NRA specific report – Summary Data e3grid2012 for Energinet.DK

Background and structure of report

Electricity transmission system operators are regulated by national and European directives. Revenue allowances are set by national regulatory authorities (NRAs). One task of NRAs in many countries is to assess that the regulated revenues are based on efficient costs. Such analysis is often based on cost benchmarking among network companies. Given the limited number of national transmission system operators (TSOs) many European NRAs have decided to collaborate to develop an international sample of comparator companies.

E3grid2012 is the project to benchmark the cost efficiency of a set of European electricity transmission operators. The purpose of this NRA specific report is to provide an overview of included company data as well as efficiency scores. In this NRA specific report, we present more detailed information on the efficiency scores and sensitivities of your company. We note that the information in this NRA specific report is based on the analysis undertaken and documented in the main e3grid2012 report[1].

The summary is structured as follows:

- **Part A**: **DEA Scores** – The note provides information on the individual efficiency score of your company as well as an indication of how your company is positioned within the set of companies. In addition, we report the efficiency scores of your company for variants of the model.

- **Part B: Data summary** – The note provides a summary of confidential data submitted by your regulated company in e3grid2012 benchmarking and as used for calculation of the efficiency scores. Further details on the calculation of these costs are included in two separate excel files attached to this NRA specific report.

- **Part C: Descriptive statistical analysis** – The note also provides some descriptive statistical analysis of your regulated company in comparison to other companies. This does not substitute for the actual formal

1 This NRA specific report does not include calculations based on data which were not included in the e3grid2012 data set e.g. due to delay in data submissions. In addition sensitivity analysis, which is not covered in the main report, e.g. returns to scale variants, are not included in this report. We note that NRAs have the option to request such specific runs in a separate study.

benchmarking analysis, but provides further background for your regulated company.

Part A: DEA efficiency scores – Summary

In the following, we provide information for your regulated company on

- Base model results;
- sensitivity analysis; as well as
- dynamic results.

Base model results

In this section we describe the results for our base model for e3grid2012. The final efficiency scores for the base model are influenced by various factors. In order to make the impact of these factors visible we show the development of the efficiency scores step by step starting from a simplified model. **Table 1** illustrates the development of the base model and the various steps. In addition we describe the reasons and interpretation of the changes in the efficiency scores for your regulated company for the single steps.

Table 1. Development of base model[2]

Model	Description
Unit Cost (before Call Z) excluding outliers	In the unit cost approach we simply compare the total costs (totex) of the TSO with the technical assets reflected by the NormalisedGrid (Unit Cost = Totex/NormalisedGrid) Unit Cost scores may serve as a first rough indication on the cost position of your regulated company with regard to the key cost driver NormalisedGrid
Unit Cost (after Call Z) excluding outliers	In this step we illustrate the impact from the Call Z cost adjustments on the (unit) costs of your regulated company compared to the other TSOs. The cost adjustment from Call Z serves only as a compensation for TSO-specific costs which are not otherwise reflected in the model specification (i.e. which are not included following the regression based cost-driver analysis). Therefore, the incremental impact of the call Z adjustment is relatively low Nevertheless, for single TSOs the additional correction for cost impacts outside the adjustments for densely-populated area and value of weighted angular towers e.g. due to certain other topographical characteristics can be substantial and can have an (improving) impact on efficiency scores This measure may serve as an indication of the impact of TSO specific cost adjustments from Call Z on the efficiency score of your regulated company
DEA NDRS (NormalisedGrid) without selected capex break	In principle the Unit Cost approach can be described as a DEA with one single output (NormalisedGrid) and an assumption of constant returns to scale In this step we introduce the non-decreasing returns to scale (NDRS) approach and calculate a DEA with only one output: NormalisedGrid This measure – compared to the "Unit Cost (after Call Z) excluding outliers" results – serves as an indication of the impact of company size on the efficiency of your regulated company. If the score increases, then this means that size has an impact on your regulated companies efficiency
DEA NDRS (composite variable) without selected capex break	In this step we acknowledge that (i) NormalisedGrid although a key cost driver does not explain all cost differences between companies and include two further cost drivers reflection environmental factors: (ii) densely-populated area; and (iii) share of angular towers Cost-driver analysis indicated the relative average importance of these three costs drivers. We use this information on the average importance of each cost driver to create a composite variable made up of the weighted sum of NormalisedGrid, densely populated area and value of weighted angular towers This measure serves as an indication on the impact from densely-populated area and share of angular towers on your regulated company based on the average importance of these cost drivers over the whole sample
Base model without selected Capex break	In this step we recognise that the relative average importance of the three cost drivers (NormalisedGrid, densely populated area and value of weighted angular towers) may vary between the companies Hence, we let the importance of the three cost drivers on the efficiency scores vary within -50% and +50% of the statistical estimates for the respective

2 For further details on the model specifications we refer to: Frontier/Sumicsid/Consentec, *e3grid2012 - European TSO Benchmarking Study*, Section 7, July 2013.

	coefficient (cost driver) This measure illustrates the importance of the two parameters covering environmental influences from density and grid complexity on your regulated company ***We note that for those TSOs (and only for those TSOs) for which selected Capex break has been applied this efficiency score should be considered as the relevant one (and not the DEA score after Capex break)***
Base model with selected Capex break	In e3grid2012 we introduced a further DEA outlier analysis – the so called "selected Capex break" – to ensure that the efficiency frontier spanned by the peer companies sets feasible cost targets that are not unduly influenced by the absence of historic investment data This measure illustrates to what extent your regulated company is affected by this additional outlier analysis. The increase in efficiency indicates that the TSOs, on which selected Capex break has been applied, influenced the efficiency score of your regulated company

Source: Frontier/Sumicsid/Consentec

In **Table 2**, we illustrate the efficiency scores of your regulated company for the different steps towards the development of the base model. We show the development of your regulated company and the average efficiency. This allows assessing the importance of the steps on the efficiency score of your regulated company compared to the whole sample of compared TSOs.

Table 2. Development of the base model

Model	Your company's efficiency	Average efficiency
Unit Cost (before Call Z) excl. outliers	89%	61%
Unit Cost (after Call Z) excl. outliers	89%	62%
DEA NDRS (NGrid) without selective capex break	89%	64%
DEA NDRS (Composite variable) without selective capex break	80%	77%
Base model without capex break	88%	84%
Base model	100%	86%

Source: Frontier/Sumicsid/Consentec

In addition DEA allows information on the weighting of the cost drivers that determine the efficiency scores. The higher (lower) the weights for one cost driver is the higher (lower) is the importance of this cost driver on the efficiency score of your regulated company. For example, a weight of 50% for NormalisedGrid indicates that the efficiency score of your regulated company is

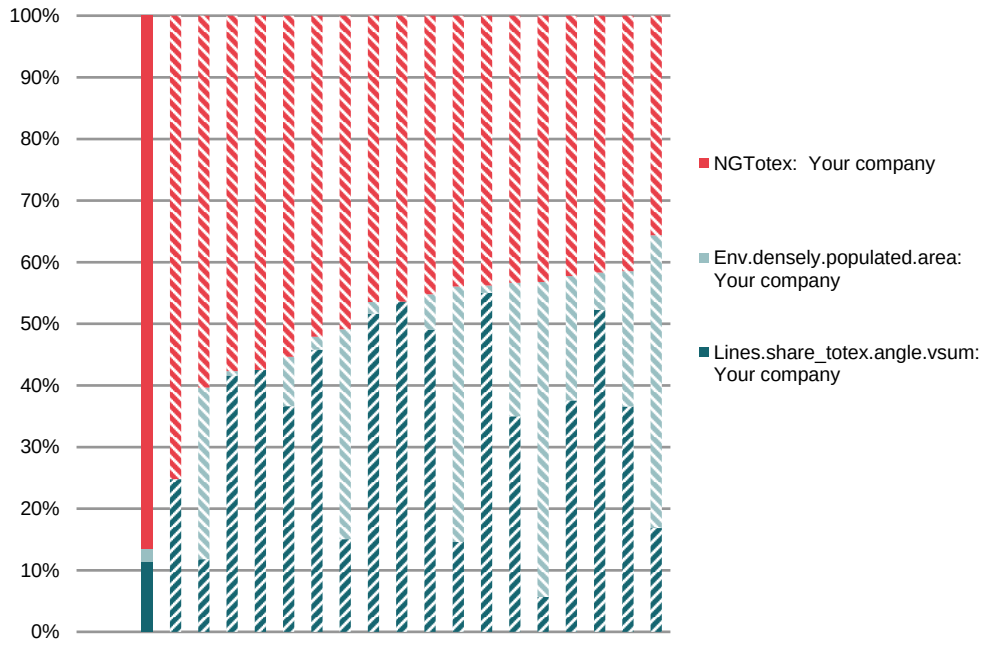
driven by 50% from NormalisedGrid. We note that by including weight restrictions we rule out that the efficiency score is only driven by one single cost driver.

Figure 1 illustrates the output weights for your regulated company and allows assessing the importance of the three cost drivers:

- NormalisedGrid;
- Densely-populated area; and
- Value of weighted angular towers

for your regulated company.

Figure 1. DEA input and output weights*



Source: Frontier/Sumicsid/Consentec
* excluding 1 outlier and 1 company with selective Capex break
Note: Companies are sorted in descending order of NGTotex.

Sensitivity analysis

In the following we discuss sensitivity analysis we have undertaken in relation to the base model.

Table 3. Sensitivities of base model[3]

Model	Description
DEA NDRS (unrestricted)	In this sensitivity we relax the weight restriction applied in DEA analysis and calculate a model without weight restrictions. In this model we let DEA determine the importance of the three cost drivers (NormalisedGrid, densely-populated area, and value of the weighted angular towers) endogenously. This may imply that the efficiency score is mainly determined by one cost driver with relative low importance (as suggested from the regression based cost-driver analysis) This measure indicates the impact from the weight restrictions in the base model on the efficiency score of your regulated company. An improvement in efficiency indicates that in particular densely-populated area and/or the value of weighted angular towers increase their weights in the calculation of efficiency
DEA NDRS (weight restrictions based on confidence intervals)	In this sensitivity we introduce stricter weight restrictions compared to those applied in the DEA base model. We use the upper/lower bounds from the confidence intervals for the output parameters estimated from the cost-driver analysis. The range of the upper/lower bounds lies inside the +/-50% range we apply in the base model. This implies stricter weight restriction compared to the base model, which should have an adverse effect in the efficiency scores This measure indicates the impact from stricter weight restrictions on the efficiency score of your regulated company. The size of the reduction of the efficiency scores indicate the impact from reducing the +/-50% range from the base model – in particular for densely-populated area and the value of weighted angular towers – on your regulated company.
DEA NDRS (PPI) ***PPI sensitivity***	In this sensitivity we assess the impact from using the Producer Price Index (PPI) instead of the CPI for indexation of the investment stream on the efficiency scores in the base model
Opex efficiency ***AdjTotex sensitivity***	In this sensitivity we assess the efficiency scores only for Opex. We have done so by adjusting the Totex figure by replacing the companies' Capex by the NormalisedGrid Capex. This allows focussing on the efficiency of the Opex by using the same output parameters in the DEA model. As the change of costs may also have an impact on the coefficients from the cost-driver analysis we have adjusted the coefficients for the weight restriction, as well. We have kept the range around the adjusted coefficients at +/-50% This measure gives an indication on the Opex efficiency of your regulated company. We note that the changes in the efficiency score compared to the base model will be substantially affected by the adjustment of the coefficients estimated from the cost-driver analysis, as the relative importance of densely-populated area and value of the weighted angular towers decrease

Source: Frontier/Sumicsid/Consentec

In **Table 4** we illustrate the efficiency scores of your regulated company for the sensitivities on the base model. We show the result for your regulated company and the average efficiency. This allows assessing the impact form the sensitivities on the efficiency score of your regulated company compared to the whole sample of compared TSOs.

3 For further details on the model specifications we refer to: Frontier/Sumicsid/Consentec, *e3grid2012 - European TSO Benchmarking Study*, Section 7, July 2013.

Table 4. Sensitivity analysis

Model	Your company's efficiency	Average efficiency
DEA NDRS (unrestricted)	100%	91%
DEA NDRS (weight restriction confidence intervals)	100%	85%
PPI sensitivity (base model)	82%	84%
Adjusted Totex sensitivity (new weights)	86%	86%

Source: Frontier/Sumicsid/Consentec

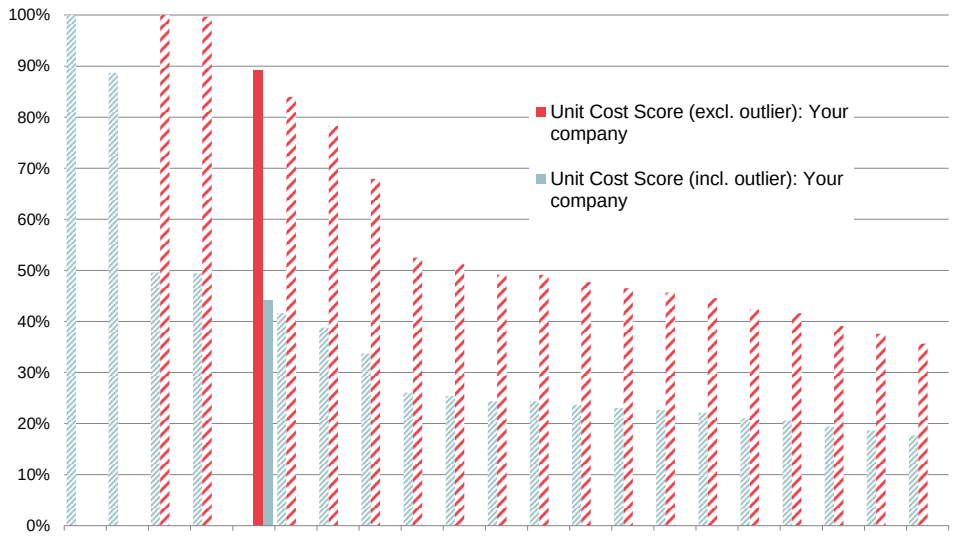
We have further undertaken so-called second stage analysis. The purpose of a second stage analysis is to ensure that we have appropriately specified the best model using the available data. The second stage analysis indicates that none of the tested parameters serves as an additional explanatory for the identified inefficiencies.

In addition, second-stage analysis allows assessing the **impact from size** on the efficiency scores, e.g. to test if large companies tend to get a low efficiency score. We used the NormalisedGrid as proxy for size and regressed the efficiency scores from our base case on this variable. The results indicate that size has no impact on the efficiency scores.

Unit cost scores – Opex and Capex information

Figure 2 illustrates the position of your regulated company compared to other TSOs based on unit costs scores (Totex, with and without outliers). A score of 100% indicates that the company is fully efficient based on this measure.

Figure 2. Unit cost scores (without Capex break)



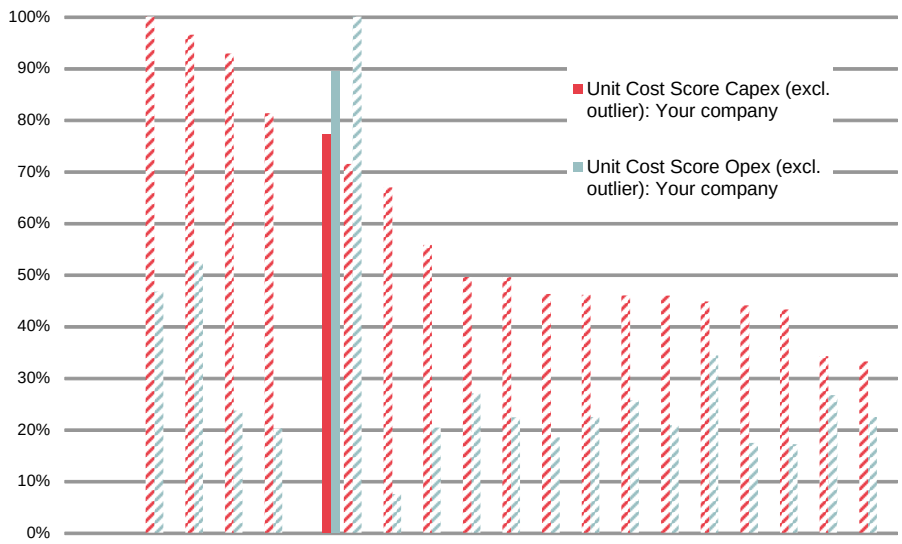
Source: Frontier/Sumicsid/Consentec
Note: Companies are sorted in descending order of unit cost score (excl. outlier).

Unit Cost scores can also be calculated for:

- Unit cost Capex (Capex/Normalised Grid); or
- Unit cost Opex (Opex/Normalised Grid).

This gives an indication on the position of your company with regard to Opex and Capex (**Figure 3**) and may serve as further indication of the Opex/Capex efficiency in addition to the Opex efficiency illustrated above. A score of 100% indicates that the company is fully efficient based on these measures.

Figure 3. UC scores for Opex and Capex



Source: Frontier/Sumicsid/Consentec
Note: Companies are sorted in descending order of unit cost score (excl. outlier).

Dynamic results

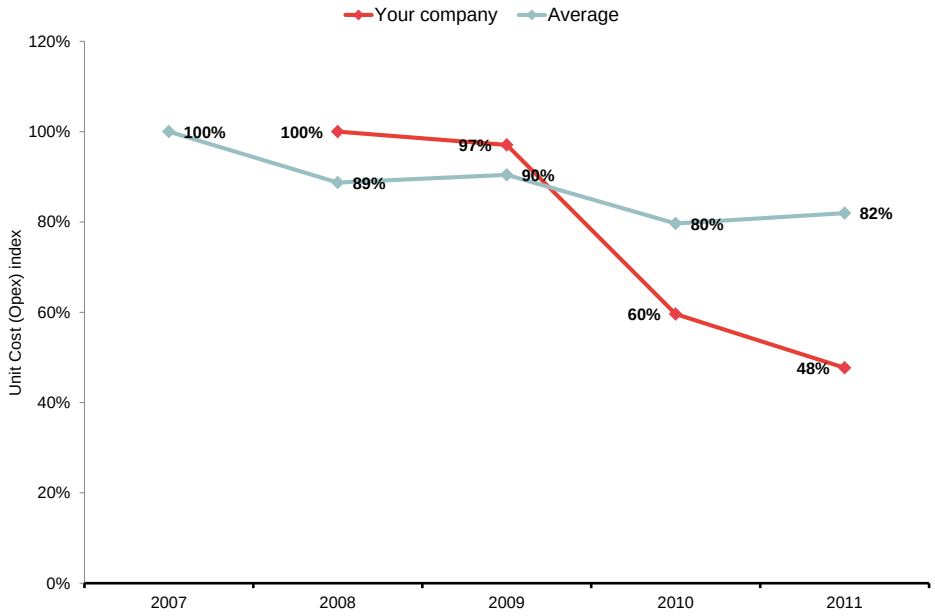
In the following we illustrate the cost development of your regulated company compared to the other TSOs and your unit costs.

Opex unit costs

Unit Cost (Costs/NormalisedGrid) may serve as a first rough indication on the cost level of your company. **Figure 4** shows the development of the Opex unit costs (after correction for Call Z) from 2007-2011 for your regulated company compared to the average (unweighted average) of other companies. Year 2007[4] is used as a reference year [100%]. If the growth index is above (below) the blue line the costs of your company grew more (less) compared to the other companies. We note that these are relative developments of your regulated company compared to the others, without taking into account the absolute level of the starting point. Hence, if your regulated company starts from a high absolute cost level compared to the other companies, it may still be inefficient even when the relative decrease of unit costs is higher compared to the others.

4 Year 2007 or the earliest year available.

Figure 4. Development of Opex unit costs for 2007-2011 (without Capex break)

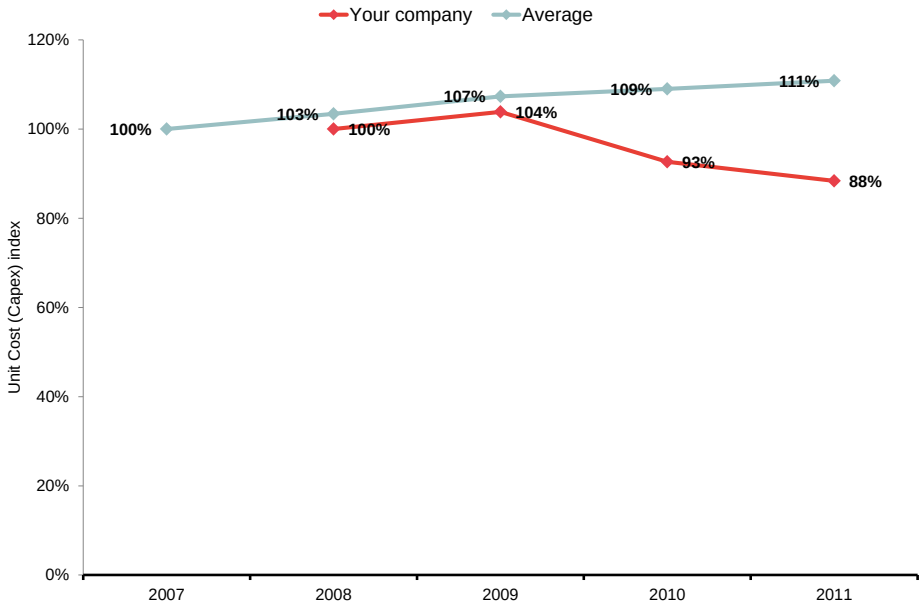


Source: Frontier/Sumicsid/Consentec

Capex unit costs

Figure 5 shows the development of the Capex unit costs from 2007-2011 for your regulated company compared to the unweighted average of other companies. Year 2007 is used as a reference year [100%]. If the growth index is above (below) the blue line the costs of your company grew more (less) compared to the other companies. We note that these are relative developments of your regulated company compared to the others, without taking into account the absolute level of the starting point. Hence, if your regulated company starts from a high absolute cost level compared to the other companies, it may still be inefficient even when the relative decrease of unit costs is higher compared to the others.

Figure 5. Development of Capex unit costs for 2007-2011 (without Capex break)



Source: Frontier/Sumicsid/Consentec

Part B: Data summary

The data summary is provided in several parts:

- Asset summary; and
- Benchmarking model data summary.

We note that a fuller data summary is attached in Excel format. The Excel file also includes background calculations.

Asset summary

In **Table 5** we summarise the assets and towers data of your regulated company provided by your regulated company in response to the Call X.

Table 5. Assets (piece count) and tower data from Call X

	Asset (piece count)	Unit
Lines	2,073	km
Cables	1,047	km
Circuit ends	375	#
Transformers	89	#
Compensation devices	36	#
Series compensation	9	#
Control center	3	#
Towers	4,898	#
Other installation	8	#
Off-shore assets	0	#
	Towers	**Unit**
Suspension	4,161	#
Angular	737	#
Wood	0	#
Steel	4,898	#
Guyed	0	#
Total	4,898	#

Source: Frontier/Sumicsid/Consentec

Model data Summary

In **Table 6** we summarise the model data for the benchmarking model applied in the R2 report. The selected parameters are based on the cost-driver analysis and the DEA calculations. The DEA calculations in the e3grid2012 report are based only on the year 2011.

- **Total cost** – Total cost consists of the sum of Opex and Capex and is based on the data your regulated company has provided in response to Call C.[5]

- **NormalisedGrid** – NormalisedGrid is a key cost driver, as the physical asset base is a natural driver for maintenance and investment costs.[6]

- **Densely populated area** – Areas of high population density may require more complex routing of transmission lines, combining of multiple circuits on one tower in order to save land, etc. Hence, it is reasonable to assume

5 For a detailed description we refer to the Excel file "e3grid2012_R2_CAPEX_OPEX_Explanation" for your company.

6 For a detailed explanation how this parameter is calculated, we refer to the Excel file "asset list_R2" for your company.

that some cost impact is explained by densely populated areas, be it alternatively or complementary to other parameters.[7]

- **Value of weighted angular towers** – Angle towers are required whenever a transmission line needs to deviate from a straight route. As angle towers need to sustain higher (lateral) forces, they require more material and are thus more costly. Therefore, the weighted share of angle towers can be interpreted as a proxy parameter representing the cost impact of topography or high population and/or load density.[8]

Table 6. Benchmarking model data summary

Name	Unit	2011	2010	2009	2008	2007
Total Cost	€	101,654,326	101,516,257	104,378,873	101,358,135	
NormalisedGrid	€	181,305	169,310	147,209	146,725	
Densely-populated area	km2	509	509	509	509	
Value of weighted angular towers	€	5,481	5,472	5,472	5,472	

Source: Frontier/Sumicsid/Consentec

Part C: Descriptive Analysis – Summary

In this section we provide a summary of

- the operating scale of the companies in the dimension of the parameters which are also used in the benchmarking model;
- development of the cost base of the company; as well as
- measures of complexity of grid structure.

Operating scale

In the following we provide some descriptive analysis of your company compared to other companies in the sample. **Table 7** illustrates the values of your company for the base model as well as key statistics about the sample of TSOs in e3grid2012 for the year 2011.

7 For a detailed explanation how this parameter is calculated we refer to the Excel file "e3grid2012_R2_calculation_of_density_area_assignment_of_NUTS".

8 For a detailed explanation how this parameter is calculated we refer to the Excel file "asset list_R2" for your company.

Table 7. Summary of data and comparison

Name	Unit	Your company	Mean	Median	St.Dev
Total Cost	€	101,654,326	334,187,238	173,058,468	481,458,861
NormalisedGrid	€	181,305	354,505	250,800	443,319
Densely-populated area	km2	509	5,206	3,665	6,869
Value of weighted angular towers	€	5,481	39,072	25,095	53,228

Source: Frontier/Sumicsid/Consentec

Complexity of grid structure

The complexity of grid structure matters as a more complex operating environment may imply higher specific asset costs. Complexity dimensions considered in the study include:

- The complexity of network topology – in particular the use of angular towers as opposed to suspension towers (and routes built in straight lines)[9]; and
- the population density in the serviced areas[10].

These are dimensions which have been found to be relevant from an engineering perspective and they are also found to be statistically significant cost drivers (see e3grid2012 report).

Complexity of network topology

The share of angular towers and line length per tower gives an indication on the complexity of the grid structure.

- **Less complex structure (upper left hand quadrant)** – A TSO located in the upper left quadrant tends to be characterised by a less complex grid structure. Companies in this quadrant are characterised by long overhead lines between towers and towers built in straight routes.
- **More complex structure (lower right hand quadrant)** – By contrast, a TSO located in the lower right quadrant tend be characterised by a complex grid structure. The distance between towers is low and more angular towers are used and routes are thereby less straight.

The other two quadrants indicate situations where a company faces complexity in one dimension (e.g. few angular towers or short distance between towers), but not the other.

9 For a detailed explanation how this parameter is calculated we refer to the Excel file "asset list_R2" for your company.

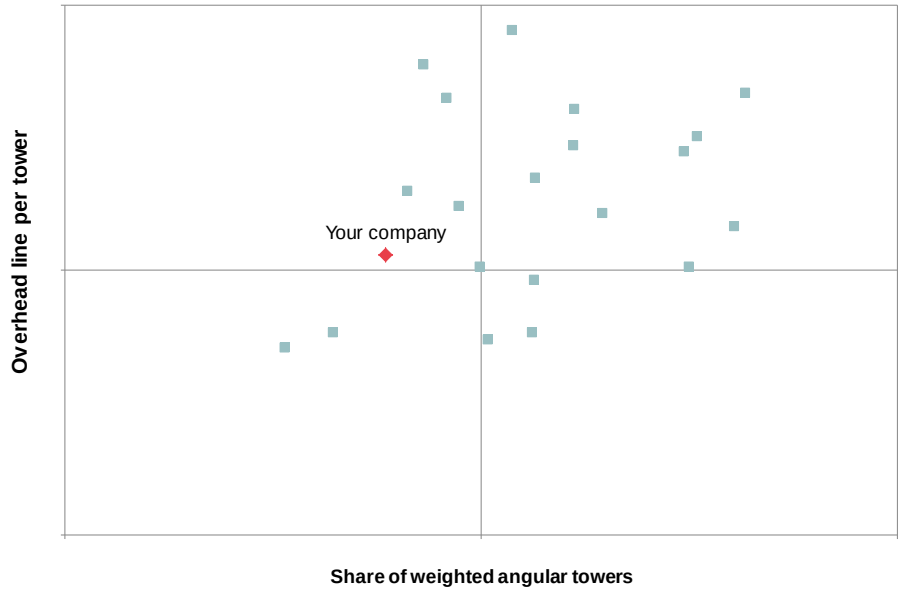
10 For a detailed explanation how this parameter is calculated we refer to the Excel file "e3grid2012_R2_calculation_of_density_area_assignment_of_NUTS".

Figure 6 illustrates the position of your company compared to other TSOs with regard to the complexity of the network topology.

We note that the figures serves as an indication for the grid complexity and include the caveat that

- the line length per tower may differ from the distance between towers as it is based on circuit (not route) length data; and
- the share of weighted angular towers is illustrated by a percentage value[11] (which has to be differentiated from the value used in the model calculations).

Figure 6. Share of weighted angular towers and line length per tower



Source: Frontier/Sumicsid/Consentec

Population density

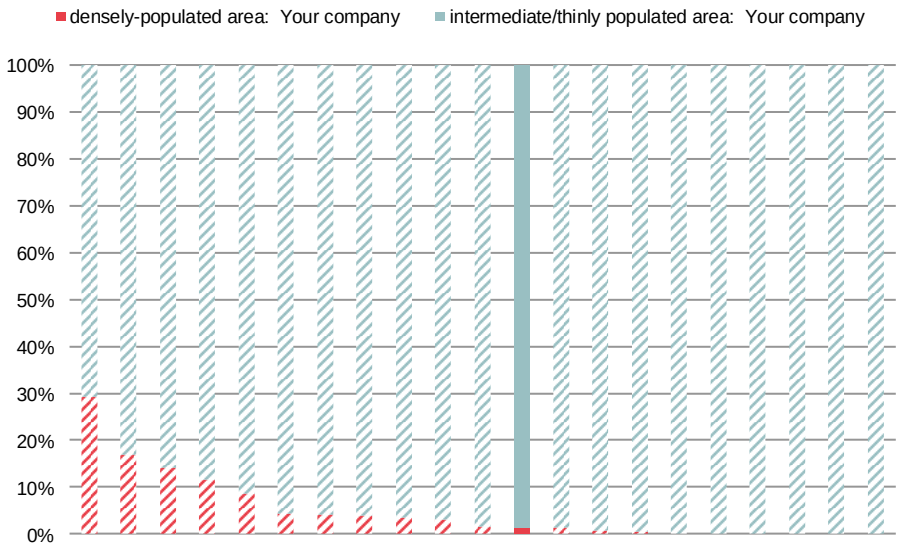
Areas of high population density may require more complex routing of transmission lines, combining of multiple circuits on one tower in order to save land, etc. Hence, it is reasonable to assume that some cost impact is explained by densely populated areas, be it alternatively or complementary to other parameters.

11 Value of weighted angular towers divided by the sum of Totex weighted lines.

Densely-populated area is defined by the size of the area with a population density of more than or equal to 500 inhabitants/sqkm. In terms of geographic granularity the NUTS3[12] regions from Eurostat have been used for the countries (or regions within countries in cases where several TSOs operate in one country) included.

Figure 7 illustrates the share of densely-populated area for your company compared to the other companies.

Figure 7. Share of densely populated area



Source: Frontier/Sumicsid/Consentec
Note: Companies are sorted in descending order of densely-populated area.

12 Eurostat, *Regions in the European Union, NUTS 2006 / EU 27*, 2007.