# Gas TSO efficiency analysis for the Dutch transmission system operator

A REPORT PREPARED FOR ACM

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Contents

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# 1 Introduction

## 1.1 Background

ACM, the Dutch energy regulator, aims to include a static efficiency measure in its method of regulation for GTS, the Dutch gas TSO. Article 13 of the European gas Regulation 715/2009 amongst others stipulates that tariffs of a TSO shall reflect the actual costs incurred, insofar as those costs correspond to those of an efficient and structurally comparable network operator. As GTS is the only gas TSO in the Netherlands, ACM has no national direct comparator to determine whether the costs of GTS are efficient. For this reason ACM uses the German gas TSO benchmark commissioned by Bundesnetzagentur (BNetzA) to determine the static efficiency of GTS.

ACM has commissioned Frontier Economics ("Frontier") and Consentec to undertake a static efficiency analysis for GTS. The aim of the benchmark study is to determine the static efficiency of the costs for GTS based on the data from all gas TSO's participating in the German benchmark undertaken in 2012 and used for the regulatory period 2013-2017, namely

- Thyssengas GmbH
- jordgasTransport
- GRT Gaz
- Nowega
- Open Grid Europe
- GASCADE Gastransport GmbH
- ONTRAS - VNG Gastransport GmbH
- EWE
- Bayernets
- terranets bw GmbH
- Gasunie
- Fluxys
- Dong

As outlined above the study is based on the German gas TSO benchmark commissioned by BNetzA. Hence, the cost and output data for the German gas TSOs were provided from BNetzA to Frontier Economics. No additional data collection from the German gas TSOs was planned at the outset of the study and undertaken during the study. The analysis is based on data from the year 2010.

## 1.2 Structure of the report

The report is structured as follows:

- Framework of the analysis (**section 2**);
- Scope of benchmarking (**section 3**);
- Benchmarking methodology (**section 4**);
- Definition of benchmarked costs (**section 5**);
- Benchmarking parameters (**section 6**);
- Model specification (**section 7**), and
- Final model – calculation of efficiency scores (**section 8**)

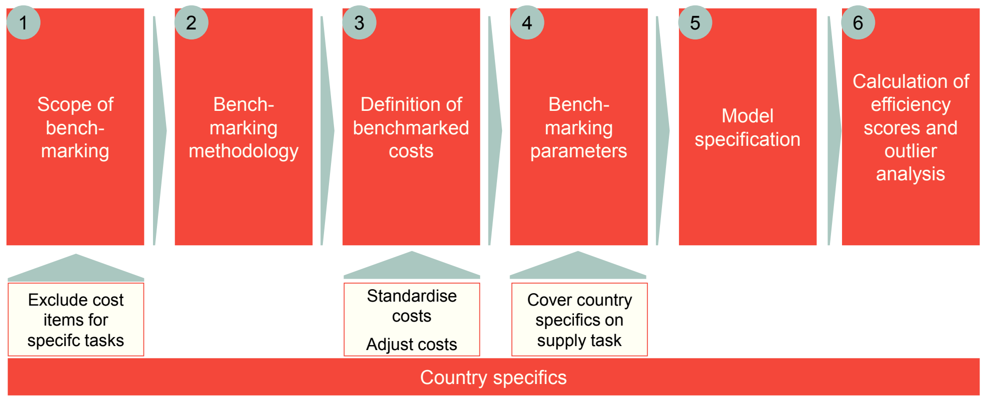
# 2 Framework of the analysis

In the following we briefly describe the sequence of steps for the benchmarking analysis. During the project GTS raised country specific claims which may give rise to adjustments in the benchmarking analysis. These country specific claims covered various topics which were treated at different stages in the analysis.

## 2.1 Steps in benchmarking analysis

In principle any efficiency analysis can be described as a sequence of the following steps (**Figure 1**):

**Figure 1.** Steps in benchmarking analysis




Source: Frontier/Consentec

- **Scope of benchmarking** – TSOs typically carry out several activities. This step defines the tasks undertaken by GTS involved in the benchmarking analysis. In this step, activities that are not comparable between different TSOs can be excluded, thus improving the comparability of the tasks considered in the benchmarking analysis.

- **Benchmarking methodology** – Several benchmarking approaches are available. The approaches differ e.g. in relation to assumptions on functional forms of the cost functions (parametric vs. non-parametric) or how they deal with noise in the data (deterministic vs. stochastic). Which approach is best employed depends on the size of the sample of comparators among other factors.

- **Definition of benchmarked costs** – The costs (input parameters, in short: inputs) may include operating expenditures (OPEX) or total expenditures (TOTEX) also including capital expenditures (CAPEX). Some standardisation of costs may be necessary to make cost data between firms comparable.

- **Benchmarking parameters – output parameter candidates** – This step prepares the selection of benchmarking parameters in order to capture fully the supply task of gas TSOs. The cost driver analysis shall identify those output parameters (in short: outputs), which best reflect the
  - supply task of the transmission system operator; and
  - other structural and environmental factors with an impact on the TSOs' costs.
- **Model specification** – In this step different output parameters are gathered into one benchmarking model in order to get the best representation of the full dimension of the supply task of the transmission system operator. The model specification is based on transparent selection criteria.
- **Calculation of efficiency scores and outlier analyses** – In the final step the efficiency scores of the TSOs are calculated using the benchmarking methodology, benchmarked costs and identified costs drivers for the full dimension of the supply task. We use outlier analyses to validate the robustness of the results.

## 2.2 Dealing with country specifics

International efficiency analysis includes an additional challenge as it has to ensure comparability between companies operating in different countries. Those companies may be exposed to various country specifics. Hence, it is important to take these country specifics into account in the course of the efficiency analysis.

GTS raised various country specific claims. We dealt with the country specific claims at different stages in the analysis:

- **Scope of benchmarking** – Some country specific claims are dealt with in determining the scope of the benchmarking analysis. As a consequence all claims which fall out of the scope of the analysis are rejected per se.
- **Definition of benchmarked costs** – Some country specific claims refer to differences between costs for the German TSOs and GTS. Some claims can be rejected *per se*, because they do not correspond to the scope of the benchmarking analysis and are not included in the database while others can be covered by adjusting /standardising costs.
- **Benchmarking parameters** – Some country specific claims refer to differences in the specific supply task of GTS compared to the German

TSOs. Some claims have to be rejected *per se* because their effects cannot be proven on an empirical basis; others may be covered by certain output parameters, or a further adjustment of costs may be necessary.

## 2.3 Process of the benchmarking analysis

ACM agreed with GTS on a sequential process for this benchmarking analysis described below. We followed the agreed process when undertaking the benchmarking analysis. When writing the report we structured it according to **section 2.1**. During the process various interactions with GTS took place and GTS provided five memos[1], one reaction to a draft report[2] and two expert reports by Jacobs Consultancy[3]. In addition, various interactions with GTS took place in the data gathering and validation process.

- **Dealing with GTS country specific claims**: Covers the discussion and decision of country specifics claims which were raised by GTS during the project. We produced two documents[4] on these claims which were iterated between ACM and GTS. ACM informed GTS in a separate letter about the closing of this sequence. We note that the results from this are included in our steps "scope of benchmarking", "benchmarking costs", and "benchmarking parameters".

- **Long list of parameter candidates**: Covers the derivation of a long list of parameter candidates (cost-drivers) potentially used as outputs in the benchmarking analysis. We note that this is part of our step "benchmarking parameters".

- **Descriptive statistics of parameter candidates:** Covers empirical analysis of the parameter candidates using GTS' and German gas TSOs data. We note that this is part of our step "benchmarking parameters".

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1 GTS, *Memorandum from September, 5th, 2014*; GTS, *Memorandum from December, 24th, 2014*; GTS, *Memorandum from January, 30th, 2015*; GTS, *Memorandum from July, 23rd, 2015 (Ontkoppeld entry-exit van GTS versus voorwaardelijke capaciteit in Duitsland)*; GTS, *Memorandum from July, 23rd, 2015 (Exogene factoren en investeringsbeslissingen)*.

2 GTS, *Reactie GTS draft Frontier Rapport Benchmark*, November, 16th, 2015.

3 Jacobs Consultancy, *Technische Exogene Factoren – een expert opinion op de door GTS aangemerkte technische verschillen, gegeven de verschillen in regelgeving tussen GTS en Duitse TSO's*, September, 1st, 2014; Jacobs Consultancy, *GTS Cost Drivers – Bevolkingsdichtheid en Grondslag*, Rapport opgesteld voor Gasunie Transport Services, October, 26th, 2015. However, we note that the second Jacobs report was submitted by GTS after the process on "country specific claims" was already closed.

4 Frontier Economics/Consentec, *Gas TSO efficiency analysis for the Dutch transmission system operator (GTS) – country specific factors*, note for ACM, July 2015; Frontier Economics/Consentec, *Gas TSO efficiency analysis for the Dutch transmission system operator (GTS)*, interim report for ACM, July 2015.

- **Priority list of parameter candidates:** Covers defining a priority list of parameter candidates from the long-list. We note that this is part of our step “benchmarking parameters”.

- **Model specification:** Covers the definition of a benchmarking model which covers the main supply task of GTS and the German gas TSOs. We note that this is covered by our step “model specification”.

- **Calculation of efficiency scores**: Covers the calculation of efficiency scores for GTS using the model specification derived in the step “model specification”. We note that this is covered in our step “Calculation of efficiency scores and outlier analyses”.

# 3 Scope of benchmarking for GTS

In the following we discuss which tasks of GTS are covered in this benchmarking analysis and the respective implications from this.

## 3.1 GTS tasks and covered tasks

GTS undertakes various tasks which are defined by article 10 and 10a of the "Gaswet":

- "**Transport taak**" – This task includes providing gas transport services and related tasks.
- "**Taak balanceren**" – This task requires GTS to balance the national gas network.
- "**Kwaliteitsconversie**" – This task consists of converting natural gas into a higher or a lower energy density as well as converting natural gas into a composition that is required by its users.
- "**Flexibiliteitsdiensten**" – This task includes the provision of flexibility services. We note that this was a task of GTS in 2010, but it is no longer a task today.

This benchmarking study covers the "Transport taak" (transportation task) and the capex from balancing of GTS. The study does not cover the opex from balancing and the task of quality conversion. We refer to our reasoning below.

The study also does not cover the task of "Flexibiliteitsdiensten", which is not a GTS task any more.

## 3.2 Country specific claims

The scope of the benchmarking analysis has some implications on the relevant costs used in the study and the related country specific claims raised by GTS.

**Table 1** summarise how we deal with country specific claims raised by GTS.

**Table 1.** GTS claims on scope of benchmarking – overview on assessment

| GTS claim | Assessment |
|---|---|
| Balancing costs | • Opex – we exclude opex for the balancing task.<br>• Capex – we include capex for balancing in the study |
| Quality conversion | We exclude the costs for "Kwaliteitsconversie" from GTS cost base:<br>• Opex – exclude GTS opex for "Kwaliteitsconversie".<br>• Capex – exclude GTS physical assets used for "Kwaliteitsconversie".<br>In addition we adjust capital costs and operating expenditures for<br>• Part of compressor stations used for quality conversion: Reducing GTS' historic investments by € 50.8 million. Reducing opex by 787 ths. € and € 533 ths €.<br>• Nitrogen transport pipeline IJmuiden (Supplier Linde) - Oudelandertocht (GTS Mixing station): Reducing GTS' historic investments by € 30.5 million. Reducing opex by 237 ths. €. |

Source: Frontier/Consentec

### 3.2.1 Balancing costs

GTS claimed that in Germany the balancing task is not undertaken by the gas TSOs but the market operator (GasPool and NetConnectGermany).[5]

This has the following implications for OPEX and CAPEX in this study:

- OPEX – Associated to balancing is not part of the cost base of the German Gas TSOs. Hence, GTS Opex for "Taak balanceren" are also excluded.
- CAPEX – In the Netherlands, ACM allocates a certain percentage, 3.3%, of GTS capital costs to balancing. We understand from ACM that this allocation was not based on a detailed cost analysis of the share of GTS network used for the balancing task.

  We note that physical assets used for balancing are part of the regulated asset base (RAB) of the German Gas TSOs, as well. Similar to the Netherlands there is no clear separation of these assets for transportation and balancing purposes. Moreover, Bundesnetzagentur does not allocate a specific part of

5 This claim corresponds to Claim A7 in the GTS Memorandum from September, 5th, 2014.

the capital costs to the balancing task. Hence, a similar % figure (as has been used by ACM) has not been established for the German gas TSOs. Additional costs for balancing (in addition to those for transport) could occur in several asset categories, e.g. due to larger pipeline diameters, higher wall thickness (that allow higher pressure ranges), higher power rating of compressors (that also allow for higher pressure ranges, instead of higher operation times) etc. Due to the fact that there is no direct relationship between specific asset categories and the purpose of balancing, an exact share of capital cost allocated to balancing is always difficult to estimate and would, at least for the German data, bear the risk of being arbitrary.

Due to the fact that capital costs for the balancing task are not documented separately for GTS and the German TSOs, we make no cost adjustment on capital costs for balancing.

### 3.2.2 Quality conversion

GTS claimed that quality conversion is not undertaken by German gas TSOs.[6] We note that quality conversion is a task undertaken by certain German Gas TSOs, e.g. Open Grid Europe and Thyssengas. However, this does not imply a high importance of quality conversion in Germany. Furthermore, for other German TSOs, e.g. Bayernets or Terranets BW, quality conversion is not a task relevant to the operator as they operate only one relatively homogeneous gas quality; and for those German TSOs that undertake quality conversion, this task is of smaller importance and mainly consists in blending H- and/or L-gas, e.g. injection of limited amounts of H-gas into L-gas sub-systems and not exceeding the technical Wobbe Index ranges for L-gas. Hence, we decided that quality conversion is out of scope in this benchmarking analysis.

This has the following implication for OPEX and CAPEX of GTS in the benchmarking analysis:

- OPEX – GTS Opex for "Kwaliteitsconversie" are not be included in the benchmarking analysis.

- CAPEX – Physical assets used for "Kwaliteitsconversie" are excluded from the regulated asset base (RAB) of GTS. We note that certain German gas TSOs include physical assets for quality conversion in the RAB, as well. However, these assets are not explicitly specified. Hence, as a conservative approach (in favour of the efficiency result of GTS) we do not correct for these physical assets for the respective German gas TSOs. However, as only few assets are affected it is likely that the upward capital cost impact for German TSOs is rather small.

6 This claim corresponds to Claim A2 in the GTS Memorandum from September, 5th, 2014.

In addition GTS claimed that

- certain compressor stations currently allocated to the "Transport taak" are primarily used for quality conversion; and
- the nitrogen transport pipeline IJmuiden (Supplier Linde) - Oudelandertocht (GTS Mixing station) is only used for quality conversion.

GTS asked Jacobs Consultancy (2014)[7] for an expert opinion on various technical issues, including quality conversion. We note that the argumentation from Jacobs (2014) seems plausible from a technical point of view. Jacobs' approach, the illustration of the calculations from GTS, the used methodology and models, in particular the tool MCA, are comprehensible. There are no logical breaks in the argumentation. We were not in the position of a detailed assessment of GTS calculations and the data used by GTS.

We acknowledge that these compressor stations should be partly allocated to the quality conversion task and make the following cost adjustments:

- **Adjustment of capital costs** – We adjust the investment stream for the respective compressor stations according to the part due to quality conversion using the information provided by GTS. This reduces GTS' historic investments by € 50.8 million.

- **Adjustment of operating costs** – We use the GTS figure, which was assessed by Jacobs as reasonable, of 787 ths. € for adjusting operating costs. This adjustment applies to "Total OPEX excl. BESeF (NOK)". For the adjustment of the cost item "Totaal BESeF" we use the GTS figures of 533 ths €.

We acknowledge that the nitrogen transport pipeline IJmuiden (Supplier Linde) - Oudelandertocht (GTS Mixing station) is used only for quality conversion and make the following cost adjustments:

- **Adjustment of capital costs** – We adjust the investment stream for the nitrogen transport pipeline IJmuiden (Supplier Linde) - Oudelandertocht (GTS Mixing station) using the information provided by GTS. This reduces GTS' historic investments by € 30.5 million.

- **Adjustment of operating costs** – We use the GTS figure, which was assessed by Jacobs as reasonable, of 237 ths. € for adjusting operating costs. This adjustment applies to "Total OPEX excl. BESeF (NOK)".

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7 Jacobs Consultancy, *Technische Exogene Factoren – een expert opinion op de door GTS aangemerkte technische verschillen, gegeven de verschillen in regelgeving tussen GTS en Duitse TSO's*, September 1st, 2014.

# **Scope** of benchmarking for GTS

# 4 Benchmarking methodology

In the following we describe the approach we use to measure the static efficiency of gas TSOs in this study. In addition we describe two approaches we use to increase the robustness of the analysis. The section is structured as follows:

- Approaches to measure static efficiency (section 4.1);
- Description of the method "Data Envelopment Analysis (DEA)" (section 4.2); and
- Description of the approaches used to identify outlier from the analysis (section 4.3).

## 4.1 Measurement of static efficiency – approaches

In general, benchmarking procedures are mathematic models which relate the quantities of output and input of specific companies to each other and – using the resulting index of productivity – estimate the efficiency of certain companies compared to other companies.

Benchmarking procedures can be differentiated based on the following criteria:

- **Parametric vs. non-parametric** – Parametric procedures (e.g. OLS, COLS, MOLS and SFA) involve an evaluation of the cost drivers, within the estimation of the efficiency frontier (hereafter referred to as "frontier"). This evaluation is based on a statistical regression of costs on those factors which cause those costs. E.g. by using the method of ordinary least squares (OLS) a coefficient to explain the relationship between cost and each cost factor is calculated. By contrast non-parametric procedures (e.g. DEA) use a (piece-wise) optimization procedure without presuming a clear functional relationship between cost and cost drivers.

- **Stochastic vs. deterministic** – Stochastic procedures consider that the frontier could be determined by outliers, e.g. by companies which recorded an exceptionally high maximum network load in the year of analysis. Stochastic approaches make a statistical correction of the frontier reflecting the possibility of data noise, resulting in the relative efficiency of the lower companies to rise. Deterministic approaches do not include such a statistical correction.

**Figure 2** classifies some of the analytical benchmarking models developed in literature. [8]

**Figure 2.** Possible methods of Benchmarking

| | deterministic | stochastic |
|---|---|---|
| non-parametric | **Data Enevelopment Analysis (DEA)**<br>*-CRS: Charnes, Cooper, Rhodes (1978),*<br>*-VRS: Banker, Charnes & Cooper (1984), Fare, Grosskopf & Lovell (1994);*<br>*-non-convex FDH: Desprins, Simar &Tulkens (1984)* | **Stochastic and chance constrained Data Envelopment Analysis (SDEA)**<br>*-CRS/VRS:*<br>*Land, Lovell & Thore (1993), Weyman-Jones (2001)* |
| parametric | **Corrected/Modified Ordinary Least Squares CRS & VRS regression**<br>*(COLS, MOLS & goal programming) Greene (1997), Lovell (1993), Aigner & Chu (1968)* | **Stochastic Frontier Analysis (SFA)**<br>*-CRS/VRS:*<br>*Aigner, Lovell & Schmidt (1977), Battese & Coelli (1992), Coelli, Rao and Battese (1998)* |

Source: Frontier/Consentec

In this study we compare the efficiency of 14 gas TSOs. The size of the sample sets restrictions on the use of parametric approaches, because more data points are necessary for statistical (econometric) regression analysis. Hence, we use Data Envelopment Analysis (DEA) as the main benchmarking methodology. DEA is widely used by other European regulators, e.g. Austria, Germany, Norway, and also used by ACM for the efficiency analysis of TenneT.

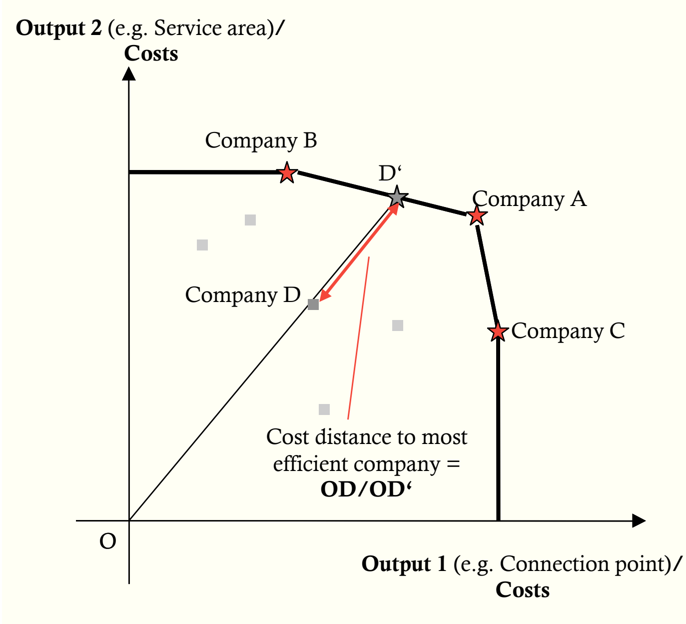
## 4.2 Data Envelopment Analysis (DEA)

By applying DEA, the relatively simple approach of comparison of partial indicators of efficiency (e.g. employees per kWh, length of transmission line per kWh etc.) is generalized, in order to compare companies with multiple inputs and outputs. The formal approach consists of enveloping the recorded input and output data of the companies by an optimal frontier. The frontier is described by those companies which realize the most favourable output-input combination. Formally, this frontier is calculated by a linear optimization program. The relative

8 It is passed on a more detailed description of the benchmarking models for lack of space. The array in Table 1 is not exhausting and there exists more literature and advanced modifications. For an introduction to benchmarking approaches we refer to: Coelli/Prasada Rao/Battese (2000), Bogetoft/Otto (2011).

efficiency of those companies which do not meet the frontier is calculated as relative distance to the frontier. DEA determines – from the multidimensional input-output area – a one-dimensional summary measure of efficiency relative to the best-performing companies.

**Figure 3.** DEA – functional diagram




Source: Federal Network Agency

In **Figure 3**, we illustrate the example of two outputs (e.g. supply area and connection points) and one input (costs). On the x-axis we illustrate the output-input combination for Output 1 (e.g. connection points) and costs and on the y-axis the combination for Output 2 (e.g. supply area) and costs. Companies A, B and C form the efficient envelope. Company D is identified as being inefficient since it is not on or near the efficient frontier. The degree of inefficiency can be represented graphically by the cost distance to the efficiency frontier (0D/0D'). This means that there is another company (or combination of companies), which can achieve the same outputs with a lower input compared to Company D.

DEA can further be distinguished by how it considers economies of scale, i.e. to what extent the size of a company is being accepted as a cost factor. The relevant academic literature has developed a number of specifications:

- *Constant returns to scale (crs)* – this approach presumes that there is no significant disadvantage of being small or large. All companies are compared amongst each other irrespective of their scale or size;

- *non-increasing returns to scale (nirs)* – this specification considers that there may be disadvantages of being large but no disadvantages of being small and adjusts for it accordingly;
- *non-decreasing returns to scale (ndrs)* – this specification considers that there may be disadvantages of being small but no disadvantages of being large and adjusts for it accordingly; and
- *variable returns to scale (vrs)* – in this specification the model considers disadvantages of being too small and too large and adjusts for it.

In the following we use the same specification on returns to scale as in the German gas TSO benchmarking study (non-decreasing returns to scale). This specification has the advantage that the companies are not punished for being too small. The possibility of gas TSOs to increase size may be limited, e.g. due to national borders, which reduces the degree of freedom to upscale the size of the company. On the other hand companies should always have the possibility to downscale their size if they are too big. This is reflected by the non-decreasing-return specification.

## 4.3 DEA outlier analysis

In order to increase the robustness of the analysis it is important to assess if the efficiency scores from the DEA calculation are driven by companies with characteristics materially different from those of the majority of the sample. The outlier analysis is focussed on identifying outliers defining the DEA efficiency frontier, as these companies may have a substantial impact on the efficiency scores of other TSOs.

The DEA outlier analysis consists of screening extreme observations in the model against average performance. Extreme observations are those that dominate (i.e. define the frontier for) a large part of the sample.

We use two approaches to pick out units that are extreme as individual observations and that have an extreme impact on the evaluation of the remaining companies.

To do so, we investigate a

- **dominance criterion** (sums-of-squares deviation indicator**)** similar to that commonly seen in parametric statistics;[9] and

9 See: Banker/Rajiv/Natarajan (2011); Banker (1996).

- **super efficiency criterion** similar to the Banker and Chang (2005) approach, although we let the cut-off level be determined from the empirical distribution of the super efficiency scores.

Companies which are qualified as positive (i.e. super-efficient) outliers are eliminated from the analysis as peers for other firms, with the efficiency score of the efficient outliers set to 100%.

### *Dominance test (sum of squares indicator)*

In order to test whether a company sets the frontier for the majority of the sample, we compare the mean efficiency of all companies, including the potential outlier, to the mean efficiency calculated excluding the potential outlier. From this we are deriving a test statistics which is then compared to a certain threshold. If the test statistic is below the threshold we exclude the potential outlier from the sample. In the following we describe the approach in more detail.

First, we calculate the efficiency scores for all companies including and excluding the potential outlier. The efficiency score (E) can be described as:

- *E(k;K):* k represents the single TSO, whereas K stands for the sample of all TSO. Therefore, *E(k;K)* is the efficiency score of TSO k calculated including the full sample of TSO.

- *E(k; K\i):* Again, k represents the single TSO, whereas K stands for the sample of all TSO. The potential outlier is labelled by *i*. Therefore, *E(k;K\i)* is the efficiency score of TSO k calculated including all TSO excluding the potential outlier *i*.

Both efficiency scores, *E(k;K)* and *E(k; K\i)*, are the basis for the test statistics *T* used in the dominance test. The test statistic is the quotient of the sum of squares of the inefficiencies for both cases, including and excluding the potential outlier.

$$T = \frac{\sum_{k \in K \setminus i} (E(\mathrm{k}; \mathrm{K} \setminus i) - 1)^2}{\sum_{k \in K \setminus i} (E(k; K) - 1)^2}$$

The test statistic is designed such that *T* is decreasing with an increasing influence of the potential outlier *i* on the efficiency scores of the remaining sample *(K\i)*. Further, *T* equals 1 if the potential outlier does not impact the efficiency scores of other companies, *E(k;K) = E(k; K\i)* over all TSOs.

This property allows the definition of hypothesis that can be tested on the basis of the F-distribution:

*$H_0$: T =1 (TSO i* ***does not*** *have an impact on the efficiency scores of the remaining sample)*

and

*$H_1$: T < 1 (TSO i* ***does*** *have an impact on the efficiency scores of the remaining sample)*

The null hypothesis can be rejected at a significance level of 95% if *T* is smaller than the value of the F-distribution at $F_{0.05,\ J\ ,\ J}$ (J represents the degrees of freedom). We evaluate the null-hypothesis based on the p-value:[10] The null-hypothesis can be rejected and *i* can be identified as an outlier if $p(H_0)<0.05$. In this case the TSO *i* has a significant influence on the efficiency score of the remaining TSO. Therefore, TSO *i* has to be excluded from the sample.

Following the dominance test, we conduct the analysis of the superefficiency criterion.

### Super efficiency

The super efficiency criterion allows the quantification of the influence of extreme observations (efficiency score) above 100%. We identify a TSO as being an outlier if its efficiency exceeds the upper quantile limit (75%) by more than one and a half times the inter-quantile range. The inter-quantile range is defined as the range of the central 50% of the data set (q(0,75) – q(0,25)). An extreme efficiency score is therefore excluded from the sample if it meets the following condition.

$$E(k; K\backslash i) > q(0.75) + 1.5 \times [q(0.75) - q(0.25)]$$

Companies that have been identified as outlier within the DEA analysis have their efficiency scores set to 100%.

10 The p-value describes the lowest significance level at which the null-hypothesis can be rejected.

# 5 Definition of benchmarked costs

In the following we discuss the costs used for this study. We also discuss how we deal with country specific claims in relation to costs raised by GTS:

- Definition of the scope of costs (**section 5.1**);
- Definition of benchmarked operating expenditures (Opex) (**section 5.2**);
- Definition of benchmarked capital expenditures (Capex) (**section 5.3**); and
- Assessment of country specific claims by GTS related to benchmarked costs (**section 5.4**).

## 5.1 Scope of costs

Benchmarking models can be grouped into two alternative designs with an effect on the scope of the benchmarked costs:

- **A short-run maintenance model**, in which the efficiency of the operator is judged-based on the operating expenditures (Opex) incurred relative to the outputs produced, which in this case would be represented by the characteristics of the network as well as the typical customer services.

- **A long-run service model**, in which the efficiency of the operator is judged-based on the total cost (Totex) incurred relative to the outputs produced, which in this case would be represented by the services provided by the operator.

The main drawback of the first model is that a large portion of costs, namely capital costs, are not taken into account. In addition, regulated companies may have an incentive to game the regulatory process by distorting its input use, e.g. substituting operating cost by investments resulting in low Opex but suboptimal (i.e. excessive) capital intensity.

Total cost benchmarking overcomes this issue. By focusing on total costs there is no incentive to declare operational costs as capital costs.[11] The total cost

[11] Investment decisions (and as a consequence capital intensity) may also be affected by interest rates over time. This means that in times of low interest rates companies will tend to prefer capital intense solutions (investments) instead of operational expenditures and vice versa. Hence, capital intensity may be different between companies depending on the interest rates the companies are exposed over time.

benchmarking approach corresponds with the general ACM regulatory approach which sets incentives on total costs.

Hence, in this study we use a long-run service model which covers total costs consisting of:

- *Operating costs* (Opex); and
- *Capital costs* (Capex).

## 5.2 Benchmarked Opex

The standardised definition and standardisation of costs play a crucial role in any benchmarking study, especially, if the study is international in scope as is the case for this study.

### 5.2.1 Source of data

When calculating the Opex we are using the following cost information:

- *For the Netherlands*: OPEX 2010 data were provided to us by ACM from the "informatieverzoek financiële data GTS";
- *For Germany*: "Anlage V – Aufwandsparameter gem. § 14 ARegV" for the German Gas TSOs – the data were provided to us by Bundesnetzagentur.

The costs Bundesnetzagentur uses for setting allowed revenues are derived from the audited annual accounts (P&L statements, balance sheets) from the German Gas TSOs for the segment "Gas Transmission". Bundesnetzagentur informed us that she additionally audits the correct allocation of costs to the segment "gas transmission" and makes adjustments if necessary (e.g. in cases where there are common costs that may be shared with unregulated services). Therefore any "adjustments" to the cost base undertaken by Bundesnetzagentur would have served to enhance the comparability of data between firms.

We note that the German cost data are declared as confidential by Bundesnetzagentur. A disclosure of the cost data from us to ACM and GTS is not allowed.

### 5.2.2 Definition of Opex

In order to ensure that comparable cost positions are included in the OPEX of GTS and German Gas TSOs we defined five cost categories:

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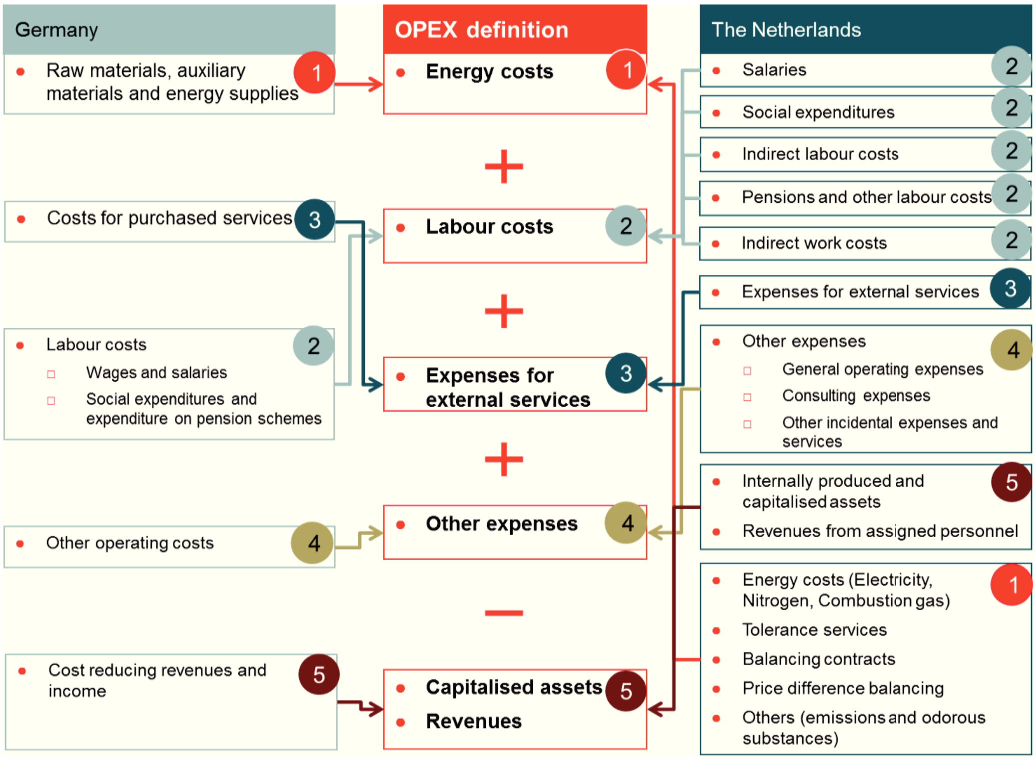
However, if the level and correlation of interest rates are similar for companies then capital intensity will be solely determined by management decisions. We note that there are strong indications that this is the case for companies operating in Germany and the Netherlands.

- *1. Energy costs;*
- *2. Labour costs;*
- *3. Expenses for external services;*
- *4. Other expenses;*
- *5. Capitalised assets and (non-tariff) Revenue*

We then allocate the cost items which were provided to us by ACM and Bundesnetzagentur to the corresponding cost categories (**Figure 4**).

**Figure 4.** Grouping of GTS and German Gas TSOs OPEX




Source: Frontier/Consentec

For GTS we are using the following allocation of cost items to the five cost categories:

**Figure 5.** Allocation of GTS costs to cost categories

| | Operationele kosten en buitengewone lasten |
|---|---|
| | |
| | (Bedragen in EURO * 1.000) |
| | |
| | Salarissen |
| | Sociale lasten |
| 2 | Indirecte personeelskosten |
| | Pensioenen en overige personeelskosten |
| | Indirecte arbeidskosten |
| 3 | Kosten aan inhuur aannemers |
| | Overige operationele kosten |
| 4 | - Algemene bedrijfskosten |
| | - Adviesdiensten derden |
| | - Overige incidentele kosten en baten |
| 5 | Aan investeringen en derden toegerekende koste |
| | **Total OPEX excl BESeF (NOK)** |
| | |
| | Electriciteit |
| | Stikstof |
| | Brandstofgas |
| 1 | Tolerance services |
| | Balanceringscontract |
| | Prijsverschil balancering |
| | Overig (emissie en odorant) |
| | |
| | **Totaal BESeF** |
| | |
| | **Totaal OPEX** |

Source: Frontier/Consentec

For the German Gas TSOs we are using the following assignment allocation of cost items to the five cost categories:

**Figure 6.** Assignment of GTS costs to cost categories

| | Position | Kostenarten |
|---|---|---|
| | I. | **Erfassung der relvanten Daten zur Ermittlung der Netzkosten** |
| | 1. | **Aufwandsgleiche Kosten** |
| | 1.1. | **Materialkosten** |
| | 1.1.1. | davon Aufwendungen für Roh-, Hilfs- und Betriebsstoffe |
| | 1.1.1.1. | Aufwendungen für die Beschaffung von Verlustenergie |
| 1 | 1.1.1.2 | Aufwendungen für die Beschaffung von Treibenergie |
| | 1.1.1.3 | Aufwendungen für die Beschaffung von Eigenverbrauch |
| | 1.1.1.4 | Aufwendungen für die Beschaffung von Entspannungsenergie |
| | 1.1.1.5 | Sonstiges |
| | 1.1.2. | davon Aufwendungen für bezogene Leistungen |
| | ~~1.1.2.1.~~ | ~~Aufwendungen an vorgelagerte Netzbetreiber~~ |
| | 1.1.2.2. | Aufwendungen für überlassene Netzinfrastruktur |
| | 1.1.2.3. | Aufwendungen für durch Dritte erbrachte Betriebsführung |
| 3 | 1.1.2.4. | Aufwendungen für durch Dritte erbrachte Wartungs- und Instandhaltungsleistungen |
| | 1.1.2.5. | Aufwendungen für die Beschaffung von Ausgleichsenergie für Basisbilanzausgleich |
| | 1.1.2.6. | Aufwendungen für Differenzmengen |
| | 1.1.2.7. | Sonstiges |
| | 1.2. | **Personalkosten** |
| | 1.2.1. | Löhne und Gehälter |
| | | Kosten/Erlöse der im gesetzlichen Rahmen ausgeübten Betriebs- und Personalratstätigkeit |
| | | Kosten/Erlöse der Berufsausbildung und Weiterbildung im Unternehmen |
| 2 | 1.2.2. | Soziale Abgaben und Aufwendungen für Altersversorgung und für Unterstützung |
| | 1.2.2.1. | davon für Altersversorgung |
| | 1.2.2.2. | davon soziale Abgaben und sonstige Aufwendungen |
| | | Kosten/Erlöse der betrieblichen und tarifvertraglichen Vereinbarungen zu Lohnzusatz- und Versorgungsleistungen, soweit diese in der Zeit vor dem 31. Dez. 2008 abgeschlossen worden sind |
| | | Kosten/Erlöse der Betriebskindertagesstätten für Kinder der im Netzbereich beschäftigten Betriebsangehörigen |
| | ~~1.3.~~ | ~~**Zinsen und ähnliche Aufwendungen (Fremdkapitalzinsen)**~~ |
| | ~~1.4.~~ | ~~**Ansetzbare betriebliche Steuern (außer Gewerbesteuer, Körperschaftsteuer, Einkommensteuer und Solidaritätszuschlag)**~~ |
| | 1.5. | **Sonstige betriebliche Kosten** |
| | 1.5.1. | davon für sonstige Flexibilitätsdienstleistungen |
| | 1.5.2. | davon für Erstellung/Bereitstellung eines Informationssystems über die Kapazitätsauslastung (§ 10 GasNZV a.F.) |
| | 1.5.3. | davon aus der Vergabe zur Reduzierung der Marktgebiete gemäß § 21 Abs. 1 GasNZV |
| | 1.5.4. | **davon für die Einrichtung und den Betrieb einer Handelsplattform (§ 14 Abs. 1 GasNZV)** |
| | 1.5.6.1 | davon aus vertraglichen Vereinbarungen mit Dritten gem. § 9 Abs. 3 Nr. 1 GasNZV (§ 6 Abs. 3 S. 2 Nr. 1 GasNZV a.F.) |
| | 1.5.6.2 | davon auf eine wirksame Verfahrensregulierung gemäß § 11 Abs. 2 S. 3 ARegV entfallende Kosten |
| | 1.5.7. | davon Wartung und Instandsetzung |
| 4 | 1.5.8. | davon Konzessionsabgaben |
| | 1.5.9. | davon Mieten, sonstige Pachtzinsen, sonstige Leasingraten, Gebühren und Beiträge |
| | 1.5.10. | davon Versicherungen |
| | 1.5.11. | davon Bürobedarf, Drucksachen und Zeitschriften |
| | 1.5.12. | davon Postkosten, Frachtkosten und ähnliche Kosten |
| | 1.5.13. | davon Rechts- und Beratungskosten |
| | 1.5.14. | davon Sponsoring, Werbung, Spenden |
| | 1.5.15. | davon Reisekosten und Auslösungen |
| | 1.5.16. | davon Bewirtung und Geschenke |
| | 1.5.17. | davon Einzelwertberichtigungen und Abschreibungen auf Forderungen |
| | 1.5.18. | davon Entgelte für vermiedene Netzkosten nach § 20a GasNEV |
| | 1.5.19. | Sonstiges |
| | ~~2.~~ | **kalkulatorische Abschreibungen** |
| | ~~3.~~ | **Kalk. Eigenkapitalverzinsung** |
| | ~~4.~~ | **Kalk. Gewerbesteuer** |
| | I.a. | **Netzkosten I.a. vor Abzug der kostenmindernden Erlöse** |
| | 5. | **Kostenmindernde Erlöse und Erträge** |
| | 5.1. | **Erlöse aus Konzessionsabgaben** |
| | 5.2. | **andere aktivierte Eigenleistungen** |
| | ~~5.3.~~ | **Erträge aus Beteiligungen** |
| | 5.4. | **Erträge aus Auflösung von Netzanschlussbeiträgen** |
| | 5.5. | **Erträge aus Auflösung von Baukostenzuschüssen** |
| 5 | ~~5.6.~~ | **Erträge aus anderen Wertpapieren und Ausleihungen des Finanzanlagevermögens** |
| | ~~5.7.~~ | **Sonstige Zinsen und ähnliche Erträge** |
| | 5.8. | **Sonstige Erlöse und Erträge** |
| | 5.8.5. | **Erlöse aus Differenzmengen** |
| | 5.8.6. | **Andere Sonstige Erlöse** |
| | 5.8.7. | **Andere sonstige Erträge** |
| | I.b. | **Netzkosten I.b. nach Abzug kostenmindernder Erlöse** |

Source: Frontier/Consentec

The following OPEX positions of German TSOs have therefore not been considered:

- *Expenditures for upstream operators (1.1.2.1) ("Aufwendungen an vorgelagerte Netzbetreiber")* – these include tariffs paid to upstream networks. There are no corresponding costs at GTS, hence, we exclude this opex position;
- *Cost of debt and similar expenses (1.3) ("Zinsen und ähnliche Aufwendungen")* – cost of debt are part of the (weighted average) cost of capital costs and thus excluded from OPEX;
- *Commercial taxes excl. (1.4) ("Ansetzbare betriebliche Steuern")* – we exclude taxes from the OPEX and ACM has asked GTS to report its corresponding cost items accordingly;
- *Imputed depreciations (2) ("kalkulatorische Abschreibungen")* – depreciation are part of capital costs and thus excluded from OPEX;
- *Imputed cost of equity (3) ("kalkulatorische Eigenkapitalverzinsung")* – cost of equity is part of the (weighted average) cost of capital costs and thus excluded from OPEX;

- *Cost-reducing revenues (5) ("Kostenmindernde Erlöse und Erträge")* – We did not consider cost reducing revenues except for other capitalised OPEX (5.2) and other revenue and income (5.8), which correspond to "Aan investeringen en derden toegerkende kosten" for GTS.

## 5.3 Benchmarked Capex

The standardised definition and standardisation of costs play a crucial role in this benchmarking study. ACM and BNetzA apply somewhat different approaches to calculate capital costs with respect to

- valuation of the regulated asset base (RAB);
- depreciation periods; and
- calculation of cost of capital.

Given the differences in the calculation of capital costs between the involved German TSOs and GTS a separate calculation of capital costs for this study is necessary. In order to make CAPEX comparable we apply the approach used by ACM for calculating CAPEX which is based on

- indexed historic costs;
- standardised depreciation periods; and
- WACC approach to calculate the cost of capital.

The approach used by ACM is based on indexed historic costs. This means that increases in investment costs over time are reflected in the capital costs. The detailed data on investment streams for GTS and the German gas TSOs allowed us to apply the excel file used by ACM when calculating the capital costs which increased the transparency of the calculations. Finally, the approach allows an alignment of the capital costs used in the benchmarking analysis and in the allowed regulatory revenues.

### 5.3.1 Source of data

When calculating the Capex for this study we are using cost information from:

- For the Netherlands: GAW model for GTS – the data were provided to us by ACM. We are using the data for GTS until 2010 corresponding to the costs data from Germany, which are also until 2010;
- For Germany: "Anlage III – Vergleichbarkeitsrechnung gem. § 14 Abs. 1 Nr. 3 und Abs. 2 ARegV " for the German Gas TSOs – the data were provided to us by Bundesnetzagentur.

We note that the German cost data are declared as confidential by Bundesnetzagentur. A disclosure of the cost data from us to ACM and GTS is not allowed.

### 5.3.2 Calculation of capex

In the following we describe the calculation of CAPEX for this study which consists of:

- Depreciation and
- Cost of capital (WACC multiplied by RAB).

#### *Depreciation*

GTS claimed that there are differences in depreciation periods between GTS and the German gas TSOs which have to be taken into account in the benchmarking analysis.[12] This is why we are not using CAPEX from the German gas TSOs in the format used by BNetzA in their national benchmarking analysis.

In order to standardise the depreciation periods for the German Gas TSOs and GTS we used the following criteria:

- *German depreciation periods ≥ Dutch depreciation periods* – we use Dutch depreciation periods;
- *German depreciation periods < Dutch depreciation periods* – the default is that we adjust the relevant GTS assets to German depreciation periods (we do this as we have no record of German assets that are already fully depreciated under the German accounting rules). In certain cases, e.g. if only a small part of investments are affected, we also use the Dutch depreciation periods.

12 This corresponds to Claim A8 in the GTS Memorandum from September, 5th, 2014.

**Table 2.** Overview on proposal for depreciation periods

| Netherlands | | Depreciation period (Years) | | Germany | Depreciation period (Years) |
|---|---|---|---|---|---|
| Pipelines and service accommodations | 01 Regional pipelines | 55 | A | IV. 1.1 Pipe lines and service lines steel PE coated | 55 |
| | 07 Service accommodations | 55 | | IV. 1.2 Pipe lines and service lines steel cathodically protected | 55 |
| | 21 Transmission pipeline | 55 | | IV. 1.3 Pipe lines and service lines steel bituminated | 55 |
| | 22 Regional transmission pipeline | 55 | | IV. 6 Valve/valve stations | 55 |
| | 23 Brigittaleiding | 55 | | IV. 7 Pig traps | 55 |
| | | | | IV. 8 Safety devices (Pipe lines/service lines) | 55 |
| Stations, installations, air separation units, office and utility buildings | 02 Gas exit point to regional network | excluded | B | I.2 Land plants, buildings for transportation services | 25 |
| | 06 Utility buildings | 25 | | I.4 Administration buildings | 30 |
| | 15 Compressor stations | 25 | | III. 1 Natural gas compression | 25 |
| | 16 LNG installations | 30 | | III. 2 Gas cleaning systems | 25 |
| | 17 Mixing station | excluded | | III. 3 Piping and fitting | 25 |
| | 18 Calibrator installations | 25 | | III. 4 Gas measuring systems | 25 |
| | 19 Landfill gas installations | excluded | | III. 5 Safety devices (Gas compressor plants) | 25 |
| | 20 Office buildings | 30 | | III. 6 Control and energy technology (Gas compressor plants) | 25 |
| | 32 Measuring and regulating stations | 25 | | III. 7 Ancillary facilities (Gas compressor plants) | 25 |
| | 33 Interconnection point | 25 | | I.3 Premises | 30 |
| | 34 Pressure control station | 25 | | III. 8 Traffic infrastructure | 25 |
| | 35 Entry points | 25 | | V. 3 Measuring systems | 30 |
| | 36 Air separation units | excluded | | V. 4 Controlling systems | 30 |
| | | | | V. 8 Ancillary facilities (Measuring, controlling and metering system | 15 |
| | | | | V. 9 Buildings (Measuring, controlling and metering systems) | 30 |
| | | | | II Gas container | 30 |
| Furniture, buildings, inventory, equipment, tools, rolling material, roads, facilities | 05 Roads and facilities | 10 | C | I.6 Office equipment (no computer facilities or tools/equipment); switching equipment | 8 |
| | 08 Furniture buildings | 8 | | I.7 Tools/equipment | 10 |
| | 09 Inventory | 8 | | I.10.1 Light vehicles | 5 |
| | 10 Equipment | 10 | | I.10.2 Heavy vehicles | 5 |
| | 11 Tools | 10 | | I.8 Storage facility | 10 |
| | 12 Motor vehicles | 5 | | | |
| | 13 Trailers | 10 | | | |
| | 14 Other rolling material | 10 | | | |
| Computers, remote measuring systems | 03 Remote measuring systems | 5 | D | I.9.1 Hardware | 3 |
| | 37 Computers | 3 | | I.9.2 Software | 3 |
| | | | | V. 6 Control and energy technology (Measuring, controlling and me | 5 |
| | | | | VI. Remote control systems | 5 |
| Land properties | 04 Land properties | | E | 3.1.2.4. Land properties | |
| | | | | 3.2.4. Land properties | |

Source: Frontier / Consentec

**Table 2** Illustrates the categorisation of asset from GTS and the German gas TSOs into different asset classes and the relevant depreciation periods which we use in this study to calculate depreciations.

Depreciations are calculated from indexed historic costs. For GTS we are using the Dutch CPI, as applied by ACM, and for the German TSOs we are using the German CPI[13].

Using gross historic investment costs (before any depreciation) from German Gas TSOs and standardised depreciation periods (according to the Dutch approach) cancels out distortions caused by differences in the calculation of capital costs for GTS and the German Gas TSOs.

When it comes to ICT costs we note that we are using the ICT costs until 2010 from the asset category "37 ICT middelen 1". From 2010 ACM split ICT costs into 3 groups, but in 2010 there were no assets with a depreciation period of 10 ("38 ICT middelen 2") and 15 years ("39 ICT middelen 3"), so these asset categories are not relevant for this study.

13 Using the German CPI for the indexation of the German historic investment data is meant to correct for differences in the historic price levels for the network assets between Germany and the Netherlands. GTS may not be held responsible for these price differences.

### Regulated asset base (RAB)

When calculating the RAB we are using:

- Annual historic gross investments for tangible assets from GTS and German gas TSOs;
- Index the historic gross investments by using the CPI – the Dutch CPI for GTS and the German CPI for the German gas TSOs;
- Apply the depreciation periods from **Table 2** to calculate the RAB for GTS and the German gas TSOs.

We note that the RAB used in this study does not include:

- Assets under construction;
- Intangible assets;
- "Terreinen' and "vulgas".

### WACC

As the base year for the cost data is 2010 we use the WACC relevant for the regulatory period 2010-2013 for GTS. The respective figure is 5.8%, which we apply to GTS and the German gas TSOs[14]. The 5.8% was confirmed by ACM.

## 5.4 Country specific claims – costs

During the project GTS raised country specific claims with regard to costs. In the following we summarise these claims and how we deal with them.

**Table 3** summarises how we deal with these country specific claims.

14 As we are not comparing financing costs between GTS and the German gas TSOs, the objective of the WACC is to transform the historic investment stream in annual costs. Hence, a uniform WACC can be used in this study.

**Table 3.** GTS claims on costs – overview on assessment

| GTS claim | Assessment |
|---|---|
| Pension costs HGB vs. IFRS | We acknowledge this claim and exclude the cost item from the GTS cost base. This reduces opex by € 16,1 million and €60.8 million. |
| Treatment of expansion investments | No cost adjustment for GTS is necessary as costs from investment measures are included in photo year 2010 of German gas TSOs |
| Treatment of non-controllable costs | We acknowledge this claim and add the non-controllable costs to the cost base of the German Gas TSOs |
| Gas receiving stations | We exclude the costs for "Gasontvangstations" from GTS cost base:<br>• Adjustments of capital costs – we exclude the asset "02 Gasontvangstations" from the asset base of GTS. This reduces GTS' historic investments by € 372.7 million.<br>• Adjustment of operating costs – GTS claims an adjustment for opex of € 16.09 million, which is 5% of the corresponding investment costs. We adjust GTS opex accordingly. This adjustment applies to "Total OPEX excl. BESeF (NOK)". For the adjustment of the cost item "Totaal BESeF" we use the GTS figures of € 3.477 million. |
| Provision of cleaning costs | We accept this claim and correct the operating costs from GTS by € 24 million. |

Source: Frontier/Consentec

### 5.4.1 Differences in accounting rules – HGB vs. IFRS[15]

The cost base of the German gas TSOs is based on HGB (German civil trade law) accounting standards. This has been confirmed by Bundesnetzagentur.

By contrast, the annual report of GTS is based on IFRS standards. GTS claims that there are differences in acknowledging pension costs between HGB and IFRS. We understand that the respective costs for 2010 are included in the cost item for the "Transport taak" in "Tabel 6 – OPEX" of GTS cost template:

- Pensioenen en overige personeelskosten – GTS reports a value of € 16,174.02 million; and

15 *This claim corresponds to Claim A4 in the GTS* Memorandum from September, 5th, 2014.

- SORIE (maakt geen deel uit van bovenstaande kosten) – GTS reports a value of € 60,843.10 million.

We acknowledge this claim and exclude the cost item from the GTS cost base. On the other hand pension costs will also be removed from the cost base of the German TSOs.

### 5.4.2 Treatment of expansion investments

GTS claims that costs for expansion investments in Germany are treated as „non-controllable costs“ and excluded from the cost base used for German TSOs in the benchmarking analysis.[16] Hence, GTS was concerned that the treatment of expansion investments may mean that the cost base of the German firms may in some way not be reflective of the full cost base.

We note that (new) investments for expansion are treated under a separate regulatory allowance (investment measure) in Germany. Investment measures allow companies to add costs for expansion investment accruing during the price control period and to be added as revenue allowance within the on-going regulation period. This is achieved by treating CAPEX approved in investment measures as non-controllable costs to be passed through with a t-0 time lag. However, the costs of investment measures will be included as "controllable" costs after expiry of investment measures (at the end of the price control period in which the investment was undertaken) and exposed to total cost efficiency benchmarking. The treatment of new expansion investment as investment measures is normally limited to one regulatory period.

The cost base 2010 for German Gas TSOs was used as the relevant photo year for the regulatory period 2013-18 and all costs from investment measures arising until 2010 are included in this cost base of the companies and treated as "controllable costs". At the same time we consider corresponding service and output measures for the year 2010. Therefore, the data for GTS and German TSOs are consistent in this regard.

### 5.4.3 Treatment of non-controllable costs

GTS claims that certain costs in Germany are treated as „non-controllable costs“ and are hence excluded from the cost base used for German TSOs in the benchmarking analysis. [17]

The German "Anreizregulierungsverordnung" includes in § 11 (2) ARegV an exhaustive list of "non-controllable costs". Non-controllable costs are treated as pass-through items in regulation and no efficiency targets are applied to this part

16 This claim corresponds to Claim A3 in the GTS Memorandum from September, 5th, 2014.

17 This claim corresponds to Claim A3 in the GTS Memorandum from September, 5th, 2014.

of the cost base. Therefore, the respective cost has been excluded from the German national benchmarking investigation.

The relevant items for this benchmarking analysis are

- costs for works committee and staff work activities according to legislation ("Kosten/Erlöse der im gesetzlichen Rahmen ausgeübten Betriebs- und Personalratstätigkeit");
- costs for occupational training and further education of staff ("Kosten/Erlöse der Berufsausbildung und Weiterbildung im Unternehmen");
- costs for add-on salaries based on companies' agreements signed before 31 December 2005 ("Kosten/Erlöse der betrieblichen und tarifvertraglichen Vereinbarungen zu Lohnzusatz- und Versorgungsleistungen, soweit diese in der Zeit vor dem 31. Dezember 2008 abgeschlossen worden sind"); as well as
- costs for play school for employees' children ("Kosten/Erlöse der Betriebskindertagesstätten für Kinder der im Netzbereich beschäftigten Betriebsangehörigen").

We acknowledge this claim. As the data for the above listed non-controllable costs are separately available for the German gas TSOs, we add these costs to the German gas TSOs' cost base in order to make GTS' and German Gas TSOs' costs comparable.

### 5.4.4 Gas receiving stations

GTS claims that gas receiving stations are owned by the distribution networks in Germany, while in the Netherlands these stations are owned by GTS.[18] Hence, GTS is concerned that GTS' cost base includes the cost for receiving stations while for the German gas TSOs this is not the case.

In a meeting with ACM, Bundesnetzagentur explained that in Germany gas receiving stations are typically owned by DSOs, while a few exceptions may exist.

We exclude the costs for "Gasontvangstations" from GTS' cost base:

- **Adjustments of capital costs** – We exclude the asset "02 Gasontvangstations" from the asset base of GTS. This reduces GTS' historic investments by € 372.7 million.
- **Adjustment of operating costs** – GTS claims an adjustment for Opex of 16.09 million €, which is 5% of the corresponding investment costs.

18 This claim corresponds to Claim A5 in the GTS Memorandum from September, 5th, 2014.

This adjustment applies to "Total OPEX excl. BESeF (NOK)". For the adjustment of the cost item "Totaal BESeF" GTS claims € 3.477 million. We use GTS' figures to adjust operating costs.

### 5.4.5 Provision of cleaning costs

GTS claims that it had an extraordinary cost for cleaning costs of € 30 million in 2010[19]. According to the approach from BNetzA these extraordinary costs should be normalised over a period of five years.

We understand that BNetzA applies normalisations of extraordinary costs when defining the cost base for the photo year. This should smooth out the impact from one extraordinary event on the photo year costs for the regulatory period. As the regulatory period in Germany is five years, BNetzA tends to use this time period for normalisation.

GTS reports that the correction in their operation costs for extraordinary cleaning costs should be € 24 million. GTS provided ACM with further details on how to derive this figure.

The costs for cleaning are included in the position "overige incidentele kosten en baten (inclusief dotatie)". GTS stated that the € 42.1 million should be split as follows:

- cleaning costs ("Voorziening opruimkosten"): € 30 million and
- others: € 12.1 million.

Eliminating 4/5 from € 30 million results in the correction of € 24 million for operating costs.

[19] This claim corresponds to Claim A9 in the GTS Memorandum from September, 5th, 2014.

# 6 Benchmarking parameters

Any efficiency comparison must account for differences in the outputs and the structural environment of the companies. A key challenge is to identify a set of parameters that describe the tasks (the cost-drivers) that most accurately and comprehensively explain the costs of the TSOs.

In the following we describe how we identify cost-drivers that serve as long-list of benchmarking parameter candidates and derive a priority list from this long-list. We discuss how we deal with country specific claims in relation to benchmarking parameters (or claimed differences in GTS's supply task) raised by GTS.

The section follows the structure below:

- Definition of requirements for benchmarking parameters (s**ection 6.1**);
- Derive a long-list of possible parameter candidates (**section 6.2**);
- Assessment of country specific claims related to the benchmarking parameters (**section 6.3**);
- Description of data used to calculate parameters (**section 6.4**) and descriptive statistics of the data (**section 6.5**); and
- Allocate the benchmarking parameters to different priorities (**section 6.6**).

## 6.1 Requirements for benchmarking parameters

The main criterion for selecting output parameters is the requirement of any benchmarking analysis to allow the calculation of efficiency scores which appropriately reflect the efficiency of gas transmission system operators taking into account structural differences in supply tasks.

The following general requirements can be derived for the respective output parameters:

- **Completeness** – The parameters should reflect the supply task of the transmission system operators as completely as possible.

- **Exogeneity** – In principle, it should not be possible for the transmission system operator to control the parameters used for the benchmarking analysis by companies' decisions.

- **Non-redundancy** – The parameters should be restricted to the essential characteristics of the supply tasks. An overlapping of parameters should be avoided, as it complicates the analysis.

- **Quantifiability** – The parameters should be measurable and quantifiable with reasonable effort.

These specifications serve as standards for the subsequent analysis steps and are widely used in benchmarking studies.[20]

## 6.2 Possible parameter candidates

In the following, we describe the approach to derive the parameter candidates (cost-drivers) (**section 6.2.1**) and the applied methodology, the reference network analysis (**section 6.2.2**). In **section 6.2.3** we describe the cost-drivers and allocate them to different dimensions of supply tasks of a gas TSOs.

### 6.2.1 Approach to derive parameter candidates

As a preparatory step of the BNetzA benchmarking study for the German gas TSOs a further study[21] was commissioned by BNetzA to define potential cost-drivers (parameter candidates) for the benchmark of gas TSOs using reference network analysis (RNA). The RNA is an analytical cost model which is capable to determine cost optimal grid solutions on given supply tasks (see also **section 6.2.2**).

Generally it should not be possible for the transmission system operator to control the parameters used for the benchmarking analysis by companies' decisions. Hence, exogenous factors with a significant impact on costs have to be determined. The cost impact from these cost drivers should be similar for the various supply tasks.

The analysis of cost drivers of the network structure of transmission system operators can be based on real companies' data or on a fictional supply task derived from realistic network characteristics. The determination of cost drivers for BNetzA was based on the latter approach. The fictional data were derived from existing German gas transmission networks taking into account their various individual network structures and corresponding supply tasks. A supply

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20 see: CEPA, Background to work on assessing efficiency for the 2005 distribution price control review, report for Ofgem, 2003; Frontier Economics/Sumicid/Consentec, *E3GRID2012 – European TSO Benchmarking Study*, report for European regulatory, 2013.

21 Consentec, *Anlage A. KTA – Durchführung einer Kostentreiberanalyse für Effizienzvergleiche gemäß § 22 ARegV für Gasfernleitungsnetzbetreiber insbesondere unter der Verwendung analytischer Kostenmodelle*, Report for Bundesnetzagentur, 2012 (not public).

task reflects all relevant factors having an impact on the network infrastructure and cannot be influenced by the network operator (and therefore can be described as exogenous). For example, this includes the requirements of the customers, coupling points, the demand for gas feed-in or withdrawal and typical network planning restrictions like accessible routing of pipelines, possible locations of facilities.

Hence, the analytical approach can be summarized in four basic steps:

- **Step 1** – For the purpose of the RNA realistic transport and supply functions have been generated which reflect - albeit in a strongly abstracted form - in their bandwidth the spectrum of both the gas transmission system operators and their supply tasks.

- **Step 2** – Each of the six supply functions have been defined on the basis of real networks through a geo-referenced distribution of entry and exit points each associated with inputs and withdrawals:

  - „large“: Large-scale, multi-meshed transmission system with a distinct surface coverage
  - „wide“: Wide-ranged, little-meshed transmission system with a small number of exit points
  - „long“: Transmission system with predominantly one-dimensional orientation
  - „small“: Small-scale, closely meshed transmission system with a high number of exit points
  - „federal state/province“: Regional transmission network with coverage in the region of a federal state
  - „single region“: Regional transmission network with coverage in the region of a single region

  Each of the six supply tasks or their combinations is representative for the existing supply tasks which have to be fulfilled by the German gas transmission system operators. Although these fictional supply tasks were derived from data of German TSOs they are able to properly reflect the supply task of GTS, as well. In particular the supply tasks“large” and “federal state/province” are best suited to characterise GTS. Structural differences – if existent – would be dealt with in **section 6.3**.

- **Step 3** – For every characteristic network type systematic parameter variations have been carried out in a subsequent step. For this purpose, each of the potential cost drivers has progressively been varied over a wide bandwidth yielding to additional supply tasks.

- **Step 4** – Using the reference network analysis, optimal network infrastructures have been determined based on the varied parameterization. In total, 209 various fictional supply tasks have been investigated with the RNA. Based on those optimal networks the relations between the variation of parameters and the annual costs of the networks were evaluated.

### 6.2.2 Description of the reference network analysis

Analytical cost models serve the purpose of generating information about the efficient cost level of system operators on the one hand and the relations between network costs and key factors on the other hand, using an analytically computer-aided modelling of cost-optimal networks and their cost evaluation. Hereby, relationships can be investigated which would not be accessible (or only with high efforts) by the use of an empirical analysis. Furthermore, empirical investigations can be confirmed or checked on plausibility.

Depending on the level of detail and in particular the accuracy of modelling of the inhomogeneity of the supply task, model network analysis and/or reference network analysis can be used as part of the cost-driver analysis for the TSOs. Compared to the model network analysis, the reference network analysis (RNA), which was used in the study commissioned by BNetzA, is able to achieve an exceeded level of detail while raising the necessary effort. Under the consideration of specific constraints cost optimal grid solutions can be determined taking into account fictional supply tasks.

When modelling, general technical constraints and planning frameworks (network structure, station construction and equipment properties) asset type-specific investment and operating costs have been considered. The modelling is based on a Brownfield approach in which the supply task incl. defined network connection and coupling points have been defined, but no existing network structure like pipelines or compressor stations in the initial state is taken into account. The core result of any analytical cost model, "network optimisation", provides a cost optimal network for the analysed supply task and subject to all boundary conditions provided. Typically for regulatory purposes it is sufficient to consider the inventory of assets needed, differentiated by asset types.

The derived inventory of assets allows calculating the costs of the developed optimal network structure. The costs are based on annual costs, i.e. long-term average costs per year calculated on the basis of today's reinvestment costs, using the assumption of a typical useful lifetime and a cyclic reinvestment after this useful lifetime. These annual costs can be calculated on the basis of specific investment and operation costs for the asset types considered in the network optimisation step. Thus, the objective function for the optimisation is the minimisation of the product of the inventory of assets (differentiated by asset types) and the respective specific costs (converted to annual costs).

The amount of the specific network cost is not relevant to the outcome of the cost-driver analysis; the relation between the determined annual network costs, depending on the supply task is the decisive factor.

### 6.2.3 Parameter candidates and dimension of supply tasks

Any gas TSO fulfils certain tasks, e.g. transporting gas from production facilities to customers, connecting customers, etc. In order to structure the analysis it is useful to categorise these tasks and evaluate which output may best reflect these tasks. In the German gas TSO benchmarking analysis three general dimensions for the gas TSOs' supply tasks have been identified, which also apply to GTS:

- **Capacity provision/gas transport** – This dimension should reflect that meeting a high level of demand for transport capacity from the feed-in points to the withdrawal points results in exceeded costs for provision and operation of the infrastructure compared to the case when demand is low. Hence, the costs are primarily driven by the provision of transport capacities (or peak load). The transported gas volumes (or work) can also drive costs, e.g. owing to compression.

- **Network expansion** – This dimension reflects the size that the network has to have in order to fulfil its supply task. A more expanded network infrastructure must be provided and operated in order to supply and transport gas over a large geographical area compared to the case that the supply task is geographically limited.

- **Network granularity** – With a more complex and more granular supply task, e.g. due to an exceeded number of connection points, more mains have generally to be laid with (in part) smaller diameters, and more infrastructure has to be provided compared to the case that a consumption is concentrated at a limited number of connection points. This issue is reflected in the granularity of the network.

For the purpose of the cost-driver analysis realistic transport and supply functions have been generated which reflect spectrum of both the gas transmission system operators and their supply tasks. 209 various supply tasks were calculated with the RNA and the following cost drivers have been determined. These cost-drivers were then allocated to the dimensions of the supply tasks:

- **Annual peak load** – The maximum gas flow per hour [$m^3/h$] to be transported is a key design parameter for the capacity dimensioning of gas pipelines. With the view to the cost-driver analysis the annual peak load corresponds to the task of capacity provisioning /gas transportation, since the maximum peak load corresponds to the requested and in fact physically used capacity.

- **Annual off taken gas volume** – The sum of the annual withdrawals at network exit points out which can consist of final / industrial customers, off taken gas by downstream networks or transit to adjacent networks and corresponds to the capacity provision over the year and reflects gas transport.

- **Pipeline volume and pipeline surface area** – Sum of the volumes / lateral surface of all pipelines taking into account the diameter. They are generally associated with large network expansion and high capacity provision.

- **Transport momentum** – The transport momentum is an operand that is used in logistical systems as a parameter and as an objective for optimization. For gas transporting the transport momentum is suitable as an exogenous cost driver for the description of the supply task.

  In the simplest case of a direct point-to-point pipeline, the transport momentum is the product of the throughput (maximum of feed-in and withdrawal in [$m^3$/h]) and the distance between entry and exit point (transport distance in [m]). [22]

- **Transport momentum * area** and **square root (transport momentum * area)** – It includes some information on load and transport area coverage and can accordingly reflect the dimension of capacity provision and/or network expansion

- **Mean transport distance** - The mean transport distance determines the minimum line length required for connecting the entry and exit points and, because of the pressure drop, the (interdependent) required pipeline diameter and the pressure difference for the transport of gas and can accordingly reflect the dimension of capacity provision and/or network expansion.

- **Supply area** – The area of a network - defined as the area of the convex hull of the entry and exit points - determines the expenses for the development and distribution of the gas volumes to be transported on various sections of pipelines.

  It reflects in the context of the cost-driver analysis the dimension of network expansion.

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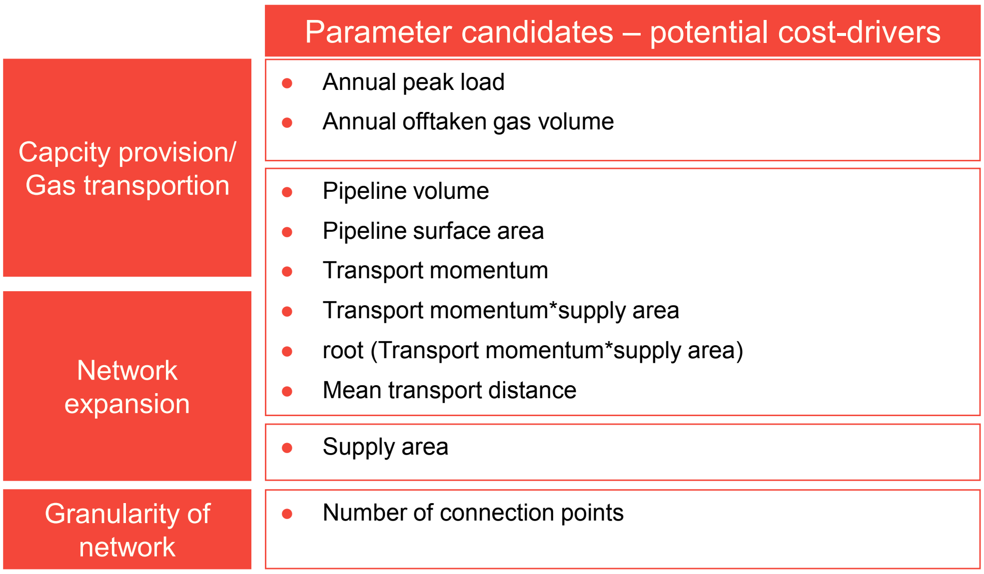
22 For more information regarding the calculation of the transport momentum we refer to **Annexe 4: Transport Momentum**.

- **Number of connection points** – The number of connection coupling points determines, for a given supply area decisively the necessary investments for area development and connecting and operating costs for metering and billing and reflects the network granularity.

This long-list serves as the starting point to describe the supply task of GTS and the German gas TSOs (**Figure 7**).

**Figure 7.** Parameter candidates and supply task




Source: Frontier/Consentec

In accordance with the use of analytic cost models in the framework of the study commissioned by BNetzA we note that:

- The cost-driver analysis using RNA gives a pre-selection of the most relevant exogenous output factors which best reflect the supply task of gas transmission system operators.
- Since the cost-driver analysis using RNA abstracts from real network structures and network costs a final choice of cost drivers is not possible. The cost-driver analysis is not able to distinguish between the fitness of various cost drivers which primarily aim at a detection of differences in costs of companies for identical outputs.

Hence, the cost-driver analysis provides only a pre-selection of possibly comparative parameters. The final suitability of each parameter candidate has to be proven in the process of the model specification taking into account real data of the TSOs.

## 6.3 Country specific claims – benchmarking parameters

During the project GTS raised country specific claims with regard to benchmarking parameters and/or the differences between the supply task of GTS and the German gas TSOs. GTS claimed that the long-list of parameters from **Figure 6** is not sufficient to cover all the specifics of GTS supply tasks as compared to the German gas TSOs.

In the following we summarise GTS' claims and discuss how we deal with them.

**Table 4** summarises how we deal with these country specific claims.

**Table 4.** GTS claims on benchmarking parameters and/or supply task – overview on assessment

| GTS claim | Assessment |
|---|---|
| Difference in Security of Supply | We acknowledge the cost impact from the difference in Security of Supply and make the following adjustments:<br>▫ Adjustment of capital costs – we adjust the investment stream for the respective compressor stations according to the part due to higher Security of Supply This reduces GTS' historic investments by € 76.5 million.<br>▫ Adjustment of operating costs – we use the GTS figure, which was assessed by Jacobs as reasonable, of 1.432 million € for adjusting operating costs. This adjustment applies to "Total OPEX excl. BESeF (NOK)". We understand from GTS that no adjustment is necessary for the cost item "Totaal BESeF". |
| Capacity products | Claim rejected |
| Gas quality | Claim rejected |
| Distance between storages (flexibility) | Claim rejected |
| Transit | Claim rejected |
| Trade off "Compressor stations vs. pipeline volume" | Claim rejected |
| Joint ventures of German TSOs | We retain the approach used by Bundesnetzagentur |
| Connection task | Claim rejected |
| Market areas | Claim rejected |
| ICT system | Claim rejected |
| Odorisation | Claim accepted |
| Safety and environmental standards | Claim rejected |
| Population density and soil type | Claim rejected |

Source:Frontier/Consentec

### 6.3.1 Difference in Security of Supply

#### *GTS claim*

GTS claimed that there is a difference in the supply task with regard to Security of Supply compared to the German TSOs.[23]

#### *Assessment of claim*

GTS states that the Dutch law prescribes that GTS should be able to fulfil its supply task at -17 degrees. We note that the respective legal act came into force in 2004.[24] Hence, in theory the impact from this law should only have an impact on the network configuration from 2004 onwards.

In its claim GTS implicitly raises two questions:

- Whether GTS truly faces a task that is significantly different from that of the German gas TSOs; and
- Whether through the choice of parameters (and the use of DEA) it is possible to reflect any differences in supply tasks (if they existed).

*On possible differences in the supply task* - We acknowledge the general effect that a higher requirement for capacity reliability (in the Netherlands) could potentially lead to higher costs, e.g. for larger pipeline or compressor dimensions or redundancies. However, there are factors that clearly limit the quantitative effects on the costs of GTS.

In a meeting with ACM, Bundesnetzagentur explained certain possible differences in the supply task: there is no temperature laid down in German legislation at which the TSO should be able to supply. Rather, it is city-gate capacity bookings by DSOs that determine overall TSO network capacity. The DSO demand is derived on a theoretical basis from temperature regression analysis, which reflects estimation of actual need and not one specific (prescribed) temperature. Relevant variables in this regression are inter alia standard load profiles and the mixture of customers. Significantly, the networks are laid out to supply gas to all customers, including the demand of temperature driven users, the latter being determined according to the norm DIN EN 12831 at temperatures between around -10 and -18 degrees Celsius for two consecutive days, according to an iso-thermic map of Germany (corrected for wind chill and

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23 This claim corresponds to Claim A1 in the GTS Memorandum from September, 5th, 2014.

24 See: Besluit van 13 april 2004, houdende regels inzake voorzieningen in verband met de leveringszekerheid (Besluit leveringszekerheid Gaswet), Artikel 2, http://wetten.overheid.nl/BWBR0016605/geldigheidsdatum_27-06-2014#Artikel2

other factors).[25] In addition to this, there is room for higher capacity bookings by the DSOs based on historic experiences and existing capacity rights; this effectively results in capacity bookings that correspond to even lower temperatures.

The EnWG (Energy Act) furthermore provides general rules for connection and access obligations (see above, paragraph 20). Private law applies as a contract is being drawn up for the amount of capacity a DSO orders from a TSO. Although the German law does not prescribe a supply task at -17 degrees, it is very likely that the German grids are able to supply at that temperature and even lower temperatures.

*On consideration of the supply task in benchmarking* - In addition, even if the supply tasks were different, this could be reflected either by parameterising the supply task or its effect on the cost base for the benchmarking analysis.

For example, if pipeline volume were used as a parameter to characterise gas TSOs (which was done in the German benchmarking analysis), the effect of a difference in supply tasks on the network configuration would already be covered within the benchmarking analysis. We note that pipeline volume will be an output parameter candidate for this benchmarking analysis, also in the Dutch investigation.

GTS claims a cost impact from higher security of supply only for compressor stations (and not pipelines). GTS notes that a choice is made for additional compression or expansion of the piping capacity for each investment project separately. It has been assumed that, with respect to providing a higher peak capacity, installing additional compression capacity at one or more of the existing compressor stations yields a lower TCO (Total Cost of Ownership) compared to increasing the piping capacity along multiple piping routes. Jacobs (2014) subscribed this approach. The GTS Memo includes detailed information on the cost impact reviewed by an expert report.

We note that the argumentation from Jacobs (2014) seems plausible from a technical point of view. Jacob's approach, the illustration of the calculations from GTS, the used methodology and models, in particular the tool MCA (Multi Case Approach (planning tool of GTS)), are comprehensible. There are no logical breaks in the argumentation. We were not in the position of a detailed assessment of GTS calculations and the data used by GTS. We acknowledge the

25 Furthermore, it is not clear that very cold temperatures are the key cost driver. Often not the very cold temperature load situations lead to flows straining physical assets, but intermediate temperatures: if it is moderately cold, then shippers have a choice from which entry they balance their portfolio, which may lead to situations where e.g. all gas enters in Northern Germany and has to be transported to Southern Germany, while at cold temperatures gas is used closer to the entry points.

cost impact from the difference in Security of Supply and propose the following cost adjustments:

- **Adjustment of capital costs** – We adjust the investment stream for the respective compressor stations according to the part due to higher Security of Supply. This reduces GTS' historic investments by € 76.5 million.

- **Adjustment of operating costs** – We use the GTS figure, which was assessed by Jacobs as reasonable, of € 1.432 million for adjusting operating costs. This adjustment applies to "Total OPEX excl. BESeF (NOK)". We understand from GTS that no adjustment is necessary for the cost item "Totaal BESeF".

### 6.3.2 Capacity products

#### *GTS claim*

Gas networks can be planned and operated under the consideration of different capacity products. Capacity products are to some extent defined by the national regulator and can have an impact on the network configuration (especially in terms of network planning) and costs. GTS claims that it provides more firm capacity products compared to the German gas TSOs. [26]

#### *Assessment of claim*

GTS correctly refers to the fact that in Germany different types of capacity products/rights are offered by the gas transmission operators on the market. The main categories of capacity products consist of firm and freely allocable capacity, capacity with conditional firmness and free allocability, firm and dynamically allocable capacity, firm capacity with restricted allocability, and interruptible and freely allocable capacity.

Within a decoupled entry-exit system shippers can contract entry and exit capacity independent of each other. Characteristic of a decoupled entry-exit system is further the presence of a virtual trading point (in order to allow transfer of gas), and a common balancing regime. A decoupled entry-exit system can be realized by one operator (like GTS in the Netherlands) or by several operators jointly in a co-operation based market area (like in Germany for the two market areas Gaspool and NetConnect Germany, each consisting of several TSOs).

In a fully decoupled entry-exit system no limitation applies to (the use of) capacity offered without restrictions. GTS operates within such a fully decoupled

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26 This claim corresponds to Claim B13 in the GTS Memorandum from September, 5th, 2014. For further details about this claim we refer to GTS Memorandum from December 24th, 2014, claim No. 11 "Restrictions on capacity products".

entry-exit system. In the market areas in which the German operators operate, certain conditions are placed on the use of a limited share of the contracted capacity. In practice, however, this does not mean that the capacity products booked from the German network operators are of a completely different quality than the capacity product of GTS. Nonetheless, certain differences exist, and on a general level the claim is not without good grounds.

However, there are three main mechanisms that clearly limit the quantitative effects of the different product categories on the network costs of GTS:

1) *The restrictions only apply to a limited share of the German TSO capacities*: The vast majority of capacities in Germany are of essentially the same quality as in the Netherlands. This varies in details, depending on the different market areas, TSOs, Entry vs. Exit sides etc. and detailed data are not available; but at least for the general level, the BNetzA monitoring report for several years[27] shows the limited (and decreasing) importance of restrictions in practice. For several German TSOs restrictions do not play an important role at all.

2) *The restrictions are not effective in many of the cases*: Network customers in Germany have pointed out in surveys that their preferences are acceptably met with the different (restricted) capacity products, see e.g. BNetzA's monitoring report for the year 2013. In the most restricted category, interruptible capacities, out of 64 customers that were holding capacities in this category, only 11 were effectively affected by interruptions, many of them only for several hours. In total, only 0.08 % of the nominated gas transports were interrupted in reality.

3) *The differences between the capacity definitions in the Netherlands and Germany are relatively new*: In both jurisdictions, the Netherlands and Germany likewise, network development took place over decades without these differences; network access was granted over many years on a common basis of a path-dependent point-to-point access regime in both jurisdictions; the differences that are the basis for GTS's claim are new, dating from the time after introduction of entry-exit-regimes and the entering into force of Art. 19 of Regulation 715/2009; more precisely, only after the obligation to offer *unrestricted* capacities has become effective, the respective claim of GTS could have become a reason for investment decisions. Thus, only costs for network development after that could partially be explained by the difference in capacity qualities.

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27 See e.g. Monitoringbericht gemäß § 63 Abs. 3 i. V. m. § 35 EnWG und § 48 Abs. 3 i. V. m. § 53 Abs. 3 GWB, 14-11-2014, Bundesnetzagentur & Bundeskartellamt, Bonn; all monitoring reports are available at: http://www.bundesnetzagentur.de/cln_1432/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institutionen/DatenaustauschundMonitoring/Monitoring/monitoring-node.html

There are further aspects that need to be taken into account, e.g. the size of market areas (because there is a trade-off between the range of a market area and potential restrictions), different methods of capacity calculation, likelihood of different flow conditions that alter the framework for capacity assessment etc.

However, exact quantitative analyses are not feasible for this claim due to a lack of available data that would need to cover the total amount of capacities, offered and/or booked, in the different categories for each TSO, the likelihood of interruption and the economic value of the real interruptions. These data, if available at all, would cause an investigative effort not acceptable on the backdrop of the likely very limited impact on the final benchmarking results.

Thus, it is preferable to choose the values of the real usage (in terms of peak load) instead of the different capacity values as benchmarking parameters, in particular for the additional reason that offered capacities may be oversized compared to the real demand in the market.

Based on the consideration 3) above we therefore suggest not to use (different categories of) capacity values and to correct the cost basis for those investments that can be proven to be a consequence of the unrestricted capacity rights after their obligatory introduction by GTS. ACM therefore requested a motivated list of investments (including documentation that shows internal decision making) specifying type, date and size that have taken place because of the obligation to offer unrestricted capacities; investments for the replacement of previously existing network infrastructure must be eliminated from the total sum of these investments. However, GTS was not able to provide such a list.

### 6.3.3 Gas quality

#### *GTS claim*

GTS claims that German TSOs have lower cost than GTS because they do less to convert gas into (just) two gas qualities.[28] In addition, GTS claims in the memorandum from January, 30th, 2015, that due to the large number of small gas fields GTS has to install more gas chronographs compared to the German TSOs to audit the gas quality.

#### *Assessment of claim*

In a meeting with ACM, Bundesnetzagentur explained that the German regulation also describes specifications of gas quality. "Table 3 – 2. Gasfamilie", DVGW, Arbeitsblatt G 260, records "brenntechnische Kenndaten". This confirms that German TSOs transport gas of differing qualities.

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28 This claim corresponds to Claim A 2 in the GTS Memorandum from September, 5th, 2014.

Firstly, we note that it is not clear that the situation in Germany is fundamentally different from that in the Netherlands.

We also note that – even if there were differences in the cost of quality conversion - it is unlikely that after we have already decided on the exclusion of the task of quality conversion from the benchmark there could be any remaining substantial effects of the comparability of cost between the Netherlands and Germany.

We note that there are also smaller gas fields in Germany and the German TSOs have gas chronographs in their assets, as well. Hence, the question reduces to the incremental number of chronographs of GTS necessary due to country specifics. We note that the process of adjusting for country specifics is meant to adjust for significant differences putting GTS at a disadvantage against German TSOs. GTS reports investment costs for chronographs of € 13.2 million. This corresponds to appr. 0.3% of GTS asset base. As only incremental investment costs occurred by GTS are relevant this figure needs to be reduced further. This is no evidence for a significant impact.

### 6.3.4 Distance between storage and industrial consumers

#### *GTS claim*

Storage of natural gas is a process that balances the variable market demand against the preferably constant supply of natural gas. Storage facilities help to maintain supply flexibility and security and meet customer requirements during peak periods. Gas is injected into storage during periods of low demand and withdrawn from storage during periods of high demand. The most important type of gas storage is underground reservoirs. There are three principal types of underground storage:

- depleted reservoirs in oil and/or gas fields,
- aquifers, and
- salt caverns.

The location of storage facilities is mostly dependent on geology. The location of consumers is not under the control of the TSO, either. As a result, distances between storages and consumers cannot be influenced by the TSO.

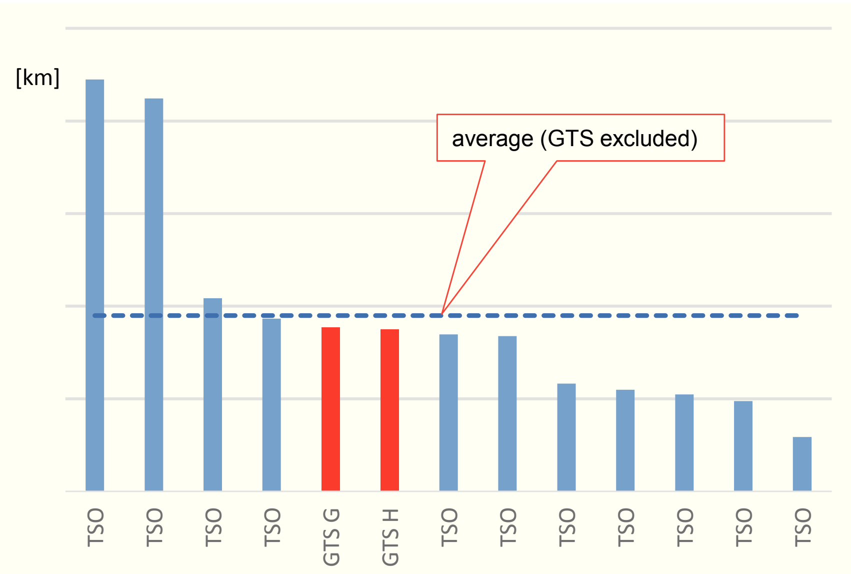
Storage facilities are used in the GTS network as well as by the German gas TSOs to facilitate the operation of the grid. GTS claims that its network is characterized by higher distances between storages and consumers as compared to the German gas TSOs and that this results in higher costs. According to GTS, the benchmarking analysis should take this structural difference into account.[29]

### *Assessment of GTS claim*

In order to deal with the claim of GTS, we compare the distances between storage facilities and industrial consumers among all TSOs, including GTS and the German TSOs. As a first step we calculated the weighted average distance to industrial facilities for each individual storage facility. The individual distances are weighted by the size of industrial facilities, i.e. annual peak of exit flows.

**Figure 8** illustrates the maximum calculated distance over the individual storage facilities for the German gas transmission networks and GTS, differentiated for various gas qualities. The red bars represent the distances of GTS for H- and G-Gas, while the blue bars represent the German TSOs. Sub-grids without storage, like the L-Gas grid of GTS, are neglected[30].

**Figure 8.** Maximum distance over individual storage facilities




Source: Frontier / Consentec

We normalise the largest maximum distance from all TSOs at 100%. The corresponding smallest maximum distance takes a value of 13%. The average maximum distance for all German TSOs is 42 %. GTS has a maximum distance

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29 This claim corresponds to Claim C15 in the GTS Memorandum from September, 5th, 2014. Further details were provided in the GTS Memorandum from December, 24th, 2014.

30 A Subgrid is a part of the whole network where all entry- and exit-points are connected by pipelines operated by the same TSO. Subgrids are subdivided in gas qualities.

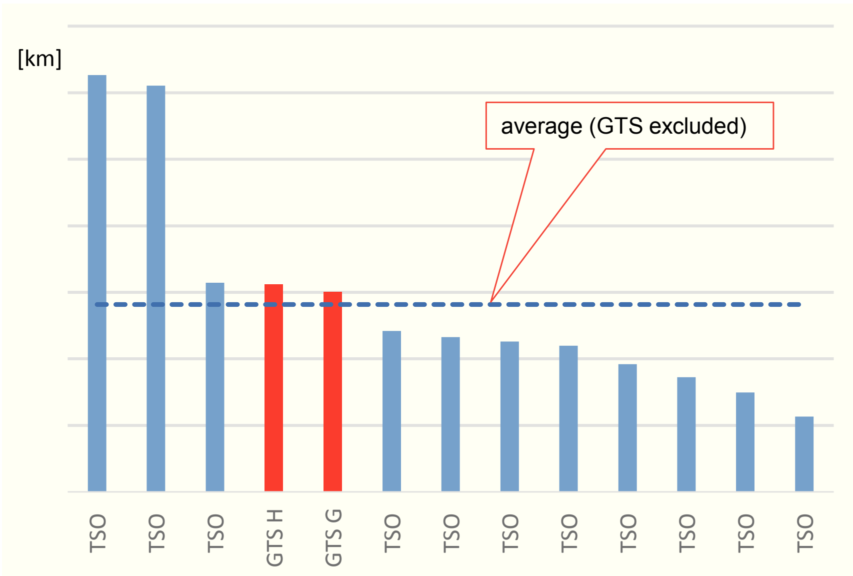
of around 38 % for gas qualities of H and G and is slightly below the average of the German TSOs.

Hence, we conclude that GTS is characterized by a medium storage-to-consumer distance. The largest distance over the comparison sample is around two times of the GTS level. We note that three of the German TSOs do not have any storage at all[31], which may indicate higher network costs for these TSOs.

In a further step we calculated the average distance over all storages for each subgrid. The individual distances for each storage facility are weighted by its size, i.e. annual peak of entry/exit flows.

**Figure 9** compares the average distance between storage and industrial consumers for the German gas transmission networks and GTS. The average distance for GTS is again differentiated for various gas qualities. We normalize the largest average distance from all TSOs at 100%. We represent the distances for the other TSOs as the ratio of the TSOs' average distances and this largest average distance. The average distance for all German gas transmission networks is approximately 47% in terms of the ratio of the highest level over all TSOs. For the GTS network, the distance is 50% for both gas qualities H and G. The highest distance over the whole sample is around two times of the GTS level. The results are similar to those for the maximum distance.

**Figure 9.** Average of distances between storage and industrial consumers




Source: Frontier / Consentec

31 One TSO does not have industrial load, which is excluded from the sample.

In addition to the analysis above, we analysed whether the distance between storage and consumers is covered by the dimensions of the supply task of a gas TSO set out in **section 3.1**.

The characteristic of gas transmission networks with regard to the distances between storage and consumers is properly covered by cost drivers covering the supply task dimensions:

- Capacity provision/gas transport
- Network expansion

Higher storage-to-consumer distance increases the need for compression and the level of demand for transport capacity, which is covered by the dimension of capacity provision/gas transport.

As described, the network expansion reflects the size the network must have in order to fulfil its supply task. Higher storage-to-consumer distance requires an expanded network infrastructure which is properly covered by this supply task dimension.

Therefore, we note that even in case GTS could claim on good grounds an extraordinary storage-to-consumers distance, the cost drivers reflecting "Capacity provision/gas transport" and "Network expansion" are already capable to take this into account, because higher storage-to-consumer distances are reflected in both dimensions.

### 6.3.5 Transit

#### *GTS claim*

Transit pipelines are an inherent component of the European gas transmission system. Most of the pipelines pass through several countries (transit countries). For example, Belgium transmits Norwegian and Dutch gas destined for France, Italy, Spain, UK, Luxemburg, and Germany. German TSOs transit Dutch gas to Switzerland, Russian gas to France and Norwegian gas to the Netherlands. Dutch and Norwegian gas is sent through Switzerland to Italy.

**Figure 10** illustrates the GTS network including the export points (transit flows) to the German and Belgian market.

**Figure 10.** GTS network including transit flows to German and Belgian markets


Source: Frontier / Consentec based on Grid map by GTS

GTS states that the supply task of transit is extraordinary due to the

- high share of transit, in combination with
- a provision of a high flexibility of the transit flows.

GTS claims that the share of transit is extraordinary high compared to the transit share of German TSOs. In order to deal with this higher share, GTS claims that the GTS network has to provide additional capacity resulting e.g. in a higher number and/or capacity of compressor stations or a higher pipeline volume. In addition, GTS states that the transit is characterized as highly volatile (thus GTS is providing flexibility) resulting in a relatively low annual energy withdrawal (compared to what would be feasible under a high utilization factor). As the energy withdrawal is identified as one possible output parameter, it may not mirror the supply task of GTS with regard to the transit. Hence, GTS claims for a consideration of this volatility or corresponding flexibility offered by the grid.

For further details about this claim we refer to the Memorandum of GTS, claim No. 13 "Flexibility"[32].

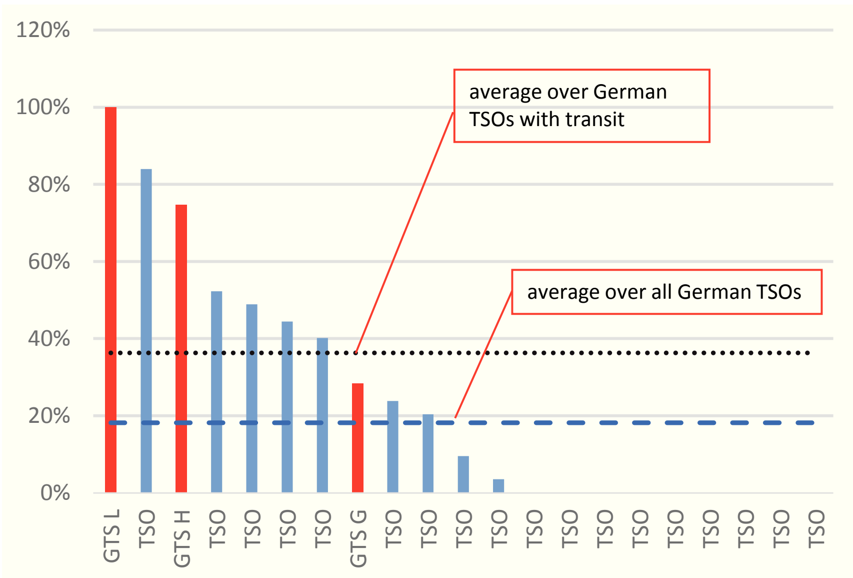
### *Assessment of GTS claim*

In order to assess the GTS claim, we compare the share of transit among different TSOs. The data provided by the German TSOs and GTS classifies the network connections to other grids into

- connection points with adjacent networks[33] as one category and
- connection points with upstream networks[34] as another category.

Thus, for the evaluation of transit we summed up the gas flows to/from adjacent grid operators as well as upstream networks to account for all the gas flows between the considered TSOs and their interconnected networks.

**Figure 11.** Share of transit: transit flows relative to annual energy feed-in/withdrawal




Source: Frontier / Consentec

**Figure 11** illustrates the share of transit in terms of the ratio of transit flows to the annual energy feed-in/withdrawal. Five of the German gas TSOs have zero or a very low share of transit (differentiated in gas qualities representing nine bars

32 GTS, Verschillen tussen GTS en de Duitse netbeheerders: memorandum, December, 24th, 2014.

33 "adjacent networks" is the English translation for the German word "Nachbarnetze" used in the original network data provided by the TSOs.

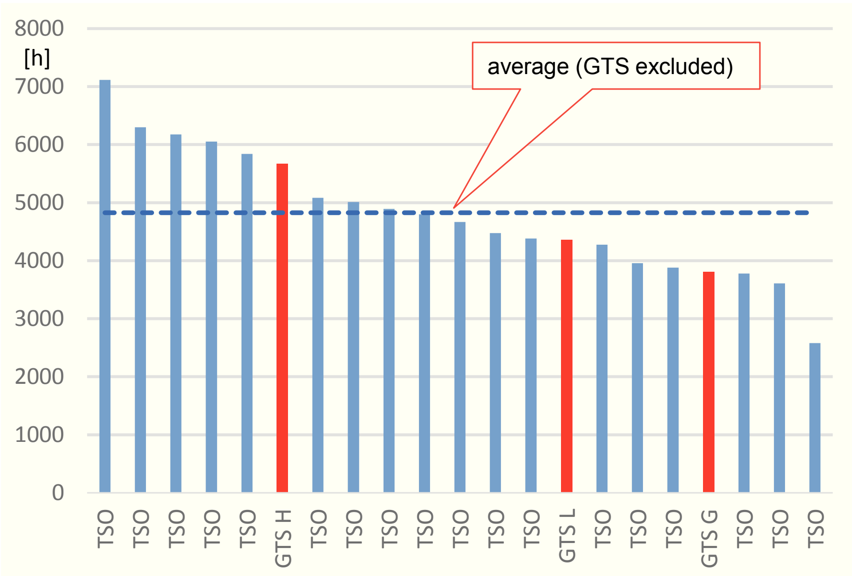
34 "upstream networks" is the English translation for the German word "Vorgelagerte Netze" used in the original network data provided by the TSOs.

for nine networks of these five TSOs in **Figure 11**). The GTS share of transit is 100% for the L-Gas meaning that the L-Gas is completely exported to the German and Belgian markets.

In case of H-Gas, GTS has a 75% share of transit, which is in the same order of magnitude like several German TSOs in the dataset. GTS' share for G-Gas is only slightly above the average, 28% compared to the average transit share over all German gas TSOs of 18%. Compared to German TSOs with transit the share of transit for G-Gas is below average (28% vs. 36%).

This means that transit is a main task for the H-Gas network of GTS, while it plays a secondary role in the G-Gas-subgrid, which largely supplies the national consumers; but in both cases, for H-Gas as well as for G-Gas, there are several German TSOs with similar values. Hence, we conclude that in none of the cases, neither for H-Gas nor for G-Gas, the GTS share of transit can be defined as extraordinary. In addition we note that the high transit share for L-Gas is a result of its definition and the special treatment of L-Gas as a pure export quality – specifically destined for the foreign markets[35].

**Figure 12.** Grid operation time: annual energy withdrawal relative to peak load




Source: Frontier / Consentec

In a next step we approach the volatility of the transit task by comparing the grid operation time (GOT) among the TSOs. **Figure 12** illustrates the grid operation

35 The conversion of H-Gas to L-Gas is covered in a cost category that is excluded from the benchmarking scope and consequently does not represent any additional burden to the transmission network. This conversion then contributes to the flexibility provided in the L-Gas exports.

time in terms of the ratio of annual energy withdrawal to peak load. The higher the GOT, the lower the volatility of the transit task. The average GOT is 4800h for the German gas transmission networks, the minimum reaches 2600h and the maximum is 7100h. For GTS H-Gas a level of 20% above average can be identified – but still in range where several of the German TSOs operate as well. Hence, the claimed lack of comparability due to extraordinary volatility cannot be confirmed.

Although an exceptional share of transit combined with high volatility could not be approved here for H- and G-Gas, the conversion of these two gas qualities near the German and Belgian markets into L-Gas can be counted as an extraordinary task. We therefore propose to adjust the cost base for GTS by excluding the costs for the converter stations. This adjustment of costs for quality conversion was already approved at a prior stage of the project.

In addition to the above, we analysed whether the aspect of transit is covered by the general dimensions of the supply task of a gas TSO as set out in **section 3**. Amongst those, the two dimensions "capacity provision/gas transport" and "network expansion", are suitable to capture the effects of transits; this is due to the fact that transit leads to the same technical and physical strain for a gas transmission network like domestic gas transport. In addition, the transit might also increase the number of connection points, which falls under the dimension of the "granularity of network".

Thus, the transit task of a gas transmission network is properly covered by the cost drivers covering all supply task dimensions:

- capacity provision/gas transport;
- network expansion; and
- granularity of network.

We note that even in the case that GTS could claim on good grounds an extraordinary task of transit, the cost drivers reflecting "Capacity provision/gas transport", "Network expansion" and "Granularity of network" are already capable to take this into account.

### 6.3.6 Trade off "Compressor stations vs. pipeline volume"

#### *GTS claim*[36]

Compressor stations facilitate the transportation of natural gas. The compressor station compresses the natural gas (increasing its pressure) thereby providing

[36] This claim was raised in: GTS, Verschillen tussen GTS en de Duitse netbeheerders: memorandum, December, 24th, 2014.

energy to move the gas through the pipeline. Natural gas, while being transported through a gas pipeline, needs to be constantly pressurized at intervals of approximately 40 to 100 miles. The size of the stations and the number of compressors vary, depending on the diameter of the pipe and the volume of gas to be transported.

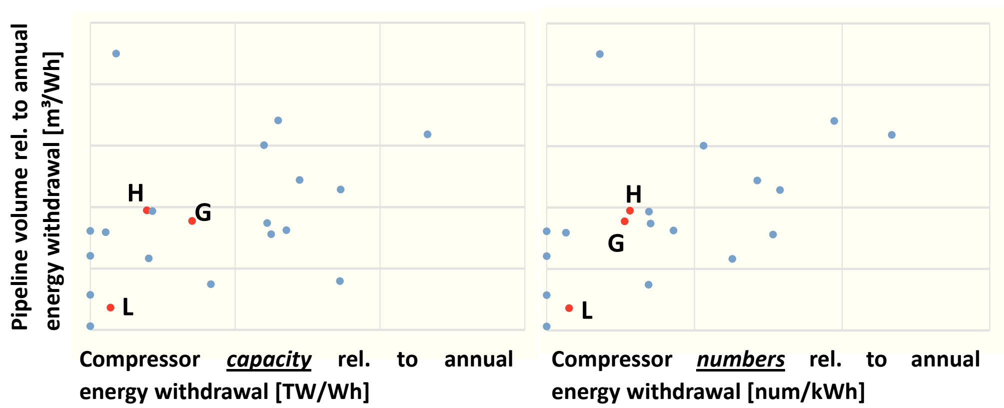
If a given amount of gas needs to be transported over a specified distance, there is a trade-off between the number/capacity of compressor stations and the pipeline volume.

GTS claims that its network is characterized by lower pipeline volume compared to the German Gas TSOs. Correspondingly, in order to accomplish the same supply task GTS claims a requirement of a higher number/capacity of compressor stations. Only considering pipeline volume as an output parameter in benchmarking analysis would, according to GTS, not adequately reflect this trade-off.

### Assessment of GTS claim

In order to analyse the justification of this claim, we analyse whether the GTS network shows particular effects of this trade-off with respect to a higher number/capacity of compressor stations compared to the network extension and tasks. Hence, we compare the pipeline volume on the one hand and the number/capacity of the compressor stations on the other hand with parameters reflecting the supply task of the gas transmission network e.g. the annual energy withdrawal or the annual peak load.

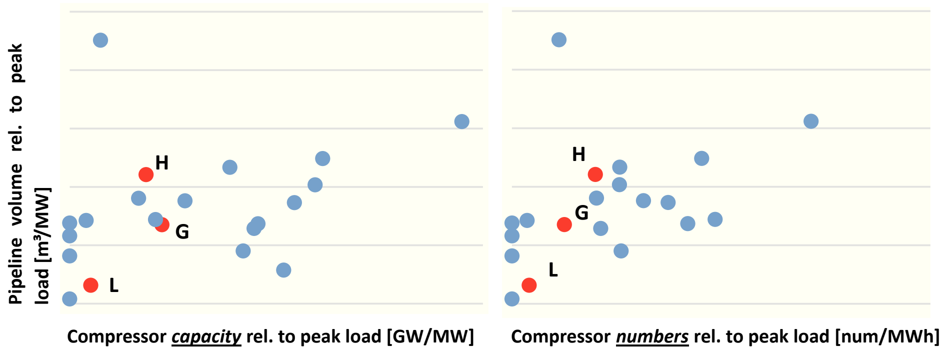
**Figure 13.** Ratio of pipeline volume and capacity/number of compressor stations to annual energy withdrawal




Source: Frontier / Consentec

**Figure 13** illustrates the ratio of pipeline volume to annual energy withdrawal versus the corresponding ratio for the compressors capacity on the left and the number of compressor stations on the right. In this analysis, a network favouring pipeline volume over the usage of compressor stations can be classified at the upper left of the plot. Respectively, a network favouring compressor stations would be shown at the bottom on the right side. Networks with a balanced trade-off are positioned nearby the line through the origin. No extreme correlation between pipeline volume and number/capacity of compressors can be identified for the networks of GTS while some of the German TSOs show a clear bias; e.g. the network at the upper left of the diagram, which is clearly dominated by pipeline volume compared to compressor stations.

**Figure 14.** Ratio of pipeline volume and capacity/number of compressor stations to peak load




Source: Frontier / Consentec

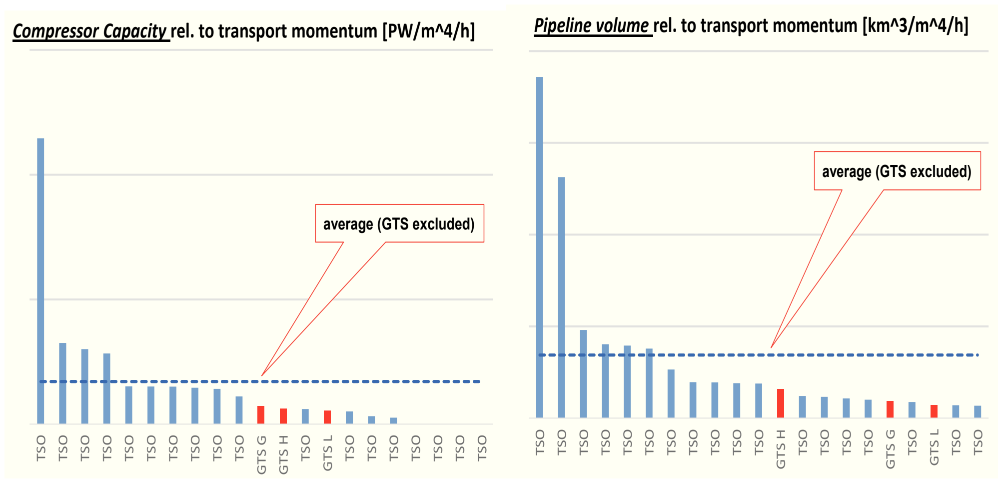
**Figure 14** illustrates the ratio of pipeline volume to peak load versus the corresponding ratio for the compressors (capacity and number of stations). The results of this analysis are completely in line with those for the annual energy withdrawal.

According to the X-axes in **Figure 13** and **Figure 14**, the GTS' compressor capacity for the G-Gas is around the average compressor capacity over the German gas TSOs. Concerning the compressor capacity of H-Gas and L-Gas, GTS positions 50% and 80% below average, respectively.

With respect to the pipeline volume (Y-axes in **Figure 13** and **Figure 14**), the GTS level for G-Gas and H-Gas is near the average volume over the German Gas TSOs, while in the category of L-Gas the GTS level is 80% below average. This underlines that the GTS networks are not in an extreme position concerning the trade-off between pipe volume and compressor capacity.

In a final step of this analytical part, we investigated the ratio of capacity of compressor stations/pipeline volume to the transport momentum (**Figure 15**). We selected the transport momentum as output parameter, which properly mimics the supply task of gas transportation with focus on load and transport distance. Below GTS is positioned near the average for all three gas qualities of G, H, and L.

**Figure 15.** Ratio of capacity of compressor stations/pipeline volume to transport momentum




Source: Frontier / Consentec

According to these analyses, we conclude that GTS' claim of having an outstanding requirement for a higher number or capacity of compressor stations cannot be confirmed by empirical data.

### 6.3.7 Joint venture

#### *GTS claim*

GTS claims that they do not have the possibility to form joint ventures with other network operators to build and operate a pipeline as some German TSOs are doing. Due to this there are cost disadvantages for GTS. In addition GTS claims that some output parameters may lead to double counting at a disadvantage for GTS.[37]

#### *Assessment of GTS claim*

We note that for the German benchmarking analyses BNetzA decided to allocate the costs for the joint ventures to the German gas TSOs according to the share in the joint venture. The same approach was applied to the cost driver parameters, as well, with the exemption of two costs drivers (supply area, number of connection points) where the allocation according to the share in the joint venture is not feasible due to conceptional reasons. This was the case for

[37] This claim corresponds to Claim B 11 in the GTS Memorandum from September, 5th, 2014.

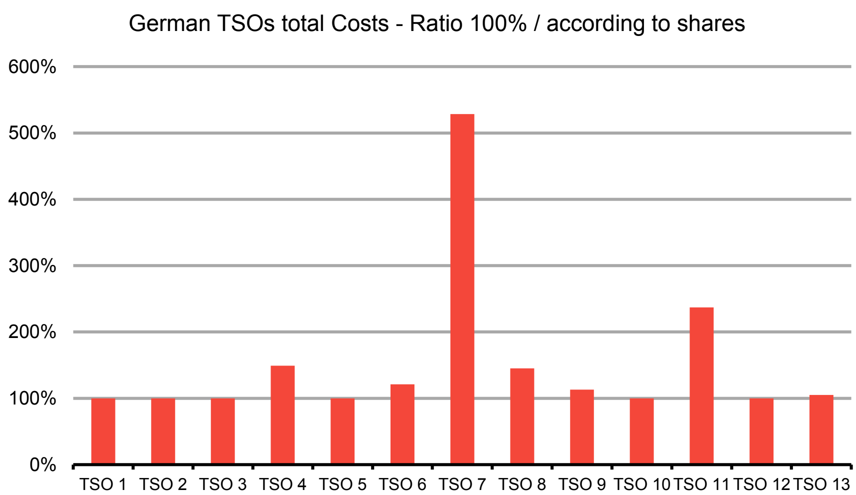
"connection points" where specifying a share for a connection point, e.g. 30% connection point would not make sense, because the connection point is reflecting the obligation for the network operator to reach this point with the network. The same holds true for the "supply area": if the company had built the pipeline on its own this would not have an impact on the affected area where the pipeline runs through.

In the following we discuss:

- the impact on total costs from allocating 100% of the joint venture costs to the German TSOs;
- the impact on the two output parameters (supply area and connection points) where the allocation is not based on the share of the joint venture but according to 100% by using either the total costs allocating 100% of the joint venture costs or allocating joint venture costs according to the share in the joint venture.

In a first step we calculate the potential impact from allocating 100% of the joint venture costs to German TSOs operating a joint venture (instead of allocating only costs according to the share in the joint venture). BNetzA provided us with detailed cost data for the joint ventures and the respective shares of the German TSOs in the joint venture. This enables us to calculate total costs which include 100% of joint venture costs for each TSOs engaged in a joint venture. We note that the maximum number of TSOs having a stake in one joint venture is three.

**Figure 16.** German TSOs total costs – Ratio for 100% cost allocation from JV to cost allocation according to shares




Source: Frontier / Consentec

**Figure 16** illustrates the results from our analysis as the ratio between

- total costs including 100% joint venture costs for the German TSOs being part of the joint venture;
- total costs including joint venture costs according to shares in the joint venture.

Six German TSOs are not affected by the 100% allocation as they are not part of a joint venture, meaning that they are in the same position as GTS. For the other German TSOs the impact on the costs can be classified within different ranges:

- 100% to 115%: three TSOs fall into this range;
- 115% to 150%: three TSOs fall into this range;
- > 150%: two TSOs fall into this range including one substantial outlier.

In Frontier/Consentec (2015)[38] we analysed individual output/input ratios as a first indication on the impact from allocating 100% joint venture costs to the German TSOs. We restricted our analysis only to the two output parameters (supply area, number of connection points) where the allocation is not based on the share of the joint venture but according to 100%. We get the following results:

- **Number of connection points** – The company having the best output/input ratio with regard to this cost driver does not change by including 100% of the joint venture costs. In addition, the company having the best ratio belongs to the group of the six German TSOs not engaged in a joint venture. Hence, this means that at least for this single ratio there should not be an effect on the relevant benchmark for GTS.

- **Supply area** – The company having the best output/input ratio with regard to this cost driver changes by including 100% of the joint venture costs. In case of allocating joint venture costs according to the share of the joint venture a company belonging to the three TSOs within the range of 115% to 150% has the best ratio. In case of allocating 100% joint venture costs a TSO from the group of the six German TSOs not engaged in a joint venture sets the best ratio.

One further important finding from the analysis is that the two German TSOs which are substantially affected by the 100% allocation of joint venture costs do not set the respective benchmark for either the connection point or supply area ratio.

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38 Frontier Economics/Consentec, *Gas TSO efficiency analysis for the Dutch transmission system operator (GTS) – Interim report for ACM*, July 2015.

Hence, the above analysis for the output/input ratios indicates that GTS will not be affected by "double counting of outputs" with regard to the parameter "connection point" if one uses total costs allocating cost from joint ventures according to the shares in the joint venture. When it comes to "supply area" we note that further analysis using results from the model specification can be used to assess the possible impact from supply area on the efficiency scores for GTS.

This means that we extended the analysis using DEA in the course of the model specification. The relevant question was: "Does including „supply area" and „connection points" impact GTS efficiency scores?". We analysed this by comparing the difference in

- efficiency score for GTS with a DEA model including „supply area" as output and two cost options (share JV and 100% JV); and
- efficiency score for GTS with a DEA model including „supply area" and „connection points" as output and two cost options (share JV and 100% JV).

**Table 5.** Impact on GTS efficiency scores from JV

| | Difference for DEA with 100% JV costs vs. share JV costs |
|---|---|
| **DEA model (1 output, total costs) – supply area** | +0.1% |
| **DEA model (2 outputs, total costs) – supply area, connection points** | +0.4% |

Remark: Results are for DEA with non-decreasing returns after outlier analysis.

Source: Frontier/Consentec

The results show that the impact on the efficiency score for GTS by including 100% JV costs is negligible. With regard to "supply area" the efficiency score of GTS only increase by 0.1% if 100% of joint venture costs are allocated to the German gas TSOs instead of the share of costs according to the share in the joint venture. Hence, we retain using the same output definitions and cost definition with regard to joint ventures as in the German benchmarking analysis.

### 6.3.8 Connection Task

#### *GTS claim*

GTS claims difference in costs due to differences in the obligation to connect customers.[39]

#### *Assessment of claim*

GTS claims that German TSOs have lower cost than GTS, because they have fewer obligations to connect customers.

In a meeting with ACM, Bundesnetzagentur explained that the German regulation also describes specifications for connection of customers. Network operators have an obligation to connect households. In paragraph 20 en 21 of Energiewirtschaftsgesetz - EnWG the obligations are briefly worded:

The network operators grant access to everyone at criteria that are technically justified. To arrange access to the gas supply system, operators of gas supply systems must offer feed-in and output capacity that enable system access without establishment of a transaction-dependent transport path and that are utilizable and transferable independently of one another. Operators of energy supply systems can reject access to the extent they demonstrate that providing system access is not possible or not reasonable based on operational or other reasons taking into account the objectives of § 1. The refusal shall be substantiated in writing and promptly notified to the Regulatory Authority (par. 20).

First, we note that it is not clear that the situation in Germany is fundamentally different from that in the Netherlands.

We also note that – even if there were differences in the obligation – it is unlikely that there could be any remaining substantial effect not covered by benchmarking parameters. We note that one benchmarking parameter candidate is the number of connections that – in the unlikely case of different obligations – would also have to be expected to be higher if there were stricter obligations in the Netherlands.

### 6.3.9 Market Areas

#### *GTS claim*

GTS claims that German TSOs would have higher costs when operating one unified countrywide market area like in the Netherlands.[40]

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39 This claim corresponds to Claim C14 in the GTS Memorandum from September, 5th, 2014.

40 This claim corresponds to Claim B10, B12 and B13 in the GTS Memorandum from September, 4th 2015.

### *Assessment of claim*

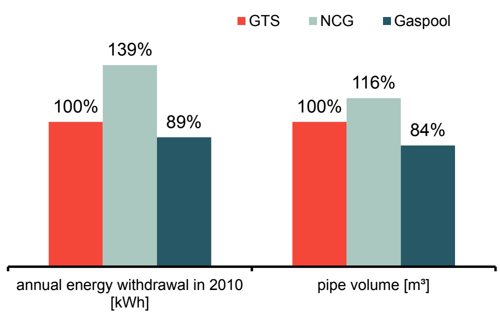
We note that benchmarking analysis refers to TSOs and not to countries. Consequently, additional costs that might result from the full merger of German market areas are not relevant. In addition, we note that already the existing German market areas are comparable in size and structure to the market area in the Netherlands.

This can be illustrated by a comparison of key indicators for describing the size of the market areas. For this comparison we use:

- annual energy withdrawal in 2010 (kWh); and
- pipeline volumes ($m^3$),

which both provide a good indication for the size of market areas. We are using data from the German gas benchmarking analysis and data provided from GTS. The German gas TSOs are allocated to their respective market areas, Gas Connect and NetConnect Germany, accordingly. The data are normalised to GTS (i.e. GTS = 100%).

**Figure 17.** Comparison of GTS, Gas Connect and NetConnect Germany




Source: Bundesnetzagentur, GTS

**Figure 17** Illustrates that NetConnect Germany is even larger than GTS with regard to annual energy withdrawal and pipeline volume. Taking GTS argumentation this would imply that the investment costs for the German gas TSOs in the NetConnect Germany market area should be reduced, thus forming a stricter benchmark in comparison to GTS. However, we propose that such hypothetical cost increases due to market area mergers should not be taken into account.

### 6.3.10 ICT system

#### *GTS claim*

GTS claims that its ICT system needs to meet higher requirements than those of German gas TSOs, placing GTS at a cost disadvantage. In addition, GTS claims that GTS is responsible for the data collection and plausibility check at the exit points to the regional grids. This has an impact on the costs for manpower, the software and hardware. GTS claims that in Germany this is done by the regional networks and not by the TSOs.[41]

#### *Assessment of claim*

In the first part of the claim GTS is concerned that its ICT system needs to meet higher requirements than those of German gas TSOs, placing GTS at a cost disadvantage.

GTS provides in the memo from January, 30th, 2015 information on the claimed cost impact:

- operating expenditures: € 1.12 million; and
- investment costs: € 10.49 million.

Most requirements which can affect ICT system from EU law and regulations and these are therefore the same for Germany and the Netherlands, for instance transparency requirements on flow data. However, on one aspect GTS differs from German TSOs: GTS reports on individual shipper balancing status near real time as this has a particular function in the Dutch balancing regime, whereas the German TSOs do not report on individual shipper status as regularly. However, in Germany the challenge for TSOs is that many market parties have to provide information to the TSOs, which the TSOs then have to process and which also has an impact on the ICT costs. Therefore, it is not clear that the ICT cost in the Netherlands and Germany are truly different. This means that only incremental cost differences should be relevant.

We note that the process of adjusting for country specifics is meant to adjust for significant differences putting GTS at a disadvantage against German TSOs. The reported investment cost corresponds to appr. 0.2% of GTS asset base and the reported Opex to app. 0.4% of total Opex. As only the incremental costs are relevant this figure needs to be reduced further. This gives no evidence for a significant impact.

41 This claim corresponds to Claim C 16 in the GTS Memorandum from September, 5th, 2014. Further details were provided in the GTS Memorandum from December, 24th, 2014 in “Punt 16: ICT systeme” and in the GTS Memorandum from January, 30th, 2015.

In the second part of the claim GTS is concerned that higher costs due to metering at exit points to regional networks puts them at a disadvantage. GTS provides in the memo from January, 30th, 2015 information on the claimed cost impact:

- operating expenditures: € 0.6 million; and
- investment costs: € 2.96 million.

We note that also German TSOs are operating metering devices at the exit points to the regional networks. Metering occurs on both sides. This means that there are also costs involved for this activity from the German TSOs. Hence, only incremental costs – if at all – for GTS can be relevant. We note that the process of adjusting for country specifics is meant to adjust for significant differences putting GTS at a disadvantage against German TSOs. The reported investment cost corresponds to appr. 0.1% of GTS asset base and the reported Opex to app. 0.2% of total Opex. As only the incremental costs are relevant this figure needs to be reduced further. This gives no evidence for a significant impact.

### 6.3.11 Odorisation

#### *GTS claim*

GTS claims that odorisation is undertaken by gas distribution companies in Germany while it is undertaken by GTS in the Netherlands.[42]

#### *Discussion*

GTS is concerned that it faces the cost of odorisation, while German TSOs do not. In Germany, odorisation is performed solely by DSOs.

GTS is reporting the cost for odorisation in the Opex cost item “Overig (emissie en odorant)”. In 2010 GTS reported “Overig (emissie en odorant)” of € 2.9 million. In the GTS Memo the exact figure for cost of odorisation is reported by € 2.855 million.

We accept this claim. We deducted € 2.855 million from the cost item “Overig (emissie en odorant)” when calculating the Opex for GTS in the benchmarking analysis.

### 6.3.12 Safety and environmental standards

#### *GTS claim*

GTS claims that safety and environmental standards are higher in the Netherlands than in Germany resulting in a cost disadvantage.[43]

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[42] This claim corresponds to Claim A6 in the GTS Memorandum from September 4th, 2014.

### *Discussion*

In a meeting with ACM, Bundesnetzagentur explained that German TSOs face a stringent collective self-regulation. German TSOs have to comply with technical rules set by the DVGW (Deutscher Verband des Gas und Wasserfaches) (§49 (2) Nr. 2 EnWG). If these rules are violated the company faces prosecution). Treatment of environmental rules is much the same in Germany as it is in Netherlands.

Hence, we conclude that the German gas TSOs place high standards on safety and environmental issues, as well.

## 6.3.13 Population density and soil type

### *GTS claim*

GTS claims that the higher population density in the Netherlands compared to Germany and the more difficult soil type of the terrain results in cost disadvantages in the range of +3% for population density and +7% for soil type.[44]

### *Discussion*

We note that the two claims, population density and soil type, were submitted by GTS after the process on "country specific claim" was closed by ACM.[45] Although GTS calls "soil type" a cost driver we would classify "soil type" clearly as a country specific claim. This is also indicated by GTS, as a reduction of costs is claimed to cover this aspect and not an additional output parameter. When it comes to "population density" there are again argument to classify this as a country specific claim. However, we note that aspects reflecting population density are already covered within the output parameters, as outlined below.

However, from a purely conceptual point of view we can comment on the main issues raised by Jacobs.

- **Population density** – Jacobs claims that a higher population density is related to higher costs due to large *wanddikte*, higher pipeline length due to less direct routes, additional compressor capacities and more crossings.

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43 This claim corresponds to Claim C16 in the GTS Memorandum from September 4th, 2014.

44 This claim was raised by GTS within the Jacobs Consultancy, *GTS Cost Drivers – Bevolkingsdichtheid en Grondslag,* Rapport opgesteld voor Gasunie Transport Services, October, 26th, 2015.

45 GTS provided ACM the Jacobs report on "population density" and "soil type" (Jacobs Consultancy, GTS Cost Drivers – Bevolkingsdichtheid en Grondslag, Rapport opgesteld voor Gasunie Transport Services, October, 26th, 2015) in the meeting between ACM and GTS on October, 30th, 2015.)

Generally, we note that the parameter candidates already capture characteristics of population density. For example, connection points are used as a proxy of the granularity of the network. A more granular network configuration can be caused by higher population density. In addition, we include the supply area as a parameter candidate. A DEA model including connection points and supply area as output parameter (together with a parameter capturing capacity provision) means that companies with a similar characteristic for connection points and supply area are compared to each other. This (partly) captures also population density.

The calculation of the cost impact on GTS by Jacobs is somehow flawed. Jacobs disregards that GTS is not compared to a single gas TSO in Germany, but with 13 gas TSOs all operating in different regions with different population densities. This means that Jacobs does not provide the appropriate information for the correction of the costs for GTS due to population density. In order to give the full picture the assessment and correction for population density for all gas TSOs, including also the German gas TSOs, would be necessary. This may even result in cost corrections for German TSOs which are similar or perhaps larger than the correction for GTS, and balance (or even outbalance) the effect on GTS. Hence, we can not conclude from the analysis from Jacobs that the correction of GTS costs by 3% is reasonable.

It is worth noting that in the German national benchmarking analysis for gas TSOs population density was not an issue for the companies, indicating that the effects were already captured by the parameter candidates derived from the different reference networks.

- **Soil type** – Jacobs claims that GTS has higher costs due to the characteristic of the terrain in the Netherlands. The higher share of "sandy" ground results in higher costs for GTS compared to the German gas TSOs.

  The calculation of Jacobs disregards again that GTS is not compared to a single gas TSO in Germany, but with 13 gas TSOs all operating in different regions with different terrain conditions. In order to give the full picture on the impact from soil on companies' costs the assessment and correction for all gas TSOs, including also the German gas TSOs, would be necessary. In addition, an extension on the different soil types is appropriate when undertaking this analysis. For example, the terrain in some German regions may be very rocky, resulting in cost disadvantages for the gas TSOs operating in these regions. Again, we can not conclude from the analysis from Jacobs that the correction of GTS costs by 7% is reasonable in particular if one is neglecting possible cost disadvantages for German gas TSOs.

Hence, we conclude that the Jacobs report does not provide sufficient information for the cost reductions of GTS. In addition, we note that the parameter candidates already cover certain claims (with regard to population density) from GTS.

## 6.4 Data used for calculation of parameters for long-list

In order to calculate the values for the parameters of the long-list of benchmarking parameters candidates for GTS from **Figure 7** we defined a data template similar to the one which was used in the BNetzA benchmarking study for the German gas TSOs. GTS provided the data according to this data template to ACM.

Based on the data we calculated the parameter candidates.

For the German gas TSOs the data for the parameter candidates was provided by BNetzA.

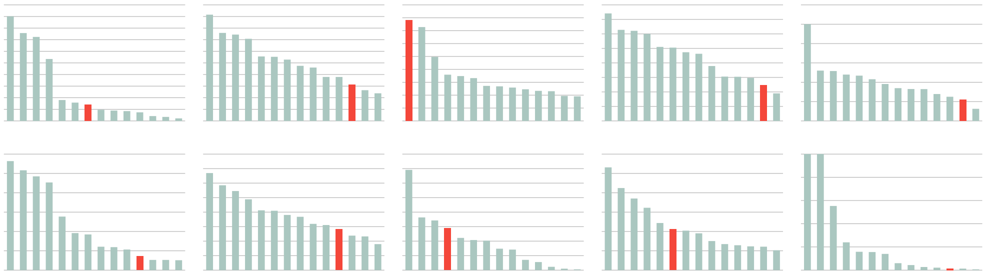
## 6.5 Descriptive analysis of parameter candidates

We evaluate the parameter candidates using actual company data and undertake a ranking of parameter candidates according to priority. The ranking is conducted considering the extent to which one parameter can more appropriately explain cost relationships than an alternative parameter. The ranking serves as an assessment criterion for selecting model candidates.

### 6.5.1 Input/Output Ratios

We analyse cost relations using actual company data and assess if the relations for GTS systematically differ from the German TSOs. **Figure 18** illustrates the cost-to-output relationship, e.g. EUR Totex/connection point, for the ten parameters from figure 7. The comparison of these indicators shows that GTS (red bar) is not systematically different compared to the sample of the German TSOs (blue bars).

**Figure 18.** Input/output indicator comparison



Remark: we note that due to confidentiality issues for the German gas TSOs we are not allowed to display which specific output we use in the above graphs.

Source: Frontier

### 6.5.2 Assessment of parameters based on correlation analysis

Due to the limited number of companies (14 TSOs) only descriptive statistical methods can be applied. Statistical analysis using multivariate regression is not possible. In order to assess the relationship between costs and single parameter candidates we use the correlation matrix as an instrument of descriptive analysis (**Figure 19**). A high correlation indicates a strong linear relationship between costs and output parameters, or between various parameters.

**Figure 19.** Correlation matrix

| | Totex | Connection point | Pipeline volume | Supply area | Peak load | Annual energy offtake | transport momentum | Pipeline surface area | mean transport distance | TM*area | SQRT (TM*area) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Totex** | 100% | | | | | | | | | | |
| **Connection point** | 76% | 100% | | | | | | | | | |
| **Pipeline volume** | 95% | 73% | 100% | | | | | | | | |
| **Supply area** | 84% | 52% | 69% | 100% | | | | | | | |
| **Peak load** | 90% | 68% | 95% | 55% | 100% | | | | | | |
| **Annual energy offtake** | 90% | 63% | 95% | 59% | 99% | 100% | | | | | |
| **transport momentum** | 93% | 64% | 96% | 64% | 99% | 99% | 100% | | | | |
| **Pipeline surface area** | 94% | 78% | 99% | 69% | 91% | 90% | 91% | 100% | | | |
| **mean transport distance** | 30% | -3% | 36% | 11% | 43% | 45% | 48% | 27% | 100% | | |
| **TM*area** | 91% | 62% | 79% | 93% | 70% | 71% | 77% | 77% | 19% | 100% | |
| **SQRT (TM*area)** | 97% | 62% | 87% | 94% | 81% | 83% | 87% | 85% | 30% | 95% | 100% |

Source: Frontier based on company data
SQRT=square-root

The correlation matrix shows different levels of correlations between parameters and costs and also among parameters. These correlations serve as an initial indication of the suitability of a parameter candidate. However, it does not necessarily mean that only a parameter with a high correlation to costs should be included in the benchmark analysis and vice versa. For example, engineering-based considerations may favour the inclusion of a parameter if this means that a further dimension of the supply task or an additional information item within the supply task can be covered by the parameter.

At the same time, the correlation matrix can help to identify to what extent parameters have the same type of effect, i.e. to what extent parameters cover similar cost relationships.

### Parameters with a high correlation to costs

The correlation matrix shows a high correlation between costs and the following parameters:

- Annual peak load;
- Annual off taken gas volume;
- Transport momentum;
- Transport momentum area;
- Root transport momentum area;
- Pipeline volume;
- Pipeline surface area; and
- Supply area.

In addition, individual parameters show similar high correlations.

Conceptual insights from the preceding cost-drivers analysis allow an initial ranking among the individual parameters. This ranking is used in **section 6.6** for the definition of the priority list:

- **Pipeline volume vs. pipeline surface area** – Both parameters show a high correlation to costs that can be substantially explained by the material costs for pipelines (in correlation to pipeline volume) and encasement and civil engineering costs (in correlation to the pipeline surface area). From a conceptual perspective, the argument in favour of the pipeline volume parameter is that it corresponds better to the capacity provided by the transmission system infrastructure than the pipeline surface area since the pipeline volume shows higher proportionality to the technical-physical transport capacity of a pipeline compared to the pipeline surface area. This is especially relevant when the parameter is to be used to cover the supply task "Capacity provision/gas transport".

- **Annual peak load vs. annual off taken gas volume** – Maximum demand is regularly the determining factor for the design and construction of transmission system infrastructures, meaning that the peak load is to be preferred to the output off taken gas volume (or other indicators of energy) because the latter is highly dependent on usage structure, which can vary over time but which has only a low impact on network costs.

### *Number of connection/coupling points*

The connection/coupling points (feed-in/withdrawal points) on average show a lower correlation across all transmission system operators. At the same time, the connection/coupling points represent an important parameter for the coverage of the supply task "granularity".

With regard to the "connection/coupling points" parameter it is important to note that the significance of the "connection/coupling points" parameter does not result from the construction costs for an individual connection point, which can vary by several orders of magnitude e.g. between a cross-border interconnection and an end-customer connection. Moreover, the focus is on the impact on the entire transmission system infrastructure in order to reach dispersed connection/coupling points. Connection/coupling points as a parameter therefore reflect, in simple terms, the necessity of laying more pipes for a larger number of connection/coupling points than for a lower number of connection/coupling points. This leads to higher costs and establishes the cost-driving effects of the parameter.

Furthermore, this parameter can better take into account the operating costs caused e.g. by higher transmission system complexity.

### *Mean transport distance*

The parameter candidate "mean transport distance" has the lowest correlation to cost. This is not surprising as this parameter has a different scaling (average value vs. absolute value) compared to the other parameter and costs. Hence, including this parameter into the DEA would require a scaling of this parameter. However, the information from "mean transport distance" is already included in the parameter "transport momentum".

## 6.6 Parameter candidates – priority list

In the following we assess whether the parameter candidates fulfil the requirements defined in **section 6.1** and define a priority list that is subsequently used in the model selection.

### 6.6.1 Requirements

In **section 6.1**, we defined requirements that a parameter has to fulfil in order to be incorporated in the benchmarking analysis:

- **Completeness** – We conclude that all parameter candidates fulfil this requirement, as they describe dimensions of the supply task based on the reference network analysis referred to in **section 6.2**.

- **Exogeneity** – In the context of this analysis, all parameter candidates are judged to be exogenous to GTS decisions. We discuss this issue below. For future benchmarking analysis, issues of endogeneity with regard to the parameters pipeline volume and pipeline surface area should be taken into account.

- **Non-redundancy** – The criterion of redundancy is assessed in combination with other parameters in **section 7**.

- **Quantifiability** – All but one parameter candidate fulfil this requirement: The parameter "mean transport distance" represent a relative parameter that would require scaling in order to be included in the analysis.

When it comes to **exogenity of benchmarking parameters**, the theoretical literature acknowledges that parameters based on the physical assets of companies should, if possible, not be included in the efficiency benchmarking analysis. The reason is that, first, costs are explained by costs and second, companies may in theory have a strategic incentive to influence the efficiency score by adjusting the parameter.[46] This could in theory be the case with pipeline volume and pipeline surface area since the parameter could theoretically be influenced by the construction of additional pipelines and the dimensioning of new pipelines.

In practice, however, it may be argued that the "controllability" of the pipeline volume and pipeline surface area is restricted in the context of this study:

  - For the current study, decisions on pipeline volume and pipeline surface area have been taken in the past, without taken into account that pipeline volume may be used as output parameter in an efficiency analysis in the future. However, if the regulator is aiming for consistency in the model specification for future efficiency analysis, then this argument may be less valid.

  - The construction of additional pipelines is subject, directly or indirectly, to special scrutiny owing to approval procedures, environmental impact

46 Cf. Tooraj Jamasb, Paul Nillesen, Michael Pollitt, *Gaming the Regulator: A Survey*, The Electricity Journal, Volume 16, Issue 10, Pages 68–80, December 2003; Tooraj Jamasb, Paul Nillesen, Michael Pollitt, *Strategic behaviour under regulatory benchmarking*, Energy Economics Volume 26, Issue 5, , p. 825–843, September 2004.

assessments etc. in which third parties (i.e. bodies external to the company) are involved;

- We understand that further checks are involved e.g. by the transmission system development plans and investment requests for large projects, which are assessed and confirmed by ACM.

This means that constructing additional pipelines without an appropriate proof of its need is unlikely to be feasible in practice today, or only under very difficult conditions. For these reasons, the use of the "pipeline volume" and "pipeline surface area" parameter in the current regulatory context can be argued to be in line with the regulatory requirements.

This is confirmed by the use of the parameter in a different context, e.g.

- Efficiency benchmarking analysis for German gas TSOs, where pipeline volume was used as output parameter.
- Efficiency benchmarking analysis for gas distribution system operators in Germany performed in 2008 and in 2013, where pipeline volume was also used as an output parameter.
- Efficiency benchmarking for electricity transmission system operators[47] where the entire physical equipment represents a significant benchmarking parameter. The intention here is, among other things, to ensure that investments in transmission system equipment serving to protect the security of supply (while potentially having a low capacity utilisation) do not cause disadvantages for companies in the efficiency benchmarking analysis.

### 6.6.2 Priority list

Based on the analysis in **section 6.5** we define a priority list for potential parameter candidates (**Figure 20**). The priority list is part of the model selection process and means for example that a parameter candidate listed under priority I tends to be better suited to describe one dimension of the supply task than a candidate listed under priority II.[48] The classification into priority I and priority II parameters is performed based on the insights gained from the cost-driver analysis and the analyses in **section 6.5.**

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47 Frontier Economics/Sumicid/Consentec, *E3GRID2012 – European TSO Benchmarking Study*, report for European regulatory, 2013.

48 For the detailed use of the priority list in the model specification phase we refer to **Section 7.3**.

**Figure 20.** Priority list

| | Priority | Granularity | Network extension | Capacity provision |
|---|---|---|---|---|
| connection points | I | | | |
| pipeline volume | I | | | |
| supply area | I | | | |
| peak load | I | | | |
| annual energy offtake | II | | | |
| transport momentum | I | | | |
| pipeline surface area | II | | | |
| TM*area | II | | | |
| SQRT (TM*area) | I | | | |

Source: Frontier / Consentec
TM = transport momentum
SQRT = square-root

In the following we explain the classification of parameter candidates under priority 1:

- **Annual peak load** – This parameter models the dimension "capacity provision/gas transport". The annual peak load is therefore a suitable parameter for each feed-in/withdrawal point in order to capture the capacity of the transmission system at and for this particular point. It is classified under priority 1.

- **Pipeline volume** – This parameter can model the dimension "capacity provision/gas transport" and the dimension "network expansion". If the pipeline volume is to be used for "capacity provision/gas transport", it should be preferred over pipeline surface area since the pipeline volume has a higher degree of proportionality to the technical-physical transport capacity of the pipeline. The pipeline volume allows the supply potential to be modelled independently of the actual capacity utilisation. It is therefore classified under priority 1.

- **Transport momentum** – This parameter can model the dimension "capacity provision/gas transport" and the dimension "network expansion" since it includes both load- and distance-related elements. It is therefore classified under priority 1.

- **Root transport momentum area** – This parameter can model the dimension "capacity provision/gas transport" and the dimension "network expansion". The parameter can be used to create potential room for an additional parameter that spans a further information dimension. The cost-driver analysis showed that the cost relationship for the combination of the transport momentum with the area is better represented by the root transport momentum area than by the transport momentum area. It is therefore classified under priority 1.

- **Supply area** – The preceding cost-driver analysis showed that this dimension appropriately models the "network expansion". It is thus classified under priority 1.

- **Feed-in/withdrawal points** – This parameter models the dimension of "granularity". It is the corrected feed-in/withdrawal point parameter (corrected coupling/connection points). It is classified under priority 1.

In the following we explain the individual parameters and their classification under priority 2:

- **Pipeline surface area** – This parameter can model the dimension "capacity provision/gas transport" and the dimension "network expansion". However, pipeline volume is to be given preference over pipeline surface area (see **section 6.2**). It is therefore classified under priority 2.

- **Transport momentum * supply area** – This parameter can model the dimension "capacity provision/gas transport" and the dimension "network expansion". The parameter can be used to create potential room for an additional parameter that spans a further information dimension. However, the cost-driver analysis showed that the cost relationship is better represented by the root transport momentum area. It is therefore classified under priority 2.

- **Annual off taken gas volume** – This parameter can model the dimension "capacity provision/gas transport" but is to be given lower priority compared with annual peak load and other load-dependent parameters since direct capacity provision has a greater cost-driving impact in gas transmission than the energy volume transported. It is therefore classified under priority 2.

The parameter candidate "Mean transport distance" is not included in the priority list as it exhibits the lowest correlation to cost and would require scaling. However, the information from "mean transport distance" is already included in the parameter "transport momentum" and no information is lost by excluding this parameter.

# 7 Model specification

In this section, we describe the process of model specification. The section is structured as follows:

- Definition of possible model candidates (**section 7.1**);
- Definition of selection criteria that are used to distinguish between different model candidates (**section 7.2**); and
- Assessment of the model candidates based on the defined selection criteria (**section 7.3**).

## 7.1 Definition of model candidates

Possible model candidates are formed based on the following three principles:

- **Modelling of the supply task** – The models should map the listed dimension of the supply tasks for transmission system operators. As described above in **section 6.2.3**, these are:
  - Capacity provision/gas transport;
  - Network expansion; and
  - Granularity.
- **Identifying inefficiencies** – The models should be suitable for mapping cost differences between companies appropriately. It should be noted that the ability to discriminate falls off correspondingly with an increasing number of parameters. Redundant mapping of certain dimensions of the supply task should therefore be avoided when specifying model candidates.
- **Practicability** – The models should be able to produce results based on the available data and given other restrictions[49]. In addition, cost of data collection should be taken into account.

Based on these principles, we define different model candidates that are generally suited to estimate GTS' cost efficiency. The ranking of model candidates for the final model specification is subsequently done based on the selection criteria described in **section 7.2**.

49 For a description how we operationalised this, we refer to **section 7.3.3**.

The approach of defining the three dimensions of the supply task points to models with three output parameters. This corresponds to the usual number of parameters proposed in literature covering a magnitude of 14 companies.[50] Additional output parameters would disproportionately restrict the power of models to discriminate when determining inefficiencies. Hence, the model candidates can be described as follows:

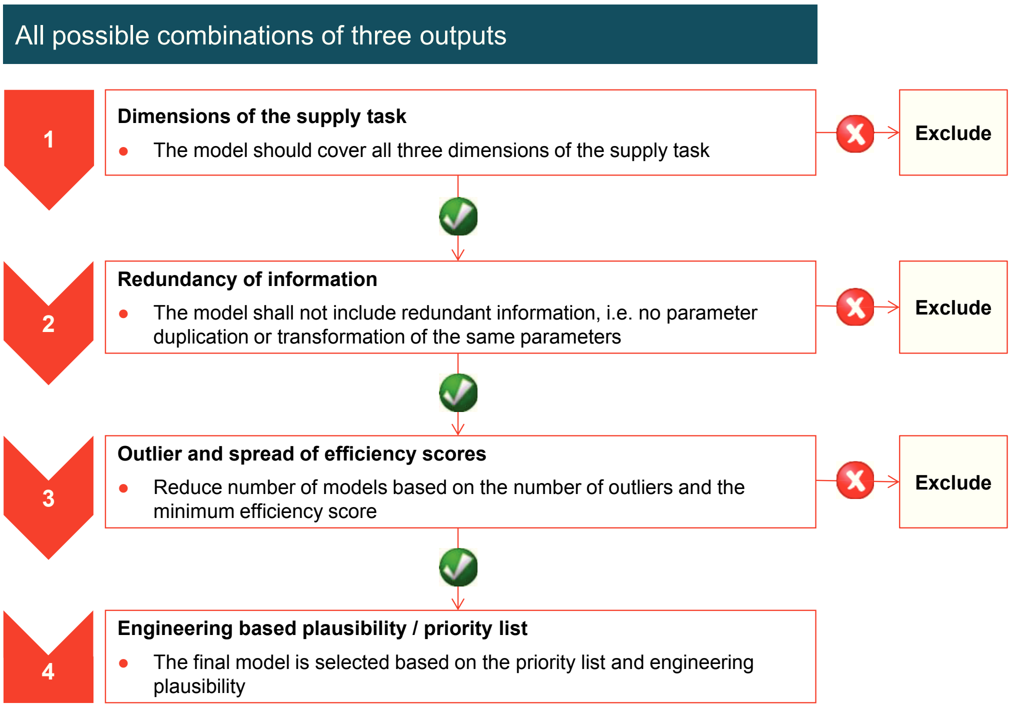
- **Benchmarking method** – The benchmarking method as specified in **Section 4** (DEA, non-decreasing returns to scale).
- **Costs** – The benchmarked costs as defined in **Section 5** (total costs, adjusted for country specifics).
- **Benchmarking parameters ("cost-drivers") –** The benchmarking parameters as defined in **Section 6** (identified cost-drivers allocated to the three dimensions of supply tasks).

## 7.2 Definition of selection criteria

In **Section 6.6**, we defined a priority list containing nine parameter candidates. In this section, we define the model selection procedure consisting of four steps. We note that due to the sample size (14 TSOs) econometric approaches are not applicable in the model selection procedure. The different steps of model selection are illustrated in **Figure 21**:

50 The literature suggests a maximum of 2-3 output parameters for a DEA with 14 companies. Cf. Cooper W.W., L.M. Seiford and K. Tone (publisher), Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References, and DEA-Solver Software, Kluwer Academic Publisher, 2007.

**Figure 21.** Model selection process




Source: Frontier

- **Step 0: All possible combinations** – All possible combinations of three outputs based on the nine parameter candidates included in the priority list serve as the starting point of the analysis.

- **Step 1: Dimensions of the supply task** – The model should include parameters that cover all three dimensions of the supply task. Therefore, we exclude models that do not cover all three dimensions.

- **Step 2: Redundancy of information** – In order to increase the amount of information included in the model, we assess whether parameter candidates (output parameter) include redundant information. Information is deemed to be redundant if

  - Two parameters are calculated based on the same information;
  - A parameter represents a transformation of another parameter that is already part of the model candidate;
  - This is indicated by engineering plausibility.

  The decision to exclude models in this step is first and foremost based on engineering-based plausibility of the parameter combinations. In addition, we take the pairwise correlation (in combination with engineering logic) as indicator for a high linear relationship between two parameters into account.

- **Step 3: Number of outlier and spread of efficiency scores** – In this step we calculate efficiency scores for the remaining models in order to assess the minimum efficiency score and the number of outliers. DEA does not allow direct testing of the statistical significance of specific parameters – in contrast to parametric benchmarking methods that are based on regression analysis. However, indications of the model "fit" can result from comparing the results of efficiency scores, e.g. the minimum efficiency scores, from different models. We argue that a lower number of outliers and a smaller spread of efficiency scores indicate that the selected model better reflects the production possibility set of the analysed sample of companies:
    - *Number of outliers:* We identify outliers based on the methodology described in **Section 4.3.** A high number of outliers reduces the spread of efficiency scores, but at the same time indicates that the selected output parameters may not fully reflect the supply task. Models with three and more outliers are assessed as critically since in this case at least 20% (3 outliers out of 14 TSOs) of the companies are identified as outliers. As a consequence, all models with three or more outliers are excluded from the selection process (irrespectively of their *spread of efficiency scores*); and
    - *Spread of efficiency scores:* The outlier analysis captures companies on the upper band of efficiency. On the other hand there may also be companies on the lower band of efficiency indicating that the chosen output parameters do not appropriately describe their supply task. As DEA is a deterministic approach, there is no intrinsic correction for this. Therefore, we consider the minimum efficiency, as well. We propose to operationalise this criterion by analysing the minimum efficiency of the remaining models with two outliers or less. We exclude models if their minimum efficiency score is below the average minimum efficiency score of all remaining models with two outliers or less.

- **Step 4: Engineering-based plausibility** – If there are still several eligible models left, we will prefer models with parameters that, from an engineering-based perspective, are classified under priority 1.

## 7.3 Assessment of model candidates

In the following, we apply the selection procedure described above. Based on three outputs and nine parameter candidates, 84 possible combinations (model candidates) are included in Step 0 ("n choose k" where n=9 and k=3). The list of all possible combinations is included in the **Annexe 1**: Details on model specification.

### 7.3.1 Step 1: Dimension of the supply task

In this step, we exclude models that do not cover all three dimensions of the supply task:

- Capacity provision/gas transport;
- Network expansion; and
- Granularity.

In **Section 6.2**, we derived the following allocation of parameters candidates to the supply tasks (**Figure 20**):

- **Network granularity** – is described only by the parameter "*number of connection points"*. Therefore we exclude models that do not include this parameter. The number of relevant models therefore reduces from 84 possible combinations to 28 possible combinations that include the parameter "*connection points*".

- **Capacity provision/network expansion** – the parameters "*peak load*" and "*annual energy offtake*" only describe the dimension of "capacity provision" but not the dimension of "*network expansion*". Therefore the model consisting of "*number of connection points*", "*peak load*" and "*annual energy offtake*" is excluded and the number of combinations is reduced to 27 possible combinations.

### 7.3.2 Step 2: Redundancy of information

In the second step of the model specification, we assess whether a model candidate includes redundant information. The decision to exclude a model candidate is primarily based on engineering logic but also informed by the assessment of pairwise correlation between parameter, i.e. a high linear correlation between two parameters may indicate that similar information is included. From the remaining 27 model candidates, the following 12 are excluded due to redundant information (**Table 6**). 15 model candidates remain after step 2.

**Table 6.** Model candidates excluded after step 2

| # | Output 1 | Output 2 | Output 3 | Comment | PWCorr |
|---|---|---|---|---|---|
| **5** | connection point | pipeline volume | pipeline surface area | *p.volume and p.surface area are calculated based on the same information* | *99%* |
| **12** | connection point | supply area | TM*area | *transformation of "supply area"* | *93%* |
| **13** | connection point | supply area | SQRT (TM*area) | *transformation of "supply area"* | *94%* |
| **15** | connection point | peak load | transport momentum | *transport momentum is calculated based on peak load* | *99%* |
| **17** | connection point | peak load | TM*area | *transport momentum is calculated based on peak load* | *70%* |
| **18** | connection point | peak load | SQRT (TM*area) | *transport momentum is calculated based on peak load* | *81%* |
| **19** | connection point | annual energy offtake | transport momentum | *highly correlated (similar information as peak load)* | *99%* |
| **21** | connection point | annual energy offtake | TM*area | *Annual energy offtake and transport momentum (TM) highly correlated. Scaling TM by area does not alter this correlation. In this case the efficiency would be mainly determined by the scaling parameter, area. The model would be similar to "connection point, annual energy offtake, area" which is already a model candidate.* | *71%* |
| **22** | connection point | annual energy offtake | SQRT (TM*area) | *Annual energy offtake and transport momentum (TM) highly correlated. Scaling TM by square root and area does not alter this correlation (see* | *83%* |

## **Model** specification

| | | | | | |
|---|---|---|---|---|---|
| | | | | *explanation on model 21)* | |
| **24** | connection point | transport momentum | TM*area | *transformation of "transport momentum"* | *77%* |
| **25** | connection point | transport momentum | SQRT (TM*area) | *transformation of "transport momentum"* | *87%* |
| **28** | connection point | TM*area | SQRT (TM*area) | *transformation of "transport momentum"* | *95%* |

Source: Frontier
PWCorr = pairwise correlation of output 2 and output 3.The correlation with output 1 is not assessed, because network granularity is described only by the parameter "number of connection points". Hence, the models have to include this parameter in order to cover all three dimensions of the supply task.

### 7.3.3 Step 3: Number of outliers and spread of efficiency scores

In this step we calculate efficiency scores for the remaining models in order to assess the minimum efficiency score and the number of outliers. We argue that a lower number of outliers and a smaller spread of efficiency scores indicate that the selected model better reflects the production possibility set of the analysed sample of companies:

#### *Number of outliers*

Models candidates with three and more outliers are assessed as critically since in this case at least 20% (3 outliers out of 14 TSOs) of the companies are identified as outliers. As a consequence, we exclude the models with 3 or more outliers. Based on this criterion, we exclude 2 possible combinations of outputs. 13 model candidates remain after this step.

**Table 7.** Model candidates excluded after step 3 (number of outlier)

| # | Output 1 | Output 2 | Output 3 | Outlier |
|---|---|---|---|---|
| **8** | connection point | supply area | peak load | 3 |
| **9** | connection point | supply area | annual energy offtake | 3 |

Source: Frontier

#### *Spread of efficiency scores*

The outlier analysis captures companies on the upper band of efficiency. On the other hand there may also be companies on the lower band of efficiency indicating that the chosen output parameters do not appropriately describe their supply task. Consequently, we exclude models if their minimum efficiency score is below the average minimum efficiency score of all remaining models with two outliers or less. From the remaining 13 models, we exclude 8 based on a minimum efficiency score lower than the average of the remaining models.

**Table 8.** Model candidates excluded after step 3 (minimum efficiency)

| # | Output 1 | Output 2 | Output 3 | Minimum efficiency |
|---|---|---|---|---|
| **2** | connection point | pipeline volume | peak load | 51% |
| **3** | connection point | pipeline volume | annual energy offtake | 51% |
| **4** | connection point | pipeline volume | transport momentum | 47% |
| **6** | connection point | pipeline volume | TM*area | 48% |
| **16** | connection point | peak load | pipeline surface area | 45% |
| **20** | connection point | annual energy offtake | pipeline surface area | 45% |
| **23** | connection point | transport momentum | pipeline surface area | 48% |
| **26** | connection point | pipeline surface area | TM*area | 56% |

Source: Frontier

### 7.3.4 Step 4: Engineering-based plausibility

After conducting steps 1 to 3, 5 possible combinations of outputs remain. In this step, we reduce the number of possible models further based on the priority assigned to the parameter candidates. Parameters with high explanatory power from an engineering point of view have been categorised as “Priority 1” while parameters that are deemed to have less explanatory power have been categorised as “Priority 2” (see **section 6.6.2**).

From the 5 remaining combinations, 2 model candidates include parameters that have been classified as priority 2:

**Table 9.** Model candidates excluded after step 4 (priority list)

| # | Output 1 | Output 2 | Output 3 | Priority |
|---|---|---|---|---|
| **11** | connection point | supply area | pipeline surface area | *Pipeline surface area has been classified as priority 2* |
| **27** | connection point | pipeline surface area | SQRT (TM*area) | *Pipeline surface area has been classified as priority 2* |

Source: Frontier

*Pipeline surface area* can model the dimension "capacity provision/gas transport" and the dimension "network expansion". However, pipeline volume is to be given preference over pipeline surface area since the pipeline volume has a higher degree of proportionality to the technical-physical transport capacity of the pipeline. Hence, we exclude the models 11 and 27, while retaining the corresponding models using *pipeline volume* instead of *pipeline surface area*.

We end up with three models after step 4, which we use for calculating the individual efficiency scores for GTS and the German gas TSOs in the following **Section 8**.

# 8 Final model – calculation of efficiency scores

In this section, we describe the calculation of efficiency scores using the methodology described in **section 4**. The section is structured as follows:

- Final model candidates (**section 8.1**); and
- Calculation of efficiency scores (**section 8.2**).

## 8.1 Final model candidates

The process of model specification in **section 7** has led to three possible model candidates (**Table 10**). Two of which have also been considered in the German TSO benchmarking. In the following we briefly describe the characteristics of the models.

**Table 10.** Final model candidates

<table>
<tr><th>#</th><th>Model A</th><th>Model B</th><th>Model C</th></tr>
<tr><td>Output 1<br>Granularity</td><td colspan="3">Connection points</td></tr>
<tr><td>Output 2<br>Capacity provision</td><td colspan="2">Pipeline volume</td><td>Transport momentum</td></tr>
<tr><td>Output 3<br>Network expansion</td><td>Supply area</td><td>SQRT (TM*area)</td><td>Supply area</td></tr>
</table>

Source: Frontier

All models fulfil the requirement of describing the different dimensions of the supply tasks:

- the dimension **Granularity** of the network is represented by “connection points”;
- the dimension **Capacity provision** is represented by “pipeline volume”, “transport momentum”; and
- the dimension **Network expansion** is represented by “supply area” and “SQRT(TM*area)”.

The models differ with regard to the degree of exogenity of the benchmarking parameters:

- **Model A** – includes pipeline volume to reflect the dimension of capacity provision. Pipeline volume can be classified as non-exogenous parameter because network companies can control this parameter by companies' decisions. However, we refer to **section 6.6.1** on the discussion of exogenity in the context of this benchmarking analysis. Hence, the model (partly) compares how efficient network companies have constructed and operated (part) of their physical assets (i.e. pipelines).

- **Model B** – includes pipeline volume and transport momentum (as part of SQRT (TM*area). Hence, it combines to questions. On the one hand the model compares how efficient network companies have constructed and operated (part) of their physical assets. On the other hand the model also compares how efficient network companies fulfil their supply task reflected by the exogenous parameter transport momentum.

- **Model C** – includes only exogenous parameters, since the transportation momentum reflects the dimension of capacity provision. Hence, the model compares how efficient network companies fulfil their exogenous supply task and neglects companies' physical assets as output.

## 8.2 Calculation of efficiency scores

In this section, we present the calculation of efficiency scores for the final three model candidates. The calculation of efficiency scores is conducted according to the method defined in **section 4**; additional information is included in **Annexe 3**.

**Table 11** illustrates that the three models differ with respect to the number of outlier, the average and minimum efficiency:

- **Model A** (connection points, pipeline volume, supply area):
  - average efficiency of 95.7%;
  - minimum efficiency of 75.3%;
  - two outliers have been removed from the sample;
  - GTS gets an efficiency score of **75.3%**.

- **Model B** (connection points, pipeline volume, SQRT (TM*area))
  - average efficiency of 88.2%;
  - minimum efficiency of 59.5%;

- one outlier has been identified;
- GTS gets an efficiency score of **79.2%**.

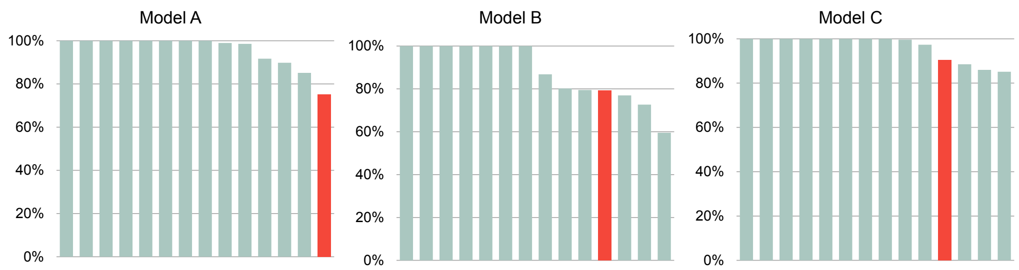
- **Model C** (connection points, transport momentum, supply area):
  - average efficiency score of 96.2%;
  - minimum efficiency of 85.1%;
  - two outliers have been removed from the calculation;
  - GTS achieves an efficiency score of **90.5%**.

**Table 11.** Final efficiency scores

| | Model A | Model B | Model C |
|---|---|---|---|
| **Output 1** *Granularity* | | Connection points | |
| **Output 2** *Capacity provision* | Pipeline volume | | Transport momentum |
| **Output 3** *Network expansion* | Supply area | SQRT (TM*area) | Supply area |
| **Average efficiency*)** | 95.7% | 88.2% | 96.2% |
| **Number of outlier** | 2 | 1 | 2 |
| **Minimum efficiency*)** | 75.3% | 59.5% | 85.1% |
| **Efficiency GTS*)** | **75.3%** | **79.2%** | **90.5%** |

Source: Frontier / Consentec
*) based on DEA (NDRS) excluding outlier

**Figure 22.** Distribution of efficiency scores (GTS represented by red bar)




Source: Frontier/ Consentec

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# Annexe 1: Details on model specification

In this annexe, we provide additional information on the process of model specification.

**Table 12.** Model candidates

| # | Output 1 | Output 2 | Output 3 |
|---|---|---|---|
| 1 | connection point | pipeline volume | supply area |
| 2 | connection point | pipeline volume | peak load |
| 3 | connection point | pipeline volume | annual energy offtake |
| 4 | connection point | pipeline volume | transport momentum |
| 5 | connection point | pipeline volume | pipeline surface area |
| 6 | connection point | pipeline volume | TM*area |
| 7 | connection point | pipeline volume | SQRT (TM*area) |
| 8 | connection point | supply area | peak load |
| 9 | connection point | supply area | annual energy offtake |
| 10 | connection point | supply area | transport momentum |
| 11 | connection point | supply area | pipeline surface area |
| 12 | connection point | supply area | TM*area |
| 13 | connection point | supply area | SQRT (TM*area) |
| 14 | connection point | peak load | annual energy offtake |
| 15 | connection point | peak load | transport momentum |
| 16 | connection point | peak load | pipeline surface area |
| 17 | connection point | peak load | TM*area |
| 18 | connection point | peak load | SQRT (TM*area) |
| 19 | connection point | annual energy offtake | transport momentum |
| 20 | connection point | annual energy offtake | pipeline surface area |
| 21 | connection point | annual energy offtake | TM*area |
| 22 | connection point | annual energy offtake | SQRT (TM*area) |
| 23 | connection point | transport momentum | pipeline surface area |

# **Annexe** 1: Details on model specification

| | | | |
|---|---|---|---|
| **24** | connection point | transport momentum | TM*area |
| **25** | connection point | transport momentum | SQRT (TM*area) |
| **26** | connection point | pipeline surface area | TM*area |
| **27** | connection point | pipeline surface area | SQRT (TM*area) |
| **28** | connection point | TM*area | SQRT (TM*area) |
| **29** | pipeline volume | supply area | peak load |
| **30** | pipeline volume | supply area | annual energy offtake |
| **31** | pipeline volume | supply area | transport momentum |
| **32** | pipeline volume | supply area | pipeline surface area |
| **33** | pipeline volume | supply area | TM*area |
| **34** | pipeline volume | supply area | SQRT (TM*area) |
| **35** | pipeline volume | peak load | annual energy offtake |
| **36** | pipeline volume | peak load | transport momentum |
| **37** | pipeline volume | peak load | pipeline surface area |
| **38** | pipeline volume | peak load | TM*area |
| **39** | pipeline volume | peak load | SQRT (TM*area) |
| **40** | pipeline volume | annual energy offtake | transport momentum |
| **41** | pipeline volume | annual energy offtake | pipeline surface area |
| **42** | pipeline volume | annual energy offtake | TM*area |
| **43** | pipeline volume | annual energy offtake | SQRT (TM*area) |
| **44** | pipeline volume | transport momentum | pipeline surface area |
| **45** | pipeline volume | transport momentum | TM*area |
| **46** | pipeline volume | transport momentum | SQRT (TM*area) |
| **47** | pipeline volume | pipeline surface area | TM*area |
| **48** | pipeline volume | pipeline surface area | SQRT (TM*area) |
| **49** | pipeline volume | TM*area | SQRT (TM*area) |

| | | | |
|---|---|---|---|
| **50** | supply area | peak load | annual energy offtake |
| **51** | supply area | peak load | transport momentum |
| **52** | supply area | peak load | pipeline surface area |
| **53** | supply area | peak load | TM*area |
| **54** | supply area | peak load | SQRT (TM*area) |
| **55** | supply area | annual energy offtake | transport momentum |
| **56** | supply area | annual energy offtake | pipeline surface area |
| **57** | supply area | annual energy offtake | TM*area |
| **58** | supply area | annual energy offtake | SQRT (TM*area) |
| **59** | supply area | transport momentum | pipeline surface area |
| **60** | supply area | transport momentum | TM*area |
| **61** | supply area | transport momentum | SQRT (TM*area) |
| **62** | supply area | pipeline surface area | TM*area |
| **63** | supply area | pipeline surface area | SQRT (TM*area) |
| **64** | supply area | TM*area | SQRT (TM*area) |
| **65** | peak load | annual energy offtake | transport momentum |
| **66** | peak load | annual energy offtake | pipeline surface area |
| **67** | peak load | annual energy offtake | TM*area |
| **68** | peak load | annual energy offtake | SQRT (TM*area) |
| **69** | peak load | transport momentum | pipeline surface area |
| **70** | peak load | transport momentum | TM*area |
| **71** | peak load | transport momentum | SQRT (TM*area) |
| **72** | peak load | pipeline surface area | TM*area |
| **73** | peak load | pipeline surface area | SQRT (TM*area) |
| **74** | peak load | TM*area | SQRT (TM*area) |
| **75** | annual energy offtake | transport momentum | pipeline surface area |

# **Annexe** 1: Details on model specification

| | | | |
|---|---|---|---|
| **76** | annual energy offtake | transport momentum | TM*area |
| **77** | annual energy offtake | transport momentum | SQRT (TM*area) |
| **78** | annual energy offtake | pipeline surface area | TM*area |
| **79** | annual energy offtake | pipeline surface area | SQRT (TM*area) |
| **80** | annual energy offtake | TM*area | SQRT (TM*area) |
| **81** | transport momentum | pipeline surface area | TM*area |
| **82** | transport momentum | pipeline surface area | SQRT (TM*area) |
| **83** | transport momentum | TM*area | SQRT (TM*area) |
| **84** | pipeline surface area | TM*area | SQRT (TM*area) |

Source: Frontier

# Annexe 2: Country specific claims

In the following we summarise how we deal with country specific claims with regard to

- scope of benchmarking;
- costs;
- benchmarking parameters and/or supply task.

**Table 13.** GTS claims on scope of benchmarking – overview on assessment

| GTS claim | Assessment |
|---|---|
| Balancing costs | • Opex – we exclude opex for the balancing task.<br>• Capex – we include capex for balancing in the study |
| Quality conversion | We exclude the costs for "Kwaliteitsconversie" from GTS cost base:<br>• Opex – exclude GTS opex for "Kwaliteitsconversie".<br>• Capex – exclude GTS physical assets used for "Kwaliteitsconversie".<br>In addition we adjust capital costs and operating expenditures for<br>• Part of compressor stations used for quality conversion: Reducing GTS' historic investments by € 50.8 million. Reducing opex by 787 ths. € and € 533 ths €.<br>• Nitrogen transport pipeline IJmuiden (Supplier Linde) - Oudelandertocht (GTS Mixing station): Reducing GTS' historic investments by € 30.5 million. Reducing opex by 237 ths. €. |

Source: Frontier/Consentec

**Table 14.** GTS claims on costs – overview on assessment

| GTS claim | Assessment |
|---|---|
| Pension costs HGB vs. IFRS | We acknowledge this claim and exclude the cost item from the GTS cost base. This reduces opex by € 16.1 million and €60.8 million. |
| Treatment of expansion investments | No cost adjustment for GTS is necessary as costs from investment measures are included in photo year 2010 of German gas TSOs |
| Treatment of non-controllable costs | We acknowledge this claim and add the non-controllable costs to the cost base of the German Gas TSOs |
| Gas receiving stations | We exclude the costs for "Gasontvangstations" from GTS cost base:<br>• Adjustments of capital costs – we exclude the asset "02 Gasontvangstations" from the asset base of GTS. This reduces GTS' historic investments by € 372.5 million.<br>• Adjustment of operating costs – GTS claims an adjustment for opex of € 16.09 million, which is 5% of the corresponding investment costs. We adjust GTS opex accordingly. This adjustment applies to "Total OPEX excl. BESeF (NOK)". For the adjustment of the cost item "Totaal BESeF" we use the GTS figures of € 3.477 million. |
| Provision of cleaning costs | We accept this claim and correct the operating costs from GTS by € 24 million. |

Source: Frontier/Consentec

**Table 15.** GTS claims on benchmarking parameters and/or supply task – overview on assessment

| GTS claim | Assessment |
|---|---|
| Difference in Security of Supply | We acknowledge the cost impact from the difference in Security of Supply and make the following adjustments:<br>▫ Adjustment of capital costs – we adjust the investment stream for the respective compressor stations according to the part due to higher Security of Supply. This reduces GTS' historic investments by € 76.5 million.<br>▫ Adjustment of operating costs – we use the GTS figure, which was assessed by Jacobs as reasonable, of 1.432 million € for adjusting operating costs. This adjustment applies to "Total OPEX excl. BESeF (NOK)". We understand from GTS that no adjustment is necessary for the cost item "Totaal BESeF". |
| Capacity products | Claim rejected |
| Gas quality | Claim rejected |
| Distance between storages (flexibility) | Claim rejected |
| Transit | Claim rejected |
| Trade off "Compressor stations vs. pipeline volume" | Claim rejected |
| Joint ventures of German TSOs | We retain the approach used by Bundesnetzagentur |
| Connection task | Claim rejected |
| Market areas | Claim rejected |
| ICT system | Claim rejected |
| Odorisation | Claim accepted |
| Safety and environmental standards | Claim rejected |
| Population density and soil type | Claim rejected |

Source:Frontier/Consentec

# Annexe 3: Efficiency scores

In this Annexe, we provide additional information on the results of the data envelopment analysis. For the three final models, we show

- The impact of the outlier analysis on efficiency scores; and
- The allocation of peer units for individual TSO.

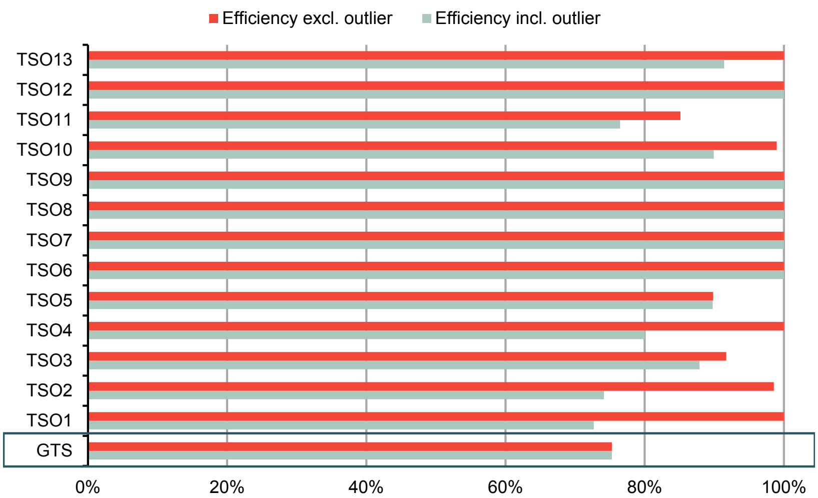
## Efficiency scores and outlier analysis

The efficiency scores are calculated according to the following logic:

- Calculation of efficiency scores using all 14 TSO;
- Identification of outliers based on "dominance test" and "superefficiency" criterion (see **section 4.3**); and
- Calculation of final efficiency scores excluding the outlying observations.

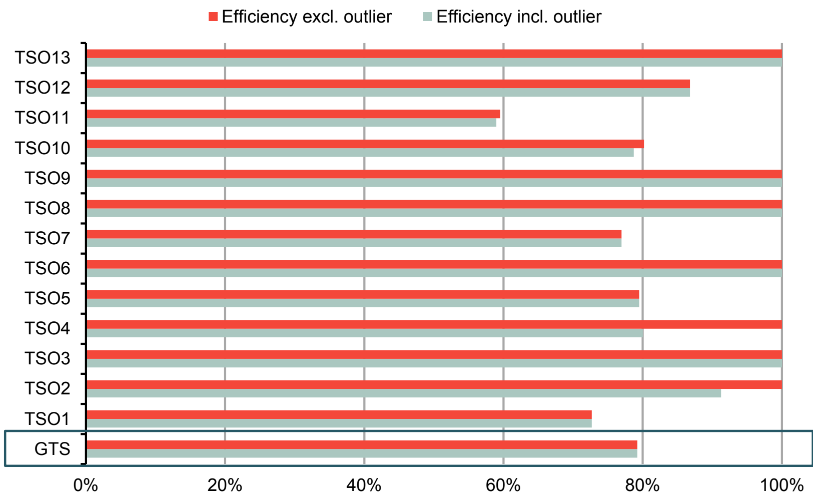
**Figure 23**, **Figure 24** and **Figure 25** illustrate the impact of excluding outliers from the analysis on individual efficiency scores.

**Figure 23.** Model A – impact of outlier analysis



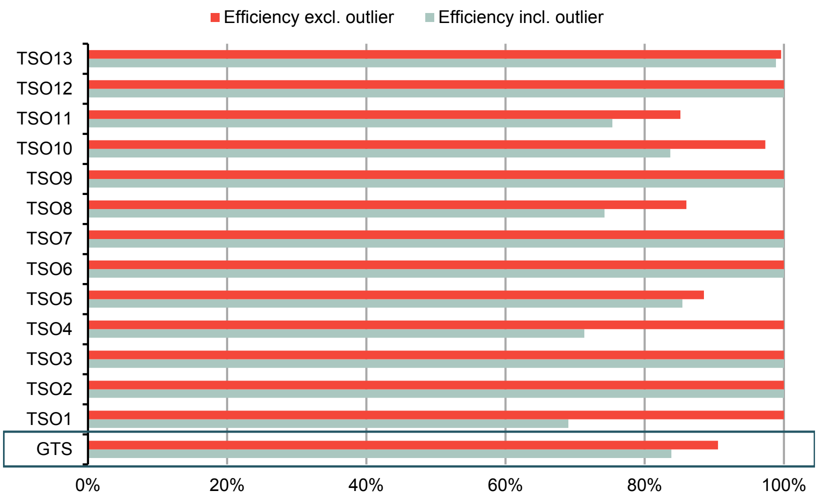

Source: Frontier / Consentec

**Figure 24.** Model B – impact of outlier analysis




Source: Frontier / Consentec

**Figure 25.** Model C – impact of outlier analysis




Source: Frontier / Consentec

## Peer units

Fully efficient firms in the sample excluding outliers span the efficiency frontier for other decisions making unit that are not fully efficient, i.e. not on the

# **Annexe** 3: Efficiency scores

efficiency frontier. In the following we show which TSO influences the efficiency score of the remaining firms.

**Figure 26.** Model A – peer units

| Name | Efficiency | Outlier? | TSO1 | TSO4 | TSO7 | TSO8 | TSO12 | TSO13 |
|---|---|---|---|---|---|---|---|---|
| GTS | 75% | | 0% | 0% | 0% | 100% | 0% | 0% |
| TSO1 | 100% | | 100% | 0% | 0% | 0% | 0% | 0% |
| TSO2 | 99% | | 0% | 82% | 0% | 0% | 0% | 18% |
| TSO3 | 92% | | 0% | 64% | 0% | 17% | 20% | 0% |
| TSO4 | 100% | | 0% | 100% | 0% | 0% | 0% | 0% |
| TSO5 | 90% | | 0% | 3% | 0% | 21% | 76% | 0% |
| TSO6 | 100% | yes | | | | | | |
| TSO7 | 100% | | 0% | 0% | 100% | 0% | 0% | 0% |
| TSO8 | 100% | | 0% | 0% | 0% | 100% | 0% | 0% |
| TSO9 | 100% | yes | | | | | | |
| TSO10 | 99% | | 0% | 88% | 0% | 2% | 10% | 0% |
| TSO11 | 85% | | 0% | 85% | 0% | 0% | 15% | 0% |
| TSO12 | 100% | | 0% | 0% | 0% | 0% | 100% | 0% |
| TSO13 | 100% | | 0% | 0% | 0% | 0% | 0% | 100% |
| | Peer for # of TSOs | | 1 | 6 | 1 | 5 | 5 | 2 |
| | Average Lambda (%) | | 100% | 70% | 100% | 48% | 44% | 59% |

Source: Frontier / Consentec

TSO 4 represents the peer unit for the majority of the sample in **Model A**. The efficiency score of GTS is determined by TSO 8, which is also peer for 4 other TSOs.

**Figure 27.** Model B – peer units

| Name | Efficiency | Outlier? | TSO2 | TSO3 | TSO4 | TSO8 | TSO9 | TSO13 |
|---|---|---|---|---|---|---|---|---|
| GTS | 79% | | 0% | 0% | 0% | 32% | 6% | 62% |
| TSO1 | 73% | | 0% | 0% | 0% | 4% | 96% | 0% |
| TSO2 | 100% | | 100% | 0% | 0% | 0% | 0% | 0% |
| TSO3 | 100% | | 0% | 100% | 0% | 0% | 0% | 0% |
| TSO4 | 100% | | 0% | 0% | 100% | 0% | 0% | 0% |
| TSO5 | 79% | | 0% | 46% | 0% | 0% | 24% | 31% |
| TSO6 | 100% | yes | | | | | | |
| TSO7 | 77% | | 0% | 98% | 0% | 0% | 2% | 0% |
| TSO8 | 100% | | 0% | 0% | 0% | 100% | 0% | 0% |
| TSO9 | 100% | | 0% | 0% | 0% | 0% | 100% | 0% |
| TSO10 | 80% | | 33% | 4% | 0% | 0% | 35% | 29% |
| TSO11 | 60% | | 20% | 20% | 0% | 0% | 43% | 17% |
| TSO12 | 87% | | 0% | 79% | 0% | 0% | 21% | 0% |
| TSO13 | 100% | | 0% | 0% | 0% | 0% | 0% | 100% |
| | Peer for # of TSOs | | 3 | 6 | 1 | 3 | 8 | 5 |
| | Average Lambda (%) | | 51% | 58% | 100% | 45% | 41% | 48% |

Source: Frontier / Consentec

TSO 9 represents the peer unit for the majority of the sample in **Model B**. The efficiency score of GTS is determined by TSO 8, TSO 9 and TSO 13.

# Annexe 3: Efficiency scores

**Figure 28.** Model C – peer units

| Name | Efficiency | Outlier? | TSO1 | TSO2 | TSO3 | TSO4 | TSO7 | TSO12 |
|---|---|---|---|---|---|---|---|---|
| GTS | 91% | | 14% | 0% | 86% | 0% | 0% | 0% |
| TSO1 | 100% | | 100% | 0% | 0% | 0% | 0% | 0% |
| TSO2 | 100% | | 0% | 100% | 0% | 0% | 0% | 0% |
| TSO3 | 100% | | 0% | 0% | 100% | 0% | 0% | 0% |
| TSO4 | 100% | | 0% | 0% | 0% | 100% | 0% | 0% |
| TSO5 | 89% | | 8% | 0% | 10% | 0% | 0% | 83% |
| TSO6 | 100% | yes | | | | | | |
| TSO7 | 100% | | 0% | 0% | 0% | 0% | 100% | 0% |
| TSO8 | 86% | | 0% | 0% | 0% | 88% | 0% | 12% |
| TSO9 | 100% | yes | | | | | | |
| TSO10 | 97% | | 0% | 0% | 0% | 89% | 0% | 11% |
| TSO11 | 85% | | 0% | 0% | 0% | 85% | 0% | 15% |
| TSO12 | 100% | | 0% | 0% | 0% | 0% | 0% | 100% |
| TSO13 | 100% | | 1% | 53% | 46% | 0% | 0% | 0% |
| | Peer for # of TSOs | | 4 | 2 | 4 | 4 | 1 | 5 |
| | Average Lambda (%) | | 31% | 77% | 60% | 91% | 100% | 44% |

Source: Frontier / Consentec

TSO 12 represents the peer unit for the majority of the sample in **Model C**. The efficiency score of GTS is determined by TSO 1 and TSO 3.

# Annexe 4: Transport Momentum

An illustrative example calculation was first created in order to represent the calculation of parameters that could be used in subsequent benchmarking analysis.

This simplified example for calculating transport momentum is based on sample data similar to the details requested by the Bundesnetzagentur and ACM and submitted by the gas transmission system operators as "Structural data II". They include, e.g., a clear identification of the coupling point (NKP) or connection point (NAP) which enables the assignment of other parameters to the NKP/NAP. A unique geographic assignment is made possible using the location ID (Standort-ID). Further requested data, summarised here in the example as input data ("Eingangsdaten") include connection pressure level, the type of coupling/connection point (with D identifying feed-in and E withdrawal), the quality of the in-feed/withdrawal gas (high- or low-caloric gas – i.e. H or L), maximum and minimum pressure and in particular the maximum feed-in and withdrawal volumes (labelled $Q_{max,Einsp}$ and $Q_{max,Entn.}$, in the example for 2007, the values for 2010 are used in the actual calculations) with the units indicated in the column headings in the diagram below.

**Figure 29.** Input data for calculating parameters

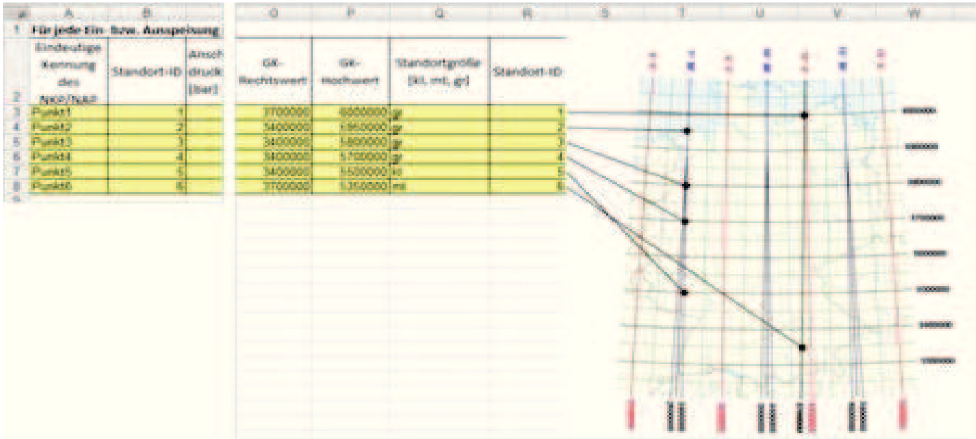
Für jede Ein- bzw. Ausspeisung an diesem Standort (Zuordnung erfolgt über Standort ID)

| Eindeutige Kennung des NKP/NAP | Standort-ID | Anschluss-druckebene [bar] | Art des Netzkoppel/anschlusspunktes | Gasqualität | maximaler Druck [bar] | minimaler Druck [bar] | Qmax,Einsp 2007 [Nm3/h] | Qmax,Entn. 2007 [Nm3/h] | Qmin,Einsp 2007 [Nm3/h] | Qmin,Entn. 2007 [Nm3/h] | Qmax,Einsp Buchbar [Nm3/h] | Qmax,Entn. Buchbar [Nm3/h] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Punkt1 | 1 | 80 | D | H | 100 | 85 | 3000000 | | 2000000 | | 3500000 | |
| Punkt2 | 2 | 80 | D | H | 85 | 67 | 2000000 | | 1500000 | | 2500000 | |
| Punkt3 | 3 | 80 | E | H | 85 | 50 | | 1500000 | | 0 | | 2000000 |
| Punkt4 | 4 | 80 | E | H | 85 | 45 | | 2700000 | | 1200000 | | 3000000 |
| Punkt5 | 5 | 80 | E | H | 85 | 20 | | 0 | | 0 | | 1000000 |
| Punkt6 | 6 | 80 | E | H | 85 | 10 | | 800000 | | 100000 | | 1000000 |

Source: Bundesnetzagentur

An example of the Gauss-Krüger coordinates and a cartographic representation is given below for the points listed (point1 to point6).

**Figure 30.** Coordinates and cartographic representation as an example of feed-in and withdrawal points



Source: ITE

These data are then used in accordance with the following methodology to determine the transport momentum (using the LP problem solver integrated with Microsoft Excel).

The first table in **Figure 31** lists the transport distance ("Transportentfernung") of all destinations between feed-in and withdrawal points that are determined from the geographical input data.

The second table in **Figure 31** shows the transport volumes ("Transportmenge") for each destination as the result of an optimisation calculation. Multiplying these transport volumes with the transport distances from the first table yields the transport momentum ("Transportmoment") for each individual destination, as presented in the third table in **Figure 31**. The transport volumes assigned to destinations are defined in such a way that the sum of the individual transport momentum (at the bottom right of the third table) gets the smallest value.

**Figure 31.** Calculating the transport momentum in the calculation example

**Transportmomentberechnung**

| Transport-entfernung (Luftlinie) [km] von | nach Punkt3 | nach Punkt4 | nach Punkt5 | nach Punkt6 |
|---|---|---|---|---|
| Punkt1 | 360,555 | 424,264 | 583,095 | 650,000 |
| Punkt2 | 150,000 | 250,000 | 450,000 | 670,820 |

| Transport-menge $[m^3/h]$ von | nach Punkt3 | nach Punkt4 | nach Punkt5 | nach Punkt6 | Summe | Soll |
|---|---|---|---|---|---|---|
| Punkt1 | 0 | 2.200.000 | 0 | 800.000 | 3.000.000 | 3.000.000 |
| Punkt2 | 1.500.000 | 500.000 | 0 | 0 | 2.000.000 | 2.000.000 |
| Summe | 1.500.000 | 2.700.000 | 0 | 800.000 | Nichtnegativität und Summe = Soll | |
| Soll | 1.500.000 | 2.700.000 | 0 | 800.000 | als Nebenbedingungen | |

| Transport-moment $[km*m^3/h]$ von | nach Punkt3 | nach Punkt4 | nach Punkt5 | nach Punkt6 | Summe |
|---|---|---|---|---|---|
| Punkt1 | 0 | 933.380.951 | 0 | 520.000.000 | |
| Punkt2 | 225.000.000 | 125.000.000 | 0 | 0 | |
| Summe | | | | zu minimierende Zielgröße: | 1.803.380.951 |

Source: ITE

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