

BETA DECOMPOSITION

Report for National Grid and SSE

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EXECUTIVE SUMMARY

Frontier Economics has been commissioned by National Grid (NG) and Scottish Southern Electricity (SSE) to carry out an independent study into the decomposition of asset betas in order to identify a robust estimate for the asset beta of pure-play regulated energy networks in Great Britain (GB).

Currently, when estimating the GB regulated energy network asset beta, Ofgem takes a simple average of the asset betas of the only five listed GB utility companies available, each of which has a material GB regulated network activity as part of its business footprint – NG, Pennon Group, SSE, Severn Trent and United Utilities. This approach is in line with the regulatory precedent from the CMA when it assessed the asset beta for Northern Ireland Electricity (NIE) in its redetermination of the RP5 price control in 2014.

However, within this sample of five utility companies, Ofgem has noted that SSE has significant non-regulated business activities in retail and generation and we understand has questioned whether as a result a simple average of the five would over-estimate the true beta for the GB regulated energy networks.

Ofgem has also stated that it is open to alternative ways to average across the beta sample, and has considered exploring decomposition in the past. However it has posited that decomposing NG and SSE would have effects that would offset each other, without providing evidence for this so far.

In this study, we take a detailed and systematic approach towards asset beta decomposition, with the aim to separate out an element that reflects the pure-play regulated GB energy network activities, in order to answer the question whether or not Ofgem's simple average approach is likely to over- or under-estimate the beta.

We provide two alternative methods in this report:

- a direct decomposition of the betas of SSE and NG, using relevant non-GB-regulated comparators to isolate the GB regulated energy network asset beta; and
- a comprehensive full-information beta estimation to simultaneously estimate the pure-play betas for regulated GB energy networks, regulated US energy networks and non-regulated energy utilities, using a larger sample and a wider set of comparators containing both regulated networks in the US and non-regulated energy utilities in the GB and Europe.

Our direct decomposition analysis suggests that the simple average of the five approach adopted by Ofgem hitherto may be underestimating the pure play GB regulated energy network beta. If Ofgem were to derive its estimate only based on the direct decomposition results of the pure-play energy networks, then this would lead to a higher range and point estimate of the pure-play regulated energy beta than Ofgem has previously signalled it intends to determine. This means that should Ofgem consider removing SSE from the sample, this would very likely lead to a material under-estimation of the beta of pure play GB regulated energy networks.

Furthermore, our direct decomposition demonstrates that water companies tend to have asset betas that are markedly lower than those of energy networks on average. This evidence therefore calls into question whether it is appropriate to estimate betas using a method that places significant weight on three water companies.

Our full-information estimation, which we consider to be a more comprehensive technique than the direct decomposition technique, also indicates that a simple average across the five GB utilities, as currently adopted by Ofgem, is producing results which are well below the estimated pure-play GB/European regulated energy network beta. The implications are that any upward bias in the simple average approach arising from the inclusion of SSE's unregulated activities is more than offset by the effect of including NG's regulated US networks and GB water companies, and that Ofgem's approach seems likely to result in an estimate of beta for energy networks that is too low.

The techniques we have deployed here are recognised in the academic literature as reasonable and can be made operational relatively straightforwardly. Our work could be externally validated and further refinements considered.

We recommend that Ofgem should carefully consider adopting beta decomposition techniques such as the ones we have demonstrated here, and use them in its determination for RIIO-T2. This would likely shift the range of betas from which Ofgem would need to determine a point estimate, and in turn avoid any bias that is being caused by the current simple average approach over five peer companies.

1 INTRODUCTION

Frontier Economics has been commissioned by National Grid (NG) and Scottish Southern Electricity (SSE) to carry out an independent study into the decomposition of asset betas in order to identify a robust estimate for the asset beta of pure-play regulated energy networks in Great Britain (GB).

1.1 Background

Currently, when estimating the GB regulated energy network asset beta, Ofgem takes a simple average of the asset betas of the only five listed GB utility companies available, each of which has a material GB regulated network activity as part of its business footprint – NG, Pennon Group, SSE, Severn Trent and United Utilities. This approach is in line with the regulatory precedent from the CMA when it assessed the asset beta for Northern Ireland Electricity (NIE) in its redetermination of the RP5 price control in 2014.

However, within this sample of five utility companies, Ofgem has noted that SSE has significant non-regulated business activities in retail and generation and we understand has questioned whether as a result a simple average of the five would over-estimate the true beta for the GB regulated energy networks.

Ofgem has also stated that it is open to alternative ways to average across the beta sample, and has considered exploring decomposition in the past. However it has posited that decomposing NG and SSE would have effects that would offset each other, without providing evidence for this so far.

While we agree with the observation that SSE's beta may be higher than that of a pure-play regulated GB energy network, it is not clear that including SSE in a simple average would necessarily lead to an over-estimate of the underlying pure play GB energy regulated network beta as Ofgem posits, due to the existence of countervailing factors from some of the other companies in the sample. In particular, NG's beta may be lower than the pure play GB regulated energy network beta due to its ownership of regulated networks in the US, which operate in a different regime and which as our analysis shows may have a lower beta. In addition, we also note the presence of the three water companies in the sample, and consider it prudent to assess the extent to which GB water companies have lower betas than pure play GB energy networks.

Owing to these factors, a comprehensive study is needed to assess whether Ofgem's simple average is likely to result in an over-estimation of the pure play energy network beta. This study therefore attempts to close this gap by exploring various techniques to decompose betas of companies with activities beyond pure play GB regulated energy networks, in order to distil from a larger sample of comparators an unbiased pure-play beta for regulated energy networks in GB.

More specifically, our study explores two alternative methodologies:

- a direct decomposition of the betas of SSE and NG, using relevant non-GB-regulated comparators to isolate the GB regulated energy network asset beta; and

- a comprehensive full-information beta estimation to simultaneously estimate the pure-play betas for regulated GB energy networks, regulated US energy networks and non-regulated energy utilities, using a larger sample and a wider set of comparators containing both regulated networks in the US and non-regulated energy utilities in the GB and Europe.

For each of these methodological approaches, we have followed the recommended approach from Indepen when estimating the underlying betas, by focusing primarily on OLS estimations using daily returns, within the relevant window of 5-, and 10-year periods.¹ We note that Indepen investigated a range of different estimation windows and frequencies, together with the use of GARCH statistical models, but ultimately found that these additional variants did not produce further insights.

The remainder of this report is structured as follows:

- Section 2 outlines our methodology;
- Section 3 discusses our results from the direct beta decomposition;
- Section 4 explains our results from the full information beta estimation; and
- Section 5 concludes.

¹ Indepen also looked into a window that contained 2000-2018, but concluded that it had limited value given it includes major events of the Global Financial Crisis and the associated structural break. See page 46 of the Indepen study – Beta Study – RIIO-2 Main Report.

2 METHODOLOGY

In this section we provide an introduction to the two decomposition methodologies that we have relied on.

2.1 Overview of approach

Within GB there are no listed pure play regulated energy networks. Regulators including Ofgem have commonly relied on the only five peers that it is agreed are most useful in estimating betas for energy network price controls, namely:

- **National Grid**, which owns regulated energy networks in GB and the US;
- **SSE**, which owns regulated energy networks in GB in addition to a large wholesale and retail energy business; and
- three regulated water companies, **Pennon Group, Severn Trent and United Utilities**.

It is acknowledged by all that the activity profiles of each of these businesses do not match perfectly that of a pure play GB regulated energy network. The question that this paper explores is whether it is possible to gain further insights into the pure play GB regulated energy network beta by undertaking decomposition analysis. We have explored two techniques.

- Direct beta decomposition; and
- Full information beta decomposition.

We explain each briefly below. We also describe in detail the wider sample of firms that we have used to implement these methods, the raw data that we have gathered and how this data has been processed in constructing our betas, in order to provide a high level of transparency around our approach.

2.2 Direct beta decomposition

Under this approach to beta decomposition, we presume that the overall observed beta for a stock at any point in time is simply:

- the weighted average of the betas of each of the underlying business activities undertaken by the stock; where
- the weights used are derived from operating income segmentation data from Bloomberg.

We can then estimate betas for all but one of the underlying business activities of the stock where peers exist, and use this simple relationship to impute the beta for any single activity where direct peers for that particular activity may not exist.

We apply this method to each of NG and SSE, in order to estimate directly the beta of NG's US network businesses and of the retail and wholesale activities of NG and SSE, such that these can be stripped out from the headline betas leaving behind an estimate of the pure play GB regulated energy network beta.

The formulae used in the process are set out in Annexes C.3 and C.4.

2.3 Full information beta decomposition

Full information beta decomposition is a well-established technique in modern corporate finance theory, where pure-play betas of different activities can be estimated from a large sample of stocks each of which may contain various proportions of the underlying activities. This technique, developed by Pratt and Grabowski (2014)², can be applied even if none of the betas in the sample are themselves pure-play betas, as long as each activity is reasonably represented (i.e. undertaken by) by a number of companies in the wider sample.

As with the direct beta decomposition approach, the objective of using the full-information beta estimation technique is to estimate a pure-play GB regulated energy network asset beta.

Full information beta estimation is a multi-beta regression which involves regressing each company's asset beta on their segmentation percentages³. The estimated coefficient on each segment will provide an estimate of the asset beta of a hypothetical pure-play company in that segment, e.g. GB regulated energy networks. The principle is therefore highly similar to the direct decomposition approach described above, but this approach adopts a regression based method to estimate the pure play betas for each activity simultaneously, based on all information in the sample.

The formulae used in the process are set out in C.5.

As before, we use operating income as our main measure to segment each company. However, as we describe below, we have explored the effect of using different segmentation metrics.

2.4 Comparator sample

To estimate the pure-play GB regulated energy network beta, both by direct decomposition of SSE and NG's betas and by full-information estimation, we need a sample of comparators that expands beyond the five GB utilities used by Ofgem.

More specifically, we need US regulated companies (in order to explore the potential effect of NG's ownership of US energy network on its beta) and companies with non-regulated energy utility businesses (in order to explore the potential effect of SSE's ownership of wholesale and retail activities on its beta).

As we set out below, we have also sought to explore the potential effect of including/excluding the three listed water companies on estimated betas. However, since excluding the three water companies would leave very little "pure play GB network" information in the sample, we supplement the sample with a number of comparators from mainland Europe. This includes European utilities with both regulated networks and unregulated activities, in addition to pure play networks. These pure-play European regulated networks also help us build a more robust sample size on the regulated energy business across GB and mainland

² Pratt, S. P., & Grabowski, R. J. (2014). Ch 11A. Examples of Computing OLS Beta, Sum Beta, and Full-Information Beta Estimates. In "Cost of Capital: Applications and Examples" (pp. 225-233). Wiley.

³ The full regression equation is in Annex C.

Europe, which is particularly helpful when water companies are separated from the GB sample.

Our GB sample then consists of Centrica, NG, Pennon Group, SSE, Severn Trent and United Utilities. Centrica is an unregulated utility company and the other five have mostly regulated activity described above.

For the European comparators, we have identified a set of companies by drawing on the peers typically used by various European regulators to estimate energy network betas in their recent regulatory decisions. The comparators in our sample are used by German, Irish, Dutch, Swiss and French regulatory decisions.

For our US sample, we have identified seven pure-play regulated utilities⁴, and a further four utilities that have a mixture of activities. These companies are either regulated US utilities, or utilities in a similar geographic location to NG's US operations (the North-East).

A full list of all of the stocks included in this analysis can be found in Figure 1 below and in Annex B.

2.5 Estimation methodology

To estimate raw equity betas, we use the variable called Total Return Index Gross Dividends from Bloomberg, for the stocks and market indices. For the latter, we use the FTSE all-share index in the UK, and the equivalent index for each of the countries in our sample⁵.

This data was collected from Bloomberg on a daily basis over a 10-year time period. The stock returns were regressed against the index returns to calculate the equity betas⁶.

Due to the inherent uncertainty involved in beta estimation it is usual to estimate betas using a range of estimation windows and frequencies. Indepen have carried out research in their report for Ofgem ("*Beta Study – RIIO-2*" of December 2018) that shows that when estimating asset betas on a weekly or monthly basis, results will depend heavily on the reference day used. They used 5-year, 10-year and 15-year windows but found 15-year problematic as it incorporates a structural break from the period before the Global Financial Crisis. Indepen concluded that daily estimates for 5-year and 10-year windows are the most appropriate specifications to use. We observe that there are pros and cons with using different lengths of estimation windows, but for the purpose this beta decomposition study we have followed Indepen's approach and report 5-year and 10-year daily results.

Equity betas are converted into asset betas⁷ using the Harris-Pringle formula commonly adopted by GB regulators, using the market gearing⁸ of comparator

⁴ By pure-play regulated utilities, we have included comparators with more than 90% of activities regulated in the US.

⁵ These are: ASX Index (GB), ATX Index (Austria), BET Index (Romania), CDAX Index (Germany), FTSEMIB Index (Italy), IBEX Index (Spain), PAX Index (Spain), PSI20 Index (Portugal), and S&P500 (US).

⁶ Technically, we have regressed the "excess return" of the stocks rather than the total return of the stocks against the return of the index. See further technical details in Annex C.

⁷ The equation for this is in Annex C.

⁸ Market gearing level is calculated using net debt and market capitalisation information collected from Bloomberg.

benchmark companies and an assumed debt beta of 0.1. We have tested the robustness of our analysis with a debt beta of 0.05, and the results lead to similar findings (see Annex A for more detail).

The table below shows the asset beta results for all the utilities in our sample using a 5-year daily specification. The table includes the asset betas for regulated utilities, split into four categories: GB, US, European and water. The table shows the average. A full comparison of the estimated asset betas for each utility in each specification is in Annex A.

Figure 1 Illustrative asset betas for each stock included in our analysis – daily betas over a 5-year period

GB Regulated		US Regulated		European Regulated		Water Utilities		Unregulated	
NG	0.40	Center-Point Energy	0.40	Enagas	0.37	Iren	0.31	A2A	0.42
Pennon Group	0.40	Consolidated Edison	0.19	Endesa	0.47	Pennon Group	0.40	Centrica	0.67
Severn Trent	0.37	Dominion	0.25	Enel	0.47	Severn Trent	0.37	EDP	0.42
SSE	0.55	DGBe Energy	0.20	Hera	0.30	United Utilities	0.36	EVN	0.22
United Utilities	0.36	Ever-source Energy	0.25	REN	0.27			E.ON	0.70
		NextEra	0.28	Snam	0.31			Gas Natural	0.46
		Public Service	0.33	Trans-electrica	0.73			GDF Suez	0.64
		TC Pipeline	0.55					Iren	0.31
								RWE	0.58
								UGI Corp.	0.41
Avg.	0.42		0.31		0.42		0.36		0.48

Source: Bloomberg data, Frontier Economics analysis

Note: categories are defined as more than 50% operating income, e.g. "GB regulated" contain companies containing more than 50% operating income in GB regulated businesses.

3 DIRECT BETA DECOMPOSITION

In this section we report the outcome of undertaking a direct beta decomposition analysis for both NG and SSE.

With our larger sample, it is possible to investigate NG and SSE's estimated asset betas with regard to how much they may be affected by non-GB-regulated activities. More specifically, we can directly decompose NG's beta into pure-play GB regulated energy networks and pure-play US regulated energy networks, by using other US regulated networks in our sample to capture that. Similarly, we use other non-regulated energy companies in our sample to capture the non-regulated activities in the SSE asset beta.

3.1 Estimating pure play US network and GB unregulated betas

To decompose NG's overall beta into separate betas for its GB and US operations, we use a number of regulated US energy network companies to estimate a US regulated asset beta. The sample of pure-play regulated⁹ US regulated energy network stocks used to estimate the US regulated energy network asset beta is shown in the table below:

Figure 2 US regulated energy network asset betas

Time Period	5-year	10-year
CenterPoint Energy	0.40	0.41
Consolidated Edison	0.19	0.26
DGBe Energy	0.20	0.26
Eversource Energy	0.25	0.35
NextEra	0.28	0.34
TC Pipeline	0.55	0.42
Average	0.31	0.34

Source: Bloomberg data, Frontier Economics analysis

The proportion of NG's operations that are allocated to the US is determined using the operating income segmentation data from Bloomberg, both for the 5-year and 10-year specifications.

To decompose SSE's beta into separate betas for its GB regulated and unregulated operations, Centrica is used as an unregulated comparator. While the sample size is therefore small, we explore the effect of a larger sample using European utility companies in our more comprehensive full-information beta estimation below. The proportion of SSE's operations that were allocated to the unregulated business was determined using the operating income segmentation data from Bloomberg for all time periods.

⁹ Defined as companies with more than 90% US regulated operations, as determined by operating income segmentation.

By assuming that the observed NG and SSE betas are the weighted average of the GB regulated energy network betas and respectively US regulated network (in the case of NG) or GB non-regulated (in the case SSE) betas, we can then solve to derive an estimate of the GB regulated energy network beta¹⁰.

Finally, we replace the original observed NG and SSE betas by the above decomposed GB regulated energy network betas in the average over the five GB utility companies. This is then compared to Ofgem's simple average of the five GB listed utility companies.

3.2 Decomposition results

We present in Figure 3 below the estimated NG and SSE betas for each of the four specifications we have considered, along with the average of the betas we used to strip out the non-GB-regulated energy network components, the weightings, and the resulting estimates of the underlying GB pure play energy network beta.

Figure 3 NG and SSE direct beta decomposition results

	5-year	10-year
NG beta	0.40	0.33
Average US beta	0.31	0.34
% US	40%	38%
Average unregulated beta	0.67	0.58
% unregulated	7%	5%
GB regulated energy network beta based on NG	0.43	0.30
SSE beta	0.55	0.46
Average unregulated beta	0.67	0.58
% unregulated	29%	17%
GB regulated energy network beta based on SSE	0.50	0.44

Source: Bloomberg data, Frontier Economics analysis

In three of our four decomposed pure-play GB regulated network betas, we find that our estimate of the underlying pure play GB regulated energy network beta is above the upper bound as estimated by Ofgem's method (0.42), using its simple average approach using the 5- and 10-year window.

3.3 Comparison with Ofgem's simple average

We can consider how this evidence compares with Ofgem's simple average. The results are shown in Figure 4 below.

¹⁰ The equations for this are in Annex C.

Figure 4 Comparison of modified GB regulated energy network asset beta with other relevant benchmarks

	5-year	10-year
Ofgem's method - simple average of five GB betas	0.42	0.35
Average of only the pure-play energy network betas derived from our NG and SSE direct decomposition	0.47	0.37
Average of the three water companies	0.38	0.33

Source: Bloomberg data, Frontier Economics analysis

This analysis suggests that the simple average of the five approach adopted by Ofgem hitherto may be underestimating the pure play GB regulated energy network beta. If Ofgem were to derive its estimate only based on the direct decomposition results of the pure-play energy networks, then this would lead to a higher range and point estimate of the pure-play regulated energy beta than Ofgem has previously signalled it intends to determine. We do however note that to do so would result in a method which draws evidence from only two companies, which is a relatively sparse data set.

Nevertheless, we consider that this analysis therefore, at the very least, supports the continued inclusion of SSE in Ofgem's current sample. Should Ofgem consider removing SSE from the sample, this would very likely lead to a material under-estimation of the beta of pure play GB regulated energy networks.

Furthermore, this direct decomposition demonstrates that water companies tend to have asset betas that are markedly lower than those of energy networks on average. This evidence therefore calls into question whether it is appropriate to estimate betas using a method that places significant weight on three water companies.

4 FULL INFORMATION BETA ESTIMATION

Above we found evidence to suggest that the inclusion of three water companies may be leading to a downward bias in Ofgem's estimation of the pure play GB regulated energy network. Below we set out the results of applying the more sophisticated full information approach to estimating betas.

4.1 Approach

As we did for our direct decomposition analysis, we aim to estimate betas for a range of segments, including the GB regulated energy networks segment, the US regulated energy networks segment and unregulated activities. By using this approach we are able to explore the effect of excluding GB water companies from our full sample to examine whether the water companies indeed have a downward bias effect on the GB regulated energy network beta.

However, as already discussed there are only two companies with regulated GB energy companies businesses in the sample (i.e. NG and SSE), and in our view relying on such a small number of observations would limit robustness. We address this problem by including additional stocks from mainland Europe to provide more observations. GB and mainland European segments are combined into one independent variable, such that the coefficient would provide an estimate for the beta of a hypothetical pure-play energy network that was regulated in either GB or Europe.

We note that this now provides a different risk of misestimation. While we are able to estimate a beta without the potential downward bias arising from the inclusion of water companies, we now have to consider the possibility that European networks do not have the same risk profile as the GB networks. This risk is noted, and we recognise that we have not undertaken a full appraisal of the relative risk of the business profiles of GB and European networks. However, we are not aware of evidence to suggest that European regimes expose networks to greater systematic risk than the GB networks, e.g. since most European energy network regimes typically have fewer and weaker financial incentives in place. In any event, this is no less credible an assumption than the assumption that UK water companies and UK energy companies are exposed to the same risks. While further research might be helpful to explore this relative risk question more fully, we do not consider that there is prima facie evidence to suggest that the pooling of GB and European networks in one segment invalidates our findings.

In order to understand the effect of the three GB water companies on our findings, and the sensitivity of the analysis to their inclusion/exclusion, we also run a sensitivity analysis that includes the three water companies in the "GB/European regulated energy network" segment.

As above, our preferred segmentation method uses the proportion of operating income in each segment, as we consider this the most representative measure of a company's capital valuation.¹¹ We note that Bloomberg does not provide a

¹¹ We note the potential consideration that different risk levels from different segments may call for risk-adjusted valuation using operating income as proportions. However, as this effect is only second order in

geographical split of operating income for five of the stocks in our sample; therefore as a sensitivity test we also used a total asset segmentation (See Annex A)¹². These sensitivities produce less robust results than our main analysis, and we do not present them here in the main report. Nevertheless, those results do not invalidate any of our conclusions drawn from the main analysis.

4.2 Results

As with our direct decomposition analysis, we run two specifications to align with the recommendations of Indepen in their “*Beta Study – RIIO-2*” report. These are shown in Figure 5 below. The results use operating income segmentation.

Figure 5 Full information beta estimation results when water companies are excluded – segmented by operating income

Time period	5-year	10-year
GB/European regulated energy networks	0.45	0.39
US regulated energy networks	0.30	0.33
Non-regulated energy utilities	0.50	0.53
Ofgem’s simple average	0.42	0.35

Source: Bloomberg data, Frontier Economics analysis

As expected, the US regulated energy networks is the segment with the lowest beta across both specifications, and the non-regulated energy segment has the highest betas. The beta for the GB/European regulated energy networks segment sits between these values. These findings are intuitive, but the quantum is nonetheless informative.

We can compare the results of this full information decomposition with Ofgem’s simple average approach. We find that Ofgem’s simple average approach underestimates the GB/European regulated energy network beta in both the 5- and 10-year specifications¹³.

We also note that the results of our full information decomposition (0.45 and 0.39 for 5-year and 10-year daily respectively) are broadly similar to the average of those we found in our direct decomposition analysis (0.48 and 0.39 for 5-year and 10-year daily respectively).

The full-information estimation, which we consider to be a more comprehensive technique than the direct decomposition technique, therefore also indicates that a simple average across the five GB utilities, as currently adopted by Ofgem, is producing results which are well below the estimated pure-play GB/European regulated energy network beta. The implications are that any upward bias in the simple average approach arising from the inclusion of SSE’s unregulated activities

this analysis, we have chosen to use the unadjusted operating income proportions in order to avoid circularity in the analysis.

¹² We would have used capital employed as a secondary segmentation measure, but the data was not available for the majority of utilities in our sample. Furthermore, sales turnover is also known in the literature as a measure for segmentation, but due to the fact that capital intensity and cost structure can differ significantly between regulated and unregulated segments in our peer companies, we consider sales turnover to be a less reliable measure.

¹³ Full results, including all coefficient estimates for both segmentation approaches and debt beta specifications, are in Annex A.

is more than offset by the effect of including NG's regulated US networks and GB water companies, and that Ofgem's approach seems likely to result in an estimate of beta for energy networks that is too low. We have carried out a sensitivity analysis that includes the three GB water companies into the sample when decomposing asset betas. The resulting beta estimates for the pure-play GB/European regulated energy networks continue to be greater than the simple average of the five GB utilities as proposed by Ofgem for both periods. The full results can be seen in Figure 10 of Annex A.

5 CONCLUSIONS

We have undertaken two separate but related beta analyses neither of which have hitherto been explored by Ofgem or its consultants. Both the direct beta decomposition and full information beta estimates we have derived produce estimates of the underlying beta for pure play GB regulated energy networks markedly above the levels currently being considered by Ofgem, which are derived from its simple average of five approach.

We draw a number of conclusions from this approach.

- There is little evidence to suggest that the simple average of five approach Ofgem has relied on so far may lead to an overestimation of the relevant beta for pure play GB regulated energy networks.
 - While it is noted that SSE's beta will be increased by its unregulated business activities, this analysis reveals that this effect is more than offset by the effective inclusion of relatively lower risk US regulated activities and GB water companies.
 - Excluding SSE from the simple average of five and relying on a simple average of four would therefore lead to an estimate of beta for GB energy networks that was markedly too low.
- On the contrary, both our direct decomposition and full information decomposition suggest that estimates derived from the simple average of five are likely to be too low.
 - We do note that the direct decomposition analysis is derived from analysis of just two companies, NG and SSE. While it would be better to have access to more data, we observe that these are the only two listed companies with GB regulated energy network activities and therefore consider it important to make the most of this evidence.
 - We observe that in respect of our full information decomposition, there is a question around the relative risk of GB energy networks and European energy networks which are included in the sample to make the regression result more robust.
 - We exclude the three GB water companies from our sample in our main analysis, but our sensitivity analysis show that including the water companies does not alter the result in a qualitative way.
 - No doubt more work could be undertaken on these topics, but we still consider the results we present here to be a relevant and important contribution to the debate on betas.

The techniques we have deployed here are recognised in the academic literature as reasonable and can be made operational relatively straightforwardly. Our work could be externally validated and further refinements considered.

We recommend that Ofgem should carefully consider adopting beta decomposition techniques such as the ones we have demonstrated here, and use them in its determination for RIIO-T2. This would likely shift the range of betas from which

Ofgem would need to determine a point estimate, and in turn avoid any bias that is being caused by the current simply average approach over five peer companies.

ANNEX A FULL LIST OF RESULTS

Figure 6 Asset beta comparison – daily betas over a 5-year period

GB Regulated ¹⁴		US Regulated ¹⁵		European Regulated ¹⁶		Water Utilities ¹⁷		Unregulated ¹⁸	
NG	0.40	Center-Point Energy	0.40	Enagas	0.37	Iren	0.31	A2A	0.42
Pennon Group	0.40	Consolidated Edison	0.19	Endesa	0.47	Pennon Group	0.40	Centrica	0.67
Severn Trent	0.37	Dominion	0.25	Enel	0.47	Severn Trent	0.37	EDP	0.42
SSE	0.55	DGBE Energy	0.20	Hera	0.30	United Utilities	0.36	EVN	0.22
United Utilities	0.36	Ever-source Energy	0.25	REN	0.27			E.ON	0.70
		NextEra	0.28	Snam	0.31			Gas Natural	0.46
		Public Service	0.33	Trans-electrica	0.73			GDF Suez	0.64
		TC Pipeline	0.55					Iren	0.31
								RWE	0.58
								UGI Corp.	0.41
Avg.	0.42		0.31		0.42		0.36		0.48

Source: Bloomberg data, Frontier Economics analysis

¹⁴ Defined as companies with more than 50% regulated operations, as determined by operating income segmentation, in the 5-year daily specification.

¹⁵ Defined as companies with more than 50% regulated operations, as determined by operating income segmentation, in the 5-year daily specification.

¹⁶ Defined as companies with more than 50% regulated operations, as determined by operating income segmentation, in the 5-year daily specification.

¹⁷ Defined as companies with more than 50% water operations, as determined by operating income segmentation, in the 5-year daily specification.

¹⁸ Defined as companies with more than 50% regulated operations, as determined by operating income segmentation, in the 5-year daily specification.

Figure 7 Asset beta comparison – daily betas over a 10-year period

GB Regulated ¹⁹		US Regulated ²⁰		European Regulated ²¹		Water Utilities ²²		Unregulated ²³	
NG	0.33	Center-Point Energy	0.41	Enagas	0.37	Iren	0.30	A2A	0.39
Pennon Group	0.35	Consolidated Edison	0.26	Endesa	0.54	Pennon Group	0.35	Centrica	0.58
Severn Trent	0.32	Dominion	0.33	Enel	0.43	Severn Trent	0.32	EDP	0.38
SSE	0.46	DGBE Energy	0.26	Hera	0.28	United Utilities	0.30	EVN	0.27
United Utilities	0.30	Ever-source Energy	0.35	REN	0.23			E.ON	0.67
		NextEra	0.34	Snam	0.30			Gas Natural	0.44
		Public Service	0.42	Trans-electrica	0.66			GDF Suez	0.64
		TC Pipeline	0.42					Iren	0.30
								RWE	0.58
								UGI Corp.	0.46
Avg.	0.35		0.35		0.40		0.32		0.47

Source: Bloomberg data, Frontier Economics analysis

¹⁹ Defined as companies with more than 50% regulated operations, as determined by operating income segmentation, in the 5-year daily specification.

²⁰ Defined as companies with more than 50% regulated operations, as determined by operating income segmentation, in the 5-year daily specification.

²¹ Defined as companies with more than 50% regulated operations, as determined by operating income segmentation, in the 5-year daily specification.

²² Defined as companies with more than 50% water operations, as determined by operating income segmentation, in the 5-year daily specification.

²³ Defined as companies with more than 50% regulated operations, as determined by operating income segmentation, in the 5-year daily specification.

Figure 8 Full beta estimation results – comparison of operating income segmentation and total assets segmentation – debt beta of 0.1 and water companies excluded

Segmentation	Operating income		Total assets	
	5-year	10-year	5-year	10-year
GB + European	0.45	0.39	0.56	0.46
US	0.30	0.33	0.30	0.34
Unregulated	0.50	0.53	0.37	0.43

Source: Bloomberg data, Frontier Economics analysis

Figure 9 Full beta estimation results – comparison of debt betas (0.1 v 0.05) – operating income segmentation and water companies excluded

Debt beta	0.1		0.05	
	5-year	10-year	5-year	10-year
GB + European	0.45	0.39	0.43	0.36
US	0.30	0.33	0.28	0.31
Unregulated	0.50	0.53	0.48	0.51
Ofgem's simple average	0.42	0.35	0.40	0.33

Source: Bloomberg data, Frontier Economics analysis

Figure 10 Full information beta estimation results when water companies included – segmented by operating income

Time period	5-year	10-year
GB/European regulated energy networks + GB water companies	0.43	0.37
US regulated energy networks	0.30	0.33
Non-regulated energy utilities	0.48	0.51
Ofgem's simple average	0.42	0.35

Source: Bloomberg data, Frontier Economics analysis

ANNEX B SAMPLE DETAILS

Figure 11 GB Utility Sample

Location	Company	Description of activities
United Kingdom	Centrica	Large GB electricity and gas generator with growing US presence.
	NG	Primarily GB gas transmission and distribution, with electricity transmission networks in GB and USA.
	Pennon Group	Provides regulated water and waste water services to England's South West. Also operates Viridor - a waste management business.
	SSE	Regulated electricity T&D in GB along with unregulated generation and retail.
	Severn Trent	Offers water and waste services in GB.
	United Utilities	Regulated water, wastewater and electricity distribution in GB .

Source: Bloomberg data, Frontier Economics analysis

Figure 12 European Utility Sample (part 1)

Location	Company	Description of activities
Austria	EVN	Electricity generator (mainly) and transmitter/distributor, used by the Swiss regulator.
France	EDF ²⁴	Electricity generator and distributor, used by the Irish regulator.
	GDF Suez	Electricity generator (mainly) and distributor, and gas distributor, used by the Irish regulator.
	Veolia ²⁵	Utility company working in water, waste and energy, used by the Irish regulator.
Germany	E.ON	International electricity utility company, mainly generation, used by the Irish regulator.
	RWE	Gas and renewables utility company, mainly generation, used by the Irish regulator.
Italy	A2A	Producer and distributor of energy born out of the merger of AEM and ASM Brescia, used by the Irish regulator.
	Enel	Electricity generator (mainly) and distributor and gas distributor, used by the Irish regulator.
	Hera	Gas, electricity, water and waste distributor, used by the Irish regulator.
	Iren	Electricity producer and distributor, used by the Swiss regulator.
	Snam	Natural gas infrastructure company, used by the German, Irish and Dutch regulators.
	Terna	Transmission systems operator in Italy, largely networks, used as a comparator by the German, Irish, French, Swiss and Dutch regulators.

Source: *Frontier Economics*

²⁴ EDF did not end up in the sample for our final analysis for our beta decomposition of full information beta estimation because it did not offer a segmentation by operating income or total assets on Bloomberg.

²⁵ Veolia did not end up in the sample for our final analysis for our beta decomposition of full information beta estimation because it did not offer a segmentation by operating income or total assets on Bloomberg.

Figure 13 European Utility Sample (part 2)

Location	Company	Description of activities
Portugal	EDP	Electricity generator and distributor, used by the Irish regulator.
	REN	Electricity and gas transmission and distribution operator, used by the German, Irish, Dutch and French regulators as a comparator.
Romania	Transelectrica	Entirely regulated electricity transmissions operator, used by the Swiss regulator.
Spain	Enagas	Owner and operator of Spain's national gas grid, used by the German and Dutch regulators.
	Endesa	Largest electric utility company in Spain, mainly in generation, used by the Irish regulator.
	Gas Natural	Also called Naturgy, electricity generator (mainly) and distributor of natural gas, used by the Irish regulator.
	Iberdrola	Electricity generator (mainly) and distributor, used by the Swiss regulator.
	Red Elctrica ²⁶	Electricity transmission operator, largely networks, used by the German, Dutch, Swiss and French regulators.

Source: *Frontier Economics*

Figure 14 US Utility Sample

Location	Company	Description of activities
United States	Avangrid	Diversified holding in regulated utilities, electricity generation and gas storage.
	CenterPoint Energy	Primarily regulated electricity T&D and gas distribution.
	Consolidated Edison	Primarily regulated electricity T&D and gas distribution.
	Dominion	Majority regulated electricity and gas infrastructure and delivery company.
	DGBE Energy	Primarily regulated electric generation and networks company.
	Eversource Energy	Primarily regulated electricity T&D and gas distribution.
	NextEra	Entirely regulated electric utility holding company – largest in the US by market capitalisation.
	Public Service	Owner of Public Service Electric and Gas Company, an entirely regulated gas and electric utility company.
	TC Pipeline	Entirely regulated part of TC Energy which generates and transports gas in the US and Canada.
	UGI Corp	Regulated electricity and gas distribution along with large LPG business.
Unitil	Primarily regulated electricity T&D and gas distribution.	

Source: *Frontier Economics*

²⁶ Red Electrica did not end up in the sample for our final analysis for our beta decomposition of full information beta estimation because it did not offer a segmentation by operating income or total assets on Bloomberg.

ANNEX C TECHNICAL DETAILS

C.1 Equity beta estimation

$$SER = \alpha + (\beta_{equity} \times IER)$$

where:

- 'α' is a constant;
- 'SER' is the stock excess return; and
- 'IER' is the index excess return.

$$SER = R_{stock} - RFR$$

$$IER = R_{index} - RFR$$

where:

- RFR is the risk-free rate, taken to be the rate on a Bank of England 10-year bond.

C.2 Asset beta conversion

$$\beta_{asset} = \frac{\beta_{equity} + (\beta_{debt} \times \frac{Debt}{Equity})}{1 + \frac{Debt}{Equity}}$$

where:

- 'β equity' is estimated for each company in C.1;
- 'β debt' is assumed to be 0.1 for all companies in the sample;
- 'debt' is a utility's net debt (taken from Bloomberg); and
- 'equity' is a utility's market capitalisation (taken from Bloomberg).

C.3 National Grid simple decomposition

$$\beta_{total} = (\beta_{US} \times \%US) + (\beta_{UK} \times \%UK)$$

$$\beta_{UK} = \frac{\beta_{total} - (\beta_{US} \times \%US)}{\%UK}$$

where:

- 'β total' is National Grid's asset beta;
- 'β US' is the simple average asset beta of six US heavily regulated utilities;
- 'β GB' is the estimate of the appropriate beta on National Grid's GB operations;
- '%US' is the percentage of National Grid's operations that are regulated in the US according to either internal numbers or publicly available operating income; and
- '%GB' is the equivalent for National Grid's GB operations.

C.4 SSE simple decomposition

$$\beta_{total} = (\beta_{Unreg} \times \%Unreg) + (\beta_{UK} \times \%UK)$$

$$\beta_{UK} = \frac{\beta_{total} - (\beta_{Unreg} \times \%Unreg)}{\%UK}$$

where:

- 'β total' is SSE's asset beta;
- 'β Unreg' is Centrica's asset beta;
- 'β GB' is the estimate of the appropriate beta on SSE's GB operations;
- '%Unreg' is the percentage of SSE's operations that are unregulated according to publicly available operating income; and
- '%GB' is the equivalent for SSE's GB operations.

C.5 Multi-beta full information beta estimation regression

$$\beta_{asset} = (\beta_{US} \times \%US) + (\beta_{Unreg} \times \%Unreg) + (\beta_{UK\&European} \times \%UK\&European)$$

where:

- 'β asset' is the asset beta estimated for each utility;
- '%US' is the percentage of each company's operations that are regulated in the US according to publicly available operating income;
- '%Unreg' is the equivalent for unregulated operations;
- '%GB&European' is the percentage of each company's operations that are regulated in either the GB or Europe; and
- 'β US', 'β Unreg' and 'β GB&European' are the estimated coefficients which serve as estimates of the asset beta of a hypothetical pure-play utility in each segment.

