PROJECT STENA

Benchmarking TenneT EHV/HV

FINAL RESULTS

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Disclaimer

This is the public version of the final report by the authors, professors Per AGRELL and Peter BOGETOFT for SUMICSID AB, analyses EHV and HV operations by TenneT Transmission System Operator as part of a mission, Special TENnet Assessment (STENA), commissioned by the Office of Energy Regulation (Energiekamer, EK), Den Haag.

As the objective of the report is the performance assessment of a particular operator, any direct or implied conclusions regarding other operators are without support in this report. For detailed information regarding the performance assessments, refer always to the underlying white paper as well as to the final reports of the e3GRID project 2009.

The methods, assumptions, conclusions and recommendations in this draft report have not undergone any review from the Commissioner and represents only the viewpoint of the authors that assume all responsibility for any errors of fact or logic.

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Executive Summary

This study is devoted to the cost efficiency of TenneT Transmission System Operator, licensed for transmission operations (TO) for high voltage (HV) and extra high voltage (EHV) assets as well as system operations (SO) on the electricity grid in the Netherlands. The study is organized in two parts: one for transmission operations, another one for the system operations assessment. The TO part is detailed benchmarking covering both the current cost efficiency level of TenneT (static efficiency analysis) and the cost efficiency development rate of comparable operators (dynamic efficiency analysis), as well as an overview of how the results from our benchmarking studies are used by other European regulators. After analyzing the prerequisites for benchmarking the recently acquired HV grids, the TO study limits the quantitative cost efficiency assessment to the prior EHV operations. The SO part should be seen as a first analysis, providing a critical review of the feasibility for a benchmarking study of SO costs and ending in recommendations on how this could be done.

Transmission operations: Methods

The purpose with the benchmarking of TO is to estimate two efficiency improvement parameters in the revenue cap regulation for TenneT, the individual efficiency catch-up target (Theta) and the expected annual productivity increase (frontier shift). Benchmarking is a useful method since TO is a relatively structured task that employs a well-defined technical asset base that is similar across Europe. International benchmarking requires, however, a clear process for standardization of capital and operating costs, including corrections for different currencies, inflation rates, salary and employment conditions, asset ages and configurations. For these purposes, SUMICSID has worked with 19 countries in CEER to develop the largest regulatory benchmarking of electricity transmission grids so far, the e^{3}GRID study.

A comparison requires a reference set of structurally comparable units. The selection of units can be made either before the analysis, based on information on technology, location etc, or by the analysis tools themselves using a standard procedure for outlier removal. In this study, we operate with two sets; one containing all 22 operators (set W1 in e^{3}GRID) and one homogenous reference set with 17 operators from continental Europe using meshed grids and steel towers (set W2 in e^{3}GRID). For this assessment, we recommend the use of reference set W2.

Benchmarking can be made against best-practice observations, that may consist of one or several transmission operators, or against average-practice values, that include all available observations in the estimate. Best-practice is sensitive to the "best" units data and comparability, but insensitive to poor data from inefficient operators. Average-practice is robust to random errors in unit data and comparability, but is sensitive to the inclusion of inefficient units. For optimal *overview and robustness, we present the scores as best-practice, best of three practice and average practice.*

In e^3GRID, the two benchmarking instruments are used: a unit cost metric and multi-output metric based on linear programming (Data Envelopment Analysis, DEA). Both methods are common in network regulation, currently about ten countries in Europe use DEA directly to regulate electricity and gas networks on lower levels. The shortcoming of unit cost metrics is that the use and location of the grid is not represented in the simple ratio. As a remedy, the DEA model has three cost drivers to capture more of the relevant cost and explain cost differences better. No ad hoc assumptions are made on the relative importance of the cost drivers in DEA, which makes it an attractive, robust and cautious method for regulatory use.

However, the preferred method for assessing the efficiency of TenneT is the Unit Cost approach due to the specific variable set that gives high chances for full efficiency in the smaller subset. One DEA cost driver in e^3GRID is density, calculated as population density. Density is complementary to the other cost drivers in that it helps explaining cost-differences resulting from urbanization, land-use constraints and environmental requirements increasing capital and operating expenditure relative to sparsely populated areas. However, since the Netherlands has the highest population density among the countries represented in the study, the DEA method (too) cautiously exaggerates the impact of the cost driver to explain any cost difference, unless a comparator is found. In addition, we have deployed statistical methods to automatically detect observations that are atypical or unduly influence the estimation of the others' efficiency. The application of these methods in DEA to TenneT EHV leads to the further removal of observations, which in combination with the small data set makes it even more difficult for the method to estimate the extra cost necessary to operate in a highly populated country. Mathematically, DEA assigns a very high cost factor to density and deducts this from the cost for TenneT EHV until the remainder looks efficient relative to the other observations.

For these reasons, DEA is not the best method to measure the efficiency of TenneT. The best approach is to use the Unit Cost metrics in combination with a validation using DEA to find good reference sets consisting of structurally comparable operators. In the current study, we have found correlation between the results for unit cost models and DEA models without automatic removal of outliers. The results are hereby relatively insensitive to the choice of estimation method, DEA or Unit Cost. Moreover, the unit cost metric ECOM+ was used in prior benchmarkings in 2003 and 2005 to regulate TenneT, among other countries. The Unit Cost approach is used with a relevant subset of observations, meaning that the outlier problem is not at hand.

The retained methods are thus

1. *Unit Cost Totex (total expenditure) under the assumption of investment cost normalization (forgiveness) prior to 2001, using a reference set of 17 homogenous TSO (not belonging to the so called "low-cost" technology).*

2. *DEA for constant returns to scale, using the same subset as above.*

Transmission operations: Static results EHV

The static results for the EHV operations in Table E1-2 *based on unit cost metrics and DEA for EHV indicate a cost efficiency of 65.5% of total expenditure, where capital expenditure up until 2000 has been treated as fully efficient. The calculations neutralizes the actual investment values for all grids prior to 2001.*

The existing asset base for TenneT is expensive compared to international peers. To be cautious in the estimation of efficiency of the opening asset base in 2000, the analysis only includes a set of TSOs from countries in Western Europe with opening asset bases prior to 2000 and not belonging to the "low-cost" operators excluded from set 2. The resulting set has 13 operators that are closely resembling TenneT in terms investment profile. The result in Table E1-1 *below show that the TenneT Capex that was declared efficient in 2000 in fact contained at least 21.8% of Capex inefficiency compared to a conservative set of average European continental operators. Further, we note that a "continental best-practice" Capex ratio would lower the TenneT score to 49%. Since 2001 the investments have been improving in efficiency and contribute to overall cost efficiency.*

Table E1-1 Analysis Capex efficiency TenneT EHV in 2000.

	TenneT EHV		Average (13 operators)	
Model	Normalized	Actual	Normalized	Actual
Unit Cost (up to 2000)	737.2	1063.6	704.7	878.9
Ratios:				
normalized/actual	0.69		0.89	
average Capex eff.	78.2%		100.0%	
best practice Capex eff.	49.4%		64.0%	

Forgiving the capital expenditure inefficiency up until 2000 as a stranded cost is not a marginal decision. It reduces benchmarked cost and also cancels existing sources of cost efficiency among the comparable grids having invested wisely in the last 20-30 years. The cost efficiency using the full investment series for all operators is about 15,9% - 21%-units lower than the corresponding results when the asset base in 2000 is treated as efficient, viz. 45% for Unit Cost, 49.7% DEA.

Table E1-2 Principal results for static cost efficiency EHV in 2006 (UnitCost and DEA)

		Best practice	Best 3 TSO's	TenneT wrt average	Average
UC	Totex all	44.96%	46.76%	73.18%	61.44%
UC	Totex (Capex 2000 forgiven for all TSO's)	65.48%	74.42%	101.48%	64.52%
DEA	Totex all	49.73%	49.73%	66.83%	74.42%
DEA	Totex (Capex 2000 forgiven for all TSO's)	65.64%	69.40%	94.53%	69.43%

Transmission operations: HV operations

TenneT has acquired a substantial assetbase of HV equipment from DSOs in the Netherlands. We investigated technical asset data submitted by TenneT and cost data from EK for the corresponding assets. However, several reasons contribute to the conclusion that robust benchmarking with other European TSOs cannot yet be made for the HV operations of TenneT.

First, the TenneT HV data does not seem to be reliable, e.g. staff numbers are missing or likely erroneous. There is furthermore a problem of internal consistency of the data, since asset data is reported separately from cost data. Normally, the same reporting part provides both asset data and the actual costs for operating those assets.

Second, the submitted asset data is not validated and analyses give strong indications of overstatements of the CAPEX importance of at least some assets (overhead lines).

Third, the inclusion of HV assets in a benchmarking like e^3GRID assumes that the equipment is operated jointly and integrated with the EHV part of the transmission system, e.g. in low-capacity grids with sparse interconnections as in Norway. However, if the HV grid primarily is used for radial transport as is normal for DSOs, then the assigned CAPEX and OPEX weights are overstated for its use.

Given that the HV integration represents approximately a doubling of the asset base for TenneT, uncertainty regarding the points above may give large and unpredictable results for the efficiency assessment of the joint operations. Hence, we conclude that new cost- and asset data must be collected for the benchmarking to be meaningful and reliable.

Transmission operations: Dynamic results

The dynamic results in Table E1-3 *below come from four calculations. In e^{3}GRID, the frontier shift in total expenditure for European TSOs was calculated to 2.2-2.5% per year based on data from nine operators for the period 2003-2006. In the current study, we make new estimates for the case of stranded investment costs until 2000. This leads to a different balance between operating and capital costs, but the frontier shift movement in total expenditure is close, 2.6%. The productivity gains are mainly coming from the fairly limited investments undertaken in the period, whereas the technology in both operating costs and capital costs is stagnating. The e^{3}GRID data contains all TSO assets, mostly EHV but also HV grids under TSO operation.*

For the HV assets, data for 51 regional transmission grids from Norway for the period 2001-2004 yields a frontier shift of 2.1% per year. Finally, a longer study for 139 US interstate transmission grids during 1994-2005 leads to the weighted average frontier shift of 2.41%. We can therefore conclude that the productivity improvement rate is similar for EHV and HV operations and that there is no need to differentiate the two in terms of frontier shift parameters. The short period for which validated data is available on Opex and Capex does not allow the derivation of robust dynamic estimates for the frontier shift with respect to operating and capital costs separately.

Table E1-3 Results for frontier-shift estimations

Methodology	Period	Frontier shift per year
EHV+HV (e^{3}GRID)	2003-2006	2.2-2.5%
EHV+HV (e^{3}GRID excluding pre-2001 Capex)	2003-2006	2.6%
HV (regional transmission grids, NO)	2001-2004	2.1%
HV (interstate transmission grids, USA)	1994-2005	2.4%

International practice

Most regulatory authorities participating in the e^{3}GRID project have used the results in some way or another. The majority of the European regulators use benchmarking to regulate their TSO and 8 of 19 countries in participating in the e^{3}GRID project used the information to set individual targets using some methodology. An additional four countries applied the frontier shift estimates from the study to regulate their TSO, whereas at least three countries used the information from e^{3}GRID to facilitate the regulatory monitoring of their TSO in other ways, such as information structuring, open target setting and investment approval. The regulators in the Czech Republic, Iceland and Great Britain commissioned studies using the method to inform regulation, but the final decision was made also on other material. In Sweden, both regulator and TSO have used the results to inform regulation, to justify investment plans and to review areas for future efficiency improvements. The overwhelming majority of the regulators are interested to repeat an international benchmarking in 2012/2013, at least 18 of 19 surveyed countries.

System operations

TenneT has proportionally high costs for system operations (SO): power system operations, reserves, congestion management and balancing services. Being an import country with capacity problems on especially the German border, the Netherlands is facing demand-matching costs that are substantial. A comparative study should be announced and planned, although with care taken to obtain robust and comparable results. Our analysis highlights two problem in the short run: lack of information and an heterogeneous task scope. Both problems are currently being addressed in the European coordination bodies CEER and ENTSO-E, warranting for the future feasibility of such study.

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1. Introduction

1.01 This report is commissioned by the Dutch Office of Energy Regulation (Energiekamer, EK), Den Haag, within a project (**S**pecial **Ten**neT **A**ssessment, STENA) on efficiency analysis for TenneT, both for EHV and HV operations.

1.02 The authors of this report from SUMICSID have been prof.dr. Per Agrell and prof.dr. Peter Bogetoft, Senior Associates.

Background

1.03 The Office of Energy Regulation (EK) needs a comprehensive analysis of the cost efficiency of the transmission system operator TenneT in order to prepare the indexation parameters for the revenue cap during the fifth regulatory period (2011-2013). In absence of national comparators, the international regulatory benchmarking ECOM+ by SUMICSID in 2003 and 2005, with extensions in 2006, were used as basis for the determination of the individual X-factor during the second, third and fourth regulatory periods. The current project is a consistent continuation of the regulatory policy established by former Dte at the outset of the economic regulation of transmission system operations.

1.04 The overall objective for all parts of this Mission is to establish a sound, reliable and consistent set of estimates for cost inefficiency in 2006 (also called static efficiency, or incumbent efficiency since it is a snapshot in time) and future productivity gains (also called dynamic efficiency or productivity) for all operations of TenneT for the fifth regulatory period that are likely to be successfully defendable in a potential judicial appeal of their use in the determination of relevant parameters.

Outline

1.05 The report contains separate analyses of transmission operations (TO) for extra high voltage (EHV) and high voltage (HV) assets, as well as a first benchmarking effort on System Operations (SO). The outline of the report is as follows:

1.06 TO: Chapter 2 contains the static analyses of TenneT TO EHV along with general documentation for the chosen models, Chapter 3 contains the dynamic analyses using three complementary approaches, Chapter 4 provides a brief summary of related post-e^{3}GRID work by other European energy regulators.

1.07 SO: Chapter 5 is devoted to a feasibility study for benchmarking of System Operations for TenneT TSO, complemented with a list of literature in the List of References (6).

Status of document

1.08 This document is released in final format as a public version of a complete report that in addition contains certain confidential data for the operator.

2. TO: Static results

2.1 Overview

2.01 The following chapter is devoted to the analysis of the static cost efficiency, i.e. the state of efficient cost at a given year, here primarily 2006. After a short introduction to EHV operations, the study presents the methods and models used, followed by documentation of the means to assure structural comparability to cost and asset standardization. An analysis of the data situation for the HV operations is made. After the results for EHV, respectively, three specific sensitivity analyses document the calculations and the robustness of the results. The chapter is closed with some conclusions and recommendations.

2.2 Introduction EHV

2.02 The TenneT EHV operations correspond to the original task scope in ECOM+ 2003 and 2005, as well as in the e^{3}GRID study. Both the asset structure and the type of activities thus correlate well to the standard assessment of TSO performance, with other European peers as well as with past performance for TenneT itself.

2.03 Analysis shows that TenneT EHV has a relatively "pure" character, the asset base is young, homogenous and the operations are highly leveraged (low staff count).

2.04 TenneT has already been benchmarked in e^{3}GRID. In the e^{3}GRID benchmarking all investments from 1965 are included to construct a comparative capital expenditure measure, irrespective of whether these investments have been depreciated or not and the regulatory conditions under which the investments are treated today. This approach is the only possible in a general benchmarking, as the national regulatory agreements at the respective introductions of the IEM directive are not applicable in other countries. An important difference with respect to this study is that here all investments prior to 2001 are "forgiven", meaning that all real investment values are replaced by standardized values (the asset weights) corresponding to average European investment costs. Consequently, some operators that today have low or high costs due to good or bad investments in the 1970s, 1980s, 1990s are put on equal footing and only compared on their recent investments in the last years (namely 2001-2006). This modification changes the ranking of a number of TSOs from the e^{3}GRID benchmarking with respect to TenneT.

2.3 Methods

2.05 The methods are described in detail in e.g. Agrell and Bogetoft (2009), here is short overview of the used models, based on a schematic model in Figure 2-1 below. The purpose of any benchmarking model is to evaluate how efficiently resources are transformed into outputs (here transmission grid provision services) subject to some exogenous environmental conditions, potentially random. Since the managerial effort is unobservable, the model needs comparable observations (cost, output, complicating factors) to establish a *reference set* for benchmarking. If the benchmarking technique used does not allow for complicating factors, the corresponding reference set can be reduced prior to the benchmarking to include only observations that employ a comparable technology (known from some other information). This is the case with the Unit Cost approach below. However, a powerful method such as Data Envelopment Analysis (DEA) allows for multiple inputs and outputs and the cohesion of the reference set can to some extent be identified endogenously by *statistical outlier detection techniques*. This gives the advantage of permitting more precision in the modeling phase and limit the risk for model specification errors by analysts.

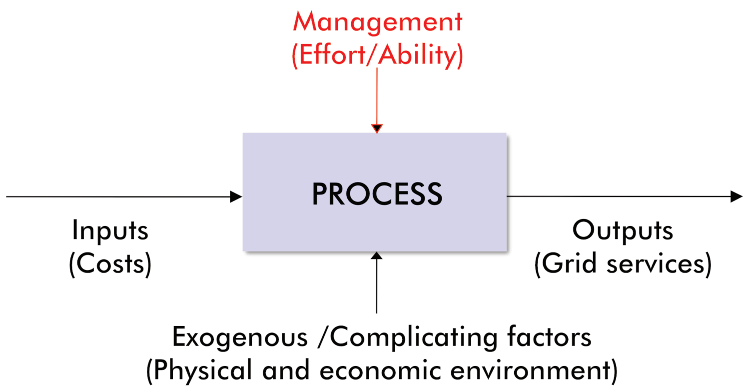

Figure 2-1 Schematic representation of benchmarking model.

Unit cost approach

2.06 The unit cost approach, similar to ECOM+ but with higher scope, is based on a normalization of the grid assets into a single number: the proxy grid output (normalized grid), cf Figure 2-2. Simplified, one may say that the unit cost approach concentrates on the provision of the grid in itself, irrespective of why it has been built, how and where it is used. The normalization includes both the CAPEX and OPEX consequences of given grid assets. The comparability of the results is assured by cost standardization including corrections for exogenous and operator-specific cost items such as national salary levels, right-of-way fees (compensation paid to landowners for the use of their land grid installations or access roads to such), cost of land leased or owned and other element (see below).

Figure 2-2 The Unit Cost (UC) model, cf ECOM+.

2.07 The method is based on constant returns to scale, a single output variable and specific operating conditions (such as asset standards or non-standard operations) are corrected through direct adjustments to the norm after investigation (not made in this case).

Non-parametric methods

2.08 The non-parametric best-practice methods, such as DEA, assume that there are multiple cost drivers with unknown relative effects and that the optimal performance can be observed and emulated from a set of comparable operators, the peers. In the following we use four models to analyze the performance of TenneT. The first model (see Figure 2-3) is a Totex model that is analogous to the retained model in e^3GRID, two others are decompositions for Capex and Opex efficiency, respectively. The fourth model in Figure 2-3 is used to calculate the impact of Capex forgiveness for EHV operations.

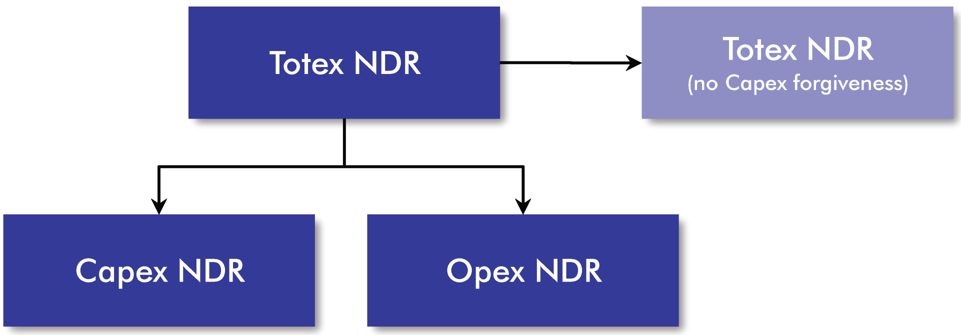

Figure 2-3 Decomposition of DEA models for TO: EHV and EHV+HV.

DEA Model Totex Grid–Density-Renewables

2.09 In order to take into account a higher amount of relevant cost drivers for the European TSOs, SUMICSID developed a set of DEA models that were validated on the full dataset and a large number of potential cost drivers and environmental factors. The principal DEA model, Totex Grid-

Density-Renewables, conforms to the retained model in e^{3}GRID, validated for a TOTEX assessment with 22 operators. It derives a TOTEX efficiency measure from two outputs: [N]ormalized grid and [R]enewable generation input, including hydro. A third cost driver, population [D]ensity (Figure 2-4), is not an output from the transmission operations in itself, but a proxy for environmental conditions linked to increased costs and requirements from urbanization and intensive land-use.

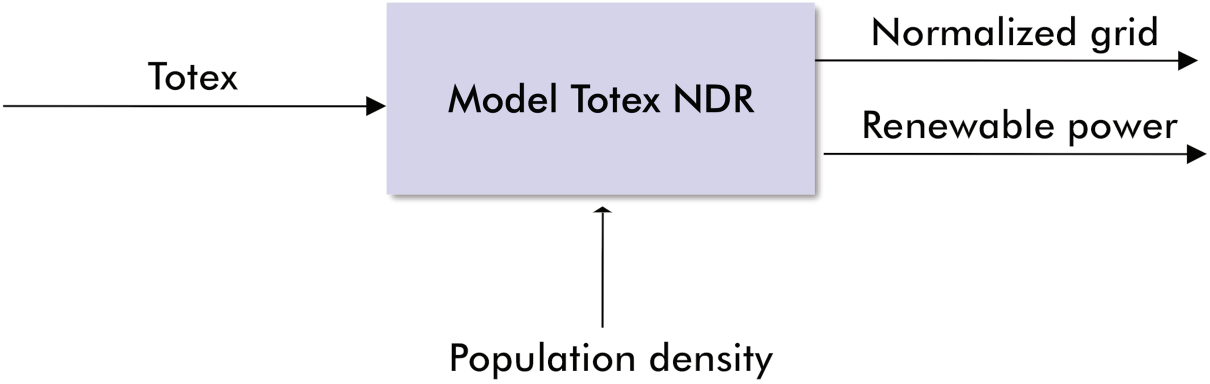

Figure 2-4 DEA Model Totex N[ormalized grid] D[ensity] R[enewable power].

Model Opex Grid–Density-Renewables

2.10 To give an information about the Opex-efficient while still maintaining the full cost base, Model Opex Grid-Density-Renewables is used. In this model (Figure 2-5) the only controllable input is Opex, while the Capex (subject to the same forgiveness procedure as above) is treated as an initial condition, a constraint. If the Capex is removed from the model, then unfeasible and suboptimal target may be identified from a Totex-viewpoint since it renders the Capex-level invisible or irrelevant. Model Opex Grid-Density-Renewables can be seen as a more radical variant of Model Totex Grid-Density-Renewables, but is use in e.g. UK and Portugal. It should be noted, however, that the addition of an extra model variable has an impact on the capacity of the model to differentiate among observations for small samples. In short, the estimated average efficiency from this decomposition is at least as high as the one for the Totex Grid-Density-Renewables model and normally higher.

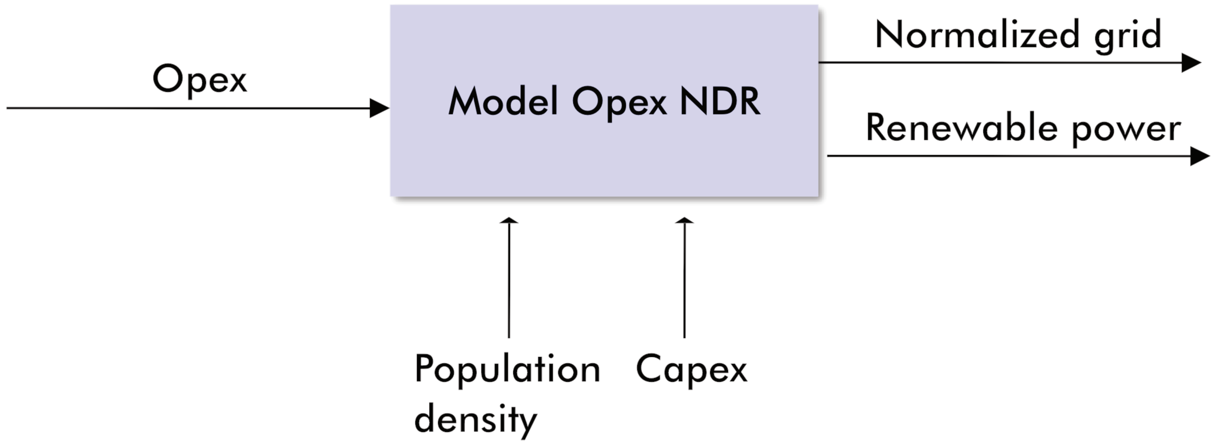

Figure 2-5 DEA Model Opex N[ormalized grid] D[ensity] R[enewable power].

Model Capex Grid-Density-Renewables

2.11 Totex consists of Opex and Capex, it is thus logical to decomposed the results from the Totex Grid-Density-Renewables model also for the Capex side using an analogous approach as for Opex. The Capex Grid-Density-Renewables model (Figure 2-6) assumes that Capex (as always expressed as a standardized real annuity) is controllable and that the Opex level is a given condition. The other variables (Grid-Density-Renewables) are identical, meaning that both decomposed models simply allocate a given sum (Totex) into smaller parts that are controllable and non-controllable, respectively. The remark above on the relation between model dimension and average efficiency is still valid.

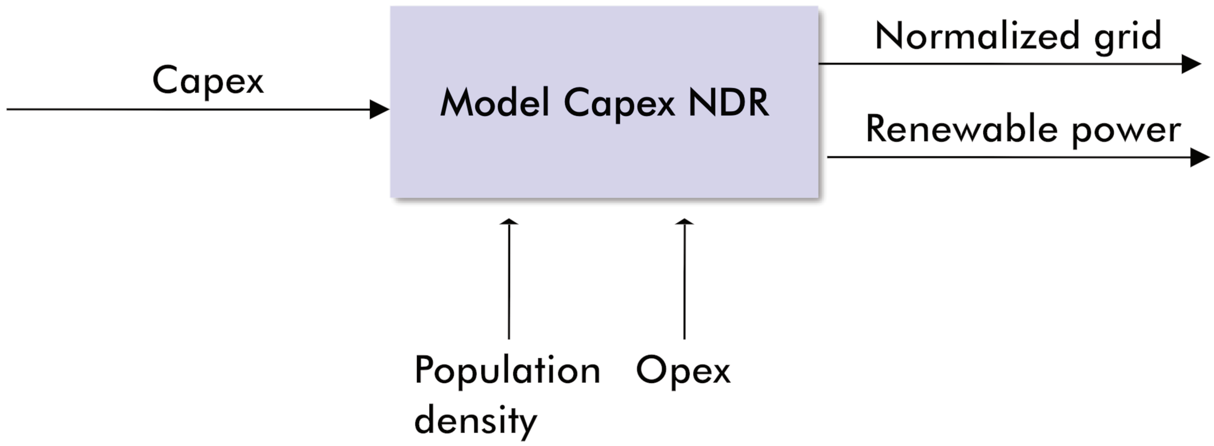

Figure 2-6 DEA Model Capex N[ormalized grid] D[ensity] R[enewable power].

2.4 Structural comparability

2.12 The data for the comparison are made comparable through several standardization steps outlined below.

Costs (functional decomposition)

2.13 The costs from e3GRID emanate from a validating process involving TSO-reviews, independents audits or NRA-controls as well as a review by expert consultants in several stages and involving feedback in three rounds. The functional decomposition is based on an established standard documented in specific guides. In addition, the analysis of cost homogeneity made in the project has eliminated activities and costs (such as market facilitation, out of scope costs and system operations) that were not mature for benchmarking in the 2008 study. The resulting datamaterial must be considered as of unprecedented quality for its purpose.

2.14 In the benchmarking, the activities Construction C, Maintenance M, Planning P and Administration A have been consistently used throughout all runs. For the HV cost reporting, only categories M and A have been used. The full cost of administration has been used without reallocation to other functions (S, X), in accordance with the e3GRID study to increase robustness to different staff intensity for these functions and subsequently, differing overhead allocation.

Personnel costs

2.15 The cost for internal staff is corrected using a European TSO cost index as to level the relative costs to a European average. The reported staff costs and staff numbers (fte) give an average salary (e.g., 54,689 EUR/fte in 2005) are below average European manpower compensation for TSO personnel, leading to a negative impact on benchmarked cost after correction. Unless proven the contrary by corrections of the staff numbers, any correction of the outsourcing costs would have to be negative as well. Due to assumptions of market origin and available data, no correction has been made in the runs below for outsourced staff. Such analysis can be made as sensitivity analysis.

Operator-specific conditions

2.16 No allowances other than those used in e3GRID have been made for other TSOs data. No corrections have been made of the TenneT costs claims for tower painting, since the suggestions submitted by the operator in e3GRID were not approved in the structured process for operator-specific claims in e3GRID (Call Z). In short, it was not shown that TenneT had other legal or regulatory obligations than other operators concerning the choice of paint or the frequency of repainting, making it a decision under the control of the operator.

Time (inflation)

2.17 The EK parameters for depreciation times per asset have been used for all TSO in the runs. Standard national CPI is used as inflation corrector, as in the e3GRID study. This parameter causes changes to the Capex component of all TSO in the direction of increasing its importance (5.4% as opposed to 4.86% in e3GRID). The impact of the change in parameters is negligible, around 0.5% change in unit cost metrics.

2.18 The EHV asset data for TenneT is unchanged from the audited and validated data base used in e3GRID study.

HV data

2.19 Data was provided from TenneT and EK with intention to enable benchmarking of the recently acquired HV grid operations. The HV asset data was reported separately by the operator using the e3GRID asset definitions and templates. No specific technical validation has been made of this reporting that in large seems to correspond to expected values. However, it is noticed that the HV submission for overhead lines in its entirety covers lines under 'special conditions' code, meaning specifically difficult conditions. As noted in Figure 2-7 below, TenneT is an outlier in this respect. The impact of this classification is a 45% higher Capex-weight assigned to the lines and thus a potential overestimation of the capital investment efficiency. This reporting is not immediately justified by e.g. a higher number of [steel] towers per circuit km of overhead line, as this value is close to the average for the sample. This observation leads to the conclusion that the asset data requires additional auditing to be comparable to other TSO data. The operating costs obtained from EK for the HV grid, on the other hand, may include operations from DSOs that are no longer performed or omit operations that will be necessary. Moreover, the incomplete staff data provided does neither match published data in the annual reports, nor validating data for expected salary ranges for the staff category. Here, we face a problem of data consistency, since the sources of the asset data and the cost data are not the same. Consequently, it is unclear whether the operator will indeed continue operation on these terms for 2009 or 2010. Finally, benchmarking of HV assets in the e3GRID benchmarking of TSOs relies on the assumption that the included assets (EHV and some HV) are deployed in an integrated system for transmission system services. In practice, this means that e.g. HV lines used in sparsely interconnected systems such as Norway are used for supply security and vital for the local matching of supply and demand. However, HV assets that are composed of primarily radial segments for transport from substations to MV layers are not integrated in TSO operations and lack the additional equipment and information that HV-TSO or HV-RTO assets require. Given the contradictory data for asset configuration and staff intensity, we cannot reject the conjecture that the integrated assets may be of DSO rather than TSO deployment in terms of installation standard, control equipment and documentation. As the HV assets altogether represent a significant amount, doubling the size of the operator, uncertainty in these dimensions may lead to unacceptable errors in either direction. Given these findings and the preliminary analysis of the HV asset data, we conclude that robust benchmarking cannot be obtained using these data in an otherwise validated TSO dataset (e^{3}GRID).

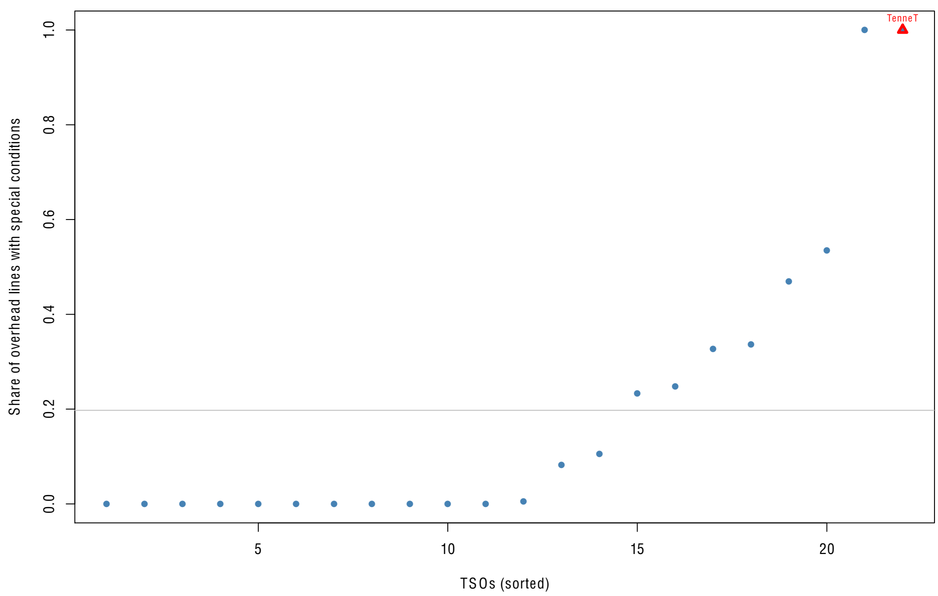

Figure 2-7 Reported share of overhead lines with special conditions, e3GRID 2006.

Asset life times

2.20 The EK-provided life times are used as in Table 2-1 below, differing somewhat from the standardized lifetimes used in e^{3}GRID. For both the EHV and HV assets, information is available to calculate the exact lifetime for each investment year, i.e. the annuity for any year. The result is a reestimation of the average investment age profile from 48.4 years for TenneT EHV, implying an annuity value of 5.859 %.

Table 2-1 Asset life times in STENA and e³GRID.

Asset category	STENA lifetime [yrs]	e³GRID lifetime [yrs]
Line	55	60
Cable	50	50
Circuit end	42	45
Transformer	35	40
Comp. device	42	40
Series comp.	42	40
Control center	30	30
Other installation	30	30

Cost data HV

Reference sets

2.21 The original data set from e³GRID contains 22 operators from 19 countries. An overview of the results demonstrates that there is a certain spread among the observations, part of which can be explained by a specific low-cost technology used in Scandinavia (flexible tower design) and by costly non-grid related costs for some operators. Although it remains to be shown to what extent it would be impossible to adopt any of the features of the Nordic technology on the continent, we have chosen to exclude these operators from the principal reference set based on a given criterion. In this manner, a maximum of information is retained while assuring comparability under a minimum of *ad hoc* interventions. Consequently, we operate with two sets: the full set (W1) of 22 operators for sensitivity analysis and a restricted set (W2) consisting of 17 operators for benchmarking.

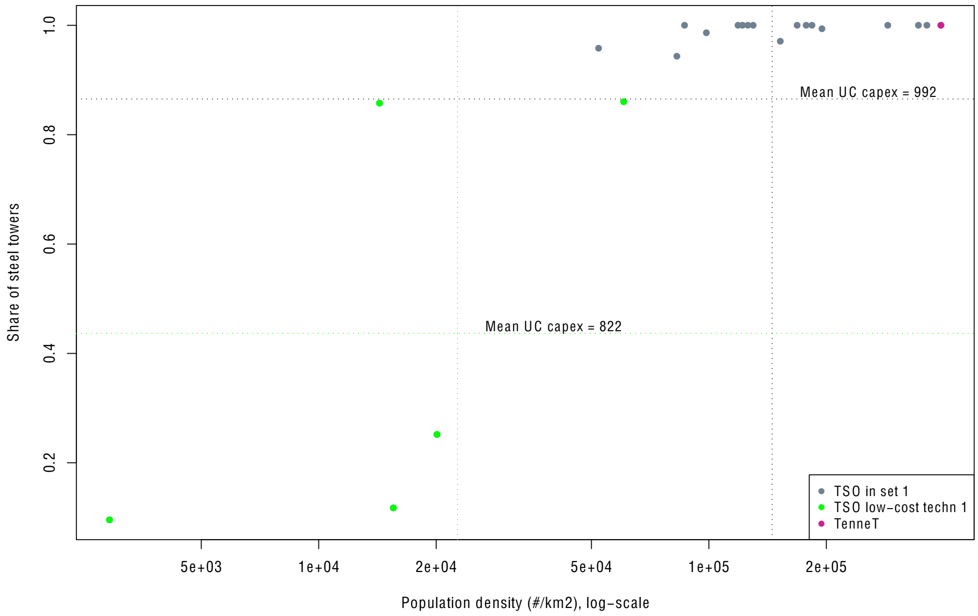

Figure 2-8 Share of steel towers vs population density and average Unit cost, 2006.

2.22 Set 2 excludes from the complete set of e3GRID operators five units that are deploying the low-cost technology. The low-cost technology is defined from the share of non-steel towers, cf Figure 2-8 , shown to be a valid proxy for a technology (long stretches of wooden cable-stayed towers, wide corridors, parallel transport lines) resulting in very low unit costs for sparsely populated countries (average Unit cost Totex is 822 compared to 992 for the continental sample in the figure). Note that the difference in technology is not limited to a question of tower design (wooden cable-stayed vs steel towers), but this variable is correlated to a series of structural choices leading to low cost service in sparsely populated areas under moderately difficult environmental challenges. The remaining set contains 17 operators for 2006 that can be classified as "continental" and represent different sizes and output profiles.

2.5 Static results

Assessment EHV

2.23 The EHV results are both intriguing (low unit-cost results and high DEA-results) and evident (variables included in both models) when considering the specificities of TenneT and the models. We analyze first the Unit Cost model and then the DEA model.

2.24 In the Unit Cost models for the relevant reference set W2, TenneT EHV is stable around 65% for Totex with Capex forgiveness. The partial efficiencies are 49.5% for Capex and 45% for Opex The Totex results for the full horizon is significantly lower than the score for Capex forgiveness: 45%. This is explained by the high Capex inefficiency for the period prior to 2000 (see Figure 2-10 below and the scores in the last row of Table 2-2 for partial Capex efficiency). For Totex and Opex, the score is very close to average, although at a distance from best-practice. For Capex partial, TenneT EHV scores above average. Note that partial efficiencies for Opex and Capex do not sum to the Totex efficiency as the partial peers are different on each axis. Given the fact that the Unit Cost scores are for a given reference set already subject to removal of less comparable operators, the recommended score is the Totex score, i.e. 45%.

Table 2-2 Best-practice results Unit Cost EHV, 2006, W2.

Model	TenneT EHV	Average
Totex (all years)	44.96%	61.44%
Totex (with Capex forgiven -2000)	65.48%	64.52%
Opex	45.28%	48.69%
Capex (with Capex forgiven -2000)	49.52%	49.66%
Capex (all years)	29.96%	47.73%

2.25 The average practice models Table 2-3 naturally depend on the chosen reference set, but most importantly on whether the capital efficiency forgiveness is extended to all operators or only limited to TenneT. In the latter case, TenneT performs significantly better than average for obvious reasons, in the former case, its performance is below in Totex and Opex. For Totex and Capex under forgiveness -2000, TenneT EHV has a typically average cost, invariant to which reference set that is chosen. For best-of-three practice, we note the small difference in Totex under Capex forgiveness -2000, a sign that the “champions” in the large set depend on low Capex values from earlier periods, as well as a 10%-unit lower Opex.

Table 2-3 Average-practice results Unit Cost EHV, 2006.

Model	TenneT EHV wrt best-3 average	TenneT EHV wrt average
Totex (all years)	46.76%	73.18%
Totex (with Capex forgiven -2000)	74.42%	101.48%
Opex	50.16%	93.00%
Capex (with Capex forgiven -2000)	71.20%	99.72%
Capex (all years)	35.69%	62.78%

DEA Results

2.26 The relevant best-practice DEA results are presented in Table 2-4, i.e. the CRS/NDRS models on the restricted dataset (W2). It is notable that the results are very stable both within type of model (CRS/NDRS). The CRS/NDRS score is equal to the Unit Cost score on the same data, which is not a general finding. Average-practice DEA scores (simply the best-practice score divided by average DEA score for each model and set) are given in Table 2-5.

2.27 The decomposed values for Capex and Opex confirm the findings from the Unit Cost model as long as it operates with CRS/NDRS and all datapoints, i.e. around 40%-50% partial efficiency on Opex and 55%-56% partial Capex efficiency.

Table 2-4 Best-practice DEA Results TenneT EHV, 2006, W2.

Model	CRS	NDRS
Totex (all years)	49.73%	49.73%
Totex (with Capex forgiven -2000)	65.64%	65.64%
Opex	53.87%	53.87%
Capex (with Capex forgiven -2000)	56.13%	56.13%

Table 2-5 Average-practice DEA/CRS Results TenneT EHV, 2006, W2.

Model	TenneT EHV wrt best-3 average	TenneT EHV wrt average
Totex (all years)	49.73%	66.83%
Totex (with Capex forgiven -2000)	69.40%	94.53%
Opex	53.87%	86.53%
Capex (with Capex forgiven -2000)	56.13%	82.14%

2.6 Sensitivity analysis: Impact of Capex forgiveness

2.28 The decision to not assess Capex efficiency prior to 2001 can be analyzed from two perspectives: the choice of horizon for the stranded cost forgiveness and the overall impact on benchmarked efficient cost under various settings.

Choice of horizon length

2.29 It is interesting to note that the timing of the Capex forgiveness coincides with a shift in investment efficiency policy at TenneT (see Figure 2-9). In fact, as shown, the choice minimizes the benchmarked Totex for TenneT, meaning that an earlier choice would penalize through including inefficient investments and a later choice by penalizing efficient investments.

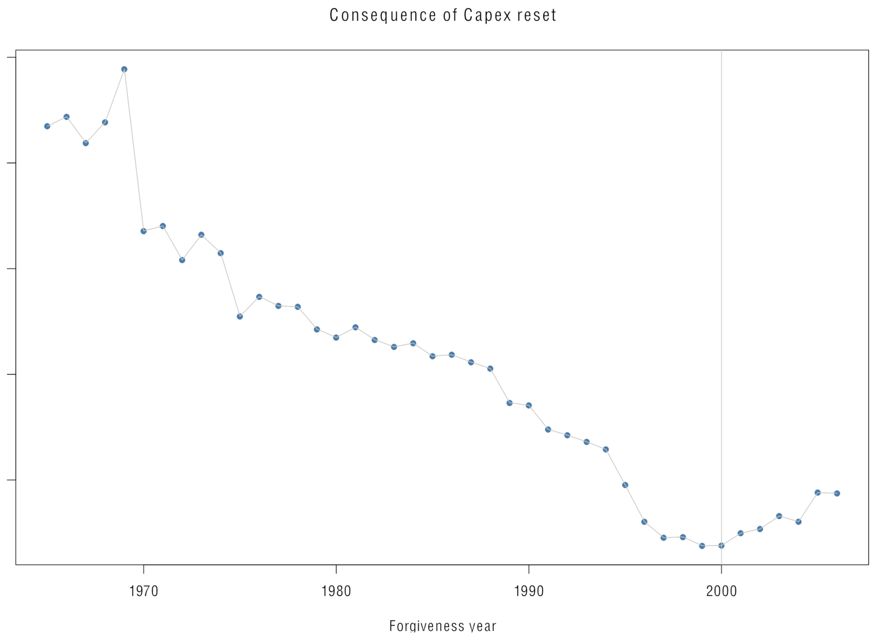

Figure 2-9 Benchmarked Totex EHV as a function of forgiveness year.

2.30 As noted in Figure 2-10, TenneT is one of relatively few TSO to benefit to this degree from the Capex forgiveness. The vertical axis shows the difference in unit cost (Totex) before and after introducing Capex forgiveness until 2000. For many TSOs, the investments prior to 2000 were characterized as efficiency-improving, meaning that they were lower than European average costs. As a consequence, their Totex actually increases if those real investment values are replaced by average values, thereby increasing unit cost for Capex and Totex. In the figure, the average impact as a dashed red line is positive, i.e. that a reset of Capex to average European values would increase their unit cost compared to actual unit cost by around 10.8%-units. Below the horizontal line marking no impact of the forgiveness, we find essentially two groups, one with two isolated firms radically profiting from the forgiveness, one of which is an outlier in the general e^{3}GRID study. TenneT is located in an intermediate group consisting of four grids, with TenneT decreasing their unit cost by about 26.5%-units. This means that

TenneT in the international benchmarking with full cost carries a "bagpack" of 26.5% of extra Capex from pre-2001 investments that impacts their comparison with other grids. This capital inefficiency relative to other grids is until now effectively considered as stranded cost through the Capex forgiveness treatment.

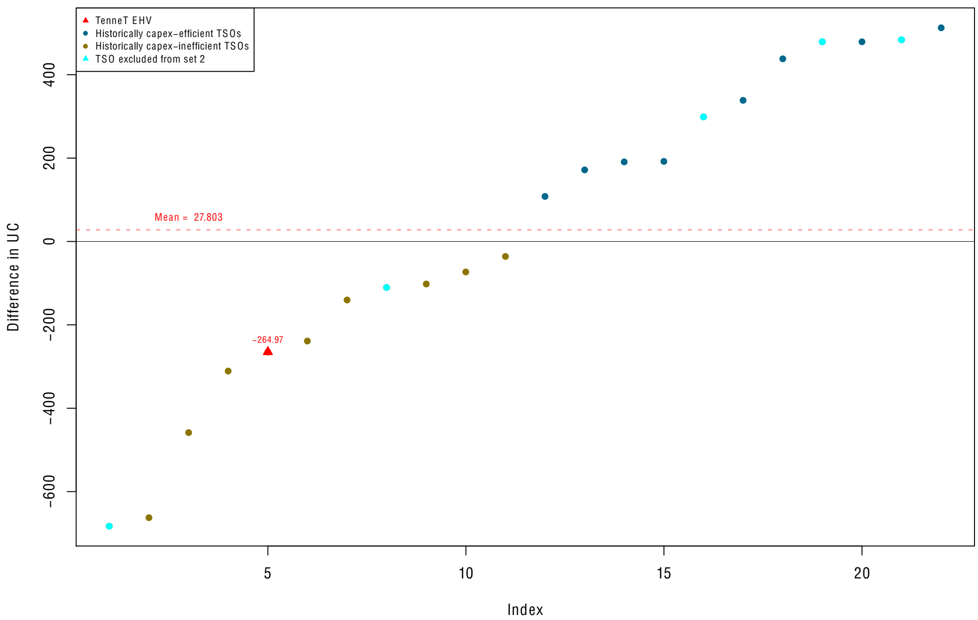

Figure 2-10 Impact of Capex forgiveness on unit cost (Totex, EHV, 2006).

Overall impact EHV

2.31 As already illustrated in Figure 2-9 above, a Capex forgiveness from 2001 on average *increases* benchmarked cost, whereas it decreases the cost for TenneT by around 21.6% of full-horizon Totex. Impact is not sensitive to assumptions of scale (CRS or NDRS), nor output dimensions such as density.

Conclusion Capex forgiveness

2.32 The reset of Capex prior to 2001 is shown to have important consequences on the reference set, leading to the irrelevance of Capex efficiency gains older than six years for the efficiency assessment. Not only does it "lean" the TenneT benchmarked cost, it also "pads" most of the other units with additional benchmarked cost to neutralize their efficient historic investments. For EHV, the impact is an increase in Totex of unit cost for 20%-units from 45% to 65.5% (in the smaller continental sample), whereas the average for the other units only changes by 3%-units. The Capex forgiveness makes the EHV operations from a high-cost operator into an average European unit-cost performer.

2.33 The simplest assessment of initial Capex efficiency at the break year 2000 is made through unit cost analysis of Capex. To be cautious, the analysis only includes a set of TSOs from countries in Western Europe with opening asset bases prior to 2000 and not belonging to the "low-cost" operators excluded from set 2. The resulting set has 13 operators that are closely resembling TenneT in terms of investment profile. The results and calculations are given in Table 2-6 below and graphically illustrated in Figure 2-11. Following the logic of the numbers, the average continental operator had a Capex-efficiency of 89% in 2000, relative to European normalized Capex values, whereas TenneT had 69% as corresponding value. Thus, compared to the average continental operator, the Capex efficiency of TenneT was 0.69/0.89 = 78.2% in 2000. What does it mean? That the TenneT Capex that was declared efficient in 2000 in fact contained at least 21.8% of Capex inefficiency compared to a conservative set of average European continental operators. Compared to best-practice the inefficiency is 50.6%.

Table 2-6 Analysis Capex efficiency TenneT EHV in 2000.

	TenneT EHV		Average (13 operators)	
Model	Normalized	Actual	Normalized	Actual
UC Capex (2000)	737.2	1063.6	704.7	878.9
Ratios:				
normalized/actual	0.69		0.89	
average Capex eff.	0.69/0.89 = 0.782		0.89/0.89 = 1.00	
best practice Capex eff.	0.69/1.40 = 0.494		0.89/1.40 = 0.64	

2.34 However dramatic this may seem, seen as a one-shot event there is no methodological problem associated with the approach. Indeed, it does bring a clear focus on the very recent investments that may provide clear targets.

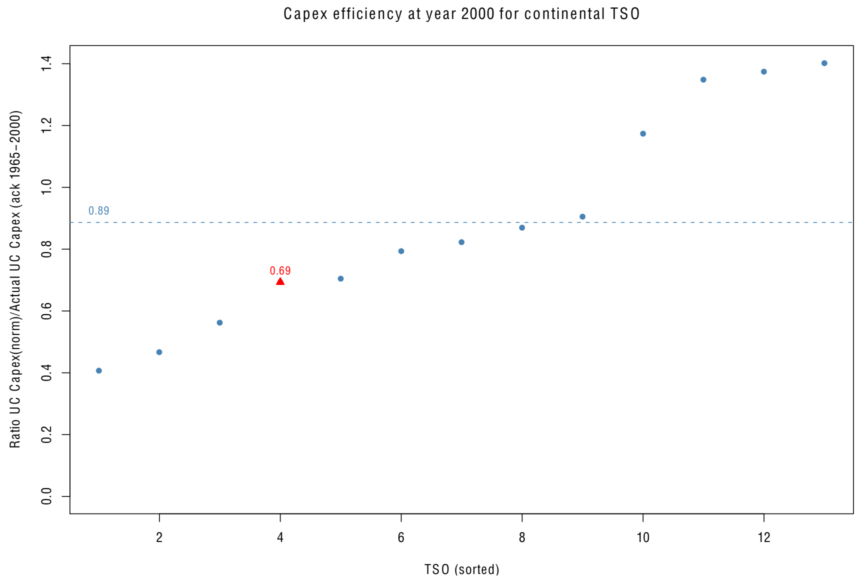

Figure 2-11 Ratio of Capex efficiency at year 2000 for a set of 13 European (continental, West) TSO.

2.7 Sensitivity analysis: Impact of scale assumptions

2.35 DEA is a robust data-driven benchmarking method. However, one of the few necessary assumptions concerns the returns to scale, which basically determines how projections are made from larger or smaller units than the one evaluated. The most general assumption is constant returns to scale (CRS), where a unit may be compared both a smaller unit scaled upwards (e.g. Luxemburg can be compared to France using a scaling parameter) as well as a larger unit scaled downwards (e.g. the Netherlands might correspond to 25% of the grid length of Svenska Kraftnät in Sweden, thus 25% of the overall costs). The assumption has been challenged by smaller units arguing that they have fixed costs (each grid must have one CEO, one legal department etc) and that scaling downwards ignore those costs. Larger grids, however, should have all the possibilities of organizing themselves as the smaller grids internally. The resulting assumption, i.e. comparison uniquely with smaller grids, is called non-decreasing returns to scale (NDRS), and is in use in Germany for network regulation of both gas and electricity at all levels (excluding gas transmission). For transmission grids, it can be seen as a cautious assumption that waives the obligation of the analyst or regulator to show that there are no fixed costs at play.

2.36 It is important to assure that the obtained results are robust to any assumptions regarding the returns to scale in the DEA model (we recall that the Unit Cost model is based on constant returns to scale by construction). The analysis is illustrated in Figure 2-12 for EHV. It is clearly visible in the figures, as well as in Table 2-4 in more detail, that the behavior of the estimator is very similar across EHV for comparable models. For CRS and NDRS, the scores for DEA are close to the corresponding scores for the Unit Cost Totex measure, for DRS and VRS (implying possibility of decreasing returns to scale for large units) the DEA estimator indicates full efficiency. In particular, the high density dimension for TenneT renders it fully efficient under VRS and DRS irrespective of other dimensions.

2.37 We can conclude that the scale assumption does not have any major impact, for TenneT the NDRS and CRS scores are perfectly correlated. In the interest of cautiousness and consistency with e[3]GRID, it may be preferable to communicate the NDRS score rather than the CRS. There is no convincing theoretical or practical evidence to use VRS or DRS as assumptions for transmission grids.

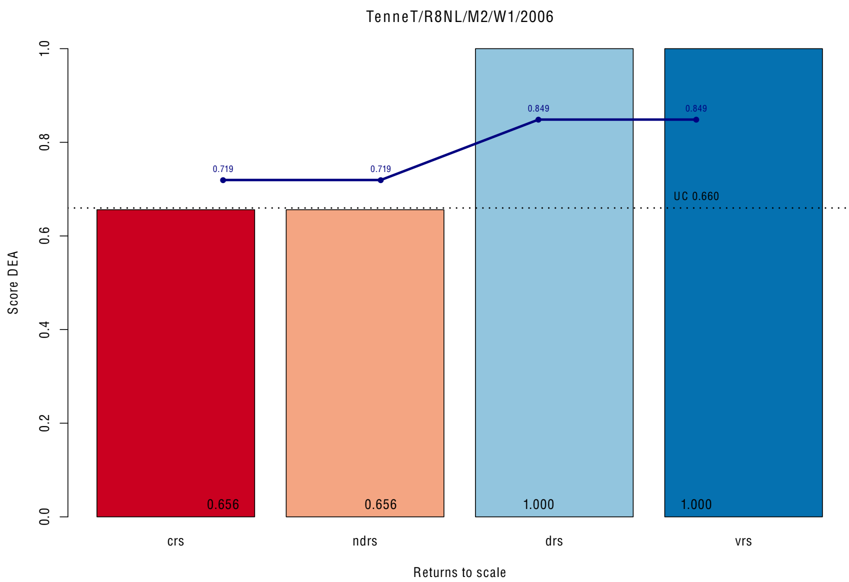

Figure 2-12 Impact of returns to scale on DEA results. Bars denote score for TenneT EHV,2006, solid line score denote average score, 22 operators.

2.8 Sensitivity analysis: Alternative models

2.38 It is beyond the scope of the current report to investigate the sensitivity of the results with respect to different methods than the DEA frontier methods and the Unit Cost approach. However, as already underlined above, the findings of the data are relatively robust with respect to a range of methods thanks to a limited number of variables. One example is a simple regression model as basis for the COLS (corrected OLS) method illustrated in Figure 2-13. Not only does it correlate well with the Unit Cost method (not shown), which falls out immediately from the linear structure of the two, but also the DEA model below. Thus, we conjecture, in line with the full evaluation in Agrell and Bogetoft (2009), that the model specification is relatively robust to choice of estimation method.

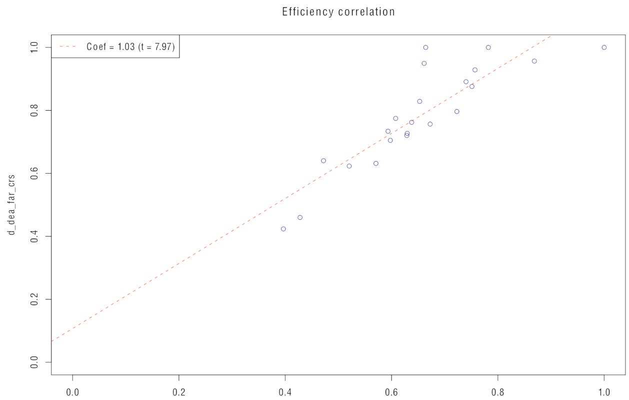

Figure 2-13 Correlation COLS vs DEA/CRS.

2.9 Conclusions

Quantitative

2.39 The recommended models and their results are summarized in below. The recommended values are the Totex assessments for which both the unit cost estimates and the DEA model (NDRS-CRS, set 2) correlate; i.e 45%/49.7% for EHV. The initial Capex efficiency in the year of 2000 is conservatively estimated to 78.2%/49.4% using unit cost metrics (continental practice and best-practice, respectively).

Table 2-7 Summary of static results TenneT EHV, 2006, W2.

	TenneT EHV	
Model	DEA	UC
Totex (all years)	**0.497**	**0.450**
Totex / Capex forgiveness	0.656	0.655
Opex	0.539	0.453
Capex	0.561	0.495
Efficiency of Capex 1965-2000	**0.782**/0.494	

Qualitative

2.40 HV costs and asset data are not shown to be of reliable quality, relating to a well-defined set of operations under the control of the operator. Asset data are shown to be partially exaggerated in Capex, the use of the HV assets is not determined, nor their factual separation from the DSOs. Cost and staff data are incomplete and stem from sources outside of TenneT. Moreover, there is some uncertainty to whether the Opex stated fully covers the acquired asset base and whether the conservative assumptions used to integrate the assets in the data are justified. A quantitative analysis based on such data, comparing it with high-quality validated data from e^{3}GRID would simply obscure the large uncertainty related to the data.

2.41 No allowance has been given for the claim on tower painting, in accordance with the assessment at the main e^{3}GRID benchmarking for EHV operations. Still, the cost development for TenneT EHV has been significantly steeper than for other grids during the entire period even if such correction would have been made. The cost development is particularly driven by non-staff maintenance costs whereas the operator shows a positive development for e.g. support costs.

2.42 In best-practice methods, such as DEA under various assumptions, the results for TenneT are either very poor, in the case the full sample is used, or very good, in the case a reduced sample is used after correction for investment efficiency differences until 2000. This makes the standard DEA model from e^{3}GRID less adequate for adjusted benchmarking of TenneT. The reason is twofold:

2.43 First, TenneT is one of the most investment-inefficient grids in the sample until 2000, whereas many of the older, cost-leading grids achieved efficiency gains through alternative procurement already in the 1980s. The Capex efficiency break levels these differences by adding average costs to benchmark operators benefitting from low investment cost in real life. This effect is a direct consequence of a settlement for stranded costs.

2.44 Second, the dimensionality of the DEA-model in combination with the number of available TSOs after removal of various grids that employ different technologies lead to a relatively small sample in which the probability of showing up as efficiency becomes large.

3. TO: Dynamic results

3.01 Productivity and efficiency concepts are closely related to the idea of a "frontier" formed by all best-practice units operating as well as possible at any given time. Over time, this frontier is moving, or "shifting" forward as units innovate, rationalize and introduce new technologies. Frontier shifts, also called *technological change rates,* are sector-wide changes of the productivity level and do not depend on the individual enterprise. In fact, frontier shifts can be calculated using international samples for the same technology without worrying about the comparison of individual units in the sample.

3.02 The frontier shift derived from such changes in the soft- and hardware of an industry can be expected to be less dependent on the specific unit being analyzed. Frontier shift is a matter of change over time, and even if the level of efficiency may depend on many local factors, the change in level is likely to be rather uniform. In turn, this suggests that one can derive interesting frontier shifts from several data sets and that the usual problem of structural comparability (validation of task base, asset base standards etc) are less important. It also implies that as long as a data set refers to entities of the same country, the usual problems of making international comparisons (correcting for differences in labor cost, fuel costs, inflation etc) can be eliminated.

3.03 On the other hand, the evaluation of changes is complicated by increased variance. The variance of an estimate of a difference or ratio may be significantly larger that the variance of its components (depending of course of the correlation between the two). This means that more years and more data sets are important in the estimation of frontier shifts.

3.04 For these reasons, we have undertaken several investigations into the frontier shifts. Large HV networks with separated, validated data are found only in Norway, Sweden and USA as RTO (Regional Transmission Operators). To get insight into the pace of technological change in the TSOs and RTOs, we have done estimations of frontier shifts based on

- A group of European TSO, some of which have large sets of HV assets (the e^{3}GRID approach), for which we have implemented the Capex forgiveness that applies to the static assessment of TenneT.
- A large group of Norwegian RTOs
- A large group of US RTOs

3.05 In the following, we report on these findings before making preliminary conclusions on likely frontier shifts and TSOs and RTOs.

3.1 European TSOs

3.06 The e3GRID project as summarized in Agrell and Bogetoft(2009) involved 22 European TSOs, some of which have large sets of HV assets. The dynamic results using the frontier model for a panel 2003-2006 developed in the project report on a yearly productivity growth for best-practice electricity transmission operators in the range of 2.2-2.5% in total expenditure for CMPA. A specific run for the STENA study using Totex under Capex forgiveness prior to 2001 yields an annual productivity growth of 2.6% for the timeperiod 2003-2006 using the full set of operators.

3.07 These frontier shift are for TOTEX model models, and since CAPEX generally adjusts much slower than OPEX, one may be tempted to conclude that the TOTEX change is a lower bound for the OPEX change. This is correct when it comes to catch-up effects, but one may question the argument in the case of frontier shifts. Truly, an innovation may be implemented at a slower rate in CAPEX since it takes time to change the assets, but this might just mean that innovation have smaller but longer marginal impact and aggregating these, one might argue that OPEX frontier shift may not be higher than TOTEX frontier shifts.

3.2 Norwegian RTOs

3.08 In Norway, the electrical distribution and transmission networks have been under high powered incentive schemes since the deregulation in 1994.

3.09 The model for regional transmission companies operating at 60 kV and above used to be a DEA based model with constant return to scale, a TOTEX measure as the input, and four outputs related to Network length, Capacity, Transformation activities and a Forest correction.

3.10 Consistent data for 51 RTOs for this model is available at www.nve.no, and we have used this information to calculate the Malmquist index *M* and its decomposition into Technical Change (TC) and Efficiency Change (EC) reflecting frontiers shifts and catch-up respectively. The results are shown in Table 3-1 below.

Table 3-1 Norwegian RTOs

Totex	2001-2004
Mi(y,x | C,S)	1.041
EC	1.021
TC	1.020
CPI growth	4.30%

3.11 These changes are calculated using running prices and there does not correct for inflation. With an inflation in this period of approximate 4.3 (based on CPI growth) this suggest a yearly frontier shift of approximately (2+4.3)%/3 = 2.1% in real terms.

3.12 Again, it should be noted that this is based on a TOTEX measure that will develop more slowly than a OPEX measure. Also, the fact that the RTOs have been under a high powered regime for several years suggest that the frontier shift is not simply a transitional or a data quality phenomena.

3.3 US RTOs and TSOs

3.13 To investigate the technological progress in a longer time span and under different regulatory conditions, we developed an aggregate transmission model using US data from FERC Form 1. Consistent data is available or the period 1994 to 2005 , excluding two years (2000 and 2002) for which statistical validation has shown poor consistency and reporting errors.

3.14 The FERC data base contains information of 114-139 system operators per year with full information on the relevant variables. A series of DEA models have been estimated. The data has been pre-cleaned using ratio filters (e.g. energy/peakload < 8760 h), and the estimation of the basic efficiency analyses models for each year have involved outlier detections and removal using a Banker threshold of 2.0, i.e. units with super-efficiency above 2 has been removed.

3.15 Based on the analyses of alternative model specifications a best model was established as in Figure 3-1 below. It explains the cost of operating and maintaining the network by cost drivers related to the capacity provision, the transport work and the asset intensity.

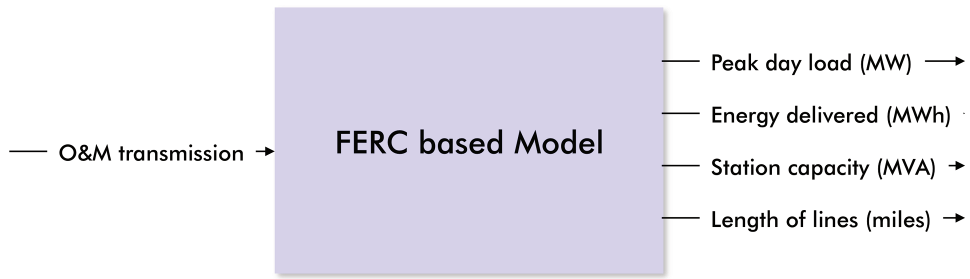

Figure 3-1 US RTOS and TSO model based on FERC data

3.16 We see that the sample contains a significant number of small networks – and a considerable variation in the size of networks. A concern in such cases is usually if the small and large units are really comparable as assumed under the assumption of constant return to scale as it is commonly used in the analyses of Malmquist decompositions. We have therefore for all model specifications done both crs and vrs analyses and compared the results. The general finding is that in the crs model, the small units are significantly more efficient than the large ones. This means that the larger units are generally dominated by a combination of a few very small units scaled up. Since data quality may well be worse for the small units, we therefore decided to rely on a vrs specification. This turns out to lower the estimated frontier shift and is therefore a choice in accordance with a cautiousness principle.

3.17 Using the resulting model, we calculate Malmquist indices for every unit and every subsequent pairs of years, e.g. from 1994 to 1995, from 1995 to 1996 etc. The Malmquist index for every unit was decomposed into a frontier shift TC and a catch up EC. The average for any of these across units are calculated, both in simple arithmetic form and in cost weighted average form. The results for the M and TC indices are shown together with average efficiencies of the TSOs / RTOs below..

3.18 Lastly, we average the yearly changes over the periods. The results are shown in Table 3-2 below in nominal terms, i.e. without any inflation adjustment.

Table 3-2 Annual changes in US RTO, nominal values, 1994-2005 (ex 2000).

	Malmquist M	Frontier shift (TC)	Efficiency change (EC)
Arithmetic average	1.057	1.005	1.061
Opex-weighted average	0.997	0.994	1.020

3.19 Inflation does not impact the EC since a unit in the EC calculation is compared to a frontier from the same year. Inflation does however affect the estimated frontier shift since a change in costs should occur simply from inflation. The inflation rate therefore comes on top of the nominal frontier shift to create the frontier shift in real terms. To be precise, (1+frontier shift in nominal values)(1+inflation)=(1+frontier shift in real terms).

3.20 To correct for inflation, one should ideally use a mix of a labor price index and an index for goods and services (which again depends on the labor price in related industries). There are no labor or goods and service index directly related to electrical TSO and RTO activities in the US. However, to cover changes in goods and service price, we can use the consumer price index CPI from US Bureau of Labor Statistics, www.bls.gov, with an annual increase of 2.64% from 1994 to 2005. Alternatively, we can use the Producer Price Index fro Construction Machinery Manufacturing from Bureau of Labor Statistics which in the period 1994 to 2006 showed an annual increase of 2.56%. To be cautious, we choose the latter as an indication of inflation in the goods and service parts. To index the labor part, it is more appropriate to use a total compensation cost index. Using the index for All Workers, again provided by Bureau of Labor Statistics, we see that the average annual increase from 1994 to 2005 is 3.45% per year. With labor and goods and services weighted equally, we therefore get an average inflation adjustment equal to 0.5(3.45%+2.56%) = 3.01%.

3.21 In nominal terms, the frontier shift is approximately nil, namely +0.5% in normal mean values and -0.6% as a weighted average. Choosing once again cautiously and since the weighted averaged also makes more sense conceptually, we use -0.6% which combined with the inflation correction of 3.01% leads to a frontier shift in real terms of 2.41%.

3.22 We consider this to be a cautious estimate – in part because the elimination of year 2002 significantly lowers the average frontier shift.

3.4 Decomposition of dynamics in Opex and Capex

3.23 In addition to the above analyses, we have investigated if it is possible to decompose the frontier shift and the catch-up effects into Opex and Capex related effects using the e3GRID data. The analysis different from the dynamic analysis in Agrell and Bogetoft (2009) for the e3GRID project since the capital base is normalized to average EU-values for all firms up and until 2000. The US data and the Norwegian data does not have the necessary level of detail in Capex to allow this decomposition in the scope of this project. The outcome from this investigation is negative, the results are not robust. The reasons for this are the following: The small number of observations makes frontier estimates depend intimately on the details of the units involved. In addition, when we move from Totex evaluations to conditional Opex and conditional Capex evaluations respectively, we increase the number of dimensions and in turn make the frontier for a given TSO even more dependent on individual observations. In clear, the assumption that the frontier shift is based on a sector wide movement is no longer supported, it becomes the consequence of some few operators' individual actions. It is clear from our investigations, that the available data cannot be used for this level of decomposition for productivity changes.

3.5 Conclusions

3.24 In addition to the specific analyses above, we have made a general literature survey to look for studies that may inform us about the likely productivity development in the TSO and RTO industry. These studies tend to report values in the same interval.

3.25 We therefore maintain that the frontier shift in the electrical TSO and RTO industry is in the interval from 2.1% to 2.5% per year. This is the interval identified by a larger group of European TSOs (some with RTO activities) (2.2%-2.5%), the same group of European TSOs with Capex forgiveness (2.6%), a large group of Norwegian RTOs (2.1%), and a large group of US TSOs and RTOs (2.4%).

4. TO: Post-e^{3}GRID work by other NRAs

4.1 Overview

4.01 Transmission system regulation under the IEM Directives 2003/54/EC, as well as under the CBT regulations EC 1228/2003, requires the establishment of "efficient costs for structurally comparable operators" in determining (part of) the reimbursement for the operation and the access conditions to the grids and transit services. Such rather explicit reference to relative efficiency is of course a reflection of the initiatives and joint projects among national regulatory authorities (NRAs) to exchange information and facilitate the organization of international benchmarking to inform regulatory decisions. In the following chapter, we give a brief overview without claims of exhaustiveness and endorsement by the quoted NRAs. The presentation of the policies adopted in the past and future refer to the authors' assessment of the policies and informal contacts with the regulators, not official responses to any inquiry from SUMICSID or the Energy Office.

4.02 A summary of the situation January 2010 in some countries in the European Union and EFTA is presented in Table 4-1 below where the use of benchmarking, participation in e^{3}GRID in 2008 and/or 2012, further exploitation of e^{3}GRID results, and type of use of the e^{3}GRID results are indicated. The entries are Y[es], N[o] and (Y) for planned or projected application. The use of results are divided into IND[ividual] results such as static scores (even in combination with frontier shift estimates, FS (Frontier Shift) and INFO[rmation] for data gathering, TSO monitoring besides incentive regulation, negotiations on other conditions or other indirect use. We note that of 30 countries, 22 have provisions for or regularly conduct TSO benchmarking as part of the regulation. Of these 22 countries, 19 participated in e^{3}GRID, 1 in an immediate predecessor to e^{3}GRID (RAMIEL) using the same methodology and 1 use an other methodology. The e^{3}GRID countries are apparently eager to use the results: there has been 7 specific studies for NRAs and an additional 5 studies are either planned, requested or performed in pair TSO-NRA.

Table 4-1 NRAs: participation and use of benchmarking in TSO regulation.

Country	Benchmarking TSO	e3GRID?	Customized e3GRID	Use of results	TSO Benchmarking 2012/2013
Austria	Y	Y	(Y)	IND	Y
Belgium	Y	N	Y	IND	Y
Bulgaria	N	N			
Cyprus	Y	Y	N	FS	Y
Czech Republic	Y	Y	Y	FS	Y
Denmark	Y	Y	Y	IND	Y
Estonia	(Y)	N	N	FS	Y
Finland	Y	Y	N	(Y)	Y
France	(Y)	N			
Germany	Y	Y	Y	IND	Y
Greece	N	N			
Hungary	(Y)	(Y)			
Iceland	Y	Y	Y	IND	Y
Ireland	Y	N			
Italy	N	Y	N	N	Y
Latvia	N	N			
Lithuania	(Y)	Y	N	FS	Y
Luxemburg	Y	Y	(Y)	N	Y
Malta	N	N			
Netherlands	Y	Y	Y	IND	Y
Norway	Y	Y	N	IND	Y
Poland	Y	Y	N	INFO	Y
Portugal	Y	Y	Y	IND	Y
Romania	N	N			
Slovakia	N	N			
Slovenia	Y	(Y)			
Spain	Y	Y	(Y)	N	Y
Sweden	(Y)	Y	(Y)	INFO	Y
Switzerland	N	N			
United Kingdom	Y	Y	(Y)	INFO	N
Y	17	17	7	0	18
(Y)	5	2	5	1	0
N	8	11	7	3	1
IND	0	0	0	8	0
FS	0	0	0	4	0
INFO	0	0	0	3	0
	30	30	19	19	19

Use of results

4.03 We have information on application from 16 countries and of absence of use from 3 countries that participated in e³GRID. Most countries applying the results as individual regulation of revenue or price-cap parameters (IND, 8 countries), followed by 4 countries using the technology change rate. Finally, 3 regulators use the information from e[3]GRID for other purposes; for public monitoring, negotiations with the TSO or data reporting standards for other potential use.

Future prospects

4.04 The chances for a continued international benchmarking of electricity transmission system operators are very good; of 19 surveyed countries 18 affirmed their willingness to participate and only one expressed a reserved response. The coverage of the benchmarking is large: besides France (that participated in the preparation of the e[3]GRID benchmarking 2008 but declined in the last minute), all major operators are part of the study. We interpret these signals as positive for both the development of NRA collaboration and as a sign of confidence in the value obtained from the e[3]GRID benchmarking.

4.05 We now review some selected countries in more detail. The same disclaimer as above applies to the analyses.

4.2 Belgium

4.06 The regulator CREG launched a highpowered regulation for the transmission system operators in 2007 with legal obligation to publish tariff parameters, including the general and individual X-factors in June 2007. The electricity TSO Elia (EHV+HV) was subject to a study deploying the e[3]GRID-ECOM+ methodology for EHV and an international RTO model for the HV assets by SUMICSID where estimates of the incumbent cost efficiency and the expected frontier shift were calculated. The results were implemented in the first revenue cap 2009-2011. Given the extent of the study in 2007 and the timing of the revenue cap, the operator and the regulator chose not to participate in e[3]GRID in 2008.

4.3 Czech Republic

4.07 The regulator in the Czech Republic commissioned a specific study in early 2009 for the operator CEPS. The purpose was to inform tariff setting in a new high powered regime from 2009. The e[3]GRID results served here as partial input for the process, which partially included negotiations with the operator on the relevant cost base, organization and rate of catch-up. The direct use of the study was to apply the technology change rate in negotiations with the TSO as to agree on an individual X-factor.

4.4 Denmark

4.08 In Denmark, the TSO activities was taken over by state-owned Energinet.dk in 2005. Following this, there has been some uncertainty as to the role of the regulator. The regulator can no longer directly set or negotiate revenue caps with the Danish TSO. Rather, the regulator's role is to monitor the performance of Energinet.dk and to inform the owner, the Ministry of Climate and Energy, about the efficiency and improvement potentials of Energinet.dk

4.09 Before 2005, ECON+ was used in the setting of revenue caps for the two Danish TSOs at that time. This year, the Regulator in their information to the Ministry of Climate and Energy has used e^{3}GRID with supplementary runs by SUMICSID.

4.10 Specifically, the post e3GRD runs have involved three rounds with a series of data corrections, a series of analyses based on sub-samples of the e^{3}GRID set of TSOs that Denmark usually are compared to and a series of alternate model specifications (Renewable Power with or without water) and models with or without Renewable Power. Also different cost scopes have been analyzed with a particular focus on Totex and Adjusted Totex.

4.11 The background material and the information prepared for the Ministry of Climate and Energy can be seen here (in Danish): http://www.energitilsynet.dk/afgoerelser-mv/4/elektricitet/afgoerelser-el/effektiviteten-i-energinetdks-el-transmission/

4.5 Germany

4.12 The German regulation of transmission system operators follows directly from the relatively detailed provisions in the Ordinance on Incentive Regulation (ARegV), specifying that all gas and electricity TSOs (there are four electricity TSOs in Germany) should be regulated by international benchmarking, and if the results or data are judged inadequate, by use of technical reference network models (such as those in use in Spain and formerly in Sweden). The ordinance also specifies the eligible set of comparators (EU members) and explicit reference is given to admissible methods (Data Envelopment Analysis and Stochastic Frontier Analysis).

4.13 The German federal regulatory authority, Bundesnetzagentur, commissioned a specific report in June 2008, finally delivered early 2009, where the specific constraints from the ordinance (reference set, controllable cost basis, parameters and methods) were taken into account. The final regulatory decision was based only on DEA under non-decreasing returns to scale assumption for a somewhat reduced subset of the e³GRID comparators after elimination of DEA-detected outliers in accordance with the ordinance (final set 17 operators).

4.14 The scope of the assessment in Germany for the first period was limited to Construction, Maintenance, Planning and Administration. The costs for System operations and Market Facilitation were indeed examined using other methods, but given the absence of proof of inefficiency or imprudent expenditure at that time, the individual X-factor applied to total controllable cost was weighted average between the result from the specific e³GRID study and a zero weight for admissible cost for system operation and market facilitation.

4.15 The formal decision for the revenue cap beginning 01/01/2009 was announced by the Beschlusskammer (Decision Chamber) in December 2008 and the scores or the method were not subject to appeal during 2009.

4.6 Great Britain

4.16 OFGEM participated in e³GRID with three operators; National Grid Electricity Transmission (NGET), Scottish Hydro Electric Transmission (SHETL) and Scottish Power Transmission Limited (SPTL). The regulation of transmission operations by OFGEM is an mixture of incentive regulation with respect to system operations, offshore connections and Opex-regulation based on prospective targets. No specific econometric methodology has been applied to transmission operations, but several approaches to bottoms-up-assessments of the "building-block" type have been performed by the NRA and its consultants. 2009/2010 OFGEM is performing the Transmission Price Review (TPR) for the operators and have adjusted the information collection format to the study. The operators, in particular NGET, have been very active in the analysis and development of the e³GRID analysis in the UK context.

4.7 Iceland

4.17 The network regulation in Iceland changed to incentive regulation from 2008, prompting revisions of the conditions for both DSOs and the TSO, Landsnett. Currently, Landsnett operates a national EHV and HV network in the sparsely populated country with the industrial clients as major load. The regulator, Orkustofnun, commissioned a specific study of the efficiency of Landsnett based on the e³GRID results, aimed at investigating the sources of inefficiency and in particular the sensitivity to changes in the exchange rate of the ISK to EUR and labor cost variations.

4.18 Given the governmental crisis in Iceland in the aftermath of the financial crisis in 2008-2009, the economic regulation of Landsnett is still under preparation.

4.8 Norway

4.19 NVE, the Norwegian regulatory authority and Statnett, the Norwegian electricity TSO, have been one of the forerunners in regulatory benchmarking starting with the 1998 study by ECON matching Statnett with neighboring Svenska Kraftnät. Later, NVE was one of the initiators (along with Dte) of the ECOM+ benchmarkings for regulation in 2003 and 2005, as well as a participant of the 2008 e^{3}GRID benchmarking. The results of efficiency benchmarking affects a single X-term in the revenue cap, analogous to the DSO regulation. The revenue cap with benchmarking only applies to grid provision, system operation is subject to a forward looking negotiated target. The operator was declared cost efficient using the DEA method of NDRS and outlier removal, which lead NVE to apply a zero-term for the individual efficiency factor for the regulatory period 2009-2011.

4.9 Portugal

4.20 The regulation of REN, the Portuguese electricity TSO, has been made using international benchmarking since the second ECOM+ round in 2005, where the regulator ERSE made provisions to incorporate the assessment in the regulatory policy.

4.21 The specificities of the electricity Act apply to the out of scope elements and to the definition of controllable cost. Since REN had to assume the role of Single Buyer for the still captive clients during a transition period and also had to incorporate the gas TSO during 2006-2008 without added resources for administration and overhead, a number of elements are reduced from their audited accounts. The controllable cost basis for REN until and inclusive the second regulatory period does not include CAPEX, due to regulatory commitments made at the privatization, nor personnel costs for fixed staff, due to stranded costs due to staff under employment status equivalent to civil servants.

4.22 A confidential study, particularly focusing at operational cost development since the last ECOM+ study using several methods (DEA and Unit Cost) was commissioned and reported in October 2008. The results of the study were implemented as an individual X-factor on controllable costs as defined by their ordinance and embedded in the hearing for tariff review for the second regulatory period in 2009 to 2012.

4.10 Sweden

4.23 The Swedish TSO, Svenska Kraftnät, was from the outset formed as a governmental commercial entity, a governance form combining the legal and financial advantages of being directly under Ministry of Energy and the Environment as an agency and the managerial effectiveness obtained in [nationalized] enterprise. However, as for the Danish counterpart since 2008, the regulation is limited to supervision of overall tariff pressure and due dilligence by the regulatory authority, Energimarknadsinspektionen (Energy Market Inspectorate).

4.24 Svenska Kraftnät participated in e^3GRID in 2008 and came out as highly efficient in both Capex and Opex. The results were released in a joint statement by the regulator and the operator in June 2009, at the occasion of the endorsement of the investment plan 2010-2012. It is worth noting that the operator has initiated a specific study with SUMICSID using the e^3GRID methodology for early 2010 in order to explore strong and weak points of its efficiency.

5. SO: Benchmarking system operations

5.1 Principles

5.01 This chapter develops a further analysis of the prospects of making an integrated or specific benchmarking including operations-based functions, notably system operations.

5.02 As a general principle, any activity can be subject to meaningful regulatory benchmarking if the underlying task if well defined, the task scope covered by the benchmarking model, the inputs and outputs are verifiable and form a coherent production space adequately explaining allocated resources, and there is a reference set of structurally comparable observations that form valid and repeatable examples of production or service. Note that the requirements for regulatory benchmarking are stricter than those for internal or process-driven benchmarking, where the purpose primarily is learning through the identification of close peers. In regulatory benchmarking, the purpose of the exercise is normally to establish a minimal cost function, implying that the interior points are less important than the best-practice points. However, the norm used (best-practice or average-practice) does not affect the criteria adopted above.

5.03 TenneT is actually participating in a process benchmarking on System Operations jointly commissioned to KEMA Consulting by 22 TSOs (cf. Franken et al. (2006, 2008). Below, we will make some reference to this project and its assumptions.

5.2 Definition of system operations

5.04 The purpose of system operations is to ensure the real-time energy balance, to manage congestion, to schedule and dispatch generation (or to review the technical feasibility of schedules submitted by others), to perform failure analysis and detection, to manage the availability and coordination for preventive and reactive reparations, and to acquire ancillary services such as disturbance reserves and voltage support, maintaining technical quality and balance within the coherent electricity supply system, also ensuring that the necessary supply capacity for physical regulation of the system is available. System operations are subject to the limitations of the existing grid, but information arrangements and tariff structure may either aggravate or alleviate congestion management problems. It also deals with the day-to-day management of the network functionality, including personnel safety (instructions, training), equipment security including relay protection, operation security, coordination with operations management of the neighbouring grids, coupling and decoupling in the network and allowances to contractors acting on the live grid. Given its central position in terms of market and technical information, the competence and independence of the system operator will have short- as well as long-term effects on social welfare. System operations may entail delegating operational balance services to subordinate (regional) transmission coordinators with limited decision rights.

5.05 In particular, we refer all costs and revenues from national and international congestion management to system operations, as well as all direct and indirect costs related to balance markets.

5.06 Costs, imposed or not, for spinning reserves, capacity provision or out-of-market guarantees or caps in case of power shortage are for the purposes of this study referred to as system operations.

5.3 Analysis of system operations costs

5.07 System operations costs constitute a major part of the operating budget for a transmission system operator. Thus, it would be unfortunate not to submit these costs to some performance assessment, like those for the asset-based functions CMPA. Based on the reasoning below, a complementary data collection was made in the e^{3}GRID project for system operations costs divided into eight predefined activities.

Activities for which cost data exists

5.08 Power system operations:

1) *Operations planning*
2) *Scheduling*
3) *Real time system monitoring and control*
4) *Coordination of system maintenance (safety)*

5.09 *Congestion management*. Costs and revenues resulting from the application of regulation EC 1228/2003 on cross-border exchanges. Cost item provided for consolidation.

5.10 *Balancing services (mechanisms)*. Costs and revenues accrued to the TSO for establishement of balance between generation and load, e.g. through being residual claimant in a balance market based on bidding or delegating to balancing responsible parties.

5.11 *Ancillary services* (less balancing and energy losses)

1) *power flow control (reactive and active)*
2) *reactive power*

3) *frequency control*
4) *restoration of supply (black start, islanding)*

5.12 Power reserves

1) *Secondary power reserve (spinning reserve). Definition: the unused capacity which can be activated on decision of the system operator and which is provided by devices that are synchronized to the network and able to affect the active power. Corresponds to the UCTE secondary (automatic and central) and synchronized tertiary control reserves (manual and central). (Rebours, Hirschen, 2005). Excludes primary power reserve, see below.*
2) *Primary power reserve, defined as unused capacity provided by TSOs solidarily inside the UCTE area, activated within 30 seconds.*

5.13 Telecommunications

1) *Commercial ITC. Call C, art 5.18. Revenues from sale or rental of telecommunication services or assets to third parties (not included in basic access tariffs), costs resulting from the depreciation, operation, leasing or staffing of such services or assets. E.g. costs and revenues for giving access on fiber cables to commercial telephone operators. Assets in this activity are counted as non-grid related.*
2) *Operational ITC. Costs for telecommunication services internal to the TSO, used to operate, monitor and document the operations and state of the grid. (Note that this position will be reallocated to M). Assets in this activity are considered grid-related and should appear in the investment stream.*

5.14 *Services to other grids*. Any costs and revenues from services in S other than those listed above (please specify under comments) provided to other grids, generators or end users.

5.15 *Training*. Costs and revenues providing both internal and external services related to training or operators, including development of instruction material and software as well as acquisition and maintenance of training facilities

1) *Training activities (internal/external)*
2) *Simulators for training (assets, operations).*

5.16 *Other* (residual from reported cost in S)

Complementary data collection

5.17 Cost data (complementary decomposition of data already reported in Call C) and physical data along with some questions regarding legal services obligations and market organization for balancing and ancillary services were collected between 21/10/2008 – 07/11/2008 for a total of nine TSO forming an unbalanced panel 2003-2006. No useful responses were given for physical and legal data.

Alternative System operation process definition

5.18 To contrast the work by SUMICSID above, we summarize some other relevant work using a different process definition. In Franken et al. (2006, 2008) documenting an industry-sponsored benchmarking by KEMA Consulting, the main system operation processes are defined as

1) *Operations planning*
2) *Scheduling*
3) *Real time operation*
4) *After the fact*
5) *Support (mainly IT)*

5.19 For each of these processes, Franken et al. (2008) define partial performance measures for which annual data are voluntarily collected from the participants, such as for Real Time Operations:

1) *Frequency control performance*
2) *Average overall system deviation*
3) *Generation and load instructions*
4) *Personnel on shift*
5) *Real Time Operations transmission outages taken*

5.20 The input to the KEMA process benchmarking models is almost exclusively staff intensity (fte) as this avoids all cost correction issues treated above. However, as argued in Franken et al. (2008), the chosen input correlates poorly to many of the performance metrics selected (in particular those related to system stability and safety) and the actual model is using a hedonic output (= uniform for all TSOs). Further, assuming constant returns to scale for environmental factors, a regression model is used.

5.21 An example for Operations Planning. The dependent variable is the number of fte staff annually allocated to the activity (self-reported), Z.

$$Z_i = \alpha + \beta_1 EF_1 + \beta_2 EF_2$$

where alfa and beta are regression constants and EF_1 and EF_2 are environmental factors, calculated as:

$$EF_1 = CE + w_1 GU + w_2 IL$$
$$EF_2 = PTO + GO + TC$$

where CE is the number of circuit ends (piece count), GU is the number of generating units (pc), IL denotes the number of interconnectors, PTO the number of planned transmission outages, GO the number of planned generation outages, TC is the number of "transmission concerns" and w_1 and w_2 are relative weights (set to 0.5 each in Franken et al. (2006, 2008).

Analysis

5.22 The approach above by KEMA is can be analyzed from several viewpoints. Essentially, the OLS model is based on the assumption that the staff intensity of a particular process in system operations (here operations planning) is driven linearly a proxy for grid size and a (endogenous?) output variable for task complexity (here: planned outages).

5.23 The model above and the OLS approach used are adequate for internal process benchmarking, certainly yielding interesting input for process improvement among the participating grids. However, little or no validation seems to be documented for the critical assumptions behind the severe separation of the different activities, nor is there any serious attempt to estimate cost consequences of the activity.

5.4 Status of power reserves

5.24 In e^3GRID, some participating TSOs submitted evidence concerning costs absorbed by them as residual claimant for the primary and/or secondary power reserve. This was claimed and approved by the experts and the corresponding NRA as a operator specific condition. The justification was a proven heterogeneity in the statutory obligation of the operators to provide for and finance primary and/or secondary power reserves under what is reported as System Operations (S) in the study. Some TSOs are obliged to procure primary and secondary control reserve without symmetric pass-through of costs. The amounts involved are substantial and the arrangement is not transitory.

Application

5.25 Costs for primary and secondary control reserves procured using competitive sourcing under legal obligations were specified separately and excluded from the general evaluation of S in e^3GRID. Complementary information (Call S) was collected from all TSOs regarding the obligations for power reserve and the amounts paid for such procurement (if applicable). Validation was made by NRA endorsement and consolidation to regulated and/or public accounts.

5.5 Analysis

5.26 The problem cited about with power reserves serves as a good illustration of the challenges involved in the benchmarking of system operations. Let us address the previously formulated criteria for a regulatory benchmarking:

Well defined task scope

5.27 As shown from the analysis in Agrell and Bogetoft (2009) and remarks in Franken et al. (2006), the system operations task varies somewhat across countries in Europe due to depth and maturity of the regulated markets, the structure and role of the electricity grid for energy supply and the initiatives of each TSO.

Full task scope covered by the benchmarking model

5.28 Clearly, the partial process models do not purport to cover the task scope (or even partial costs). However, unless the benchmarking model involves outputs such as those defined in the TSO Charter of Accountability (Agrell and Bogetoft, 2005),e.g. Energy at Risk and Value of Energy Not Delivered, the full task scope cannot be covered in the model. In addition, activities such as training, contingency planning and adequacy planning result in system performance that may require longer or dynamic indicators.

Verifiable inputs and exogenous outputs

5.29 The current information base following e^3GRID 2008 does not contain a sufficient number of exogenous output variables to address the largest cost drivers in system operations, namely those related to congestion management, power reserves, balance markets and ancillary services. Worse, since part of these activities are shown to be net income for the TSOs in the data above, care must be taken to account for the endogeneity of the inputs to achieve maximum (or target) output (revenue) on markets that have different level of competition.

Coherent production space

5.30 As shown in the statistical part of Agrell and Bogetoft (2009), further methodological work is necessary to determine the most justified production theoretical assumptions on the production possibility space for system operations. Claims on economies of scale, synergies within the function or with other functions need to be carefully tested using a larger data material.

Model has explanatory power for observed cost

5.31 Agrell and Bogetoft (2009) using the e^3GRID data reveals that the cost drivers for the asset-driven functions (C, M, P, A) are not significant explanatory factors for system operations costs. The derived factors in the preliminary run were not satisfactory and the additionally collected data did not suffice in 2008 to definitely determine a set of explanatory variables.

Reference set of structurally comparable observations

5.32 As argued above, the heterogeneity in the task basis causes difficulties in the direct data collection. Further work is necessary to establish standardized tasks for data collection as has been done with the asset-driven functions. Moreover, aggregation of costs for certain activities (e.g. provision of primary power reserves) clearly differs between countries in both obligation, cost of provision and residual claim of possible gains.

Valid and repeatable examples of production or service.

5.33 System operations involves consequences that relate to strong exogenous influences, such as grid outages, energy price fluctuations and load variations. As the operator is obliged to act prior to the events and even in real time, a hind-sight evaluation using ex post or average prices or volumes requires a careful analysis on how the results are to be used in the regulatory regime. As opposed to the asset-driven functions for grid provision, system operations introduce a potential risk sharing between the regulator and the operator which requires analysis to assure its optimality.

5.6 Conclusion

5.34 In Agrell and Bogetoft (2009) regression studies of the possible scope for frontier models are presented in order to determine common cost drivers for both asset-based functions (C, M, P) and operations-based functions (X and S). However, both statistical results and conceptual reasons (controllability of variables, assumptions about the comparability of factor markets, service heterogeneity) lead to the conclusion that the operations-based functions cannot be included in a common frontier model without making assumptions that might not be compliant with the cautiousness principle adopted initially.

5.35 Indeed, the process models above provide no alternative for the benchmarking, as they require unverifiable information, rely on strong assumptions of separability for the costs and partially on highly endogenous explanatory factors.

Recommendation

5.36 System operations in general and for TenneT in particular should be part of a regulatory benchmarking. However, in the short run the data material is too scant and the task basis not sufficiently well-defined to deliver robust results in 2009.

5.37 Our recommendation is to pursue a coordinated activity of the CEER type made for electricity (e^3GRID) and gas transmission as well as tariff levels. Such project, already discussed as an extension of the e^3GRID benchmarking for 2011, should preferably be made in such depth and scope as to permit unambiguous data definitions and data collection procedures for inclusion in larger models.

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