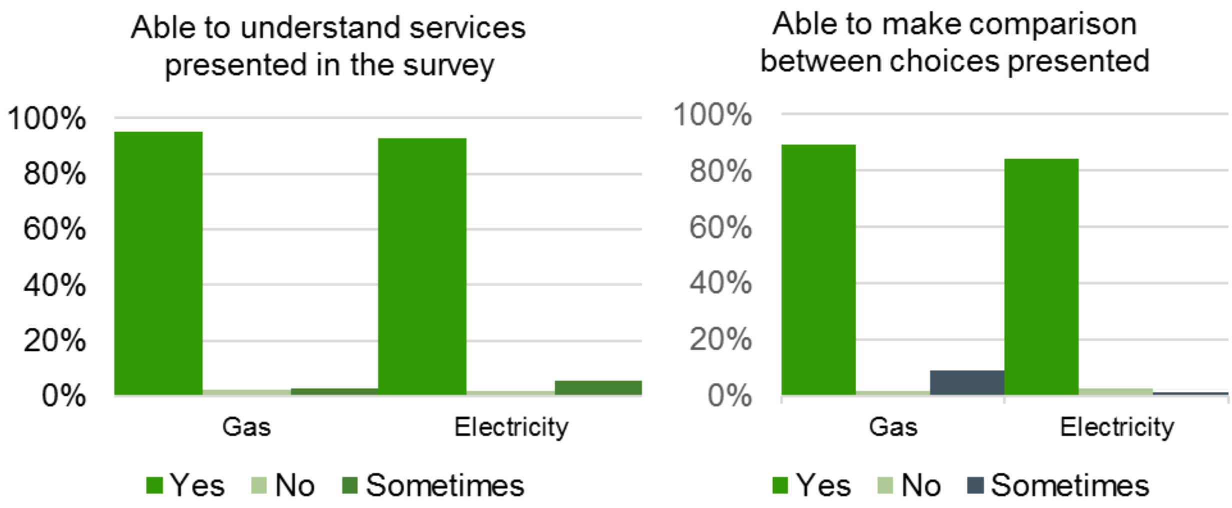


Figure 4.2: Non-Domestic Respondents' Reported Ability to Understand Attributes and Compare Packages



The vast majority of respondents stated that they were able to understand the services (i.e. attributes) presented to them, and that they were able to make comparison between the choices presented. In our experience, these responses compare favourably with similar surveys of this type.

Secondly, it is important that respondents did not randomize their choices, for instance because they were clicking through the online survey questions to finish the survey as quickly as possible. The average time respondents took to answer the questions is therefore an indicator as to whether they spent enough time reading the questions and comparing the choices.

As we set out in Table 3.2 above, for the gas and electricity pilot surveys, respondents took 29 and 32 minutes respectively, on average. For the main surveys, we found a similar result, 30 and 37 minutes for the domestic surveys, and 21 and 33 minutes for non-domestic surveys.[26] For face-to-face surveys we found similar durations, 33 and 35 minutes. Similar duration for face-to-face and online suggests people did not just "click though" the online version. We also did not find that a significant number of respondents consistently selected the same package (e.g. 'A' 5-times or 'B' 5-times)[27], again suggesting they did not "click through" the survey. Therefore, we conclude that respondents spent a sufficient amount of time on the surveys to allow them to consider trade-offs between the alternatives presented.

4.4. Evidence of Protest Responses

Protest responses – where a respondent does not engage with the survey because they reject the notion that they should pay higher bills for better service, do not believe in the proposed investments or other such reasons – may interfere with the data and provide inaccurate estimates of consumer valuations.

We identify protest respondents by examining specific questions which were integrated into the survey to allow us to assess the validity of responses. After respondents stated whether they understood the services offered and if they were able to make comparison between the service levels, they were asked if they wanted to specify their answer in more detail. We assess the answers to these questions against four criteria, which are reasons that people might protest. The criteria were developed from our experience of previous SP studies. The four criteria are:

1. Respondent believes that the companies are responsible for paying for service improvements, rather than consumers;
2. Respondent believes that current monies are being misspent by the companies;
3. Respondent does not believe service changes will actually happen; and
4. Respondent does not believe the methods presented are an appropriate way of achieving the service improvement.

We consider best practice to involve a quite demanding test for protest responses, so that only very extreme protest responses are omitted from the data. If many observations are omitted this raises questions about whether the sample is truly random. Additionally, the statistical analysis is able to draw a distinction between the portion of respondents' choices that is systematic and therefore represents real underlying preferences versus the portion of choices that is random noise, which would be expected to be true for protest responses.

[26] The shorter duration for non-domestic gas reflects that participants only answered one choice experiment.

[27] We find that, on average, 4.39% of gas respondents and 4.59% of electricity respondents chose 'A' or 'B' five times, whereas, based on the probability that respondents' preference is actually five times 'A' or five times 'B', we expect 3.13% of respondents to click five times 'A' or 'B'. Based on the small difference between the actual percentage and the expected percentage, we conclude that no significant number of respondents that consistently selected the same package.

Based on these criteria, we removed seven respondents from the domestic gas survey, nine respondents from the domestic electricity survey, three respondents from the non-domestic gas survey, and five respondents from the non-domestic electricity survey. Appendix E shows our WTP estimates and model coefficients re-estimated with protest responses removed.

5. Results from Quantitative Analysis

In this section, we describe the main results for each survey, focusing on willingness to pay estimates, which model the theoretical framework, quantitative techniques and model selection approach which we describe in.

5.1. Electricity Domestic Results

Table 5.1 shows our approach to determining our recommendation valuations using the survey data, in particular how we follow from a general-to-specific model procedure to develop econometric models, and combine the results of CE and CV modelling to derive valuation results. We explain these steps in more detail in the sections below.

Table 5.1: Method for Econometric Model Estimation and Deriving Valuations from the Choice Experiment and Contingent Valuation Results

General-to-specific model selection procedure	▪ We started by estimating a basic model, which only controlled for service levels and bill effects. ▪ We then expanded it, following a "general to specific" modelling process, estimating multiple conditional logit models to test for the effect of respondents' demographic characteristics and other factors: – Gender, SEG, age, income, region, household size, family status – Research method (f-2-f vs. online), prior experience of interruptions, understanding of the services – Non-linearity in consumers' preferences ▪ We estimated a final "mixed logit" models using statistically significant factors. Where we control for consumer demographics, we estimate WTP for the population mean.
Standard procedure to avoid overstating WTP	▪ We also follow two steps to test if WTP from choice experiments is overstated: – We find that WTP does not depend on the statement in the survey about the "bill change for other reasons" – We compare consumers' WTP for each attribute in the CEs to their overall WTP in the CV, and scale down the CE WTP results.

Source: NERA analysis

5.1.1. Simple Models

We started by running a basic model using the data generated from the choice experiments, which included only the service level and bill level variables, excluding controls for consumer characteristics (e.g. age, income, etc.). Table 5.2 shows the WTP results we obtain for the attributes covered by the domestic electricity survey.[28] As explained in Section B.2.2, the mixed logit specification is likely to be a richer and more theoretically justified estimation

[28] The regression coefficients underlying these WTP estimates are shown in Appendix C.

method. Therefore, we place greatest weight on the mixed logit model when interpreting the results and making recommendations about appropriate valuation assumptions.

Table 5.2: Willingness to Pay (£/consumer/year) Estimated from the Simple Model, Excluding Respondent Characteristics

	Conditional Logit		Mixed Logit	
Attributes	WTP (£)	Statistically Significant	WTP (£)	Statistically Significant
Every 1 hour decrease in the hours of powercuts at a 1.5% probability	5.23	Yes	5.32	Yes
Every fewer day to recover from a blackout	4.80	Yes	4.75	Yes
Undergrounding Overhead Transmission Lines				
20 miles additional underground in National Parks etc.	11.36	Yes	10.79	Yes
20 miles additional underground in other areas	8.70	Yes	8.33	Yes
Improving visual amenity of Overhead Transmission Lines				
Additional visual impact work in National Parks etc.	4.62	Yes	4.95	Yes
Additional visual impact work in National Parks and other areas	7.88	Yes	7.80	Yes
Every additional transmission site environment improved	0.43	Yes	0.45	Yes
Investing in innovation projects				
Medium Scale Projects compared to Small Scale Projects	3.65	Yes	3.17	Yes
Large Scale Projects compared to Small Scale Projects	6.78	Yes	6.79	Yes
Supporting local communities				
Current level of community activities	10.42	Yes	11.00	Yes
Current level of community activities and additional funding to charities	11.58	Yes	11.99	Yes
Investing in EV Charging Infrastructure				
Invest before definite need	11.94	Yes	12.33	Yes
Investing in infrastructure to connect to renewable generation				
Invest before definite need	14.79	Yes	15.70	Yes

Source: NERA Analysis

The results in Table 5.2 show that consumers have a higher WTP for higher levels of service across all attributes, in line with economic intuition that consumers prefer higher levels of service and place some positive value on the improvements in service that could be provided by the TOs and the avoidance of deteriorating service. All attributes have a statistically significant WTP estimate, according to both the conditional and mixed logit estimation methods. The results for both estimation methods (conditional and mixed) are similar, indicating our analysis is robust to estimation method.

Also in line with intuition, respondents value undergrounding in National Parks more than undergrounding in other rural and urban areas, which suggests that, while consumers prefer undergrounding in National Parks to other areas, they place some value on undergrounding in other areas.

On the face of it, the table above could be read as suggesting that consumers value undergrounding more highly than improving visual amenity, which would be intuitive since the attribute referred to measures to mitigate the appearance of overhead lines that fall short of removing them. However, because the value we obtain for undergrounding is based on 20 miles additional undergrounding, while the value of improvements in visual amenity give a budget for the types of works described in the survey instrument, we cannot draw direct/firm conclusions about whether consumers place higher or lower value on undergrounding relative to other improvements in visual amenity.

According to the results shown above, consumers also place a value on the TOs undertaking community activities (£11.00/consumer/year), as per the TO's current provision, as well as a slightly higher WTP for providing the current level of community activities alongside additional charitable giving (around £12/consumer/year), although we find that WTP for this higher service level is not statistically significantly different to providing the current service level.[29]

The modelling results shown above also suggest that consumers value moving from small to medium scale innovation projects, by £3.17/consumer/year, and from small to large scale innovation projects £6.79/consumer/year.

In relation to reducing the risk of power cuts, the analysis suggests that consumers place a value of around £5/consumer/year to reduce the length of an interruption to power supply, which occurs with a 1.5% probability, by 1 hour. They are also willing to pay around £5/consumer/year to reduce by a day the duration of a prolonged interruption causing widespread disruption.

As a cross check on the value consumers associate with reduced interruptions, we have converted these figures into an approximate Value of Lost Load (VOLL). For the purpose of this simple illustration, we assume that a residential consumer consumes 4,000kWh (4MWh) per annum, and therefore around 11kWh (4,000 / 365) per day:

- The results above suggest that consumers value reducing the duration of a widespread interruption (that occurs with 1.5% probability) by £5.32/hour. Hence, this implies a value of £355 / hour to reduce the duration of each interruption incident by 1 hour of £355 / consumer (5.32 / 1.5%). Dividing this figure by the typical consumption per hour (11kWh / 24), gives a VOLL estimate of £777,450 / MWh.
- The results above also suggest that consumers value reducing the time required to recover from a blackout by 1 day by £4.75. This implies a value of £43/MWh (4.75 / (4000 / 365)) if this event occurred with a probability of 100%, so if we assume it occurs with a probability of 1-in-10,000, the equivalent VOLL estimate is £433,438/MWh (4.75 x 10,000).

These estimates are high relative to some other estimates of VOLL, such as London Economics 2013 Study for Ofgem and DECC, which are typically in the tens of thousands of pounds per MWh.[30] However, a possible explanation is that the types of attributes underpinning these and previous estimates are different. In particular, the attributes described here relate to extremely severe blackouts causing widespread disruption due to a failure of the transmission system, whereas other VOLL studies have typically examined the consequences of relatively short interruptions to particular consumers' properties. Hence, the conversion of our valuation results into a simple VOLL statistic may not be meaningful, as the dis-amenity caused by these interruptions may arise from other types of disruption such as the closure of businesses and other amenities in the wider community.

29 We conducted a t-test to test whether WTP for a movement in "supporting local communities" from level 1 to 2 (£11.00/consumer/year) is significantly different from WTP for a movement form level 1 to 2, and found that it is not.

30 London Economics (July 2013), The Value of Lost Load (VoLL) for Electricity in Great Britain, Final Report for OFGEM and DECC, p. 21-22.

The results also suggest consumers are willing to pay £12.33/consumer/year and £15.70/consumer/year respectively to fund investments to accommodate EVs and renewable generation before the definite need emerges.

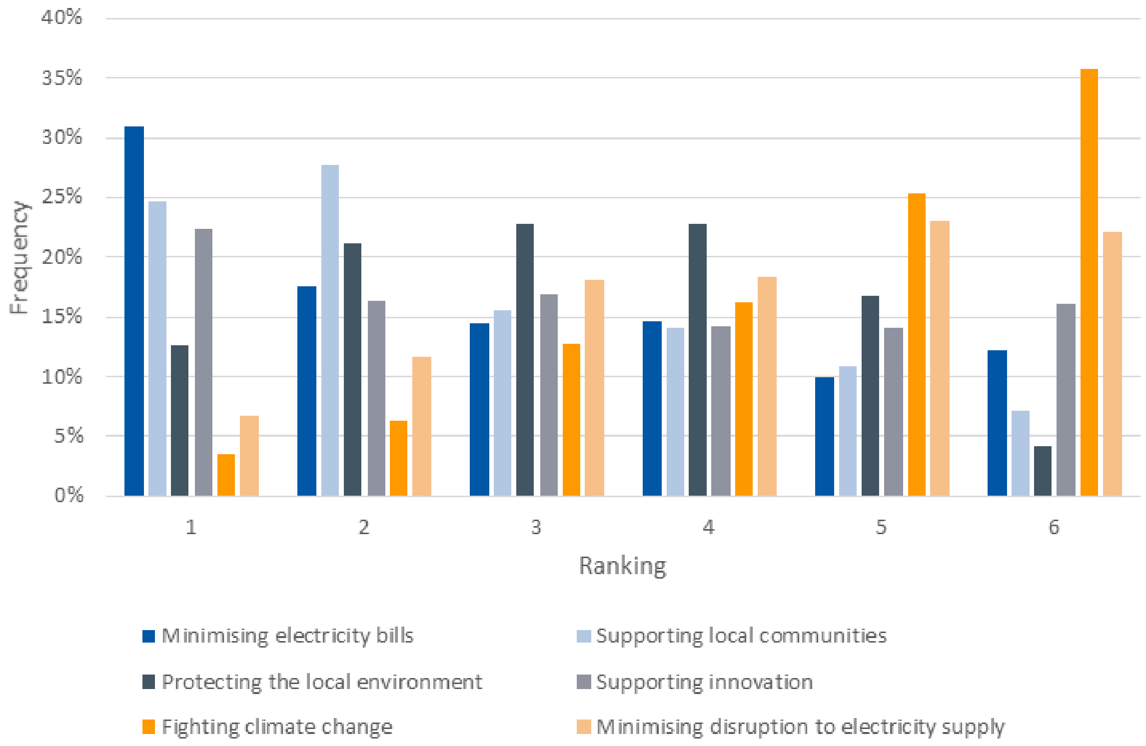
5.1.2. Cross-check based on consumers' stated priorities

As a crosscheck to these results, respondents were asked to rank six broad priorities (which covered the nine specific attributes they had been asked to value in the choice experiments as well as the level of bills), by ranking them from 1 to 6 ("most important attribute" to "least important attribute"), once they had completed the exercises. The results are shown in the figures below. Figure 5.1 shows the percentage of respondents which ranked each attribute as their highest priority, second highest priority etc: 30% of respondents chose "minimising electricity bills" as their highest priority, a more popular highest priority than other attributes, and over 35% of respondents selected "fighting climate change" as their lowest priority. Figure 5.2 shows the average rank of all attributes. This figure shows that "supporting local communities" has the highest average rank and "fighting climate change" has the lowest average rank.

The relatively low ranking of "fighting climate change" may be surprising, given our finding that consumers are willing to pay for environmental improvements, including investment ahead of need in transmission to facilitate electric vehicles and renewables. However, these results are not directly comparable, nor do they necessarily mean consumers are not willing to pay higher energy bills to pay for environmental improvements.

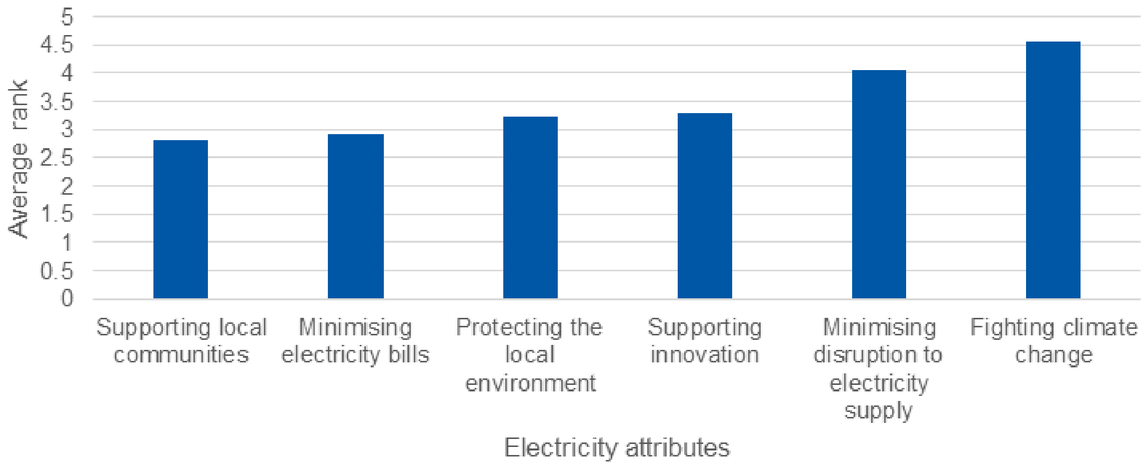
For instance, although Figure 5.1 shows how many respondents ranked an attribute as highest priority, second priority, etc, it does not provide information how respondents value attributes compared to other attributes. The definition of "fighting climate change" may also have been less clear and less tangible than the specific measures explained in the stated preference exercises (improving the environment around transmission sites, investments to support electric vehicles, etc). This less precise definition may have led consumers to place less weight on it in this exercise than the environmental attributes in the valuation exercises. For instance, some consumers may be willing to support specific measures the TOs propose to reduce the environmental impact of their work, but be put off by the wider theme of "fighting climate change" which they associate with other interventions.

Figure 5.1: Respondents' Ranked Priorities from 1 as "Most Important" to 6 as "Least Important"



Source: NERA Analysis.

Figure 5.2: Respondents' Average Ranking of Priorities



Source: NERA Analysis.

5.1.3. Respondent controls

To further examine the survey results and as an additional cross-check on the valuation results shown above, we also expanded our simple model (which only included service levels and bill impacts as explanatory variables) to include drivers reflecting respondents' demographic characteristics and other factors.

As explained in Section B.3, we conducted a model selection process using a "general-to-specific" approach in which we tested the statistical significance of a number of potential factors that could affect respondents' choices. To conduct this model selection process, we used conditional logit modelling, as the alternative mixed logit model takes a considerable amount of time to solve, making repeated model estimation to refine the model specification impractical. However, following this model selection process, we estimated the resulting model both using the conditional and mixed logit modelling approaches, as in the simpler model described above.

As part of our model selection process, we tested whether WTP is sensitive to gender, SEG, age, income, region, household size. We also tested sensitivity to research method (face-to-face vs. online), prior experience of interruptions, understanding of the services. We tested whether consumers' overall WTP is sensitive to demographics, by testing whether the coefficient on the bill change (representing their marginal utility of income) depends on demographic variables. We also tested whether consumers' WTP for changes in individual service attributes depends on demographic characteristics (i.e. by interacting demographic variables with service levels).

The majority of these tests produced statistically insignificant results, suggesting we did not find evidence of differences in consumer preferences by these demographic and other variables. However, we did find that respondents' valuation of "improvements in visual amenity of OHL" and "investing in EV charging" varies for different age groups, "undergrounding OHL" is sensitive for income and "supporting local communities" is sensitive gender. The regression results for the model in which we control for these consumer attributes are shown in Appendix C, with the WTP by consumer type shown in Table 5.3.[31] This analysis suggests that:

- Respondents in the age group 18 – 44 value improvements in the visual amenity of OHLs and investing in EV charging materially less than respondents in the 45+ age group.[32] This could reflect older consumers' higher likelihood of car ownership and higher likelihood of visiting the British countryside;
- Respondents with a higher income value undergrounding OHLs more than respondents with a lower income, which is economically intuitive. As the table below shows, we find that, for every £10,000 increase in respondents' income, their willingness to pay for the 20-mile undergrounding projects covered in the survey increase by between £2-3 per consumer; and
- Female respondents appear to value supporting communities more than male respondents.

[31] We estimated WTP for control groups using our simple, conditional logit model.

[32] We also tested for a linear age variable, but we did not find a statistically significant result. We tested if younger (18 – 24) respondents had a different WTP for different attributes. We found the same significant results if we used the "18 – 24" bracket to the "18 – 44", but we did not find a statistically significant difference between WTP for ages 18 – 24 and 25 – 44. Therefore, while consumers of different ages within these relatively wide bands may have different preferences, the statistical modelling suggests this variable comparing those in the 18-44 and 45+ age bands best-controls for differences in preferences linked to consumers' age.

Table 5.3: Differences in Willingness to Pay (£/consumer/year) Resulting from Controlling for Differences Between Consumers

Demographic control	Attribute	WTP	
		18 - 44	**45 +**
Age	Visual amenity of OHL (level 1 to 2)	1.36	8.30
Age	Visual amenity of OHL (level 1 to 3)	3.17	12.99
		Additional WTP per £10,000 income	
Income	Undergrounding OHL (level 1 to 2)	2.83	
Income	Undergrounding OHL (level 1 to 3)	2.15	
		18 - 44	**45 +**
Age	Investing in EV charging	11.39	15.90
		Male	**Female**
Gender	Supporting Communities (level 1 to 2)	8.61	13.11
Gender	Supporting Communities (level 1 to 3)	8.30	15.57

Source: NERA Analysis

Given some demographic controls were statistically significant determinants' of respondents choices in the survey instrument, we have re-estimated WTP using the "controlled" model that accounts for these factors. Relative to the results shown in Table 5.2, the revised results that account for these effects are potentially more reliable because the omission of important drivers of respondents' choices from the logit modelling can potentially create bias. As such, we would expect the results shown on the right-hand side of Table 5.4 to be more reliable than the estimates emerging from the simple model on the left. However, as the table shows, the difference in the resulting WTP estimates are small.[33]

[33] Note, in the revised logit model that controls for statistically significant demographic characteristics, the coefficients on the variables representing the service levels for the undergrounding attributes becomes statistically insignificant, so we omit them from the model. However, the variables in which we "interact" the attributes with income are statistically significant. Where we included demographic or respondent characteristics, we estimate WTP by evaluating the estimated equations at the sample mean values of demographic attributes.

Table 5.4: Willingness to Pay (£/consumer/year) – Impact of Adding Controls for Significant Consumer Characteristic Variables

Attributes	No control variables WTP (£)	No control variables Statistically Significant	Control variables WTP (£)	Control variables Statistically Significant
Every 1 hour decrease in the hours of powercuts at a 1.5% probability	5.32	Yes	4.93	Yes
Every fewer day to recover from a blackout	4.75	Yes	4.59	Yes
Undergrounding Overhead Transmission Lines				
20 miles additional underground in National Parks etc.	10.79	Yes	8.81	Yes
20 miles additional underground in other areas	8.33	Yes	6.80	Yes
Improving visual amenity of Overhead Transmission Lines				
Additional visual impact work in National Parks etc.	4.95	Yes	5.31	Yes
Additional visual impact work in National Parks and other areas	7.80	Yes	8.58	Yes
Every additional transmission site environment improved	0.45	Yes	0.46	Yes
Investing in innovation projects				
Medium Scale Projects compared to Small Scale Projects	3.17	Yes	3.16	Yes
Large Scale Projects compared to Small Scale Projects	6.79	Yes	6.78	Yes
Supporting local communities				
Current level of community activities	11.00	Yes	10.97	Yes
Current level of community activities and additional funding to charities	11.99	Yes	11.99	Yes
Investing in EV Charging Infrastructure				
Invest before definite need	12.33	Yes	12.69	Yes
Investing in infrastructure to connect to renewable generation				
Invest before definite need	15.70	Yes	15.65	Yes

Source: NERA Analysis

5.1.4. Linearity tests

For domestic consumers, we tested for possible non-linearities in consumers’ utility function for the attributes that are defined quantitatively, such as the length of interruptions. In the absence of non-linearities, consumers’ utility is taken to be a linear function of the service levels, as illustrated by the thick black line in Figure B.2. As explained in Section B.3, the model needs to correctly represent the ‘shape’ of their utility functions (and profit functions for non-domestics). Therefore, we tested for non-linearity in consumers’ WTP.[34]

For the qualitative attributes, we represent these in the econometric models as “dummy variables”, allowing us to value each option separately. Hence, there is no need to test for non-linearity. We only tested for non-linearity for risk of power cuts, and the number of sites around which the TOs improve the environment, as these are the only attribute defined quantitatively:

- As Table 5.5 shows, accounting for non-linearity increases the value estimated for moving from Level 1 (6-hour power cut) to Level 2 (4-hour power cut) from £10.45/consumer/year to £14.02/consumer/year. The value of moving from Level 1 to Level 3 (2-hour power cut) falls slightly, from £20.91 to £20.81/consumer/year.
- Accounting for non-linearity increases the value estimated for moving from Level 1 (no sites improved) to Level 2 (25 sites improved) from £10.85/consumer/year to £13.08/consumer/year. The value of moving from Level 1 to Level 3 (45 sites improved) falls slightly, from £19.52 to £19.29/consumer/year.

34 We conducted these tests using our simple, conditional logit model.

As WTP with a linear approach is more conservative, we chose to implement these attributes linearly when making recommendations about WTP for service improvement.

Table 5.5: Impact of Non-linearity on Estimated Willingness to Pay (£/consumer/year)

	£ WTP (non-linear)	£ WTP (linear)	
Every 1 hour decrease in the hours of power cuts at a 1.5% probability	N/A	5.23	
Level 1 (6 hour power cut) to level 2 (4 hour power cut)	14.02	WTP = 5.23*2	10.45
Level 1 (6 hour power cut) to level 3 (2 hour power cut)	20.81	WTP = 5.23*4	20.91
Every additional transmission site environment improved	N/A	0.43	
Level 1 (no sites improved) to level 2 (25 sites improved)	13.08	WTP= 0.43*25	10.85
Level 1 (no sites improved) to level 3 (45 sites improved)	19.29	WTP= 0.43*45	19.52

Source: NERA analysis

5.1.5. Testing for the effect of budget constraints

As explained in Section 3.7, the survey told consumers the amount by which their electricity bill is expected to change for reasons other than changes in the service attributes covered by this study. We use this feature of the survey to test whether budgetary constraints affect the values that consumers have stated they are willing to pay for improvements in service, and whether consumers' WTP might change if other factors cause consumers' energy bills to rise or fall. We found no statistically significant evidence that WTP for changes in service depended on the statement in the survey about the "bill change for other reasons".

We also included a Contingent Valuation experiment as a final valuation question in the survey exercise, which brings together the attributes examined in the two CE exercises in each survey. We use it to test whether there is any discrepancy between respondents' willingness to pay when they are presented with the subset of attributes for each survey versus being presented with the whole vector of service attributes. In practice we would usually expect to observe lower valuations from the CV exercises when respondents are presented with the whole package.

To allow us to have all attributes on one choice card without overburdening respondents, we designed the CV choice cards to be less complex than the CE choice cards. The CV choice cards have fewer varying attributes, with each group of attributes included in the first and second CEs set at the same service level (1, 2 or 3) in each package (see Section 3.3).

The comparison of the CE and CV estimates compares whether the overall estimate for a package of attributes is less than the sum of the individual estimates. From the structure of the CV choice card, we can obtain willingness to pay estimates for all attributes in choice set 1 and all attributes in choice set 2 for each survey. However, we cannot identify estimates for each attribute individually. The results of the CE and CV calculations are shown in Table 5.6.

It shows that the sum of the valuations for each attribute in choice set 1 from the CE is 22% higher than the value indicated in the CV exercise in relation to the difference between service levels 1 and 2. Between service levels 2 and 3, the CV exercise finds a valuation 80% below the sum of the valuations for choice set 1 obtained from the CE. This may suggest that consumers place a high weight on the blackouts attribute, for which there is no difference between service levels 2 and 3. Also, some of the changes between service levels 2 and 3 may appear smaller than the changes observed between levels 1 and 2, which may lead consumers to place less weight on the movements between level 2 and 3 as compared to between levels 1 and 2 when making their choices in the CV exercise.

For choice set 2, the difference between the CE and CV was similar to the first choice set between Levels 1 and 2 (25%), but the value we obtained from the CV exercise for the change between Levels 2 and 3 implied consumers place a zero value on this change in service levels. Indeed, the estimated value for improving from Level 2 to Level 3 was negative, although not statistically significant. One interpretation of this is that consumers do not consider the changes in service between Level 2 and Level 3 in the second choice to be material, when set against changes in the wider set of attributes. This is possible, that only two attributes on choice set 2 change between Level 2 and Level 3 (large scale innovation rather than medium, and providing additional funding to charities and other organisations to support consumers). However, consumers did place some value on these attributes in the CE.

Table 5.6: Comparison CE and CV Exercises – Willingness to Pay (£/consumer/year)

First Exercise

Attribute	WTP (1 to 2)	WTP (2 to 3)
Power Cuts	9.87	9.87
Blackouts	9.18	0.00
Undergrounding	8.81	-2.01
Visual Amenity	5.31	3.28
Improving tranmission sites	11.44	9.15
Total	44.60	20.28
Package Question	34.79	4.13
Difference (Package questions relative to exercises)	**-22%**	**-80%**

Second Exercise

Attribute	WTP (1 to 2)	WTP (2 to 3)
Innovation	3.16	3.62
Supporting Communities	10.97	1.01
Ready for EV	12.69	-
Ready for renewables	15.65	-
Total	42.47	4.64
Package Question	31.96	-5.93
Difference (Package questions relative to exercises)	**-25%**	**-228%**

Source: NERA Analysis

5.1.6. Recommended valuations

Given the finding from the CV exercise, that consumers' WTP for changes in the package of attributes is lower than the sum of their stated WTP from the CEs for changes in individual attributes, we recommend the use of "scaled" valuation results as a conservative valuation assumption. If the TOs were considering small changes in a sub-set of the attributes presented in this survey, the higher CE valuations might be more appropriate. However, given their intended use for RIIO2 business planning, we consider that the lower scaled CV results represent a conservative estimate of the valuations consumers place on the changes in service presented to them.

As Table 5.7 below shows, in the scaled results we have taken the percentage difference between the valuation results for the CE and CV exercises. The CE results are based on the mixed logit model, which we consider to be a more reliable estimation tool, that includes respondent those characteristics we find to have a statistically significant effect on choices, shown in Table 5.3. We rely upon the -80% scaling factor (the difference between level 1 and level 3 for first exercise attributes) for all attributes at service level 3, since the CEs show that respondents do indeed have some positive valuation for level 3 for attributes "investing in innovation projects" and "supporting local communities" even though the CV exercise implied a negative scaling factor. However, an even more conservative assumption would be that consumers' WTP to move to level 3 for these two attributes is zero.

Table 5.7: Unscaled and Scaled results – Willingness to Pay (£/consumer/year)

Attributes	Unscaled WTP (£)	Scaled WTP (£)
Risk of powercuts		
2 hours decrease in the hours of powercuts at a 1.5% probability	9.87	7.70
4 hours decrease in the hours of powercuts at a 1.5% probability	19.73	9.70
Every fewer day to recover from a blackout	4.59	3.58
Undergrounding Overhead Transmission Lines		
20 miles additional underground in National Parks etc.	8.81	6.87
20 miles additional underground in other areas	6.80	6.46
Improving visual amenity of Overhead Transmission Lines		
Additional visual impact work in National Parks etc.	5.31	4.14
Additional visual impact work in National Parks and other areas	8.58	4.81
Additional transmission site environment improved		
25 additional sites	11.44	8.92
45 additional sites	20.58	10.78
Investing in innovation projects		
Medium Scale Projects compared to Small Scale Projects	3.16	2.38
Large Scale Projects compared to Small Scale Projects	6.78	3.11
Supporting local communities		
Current level of community activities	10.97	8.26
Current level of community activities and additional funding to charities	11.99	8.46
Investing in EV Charging Infrastructure		
Invest before definite need	12.69	9.55
Investing in infrastructure to connect to renewable generation		
Invest before definite need	15.65	11.78

Source: NERA Analysis

5.2. Electricity Non-Domestic Results

5.2.1. Analysis of data from choice experiments

Our modelling performed using the electricity non-domestic survey data followed a very similar approach to domestic consumers. However, we use the conditional logit approach in the non-domestic survey and in the non-domestic survey the bill changes were presented in percentage terms. This approach was necessary due to the wide range of variation in non-domestic consumers' bills in monetary terms. We therefore performed the logit modelling using bill changes specified in percentage terms to reflect the survey design.

Also, possibly because of wide range of heterogeneity between firms use of energy and the amount they consume, we found that the standard statistical procedures used to estimate mixed logit models did not converge to a solution, so we performed the analysis using conditional logit models.

As for the domestic surveys, we started by running basic models using data from the CEs, excluding controls for consumer characteristics (e.g. firm size, region etc.). Table 5.8 shows the WTP results we estimate for the attributes covered by the domestic electricity survey, with the detailed econometric results shown in Appendix C.

Table 5.8: Willingness to Pay (% bill change/consumer/year) Estimated from the Simple Model Excluding Consumer Characteristics

	Conditional Logit	
Attributes	WTP (£)	Statistically Significant
Every 1 hour decrease in the hours of powercuts at a 1.5% probability	1.00%	Yes
Every fewer day to recover from a blackout	0.56%	Yes
Undergrounding Overhead Transmission Lines		
20 miles additional underground in National Parks etc.	2.07%	Yes
20 miles additional underground in other areas	2.15%	Yes
Improving visual amenity of Overhead Transmission Lines		
Additional visual impact work in National Parks etc.	1.26%	Yes
Additional visual impact work in National Parks and other areas	1.79%	Yes
Every additional transmission site environment improved	0.08%	Yes
Investing in innovation projects		
Medium Scale Projects compared to Small Scale Projects	0.80%	Yes
Large Scale Projects compared to Small Scale Projects	1.15%	Yes
Supporting local communities		
Current level of community activities	1.46%	Yes
Current level of community activities and additional funding to charities	0.76%	No
Investing in EV Charging Infrastructure		
Invest before definite need	2.46%	Yes
Investing in infrastructure to connect to renewable generation		
Invest before definite need	2.95%	Yes

Source: NERA Analysis

The results in Table 5.8 show that, like domestic consumers, non-domestic consumers express a statistically significant WTP for improvements in reliability. They are also willing to pay for undergrounding and improvements in visual amenity.

In contrast with domestic consumers, businesses appear to marginally prefer undergrounding in “other areas” over undergrounding in National Parks etc, though the WTPs are so close this could suggest consumers are indifferent as to where undergrounding takes place. It could also reflect consumers preferring undergrounding outside national parks, closer to where their businesses and consumers’ premises are located.

Non-domestic consumers also have a statistically significant WTP for the TOs to invest ahead of definite need for capacity to accommodate EVs and renewables, and to perform innovation projects. They are also willing to pay for the TOs to undertake community activities, but we found the WTP for the extra work the TOs could do to provide additional funding to charities was not statistically significant. This may reflect that non-domestic consumers’ already have their own corporate and social responsibility schemes, making them less willing for the TOs to fund additional measures through the electricity bill, and/or a preference for direct charitable giving.

As for the domestic survey, we expanded the simple model to include drivers reflecting the characteristics of the non-domestic consumers covered by the survey. We tested whether WTP is sensitive to firm size (as measured by employee numbers), region, and prior experience of interruptions. However, we found that none of these factors had a statistically significant effect on consumers' choices.

We also examined possible non-linearities in consumers' utility function. As mentioned in Section 5.1.4, we only test for non-linearity in WTP for reducing risk of power cuts and improving the environment around transmission sites as these are quantitatively defined attributes. While we do find statistically significant evidence of non-linearity, with different per-unit valuations between levels 1-2 and levels 2-3, the table below shows these effects are very small. Hence, we base our recommended valuation (per unit) on the lowest figure shown in the table below (2.00%/consumer/year for power cuts and 1.93% for transmission sites), which is the value obtained when we control for non-linearity in the "controlled" model that applies between levels 1 and 2.[35]

Table 5.9: Impact of Non-linearity on Estimated Willingness to Pay (%/consumer/year)

	£ WTP (non-linear)	**£ WTP (linear)**	
Every 1 hour decrease in the hours of power cuts at a 1.5% probability	N/A	1.00%	
Level 1 (6 hour power cut) to level 2 (4 hour power cut)	1.78%	WTP = 1%*2	2.00%
Level 1 (6 hour power cut) to level 3 (2 hour power cut)	3.99%	WTP = 1%*4	3.99%
Every additional transmission site environment improved	N/A	0.08%	
Level 1 (no sites improved) to level 2 (25 sites improved)	1.87%	WTP = 0.08%*25	1.93%
Level 1 (no sites improved) to level 3 (45 sites improved)	3.48%	WTP = 0.08%*45	3.48%

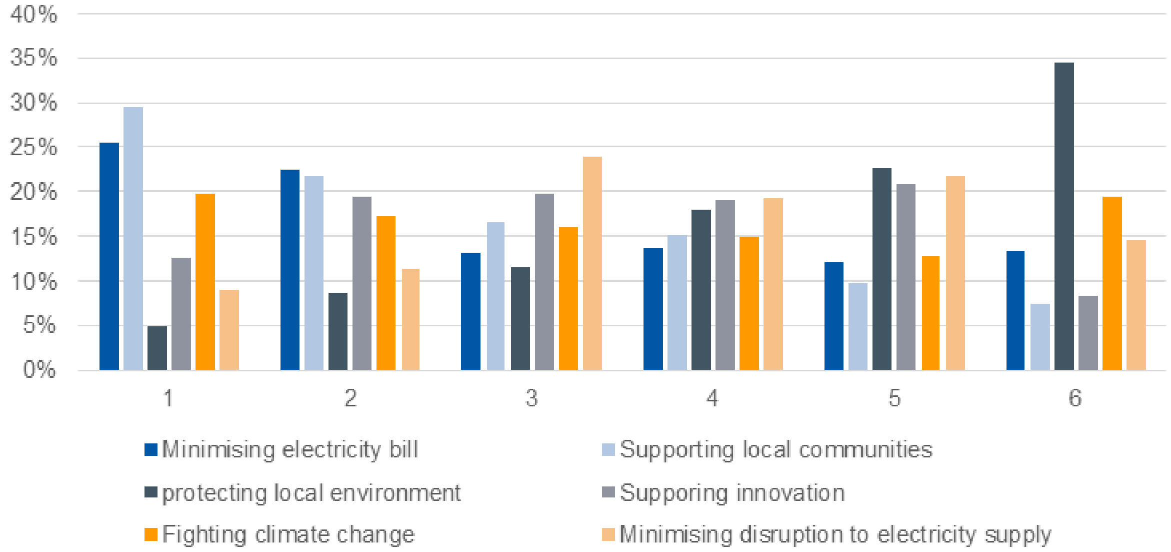
Source: NERA analysis

We also tested whether the amount by which we told consumers the bill would change due to other factors not considered in this survey affected consumers choices, and found no statistically significant evidence that it did.

After the choice exercises, like domestic consumers, respondents carried out a short priority ranking exercise (see Section 5.1.1). As Figure 5.3 shows, 30% of respondents chose "Supporting local communities" as their highest priority, while 25% of respondents chose "minimising their bills". Figure 5.4 shows the average rank of all attributes, suggesting that "supporting local communities" has the highest average rank and "minimising disruption to electricity supply" has the lowest average rank.

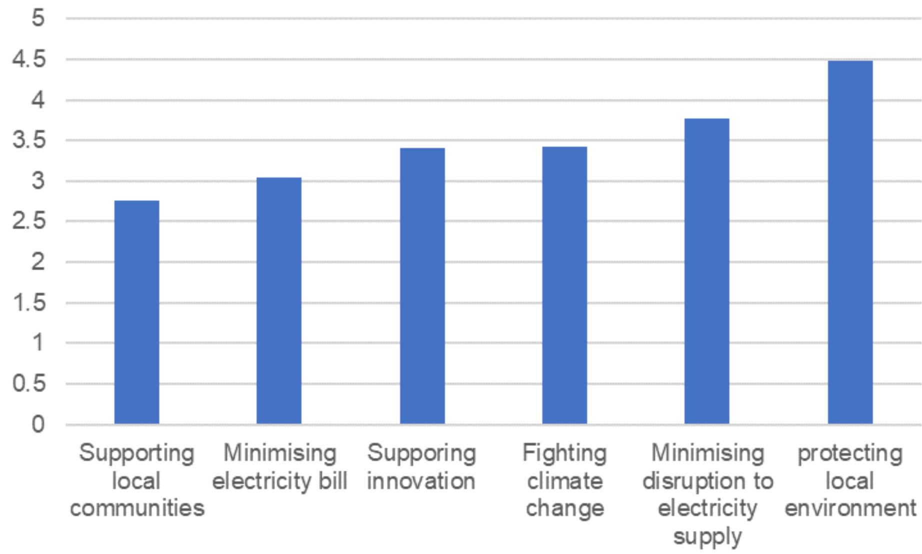
35 We conducted these tests using our simple, conditional logit model.

Figure 5.3: Respondents' Ranked Priorities from 1 as "Most Important" to 6 as "Least Important"



Source: NERA Analysis.

Figure 5.4: Respondents' Average Ranking of Priorities



Source: NERA Analysis

5.2.2. Analysis of data from the contingent valuation exercise

As in the domestic electricity survey, we used a CV exercise combining all attributes to test whether the sum of stated values for changes in all attributes overstates consumers' overall WTP for changes in service. We show a comparison between the CE and CV valuation results in Table 5.10.

We find that the values stated for service levels 1-2 are somewhat lower in the CV exercise for both sets of attributes, by between 40 and 63 per cent. Non-domestic consumers appear willing to pay more for attributes from the first exercise relative to those in the second.

Consistent with the domestic results, we also find that non-domestic consumers are less willing (or not at all) to pay for movement to the highest levels of service (level 3).

We recommend WTP assumptions from the CE exercises, but scaled based on the difference between consumers' WTP for movement between levels 1 and 2, and 2 and 3 in the CE and CV exercises. For level 2 and 3 in the second exercise we assume the scaling factor of level 1 to 2 also applies. However, an even more conservative interpretation of the CV results would be that WTP is zero above the "Level 2" thresholds.

This finding may be consistent with the CE results, which suggested consumers were not willing to support the TOs in conducting charitable giving. Hence, a conservative approach would be to assume that consumers' WTP for the TOs to move from the highest level of service for the second choice set is zero. However, this is conservative, since the CEs suggested non-domestic consumers did express a positive WTP for the TOs to deliver the highest level of innovation projects.

Table 5.10: Comparison Between CE and CV Results – Willingness to Pay (% bill Change consumer/year)

First Exercise

Attribute	**WTP (1 to 2)**	**WTP (2 to 3)**
Power Cuts	2.00%	2.00%
Blackouts	1.11%	0.00%
Undergrounding	2.07%	0.07%
Visual Amenity	1.26%	0.53%
Improving transmission sites	1.93%	1.55%
Total	8.38%	4.15%
Package Question	5.05%	1.37%
Difference (Package questions relative to exercises)	**-40%**	**-67%**

Second Exercise

Attribute	**WTP (1 to 2)**	**WTP (2 to 3)**
Innovation	0.80%	0.35%
Supporting Communities	1.46%	-0.70%
Ready for EV	2.46%	0.00%
Ready for renewables	2.95%	0.00%
Total	7.68%	-0.36%
Package Question	2.81%	0.85%
Difference (Package questions relative to exercises)	**-63%**	**-338%**

We therefore recommend the TOs rely on the scaled results shown in Table 5.11, but consider that these may understate the true value non-domestic consumers place on the large innovation projects.

Table 5.11: Unscaled and Scaled results – Willingness to Pay (£/consumer/year)

Attributes	Unscaled WTP (£)	Scaled WTP (£)
Risk of powercuts		
2 hours decrease in the hours of powercuts at a 1.5% probability	2.00%	1.20%
4 hours decrease in the hours of powercuts at a 1.5% probability	3.99%	1.86%
Days to recover from a blackout		
2 fewer days to recover form a blackout	1.11%	0.67%
Undergrounding Overhead Transmission Lines		
20 miles additional underground in National Parks etc.	2.07%	1.25%
20 miles additional underground in other areas	2.15%	1.27%
Improving visual amenity of Overhead Transmission Lines		
Additional visual impact work in National Parks etc.	1.26%	0.76%
Additional visual impact work in National Parks and other areas	1.79%	0.94%
Every additional transmission site environment improved	0.08%	0.05%
Investing in innovation projects		
Medium Scale Projects compared to Small Scale Projects	0.80%	0.29%
Large Scale Projects compared to Small Scale Projects	1.15%	0.42%
Supporting local communities		
Current level of community activities	1.46%	0.53%
Current level of community activities and additional funding to charities	0.76%	0.28%
Investing in EV Charging Infrastructure		
Invest before definite need	2.46%	0.90%
Investing in infrastructure to connect to renewable generation		
Invest before definite need	2.95%	1.08%

Source: NERA Analysis

5.2.3. Recommended valuations

Because we conduct our modelling based on percentage changes in bill, the final step in the process is to convert these figures into WTP in monetary terms. We monetise these percentage WTP estimates by multiplying them by the median bill of non-domestic respondents who reported their bill in the survey. We consider this approach to be conservative because we would expect a positive skew in the distribution of bills across non-domestic consumers because some will use large amounts of energy. Based on the survey data, the median reported bill was £3,600 for non-domestic electricity consumers.

We have therefore converted the recommended WTP figures in percentage terms from Table 5.11 above into monetary terms in Table 5.12 below.

Table 5.12: Recommended Valuation Results (Unscaled) in Percentage and Monetary Terms

Attributes	WTP (%)	WTP (£)
Risk of powercuts		
2 hours decrease in the hours of powercuts at a 1.5% probability	1.20%	**43.30**
4 hours decrease in the hours of powercuts at a 1.5% probability	1.86%	**66.95**
Days to recover from a blackout		
2 fewer days to recover form a blackout	0.67%	**24.15**
Undergrounding Overhead Transmission Lines		
20 miles additional underground in National Parks etc.	1.25%	**45.02**
20 miles additional underground in other areas	1.27%	**45.90**
Improving visual amenity of Overhead Transmission Lines		
Additional visual impact work in National Parks etc.	0.76%	**27.36**
Additional visual impact work in National Parks and other areas	0.94%	**33.68**
Every additional transmission site environment improved	0.05%	**1.68**
Investing in innovation projects		
Medium Scale Projects	0.29%	**10.56**
Large Scale Projects	0.29%	**10.56**
Supporting local communities		
Current level of community activities	0.53%	**19.23**
Current level of community activities and additional funding to charities	0.53%	**19.23**
Investing in EV Charging Infrastructure		
Invest before definite need	0.90%	**32.38**
Investing in infrastructure to connect to renewable generation		
Invest before definite need	1.08%	**38.89**

Source: NERA Analysis

5.3. Gas Domestic Results

5.3.1. Analysis of consumer preferences on service levels

We started by running a basic model for the choice experiments, excluding controls for consumer characteristics (e.g. age, income, etc.). Table 5.13 shows the WTP results we estimate for the attributes covered by the first question, with more detailed econometric results shown in Appendix C.

Table 5.13: Willingness to Pay (£/consumer/year) Estimates from the Simple Model

	Conditional Logit		Mixed Logit	
Attributes	WTP (£)	Statistically Significant	WTP (£)	Statistically Significant
For a 1/10,000 reduction in the probability of a supply interruption.	7.19	Yes	7.97	Yes
Improving environment around transmission sites				
Additional 3 large sites and 10 small sites	3.23	Yes	3.62	Yes
Additional 11 large sites and 30 small sites	4.95	Yes	5.28	Yes
Supporting local communities				
Current level of community schemes compared to no support	4.78	Yes	4.83	Yes
Current level of community schemes and additional funding to charities and other organizations compared to no support	6.74	Yes	6.89	Yes
Investing in innovation projects				
Small scale projects compared to no innovation projects	6.14	Yes	6.17	Yes
Large scale projects compared to no innovation projects	9.45	Yes	9.49	Yes
Supporting consumers in fuel poverty				
Provide information to lower their energy bills compared to no information	1.42	No	1.54	Yes
Provide information to lower their energy bills and funding/financing compared to no support	4.83	Yes	5.09	Yes

Source: NERA Analysis

The results in Table 5.13 show, in line with expectation, that consumers have a higher WTP for higher levels of service. All attributes have a statistically significant WTP, except for the variable related to providing information to fuel poor consumers to help them lower their energy bills. However, it is significant in the mixed logit model, which we consider to be a more robust estimator.

The table shows that consumers value improvements to the environment around transmission sites, with a higher value placed on improving a higher number of sites. They also value National Grid providing more community support, investing in innovation and supporting consumers in fuel poverty. Regarding reliability, consumers place a very high value on improving reliability, of £7.97/consumer/year for a reduction in the probability by 1/10,000 of a major incident, causing a systematic loss of gas throughout a large part of the country lasting several months.

It is difficult to compare this to existing VoLL metrics, which are not based on survey evidence related to this particular type of severe and rare incident. However, if consumers consume 1,000kWh per month, then a 1/10,000 change in the probability of this incident changes expected consumption by 0.1kWh/year. Hence, we obtain a VOLL of £79,700/MWh of gas. Hence, like the electricity domestic survey (see Section 5.1.1), we find consumers stating they are willing to pay relatively large sums to improve reliability of the transmission system and avoid severe interruptions that would cause wide-spread disruption.

As described in Section 5.1.3 for the electricity survey, we also tested the sensitivity of valuation results to demographic characteristics. We followed a general-to-specific model selection procedure to assess which consumer attributes and other variables had a statistically significant impact on respondents' choices, and estimated a new mixed logit model to derive WTP using a model that controls for these effects.

We tested whether WTP is sensitive to gender, SEG, age, income, household size, north-Scotland, south-Scotland and Scotland in total We also tested sensitivity to research method (face-to-face vs. online), prior experience of interruptions, understanding of the services. We tested both whether overall WTP is sensitive to demographics (i.e. by interacting demographic variables with the bill variable) and whether WTP for individual attributes depends on demographics (i.e. by interacting demographic variables with service levels):

- We find that respondents' valuation of "improving environment around transmission sites", "supporting local communities" and "supporting consumers in fuel poverty" is sensitive to gender, with women valuing these attributes more than men.
- The value of the "risk of supply interruption" attribute is also sensitive to age, with older respondents (aged 45 and over[36]) valuing improved reliability more highly than younger groups. While we do not find a statistically significant link between consumers' income and their WTP, the statistically significant link between WTP for reliability and age may be related to older people tending to have higher income. It may also relate to other factors, such as placing a higher value on the continued availability of gas for heating and cooking, or the balance between rural and urban households at different ages.
- We also find that consumers' WTP for improving reliability is sensitive to whether respondents answered "yes" to the question asking whether they believe that a supply interruption could actually happen.
  - Based on intuition, we would expect that respondents' who do not believe these events can actually happen would be reluctant to select more expensive service packages to reduce their likelihood. Hence, we would expect their willingness to pay to improve reliability to be lower than other consumers who perceived these events could happen. However, the results show the contrary, as we find that consumers are willing to pay more if they do not believe these events can actually happen.
  - Given this finding, we considered excluding the attribute capturing prior experience of an interruption as a variable in our econometric models, on the basis that the statistical relationship is not economically intuitive. However, to be conservative in the valuation results we obtain, we included it in our models. When estimating WTP, we use the models to estimate WTP for the consumers that stated they did believe the events could happen.

[36] Note, the survey provided us with more granular age data than these two brackets (18-44 and 45+). However, we only found a statistically significant relationship between age and respondents' choices when we used this relatively wide age brackets.

Table 5.14: Differences in Willingness to Pay (£/consumer/year) Resulting from Controlling for Differences Between Consumers

Demographic control	Attribute	WTP (£)	
		Male	**Female**
Gender	Environment around sites (level 1 to 3)	3.89	6.69
Gender	Supporting Communities (level 1 to 3)	5.26	8.26
Gender	Supporting consumers in fuel poverty (level 1 to 2)	-0.29	2.92
Gender	Supporting consumers in fuel poverty (level 1 to 3)	3.03	6.87
		18 - 44	**45+**
Age	Supply interruption	4.12	8.84
		Believe	**Not believe**
Believe in interruptions	Supply interruption	8.84	12.54

Source: NERA Analysis

Table 5.15 below shows the effect of controlling for the statistically significant consumer characteristics described above. However, because we evaluate the logit model for the average respondent, so the TOs can use the results to value schemes that affect the generality of consumers not specific groups, the results are relatively similar to the results emerging from the model that does not control for these effects.

Table 5.15: Results Mixed Logit Models, With and Without Control Variables – Willingness to Pay (£/consumer/year)

	No control variables		**Control variables**	
Attributes	WTP (£)	Statistically Significant	WTP (£)	Statistically Significant
For a 1/10,000 reduction in the probability of a supply interruption.	7.97	Yes	6.71	Yes
Improving environment around transmission sites				
Additional 3 large sites and 10 small sites	3.62	Yes	3.61	Yes
Additional 11 large sites and 30 small sites	5.28	Yes	5.37	Yes
Supporting local communities				
Current level of community schemes compared to no support	4.83	Yes	4.79	Yes
Current level of community schemes and additional funding to charities and other organizations compared to no support	6.89	Yes	6.85	Yes
Investing in innovation projects				
Small scale projects compared to no innovation projects	6.17	Yes	6.05	Yes
Large scale projects compared to no innovation projects	9.49	Yes	9.40	Yes
Supporting consumers in fuel poverty				
Provide information to lower their energy bills compared to no information	1.54	Yes	1.41	Yes
Provide information to lower their energy bills and funding/financing compared to no support	5.09	Yes	5.06	Yes

Source: NERA Analysis

We also examined possible non-linearities in consumers' preferences for reliability, as this is the only attribute defined quantitatively (i.e. as a probability of an incident). While we do find statistically significant evidence of non-linearity, with different per-unit valuations between levels 1-2 and levels 2-3, the table below shows these effects are very small. Hence, we base our recommended valuation (per unit) on the linear measure, which is also the lowest figure shown in the table below (£6.76/consumer/year), meaning our approach is likely to be conservative[37].

Table 5.16: The Effect on WTP of Controlling for Non-Linearity in Preferences for Improved Reliability - Willingness to Pay (£/consumer/year)

	£ WTP (non-linear)	£ WTP (linear)	
For a 1/10,000 reduction in the probability of a supply interruption.	N/A	7.19	
Level 1 (1 in 5,750) to level 2 (1 in 12,500)	7.01	7.19 scaled by difference between level 1 and level 2	6.76
Level 1 (1 in 5,750) to level 3 (1 in 13,750)	7.09	7.19 scaled by difference between level 1 and level 3	7.28

Source: NERA analysis

Unlike the electricity survey, the gas survey did not include a CV question at the end bringing together two sets of results from different CEs, as it considered a smaller number of attributes. Therefore, there was no need to scale down the CE valuation results to capture the effect of consumers' stated WTP for some attributes being higher than their stated WTP for changes in all attributes when considered together. We also tested whether the amount by which respondents were told the bill would change due to other factors not covered by the survey, and found it was not statistically significant. As such, there is no basis for scaling down the results of the CEs. Our recommended valuations are shown in Table 5.17 below.

37 We conducted these tests using our simple, conditional logit model.

Table 5.17: Gas Valuation Recommendations – Willingness to Pay (£/consumer/year)

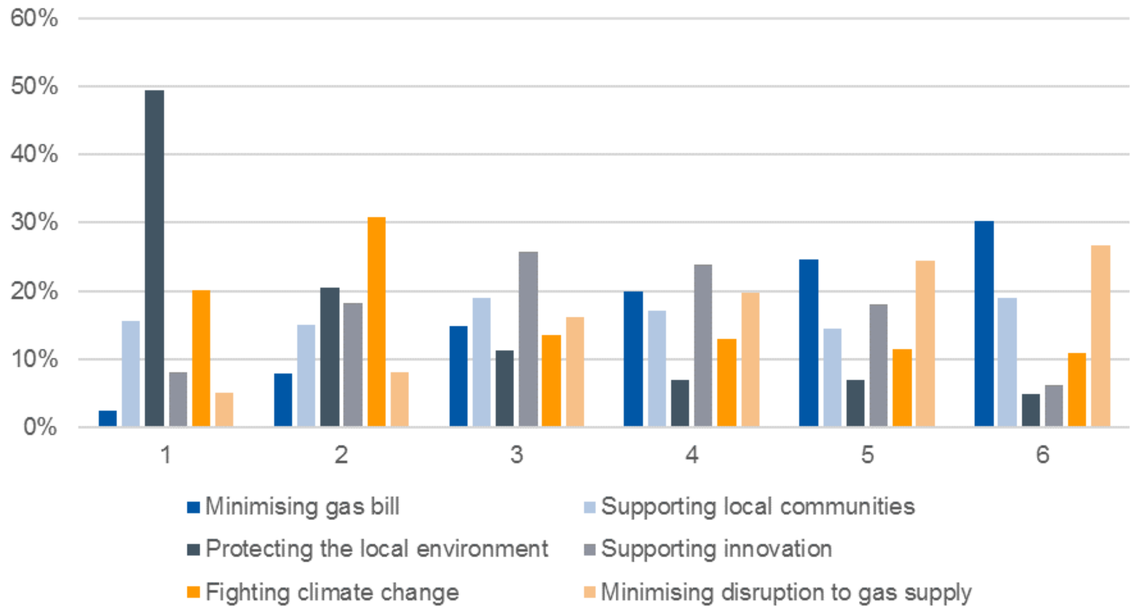
Attributes	WTP (£)
For a 1/10,000 reduction in the probability of a supply interruption.	6.71
Improving environment around transmission sites	
Additional 3 large sites and 10 small sites	3.61
Additional 11 large sites and 30 small sites	5.37
Supporting local communities	
Current level of community schemes compared to no support	4.79
Current level of community schemes and additional funding to charities and other organizations compared to no support	6.85
Investing in innovation projects	
Small scale projects compared to no innovation projects	6.05
Large scale projects compared to no innovation projects	9.40
Supporting consumers in fuel poverty	
Provide information to lower their energy bills compared to no information	1.41
Provide information to lower their energy bills and funding/financing compared to no support	5.06

Source: NERA Analysis

5.3.2. Cross-check based on consumers' stated priorities

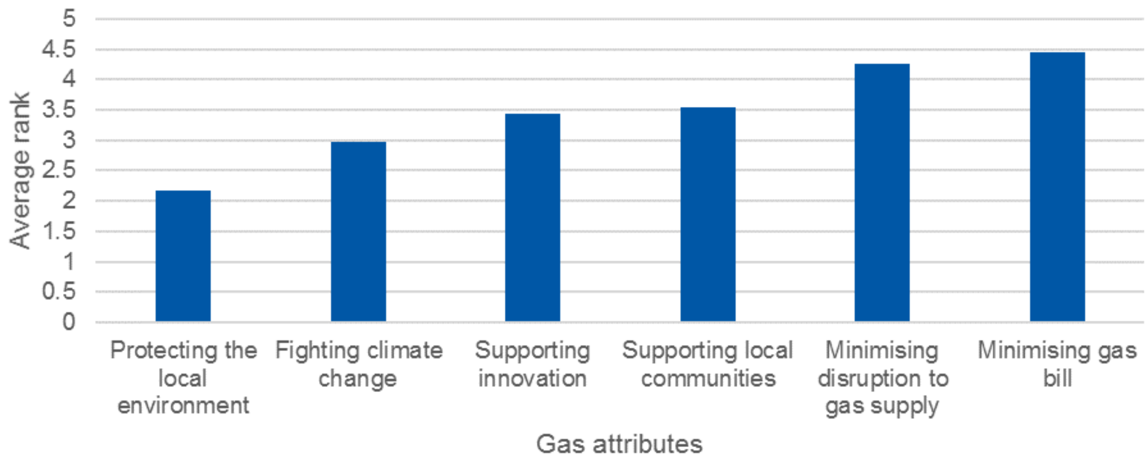
Respondents were asked to rank six broad priorities (which covered the five attributes they valued in the choice experiment as well as the level of bills), by ranking them from 1 to 6 ("most important attribute" to "least important attribute"). Figure 5.5 shows what percentage of respondents ranked a certain attribute as highest priority, second priority etc. Almost 50% of respondents chose "protecting the local environment" as their highest priority, while Figure 5.6 below shows that "protecting the local environment" has the highest average rank, while "minimising gas bill" has the lowest average rank.

Figure 5.5: Respondents' Ranked Priorities from 1 as "Most Important" to 6 as "Least Important"



Source: NERA Analysis.

Figure 5.6: Respondents' Average Ranking of Priorities



Source: NERA Analysis.

5.3.3. Analysis of consumer preferences on alternative heating technologies

In the second CE in the gas questionnaire, we asked consumers about their preferences for alternative heating technologies. We ask consumers to make choices between five technologies: gas boilers, air source heat pumps, hybrid heat pumps, ground source heat pumps and district heating. Respondents saw a series of choice cards which each included two of these (randomly selected) technologies. The choice card showed information about the technology: an indicator of its environmental impact, its running costs and the level of disruption required to install it.

This exercise asked consumers, at the point when it comes to replacing their existing gas boiler, which of two alternative heating technologies that are presented in each choice card would they prefer. We ask consumers to choose between two alternatives, considering the characteristics of the alternatives presented, and a randomized installation cost, which in this exercise is the payment vehicle we use to estimate WTP. This means that our WTP estimates can be interpreted as the extent to which an alternative technology must be cheaper than a gas boiler for consumers to choose to switch heating technologies, i.e. from a gas boiler to the alternative, when they would be changing their boiler anyway.

Table 5.18 shows the results we estimate for the different heating systems, with regression coefficients shown in Appendix C. The table shows that consumers would require the alternative heating technologies presented to them to be considerably cheaper before they would be willing to switch away from a gas boiler. For example, the average consumer would require an air source heat pump to be offered at a price £11,508 less than the cost of a gas boiler. Comparing the cost of a new boiler (approximately £2,000) with the much higher cost of a heat pump, this suggests a substantial subsidy would be required to encourage the "average" consumer to switch.

Table 5.18: Willingness to Pay Estimated from a Model Excluding Control Variables on Consumer Characteristics (£/consumer/year)

	Conditional Logit		Mixed Logit	
Attributes	WTP (£)	Statistically Significant	WTP (£)	Statistically Significant
Air Source Heat Pump instead of installing a Gas Boiler	-11773.00	Yes	-8816.13	Yes
Ground Source Heat Pump instead of installing a Gas Boiler	-15464.22	Yes	-13578.62	Yes
District Heating System instead of installing a Gas Boiler	-11518.47	Yes	-8941.26	Yes
Hybrid Heat Pump instead of installing a Gas Boiler	-19808.53	Yes	-19935.40	Yes

Source: NERA Analysis

We also tested whether particular types of consumers had higher or lower WTP for these alternative heating technologies. As Table 5.19 shows, we found younger[38] consumers tended to require lower discounts for alternative technologies relative to gas boilers, possibly reflecting their greater openness to new technologies or greater concern for the environment.

Table 5.19: Variation in Willingness to Pay (£/consumer/year) For Alternative Heating Technologies with Respondent Characteristics

Demographic control	**Attribute**	**WTP (£)**	
		18 - 44	**45+**
Age	Air Source Heat Pump	-6,202	-11,096
Age	Ground Source Heat Pump	-10,380	-15,723
Age	District heating System	-6,493	-11,100

Source: NERA Analysis

38 We also tested a linear age variable, but did not find a statistically significant relationship. Therefore, we conclude that we correctly control for differences in WTP for younger respondents by using a 'threshold', i.e. under and over 45.

As well as testing whether respondents had different preferences for particular technologies, we also tested whether the demographic variables had a statistically significant impact on the installation cost variable, which determines the "price-sensitivity" of respondents' choices. We tested for various age brackets and found that younger (18 – 44) respondents are more price sensitive, as for a given price difference, they would be more likely to switch away from a gas boiler. However, they would still require alternative technologies to be materially cheaper than a gas boiler before they would be willing to switch, as Table 5.20 shows.

Table 5.20: Variation in Willingness to Pay (£/consumer/Year) by Age Group

Demographic control	Attribute	£WTP	
		18 – 44	**45+**
Age	Air Source Heat Pump	-2,990.76	-8,195.63
Age	Ground Source Heat Pump	-4,237.75	-11,612.80
Age	District heating System	-2,991.68	-8,198.16
Age	Hybrid Heat Pump	-5,117.30	-140,23.06

Source: NERA Analysis

We show the results for the average consumer from the controlled and uncontrolled model in Table 5.21.

Table 5.21: Mixed Logit Results With and Without Controls – Willingness to Pay (£/consumer/year)

	No control variables		Control variales	
Attributes	WTP (£)	Statistically Significant	**WTP (£)**	Statistically Significant
Air Source Heat Pump instead of installing a Gas Boiler	-8816.13	Yes	-8965.90	Yes
Ground Source Heat Pump instead of installing a Gas Boiler	-13578.62	Yes	-13426.76	Yes
District Heating System instead of installing a Gas Boiler	-8941.26	Yes	-9099.76	Yes
Hybrid Heat Pump instead of installing a Gas Boiler	-19935.40	Yes	-19140.36	Yes

Source: NERA Analysis

5.4. Gas Non-Domestic Results

5.4.1. Analysis of consumer preferences on alternative service levels

We also used conditional logit modelling with percentage bill changes to analyse the results of the gas non-domestic survey. The results from the basic models that exclude variables apart from bill impact and service levels are shown in Table 5.22 below. As the table shows, we find statistically significant evidence that non-domestic consumers are willing to pay more to improve service across all attributes, with the following exceptions:

- We find that estimated WTP to improve a small number of transmission sites is not statistically significant, although the valuation implied by the basic model is positive and the larger improvement does have a statistically significant WTP. This suggests consumers do value environmental improvement around transmission sites, and their WTP increases with the number of sites improved, but the variance around WTP per site improved is sufficiently wide that it is not discernibly different from zero at low levels.

- We also do not find a statistically significant WTP from non-domestic consumers for measures to address fuel poverty. This may reflect non-domestic consumers responding to survey questions based on their private interests, without considering wider societal benefits of alleviating fuel poverty. It may also reflect that non-domestic consumers already participate in their own charitable or corporate social responsibility schemes.

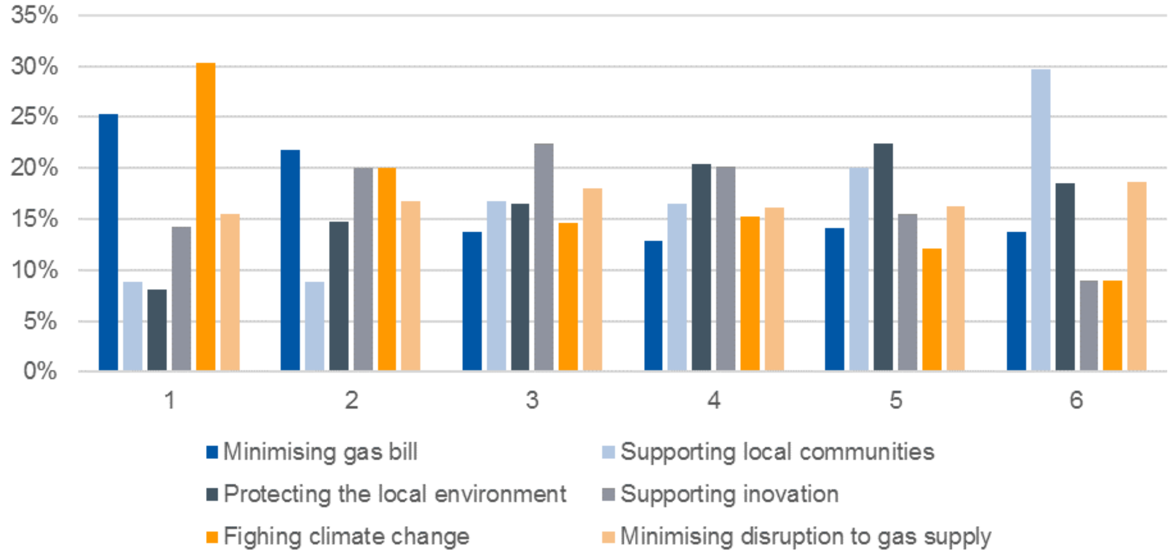
Table 5.22: Willingness to Pay (% bill change/consumer/year) from Basic Models

	Conditional Logit	
Attributes	WTP (£)	Statistically Significant
For a 1/10,000 reduction in the probability of a supply interruption.	1.55%	Yes
Improving environment around transmission sites		
Additional 3 large sites and 10 small sites	0.59%	No
Additional 11 large sites and 30 small sites	1.17%	Yes
Supporting local communities		
Current level of community schemes compared to no support	1.46%	Yes
Current level of community schemes and additional funding to charities and other organizations compared to no support	1.71%	Yes
Investing in innovation projects		
Small scale projects compared to no innovation projects	1.40%	Yes
Large scale projects compared to no innovation projects	2.28%	Yes
Supporting consumers in fuel poverty		
Provide information to lower their energy bills compared to no information	0.36%	No
Provide information to lower their energy bills and funding/financing compared to no support	-0.20%	No

Source: NERA Analysis

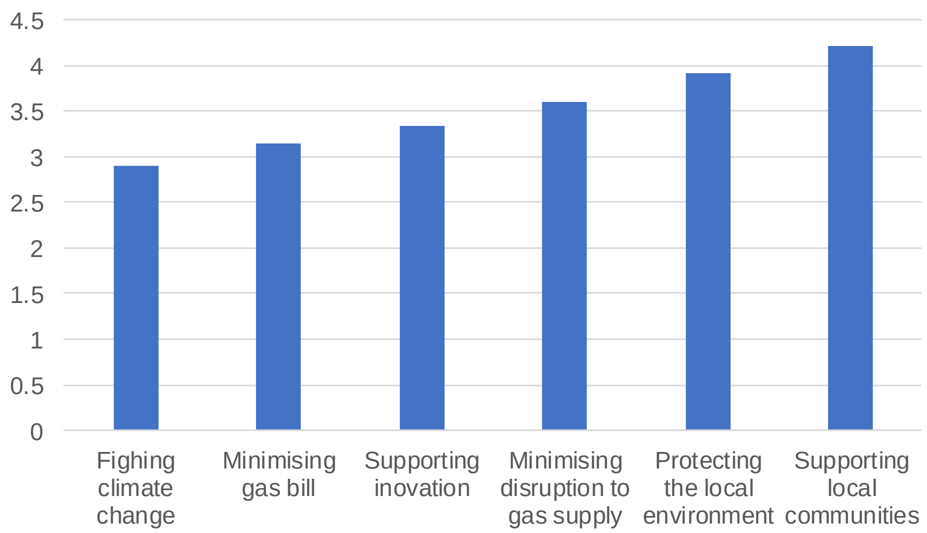
After the choice exercises, respondents carried out a short priority ranking exercise. Figure 5.7 shows what percentage of respondents ranked each attribute as highest priority, second priority etc. 30% of respondents chose “fighting climate change” as their highest priority, while 25% chose “minimising gas bills” as their highest priority. The second figure below shows that “supporting local communities” has the highest average rank and “fighting climate change” has the lowest average rank across all respondents.

Figure 5.7: Respondents' Ranked Priorities from 1 as "Most Important" to 6 as "Least Important"



Source: NERA Analysis.

Figure 5.8: Respondents' Average Ranking of Priorities



Source: NERA Analysis.

We also tested the sensitivity of valuation results to demographic characteristics. As explained above in Section 5.1.3, we control the conditional logit model for firms' characteristics.

As for the other surveys, we expanded the basic model by including drivers reflecting firms' characteristics and other factors. We tested whether WTP is sensitive to firm size and region. We also tested sensitivity to prior experience of interruptions and understanding of the services. We tested both whether overall WTP is sensitive to characteristics (i.e. by interacting demographic variables with the bill variable) and whether WTP for individual attributes depends on firm characteristics (i.e. by interacting characteristics with service levels.

As the regression results in Appendix C show, we find that respondents' valuation of "supporting local communities" is sensitive to firm size. As Table 5.23 shows, our estimated WTP is higher in percentage terms for larger firms (over 50 employees). This may reflect that larger firms have higher WTP in absolute terms, but lower WTP as a percentage of their gas bill.

Table 5.23: Willingness to Pay for Sub-Groups of Non-domestic Consumers (% bill change/consumer/year)

Attribute	% WTP	
	Small firms	**Large firms**
Supporting communities	2.25%	1.01%

Source: NERA Analysis

We also tested whether respondents had a higher or lower overall WTP for all attributes, by interacting firm characteristics with the bill change variable in our logit models. We found that large firms have a higher WTP than smaller firms (see Table 5.24), though as noted above with reference to the "supporting communities" attribute their WTP may be just as large (or larger) in absolute terms if they use more energy than smaller firms.

Table 5.24: Variation in Willingness to Pay (£/consumer/year) for Large / Small Firms

Attribute	% WTP	
	Small firms	**Large firms**
Environment around sites (level 1 to 2)	0.37%	0.39%
Environment around sites (level 1 to 3)	0.76%	0.81%
Supporting communities (level 1 to 2)	1.51%	1.60%
Supporting communities (level 1 to 3)	1.14%	1.21%
Investing in innovation (level 1 to 2)	0.91%	0.97%
Investing in innovation (level 1 to 3)	1.51%	1.60%

Source: NERA Analysis

Table 5.25 below also shows the impact on average WTP from re-estimating the models in a way that controls for the different preferences of larger and smaller non-domestic consumers. As for the other surveys discussed above, controlling for respondents' characteristics results in only small changes to our average WTP estimates.

Table 5.25: Impact of Controlling for Firm Size on Average Willingness to Pay (% bill change/consumer/year)

	No control variables		Control variables	
Attributes	WTP (£)	Statistically Significant	WTP (£)	Statistically Significant
For a 1/10,000 reduction in the probability of a supply interruption.	1.55%	Yes	1.53%	Yes
Improving environment around transmission sites				
Additional 3 large sites and 10 small sites	0.31%	No	0.55%	No
Additional 11 large sites and 30 small sites	1.17%	Yes	1.13%	Yes
Supporting local communities				
Current level of community schemes compared to no support	1.46%	Yes	1.45%	Yes
Current level of community schemes and additional funding to charities and other organizations compared to no support	1.71%	Yes	1.70%	Yes
Investing in innovation projects				
Small scale projects compared to no innovation projects	1.40%	Yes	1.36%	Yes
Large scale projects compared to no innovation projects	2.28%	Yes	2.25%	Yes
Supporting consumers in fuel poverty				
Provide information to lower their energy bills compared to no information	0.36%	No	0.36%	No
Provide information to lower their energy bills and funding/financing compared to no support	-0.20%	No	-0.19%	No

Source: NERA Analysis

We also examined possible non-linearities in consumers' utility function for the reliability variable, as this is the only attribute defined quantitatively (i.e. as a probability of an incident). While we do find statistically significant evidence of non-linearity, with different per-unit valuations between levels 1-2 and levels 2-3, the table below shows the effects are of non-linearity very small. Hence, we base our recommended valuation (per unit) on the linear measure, consistent with our approach for domestic consumers.[39]

Table 5.26: Impact of Non-linearity on Estimated Willingness to Pay (%/consumer/year)

	% WTP (non-linear)	**% WTP (linear)**	
For a 1/10,000 reduction in the probability of a supply interruption.	N/A	1.55%	
Level 1 (1 in 5,750) to level 2 (1 in 12,500)	1.27%	1.55% scaled by difference between level 1 and 2	1.46%
Level 1 (1 in 5,750) to level 3 (1 in 13,750)	1.71%	1.55% scaled by difference between level 1 and 3	1.57%

Source: NERA analysis

Finally, we tested whether respondents' WTP for changes in service depend on the statement in the survey about the "bill change for other reasons" and found no statistically significant evidence that it does.

39 We conducted these tests using our simple, conditional logit model.

5.4.2. Recommended valuations in monetary terms

Based on the results described above, we recommend the use of the average WTP emerging from the controlled model, though because the value of improving the environment around transmission sites is only significant for the higher level of service, we recommend valuing this attribute on a "per unit" basis based on the valuation for the highest service level (i.e. 1.13%). Hence, we recommend valuing the lower level of service at 3/11 of the value estimated for the higher level of service (1.13% x 3 / 11 = 0.31%). We also recommend zero valuations on the fuel poverty attributes.

We conducted our modelling based on percentage changes in bill, and converted into WTP in monetary terms post-modelling. We monetise percentage WTP based on the *median* bill of non-domestic respondents who reported their bill, which is conservative given the positive skew in the bill distribution. We find a median bill of £3,210 for gas consumers. Table 5.27 shows the final recommended valuation for the non-domestic gas survey.

Table 5.27: Recommended Non-domestic Gas Willingness to Pay values in Percentage and Monetary Terms (/consumer/year)

Attributes	WTP (%)	WTP (£)
For a 1/10,000 reduction in the probability of a supply interruption.	1.53%	**49.08**
Improving environment around transmission sites		
Additional 3 large sites and 10 small sites	0.31%	**9.91**
Additional 11 large sites and 30 small sites	1.13%	**36.35**
Supporting local communities		
Current level of community schemes compared to no support	1.45%	**46.65**
Current level of community schemes and additional funding to charities and other organizations compared to no support	1.70%	**54.73**
Investing in innovation projects		
Small scale projects compared to no innovation projects	1.36%	**43.74**
Large scale projects compared to no innovation projects	2.25%	**72.27**
Supporting consumers in fuel poverty		
Provide information to lower their energy bills compared to no information	0	**0**
Provide information to lower their energy bills and funding/financing compared to no support	0	**0**

Source: NERA Analysis

6. Conclusions

6.1. Summary of Modelling Results

This study estimates domestic and non-domestic consumers' WTP for service improvements (and current levels of service) that the TOs can provide through business planning decisions taken through the RIIO-T2 price control review. It also investigates gas domestic consumers' preferences for alternative heating technologies in their homes.

We conducted four stated preference surveys, using a mix of face-to-face and online methods, adhering to best practice in the conduct of WTP surveys, and before conducting fieldwork we tested the survey instrument thoroughly to ensure it was understandable.

The survey instrument performed well, providing a base estimate for the TOs' societal valuations to inform RIIO-T2 business planning decisions. We found that respondents appeared to engage well with the instrument, and that an overwhelming majority reported that they were able to understand the attributes and make choices between the options presented to them.

We find that domestic gas and electricity consumers are, on average, willing to pay for improvements in all attributes which were presented to them. However, we found that electricity consumers give lower valuations when they valued the whole package at once (in the CV exercise) than when they valued trade-offs between individual attributes (in the CEs). The CV exercise also suggested consumers are willing to pay less for improvements to the highest service levels. Therefore, we recommend the TOs rely on the scaled WTP estimates presented in Table 6.1 below.

We also find non-domestic electricity consumers are willing to pay for higher service across most attributes. Our recommended valuations are shown in the final column of Table 6.2 below.

Table 6.1: Recommended Domestic Electricity Willingness to Pay values (£/consumer/year)

Attributes	WTP (£)
Risk of powercuts	
2 hours decrease in the hours of powercuts at a 1.5% probability	7.70
4 hours decrease in the hours of powercuts at a 1.5% probability	9.70
Every fewer day to recover from a blackout	3.58
Undergrounding Overhead Transmission Lines	
20 miles additional underground in National Parks etc.	6.87
20 miles additional underground in other areas	6.46
Improving visual amenity of Overhead Transmission Lines	
Additional visual impact work in National Parks etc.	4.14
Additional visual impact work in National Parks and other areas	4.81
Additional transmission site environment improved	
25 additional sites	8.92
45 additional sites	10.78
Investing in innovation projects	
Medium Scale Projects compared to Small Scale Projects	2.38
Large Scale Projects compared to Small Scale Projects	3.11
Supporting local communities	
Current level of community activities	8.26
Current level of community activities and additional funding to charities	8.46
Investing in EV Charging Infrastructure	
Invest before definite need	9.55
Investing in infrastructure to connect to renewable generation	
Invest before definite need	11.78

Source: NERA Analysis

Table 6.2: Recommended Non-domestic Electricity Willingness to Pay values in Percentage (% bill/consumer/year) and Monetary Terms (/consumer/year)

Attributes	WTP (%)	WTP (£)
Risk of powercuts		
2 hours decrease in the hours of powercuts at a 1.5% probability	1.20%	**43.30**
4 hours decrease in the hours of powercuts at a 1.5% probability	1.86%	**66.95**
Days to recover from a blackout		
2 fewer days to recover form a blackout	0.67%	**24.15**
Undergrounding Overhead Transmission Lines		
20 miles additional underground in National Parks etc.	1.25%	**45.02**
20 miles additional underground in other areas	1.27%	**45.90**
Improving visual amenity of Overhead Transmission Lines		
Additional visual impact work in National Parks etc.	0.76%	**27.36**
Additional visual impact work in National Parks and other areas	0.94%	**33.68**
Every additional transmission site environment improved	0.05%	**1.68**
Investing in innovation projects		
Medium Scale Projects	0.29%	**10.56**
Large Scale Projects	0.29%	**10.56**
Supporting local communities		
Current level of community activities	0.53%	**19.23**
Current level of community activities and additional funding to charities	0.53%	**19.23**
Investing in EV Charging Infrastructure		
Invest before definite need	0.90%	**32.38**
Investing in infrastructure to connect to renewable generation		
Invest before definite need	1.08%	**38.89**

Source: NERA Analysis.

In the gas domestic survey we find positive WTP for all service attributes, shown in Table 6.3 below. We also find domestic gas consumers require, on average, large sums of compensation in order to switch from a gas boiler to an alternative heating technology, as indicated by the negative values for each technology in Table 6.4.

We also find non-domestic gas consumers are willing to pay for higher service across most attributes, although for some attributes, non-domestic consumer's WTP is not statistically significantly different from 0. To ensure we take a conservative approach, we have assumed WTP is zero for the attributes where we did not identify a statistically significant WTP. Our recommended valuations are shown in the final column of Table 6.5 below.

Table 6.3: Recommended Domestic Gas Willingness to Pay values (£/consumer/year)

Attributes	WTP (£)
For a 1/10,000 reduction in the probability of a supply interruption.	6.71
Improving environment around transmission sites	
Additional 3 large sites and 10 small sites	3.61
Additional 11 large sites and 30 small sites	5.37
Supporting local communities	
Current level of community schemes compared to no support	4.79
Current level of community schemes and additional funding to charities and other organizations compared to no support	6.85
Investing in innovation projects	
Small scale projects compared to no innovation projects	6.05
Large scale projects compared to no innovation projects	9.40
Supporting consumers in fuel poverty	
Provide information to lower their energy bills compared to no information	1.41
Provide information to lower their energy bills and funding/financing compared to no support	5.06

Source: NERA Analysis

Table 6.4: Recommended Domestic Alternative Heating Technology Willingness to Pay values (£/consumer/year)

Attributes	WTP (£)
Air Source Heat Pump instead of installing a Gas Boiler	-8965.90
Ground Source Heat Pump instead of installing a Gas Boiler	-13426.76
District Heating System instead of installing a Gas Boiler	-9099.76
Hybrid Heat Pump instead of installing a Gas Boiler	-19140.36

Source: NERA Analysis

Table 6.5: Recommended Non-domestic Gas Willingness to Pay values in Percentage and Monetary Terms (/consumer/year)

Attributes	WTP (%)	WTP (£)
For a 1/10,000 reduction in the probability of a supply interruption.	1.53%	**49.08**
Improving environment around transmission sites		
Additional 3 large sites and 10 small sites	0.31%	**9.91**
Additional 11 large sites and 30 small sites	1.13%	**36.35**
Supporting local communities		
Current level of community schemes compared to no support	1.45%	**46.65**
Current level of community schemes and additional funding to charities and other organizations compared to no support	1.70%	**54.73**
Investing in innovation projects		
Small scale projects compared to no innovation projects	1.36%	**43.74**
Large scale projects compared to no innovation projects	2.25%	**72.27**
Supporting consumers in fuel poverty		
Provide information to lower their energy bills compared to no information	0	**0**
Provide information to lower their energy bills and funding/financing compared to no support	0	**0**

Source: NERA Analysis.

For all four surveys, we find that our WTP estimates are robust to a range of different assumptions in our modelling, for example controlling for respondent characteristics (such as demographic characteristics and firm size), as well as alternative econometric approaches (since we use both the mixed logit and conditional logit modelling techniques).

6.2. Considerations for Use in CBA Modelling

We have made recommendations using the stated preference research that (for a range of reasons described above) make a very conservative assessment of the statistical evidence when estimating consumers' WTP for service improvement, particularly with regards to our assumptions about consumers' WTP for the highest levels of service.

Despite this conservative approach, we understand from our discussions from the TOs that the level of willingness to pay identified through this research exceeds the likely costs of provision by the TOs. On the face of it, this provides good evidence of an economic case for the TOs providing the services considered by the survey. However, this finding comes with a number of caveats that the TOs will need to consider during the business planning process.

- First, as further validation of the willingness to pay results, when used in business planning these WTP estimates would also benefit from being triangulated alongside other sources of valuation evidence, as well as other evidence of consumer preferences, such as qualitative research and analysis of consumers' support for business plan proposals. This reflects, for instance, cautionary guidance offered by Ofwat regarding potential overreliance on stated preference methodology.
- Even if the willingness to pay values we obtain are relatively high when compared to the costs of changing service levels, and if these findings are supported by other forms of quantitative or qualitative engagement evidence, it would not be appropriate for the TOs to use this study as evidence that consumers support the provision of service levels that go beyond the ranges considered in this report. Hence, our valuation results should not be

applied outside the ranges of service we presented to respondents on the survey instruments.

- The valuations we have estimated do not (in isolation) provide sufficient evidence to justify the TOs carrying out any particular investment or scheme. They would need to feed into more detailed cost-benefit analysis (CBA) to justify particular initiatives or investments. For instance, even if consumers are willing to pay for the TOs to invest to accommodate renewable generation or electric vehicles ahead of a definite need, the valuation we obtain could only be interpreted as an approximate budget that consumers might be willing to contribute to such investments, and does not support any particular investment project. Further technical and economic analysis would be needed to demonstrate the value of particular investments, with this willingness to pay evidence providing a cross-check and/or an input into CBA modelling.
- Finally, while our results demonstrate consumers value the service attributes covered in this research against the context of attribute descriptions that explain these services could be provided by the TOs, our analysis does not prove definitively which industry bodies should provide such support. For instance, while we have found evidence that domestic consumers are willing to pay for the TOs to provide additional support to fuel-poor consumers during RIIO-T2, our analysis does not prove conclusively that the TOs are best placed to provide additional support, or that consumers would not be equally willing to pay for other parties to deliver the same service.

For these reasons, willingness to pay studies of this sort should not be relied upon as the sole determinant of the levels of service provided by the TOs through their RIIO2 business plans. However, it does indicate whether and by how much consumers are willing to see their bill go up to fund a certain change in service, even in light of the fact they have budget constraints, and they face trade-offs with other attributes.

Appendix A. Glossary of Terms

Acronym	Term	Definition
CE	Choice Experiment	Choice Experiments ask respondents to make choices between packages of service, making a trade-off between cost and quality. In tis study, our CE questions allow us to value marginal changes in specific aspects of service, as well as (by summation) valuing whole packages of service.
	Cognitive interview	Explores how respondents answer individual questions, understand specific terms, retrieval of relevant information, the decision-making processes, and overall understanding of the information and exercises within the tools
	Conditional logit	A version of the logit model that allows for the characteristics of the different choices to vary between respondents, sometimes referred to as a fixed-effects logit model.
CV	Contingent Valuation	Like CEs, Contingent Valuation analysis is another methods of asking respondents to state the value they place on a good or service. In this study, we use CV exercises to value the whole set of attributes together. It can only be used to derive estimates for the whole package of service attributes rather than for individual service attributes.
	Logit models	An econometric model form which allows us to estimate the probability a respondent will chose a given option from binary choices.
	Lognormal distribution	A lognormal (log-normal or Galton) distribution is a probability distribution with a normally distributed logarithm.
	Marginal utility (of income)	The additional benefit gained from consuming additional units/service
	Median	The middle value of a dataset (i.e. the value separating the higher half of a data sample from the lower half.
	Mixed logit	A version of the logit model which allows parameters in the logit model to vary, following a statistical distribution.
	Normal distribution	A function that represents the distribution of many random variables as a symmetrical bell-shaped graph (average values are more common than extreme values)
OHL	Overhead lines	Electricity power cables carried above ground on pylons (as opposed to buried underground).
	Payment vehicle	The manner by which respondents are told they will pay for service improvements on a CE or CV exercise.
	Pilot fieldwork	Small-scale preliminary survey to test the survey instrument.
	Positive skew (distribution)	A distribution that is uneven and asymmetric (skewed), possessing a longer tail on the right (positive)
	Regression coefficient	In a linear regression, the regression coefficient is a parameter that represents the rate of change of one variable
RIIO-T2	RIIO-T2	RIIO (Revenue = Incentives+Innovation+Outputs) - Transmission 2 will be the next price controls for the network companies running the gas and electricity transmission networks.
	“Scaled” valuation results	CE valuations for attributes “scaled down” according to the results of a CV exercise considering the same attribute alongside other attributes.
SEG	Socio-economic group	Socio-economic groups are divisions of people by type of occupation that is correlated with income
	Stated preference study	Survey-based experiments where respondents choose between packages of service and associated bill levels
	Survey instrument	A tool for consistently implementing a survey with multiple respondents (e.g. a survey that provides a script for presenting questions/answers)
	Triangulation	Considering valuations alongside other sources of evidence
	Undergrounding	Putting overhead lines underground (in tunnels or buried).
	Utility	Utility is an economic concept of consumers’ general wellbeing

Acronym	Term	Definition
VoLL	Value of Lost Load	Monetary measure of the value of a supply interruption (to gas or electricity)

Please note that the definitions shown in this table relate to the usage of defined terms in this report, so the definitions should only be used in this context.

Appendix B. Our Approach to Estimating Willingness to Pay

B.1. Theoretical Foundations

B.1.1. Domestic Consumers

We estimate willingness to pay for service improvements by estimating consumers' utility functions using 'logit' modelling. Utility is an economic concept of consumers' general wellbeing. We assume that the consumers' utility depends on the quality of service they receive from the TOs (i.e. the probability of interruption, etc.) and on the bill, which acts as a proxy for the money they have available to spend on other things. Hence consumers' utility improves as the quality of service from the TOs improves, and falls as the bill rises. Willingness to pay is related to the concept of utility, as it represents the change in bill that keeps the consumers' utility constant when the service level changes. Below we describe how willingness to pay is derived from estimated utility functions.

The relationship between consumers' utility, service improvements and the bill can be represented in an equation:

(1) *Utility (U) = a x Quality of Service (Q) - b x Bill (B) + Residual, or random error (e)*

The residual represents all the other factors that determine utility which are not represented in the equation. Willingness to pay is the bill change that keeps consumers' utility constant when service levels change. Thus, we need to examine *changes* in the utility function, which we represent using the "Δ" notation:

$$(2) \qquad \Delta U = a\Delta Q - b\Delta B$$

Then to find the bill change required to keep utility constant given a change in the service level we set ΔU = 0 and rearrange the equation to obtain:

$$(3) \qquad WTP = \Delta B = (a / b) * \Delta Q$$

Hence, willingness to pay for service improvements is defined by the ratio *a/b*. These calculations, made slightly more complex by controlling variables like consumers' demographic characteristics, underpin the estimation of willingness to pay for domestic consumers, described later in this chapter.

In the second gas exercise (see Section 5.3.3), we model consumers' utility functions in a similar way, this time assuming that consumers' utility depends upon the heating technology they have, and the cost of installing the technology that represents the money they have available to spend on other things, using the following equation:

(4) Utility (U) = a x Heating Technology (Q) - b x Installation Costs (B) + Residual (e)

Hence, using formulas *(2)* and *(3)* from above, we assume that WTP for alternative heating technologies is defined by the ratio *a/b*.

B.1.2. Non-Domestic Consumers

Firms wish to maximise profit rather than utility. Therefore, the equivalent relationship to that of consumer's utility between firm's profits, service improvements and the bill is as follows:

Profits (Π) = a x Quality of Service (Q) - b x Bill (B) + Residual, or random error (e)

Generally speaking, this assumption is intuitive – if there is an electricity/gas supply interruption, we would expect the profits of affected businesses to fall as they may have to reduce production for example. However, for some attributes the assumption requires slightly more explanation – for instance, that firms are willing to pay for TOs to provide "support for local communities", because improving the wellbeing of individuals is likely to increase demand for firms' goods and services. Most of the service attributes can be related to profits in some way and therefore we believe this assumption is justified. This model is also implicitly used in all willingness to pay studies that focus on non-domestic consumers.

Computationally, however, we use the same logit modelling technique to value improvements in non-domestic consumers' willingness to pay for improvement. The theoretical basis for this model, as described above, is the additive random utility model. In this case, our use of this approach assumes that the utility of the respondent, in their capacity as a manager of the consumer's firm, depends on the profitability of the firm itself.

However, unlike domestic consumers, non-domestic consumers are extremely heterogeneous, and pay a much wider range of bill than domestic consumers. In particular, non-domestic consumers use gas and electricity for a large variety of different purposes and in many different ways.

The greater variability among non-domestic consumers, particularly in bill levels, implies that the linear model we used for domestic consumers may not be suitable. We therefore perform the modelling for non-domestic consumers in percentage terms as we discuss further in Section B.1.2.

B.2. Quantitative Techniques

B.2.1. Conditional logit and mixed logit

'Logit' models allow us to estimate (i.e. parameterise) consumers' utility functions, and so estimate how much consumers are willing to pay for improvements in service. There are two logit modelling techniques which we can use: the conditional logit model, which is a simpler, more easily implementable technique, and the mixed logit model, where we assume that respondents' valuations of service improvements vary across the population, and are assumed to follow some statistical distribution.

The basic 'conditional logit' model has several limitations. In particular, it estimates willingness to pay values for the average respondent in the sample, and does not allow for the possibility that different respondents place different values on service improvements. The mixed logit model overcomes this drawback of the conditional logit model, in particular by allowing for random taste variation amongst the population. This allows more information to be retrieved from the model since a distribution over all consumers' willingness to pay for service improvements attributes can be calculated.

A drawback of the mixed logit procedure is that it is computationally demanding, although this is not such a problem now computational power has advanced and the algorithms for estimating it have been programmed into standard statistical software packages like Stata. It also requires an assumption regarding the distribution of the statistical parameters in the utility function, as discussed in detail in Section B.2.2. On balance, however, the mixed logit specification is likely to be a richer and more theoretically justified estimation method, as long as distributional assumptions can be justified.[40]

B.2.2. Distributional assumptions in mixed logit

When we implement the mixed logit model, we assume that the marginal utility consumers derive from service improvement varies across the population, such that some people value service improvements more than others. Hence, we need to make an assumption about the shape of the statistical distribution that this marginal utility of service improvements follows. There are two main candidates for the type of data we have, as depicted in Figure B.1:

1. Normal distribution: this distribution is very well known and has easily interpretable values. It is the red symmetric distribution shown in Figure B.1. The key drawback of assuming a normal distribution in our context is that it assumes that some consumers have a negative willingness to pay for service improvements. That is, it implies some respondents are made worse off by improved service attributes when their bill is held constant, which is highly unlikely in practice. Using the normal distribution could therefore lead us to understate willingness to pay estimates in the electricity exercises and in the first gas exercise;[41] and
2. Lognormal distribution: this distribution ensures that no respondents have negative willingness to pay for service improvements, as the blue curve in Figure B.1 illustrates, and therefore avoids the unrealistic implication of using a normal distribution. However, it has a large right-hand tail, implying that some respondents have extremely large valuations, and therefore could overstate willingness to pay values.

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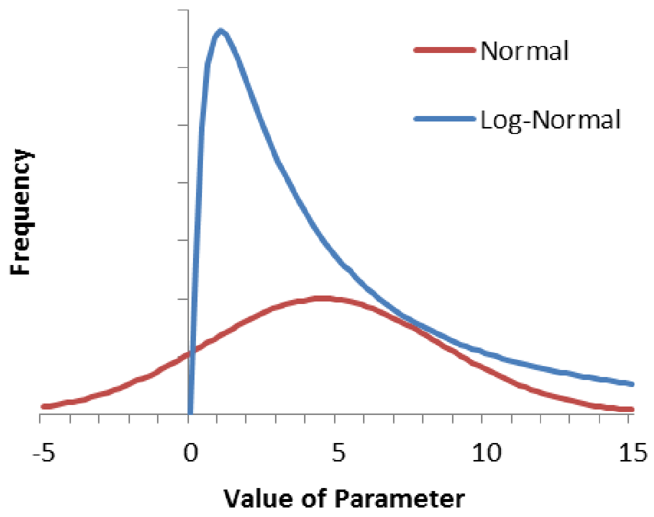
[40] Moreover, statistical tests we applied to the results of the mixed logit models suggest that random taste variation is present in the sample, and so the single deterministic value restriction imposed by the basic conditional logit model do not appear to hold in practice. Specifically, we find that the standard deviations of the estimated distribution in the mixed logit models are statistically significant.

[41] In the second gas exercise, a normal distribution is not fundamentally likely to understand WTP, since it is conceivable that consumers' utility will increase or decrease when using alternative heating technologies.

Figure B.1
Normal vs Log-Normal Distribution



Faced with a choice between these distributions, using a normal distribution ensures we obtain relatively conservative estimates of willingness to pay. This follows because the normal distribution may understate mean willingness to pay, whereas the log-normal distribution may overstate willingness to pay. Therefore, our approach is to implement the mixed logit model assuming a normal distribution around consumers' marginal utility from service improvements (and marginal *dis*utility from service reductions).

In our mixed logit models we assume that only the attribute levels enter consumers' utility functions with random coefficients. Hence, while consumers' marginal willingness to pay for service improvements varies across the population, we assume that each consumer has the same marginal utility of income, i.e. incurs the same disutility from a bill increase (or change in heating system installation costs).[42]

B.3. Model Selection Approach

Accurate willingness to pay valuations need to be calculated from a model that is correctly specified to avoid biased results. In other words, the model needs to comprehensively account for the variables that may influence consumers' willingness to pay for service improvements, and correctly represent the 'shape' of their utility and profit functions.

To identify a model that 'controls' for all potentially relevant variables and accurately represents consumers' utility and profit functions, we expanded our simple models, which only control for the attributes on the choice cards, by a range of other variables that are

42 It is possible to randomise respondents' marginal utility of income within the mixed logit framework. However, if we do so then the distribution over consumers' willingness to pay values might not exist (Daly et al. (2011)).

Willingness to pay is calculated as a ratio of the attribute coefficient to the bill coefficient. Therefore if the bill change has its own distribution over random values then willingness to pay is a random variable over another random variable. The willingness to pay values will then have their own distribution, but Andrew Daly, Stephane Hess and Kenneth Train in "Assuring Finite Moments for Willingness to Pay in Random Coefficient Models" (2011) show that this distribution doesn't exist if care is not taken with the selection of the bill distribution. If the bill coefficient is fixed then the willingness to pay distribution does exist and is the same type of distribution as the coefficient estimates. Therefore we estimate the bill coefficient as a fixed variable.

potentially relevant to explaining respondents' choices in the survey (the 'long' model). We then identified which of these factors were important in determining the respondent's choice by assessing the statistical significance of these factors and by sense checking the implied effects of the factors on utility (or profit) and willingness to pay. Through this process, we eliminated variables that were not statistically significant and obtained a final list of variables to be included in the model.

In general, we assessed the statistical significance of explanatory variables using 5% and 10% levels of significance to ensure our model selection process was sufficiently inclusive.

The variables discussed in the following subsections related to respondent characteristics, age, income, etc, are included in the models as 'interaction' terms, whereby we test whether consumers' preferences for either individual attributes (the a terms in the equations above) or their marginal utility of income (the b terms) vary with factors like demographics.[43]

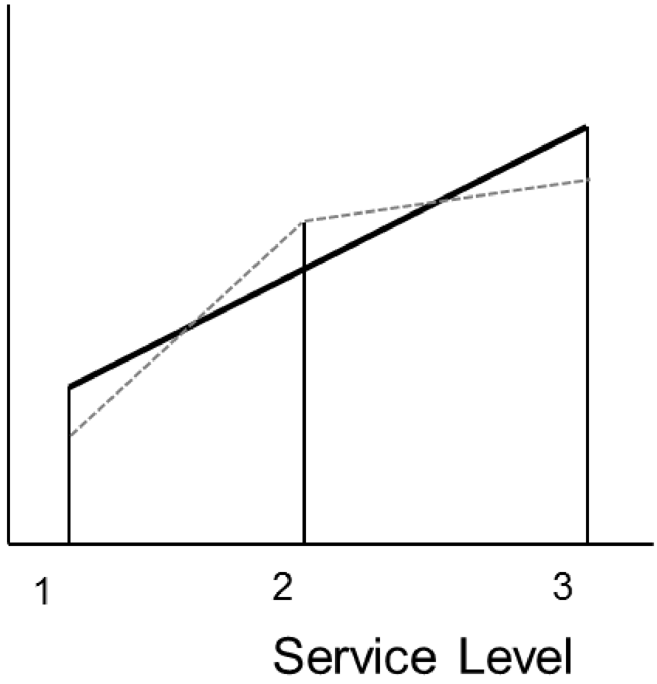
We tested the following groups of attributes:

- **Respondent Characteristics:** In the domestic and non-domestic surveys respectively, we collected information on respondents' households and firms, for instance demographic characteristics, such as age and income, and firm characteristics, such as number of employees and region. We describe in more detail the variables we tested and selected for each individual model in Chapter 5 above. We also tested control variables related to the cognitive questions respondents answered after completing the exercises (see Section 3.2), for instance about respondents' ability to understand the survey, and whether or not respondents reported that they believed supply interruptions "could actually happen".[44]
- **Non-linearities:** Some service levels presented to consumers represented non-continuous "packages" of service, which we model discretely, i.e. allowing for WTP to vary between level 1 and level 2, and between level 2 and level 3. For other attributes, such as those related to supply interruptions, we modelled attributes continuously, thus allowing us to estimate consumers' WTP for incremental changes in service which were not presented to consumers. We tested for non-linearities in consumers WTP for attributes which were presented as continuous variables. In the absence of non-linearities, consumers' utility is taken to be a linear function of the service levels, as illustrated by the thick black line in Figure B.2 below. However, the true relationship may differ depending on the level of service provided. For example, for the interruption attribute people may be willing to pay a large amount to reduce the possibility of an unexpected interruption occurring from level 1 to level 2. but then people may only be willing to pay a small amount to move beyond level 2, since they view the possibility of an unexpected interruption happening at level 2 to already be sufficiently low. Our approach to modelling this relationship is shown in Figure B.2 by the thinner lines that allow for a 'kink'.

[43] To be identifiable in the modelling, the attribute variables have to vary within individuals – so that they are not the same for each of individual respondents' choices. We therefore transform the attributes in the analysis by multiplying or 'interacting' the attribute variable by a variable that changes over respondents' choices, either the bill or the service levels. For example, income is the same for all of an individual respondent's choices. This approach is the standard econometric way of controlling for attributes in discrete choice modelling.

[44] In practice, very few respondents reported that they did not understand the attributes or were unable to make trade-offs – see Section 4.3.

Figure B.2
Illustration of Non-Linearity in Consumers' Utility Function



- **Budget Constraints:** We tested for respondent's budget constraints in two ways. Firstly, we included a "bill change for other reasons" element in each questionnaire, reminding consumers that their energy bill will be different over the course of RIIO-T2 compared to today. This element varied according to three scenarios (see Section 3.7); by controlling for which of the three scenarios each respondent fell into, we could test whether respondents' WTP varies according to the external budget constraints they face. Secondly, in the electricity surveys, we tested for whether respondents' budget constraints led consumers to report lower WTP in the third CV exercise, which included all nine electricity attributes together, compared to when they were presented with subsets of attributes in the first two CEs. We describe our analysis of budget constraints using the CV exercise in more detail in Section 5.1.5 above.

Appendix C. Detailed Regression Results

Table A.1
Domestic First Gas Question – Simple Conditional Logit

Attributes	Coefficient	P-value
Risk of Supply Interruptions	4858.92	0.00*
Improving the environment around transmission sites (0 to +1)	0.22	0.00*
Improving the environment around transmission sites (0 to +2)	0.33	0.00*
Supporting local communities (0 to +1)	0.32	0.00*
Supporting local communities (0 to +2)	0.46	0.00*
Investing in innovation projects to create future benefits for consumers (0 to +1)	0.41	0.00*
Investing in innovation projects to create future benefits for consumers (0 to +2)	0.64	0.00*
Supporting consumers in fuel poverty (0 to +1)	0.10	0.08**
Supporting consumers in fuel poverty (0 to +2)	0.33	0.00*
Bill	-0.07	0.00*

*Significant at a 5% statistical significance level
**Significant at a 10% statistical significance level

Table A.2
Domestic First Gas Question – Simple Conditional Logit - WTP (£/consumer/year) and Confidence Interval

Attributes	WTP (£)	95% Confidence interval
For a 1/10,000 reduction in the probability of a supply interruption.	7.19	5.158 - 9.227
Improving environment around transmission sites		
Additional 3 large sites and 10 small sites	3.23	1.620 - 4.849
Additional 11 large sites and 30 small sites	4.95	3.146 - 6.750
Supporting local communities		
Current level of community schemes compared to no support	4.78	3.028 - 6.527
Current level of community schemes and additional funding to charities and other organizations compared to no support	6.74	4.801 - 8.671
Investing in innovation projects		
Small scale projects compared to no innovation projects	6.14	4.207 - 8.077
Large scale projects compared to no innovation projects	9.45	7.109 - 11.798
Supporting consumers in fuel poverty		
Provide information to lower their energy bills compared to no information	1.42	-0.176 - 3.012
Provide information to lower their energy bills and funding/financing compared to no support	4.83	3.066 - 6.602

Table A.3
Domestic Second Gas Question – Simple Conditional Logit

Attributes	Coefficient	P-value
Air source heat pump	-0.93	0.00*
Ground source heat pump	-1.22	0.00*
District heating System	-0.91	0.00*
Hybrid heat pump	-1.56	0.00*
Installation costs	-0.00008	0.00*

*Significant at a 5% statistical significance level
**Significant at a 10% statistical significance level

Table A.4
Domestic Second Gas Question – Simple Conditional Logit - WTP (£/consumer/year) and Confidence Interval

Attributes	WTP (£)	95% Confidence interval
Air Source Heat Pump instead of installing a Gas Boiler	-11773.00	-15,513.791 - -8,032.058
Ground Source Heat Pump instead of installing a Gas Boiler	-15464.22	-20,585.249 - -10,343.005
District Heating System instead of installing a Gas Boiler	-11518.47	-14,846.386 - -8,190.403
Hybrid Heat Pump instead of installing a Gas Boiler	-19808.53	-27,064.773 - -12,552.049

Table A.5
Domestic First Gas Question – Simple Mixed Logit

Attributes	Coefficient	P-value	Standard Deviation
Risk of Supply Interruptions	6946.02	0.00*	12422.30
Improving the environment around transmission sites (0 to +1)	0.32	0.00*	0.41
Improving the environment around transmission sites (0 to +2)	0.46	0.00*	0.76
Supporting local communities (0 to +1)	0.42	0.00*	0.28
Supporting local communities (0 to +2)	0.60	0.00*	0.37
Investing in innovation projects to create future benefits for consumers (0 to +1)	0.54	0.00*	0.42
Investing in innovation projects to create future benefits for consumers (0 to +2)	0.83	0.00*	0.65
Supporting consumers in fuel poverty (0 to +1)	0.13	0.04*	0.26
Supporting consumers in fuel poverty (0 to +2)	0.44	0.00*	0.69
Bill	-0.09	0.00*	N/A

*Significant at a 5% statistical significance level
**Significant at a 10% statistical significance level

Table A.6
Domestic First Gas Question – Simple Mixed Logit - WTP (£/consumer/year) and Confidence Interval

Attributes	WTP (£)	95% Confidence interval
For a 1/10,000 reduction in the probability of a supply interruption.	7.97	5.962 - 9.977
Improving environment around transmission sites		
Additional 3 large sites and 10 small sites	3.62	2.075 - 5.158
Additional 11 large sites and 30 small sites	5.28	3.551 - 7.002
Supporting local communities		
Current level of community schemes compared to no support	4.83	3.238 - 6.425
Current level of community schemes and additional funding to charities and other organizations compared to no support	6.89	5.158 - 8.622
Investing in innovation projects		
Small scale projects compared to no innovation projects	6.17	4.467 - 7.864
Large scale projects compared to no innovation projects	9.49	7.497 - 11.484
Supporting consumers in fuel poverty		
Provide information to lower their energy bills compared to no information	1.54	0.054 - 3.034
Provide information to lower their energy bills and funding/financing compared to no support	5.09	3.466 - 6.721

Table A.7
Domestic Second Gas Question – Simple Mixed Logit

Attributes	Coefficient	P-value	Standard Deviation
Air source heat pump	-0.99	0.00*	0.06
Ground source heat pump	-1.53	0.00*	1.55
District heating System	-1.01	0.00*	0.98
Hybrid heat pump	-2.25	0.00*	2.11
Installation costs	-0.00011	0.00*	N/A

Table A.8
Domestic Second Gas Question – Simple Mixed Logit - WTP (£/consumer/year) and Confidence Interval

Attributes	WTP (£)	95% Confidence interval
Air Source Heat Pump instead of installing a Gas Boiler	-8816.13	-11,879.072 - -5,753.215
Ground Source Heat Pump instead of installing a Gas Boiler	-13578.62	-18,411.157 - -8,746.123
District Heating System instead of installing a Gas Boiler	-8941.26	-11,588.832 - -6,293.699
Hybrid Heat Pump instead of installing a Gas Boiler	-19935.40	-27,313.789 - -12,557.059

*Significant at a 5% statistical significance level
**Significant at a 10% statistical significance level

Table A.9
Domestic First Gas Question – Mixed Logit Controlled

Attributes	Coefficient	P-value	Standard Deviation
Risk of Supply Interruptions	8715.61	0.00*	11685.80
Improving the environment around transmission sites (0 to +1)	0.31	0.00*	0.32
Improving the environment around transmission sites (0 to +2)	0.58	0.00*	0.72
Supporting local communities (0 to +1)	0.41	0.00*	0.28
Supporting local communities (0 to +2)	0.71	0.00*	0.37
Investing in innovation projects to create future benefits for consumers (0 to +1)	0.52	0.00*	0.36
Investing in innovation projects to create future benefits for consumers (0 to +2)	0.81	0.00*	0.66
Supporting consumers in fuel poverty (0 to +1)	0.25	0.00*	0.18
Supporting consumers in fuel poverty (0 to +2)	0.59	0.00*	0.67
Bill	-0.09	0.00*	N/A
Interactions			
Gender x Improving the environment around transmission sites (0 to +2)	-0.24	0.04*	N/A
Gender x Supporting local communities (0 to +2)	-0.26	0.02*	N/A
Gender x Supporting consumers in fuel poverty (0 to +1)	-0.27	0.03*	N/A
Gender x Supporting consumers in fuel poverty (0 to +2)	-0.33	0.01*	N/A

*Significant at a 5% statistical significance level
**Significant at a 10% statistical significance level

Table A.10
Domestic Second Gas Question – Mixed Logit Controlled

Attributes	Coefficient	P-value	Standard Deviation
Air source heat pump	-1.31	0.00*	0.06
Ground source heat pump	-1.86	0.00*	1.50
District heating System	-1.31	0.00*	1.00
Hybrid heat pump	-2.25	0.00*	2.03
Installation costs	-0.00016	0.00*	N/A
Interactions			
Age x Air source heat pump	0.58	0.00*	N/A
Age x Ground source heat pump	0.63	0.00*	N/A
Age x District heating System	0.55	0.00*	N/A
Installation costs	0	0.00*	N/A
Age x installation costs	0.0001	0.00*	N/A

*Significant at a 5% statistical significance level
**Significant at a 10% statistical significance level

Table A.11
Domestic First Electricity Question – Simple Conditional Logit

Attributes	Coefficient	P-value
Risk of Powercuts	0.19	0.00*
Recovering from Blackouts	0.17	0.00*
Undergrounding OHLs (0 to +1)	0.41	0.00*
Undergrounding OHLs (0 to +2)	0.32	0.00*
Improving visual amenity of OHLs (0 to +1)	0.17	0.00*
Improving visual amenity of OHLs (0 to +2)	0.29	0.00*
Improving environment around transmission sites	0.02	0.00*
Bill	-0.04	0.00*

*Significant at a 5% statistical significance level
**Significant at a 10% statistical significance level

Table A.12
Domestic First Electricity Question – Simple Conditional Logit - WTP (£/consumer/year) and Confidence Interval

Attributes	WTP (£)	95% Confidence interval
Every 1 hour decrease in the hours of powercuts at a 1.5% probability	5.23	4.115 - 6.340
Every fewer day to recover from a blackout	4.80	3.360 - 6.250
Undergrounding Overhead Transmission Lines		
20 miles additional underground in National Parks etc.	11.36	7.947 - 14.770
20 miles additional underground in other areas	8.70	5.385 - 12.005
Improving visual amenity of Overhead Transmission Lines		
Additional visual impact work in National Parks etc.	4.62	1.654 - 7.579
Additional visual impact work in National Parks and other areas	7.88	4.768 - 10.994
Every additional transmission site environment improved	0.43	0.337 - 0.531

Table A.13
Domestic Second Electricity Question – Simple Conditional Logit

Attributes	Coefficient	P-value
Investing in innovation projects to create future benefits for consumers (0 to +1)	0.12	0.01*
Investing in innovation projects to create future benefits for consumers (0 to +2)	0.23	0.00*
Supporting local communities (0 to +1)	0.35	0.00*
Supporting local communities (0 to +2)	0.39	0.00*
Investing to make sure the network is ready for electric vehicle charging (0 to +1)	0.40	0.00*
Investing to make sure the network is ready to connect renewable generation (0 to +1)	0.50	0.00*
Bill	-0.03	0.00*

*Significant at a 5% statistical significance level
**Significant at a 10% statistical significance level

Table A.14
Domestic Second Electricity Question – Simple Conditional Logit - WTP (£/consumer/year) and Confidence Interval

Attributes	WTP (£)	95% Confidence interval
Investing in innovation projects		
Medium Scale Projects compared to Small Scale Projects	3.65	0.740 - 6.564
Large Scale Projects compared to Small Scale Projects	6.78	3.539 - 10.018
Supporting local communities		
Current level of community activities	10.42	7.057 - 13.774
Current level of community activities and additional funding to charities	11.58	8.025 - 15.130
Investing in EV Charging Infrastructure		
Invest before definite need	11.94	8.672 - 15.203
Investing in infrastructure to connect to renewable generation		
Invest before definite need	14.79	11.114 - 18.469

Table A.15
Domestic First Electricity Question – Simple Mixed Logit

Attributes	Coefficient	P-value	Standard Deviation
Risk of Powercuts	0.25	0.00*	0.28
Recovering from Blackouts	0.23	0.00*	0.37
Undergrounding OHLs (0 to +1)	0.51	0.00*	0.58
Undergrounding OHLs (0 to +2)	0.40	0.00*	0.52
Improving visual amenity of OHLs (0 to +1)	0.24	0.00*	0.03
Improving visual amenity of OHLs (0 to +2)	0.37	0.00*	0.13
Improving environment around transmission sites	0.02	0.00*	0.65
Bill	-0.05	0.00*	N/A

Table A.16
Domestic First Electricity Question – Simple Mixed Logit - WTP (£/consumer/year) and Confidence Interval

Attributes	WTP (£)	95% Confidence interval
Every 1 hour decrease in the hours of powercuts at a 1.5% probability	5.32	4.330 - 6.328
Every fewer day to recover from a blackout	4.75	3.414 - 6.131
Undergrounding Overhead Transmission Lines		
20 miles additional underground in National Parks etc.	10.79	8.135 - 13.999
20 miles additional underground in other areas	8.33	5.713 - 11.676
Improving visual amenity of Overhead Transmission Lines		
Additional visual impact work in National Parks etc.	4.95	2.163 - 7.758
Additional visual impact work in National Parks and other areas	7.80	5.022 - 10.746
Every additional transmission site environment improved	0.45	0.368 - 0.542

*Significant at a 5% statistical significance level
**Significant at a 10% statistical significance level

Table A.17
Domestic Second Electricity Question – Simple Mixed Logit

Attributes	Coefficient	P-value	Standard Deviation
Investing in innovation projects to create future benefits for consumers (0 to +1)	0.14	0.02	0.07
Investing in innovation projects to create future benefits for consumers (0 to +2)	0.30	0.00	0.72
Supporting local communities (0 to +1)	0.48	0.00	0.80
Supporting local communities (0 to +2)	0.52	0.00	0.65
Investing to make sure the network is ready for electric vehicle charging (0 to +1)	0.54	0.00	1.06
Investing to make sure the network is ready to connect renewable generation (0 to +1)	0.68	0.00	1.09
Bill	-0.04	0.00	N/A

Table A.18
Domestic Second Electricity Question – Simple Mixed Logit - WTP (£/consumer/year) and Confidence Interval

Attributes	WTP (£)	95% Confidence interval
Investing in innovation projects		
Medium Scale Projects compared to Small Scale Projects	3.17	0.467 - 5.871
Large Scale Projects compared to Small Scale Projects	6.79	3.783 - 9.794
Supporting local communities		
Current level of community activities	11.00	8.096 - 13.903
Current level of community activities and additional funding to charities	11.99	8.852 - 15.127
Investing in EV Charging Infrastructure		
Invest before definite need	12.33	9.268 - 15.396
Investing in infrastructure to connect to renewable generation		
Invest before definite need	15.70	12.380 - 19.028

*Significant at a 5% statistical significance level
**Significant at a 10% statistical significance level

Table A.19
Domestic First Electricity Question – Mixed Logit Controlled

Attributes	Coefficient	P-value	Standard Deviation
Risk of Powercuts	0.23	0.00*	0.26
Recovering from Blackouts	0.21	0.00*	0.36
Undergrounding OHLs (0 to +1)	N/A	N/A	N/A
Undergrounding OHLs (0 to +2)	N/A	N/A	N/A
Improving visual amenity of OHLs (0 to +1)	0.39	0.00*	0.58
Improving visual amenity of OHLs (0 to +2)	0.58	0.00*	0.38
Improving environment around transmission sites	0.02	0.00*	0.02
Bill	-0.05	0.00*	N/A
Interactions			
Age x Improving visual amenity of OHLs (0 to +1)	-0.33	0.02*	N/A
Age x Improving visual amenity of OHLs (0 to +2)	-0.42	0.001*	N/A
Income x Undergrounding OHLs (0 to +1)	0.000013	0.00*	N/A
Income x Undergrounding OHLs (0 to +2)	0.00001	0.00*	N/A

*Significant at a 5% statistical significance level
**Significant at a 10% statistical significance level

Table A.20
Domestic Second Electricity Question – Mixed Logit Controlled

Attributes	Coefficient	P-value	Standard Deviation
Investing in innovation projects to create future benefits for consumers (0 to +1)	0.14	0.02*	0.08
Investing in innovation projects to create future benefits for consumers (0 to +2)	0.3	0.00*	0.71
Supporting local communities (0 to +1)	0.57	0.00*	0.79
Supporting local communities (0 to +2)	0.68	0.00*	0.66
Investing to make sure the network is ready for electric vehicle charging (0 to +1)	0.65	0.00*	1.07
Investing to make sure the network is ready to connect renewable generation (0 to +1)	0.68	0.00*	1.08
Bill	-0.04	0.00*	N/A
Interactions			
Gender x Supporting local communities (0 to +1)	-0.2	0.07**	N/A
Gender x Supporting local communities (0 to +2)	-0.33	0.01*	N/A
Age x Investing to make sure the network is ready for electric vehicle charging (0 to +1)	-0.25	0.04*	N/A

*Significant at a 5% statistical significance level
**Significant at a 10% statistical significance level

Table A.21
Non - Domestic First Gas Question – Simple Conditional Logit

Attributes	Coefficient	P-value
Risk of Supply Interruptions	2767	0.00*
Improving the environment around transmission sites (0 to +1)	0.10	0.11***
Improving the environment around transmission sites (0 to +2)	0.21	0.00*
Supporting local communities (0 to +1)	0.26	0.00*
Supporting local communities (0 to +2)	0.30	0.00*
Investing in innovation projects to create future benefits for consumers (0 to +1)	0.25	0.00*
Investing in innovation projects to create future benefits for consumers (0 to +2)	0.41	0.00*
Supporting consumers in fuel poverty (0 to +1)	0.06	0.33***
Supporting consumers in fuel poverty (0 to +2)	-0.03	0.60***
Bill	-17.81	0.00*

*Significant at a 5% statistical significance level
**Significant at a 10% statistical significance level
***Not significant

Table A.22
Non - Domestic First Gas Question – Simple Conditional Logit - WTP (%/consumer/year) and Confidence Interval

Attributes	WTP (£)	Confidence Interval
For a 1/10,000 reduction in the probability of a supply interruption.	1.55%	0.651 - 2.456
Improving environment around transmission sites		
Additional 3 large sites and 10 small sites	0.59%	-0.161 - 1.339
Additional 11 large sites and 30 small sites	1.17%	0.319 - 2.015
Supporting local communities		
Current level of community schemes compared to no support	1.46%	0.591 - 2.328
Current level of community schemes and additional funding to charities and other organizations compared to no support	1.71%	0.762 - 2.659
Investing in innovation projects		
Small scale projects compared to no innovation projects	1.40%	0.526 - 2.276
Large scale projects compared to no innovation projects	2.28%	1.149 - 3.411
Supporting consumers in fuel poverty		
Provide information to lower their energy bills compared to no information	0.36%	-0.384 - 1.110
Provide information to lower their energy bills and funding/financing compared to no support	-0.20%	-0.941 - 0.549

Table A.23
Non - Domestic First Gas Question –Conditional Logit Controlled

Attributes	Coefficient	P-value
Risk of Supply Interruptions	2.76E+03	0.00*
Improving the environment around transmission sites (0 to +1)	0.10	0.13***
Improving the environment around transmission sites (0 to +2)	0.20	0.00*
Supporting local communities (0 to +1)	0.41	0.00*
Supporting local communities (0 to +2)	0.31	0.00*
Investing in innovation projects to create future benefits for consumers (0 to +1)	0.25	0.00*
Investing in innovation projects to create future benefits for consumers (0 to +2)	0.41	0.00*
Supporting consumers in fuel poverty (0 to +1)	0.06	0.33***
Supporting consumers in fuel poverty (0 to +2)	-0.03	0.61***
Bill	-2.69E+01	0.00*
Interactions		
Firm size x Supporting local communities (0 to +1)	-0.22	0.06*
Firm size x Bill	13.84	0.05*

*Significant at a 5% statistical significance level
**Significant at a 10% statistical significance level
***Not significant

Table A.24
Non - Domestic First Electricity Question – Simple Conditional Logit

Attributes	Coefficient	P-value
Risk of Powercuts	0.16	0.00*
Recovering from Blackouts	0.09	0.00*
Undergrounding OHLs (0 to +1)	0.34	0.00*
Undergrounding OHLs (0 to +2)	0.35	0.00*
Improving visual amenity of OHLs (0 to +1)	0.21	0.00*
Improving visual amenity of OHLs (0 to +2)	0.29	0.00*
Improving environment around transmission sites	0.01	0.00*
Bill	-16.32	0.00*

*Significant at a 5% statistical significance level
**Significant at a 10% statistical significance level

Table A.25
Non - Domestic First Electricity Question – Simple Conditional Logit - WTP (%/consumer/year) and Confidence Interval

Attributes	WTP (£)	Confidence Interval
Every 1 hour decrease in the hours of powercuts at a 1.5% probability	1.00%	0.702 - 1.293
Every fewer day to recover from a blackout	0.56%	0.190 - 0.923
Undergrounding Overhead Transmission Lines		
20 miles additional underground in National Parks etc.	2.07%	1.116 - 3.034
20 miles additional underground in other areas	2.15%	1.240 - 3.059
Improving visual amenity of Overhead Transmission Lines		
Additional visual impact work in National Parks etc.	1.26%	0.402 - 2.120
Additional visual impact work in National Parks and other areas	1.79%	0.869 - 2.720
Every additional transmission site environment improved	0.08%	0.052 - 0.103

Table A.26
Non - Domestic Second Electricity Question – Simple Conditional Logit

Attributes	Coefficient	P-value
Investing in innovation projects to create future benefits for consumers (0 to +1)	0.11	0.07**
Investing in innovation projects to create future benefits for consumers (0 to +2)	0.16	0.03*
Supporting local communities (0 to +1)	0.21	0.00*
Supporting local communities (0 to +2)	0.11	0.13***
Investing to make sure the network is ready for electric vehicle charging (0 to +1)	0.35	0.00*
Investing to make sure the network is ready to connect renewable generation (0 to +1)	0.42	0.00*
Bill	-14.19	0.00*

*Significant at a 5% statistical significance level
**Significant at a 10% statistical significance level
***Not significant

Table A.27
Non - Domestic Second Electricity Question – Simple Conditional Logit - WTP (%/consumer/year) and Confidence Interval

Attributes	WTP (£)	Confidence Interval
Investing in innovation projects		
Medium Scale Projects compared to Small Scale Projects	0.80%	-0.087 - 1.692
Large Scale Projects compared to Small Scale Projects	1.15%	0.147 - 2.151
Supporting local communities		
Current level of community activities	1.46%	0.515 - 2.408
Current level of community activities and additional funding to charities	0.76%	-0.208 - 1.725
Investing in EV Charging Infrastructure		
Invest before definite need	2.46%	1.461 - 3.459
Investing in infrastructure to connect to renewable generation		
Invest before definite need	2.95%	1.886 - 4.023

Appendix D. Alternative Presentation of Gas Valuation Results

National Grid Gas has asked us to provide an alternative presentation of the estimated WTP for improvements (or declines) in service relative for the interruptions attribute to the current service level. Table D.1 shows the estimated value of a 10% deterioration/improvement compared to the current service level (i.e. a 1 in 12,500 probability of a supply interruption). Based on the recommended value of £6.71/consumer/year for a 1 in 10,000 (or a 0.01 percentage point) decrease in probability for domestic consumers (see Table 5.15 in the body of the report), we rescale the valuation for a 10% deterioration/improvement (i.e. +/- 0.0008%) compared to current service level, and find a valuation of £0.54/consumer/year for a 10% change in current service level.

To calculate this valuation in the final column, we multiply the "percentage point difference in probability of an interruption" column by [£6.71/0.01%]. We apply the same procedure to the non-domestic valuation, as shown in the table below.

Table D.1: Domestic and Non-Domestic Gas Supply Interruption Valuation – 10% Deterioration/Improvement Compared to Current Level of Service

Gas Supply Interruptions	Valuation	
Domestic consumers	**£6.71**	for a 1 in 10,000 (or 0.01 percentage point) change per consumer per year
Non domestic consumers	**1.53%**	of a consumer's gas bill for a 1 in 10,000 (or 0.01 percentage point) change per consumer per year
Non domestic consumers	**£49.08**	for a 1 in 10,000 (or 0.01 percentage point) change per consumer per year

	Probability of a supply interruption		percentage point difference in probability of an interruption relative to level 2 (current level)	WTP for a change **relative to level 2** per customer per year		
	1 in X terms	percentage terms		Domestic consumers	Non-domestic consumers (%)	Non-domestic consumers (£)
Level 1	1 in 5,750	0.0174%	-0.0094%	**-£6.31**	**-1.44%**	**-£46.10**
Level 2	1 in 12,500	0.0080%	0.0000%	**£0.00**	**0.00%**	**£0.00**
Level 3	1 in 13,750	0.0073%	0.0007%	**£0.49**	**0.11%**	**£3.57**
10 per cent deterioration from Level 2	1 in 11,364	0.0088%	-0.0008%	**-£0.54**	**-0.12%**	**-£3.93**
Level 2	1 in 12,500	0.0080%	0.0000%	**£0.00**	**0.00%**	**£0.00**
10 per cent improvement on Level 2	1 in 13,889	0.0072%	0.0008%	**£0.54**	**0.12%**	**£3.93**

Appendix E. Sensitivity Excluding Protesters

Domestic Electricity Survey	With protest votes	Without protest votes
Attributes	**WTP (£/consumer)**	**WTP (£/consumer)**
Every 1 hour decrease in the hours of power cuts at a 1.5% probability	3.85	3.80
Every fewer day to recover from a blackout	3.58	3.63
Undergrounding Overhead Transmission Lines		
20 miles additional underground in National Parks etc.	6.87	7.02
20 miles additional underground in other areas	5.30	5.34
Improving visual amenity of Overhead Transmission Lines		
Additional visual impact work in National Parks etc.	4.14	4.05
Additional visual impact work in National Parks and other areas	6.70	6.70
Every additional transmission site environment improved	0.36	0.35
Investing in innovation projects		
Medium Scale Projects	2.38	2.36
Large Scale Projects	5.10	4.99
Supporting local communities		
Current level of community activities	8.26	8.09
Current level of community activities and additional funding to charities	9.02	8.94
Investing in EV Charging Infrastructure		
Invest before definite need	9.55	10.13
Investing in infrastructure to connect to renewable generation		
Invest before definite need	11.78	11.39

Domestic Gas Survey First Question	With protest votes	Without protest votes
Attributes	**WTP (£ / consumer)**	**WTP (£ / consumer)**
For a 1/10,000 reduction in the probability of a supply interruption.	7.85	7.92
Improving environment around transmission sites		
Additional 3 large sites and 10 small sites	3.61	3.46
Additional 11 large sites and 30 small sites	5.38	5.14
Supporting local communities		
Current level of community schemes compared to no support	4.78	4.88
Current level of community schemes and additional funding to charities and other organizations compared to no support	6.82	6.85
Investing in innovation projects		
Small scale projects compared to no innovation projects	6.03	5.87
Large scale projects compared to no innovation projects	9.36	9.26
Supporting consumers in fuel poverty		
Provide information to lower their energy bills compared to no information	1.43	1.45
Provide information to lower their energy bills and funding/financing compared to no support	5.06	5.03

Domestic Gas Survey Second Question	With protest votes	Without protest votes
Attributes	**WTP (£ / consumer)**	**WTP (£ / consumer)**
Installing Air Source Heat Pump instead of using a Gas Boiler	-8965.90	-8935.00
Installing Ground Source Heat Pump instead of using a Gas Boiler	-13426.76	-13376.26
Installing District Heating System instead of using a Gas Boiler	-9099.76	-9224.04
Installing Hybrid Heat Pump instead of using a Gas Boiler	-19140.36	-18994.09

Non - Domestic Electricity Survey	With protest votes	Without protest votes
Attributes	**WTP (£/consumer)**	**WTP (£/consumer)**
Risk of power cuts		
Decrease in the duration of power cuts at a 1.5% probability from 6 to 4 hours	43.30	43.18
Decrease in the duration of power cuts at a 1.5% probability from 6 to 2 hours	47.30	50.30
Days to recover from a blackout		
2 fewer days to recover form a blackout	24.15	24.51
Undergrounding Overhead Transmission Lines		
20 miles additional underground in National Parks etc.	45.02	45.16
20 miles additional underground in other areas	45.02	45.16
Improving visual amenity of Overhead Transmission Lines		
Additional visual impact work in National Parks etc.	27.36	27.61
Additional visual impact work in National Parks and other areas	21.26	23.20
Every additional transmission site environment improved	1.68	1.68
Investing in innovation projects		
Medium Scale Projects	10.56	10.43
Large Scale Projects	15.13	15.32
Supporting local communities		
Current level of community activities	19.23	19.75
Current level of community activities and additional funding to charities	19.23	19.75
Investing in EV Charging Infrastructure		
Invest before definite need	32.38	34.92
Investing in infrastructure to connect to renewable generation		
Invest before definite need	38.89	40.78

Non - Domestic Gas Survey	With protest votes	Without protest votes
Attributes	**WTP (£)**	**WTP (£)**
For a 1/10,000 reduction in the probability of a supply interruption.	49.08	49.47
Improving environment around transmission sites		
Additional 3 large sites and 10 small sites	9.91	10.34
Additional 11 large sites and 30 small sites	36.35	37.92
Supporting local communities		
Current level of community schemes compared to no support	46.65	46.49
Current level of community schemes and additional funding to charities and other organizations compared to no support	54.73	55.32
Investing in innovation projects		
Small scale projects compared to no innovation projects	43.74	42.62
Large scale projects compared to no innovation projects	72.27	71.11
Supporting consumers in fuel poverty		
Provide information to lower their energy bills compared to no information	0.00	0.00
Provide information to lower their energy bills and funding/financing compared to no support	0.00	0.00

Appendix F. Survey Instruments and Scripts from Video Introductions to Survey Attributes

F.1. Domestic Electricity Survey

Thank you for taking part in our survey

This survey has been designed by Explain Market Research, an independent research agency, working with the Electricity Transmission Companies to gain your views through a number of questions.

The research is being conducted under the terms of the Market Research Society (MRS) code of conduct and is completely confidential. If you would like to confirm Explain's credentials please call the MRS free on 0800 975 9596.

During this survey you will need to watch and listen to some videos. Please make sure your sound is working and turned up.

Before we start, we just need to ask you a couple of questions to ensure we are speaking to the right people:

Are you responsible for paying an electricity bill or choosing an electricity supplier in your household? *

- ○ Solely
- ○ Jointly
- ○ Neither

What is your gender? *

- ○ Male
- ○ Female
- ○ Other
- ○ Prefer not to say

What is your age? *

- ○ 18 to 24
- ○ 25 to 34
- ○ 35 to 44
- ○ 45 to 54
- ○ 55 to 64
- ○ 65 plus

How would you describe the occupation of the main income earner in your household? If you or they are retired, please describe the occupation they had before you/they retired *

- Higher managerial / professional / administrative (e.g. Established doctor, Solicitor, Board Director in a large organisation (200+ employees), top level civil servant/public service employee)
- Intermediate managerial / professional / administrative (e.g. Newly qualified (under 3 years) doctor, Solicitor, Board director small organisation, middle manager in large organisation, principal officer in civil service/local government)
- Supervisory or clerical / junior managerial / professional / administrative (e.g. Office worker, Student Doctor, Foreman with 25+ employees, salesperson, etc)
- Student
- Skilled manual worker (e.g. Skilled Bricklayer, Carpenter, Plumber, Painter, Bus/ Ambulance Driver, HGV driver, AA patrolman, pub/bar worker, etc)
- Semi or unskilled manual work (e.g. Manual workers, all apprentices to be skilled trades, Caretaker, Park keeper, non-HGV driver, shop assistant)
- Casual worker - not in permanent employment
- Housewife / Homemaker
- Unemployed or not working due to long-term sickness
- Full-time carer or other household member

What is the first part of your postcode? *

e.g. NE1

Please make sure you have answered all questions marked with a * before clicking continue

Continue

Where do you live? (please select area on the map)*

Please make sure you have answered all questions marked with a * before clicking continue

Thank you for your answers so far!

This survey is being run on behalf of the Electricity Transmission Companies: National Grid, SP Transmission and SSEN Transmission.

The Electricity Transmission Companies run and manage the very high voltage electricity networks which take power from windfarms, power stations and other generators and transport it over long distances to areas of demand. They connect to lower voltage distribution networks, which then connect to people's homes and businesses. National Grid Electricity Transmission covers the whole of England and Wales, SP Transmission covers Southern Scotland and SSEN Transmission covers Northern Scotland.

The Electricity Transmission Company in your area is National Grid.

You pay your bill to your energy supplier, but some of that bill is the cost of running the transmission networks.

We have sent you this survey because we want to understand your priorities for future investments.

Throughout this survey we refer to 'consumers'. By this, we mean you and other members of the public who use electricity. Although you don't pay a bill to the Transmission Companies and aren't their direct customer, you are a consumer of the electricity they transmit.

Continue

Before we get started, we would like to understand a bit more about how you use electricity in your home...

When did you last experience a power cut at your property? *

- Within the last year I have had several power cuts
- Within the last year, but just once
- Within the last 1-2 years
- More than 2 years ago
- Never
- Can't remember

Do you use electricity or gas in your home for the following:

Heating your home *

- Gas
- Electric
- Both
- Neither
- Don't Know

Heating your water *

- Gas
- Electric
- Both
- Neither
- Don't Know

Cooking *

- Gas
- Electric
- Both
- Neither
- Don't Know

Please make sure you have answered all questions marked with a * before clicking continue

Continue

Thinking about your household's energy costs, do you know your typical **electricity bill**? Please complete one of the following:

(If you only know your combined electricity and gas bill please click don't know)

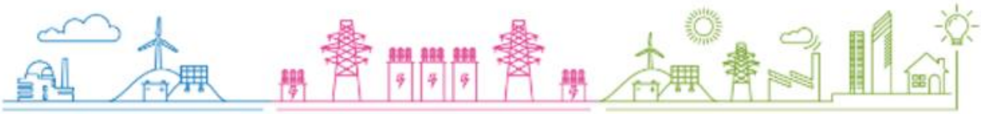
I spend £ 50 per Month ▾ Don't know

This means you spend around **£600.00** per year on electricity.

Continue

The electricity system

This survey is about the **Transmission** Network



Generation

Electricity is generated through power stations, windfarms and other generators.

Transmission

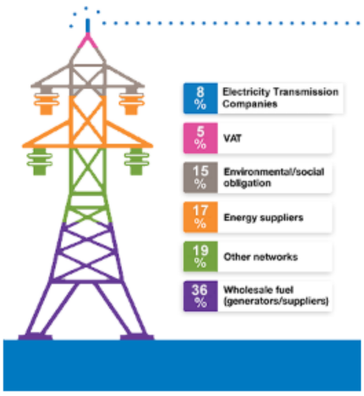
The Transmission Network is made up of overhead lines, underground cables and substations. It transports electricity from where it is generated over long distances to areas of demand where the Distribution Network then connects the electricity to people's homes.

Distribution

The Distribution Network connects electricity to people's home and businesses.

Continue

Where your money goes



Although you don't pay a bill to the Electricity Transmission Companies and aren't their direct customer, you consume the electricity they transmit. 8% of your electricity bill goes to the Electricity Transmission Companies.

Continue

Your transmission costs

Between 2021 and 2026, UK government projections suggest that electricity bills will be **25% higher** (in today's prices) than over the last five years, due to changes in the costs of electricity generation and other factors.

Therefore, your annual electricity bill is likely to change from **£600.00** to **£750.00** (in today's prices), irrespective of any changes in the service you receive.

Currently, the costs of electricity transmission make up around **8%** of your bill, or around **£48.00** per year.

In the rest of this survey, we are going to ask you about the electricity service you receive and the cost of that service between 2021 and 2026.

Continue

Why are you asking me these questions?

The Transmission Companies are in the process of preparing a business plan for the period 2021 to 2026.

They want to understand what your priorities are for future service and investment to feed into this business plan.

In the next section we will ask you to make some choices about possible changes in the service provided by the Transmission Companies, and about the bill you would have to pay during the period from 2021 to 2026 if each option was undertaken.

Continue

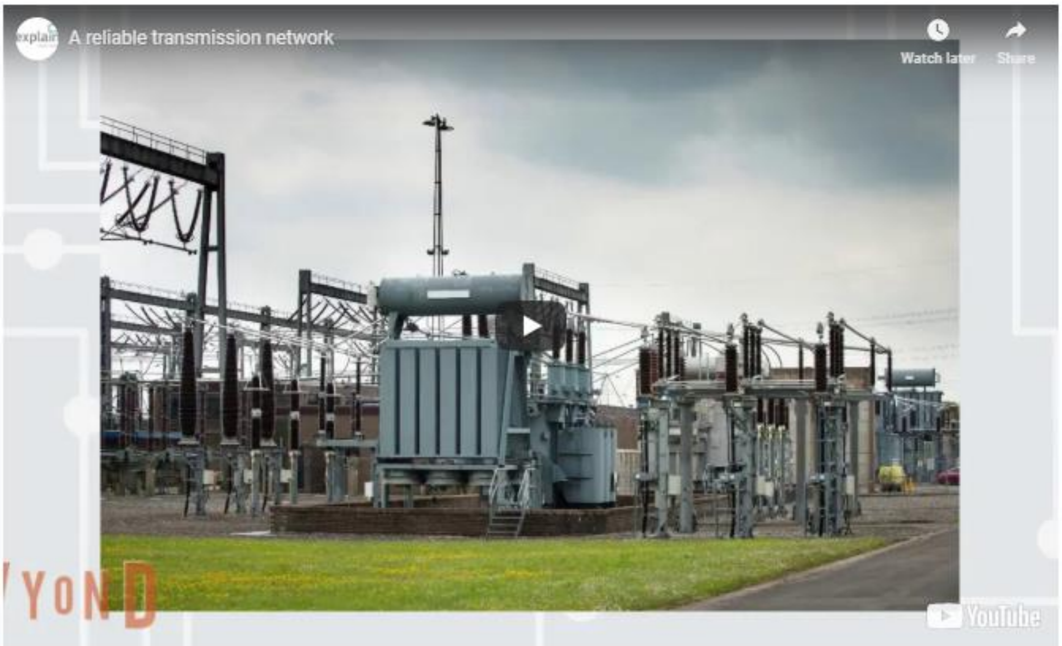
The online survey contained five videos at this point, the text below shows the information provided in each video

The first set of services we will look at are summarised in each of these videos. Please watch all five and then move onto the next screen.

Continue

The video below will begin to play automatically. Please do not click on the YouTube logo as this will take you through to the YouTube site.

Please make sure you have the sound turned on to watch the video.



A reliable transmission network

What does this mean?

The Transmission Companies invest in their networks to make sure electricity is available when people need it. The amount they invest is not fixed.

What would this investment involve?

The Transmission Companies invest in maintaining, repairing and replacing equipment. This includes equipment within their sites (called substations), including transformers which change voltage levels and cost millions of pounds each, to smaller pieces of equipment which help keep the network safe. It also includes repairing and replacing pylons, overhead lines and cables which connect the substations together.

What would the impact be?

Investing more can reduce the possibility of consumers experiencing a power cut due to a failure in the transmission system. Investing less can increase the risk of a power cut.

What is the chance of a transmission power cut happening now?

At the moment, there's a very low chance of consumers experiencing a power cut caused by a failure in the transmission system.

The chance of a household experiencing a 4 hour power cut caused by the transmission network is around 1.5% in any given year.

The most recent large-scale events were in London and Birmingham in 2003, and in the whole of the Northern Scotland in 2014.

Do Transmission Companies invest in this already?

Yes they do, and we want to ask you how much you value a reliable network to help the Transmission Companies set the right level of investment.

Recovering from black outs

What is a black out?

The electricity transmission networks could be affected by events such as cyber-attacks, severe weather or terrorist attacks, and these could result in power cuts lasting several days and affecting large parts of the country. These are called black outs.

There are no recent examples of these types of large-scale power cuts in Great Britain. However, there have been recent examples in other countries:

In the Ukraine in 2016 there was a blackout which affected parts of the capital, Kiev, and was caused by a cyber-attack on the transmission network.

In South Australia in 2016 there was a widespread blackout due to storm damage to the electricity transmission infrastructure, during which almost the entire state lost its electricity supply

What investment can the Transmission Companies make?

The Transmission Companies invest in their networks to try to stop black outs from happening, but there is always a chance that something could happen. They can therefore invest to limit the amount of time it would take to recover from this type of event and restore power to everyone.

What would the impact of this investment be?

Long, widespread power cuts caused by these events are very unlikely in Great Britain. If they did happen, at the moment, the worst case scenario is it could take up to 7 days to restore power to everyone. Transmission Companies can change the amount they invest to change this timescale.

Do Transmission Companies invest in this already?

Yes they do, and we want to ask you how much you value the speed at which companies restore power after this type of event to help the Transmission Companies set the right level of investment.

Putting existing overhead lines underground

What does this mean?

The transmission network is made up of overhead lines and underground electricity cables.

In order to improve the look of the landscape, the Transmission Companies could take existing overhead lines and put them underground.

What would the impact be?

Currently, this work is focused on Areas of Outstanding Natural Beauty, National Parks and National Scenic Areas. These areas all have particular landscape value.

Areas of Outstanding Natural Beauty can be found across England and Wales. They include places like the Cotswolds, Northumberland Coast and Gower Peninsular.

National Parks can be found across England, Scotland and Wales and there are 15 in total.

National Scenic Areas can be found across Scotland and include mountain ranges - such as Skye Cullins, Ben Nevis and Glencoe.

Do the Transmission Companies do this already?

Yes they do, in National Parks, National Scenic Areas and Areas of Outstanding Natural Beauty. In total, between 2013 and 2021 the Transmission Companies have agreed to put 22 miles of overhead cables underground (although not all of this work will be complete by 2021).

In the future, this work could be extended to other parts of the country such as other rural areas, or parts of urban areas.

We want to ask you how much you value this work going forward.

Improving the visual impact of existing overhead lines

What does this mean?

The transmission network is made up of overhead lines and underground electricity cables.

In order to improve the landscape, the Transmission Companies could invest to improve the look of existing overhead lines. For example, they could plant trees or divert footpaths away from overhead lines, or they could look to create more appealing pylon designs or move existing lines.

What would the impact be?

Currently, this work is focused on Areas of Outstanding Natural Beauty, National Parks and National Scenic Areas. These areas all have particular landscape value.

Do the Transmission Companies do this already?

Yes they do, in National Parks, National Scenic Areas and Areas of Outstanding Natural Beauty. In total, between 2013 and 2021 the Transmission Companies will have carried out this type of work in 25 locations across Great Britain. This includes planting hundreds of trees across over 400,000 square metres of land, restoring 3 miles of hedges, planting 2 miles of new hedges and building 11 miles of new paths. .

In the future, this work could be extended to other parts of the country such as other rural areas, or parts of urban areas.

We want to ask you how much you value this work going forward.

Improving the environment around transmission sites

What does this mean?

The Transmission Companies could invest to improve the environment around their sites, including around substations. A substation is a part of the transmission network that changes the voltage of electricity that runs through the systems.

For example, they can work with local organisations to create wildflower meadows, introduce animals to graze, introduce beehives or manage the local woodland.

What would the impact of this investment be?

This type of investment means that land around sites can be used productively.

Do the Transmission Companies do this already?

Improvements are planned for over 40 electricity sites between 2013 and 2021 (from a total of over 500 sites in England, Scotland and Wales). We want to ask you about how much you value this going forward.

You are now going to be asked to make some choices between various levels of service in the areas you just watched in the videos.

Each package shows different levels of service the Transmission Companies could provide and the impact on your electricity bill.

Please compare each package and select Package A or Package B at the bottom of the table depending on which one you prefer.

We will repeat this exercise five times, with different combinations of service levels and electricity bill each time, so we can get a better understanding of your preferences in different circumstances.

When making your choices please remember that:

- Your electricity bill will also increase by inflation;
- Other household bills may go up or down, affecting the amount of money you have to spend in general;
- Your household income and expenses might change, so please be mindful of your overall financial situation when making your decisions;
- Any money you pay to improve the service offered by the electricity transmission operators will not be available for you to spend on other things; and
- Any choices you make to increase or reduce your bill in the period from 2021 to 2026 are permanent changes, so they will still apply each year after 2026.

Continue

The following show card was shown five times, each time containing different service options for each attribute

Which of the following packages do you prefer?

Down the left hand side of each table you will see all of the service areas that were explained in the videos you have watched. You can click on each of these to see a short description or to watch the videos again.

Colour coding has been used to help you compare Package A and B. If a row has shading it means there are changes to the service, if there is no shading it means Package A and Package B are the same for that service. The last row in each table will always be shaded, this row is in relation to the impact on your business' bill.

1 / 5

	Package A	Package B
A reliable transmission network	**Shorter** power cuts (1.5% chance of a **2** hour power cut each year)	**Longer** power cuts (1.5% chance of a **6** hour power cut each year)
Recovering from blackouts	Faster restoration of power (**5** days to restore power to everyone)	Same level as now (**7** days to restore power to everyone)
Putting existing overhead lines underground	Up to 20 miles of additional undergrounding **in National Parks, AONBs and NSAs**	Up to 20 miles of additional undergrounding **in other areas** (i.e. areas which are not National Parks, AONBs and NSAs)
Improve the visual impact of existing overhead lines	**No** additional visual impact works	Additional visual impact works **in National Parks, AONBs and NSAs**
Improving the environment around transmission sites	**45** sites improved between 2021 and 2026	**45** sites improved between 2021 and 2026
Change in your electricity bill excluding inflation	**Your electricity bill would be 2% more per year** Your electricity bill between 2021 and 2026 would be £2570.40 per year	**Your electricity bill would be 2% less per year** Your electricity bill between 2021 and 2026 would be £2469.60 per year

*

Package A | Package B | Don't Know

Continue

The online survey contained four videos at this point, the text below shows the information provided in each video

You will now be asked to make some different choices about possible changes in the service provided by the Electricity Transmission Companies, and about the bill you would have to pay during the period from 2021 to 2026 if each option was undertaken.

The second set of services we will look at are summarised in each of these videos. Please watch all four and then move onto the next screen.

Continue

The video below will begin to play automatically. Please do not click on the YouTube logo as this will take you through to the YouTube site.

Please make sure you have the sound turned on to watch the video.

Investing in innovation projects to create future benefits for consumers

What does this mean?

Innovation can be described as a new idea or better way of doing something.

The Transmission Companies invest in innovation projects to find new and efficient ways of running their networks.

What is the impact of innovation?

Innovation projects can reduce costs, improve levels of customer service, or create environmental benefits, for example.

However innovation projects are about trying new things and so no project is guaranteed to deliver a benefit.

Can you give me some examples of innovation?

There are currently two innovation funding schemes for Transmission Companies.

One is for smaller projects which can cost anywhere between a few tens of thousands of pounds and several million. They tend to run from 1 to 2 years, must be relevant to transmission, and have to show a consumer benefit. A recent example was a project to develop a new tool to test for leaks of harmful greenhouse gases from transmission equipment.

The other scheme is for larger projects which usually cost millions of pounds and which create environmental and consumer benefits. These types of projects usually try to find solutions to technical, engineering problems. Recent examples include a project to develop new types of pylons which have less of an impact on the landscape, and projects to speed up the build time (and reduce the cost) of new equipment.

Do the Transmission Companies do this already?

Yes they do, and we want to ask you how much you value this going forward.

Supporting local communities

What does this mean?

The Transmission Companies could make investments to support local communities.

Do the Transmission Companies do this already?

Yes they do. Examples include:

A community grant program, which is aimed at community organisations and charities in areas where the Transmission Companies' work is affecting local people. Grants of up to £20,000 are available, with £214,000 awarded in 2017-18.

Employee volunteering schemes to support schools, charities and other organisations. In 2017-18, the companies provided over 26,000 hours of voluntary support.

We want to understand how much you value these types of activities going forward.

Investing to make sure the network is ready for electric vehicle charging

What does this mean?

This is about the investments the Transmission Companies could make to make sure their networks are ready and able to cope if there is a big uptake of electric vehicles in the future.

What would this involve?

This would involve adding new connection points to the transmission network which could be used to connect charging points for electric vehicles. These would be in places such as motorway service areas, not at people's homes.

Why would the Transmission Companies do this?

The Transmission Companies have two options:

1. Invest before there is a definite need – be ready.
    a. This means the network will be ready to connect charging points for electric vehicles as and when they are needed.
    b. The Transmission Companies won't slow down the uptake of electric vehicles by not being ready with charging points. Without enough charging points, people may not buy an electric vehicle because how far they can drive would be limited.
    c. This could mean that the Transmission Companies make investment that isn't needed, if there isn't a wider take up of electric vehicles in the future.
2. Invest later – wait and see.
    a. Wait until there is a clearer view of the demand for electric vehicles
    b. This lowers the risk of investing in something that isn't needed in the future
    c. This could also mean that the Transmission Companies might slow down the take up of electric vehicles in the future, because it will take time to connect the charging points

What is the predicted demand for electric vehicles?

It is predicted that in the UK, sales of electric vehicles could overtake sales of petrol and diesel vehicles by 2027.

Is this investment that the Transmission Companies make already?

No it isn't. We want to understand how much you would value this going forward.

Investing to make sure the network is ready to connect renewable generation

What does this mean?

This is about the investments the Transmission Companies make to get their networks ready to connect more sources of renewable generation in the future.

What is renewable generation?

Renewable technologies use natural energy to make electricity. For example:

- Wind farms use wind to generate electricity
- Solar panels use sunlight to generate electricity
- Hydroelectric farms use water to generate electricity

What investment would the Transmission Companies need to make?

This would involve increasing the capacity of the transmission network so it is ready to connect more sources of renewable (and other) generation in the future.

Why would the Transmission Companies do this?

The Transmission Companies have two options:

1. Invest before there is a definite need – be ready.
    a. This means the network will be ready to connect new renewable energy sources when they want to connect.
    b. The Transmission Companies won't slow down the uptake of renewable generation as the network will have capacity to cope.
    c. However, if the new sources of generation do not ever connect, the investment may not be needed.
2. Invest later – wait and see.
    a. Wait until new generators approach the Transmission Companies asking to connect to their networks
    b. This lowers the risk of investing in something that isn't needed in the future
    c. However this could also mean that the Transmission Companies slow down the transition to renewable generation and a low carbon economy, because it will take time for the Transmission Companies to make the new connections.

What is the predicted demand for electric vehicles?

Renewable energy use grew by 10% between 2016 and 2017 and is now almost eight times the level it was at in 2000.

The UK aim to have 30% of electricity by 2020 to come from renewable sources.

Is this investment that the Transmission Companies make already?

No it isn't. We want to understand how much you would value this going forward.

Like before, you are now going to be asked to make some choices between various levels of service.

Each package shows different levels of service the Transmission Companies could provide and the impact on your electricity bill.

Please compare each package and select Package A or Package B at the bottom of the table depending on which one you prefer.

We will repeat this exercise five times, with different combinations of service levels and electricity bill each time, so we can get a better understanding of your preferences in different circumstances.

When making your choices please remember that:

- Your electricity bill will also increase by inflation;
- Other household bills may go up or down, affecting the amount of money you have to spend in general;
- Your household income and expenses might change, so please be mindful of your overall financial situation when making your decisions;
- Any money you pay to improve the service offered by the electricity transmission operators will not be available for you to spend on other things; and
- Any choices you make to increase or reduce your bill in the period from 2021 to 2026 are permanent changes, so they will still apply each year after 2026.

Continue

The following show card was shown five times, each time containing different service options for each attribute

Which of the following packages do you prefer?

Down the left hand side of each table you will see all of the service areas that were explained in the videos you have watched. You can click on each of these to see a short description or to watch the videos again.

Colour coding has been used to help you compare Package A and B. If a row has shading it means there are changes to the service, if there is no shading it means Package A and Package B are the same for that service. The last row in each table will always be shaded, this row relates to the impact on your bill.

Please note that the bill values selected in the different exercises aren't in addition to each other and each task should be considered independently.

1/5

	Package A	Package B
Investing in innovation projects to create future benefits for consumers	**Large scale**, longer-term innovation projects which are more transformational and focus on creating benefit for the broader energy industry and/or wider community, but also carry a level of uncertainty and risk	**Medium scale** innovation projects which aim to deliver benefit in up to 10 years but which come with a level of uncertainty and risk
Supporting local communities	**Maintain current level** of community activities	**Maintain current level** of community activities
Investing to make sure the network is ready for electric vehicle charging	**Invest** before there is a definite need for electric vehicle charging connections	**Invest** before there is a definite need for electric vehicle charging connections
Investing to make sure the network is ready to connect renewable generation	**Do not invest** before there is a definite need for new renewable generation connections	**Invest** before there is a definite need for new renewable generation connections
Change in your electricity bill excluding inflation	**Your electricity bill would be £10 less per year** Your electricity bill between 2021 and 2026 would be £335.00 per year	**Your electricity bill would be £10 more per year** Your electricity bill between 2021 and 2026 would be £355.00 per year

*

Package A	Package B	Don't Know

Continue

In these final choices, please consider all of the factors together.

When making your choices please remember that:

- Your electricity bill will also increase by inflation;
- Other household bills may go up or down, affecting the amount of money you have to spend in general;
- Your household income and expenses might change, so please be mindful of your overall financial situation when making your decisions;
- Any money you pay to improve the service offered by the electricity transmission operators will not be available for you to spend on other things; and
- Any choices you make to increase or reduce your bill in the period from 2021 to 2026 are permanent changes, so they will still apply each year after 2026.

As before, you will be presented with a table showing two alternative packages, labelled Package A and Package B.

Continue

The following show card was shown five times, each time containing different service options for each attribute.

Which of the following packages do you prefer?

Down the left hand side of each table you will see all of the service areas that were explained in the videos you have watched. You can click on each of these to see a short description or to watch the videos again.

Colour coding has been used to help you compare Package A and B. If a row has shading it means there are changes to the service, if there is no shading it means Package A and Package B are the same for that service. The last row in each table will always be shaded, this row relates to the impact on your bill.

Please note that the bill values selected in the different exercises aren't in addition to each other and each task should be considered independently.

1 / 5

	Package A	Package B
A reliable transmission network	**Longer** power cuts (1.5% chance of a **6** hour power cut each year)	**Same duration** of power cuts as today (1.5% chance of a **4** hour power cut each year)
Recovering from blackouts	Same level as now (**7** days to restore power to everyone)	Faster restoration of power (**5** days to restore power to everyone)
Putting existing overhead lines underground	**No** additional undergrounding	Up to 20 miles of additional undergrounding **in National Parks, AONBs and NSAs**
Improve the visual impact of existing overhead lines	**No** additional visual impact works	Additional visual impact works **in National Parks, AONBs and NSAs**
Improving the environment around transmission sites	**No** sites improved	**25** sites improved between 2021 and 2026
Investing in innovation projects to create future benefits for consumers	**Large scale**, longer-term innovation projects which are more transformational and focus on creating benefit for the broader energy industry and/or wider community, but also carry a level of uncertainty and risk	**Medium scale** innovation projects which aim to deliver benefit in up to 10 years but which come with a level of uncertainty and risk
Supporting local communities	**Maintain current level** of community activities **and provide additional funding** to charities and other organisations to support consumers	**Maintain current level** of community activities
Investing to make sure the network is ready for electric vehicle charging	**Invest** before there is a definite need for electric vehicle charging connections	**Invest** before there is a definite need for electric vehicle charging connections
Investing to make sure the network is ready to connect renewable generation	**Invest** before there is a definite need for new renewable generation connections	**Invest** before there is a definite need for new renewable generation connections
Change in your electricity bill excluding inflation	**Your electricity bill would be £20 less per year** Your electricity bill between 2021 and 2026 would be £325.00 per year	**Your electricity bill would be £10 more per year** Your electricity bill between 2021 and 2026 would be £355.00 per year

*

Package A	Package B	Don't Know

Continue

Final questions

Thank you for your answers! We now have some questions for you about the choices you just made.

Did you feel able to make comparisons between the choices that were presented to you? *

Yes	No	Sometimes

Did you feel you understood the services offered by the Transmission Companies and the levels of service included in your choices? *

Yes	No	Sometimes

Did you believe that the more unlikely events, like losing your electricity supply for several days, could actually happen? *

Yes	No

Thinking about the choices you made, which factors were most important to you? (Drag the factors from the left hand side into the box and order them by importance)

- Minimising electricity bills
- Supporting local communities
- Protecting the local environment
- Supporting innovation
- Fighting climate change
- Minimising disruption to electricity supply

MOST IMPORTANT

LEAST IMPORTANT

Are there any areas where you would like to see the Transmission Companies make investments that you think have been missed from the survey? *

Yes	No

Would you be willing to take part in future research with the Transmission Companies? *

Yes	No

Please make sure you have answered all questions marked with a * before clicking continue

Continue

Final questions

At the moment, including yourself, how many people live in your household between the following ages.

Adults between 18 and 65 years old

Adults over 65 years old

Children less than 18 years old

What type of property do you live in? *

- Flat
- Detached house
- Semi-detached house
- Terraced property
- Other (please state)

Which of the following best describes you? *

- I am a home owner
- I privately rent my property
- I live in social housing
- Other (please state)

Do you have a pre-payment meter? *

- Yes
- No
- Unsure

What is your average annual household income? *

- £0 - £19,999
- £20,000 - £39,999
- £40,000 - £59,999
- £60,000 - £79,999
- £80,000 - £99,999
- £100,000 - £119,999
- £120,000+
- Prefer not to say

How often do you visit National Parks, National Scenic Areas, or other parts of the country designated as Areas of Outstanding Natural Beauty? (Click here for a description) *

- Frequently
- Occasionally
- Rarely
- Never

Please make sure you have answered all questions marked with a * before clicking continue

Thank you so much for your answers, now simply hit submit to send your responses!

Submit

F.2. Domestic Gas Survey

Thank you for taking part in our survey

This survey has been designed by Explain Market Research, an independent research agency, working with National Grid Gas Transmission to gain your views through a number of questions.

The research is being conducted under the terms of the Market Research Society (MRS) code of conduct and is completely confidential. If you would like to confirm Explain's credentials please call the MRS free on 0800 975 9596.

During this survey you will need to watch and listen to some videos. Please make sure your sound is working and turned up.

Before we start, we just need to ask you a couple of questions to ensure we are speaking to the right people:

Is your home connected to the natural gas network? (For example, do you use gas in your home? You might have gas heating or a gas cooker) *

- ○ Yes
- ○ No
- ○ Unsure

Are you responsible for paying a gas bill or choosing a gas supplier in your household? *

- ○ Solely
- ○ Jointly
- ○ Neither

What is your gender? *

- ○ Male
- ○ Female
- ○ Other
- ○ Prefer not to say

What is your age? *

- ○ 18 to 24
- ○ 25 to 34
- ○ 35 to 44
- ○ 45 to 54
- ○ 55 to 64
- ○ 65 plus

How would you describe the occupation of the main income earner in your household? If you or they are retired, please describe the occupation they had before you/they retired *

- Higher managerial / professional / administrative (e.g. Established doctor, Solicitor, Board Director in a large organisation (200+ employees), top level civil servant/public service employee)
- Intermediate managerial / professional / administrative (e.g. Newly qualified (under 3 years) doctor, Solicitor, Board director small organisation, middle manager in large organisation, principal officer in civil service/local government)
- Supervisory or clerical / junior managerial / professional / administrative (e.g. Office worker, Student Doctor, Foreman with 25+ employees, salesperson, etc)
- Student
- Skilled manual worker (e.g. Skilled Bricklayer, Carpenter, Plumber, Painter, Bus/ Ambulance Driver, HGV driver, AA patrolman, pub/bar worker, etc)
- Semi or unskilled manual work (e.g. Manual workers, all apprentices to be skilled trades, Caretaker, Park keeper, non-HGV driver, shop assistant)
- Casual worker - not in permanent employment
- Housewife / Homemaker
- Unemployed or not working due to long-term sickness
- Full-time carer or other household member

What is the first part of your postcode? *

e.g. NE1

Please make sure you have answered all questions marked with a * before clicking continue

Continue

Where do you live? (please select area on the map)*

Please make sure you have answered all questions marked with a * before clicking continue

Thank you for your answers so far!

This survey is being run on behalf of National Grid Gas Transmission.

National Grid Gas Transmission transports gas from where it comes into the country to the gas distribution networks or directly to power stations and other large industrial users. The gas distribution networks then connect to people's homes. National Grid Gas Transmission also has day-to-day responsibility for balancing supply and demand through their System Operator. National Grid Gas Transmission covers the whole of Great Britain.

You pay your bill to your gas supplier, but some of that bill is the cost of running the gas transmission network.

We have sent you this survey because we want to understand your priorities for future investments.

Throughout this survey we refer to "consumers" this is you and other members of the public who are served by the gas transmission network. Although you don't pay a bill to National Grid Gas Transmission and aren't their direct customer, you are a consumer of the gas they transport.

Continue

Before we get started, we would like to understand a bit more about how you use gas in your home...

When did you last experience a gas supply interruption at your property? *

- In the last year, several times
- In the last year, but just once
- Within the last 1-2 years
- More than 2 years ago
- Never
- Can't remember

Do you use electricity or gas in your home for the following:

Heating your home *

- Gas
- Electric
- Both
- Neither
- Don't Know

Heating your water *

- Gas
- Electric
- Both
- Neither
- Don't Know

Cooking *

- Gas
- Electric
- Both
- Neither
- Don't Know

Please make sure you have answered all questions marked with a * before clicking continue

Continue

Are you familiar with the following heating technologies (select all that apply) *

- [ ] Ground source heat pump
- [ ] Air source heat pump
- [ ] District heating system
- [ ] Hybrid heat pump
- [ ] None of the above

Do you currently use any of the following for heating your home (select all that apply): *

- [ ] Ground source heat pump
- [ ] Air source heat pump
- [ ] District heating system
- [ ] Hybrid heat pump
- [ ] None of the above

Please make sure you have answered all questions marked with a * before clicking continue

Continue

Thinking about your household's energy costs, do you know your typical gas bill? Please complete one of the following:

(If you only know your combined electricity and gas bill please click don't know)

I spend £ 50 per Month Don't know

This means you spend around **£600.00** per year on gas.

Continue

The gas system

This survey is about the **transmission** system

Producers

Gas isn't produced in Great Britain, it is mainly sourced from gas fields in the North and Irish seas, piped from Europe or imported as Liquefied Natural Gas via tankers.

Transmission

The transmission system transfers large amounts of gas at high pressure from where it enters the country to where it is needed. Compressor stations located along the network push gas through the system at the right pressure to be used by distribution networks who supply gas to people's homes. They also have responsibility for balancing supply and demand.

Distribution

Gas distribution networks then connect gas to people's homes and businesses.

Continue

Where your money goes

Although you don't pay a bill to National Grid Gas Transmission and aren't their direct customer, you consume the gas they transport. 1.6% of your gas bill goes to National Grid Gas Transmission.

Continue

Your Gas Costs

Between 2021 and 2026, UK government projections suggest that gas bills will be **10% higher** plus the effect of inflation due to changes in the costs of wholesale gas and other factors.

Therefore, your annual gas bill is likely to increase from **£600.00** to **£660.00**, irrespective of any changes in the service you receive.

Currently, the costs of Gas Transmission make up around **1.6%** of your bill, or around **£9.60** per year.

In the rest of this survey, we are going to ask you about the service you receive from National Grid Gas Transmission and the cost of that service between 2021 and 2026.

Continue

Why are you asking me these questions?

National Grid Gas Transmission is in the process of preparing a business plan for the period 2021 to 2026.

They want to understand your priorities for future services and investment to feed into this business plan.

In the next section we will ask you to make some choices about possible changes in the service provided by National Grid Gas Transmission, and about the bill you would have to pay during the period from 2021 to 2026 if each option was undertaken.

Continue

The first set of services we will look at are summarised in each of these videos. Please watch all five and then move onto the next screen.

Continue

The video below will begin to play automatically. Please do not click on the YouTube logo as this will take you through to the YouTube site.

Please make sure you have the sound turned on to watch the video.

Reducing the risk of a transmission interruption to the gas supply

What does this mean?

National Grid Gas Transmission invest in the network to make sure gas is available when people need it. The amount they invest is not fixed.

What would this investment involve?

National Grid Gas Transmission could make upgrades to their equipment in order to make it more reliable.

What is the chance of a gas interruption because of the transmission network happening now?

It is very low. One in every 12,500 households per year.

In the UK there has never been a significant gas interruption to domestic consumers caused by the Gas transmission system.

Due to the increasing age of the equipment and changing use of the network, National Grid Gas Transmission needs to increase the maintenance of the gas network, to maintain the current low risk of a consumer experiencing an interruption to their gas supply.

At the moment, this risk is very low due to the work currently undertaken, however the risk could rise or fall depending on how much maintenance work National Grid Gas Transmission carries out.

But I know people who have had their gas supply cut off!

There are two different parts of the gas network – distribution and transmission. National Grid Gas Transmission look after the transmission part of the network.

You are more likely to have experienced an interruption from the distribution part of the network as they have been replacing a lot of gas mains in towns and cities, but that has nothing to do with National Grid Gas Transmission.

A transmission level interruption could affect around 200,000 households at a time and would likely last weeks or months before all consumers were restored. This is because all household boilers would require checking and relighting by a qualified engineer as supplies were restored.

Distribution level interruptions usually affect smaller local areas, so would be smaller scale and could last between a few hours to a week.

Does National Grid Gas Transmission invest in this already?

Yes they do, and we want to ask you how much you value a reliable gas transmission network going forward.

Improving the environment around transmission sites

What does this mean?

National Grid Gas Transmission could invest to improve the environment around their sites, such as around compressors stations.

For example, they can work with local organisations to create wildflower meadows, introduce animals to graze, introduce beehives or manage the local woodland to benefit the local community and wildlife.

What is a gas transmission site?

Transmission sites house compressors. A gas compressor is a large piece of equipment that pushes gas through the pipelines

What would the impact of this investment be?

This type of investment means that land around sites can be used productively.

Does National Grid Gas Transmission do this already?

Yes they do, National Grid Gas Transmission currently invest in 7 of a possible 23 sites.

We want to ask you about how much you value this going forward.

Investing in innovation projects to create future benefits for consumers

What does this mean?

Innovation can be described as a new idea or better way of doing something.

National Grid Gas Transmission invests in innovation projects to find new and efficient ways of running their network.

What is the impact of innovation?

Innovation projects can reduce costs, improve levels of customer service, or create environmental benefits.

However, innovation projects are about trying new things and so no project is guaranteed to deliver a benefit.

Can you give me some examples of innovation?

Approximately £4m is currently invested in innovation. Some of these are shorter term smaller projects and some are larger more long-term projects.

Here is an example of a short-term project:

In some areas National Grid Gas Transmission have found that there are parts of their pipeline that are covered by less than a metre of earth, the minimum level of coverage needed to protect the pipeline from being hit my diggers etc. This includes pipeline in farmers' fields that is regularly ploughed, posing a safety threat. National Grid Gas Transmission therefore developed plastic protection slabs that are buried just above the pipeline to protect the pipes, the farmers and significantly reduce disruption to landowners. Payback on this type of project tends to be within a few years.

Here is an example of a long-term project:

Project GRAID involved developing robots that can be sent into high pressure gas pipelines to assess their condition. This helps National Grid Gas Transmission to see pipelines without having to dig them up making it cheaper, safer and more efficient. Payback on this type of project tends to be 5-10 years.

Does National Grid Gas Transmission do this already?

Yes they do. Going forward, National Grid Gas Transmission could invest more in innovation projects which could deliver benefits to consumers in terms of cost savings or service improvements. However, there are no guarantees.

We want to ask you how much you value this going forward.

Supporting local communities

What does this mean?

National Grid Gas Transmission could make investments to support local communities.

Does National Grid Gas Transmission do this already?

Yes they do, and we want to understand how much you value these types of activities going forward.

For example:

National Grid currently runs a Community Grant Programme, which is aimed at community organisations and charities in areas where our work is impacting on local people. Grants of up to £20,000 are available, with £214,000 awarded to various charities and community programmes in 2017-18.

They also promote employee volunteering schemes to support schools, charities and other organisations. In 2017-18, electricity and gas employees provided over 22,000 hours of voluntary support.

Supporting those in fuel poverty

What is fuel poverty?

A household is deemed to be in fuel poverty when they are unable to afford to heat their home at a reasonable cost. There are an estimated 2.55 million fuel poor households in the UK.

How could National Grid Gas Transmission help those in fuel poverty?

They could do things like support existing schemes which help consumers be more energy efficient and reduce their bills.

For example, they could support schemes which help consumers find and fund green solutions for their homes, reducing both their energy bills and their carbon emissions.

For example, they could invest in schemes like the Energy Loop. The Energy Loop is a fast, easy, free online service to help consumers find and fund green solutions for their home. From energy saving kettles, to solar panels, and everything in between. The Energy Loop explains everything in plain, honest language, supporting consumers through every step and helping to understand how much can be saved.

Does National Grid Gas Transmission do this already?

They don't. This is because as an organisation they are removed from the consumer. They don't send consumers a bill or have any interaction on a day to day basis. This makes it difficult to offer help.

However, we want to understand how much you would value investment in this area going forward.

You are now going to be asked to make some choices between various levels of service based on the videos you just watched.

Each package shows different levels of service National Grid Gas Transmission could provide and the impact on your gas bill.

Please compare each package and select Package A or Package B at the bottom of the table depending on which one you prefer.

We will repeat this exercise five times, with different combinations of service levels and gas bill each time, so we can get a better understanding of your preferences in different circumstances.

When making your choices please remember that:

- Your gas bill will also increase by inflation;
- Other household bills may go up or down, affecting the amount of money you have to spend in general;
- Your household income and expenses might change, so please be mindful of your overall financial situation when making your decisions;
- Any money you pay to improve the service offered by National Grid Gas Transmission will not be available for you to spend on other things; and
- Any choices you make to increase or reduce your bill in the period from 2021 to 2026 are permanent changes, so they will still apply each year after 2026.

Continue

The following show card was shown five times, each time containing different service options for each attribute

Which of the following packages do you prefer?

Down the left hand side of each table you will see all of the service areas that were explained in the videos you have watched. You can click on each of these to see a short description or to watch the videos again.

Colour coding has been used to help you compare Package A and B. If a row has shading it means there are changes to the service, if there is no shading it means Package A and Package B are the same for that service. The last row in each table will always be shaded, this row relates to the impact on your bill.

1 / 5

	Package A	Package B
Reducing the risk of a transmission interruption to the gas supply	**Same** probability as today (1 in **12,500** households per year)	**Same** probability as today (1 in **12,500** households per year)
Improving the environment around transmission sites	15 large sites and 30 smaller sites	4 Large sites
Supporting local communities	**Maintain current level** of community schemes **and provide additional funding** to charities and other organisations to support consumers	**No** community schemes
Investing in innovation projects to create future benefits for consumers	**No** innovation projects	**No** innovation projects
Supporting those in fuel poverty	Continue as is - no proactive support	Continue as is - no proactive support
Change in your gas bill excluding inflation	**No change** Your gas bill between 2021 and 2026 would be £660.00 per year	**Your gas bill would be £5 less per year** Your gas bill between 2021 and 2026 would be £655.00 per year

*

Package A	Package B	Don't Know

Continue

You will now be shown a different set of choices.

Changes in technology may affect the heating technologies available to households. When you replace your existing gas boiler, a wider range of options may be available to you.

You will now be asked to make some choices about possible alternative heating technologies that could replace your existing gas boiler.

These alternatives have different upfront installation and running costs. Fitting alternative technologies may also be more disruptive. However, the alternatives to gas boilers may reduce your household's greenhouse gas emissions.

The average gas bill for a household who has a gas boiler is £500, and the average cost to have a new boiler installed is approximately £2000.

Watch the videos below to learn about each alternative heating technology.

Continue

The online survey contained five videos at this point, the text below shows the information provided in each video

The video below will begin to play automatically. Please do not click on the YouTube logo as this will take you through to the YouTube site.

Please make sure you have the sound turned on to watch the video.

Air source heat pump

Air source heat pumps are a system that transfers heat from outside to inside a building or vice versa. The positives of this is less impact on the environment. The negatives are initial high cost to have this installed, and in house disruption to alter all radiators.

Air is transferred from outside into the house and is absorbed at low temperature into a fluid. This fluid then passes through a compressor where its temperature is increased and transfers its higher temperature heat to the heating and hot water circuits of the house.

What is the disruption?

The main disruption of having an air source heat pump installed is that all radiators would need to be replaced.

Also, if a gas heating system was to be replaced with an alternative heating source, this would mean all gas would be removed from the home, therefore if there was a gas cooker this would need to be replaced.

How long will it last?

On average, an air source heat pump lasts 10 years before needing to be replaced.

Ground source heat pump

Ground source heat pumps transfer heat from the ground to inside a building or vice versa. The positives of this is lower annual energy cost. The negatives are initial high cost to have this installed, in house disruption to alter radiators, and it requires land excavations to install.

Ground source heat pump uses fluid to absorb heat from the ground. Using electricity, the pump compresses the fluid and releases it at a higher temperature. Heat is then sent to radiators and/or underfloor heating – the remainder is stored in a hot water cylinder/buffer tank.

What is the disruption?

The main disruption of having a ground source heat pump installed is in house disruption to alter radiators, and it requires land excavations to install. Gas cookers would need to be replaced.

How long will it last?

On average, a ground source heat pump lasts 25 years before needing to be replaced.

District heating System

District heating is a system that distributes heat generated in one location amongst a district or group of buildings. It is suitable for any type of property. The positives of this are that it is relatively cheap to install, the disruption is minimal as existing radiators could be used, and it is fuel neutral and therefore easy to switch to lower carbon fuels in the future. The negatives are the need for pipework replacement, and it locks consumers in to long term contracts with little or no options for switching. This type of heating system is currently unregulated.

Heat is produced at the heat production plant. Heat is then transferred to individual buildings through pipes, and a system of pipework is connected to a radiator.

What is the disruption?

Disruption would be minimal as there is no need to replace radiators. Gas cookers would need to be replaced.

How long will it last?

On average, a district heating system lasts 15 to 20 years before needing to be replaced.

Hybrid heat pump

Hybrid heat pumps are retrofitted on to existing gas boilers and allow the use of hydrogen as well as natural gas.

Hybrid heat pumps combine the benefits of heat pumps as described previously with the ability of gas boilers to ramp up heat quickly. They switch between energy source depending on which is the most efficient at any given time.

What is the disruption?

There would be some disruption. There is no need to replace radiators and the boiler can be retrofitted, however pipework will need to be replaced with steel. Gas cookers would need to be replaced.

How long will it last?

On average, a hybrid heat pump lasts 10 years before needing to be replaced.

You will next be presented with a table showing two alternative heating technologies based on the information you just watched in the videos.

Thinking about the alternatives shown, please state which you would prefer when you come to replace your current gas boiler.

Each choice will be presented in a table showing two alternative packages, labelled Package A and Package B.

As before, please remember that:

- Your ongoing running costs will also increase by inflation;
- Other household bills may go up or down, affecting the amount of money you have to spend in general;
- Your household income and expenses might change, so please be mindful of your overall financial situation when making your decisions; and
- Any money you pay to replace your existing gas boiler will not be available for you to spend on other things.

Continue

The following show card was shown five times, each time containing different heating technologies

Which of the following packages do you prefer if you were replacing your boiler?

1/5

	Package A	Package B
Name of heating technology	Gas boiler	Hybrid heat pump
Ongoing running costs	£500	£700
Carbon dioxide emissions	High	Medium
Level of disruption	None	Some. No need to replace radiators. Boiler can be retrofitted, however pipework will need to be replaced with steel.
Installation costs	£2000	£26000

*

Package A	Package B	Don't Know

Continue

Final questions

Thank you for your answers! We now have some questions for you about the choices you just made.

Did you feel able to make comparisons between the choices that were presented to you? *

Yes	No	Sometimes

Did you feel you understood the services offered by National Grid Gas Transmission and the levels of service included in your choices? *

Yes	No	Sometimes

Did you understand the different heating technologies that were presented? *

Yes	No

Did you believe that the more unlikely events, like losing your gas supply for several days, could actually happen? *

Yes	No

Thinking about the choices you made, which factors were most important to you? (Drag the factors from the left hand side into the box and order them by importance)

- Protecting the local environment
- Fighting climate change
- Supporting innovation
- Supporting local communities
- Minimising gas bills
- Minimising disruption to gas supply

MOST IMPORTANT

LEAST IMPORTANT

Are there any areas where you would like to see the Transmission Companies make investments that you think have been missed from the survey? *

Yes | No

Would you be willing to take part in future research with the Transmission Companies? *

Yes | No

Please make sure you have answered all questions marked with a * before clicking continue

Continue

Final questions

At the moment, including yourself, how many people live in your household between the following ages.

Adults between 18 and 65 years old

Adults over 65 years old

Children less than 18 years old

What type of property do you live in? *

- Flat
- Detached house
- Semi-detached house
- Terraced property
- Other (please state)

Which of the following best describes you? *

- I am a home owner
- I privately rent my property
- I live in social housing
- Other (please state)

What is your average annual household income? *

- £0 - £19,999
- £20,000 - £39,999
- £40,000 - £59,999
- £60,000 - £79,999
- £80,000 - £99,999
- £100,000 - £119,999
- £120,000+
- Prefer not to say

Please make sure you have answered all questions marked with a * before clicking continue

Thank you so much for your answers, now simply hit submit to send your responses!

Submit

Appendix G. Findings from Cognitive Interviews

The table below summarises the key findings from the cognitive interviews, and the recommended changes to the survey instrument that followed from them.

Finding	Recommendation	Gas/Elec/Both
'Clicking through' odd choice of words	Change to 'Thank you for taking part in our survey'	
SEG difficult to answer	Remove this question, replace with average household income	Both
Unsure how much of postcode to enter	Give example – e.g. NE1	Both
Difficult to tell if section of map has been selected	Grey/black out region once selected	Both
Unsure how to answer how many living in household as changes depending on time of year. Also confusion about how to answer question.	Change to 'At the moment, how many people live in your household between the following ages'	Both
'Do you use gas or electricity in your home for the following:' Some people found this difficult to answer as didn't know	Remove question – not needed as a screener as we ask if they have gas at beginning of gas survey, and carry on with the elec survey regardless of responses	Both
Maps in linked to document don't define the areas covered	Add specific examples to National Parks and National Scenic Areas	Both
'Before we get started, we'd like to know a bit more about you' Already answered quite a few questions by this point.	Remove 'before we get started' from text	Both
Type or property – found difficult to answer	Add descriptions	Both
Are you familiar with the following heating technologies – need to add 'select all the apply'	Add ' select all that apply'	Gas

Confused how to answer the question which asks which of the alternative heating sources you use – wasn't sure whether should tick none of the above or tick other and put gas boiler	Remove 'other' option Or If 'other' option is needed, add gas boiler as an option	Gas
Last question, options should only show if they have said they are aware of these options in questions above	Add routing so options are only shown if they selected responses in previous question	Gas
This page caused quite a lot of confusion – people missed the info about combined bills, when don't know was selected some thought the next sentence was a repeat of the first, some nearly clicked 'don't know' rather than 'continue'	1. Put gas/electricity bill in bold in first sentence 2. Put sentence in bold 'If you only know your combined electricity and gas bill, please click don't know) 3. Don't know button to be moved to the right hand side next to monetary boxes 4. If 'don't know' is selected, first sentence to be hidden, and 'combined electricity and gas bill' in bold 5. 'Are you sure your values are correct' shouldn't appear if someone enters values but then selects don't know	Both
Too much text	Break Transmission text into bullet points	Both
Unclear which bit TO is responsible for	Bold 'Transmission'	Both
Numbers don't add to 100% due to rounding	Add decimal places back in	Gas
Blue box underneath flame doesn't look right	Remove blue box	Gas
	Bold % increase in first sentence	Gas
Says 1.6% of bill goes to NG, but in diagram this is rounded to 2%	Show same figure on both pages 1.6% or 2%?	Gas
	Add reminder before videos to make sure sound is turned on/up	

Transcripts showing underneath videos confusing, many respondents thought they needed to read this as didn't realise it was same as what they had seen in the video.	Hide transcript, add text under video – if you would like to read the information you have just seen in the video again, please click here – otherwise click continue. Then have continue button underneath	Both
Volume issues on some videos	Re-record voiceovers	Gas
Improving environment video – examples not very good	Provide alternative examples	Gas
Innovation video – too much information on one page, descriptions too long	Cut down the amount of information provided	Gas
Communities video – too much information	Cut down amount of information provided	Gas
Video 3 and 4 - Information about AONBs etc. repetitive as shown in both videos.	Delete repeated information from video 4	Elec
Need option to watch again	Add text in to inform that the videos will be available to watch again later in the survey	Both
'Answer questions to follow' text at start confusing as questions aren't until after all videos and further pages	Change text to 'The video below will begin to play automatically. Please do not click on the YouTube logo as this will take you through to the YouTube site.	Both
Some people missed start of video as not all was showing on screen – didn't realise the need to scroll down	Remove the text at the top once the video starts	Both
Suggestion to mix up voice recording to avoid monotony	Re-record voiceovers – one voice asking questions and another answering	

Confusion about what the exercises are asking – people didn't pay much attention to task requirements	Change script to provide more detailed explanation – explain that the same services will be shown but showing different options for these to increase/decrease or same the same (Suggested script at end of document)	Both
Some interpretation that +£10 meant £10 better off rather than increase in bill	Change to text to say your gas/elec bill would be £10 more/less	Both
Didn't notice could revisit a short description and the video. Make this clearer on page	Add text at top 'Down the left hand side of each table you will see all the services that were explained in the videos you have watched. You can click on each of these to see a short description or to watch the videos again' Remove use of word 'attribute'	Both
Probability – some people didn't understand. Thought that a higher number must mean more interruptions therefore worse.	Change wording – in bold – higher/lower chance of an interruption (Every one in 12,500 years)	Gas
Transparent text – not obvious in some tables, some had no transparent text as all attributes had changes but explanation of what transparent text was for a top - confusing	Remove use of transparent text, use coloured cells to show which attributes have changed – however highlight both cells rather than showing which is better	Both
Not sure what to select, some people thought they had to choose A or B for each row.	Better explanation above the table explaining what to do – see text at end of document	Both
Not obvious second table was different, not sure why answering same question a number of times	Show progress e.g. Table 1/5, 2/5 etc. Add text after each table, e.g. 'we are now going to show you are similar table with different options for change to the service with different cost impacts. As before, please select which you prefer, Package A or Package B'.	Both

Confusion over how prices could be lower when service has improved	Need better explanation at introduction of how exercise and pricing works – NERA to provide	Both
Unsure how to select preferred package, can't see buttons at bottom without scrolling down.	Add text in intro ' Once you have made your choice, please scroll down to the bottom of the page to select 'Package A or Package B'	Both
AONBs and NPs – forgotten what these refer to	Explain abbreviation in description in left-hand column	Both
Feedback on green shading was varied – for some it was leading as would select columns with most green	As above: remove use of transparent text, use coloured cells to show which attributes have changed – however highlight both cells rather than showing which is better	Both
Doesn't explain if you still keep gas for other things	Need to explain this – how will this impact bill costs shown?	Gas
	Any changes made to structural changes of first set of videos, to be made to second set	Both
Doesn't give much explanation about the technologies	More info about how technologies work/benefits. Talk through the diagrams that are shown	Gas
Need reminder that these are alternatives to boiler	Add more info to videos	Gas
Some found it took longer and harder to make decisions without the green shading of exercise one. Others felt the decision wasn't being made for them about which was better as it was in exercise one	Use coloured cells to show which attributes have changed – however highlight both cells rather than showing which is better	Elec
Question over overall bill changes – would it be +£20 based on both exercises	Need to add text to explain this - NERA	Elec

Not aware option to re-watch video	Add text at top - 'Down the left hand side of each table you will see all the heating technologies that were explained in the videos you have watched. You can click on each of these to see a short description or to watch the videos again'	Gas
Confusion about ongoing running costs	Change text to 'cost of annual bill'	Gas
Heating exercise – changing costs didn't make sense compared with information provided in videos	Remove all references to costs from videos – as with the other exercises costs should only be provided in exercise	Both
No information about payback time so difficult to know if worth the extra cost	Add info to video to identify payback time	Gas
District heating – Unsure if applicable to property therefore had to choose other package		Gas
	Any formatting changes made at exercise one to be applied here too	Elec
Needs explanation as to why being asked again	Provide an introduction in the text above exercise: we are now going to show you are similar table with different options for change to the service with different cost impacts. As before, please select which you prefer, Package A or Package B'.	Elec
Inclination to select DK as more difficult to make a comparison	Add colour coding as per previous exercise suggestion	Elec
Thought at first this exercise was pulled together based on previous answers – summary of responses so far	Explanation at top of exercise to explain why this is being asked again	Elec

Difficult to answer with so many choices	Colour shading for those with changes	Elec
Drag and drop exercise. Cause some confusion – people unsure what to do.	Remove question if not needed? If it is needed, better description. Make ‘drag and drop’ bold. Change names of choices to match those in the exercises	Both

Appendix H. Pilot Results

This appendix sets out our preliminary results of the pilot surveys for domestic gas and electricity consumers. Section H.1 summarises respondents' characteristics and their responses to cognitive understanding questions, while sections H.2 and H.3 show the willingness to pay (WTP) for each attribute in the gas and electricity surveys.

H.1. Respondent Characteristics and Qualitative Statistics

H.1.1. Summary statistics

In total, 125 respondents competed the gas survey, and 119 respondents completed the electricity survey.

Table H.1: Payment Type of Respondents

Payment type	Gas Survey		Electricity Survey	
	Nr	%	Nr	%
Jointly	55	34.38	57	34.34
Solely	96	60.00	101	60.84
Neither	9	5.63	8	4.82

Source: NERA Analysis

Table H.2: Gender of Respondents

	Gas Survey		Electricity Survey	
Gender	Nr	%	Nr	%
Male	85	52.80	75	45.18
Female	76	47.21	91	54.82

Source: NERA Analysis

Table H.3: Age Range of Respondents

	Gas Survey		Electricity Survey	
Age	Nr	%	Nr	%
18-24	3	1.86	4	2.41
25-34	42	26.09	31	18.67
35-44	39	24.22	42	25.30
45-54	35	21.74	36	21.69
55-64	34	21.12	46	27.71
65+	8	4.97	7	4.22

Source: NERA Analysis

Table H.4: Occupation of Respondents

	Gas Survey		Electricity Survey	
Age	**Nr**	**%**	**Nr**	**%**
Casual worker	2	1.25	1	0.60
Higher managerial	16	10.00	24	14.46
Housewife/homemaker	4	2.50	3	1.81
Intermediate managerial	35	21.88	36	21.69
Semi-unskilled manual	10	6.25	16	9.64
Skilled manual	21	13.13	24	14.46
Supervisory/clerical	59	36.88	54	32.53
Unemployed/sick	13	8.13	8	4.82

Source: NERA Analysis

Table H.5: Region of Respondents

	Gas Survey		Electricity Survey	
Age	**Nr**	**%**	**Nr**	**%**
East England	15	10.07	15	9.04
East-Midlands	7	4.70	9	5.42
London	20	13.42	15	9.04
North East	9	6.04	11	6.63
North Scotland	4	2.69	4	2.41
North West	10	6.71	20	12.05
South East	22	14.77	28	16.87
South Scotland	7	4.70	6	3.61
South West	15	10.07	14	8.43
Wales	7	4.70	5	3.01
West Midlands	21	14.09	12	7.23
Yorkshire	12	8.05	15	9.04

Source: NERA Analysis

H.1.2. Cognitive questions

After completing the WTP exercises, each survey asked respondents a series of questions about their understanding of the survey. The overwhelming majority of respondents reported that they were able to make comparisons between the choices presented to them, and that they understood the different service levels offered by the transmission companies.

Table H.6: Ability to Compare Choices of Respondents

	Gas Survey		Electricity Survey	
Comparison	**Nr**	**%**	**Nr**	**%**
Yes	123	98.40	115	96.64
No	2	1.60	4	3.36

Note: Respondents were asked "Did you feel able to make comparisons between the choices that were presented to you?
Source: NERA Analysis

Table H.7: Respondents' Understanding of Service Levels Offered

	Gas Survey		Electricity Survey	
Understanding	**Nr**	**%**	**Nr**	**%**
Yes	121	96.68	113	95.76
No	4	3.20	5	4.24

Note: Respondents were asked "Did you feel you understood the services offered by the transmission companies and the levels of service included in your choices?"
Source: NERA Analysis

Respondents were also asked whether they "believe that the more unlikely events, like losing your electricity supply for several days, could actually happen". In the electricity survey, approximately 20% respondents did not believe a transmission power cut would actually happen, whereas almost 95% of gas respondents did not believe a gas supply interruption would actually happen. In both electricity and gas surveys, the transmission supply attribute concerned low probability events, of 1.5% per year in the electricity survey (see Section H.3.1) and between 1 in 5,750 and 1 in 13,750 in the gas survey (see Section H.2.1). The larger proportion of gas consumers who did not believe such events could happen, likely reflects that a gas transmission interruption is many times less likely than an electricity transmission interruption.

Table H.8: Respondents Who Believe They Could "Actually" Losetheir Electricity/Gas Supply

	Gas Survey		Electricity Survey	
Believe	**Nr**	**%**	**Nr**	**%**
Yes	7	5.60	92	77.97
No	118	94.40	26	22.03

Source: NERA Analysis

H.2. Gas Survey WTP Results

H.2.1. First exercise

The first gas exercise was a "Choice Experiment" (CE) which asked respondents to choose between two packages comprising of the following four "quality of service" attributes and a bill level, each of which took the following service levels follows:

- Risk of supply interruptions;

  - Higher probability than today (1 in 5,750 households per year)
  - Same risk of Supply interruption probability (1 in 12,500 households per year)
  - Lower probability than today (1 in 13,750 households per year)
- Improving the environment around transmission sites;
  - 4 large sites
  - 7 large sites and 10 small sites
  - 15 large sites and 30 small sites
- Supporting local communities;
  - No community schemes
  - Maintain current level of community schemes
  - Maintain current level of community schemes and provide additional funding to charities and other organisations to support consumers
- Investing in innovation projects to create future benefits for consumers;
  - No innovation projects
  - Small scale innovation projects focused on making our operations more efficient
  - Large scale innovation projects focused on benefits for third parties and consumers
- Supporting consumers in fuel poverty;
  - No proactive support
  - Provide information, advice to achieve lower energy bills
  - Provide information, advice to achieve lower energy, funding for consumers in fuel poverty and / or low-cost financing for consumers to deploy energy measures in their homes to reduce energy usage.
- The change in gas bill;
  - £5 less on yearly bill
  - No change in yearly bill
  - £5 extra on yearly bill

We summarise our preliminary WTP estimates for this exercise in Table H.9.

Table H.9: First Gas Exercise Marginal WTP Estimates

Attributes	WTP (£)	Significant?
For a 1/10,000 reduction in the probability of a supply interruption.	8.08	Yes
Improving environment around transmission sites		
Additional 3 large sites and 10 small sites	4.61	No
Additional 11 large sites and 30 small sites	7.39	Yes
Supporting local communities		
Current level of community schemes compared to no support	6.29	No
Current level of community schemes and additional funding to charities and other organizations compared to no support	3.56	No
Investing in innovation projects		
Small scale projects compared to no innovation projects	3.78	No
Large scale projects compared to no innovation projects	11.90	Yes
Supporting consumers in fuel poverty		
Provide information to lower their energy bills compared to no information	0.01	No
Provide information to lower their energy bills and funding/financing compared to no support	2.97	No

Source: NERA Analysis.

For gas supply interruptions, our preliminary results suggest that respondents are willing to pay £8.08 for every 1/10,000 deduction in the probability of experiencing a supply interruption. For example, this suggests that consumers are willing to pay £1.56 for a reduction in probability of a supply interruption from 1/12,500 to 1/13,750.

They are also willing to pay £7.60 to improve the environment around an additional 11 large sites and 30 small sites compared to around 4 large sites (i.e. the difference between level 2 and level 1). They are also willing to pay £12.24 for large scale innovation projects compared to no innovation projects.

The preliminarily results are broadly intuitive and in line with our prior expectations. For each attribute, respondents are willing to pay more for higher levels of service.

However, “Supporting local communities” attributes are not statistically significant at the 95% level, which may suggest that consumers are not willing to pay for supporting local communities via their gas bill. “Supporting consumers in fuel poverty” attributes are also not significant, which may suggest that consumers are not willing to pay for consumers in fuel poverty.

Positive and statistically significant WTP estimates for reducing supply interruptions and maintaining the environment around transmission sites, but statistically insignificant WTP estimates for supporting fuel poor consumers and local communities, may suggest that consumers consider the “core activities” of the TO to be most important.

As a sensitivity of the results presented in Table H.9, we also tested for non-linearities in consumers’ valuation of gas supply interruptions, i.e. whether respondents are willing to pay more for a 1/10,000 reduction in the probability of a supply interruption at different starting levels. When assuming a non-linear relationship between the different service levels, we find consumers are willing to pay £5.16 (i.e. 10.00-4.84) for an improvement in WTP from level 2 to level 3, compared to £1.56 in the model presented in Table H.10. This suggests respondents place a greater value on reducing the risk of supply interruptions than they do on maintaining the current level of risk, or that in making their choices, they focus more on the direction of improvement than on the incremental change between service levels.

Table H.10: First Gas Exercise Marginal WTP Estimates – Non-linear Estimate of Supply Interruption Valuation

Attributes	WTP (£)	Significant?
Probability of gas supply interruptions		
Reducing probability from level 1 to level 2	4.84	Yes
Reducing probability from level 1 to level 3	10.00	Yes
Improving environment around transmission sites		
Additional 3 large sites and 10 small sites	4.65	No
Additional 11 large sites and 30 small sites	7.60	Yes
Supporting local communities		
Current level of community schemes compared to no support	6.13	No
Current level of community schemes and additional funding to charities and other organizations compared to no support	3.37	No
Investing in innovation projects		
Small scale projects compared to no innovation projects	3.74	No
Large scale projects compared to no innovation projects	12.24	Yes
Supporting consumers in fuel poverty		
Provide information to lower their energy bills compared to no information	0.33	No
Provide information to lower their energy bills and funding/financing compared to no support	3.21	No

Source: NERA Analysis.

H.2.2. Second exercise

The second gas exercise asks consumers to choose between two of the following five heating technologies:

Table H.11: Alternative Options in Second Gas Exercise

	Gas Boiler	Air Source Heat Pump	Ground Source Heat Pump	District Heating System	Hybrid Heating Pump
Running costs per year	£500	£700	£600	£850	£700
CO2 Emission	High	Low	Low	Medium	Medium
Disruption	None	Replace radiators	Alter radiators, Installation requires land and excavations	Minimal	Boiler retrofitted, pipework replaced with steel

Each option also included an "installation cost"; and we randomised installation costs for both technologies, so that upfront installation costs acts as the "payment vehicle", similar to our use of bill level in the first exercise above; calculating WTP by dividing the coefficient on each attribute by the coefficient on installation costs.

We summarise our preliminary WTP estimates for this exercise in Table H.12.

Table H.12: First Gas Exercise Marginal WTP Estimates

Attributes	WTP (£)	Significant?
Air Source Heat Pump instead of a Gas Boiler	-10,521.73	Yes
Ground Source Heat Pump instead of a Gas Boiler	-10,609.13	Yes
District Heating System instead of a Gas Boiler	-8,787.88	Yes
Hybrid Heat Pump instead of a Gas Boiler	-14,273.49	Yes

Source: NERA Analysis.

Our preliminary results suggest that households are willing to pay £10,521.73 to use a Gas Boiler over an Air Source Heat Pump. To put this another way, this suggests that households are only willing to switch to an Air Source Heat Pump instead of a Gas Boiler, if it is £10,521.73 less expensive to install.

They are also willing to pay £10,609,13 to use a gas boiler over a ground source heat, £ 8,787.88 to use a gas boiler over a district heating system, and £14,273.49 to use a gas boiler over a hybrid heat pump.

For each technology, WTP is negative (relative to a gas boiler), suggesting the average household would require compensation or subsidy in order to switch to alternative technologies. For instance, at current costs, an air source heat pump is around £6,000 more expensive than a gas boiler to install; therefore, the average household would require a total of £16,500 in compensation/subsidy to switch. A possible explanation is that households consider the level of disruption from switching technology to be greater than the benefits of lower carbon emissions and running costs.

H.3. Electricity Survey WTP Results

H.3.1. First exercise

The first electricity exercise was a "Choice Experiment" (CE) which asked respondents to choose between two packages comprising of the following four "quality of service" attributes and a bill level, each of which took the following service levels follows:

- Risk of Power Cuts;
  - Longer power cuts (1.5% chance of a 6 hour power cut each year)
  - Same duration of power cuts (1.5% chance of a 4 hour power cut each year)
  - Shorter power cuts (1.5% chance of a 2 hour power cut each year)
- Risk of Blackouts;
  - Same level as now (7 days to restore power to everyone)
  - Faster restoration of power (5 days to restore power to everyone)
- Undergrounding Overhead Transmission Lines;
  - No additional Undergrounding
  - Up to 20 miles of additional undergrounding in other areas (i.e. areas which are not National Parks, AONBs and NSAs)
  - Up to 20 miles of additional undergrounding in other areas (i.e. areas which are not National Parks, AONBs and NSAs)
- Improving visual amenity of Overhead Transmission Lines;
  - No additional visual impact works
  - Additional visual impact works in National Parks, AONBs and NSAs
  - Additional visual impact works in National Parks, AONBs and NSAs, as well as other rural and urban areas
- Improving environment around Transmission Sites;
  - No sites improved
  - 25 sites improved between 2021 and 2026
  - 45 sites improved between 2021 and 2026
- The change in electricity bill;
  - £10 less on yearly bill
  - No change in yearly bill
  - £10 extra on yearly bill

We summarise our preliminary WTP estimates for this exercise in Table H.13.

Table H.13: First Electricity Exercise Marginal WTP Estimates

Attributes	WTP	Significant?
Every 1 hour decrease in the hours of powercuts at a 1.5% probability	4.58	Yes
Every fewer day to recover from a blackout	2.87	Yes
Undergrounding Overhead Transmission Lines		
20 miles additional underground in National Parks	14.90	Yes
20 miles additional underground in other areas	11.64	Yes
Improving visual amenity of Overhead Transmission Lines		
Additional visual impact work in National Parks	6.00	No
Additional visual impact work in National Parks and other areas	7.26	Yes
Every additional transmission site environment improved	0.34	Yes

Source: NERA Analysis.

For risk of power cuts, our preliminary results suggest that households are willing to pay £4.58 for every 1-hour decrease in the hours of power cuts at a 1.5% probability. For example, this suggests that households value maintaining the duration of power cuts (1.5% chance of a 4-hour power cut each year) at £9.16, relative to longer power cuts (1.5% chance of a 6-hour power cut each year).

Households are willing to pay £2.87 for a one-day reduction in recovery time from a blackout. They are also willing to pay £14.90 for 20 miles of additional undergrounding of transmission lines in National Parks etc., but only £11.64 for 20 miles of additional undergrounding in other areas..

Our preliminary results also suggest that Consumers are willing to pay £7.26 for improving the visual amenity of overhead transmission lines in National Parks, rural, and urban areas, compared to no visual impact works. They are also willing to pay £0.34 for every additional transmission site environment improved compared to no sites improved.

In our preliminary model, “Additional visual impact work in National Parks” in “Improving visual amenity of Overhead Transmission Lines” attributes is not significant, which may suggest that Consumers are not willing to pay for Additional visual impact work in National Parks.

The results obtained are intuitive and in line with our expectations. Consumers are willing to pay more to reduce the number of hours of power cuts at a 1,5%. Also, consumers are willing to pay more for a reduction in days to recover from a blackout.

It is also intuitive that Consumers are willing to pay more for putting Overhead Transmission Lines underground compared to improving visual amenity of Overhead transmission lines, as Consumers prefer Overhead transmission lines to be not visible instead of less visible.

H.3.2. Second exercise

The second electricity exercise was also a CE, and was similar to the first electricity exercise, except that it consisted of a second set of attributes, as follows:

- Innovation projects;
  - Small scale innovation projects focused on improving the way we do things

- Medium scale innovation projects which aim to deliver benefit in up to 10 years but which come with a level of uncertainty and risk
  - Large scale, longer-term innovation projects which are more transformational and focus on creating benefit for the broader energy industry and/or wider community, but also carry a level of uncertainty and risk
- Supporting local communities;
  - No community activities
  - Maintain current level of community activities
  - Maintain current level of community activities and provide additional funding to charities and other organisations to support Consumers
- Investing to make sure the network is ready for electric vehicle charging;
  - Do not invest before there is a definite need
  - Invest before there is a definite need
- Investing to make sure the network is ready to connect renewable generation;
  - Do not invest before there is a definite need
  - Invest before there is a definite need
- The change in electricity bill;
  - £10 less on yearly bill
  - No change in yearly bill
  - £10 extra on yearly bill

We summarise the valuation results below in Table H.14.

Table H.14: Second Electricity Exercise Marginal WTP Estimates

Attributes	WTP	Significant?
Investing in innovation projects		
Medium Scale Projects	4.15	No
Large Scale Projects	0.77	No
Supporting local communities		
Current level of community activities	5.75	No
Current level of community activities and additional funding to charities	5.28	No
Investing in EV Charging Infrastructure		
Invest before definite need	9.77	Yes
Investing in infrastructure to connect to renewable generation		
Invest before definite need	9.58	Yes

Source: NERA Analysis

For investing in EV Charging Infrastructure, our preliminary results suggest that Consumers are willing to pay £9.77 for investing in EV charging infrastructure before there is a definite need, compared to no investments in EV charging infrastructure (i.e. the difference between level 2 and level 1).

Our preliminary results also suggest that respondents are willing to pay £9.58 for investing in infrastructure to make sure the network is able to connect to renewable generation, compared to no such investments.

In our preliminary model, "Investing in innovation projects" attributes are not significant, which may suggest that respondents are not willing to pay for investing in innovation projects and supporting local communities via their electricity bill. "Supporting local communities" attributes are also not significant, which may suggest that respondents are not willing to pay for supporting local communities.

The analysis also suggests that respondents are willing to pay more for investing in EV Charging Infrastructure before definite need compared to no investment. Also, respondents are willing to pay more for investing in infrastructure to connect to renewable generation before definite need instead of no investment. The results obtained are intuitive and in line with our expectations because consumers may care about the future environment and therefore willing to invest.

The result of the insignificant "Supporting local communities" attributed is also in line with intuition. Local communities are not related to the consumer's gas quality and bills, therefore respondents may not value this attribute enough to be willing to pay for supporting local communities.

H.3.3. Third exercise

The third electricity exercise asks respondents to choose between investment packages of the first and the second electricity exercise together, comprising of the following nine attributes:

- First exercise attributes include risk of power cuts, recovery from blackouts, undergrounding overhead transmission lines, improving the visual amenity of overhead transmission lines, and improving the environment around transmission sites.
- Second electricity exercise attributes include investing in innovation projects, supporting local communities, investing in EV charging infrastructure, and investing in infrastructure to ensure the network is ready to connect to renewable generation.
- The change in electricity bill;
  - £10 less on yearly bill
  - No change in yearly bill
  - £10 extra on yearly bill

Whereas we used a CE design to randomise service levels in the previous two exercises, we used a CV (Contingent Valuation) design in this exercise, constraining the groups of attributes from the previous two exercises to move together from one package to another.

Therefore, rather than estimating WTP for individual attributes, our model estimates WTP for each group of attributes together. We summarise our preliminary WTP estimates for this exercise in Table H.15.

Table H.15: Third Electricity Exercise Marginal WTP Estimates

Attributes	WTP (£)	Significant?
Second Exercise Attributes		
Moving from Level 1 to Level 2	23.13	Yes
Moving from Level 1 to Level 3	52.18	Yes
First Exercise Attributes		
Moving from Level 1 to Level 2	31.38	Yes
Moving from Level 1 to Level 3	28.58	Yes

Source: NERA Analysis

Our preliminary results suggest that respondents are willing to pay £23.13 for increasing the level of service of all attributes in the first electricity exercise from level 1 to 2 (i.e. level 2 of power cuts, blackouts, undergrounding, improving visual amenity and improving environment around transmission sites instead of level 1). Also, respondents are willing to pay £52.18 for increasing the level of service of all attributes in the first electricity exercise from level 1 to 3.

Respondents are willing to pay £31.38 for increasing the level of service of all attributes in the second electricity exercise from level 1 to 2 (i.e. level 2 of investing in innovation projects, supporting local communities, investing in EV charging, investing in infrastructure for connecting to renewable generation instead of level 1). Also, respondents are willing to pay £28.58 for increasing the level of service of all attributes in the first electricity exercise from level 1 to 3.

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