Comparing the STENA2012 and e3grid2012 results for TenneT NL

Frontier, Sumicsid and Consentec conducted the international TSO benchmarking analysis (e3grid2012) on behalf of a group of European regulators. ACM has asked for a country specific variation of this analysis (STENA2012).

The purpose of this note is to explore in how far the analysis differs between the two studies and thereby why the efficiency scores of TenneT NL differs from 83% in STENA2012 to 100% in the e3grid2012.

The note is structured as follows:

- Main scope – we start by explaining the principle scope of the benchmarking study and how it differs between the two studies.
- Differences in detail – we then explore the main detailed differences between
  - the input parameters in the two studies (mainly CAPEX),
  - the estimation of cost relationships (assessed through regressions) and
  - their effect on the efficiency scores.

Main scope of the study

ACM asked to illustrate what the results from e3grid2012 and STENA2012 tells about the efficiency of TenneT and the reasons for deviating results between those two studies.

Insights from e3grid2012

Given the complex and heterogeneous tasks of national electricity transmission operators, it is natural that regulators turn to structured approaches for performance assessment. The key to measure the cost efficiency of the operators is

- defining the scope to activities and assets that are comparable,
- isolating and validating the separation of costs between benchmarked and non-benchmarked activities, and
- choosing an estimation methodology that is cautious and parsimonious with a priori technological assumptions.

In the general e3grid2012 study, a large part of the effort is invested in the creation of a reliable database of asset, cost and performance data that serve to inform regulatory assessments for different needs. Since the scope of the benchmarking exercise is total expenditure, rather than operating costs, the study hedges against the risk of bias due to heterogeneous financial and organizational structure (renting, operational leasing and subcontracting with staff). The activities included encompass

- Construction (C),
- maintenance (M) and
- (administrative, A) support.

These could be considered as the minimal common factor among all transmission operators. On the other hand, the functions related to system operations, planning and market facilitation are not included since the outputs for these functions are less homogenous and observable than the asset-provision.

The methodology in the general e3grid2012 study assesses efficiency by standardising certain data so that all operators face a hypothetical common cost structure; financing costs and depreciation principles, service markets and labour costs. The study considers and adjusts for conditions that may potentially create a particular bias or favour for any operator.

This assessment suggests that the total cost efficiency for the benchmarked functions (CMA) is about 86% on average. The results are based on very cautious assumptions of non-decreasing returns to scale, full justification for all investments and controlling for exogenous cost differences.

In short, this means that the sector could have on average saved at least 14% of the benchmarked total expenditure in 2011. Albeit seemingly modest, the savings potential sums to 1,800 M€ in 2011 across the benchmarked TSO.

However, part of this savings may not be easily implemented by the TSOs through cost savings as they relate to sunk cost.

What can be said about TenneT in the general study? Under the cautious assumptions in the common benchmarking study, increasing returns to scale, common capital and labor costs, removing outliers, etc the TenneT cost efficiency is shown to be 100%. This means that the study cannot positively identify any savings potential under the settings (used in the e3grid2012 study). The general study mildly restricts the weight (or "marginal cost") put at densely populated area in the model, which explains the result of the assessment. A prior model in 2008, where population density was included directly with a similar dataset, also led to the same conclusion in the general study.

The general e3grid2012 study is less suitable to provide normative guidance to ACM, since it does not take into account the specific costs and restrictions facing the regulation of any TSO, but averages these for a hypothetical European operator.

Rationale for the STENA study

We note, that the e3grid2012 process served to provide different national regulators with a common input data set for all companies. This provides a starting point (data set) from each national regulator from which different national regulators can refine the analysis to reflect the benchmarking questions to be explored in their national context. In particular:

- labour cost have been adjusted to normalise for differences in national labour cost);
- Capex – assumptions have been made to standardise capex (return, depreciation period, asset inflation)

STENA2012 serves to consider Dutch specific regulatory questions and data. In particular, standardised capex data is calculated in a way consistent with the Dutch regulatory parameters. Thereby, TenneT is compared with the cost of other international TSOs which these would have incurred, had they faced the same cost of capital (WACC etc).

Had the international TSOs actually faced this cost of capital, they might have chosen a different mix of production factors (in particular capital and labour) and might then have exhibited lower cost than they show now. In this regard the use of (Dutch) standard assumptions as regards cost of capital may lead to a somewhat softened benchmark.[1]

Consider the situation in **Figure 1** for operator C. Here the sloping straight lines indicate relative factor prices.

In the general assessment, the unit C is classed as fully efficient, since it is both at the frontier and at the tangent (minimum budget constraint) for the common factor price combination marked "General prices". However, in this example operator C faces a different price situation where the cost of capital is higher when considering national data. Taking this into consideration in the run using the red budget line, operator C is revealed as cost inefficient at its actual national prices.

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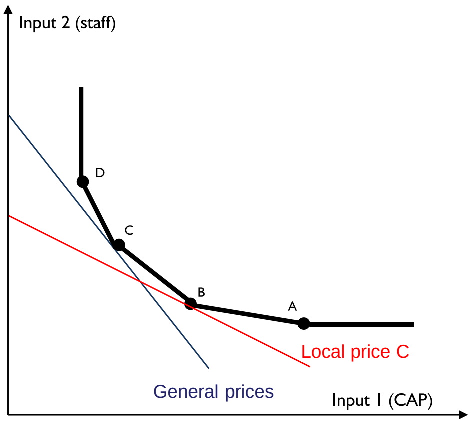
1 At the same time we note that also TenneT's cost of capital will change over time and this may lead to differing optimal mixes of capital and labour over time. In essence, we therefore expect this "softening" of the benchmark to not be very material.

Figure 1. Example of general and specific assessment.



Source: Sumicsid

Analogously for the STENA 2012 study, the outcome at actual costs is information uniquely defined for the operator at hand, since all operators are evaluated at the local cost (which may not be relevant for the rest of the reference set). Note that this gives a lower bound for the inefficiency, as the other operators likely not have optimized their production for this specific factor price combination.

For a national regulator, the results from the run that uses national factor price data is the most relevant, since this data refers to the specific situation of the operator under regulation, and not to an average price situation. In STENA 2012, the result of 83% can be interpreted simply as "if TenneT would invest and operate as efficiently as the peer units subject to the parameters of TenneT, then 83% of the total expenditure for construction, maintenance and share of support would be enough to provide all current services". Inversely, "17% of the current total expenditure for construction, maintenance and share of support could have been avoided if TenneT had applied the best practices of TSO peers operating under the same financial constraints as TenneT".

Differences in the details

We now turn to describing differences in the analysis in greater detail.

Key differences in the underlying data

The STENA2012 runs are performed using the Dutch specific regulatory parameters on all firms in the dataset. Compared to the e^{3}grid 2012 study the variations in the input data relate to (also explained in section 3.2 of the STENA report):

- The choice of consumer price index for inflation adjustment – ACM provided us with the series of consumer price index from CBS which are used in the national regulation. In national regulation August-August CPI values are used and a one year time-lag for CPI data is applied. In e3grid2012 we used OECD data;

- The specification of the depreciation periods – for STENA2012 ACM provided us with depreciation periods used in national regulation for TenneT, which deviated from the periods used in e3grid2012 for some asset categories, e.g. lines – 55 years instead of 60 years; transformers – 35 years instead of 40 years;

- The WACC to be used in the CAPEX calculation – for STENA2012 ACM provided us with a WACC of 6% (real). In e3grid2012 we used a WACC of 4.36% (real).

This leads to some rescaling of several parameters that enter the benchmarking:

- Input parameter in the benchmarking – Totex cost measure ;
- Output parameters in the benchmarking:
  - NormalisedGrid and
  - Share of the value of angular towers.

The differences in key statistics of the sample are illustrated in **Table 1**:

Table 1. Descriptive statistics

STENA				
	Mean	**St.Dev.**	**Min**	**Max**
Totex	384.916.930	564.191.843	8.694.273	2.509.204.041
Totex with capex break	482.992.409	603.056.524	8.686.195	2.509.204.041
NormalisedGrid	410.976	517.820	11.891	2.443.551
Densely-populated area	5.252	6.819	0	21.744
Share of the value of angular towers	45.750	61.570	883	290.268
E3GRID				
	Mean	**St.Dev.**	**Min**	**Max**
Totex	315.085.414	457.459.345	7.046.739	2.031.655.166
Totex with capex break	389.965.469	486.729.992	7.040.640	2.031.655.166
NormalisedGrid	335.631	423.352	10.630	2.001.325
Densely-populated area	5.252	6.819	0	21.744
Share of the value of angular towers	37.758	51.143	720	241.541

Source: Sumicsid

We see that in STENA2012 the Totex measure is on average 22% larger than in e3grid2012. The same holds for the two cost drivers NormalisedGrid and Value of the share of weighted angular towers. The parameter for density however does not change. This is seen also if we norm by Totex as in **Table 2**.

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Table 2. Descriptive statistics (normed)

STENA (normed with Totex)				
	Mean	**St.Dev.**	**Min**	**Max**
Totex	1.000	0.000	1.000	1.000
Totex with capexbreak	1.427	0.709	0.999	4.140
1000* NormalisedGrid	1.475	0.963	0.658	4.293
1000* Densely-populated area	0.016	0.026	0.000	0.155
10000* Share of the value of angular towers	0.155	0.104	0.046	0.491
E3GRID (normed with Totex)				
	Mean	**St.Dev.**	**Min**	**Max**
Totex	1.000	0.000	1.000	1.000
Totex with capexbreak	1.399	0.664	0.999	3.937
1000* NormalisedGrid	1.469	0.945	0.592	4.230
1000* Densely-populated area	0.019	0.033	0.000	0.204
10000* Share of the value of angular towers	0.155	0.105	0.043	0.501

Source: Sumicsid

Effect of refined input assumptions on TenneT's Totex in STENA2012

The growth of the Totex measure in STENA2012 compared to e3grid2012 is explained by the growth of Capex, driven by

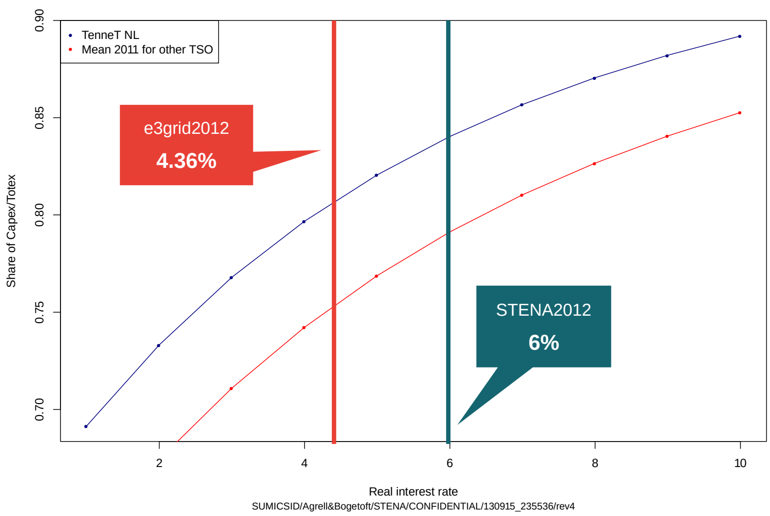
- the increase in the WACC (+15.5% for TenneT, the average impact +13.4% in 2011 for all TSOs) and
- to a minor extent by the change in inflation index (+1.8%, TenneT only).

However, the change is relatively neutral for most other TSOs, since the NormalisedGrid measure also depends on the same annuity term as Capex. Thus, the increase in NormalisedGrid normally corresponds to the change in Totex (+13.99% in 2011 for all TSOs, +15.2% for TenneT in 2011).

Naturally, the increase in Capex for a given Opex (**Figure 2**) gradually transforms the benchmarking from a pure Opex-benchmarking (for interest rate 0%, because the annuities used as Capex become zero) into a pure Capex-benchmarking (for a very high interest rate).

We note here that TenneT in e3grid2012 already has a higher Capex share (in Totex) than the average TSO. This pattern is maintained as the interest rate is increased in STENA2012.

Figure 2. Share of capex in totex as a function of real interest rate



Source: STENA

Differences in cost driver analysis through regressions

In a further step we have analysed the relationship between Totex and the key cost drivers. This analysis partly serves to confirm the significance of cost relationships and partly to explore realistic ranges for the relative importance (or elasticity) of certain cost drivers in relation to cost.

Our statistical analysis suggests that in STENA2012, the NormalisedGrid and Value of weighted angular towers is slightly more strongly correlated with Totex than in e3grid2012, while the Densely populated area (unaffected by the refinement of input data for STENA2012) becomes slightly less correlated with the Totex in STENA2012. This impacts the value of the elasticities we obtain through regression analysis. The respective elasticities inform the weight restrictions that we apply in DEA benchmarking analysis.

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Table 3. STENA2012 – results robust regression

Cost driver	Regression coefficient	Standard deviation	t-value
Intercept	7.9848	0.28626	27.894***
NormalisedGrid (+1)	0.66805	0.04816	13.871***
Densely populated area (+1)	0.06654	0.01073	6.201***
Value of weighted angular towers (+1)	0.25435	0.03626	7.015***

***Significant at 99% level

Source: Frontier/Sumicsid/Consentec

Table 4. e3grid2012 – results robust regression

Cost driver	Regression coefficient	Standard deviation	t-value
Intercept	9.19976	0.44508	20.670***
NormalisedGrid (+1)	0.51355	0.06199	8.285***
Densely populated area (+1)	0.12777	0.02112	6.049***
Value of weighted angular towers (+1)	0.27428	0.03940	6.961***

***Significant at 99% level

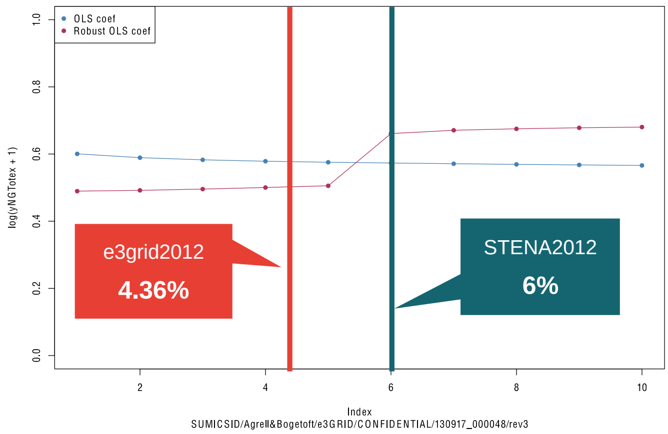
Source: Frontier/Sumicsid/Consentec

Table 3 and **Table 4** illustrate that density plays a more important role in explaining cost variations using the e3grid2012 parameters (0.12777) than it does using the STENA2012 parameters (0.06654).

A deeper investigation of the change in coefficients can be done by considering the differences between normal and robust OLS coefficients as the interest rate changes (excluding the marginal effect of the CPI changes). Below we vary the real interest rate between 1% and 10% annually and derive the corresponding regression coefficients as above.

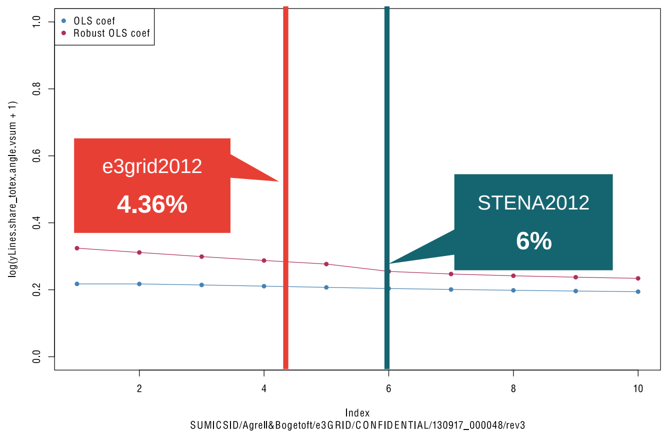
As seen in the figures below, the regular OLS coefficient is rather stable and smooth, whereas the robust OLS coefficient switches between two stationary levels at a real rate of return of about 4.8% (**Figure 3**). Analogously, the OLS coefficients for densely populated area in Error! Reference source not found. illustrate the reverse pattern; the robust OLS drops to a stationary lower level for an interest rate of about 4.8%.

Figure 3. Regression coefficients for NormalisedGrid



Source: Sumicsid

Figure 4. Regression coefficients for Value of weighted angular towers



Source: Sumicsid

In the following we have analysed, why the robust OLS coefficients react in this discontinuous manner. The explanation is found in the working of the robust regression (cf. Yohai, 1987[3]), which is based on a weighted sum of quadratic deviations. An observation that is beyond a certain limit of plausibility is considered as a statistical outlier and its deviation is not included in the sum. For

3 Victor J. Yohai, High Breakdown-Point and High Efficiency Robust Estimates for Regression, Annals of Statistics, Volume 15, Number 2 (1987), 642-656.

interest rates below 5% there are only 5 observations (of 81) that are considered outliers, above 6% the number is 12 and increasing to 15. The drop of outliers is stepwise and causes the effect illustrated in the curves.

Differences in the resulting weight constraints

Consider now the weights attached to the cost drivers in the two benchmarking studies. As shown below, TenneT gets its best possible evaluation in the unrestricted DEA case by assigning all weights to the density parameter. This happens in e3grid2012 and STENA2012 (**Table 5** and **Table 6**, First row).

The second row in **Table 5** and **Table 6** illustrates the mean weights that e3grid2012 and STENA2012 derive from the regressions. The actual weight restrictions applied in DEA are derived from these second rows by using a 50% variation around these mean values as explained in the e3grid2012 report. We see that the STENA2012 study allows significantly less weight on the density parameter since density plays a smaller role in explaining the cost variation as it is estimated based on the panel of 102 observations.

The third row in **Table 5** and **Table 6** illustrates the optimal weights for TenneT when we impose the constraints. As one would expect, TenneT in both studies is evaluated by putting maximal (150%) weight in density (*v2*) and minimal (50%) weight on the other cost drivers (*v1* corresponds to Normalised Grid, *v3* to share of angular towers).

Table 5. STENA2012 weights

STENA2012	v1/v1	v2/v1	v3/v1
Tennet unrestricted	0.00	Max	0.00
estimated restrictions (mean weights)	1.00	8.31	3.49
TenneT with relaxed (+/-50%) restriction	1.00	12.47	2.45

Source: Sumicsid

Table 6. e3grid2012 weights

E3GRID2012	v1/v1	v2/v1	v3/v1
Tennet unrestricted	0.00	Max	0.00
estimated restrictions (mean weights)	1.00	16.94	4.85
TenneT with relaxed (+/-50%) restriction	1.00	25.41	2.95

Source: Sumicsid

To sum up, we see that in both cases, TenneT, is benefitting from putting maximum weight on density and minimal weight on the other parameters. In e3grid2012, however, there is more freedom to emphasize density compared to the other cost drivers.

Sensitivity to the weight restrictions

To further explore the differences between e3grid2012 and STENA2012, we have calculated the TenneT efficiency scores using different weight restrictions (variations around the rates of substitution/cost elasticity estimated from the log-linear regressions) for the base case.

Table 7. Efficiencies and weight sensitivities

	STENA	E3GRID
Base case with +/- 300% range	100%	100%
Base case with +/- 200% range	100%	100%
Base case with +/- 100% range	90%	100%
Base case with +/- 50% range	83%	100%
Base case with +/- 40% range	81%	100%
Base case with +/- 40% range	80%	97%
Base case with +/- 20% range	79%	93%
Base case with +/- 10% range	77%	90%
Base case with +/- 0% range	75%	87%

Source: Sumicsid

We see that in STENA2012 by relaxing the weight restrictions in DEA (and beyond what is implied by the regression analysis), we obtain higher scores for TenneT's efficiency. However, we have to relax the range for weight restrictions from a reasonable 50% (in the STENA2012 and e3grid2012 base case) to 200% considerably to let TenneT appear as fully efficient.

In e3grid2012 on the other hand, we observe a non-trivial drop in efficiency if we tighten the constraint by an extra 30% points.

Summary

The specific STENA2012 study is more suitable to provide normative guidance to ACM, than the general e3grid2012 study.

For a national regulator such as ACM, the efficiency results from the run that uses national factor price data (in particular the Dutch value for the WACC) is the most relevant, since this data refers to the specific situation of the operator under regulation. One should expect a DEA benchmarking analysis based on specific assumptions for one country to provide a lower bound for the inefficiency for the TSO of that country, as the other (foreign) operators are not likely to have optimized their production process to this specific factor price combination.

The main difference between the results from e3grid2012and STENA2012 is that with the parameters that more closely reflect the regulatory parameters in the Netherlands (the STENA2012 parameters), the size of grid and the share of angular towers explain costs of the European TSO better, while the density becomes a statistically less important cost driver (when using robust regressions).

This effect is primarily driven by the WACC at 6% via impact on the regression coefficients, the effect of other changes to input data in Stena2012 (depreciation periods the choice of consumer price index) being marginal.

The lower OLS coefficient for density implies that we allow less importance to be given on density in the STENA2012 study. The use of a tighter weight restriction on the variable of populated area is informed by statistical analysis in the case of using Dutch specific Capex parameters. The estimated weights exhibit a high level of statistical significance. In turn, since TenneT NL's score is strongly affected by the maximal weight it can claim on the density parameter, TenneT is getting a lower score in the specific STENA2012 study using national parameters more suitable to provide normative guidance to ACM than the e3grid2012study.