CEER TSO Cost Efficiency Benchmark TCB21

Special conditions response note

Version V1.0
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1. Introduction

1. On 17 May 2023 CEER started the process of collecting and analysing so-called special conditions. In this process participants get the opportunity to signal conditions that are deemed specific to a certain TSO and that are not taken into account (sufficiently) by the benchmark model, but should have been in the eyes of the claimant. Such conditions are referred to as special conditions. The concept of special conditions evolves from previous CEER benchmarks (called “Z-factors” in benchmarks before TCB18.)

2. Participants were given until 31 July 2023 to submit claims. From there on CEER analyzed the claims and decided how to deal with these in TCB21. Instructions for submitting claims and criteria for special conditions were laid down in the “Special conditions reporting guide”, version V10, 17 May 2023.

3. CEER’s analysis of a claim will either lead to specific attention in the benchmark, or to the conclusion that the claim does not help to get closer to the goal of the benchmark.

4. This document describes the claims for special conditions made by several participants and the analysis and conclusions by CEER. The claims were done on the project platform, visible to all participants except for confidential material.

5. In this document, the claims (marked in orange) are described based on the original text, but sometimes edited or summarized for the sake of readability and to make sure that the claim itself is the perspective of the claimant and the assessment is CEER’s perspective and decision. Unabridged versions of the claims can be found on, and downloaded from, the project platform until the end of the project.

6. For electricity, the following claims were submitted:

E1	Energinet	Acquired 132/150 kV transmission grids
E2	TenneT	High population density
E3	TenneT	Changing energy landscape and decentralized electricity production
E4	TenneT	Assets near and below sea level
E5	TenneT	Wintrack towers
E6	APG	Labour cost
E7	TSO-Cyprus	Asset separation
E8	TSO-Cyprus	Lack of GIS cable data
E9	TSO-Cyprus	Small isolated system

7. For gas claims were submitted by:

G1	Enagás	Soil rockiness
G2	GTS	Network age differences
G3	GTS	Differences in functionality of TSO networks
G4	GTS	Network complexity (legal obligations)
G5	GTS	Obligation to connect
G6	GTS	Obliged security of supply standard

Assessment of claims by CEER

8. CEER notes that almost all of the claims and information have been shared with CEER before, e.g. in previous benchmarks, in response to TCB21 consultation notes, in TCB21 workshops, or via other communication between NRAs and TSOs. To CEER this confirms that it has not overlooked important topics. Nevertheless, it also signals that some TSOs think that so far CEER has not paid proper attention to several important topics in the TCB21 benchmark analysis. As such CEER will not respond to the claims made in TCB21 in terms of acceptance or rejection, but rather looks at the claims as requests by some TSOs to take another or a deeper look at certain topics.

9. In this document, for each claim CEER first describes the claim, staying as close as possible to the wording of the claimant. CEER only edited a TSO's wording where necessary to make sure that there can be no misunderstanding about the position of the TSO or CEER regarding the topic that is addressed. After the description, CEER explains how it looks at the claim and how it may change the analysis or lead to further action.

Claim E1 (Energinet): Acquired 132/150 kV transmission grids

Description of the claim (by the TSO)

10. In 2009 and 2012 Energinet (DK) acquired 11 regional transmission grids (132/150 kV) as a result of a politically imposed purchase obligation with the
aim of ensuring separation between transmission and production activities.
Energinet assumed the purchase obligation of the Danish State in pursuance of the National Electricity Supply Act and EU Directive 54/2003 on unbundling in the energy sectors. After the acquisition in 2009 and 2012, the total 132/150 kV transmission grid was thus gathered at Energinet.

11. Energinet's purchase price for the regional transmission grids was determined on the basis of a valuation method which was approved by the Danish Ministry of Climate and Energy and subsequently approved by the regulator.

12. The total purchase price (valuation method) for the grids was determined on the basis of the discounted present value of future payment flows, where financial and operational synergies have been included over a long-term and forward-looking valuation period of approx. 70 years, which is thus not based on the original acquisition cost of the assets. The remuneration (added value) is the difference between the book values for the grids and the purchase price.

13. In the financial reporting to TCB21 (Investment stream/Capex) and following a request from the NRA, the total purchase price, including the added price, for the grids has been reported.

14. The TCB benchmark calculates a Capex annuity based on historical investment streams typically based on the original acquisition cost. If the added value, which does not reflect the original actual acquisition cost, is added, the CAPEX annuity will increase, which will have a significant impact in efficiency measurement. Energinet continues that, on the other hand, all the savings (synergies), that form the basis for the added value, are not included. These are to a great extent based primarily on future financial savings, and future investment and operating synergies which are not included in the measurement.

15. In Energinet’s view asymmetry will thus arise, if only the added value (Capex) is included, as the financial savings effect and future investment and operating synergies will not be included in the statement. Energinet

remarks that this aspect was also discussed in the last benchmark (TCB18), where it was accepted that investments should be reported with the actual original acquisition cost for the assets.

16. Energinet further remarks that the accounting principles have resulted in the added value being recognized in property, plant, and equipment and not as an independent item such as goodwill.

17. The benchmark method has defined several criteria for Special Conditions to be approved. In Energinet's opinion, these criteria have been met. The method does not consider the lack of parallelism, and it concerns definable values and materiality.

18. According to Energinet the added value constitutes 10,8% of the total TMP Capex and thus constitutes a significant impact. In the request for correction for Special Conditions Energinet will document and report the exact amounts distributed on the assets in the TSO folder.

19. Energinet concludes that, moreover, it is essential that Energinet has been ordered, through the legislation, to buy the grids at a purchase price determined by a negotiated valuation method, which deviates from the principles used in the TCB benchmark. It would not be fair to maintain Energinet at an additional increase in Capex due to an external imposition (objectification).

20. Energinet requests, that the added value included in the Capex will be accepted as Special Conditions and thus not included as a reported Capex value, as it does not reflect the actual original acquisition cost for the assets.

Assessment by CEER

21. CEER finds that the uniqueness of the claim is not obvious as CEER is aware of several acquisitions that happened in conjunction with the EU directive regarding unbundling of the energy sector, with at least two cases having used a similar method of valuation using discounted future cash flows.

22. Note that methods of evaluation may differ, but the common ground is that they all lead to cost for the acquiring TSO that became part of the tariff base. For TCB21 that is what is relevant, i.e. TCB21 measures input and outputs without judging the reason for what comes out. The latter is up to NRAs that apply TCB21.

23. This becomes even more important realizing that, in the particular case of Energinet, the objectivity of the claim is also not obvious, as the price of Energinet's acquisition was not determined externally, but through negotiation between Energinet and the other party.

24. Based on the considerations above, CEER does not see the claim as something that warrants special treatment in TCB21.

Claim E2 (TenneT): High population density

Description of the claim (by the TSO)

25. In the eyes of TenneT, population density is a key cost driver for all kind of TSO costs, which is not reflected in the current approach of TCB21, as not all cost impacts of a high population density are related to land use and more TSO activities than only the construction of lines and cables is affected by population density. For example: 'Not in my backyard' (NIMBY) challenges also result in extra costs for permitting, station architecture, and noise abatement during construction (e.g. piles are not driven but rather screwed into the ground) and operation (e.g. low noise transformers and special sound walls around stations). Furthermore, the way in which land use is determined in TCB21 is also not adequate: almost no infrastructure is picked up by the granularity of the CORINE database and the corridor approach does not take into account the extra cost of crossings and electromagnetic interference.

26. TenneT would also like to stress that this is not a trivial issue: just looking at the numbers (Population density [TPS00003]) shows that the Netherlands is a completely different operating area in this regard than any other country involved in TCB21. TenneT stresses that these density differences are significant also for land use categories where the current assessment is that they provide for little complexity (I.e. agriculture). As long as the influence of a large population per square kilometre is not sufficiently taken into account, TCB21 will not yield any useful results about TenneT's efficiency level.

27. The impact of a high population density has been treated differently in past CEER benchmarks and therefore also in the legacy models proposed in TCB21. In E3Grid, density was used as an output parameter. This allowed for the model to implicitly take into account all consequences of population density without the need for a detailed understanding of the exact cost impact.

28. In TCB18, two mechanisms were taken into account: the share of angular towers allegedly represented the spatial complexity of line routing, and the use of land area should represent the physical obstacles present in the landscape. According to the TCB18 main report, it was therefore not needed to approve the special condition TenneT filed. TenneT believes this approach was insufficient to adequately capture the full impact of population density.

29. In TCB18, TenneT also claimed that the costs for brownfield investments are higher than greenfield investments. The need to built in a brownfield

situation is related to a high population density, as in a densely populated area there is little vacant space for greenfield development. Therefore in TCB21 TenneT treats them together as one condition. The grounds on which this claim was rejected in TCB18 (age effects) do not address the cost impact of building (renovating, substituting, expanding) in an existing built environment.

30. Currently, only land use (urban area) is taken into account in the benchmarking model, and only concerning lines and cables. This method significantly underestimates the complexity caused by a) densely populated non-urban environment b) the complexity faced while constructing or maintaining substations and c) the complexity resulting from the proximity to other infrastructure (including underground infrastructure such as gas pipelines, telecom cables and water pipelines) especially since hardly any infrastructure is recognised by the CORINE database. Furthermore, it is not clear if the complete cost impact of a high population density in combination with an urban environment is taken into account in the proposed environmental correction.

31. In this regard, TenneT refers back to the points made in the environmental cost factors (ECF) consultation. Here, TenneT showed how the land use categories of the CORINE database do not acknowledge differences in fragmentation, the urban characteristics of greenhouses, or hardly any infrastructure like motorways and railways.

32. The condition of high population density can be objectively measured and quantified using readily available demographic data. Population density, expressed as the number of inhabitants per square kilometer, is a widely used indicator that provides a clear and objective measure of the condition's magnitude.

33. TenneT continues that the condition of high population density is durable and structural as it represents a long-term and persistent characteristic of the Netherlands' operating environment. It does not result from temporary or sporadic occurrences but rather from the inherent nature of a densely populated country. TSOs operating in such regions face ongoing challenges associated with high population density that have a lasting impact on their operations and costs.

34. In the ECF note consultation, TenneT has used the example of the Rilland 380 kV station. DNV has determined, commissioned by ACM, that TenneT should have foreseen the environmental complexities of which DNV estimated the cost impact at in approximately 7 million Euro for this

one project alone[1]. The TCB21 team responded on this consultation that *"The mentioned project (Rilland 380kV) is a rather particular one. It is coincidentally located close to a relatively narrow passage to an island in the province of Zeeland. The complexity of the existing infrastructure (motorways, roads, railroads, shipways, vicinity of brittle main water pipelines etc. etc.) and the associated impact on the environment and cost is quite unique for that specific location, rather than being representative for substation locations."*

35. The point that the TCB21 team is missing here, is that the location of this substation near complex existing infrastructure is not a coincidence at all. It is a direct consequence of having to build in a densely populated country, even though the CORINE database shows this area of Zeeland to be mainly agricultural (even the A58 motorway is not on the CORINE maps!) Primarily, the chosen location of the substation was driven by the existing EHV lines the substation were to be connected to. However, the location of these existing lines was not accidental either: they are purposely aligned with other infrastructure in order to minimize the impact on the already scarce space. If there was abundant vacant space, TenneT and relevant authorities would obviously have selected a less complex location for these lines and therefore also for this substation. In other words: the associated impact on the environment and costs is not unique for that specific location, but representative for substation locations in densely populated countries.
NB: One could argue that if complexity of substations always coincides with complexity of lines and cables, it would be enough to only correct one of those in the benchmark. That would however assume equal shares of substations versus lines/cables between all TSOs, which is demonstrably false. As the share of substations within the assed base varies, only allowing for a correction by correlation with line/cable complexity penalizes TSOs with a large share of substations, and favour TSOs with a small share of substations.

36. The complexities known to the TCB21 consultants in the Rilland project are just one example of how nearby infrastructure affects costs. Some other examples include:

37. a) EMC mitigating measures
When electricity transmission infrastructure is near railway infrastructure, gas or heat pipelines or other infrastructure sensitive to electromagnetic

[1] DNV (2021), "Doelmatigheidsrapport station Rilland", page 12 and 13: TenneT notes that DNV estimates the total difference between the actuals and the counter budget on the line segment at 11,9 MEUR, of which 4,8 MEUR is estimated to be caused by the HEP contract issues, leaving 7,1 MEUR to be caused by environmental complexities.

interference, problems with electromagnetic compatibility (EMC) may arise. These need to be mitigated before the line can be taken in service without risks to rail traffic or other infrastructure. See for example the following scientific paper: https://www.icrepq.com/icrepq'14/437.14-Novitskiy.pdf. Although this paper deals with the possibility of common pylons, similar EMC challenges arise when electricity lines have to be built in parallel or close proximity to sensitive infrastructure.

38. Mitigating measures can include additional earthing, cathodic protection, capacitor banks or other equipment. This is also known by TCB21's consultant DNV as they are one of the consultancy agencies that advice TenneT on required EMC mitigation measures. As an illustration: in the current expansion project "Zuid-West 380 kV Oost" (from Rilland to Tilburg), current estimates are that EMC measures will add up to 13 million euro for this project alone. Again, CORINE shows the routing of this project (that avoids any large urban areas in the region) as mainly agricultural, not recognizing this complexity resulting from the still highly populated area.

39. b) Costs of crossing other infrastructure

As mentioned before, the CORINE land use database hardly recognizes any above-ground infrastructure, let alone underground infrastructure. As TenneT has indicated before (e.g. in ENV-24) , especially crossing of certain environments (e.g. crossing a highway, or a waterway) has considerable impacts on cost, such as:

- Required horizontal drilling (HDD) instead of laying cable in open trenches.
- Higher pylons and water-resistant foundations.
- Reconstruction of existing infrastructure if crossing is not allowed or possible.
- Allowances for either undisturbed operation of the existing infrastructure, like safety measures, or planned unavailability like route diversions, closures and train-free periods.

40. TenneT notes that a lot of infrastructure and other cost increasing elements are not immediately visible in the landscape, but very relevant when constructing towers, substations or cables, such as water, gas, oil, heating and sewage pipelines, electricity, telecom and data cables, remains of historic construction works (with or without archaeological value), undiscovered explosives from World War II, soil pollution, old landfills, et cetera. Simply said: in country that is so extremely densely populated as the Netherlands, there is no area that is 'not complex', even though it may look simple from above.

41. In the corridor approach, when crossing a certain environment, only a very limited part of the corridor (i.e. the width waterway where it is crossed) is adjusted for this landcover. Thereby a 10 km line alongside a waterway (assuming it is recognized by CORINE) will be qualified as considerably more complex/costly than a 10 km line crossing several waterways (assuming all other landcover equal). In the response to ENV-24 the TCB21 team considers this a 'relevant' point, but so far TenneT has not understood how this will be solved, therefore TenneT files it as a part of the special condition 'population density' again.

42. c) Cost of zoning constraints and brownfield building
TSOs operating in densely populated areas often have limited flexibility in determining optimal locations for their assets. Simply stated, every square meter of the Netherlands is already in use by something or someone, and if new electricity transmission infrastructure needs to be build, it needs to be fitted in the existing zoning plans with great care and least disturbance of current (nearby) residents, users and owners. In a densely populated area, TSO and relevant authorities usually have to chose the lesser of two evils; which increases costs for both initial investment and maintenance, for example, but not limited to:

- The requirement to build and work as small as possible to fit a substation in a designated space (note that not only the final project is limited in space, but also the construction work itself, the work roads, transport of large equipment, etc.).
- The requirement to limit electromagnetic radiation as much as possible to fit infrastructure near an urban area.
- The need to work in or near an ecological vulnerable area like a Natura 2000 conservation area, which has its own rules and mitigating measures (note that the Netherlands has relatively many different Natura 2000 areas).
- The need to work near a railway or other interfering infrastructure as mentioned above. (EMC, train-free periods).

43. TenneT continues that not only the actual work in these limited spaces add costs, but also the extensive engagement with local communities, industry stakeholders and public entities to agree on the location and compensation measures for the environment. This includes consultations, public hearings, obtaining permits, and addressing concerns regarding visual impact, noise pollution and disruption during construction. In short, negotiating with numerous stakeholders and landowners, seeking changes in zoning plans, and dealing with more complex permitting processes are time-consuming and resource-intensive activities. This also relates to the fragmentation of land ownership and usage that occurs

in a densely populated area, which TenneT also illustrated with satellite images in the ECF consultation.

44. Also, brownfield development requires more intricate project scheduling and coordination to minimise disruption to existing urban services and activities. Delivering materials, heavy equipment, and construction machinery to the site can be more time-consuming and costly due to restricted access and the need to minimise disruptions to the surrounding urban environment. Coordinating with local authorities, businesses, and residents to ensure minimal impact on their daily routines and services increases project management complexity and costs.

Assessment by CEER

45. TCB21 proposes two models for the benchmarking of electricity TSO; E3395 and E2388. Both models address the dimensions evoked in the claim using various measures.

46. Model E2388.V2.4.env2 is environmentally corrected for landuse, slope, and gravel conditions (LSGG) for both cable and line locations, as well as incorporating a weighted measure for angular towers in the line output.

47. Model E3395 includes as outputs also the number of substations HV, differentiating among TSO with varying degrees of HV/EHV interfacing. The model is environmentally corrected for landuse, slope, and gravel conditions (LSGG) as E2388.

48. TenneT argues that population density is a key driver for “all kind” of TSO costs. The project has acknowledged the importance of density as one element of the operating context, cf. Note on Environmental Modelling 2023-01-13, V1.4, pp 15-16. However, the engineering analysis reveals that the density effects are related to the asset locations, not to the overall population density in a country. The operating and investment cost for TenneT assets in less populated areas such as Eastern Netherlands is more correctly comparable to costs for similar operating conditions in e.g. Germany than to e.g. the cost of urban locations (e.g. Stockholm) in an otherwise sparsely populated country such as Sweden. The examples in art. 25 are all valid only to the extent that it concerns assets for the operator. Therefore, the landuse factors are the economically most correct approach to address density. In TCB21, all elements of landcover complexities are used, not only urban areas (cf. 30).

49. As to the earlier inclusion (ref. art. 27), using population density as a ratio (habitants per km2) is not an economically correct output candidate in an

additive cost function as it does not relate to the scale of operations. A parameter as zDensityArea is equivalent to using a population measure, which is closely related to the overall residential energy demand. As such, the population is not a techno-economic output in itself, but a second-order indicator of one of the TSO's service tasks. This led in earlier benchmarks to methodological complexities such as the introduction of weight restrictions so as not to award an arbitrarily high marginal cost to a non-asset related complexity factor.

50. As to individual installations (ref. art. 34), each TSO may exhibit installations that are particularly costly due to environmental, historical and/or exogenous circumstances in urban and rural settings. A benchmarking like TCB21 is concerned with average conditions as all assets and costs are aggregated and compared to equally aggregated measures for comparators. It is therefore not a feasible approach to draw interferences from a particular location and installations to a full asset base.

51. As bias in structure (ref. art. 35), TenneT claims that the substation locations and incidence are sources of bias for its assessment. Model E3395 has the number of substations as an output, which contradicts this statement. A Tobit regression of the share of substations towards the DEA-scores shows no significance (see Appendix), no bias can be shown.

52. Concerning bias in the score, density metrics have been tested as explanatory factors for all model results in second-stage tests, both panel and for the crosssection 2020 The density parameters tested are listed in Table 1 below. In the Tobit regressions reported in the Note on Model Specification V1.0, no density parameter comes out as significant for models E2388.V2.4 and E2388.V2.4.env2. Certain density parameters do show up as significant in for E3395.V2.4 and E3395.V2.4.env2. However, as E2388.V.2.4 gives a 13%-units higher efficiency score, implicitly there is already a compensation for density in the provision of two models, one of which is not sensitive to density, population or urban parameters.

Table 1 Density parameters in TCB21.

Parameter	Formula
zDensity.pop	Average 2019 population/land area (country)
zDensity.nuts3	Average 2019 population/land area (NUTS3 asset area)
zDensityArea	zArea.tot*zDensity.pop*yShare.area.urban.tot
zDensityNGcp.circuits.nuts	zDensity.nuts3*yNGcp_10
zDensityNGce.circuits.nuts	zDensity.nuts3*yNGce_10

zDensityNGop.circuits.nuts	zDensity.nuts3*yNGop_10
zDensityNGC.nuts	zDensity.nuts3*yNGC
zDensityNGO.nuts	zDensity.nuts3*yNGO
zDensity_circuits.nuts	zDensity.nuts3*yCircuits_tot
zDensity_lines.nuts	(lines)zDensity.nuts3*yLines_tot
zDensity_cables.nuts	(cables)zDensity.nuts3*yCables_tot
zDensityArea.nuts	zDensity.nuts3*zArea.tot

53. As to sensitivity analysis, a 4-parameter model has been tested with the outputs: lines, transformers, NG-residual and zDensityNGop.circuits.nuts (population density in NUTS3 asset areas weighted with the non-age censored Normgrid), E4099.V1. The model essentially replicates the results of E2388 in level (+1.2% in mean score) and in terms of peers and outliers (8 of 9). This further underlines that the inclusion or exclusion of density does not radically change the assessment of efficiency. However, note that the inclusion of a density-type parameter without any restrictions gives absurd marginal effects for certain operators, as discussed in the TCB18 reporting. The Pearson rank-order correlation in Table 2 below indicates high correlations between the rankorder (i.e. the relative scores in the models) across models, in particular with E3395. Indeed, the rank order for the E4099 model has a stronger correlation to E3395 than the intercorrelation between models E2388 and E3395. This is another argument to support that the impact of density is already effectively covered in the existing models. The regression results for E4099.V1 are provided in Appendix A.

Table 2 Pearson correlation and mean DEA-score (ndrs, ex.out, 2020).

mod	E3395.V2.4	E2388.V2.4	E2388.V2.4.env2	E4099.V1
E3395.V2.4	1.000	0.459	0.507	0.757
E2388.V2.4	0.459	1.000	0.947	0.697
E2388.V2.4.env2	0.507	0.947	1.000	0.649
E4099.V1	0.757	0.697	0.649	1.000
Mean score	0.883	0.882	0.900	0.894
#peers	5	7	7	8
#outl	3	2	3	2

54. As to brownfield costs (ref. art. 42), the engineering assessment of construction costs for greenfield vs brownfield costs is not clear. TenneT evokes costs that are increased, as well as limiting operations. However, part of the arguments (landowner settlements, new zoning areas, environmental impact assessments) are arguments used in favor of

brownfield locations from other operators. Further, technical development has tended to reduce the space requirements which alleviates the flexibility constraints.

55. Overall, CEER finds no compelling reason to either award an operator-specific condition to TenneT for the national population density or to include the density effects in the limited dimension suggested by the claim.

Claim E3 (TenneT): Changing energy landscape and decentralized electricity production

Description of the claim (by the TSO)

56. TenneT notes that TSOs are no longer just “wire/pipe companies” as claimed in the COMP note. The energy transition, marked by the rise of renewable energy sources and increased electrification, has far-reaching implications. As TSOs adapt to the changing energy landscape to be ‘fit for the future’, they face the need to invest in personnel and expand their workforce. The integration of renewable energy sources introduces variability, necessitating enhanced grid flexibility. This changing energy landscape requires innovation, new ways of thinking, and collaboration with industry and public stakeholders. Therefore, in the current operations of a TSO, additional effort is spent on energy system planning compared to the more traditional way of working of 10-20 years ago.

57. Energy production by solar PV especially introduces complexity for the electricity transmission system due to its decentralized nature. Unlike large hydro, wind or bio-energy power plants, solar PV systems often are distributed across various sites, connected to the distribution grid at the low voltage level, turning previously just consuming households into many small electricity producers. The decentralized deployment of solar PV systems leads to variable generation patterns based on local weather and requires managing bidirectional power flows between the DSO and TSO grids. High concentrations of solar PV systems in certain areas can lead to localized grid congestion and rapid fluctuations in generation can impact the overall grid response and necessitate additional measures to ensure system stability. Decentral power sources also have other challenges for the electricity system, like the availability of balancing power, inertia, reactive power etc.

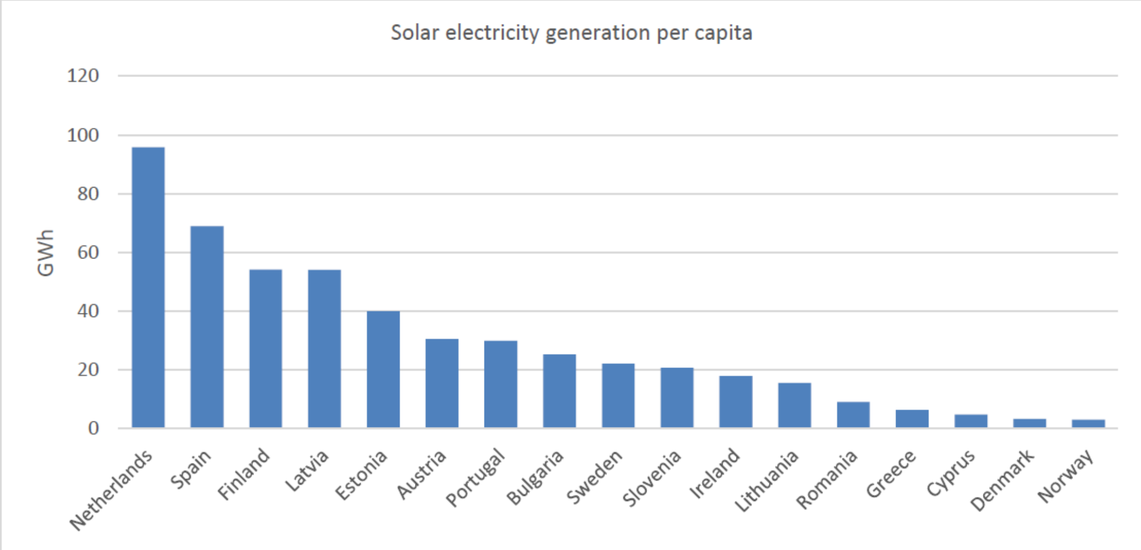
58. TenneT continues that to accommodate the growing renewable energy capacity (especially solar-PV and (offshore) wind power, which are the main future sources of electricity in the Netherlands) and meet increasing electricity demand, TSOs must invest in upgrading and expanding the electricity grid infrastructure. This growing project portfolio requires additional personnel. With the recruitment of new personnel to meet the demands of the energy transition, TSOs must also invest resources and time in onboarding and training programs. The initial onboarding process and training period make it challenging for new staff members to be fully productive from day one. As a result, TSOs must account for the time and resources invested in training, integrating new personnel, and related overhead costs (e.g. HR) before these costs can be capitalized.

59. In addition to that shortages in available capacity are inevitable. Consequently, TSOs also need to invest in digitalisation of assets to allow for more flexible usage of the grid. There is currently no output foreseen in the benchmark to account for IT investments, which means that a different level of digitalization between TSOs (with respective costs in both OPEX and CAPEX) will lead to a bias, where TSOs that invest more in digitalization are penalized. This needs to be addressed.

60. This claim has not been claimed in a previous benchmark, as far as TenneT is aware. The additional costs related to be fit for the future, has been a topic of discussion between TenneT and the ACM.

61. Possibly, in time, the efficient costs of both innovative energy system planning and personnel growth could become visible in the physical outputs that can be measured in the TSO benchmark. In that case, there is at least a time lag between those expenditures and actual measurable outputs. In other cases, depending on the innovative solutions to new problems and certainly in the case of IT solutions, the results of these efforts might not be reflected in physical grid assets at all and therefore not measurable by TCB21. This would not be a problem if all electricity TSOs in TCB21 face the same portfolio increase, the same personnel growth and the same challenges to develop a new, renewable and decentralized energy system. However, the extent to which TSOs face these costs differs as for example the level of decentralization differs between the countries, and therefore these costs need to be taken into account in TCB21. The same applies for IT investments (OPEX and CAPEX) and additional efforts on implementing for instance congestion management.

62. Specifically in the Netherlands, renewable generation is very decentralized and therefore requires a substantive change to an innovative system. See for example the solar electricity generation per capita for the countries in TCB21:



Source: https://ourworldindata.org/grapher/solar-electricity-per-capita

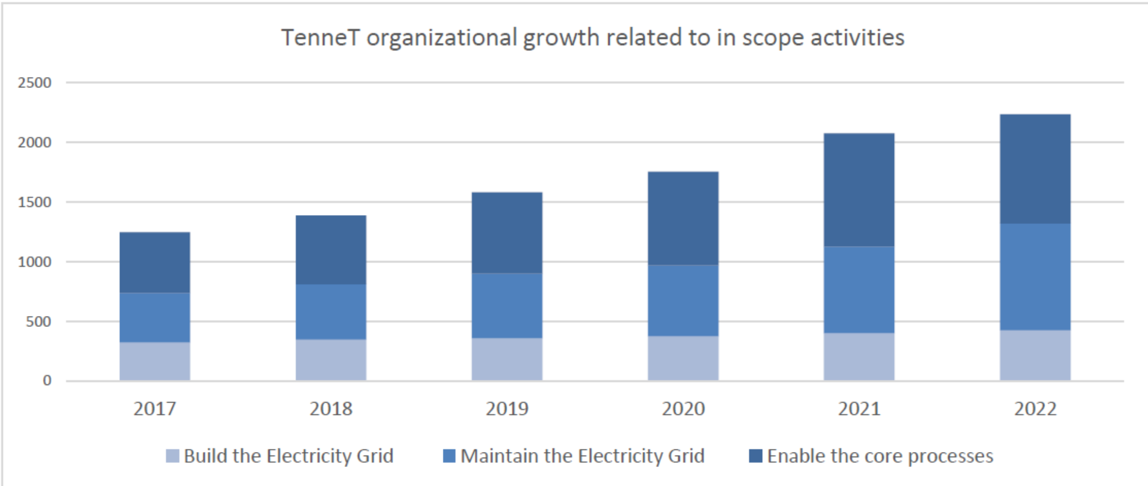
63. TenneT continues that the condition can be objectively assessed by examining the tangible changes in TSO operations, infrastructure investments, and workforce growth related to the energy transition. This includes quantifying investments in grid infrastructure that were under construction but not yet in service in base year 2020, the expansion of personnel during the benchmarked years and the development of the expected portfolio to be realised in the coming ten years.

64. TenneT further remarks that the energy transition is a durable and structural condition that extends beyond short-term fluctuations. Its effects persist over a substantial period, shaping TSO operations and requiring continuous adjustments to meet the demands of the evolving energy landscape.

65. TenneT distinguishes between five 'core processes' of the TSO. Next to that, there are activities that are enabling the core processes. As far as the Dutch onshore grid concerns, one could roughly map TenneT's core processes to the TCB21 activities as follows:

TenneT core process	TCB21 activity	In or out of scope?
Enable the Energy Market	X Market facilitation;	Out of scope
Design the Energy System	P Planning	In scope
Build the Electricity Grid	T Transport	In scope
Maintain the Electricity Grid	M Maintenance	In scope
Operate the Electricity System	S System operations	Out of scope
Enable the core processes	I Indirect expenses	Partly in scope

66. TenneT concludes with the following graph showing the organizational growth of TenneT NL, excluding solely offshore activities, of the core processes in scope of the TCB21 benchmark. Note that the activities that would fall under the Design or planning (P) category, are not separately matched to fte numbers, but are included in the other categories (e.g. build/T or enabling / I). N.B. this mapping does not 100% align with the personnel expenses as reported in the TCB21 financial reporting, but rather serves as an illustration of the significant growth of the organisation during those years. Note that although the headcount grows with a factor 1.4 between 2017 and 2020, the Normgrid only grows with a factor 1,07 in this period[2]. This underlines the apparent time lag between organisational growth and output in terms of physical infrastructure.



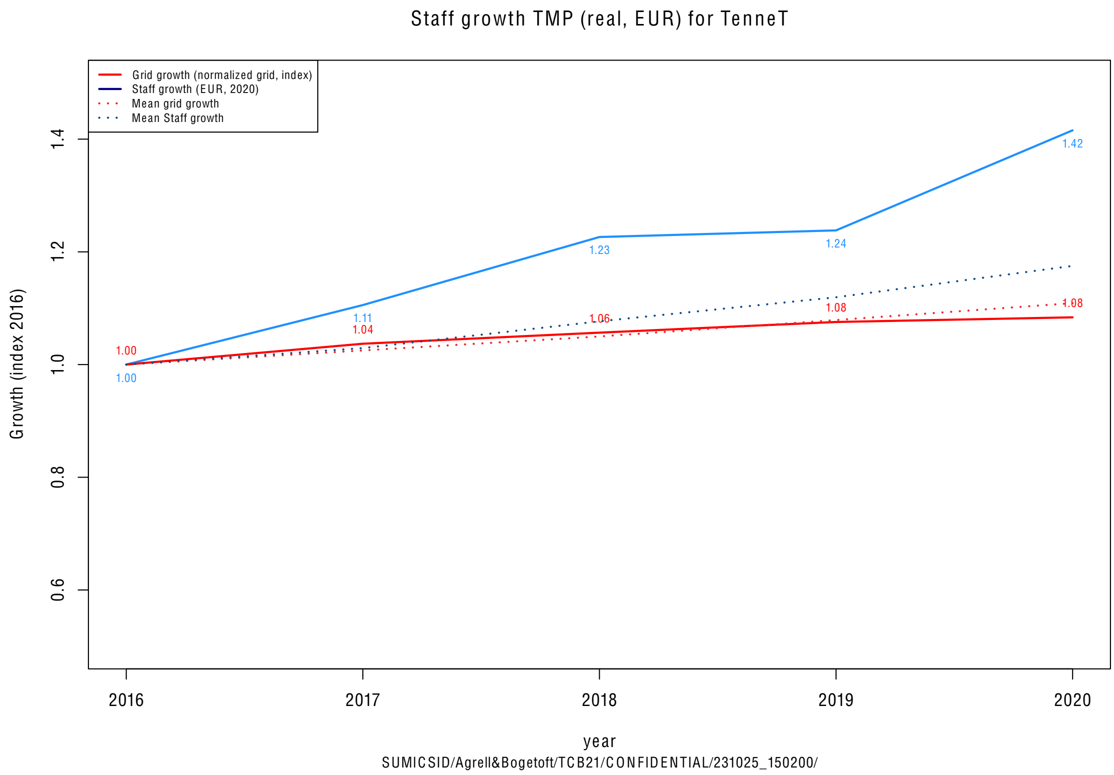
Assessment by CEER

67. TenneT argues for the consideration of additional costs (staff, IT, services) related to energy sector changes in the Netherlands.

68. Concerning the energy sector challenges, CEER notices that these are largely shared in multiple facets across the common energy market. Although E3 shows an exhibit for one DER (PV) per capita, the overall cost impact should be related to overall investments in DER, the different technologies involved, and market participation. The interaction of TSO, RTO, and DSO across energies is particularly important, along with the regulations concerning connection to the grid for DER at different voltage levels. CEER cannot find that NL poses an operator-specific condition in this regard.

[2] According to the file tcb21_dump.var.DVC_349_NL_230418-181103.DR.230303.xlsx. TenneT claims that this Normgrid calculation is known to contain errors, but that it is the most recent one TenneT received from TCB21 at the time of writing. TenneT suspects however that the corrected calculation will show a similar Normgrid growth in this period.

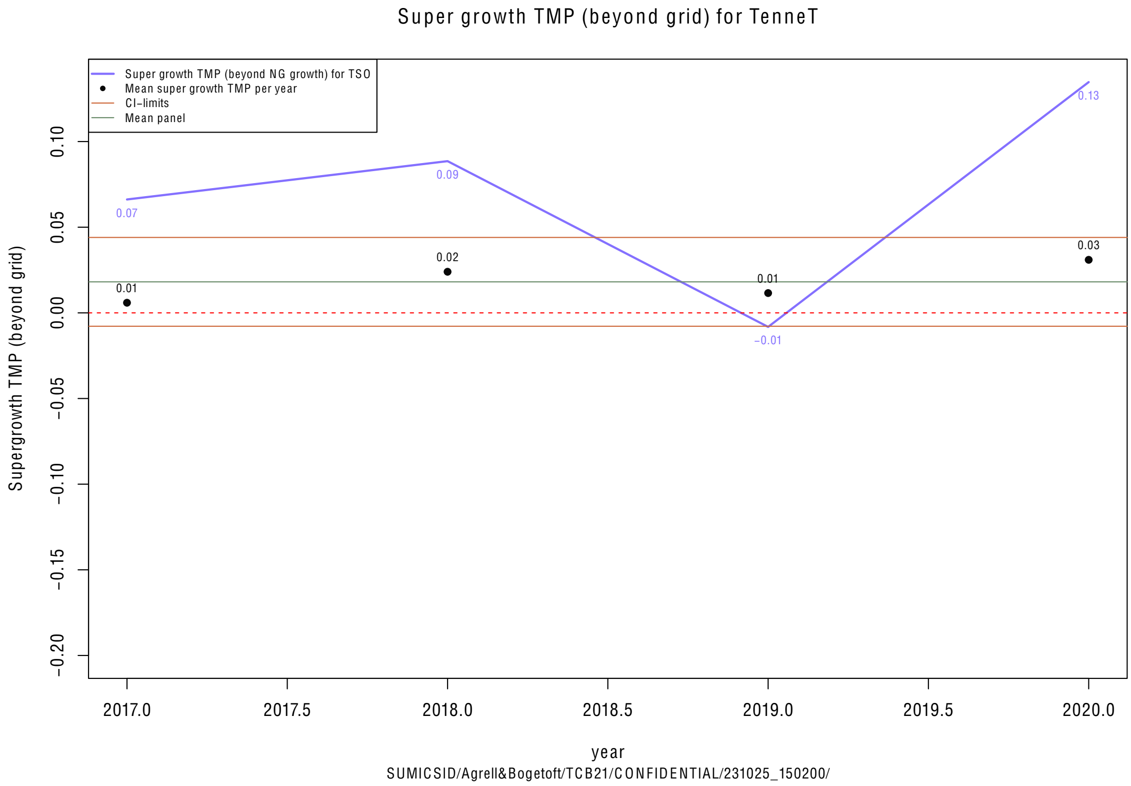
69. One of the testable effects relates to staff intensity. It is demonstrated below that TenneT individually has increased their in-scope staff costs by 42% whereas the Normgrid growth has been a mere 8% (mean TCB21: 9%) and the load growth has been -5%.



70. Studying this super-growth (i.e increase of staff beyond the load-asset growth) for all operators across the period 2016-2020 reveals (below) that indeed there is a tendency to super-growth (1-3% per year) in the sample, but no significant effect. From this we can draw two conclusions:

a) The condition of TenneT is not unique but shared by several operators. For example, one of the peers in the benchmarking has a staff growth of 46% for a grid growth of 5%, even stronger than TenneT --- but overall costs are under control.

b) The condition of super-growth in staff per se is not logically linked to cost-causality, but potentially to the organizational choices (in-house/outsourced services, non-grid services), neither is it proven to be exogenously driven. A TSO may increase its in-house staff to lower the cost of external services and consultancy, reduce general workload, anticipate increases in load, or other internal reasons. The claim does not prove why the increase for TenneT would be efficiency (output) increasing.



71. We have also investigated the hypothesis that investments (measured as capex unit cost) would be significantly increasing at the end of the period (ie 2019-2020). We test the hypothesis that UC-capex 2019-2020 is higher than UC-capex 2017-2018 with a Wilcoxon ranked sum exact test, the hypothesis is rejected at level 75%.

```
    Wilcoxon rank sum exact test

data:  data.2yrs$inv.uc by data.2yrs$new
W = 461, p-value = 0.7541
alternative hypothesis: true location shift is greater than 0
```

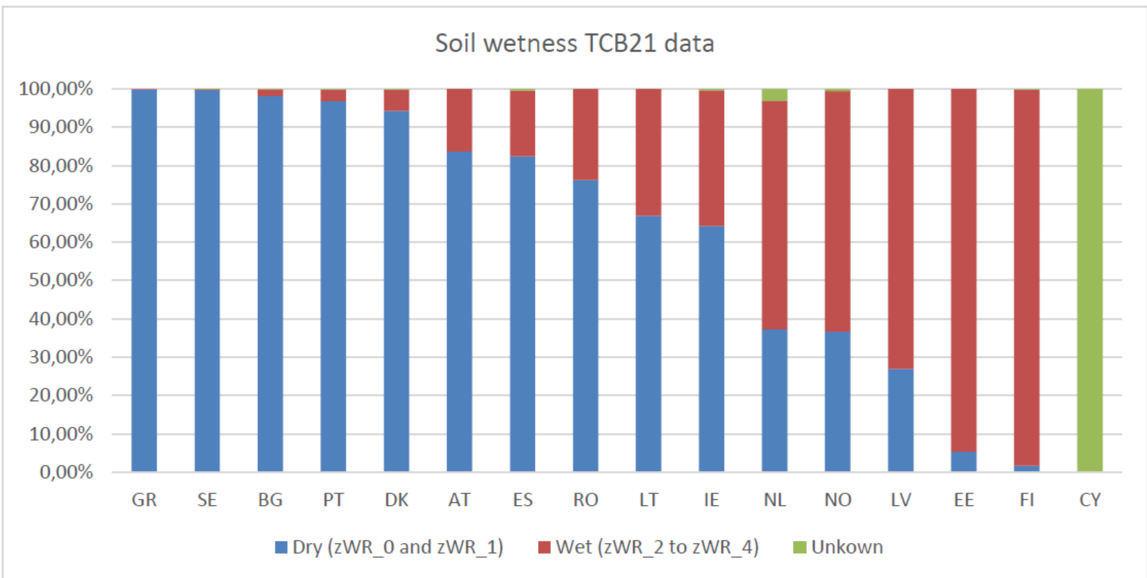
72. CEER finds that the claim falls on cost-causality and uniqueness both in general and in the particular example given.

Claim E4 (TenneT): Assets near and below sea level

Description of the claim (by the TSO)

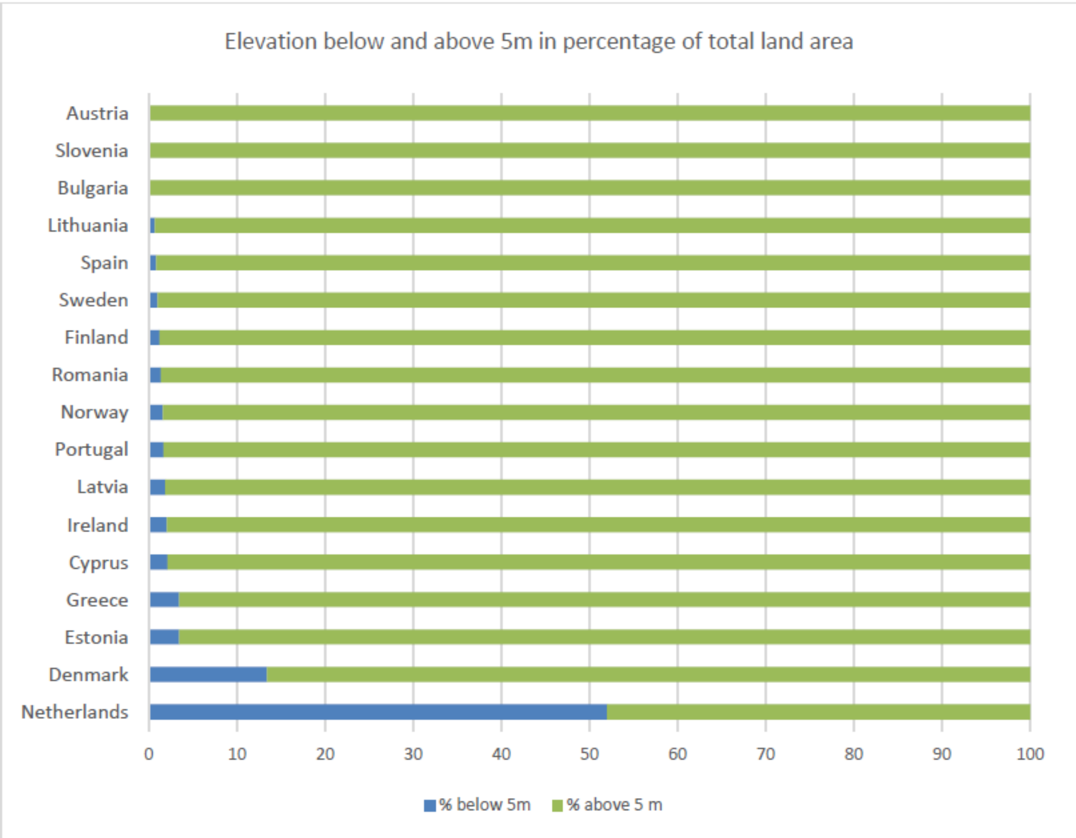
73. TenneT remarks that the presence of land below sea level necessitates extensive water management measures, including drainage and pumping systems, to ensure the stability of the land and protect infrastructure from water-related risks. TSOs in these areas are responsible for managing the impact of water on their infrastructure, such as a waterproof building of foundations. Additionally, the presence of water and the proximity to the sea can lead to corrosion, requiring more frequent maintenance activities such as painting and coating of towers.

74. TenneT has claimed comparable conditions before. The TCB18 report considered soil, icing and wind conditions. Several of these conditions have been considered by the TCB21 team. In the Environmental Analysis Matrix Electricity, chapter 4 is dedicated to ‘subsoil conditions’, in which several cost increasing mechanisms, such as the need for stronger tower foundations, are described. Also, in the env_ELEC_OHL excel file, the extend of ‘subsoil wetness’ is given for all TSOs and in the answer to ENV21 the TBC21 responded to TenneT’s question on this topic with *“The relevance is for underground installations (cables), tower fundaments and foundation costs of stations as the ground preparation will be more extensive.”* However, according to TenneT this concept is not reflected in the cost factors in the appendix of the ECF note and not mentioned in either the model specification note or the material of Workshop 4. Therefore it is TenneT’s current assumption there is no provision for all cost impact of assets near and below sea level.



75. The Netherlands has a unique geographical characteristic, where a significant portion of the land lies below the sea level. The additional costs of protecting assets against possible influences by the sea or floods should be taken into account in the benchmark. This is related but not limited to the subsoil wetness as summarized in the graph above.

76. TenneT continues that the service area below sea level of a TSO can be objectively determined with topographic maps. For example, the World Bank measures land area with an elevation below 5 meters; see graph below for an illustration with TCB21's participating countries. TCB21's technical consultants can objectively assess the specific infrastructure design and maintenance requirements, water management systems, and the frequency of maintenance tasks due to corrosion risks. There are already numbers included in the TCB21 data files on subsoil wetness, which is part of this condition. By quantifying the additional costs and resources allocated to address these challenges, the condition's objectifiability is established.



Source: https://data.worldbank.org/indicator/AG.LND.EL5M.ZS

77. TenneT remarks that the land below sea level condition is a durable and structural aspect for TSOs operating in the Netherlands.

78. According to chapter 4 of the ECF matrix, in the condition of a wet subsoil, *"[t]he additional steel material and the construction work can cause additional costs, in the range of 10% or higher."* TenneT notes that also in this case, the effect of subsoil wetness is not limited to cables and pylon foundations, but also affects substation foundations.

79. As for corrosion effects, TenneT spends about 11 million Euro per year on painting. TenneT has no specific reference data on the painting requirements in less corrosive environments and trusts CEER and the TCB21 technical consultants will have this data.

Assessment by CEER

80. The engineering analysis in TCB21 has not shown that subsoil wetness has a major impact on costs beyond the factors included for humidity.

81. For cables, the cable designs themselves (particularly those with water ingression withstand) are done for the whole length, not special design for a particular section. Generally, the modern cable design standards concerning humidity withstand are higher than the specific condition on any given section, thus wetness is not considered in construction. On Installation, the impact is also minor as the humidity withstand is mainly from cable design instead of installation/cable protection per section.

82. For overhead lines, the wetness may lead in specific cases to higher construction complexity (also water management/drainage) that can affect the costs. The effect is not universal and can differ in specific areas. Furthermore, the impact connected with soil/foundation cost would be more considerable to OHL as they are vast constructions and spread over a long length. In the case of substations, it is less relevant as in any case, preparation of the location is necessary.

83. Notwithstanding the engineering analysis, the relevant factor (WR) has been included in the environmental assessment and the second-stage analysis (see the Model Specification ELEC, V1.0), using four levels (zWR_0, … , zWR_4).

84. The subsoil wetness does not come out as Tobit significant for any of the relevant models E3395 and E2388 for the 2020 DEA scores. This is likely because various degrees of wetness indeed are shared among the countries in TCB21 for which higher wetness is not necessarily a source of efficiency loss.

Claim E5 (TenneT): Wintrack towers

Description of the claim (by the TSO)

85. TenneT remarks that in several large EHV expansion projects, TenneT has been obliged to build Wintrack towers instead of regular lattice towers. This increases costs compared to other TSOs. In TCB18, the cost impact of Wintrack projects has not been taken into account in the benchmarking score, but corrected for afterwards by ACM. As, in TenneT's view, the need for a correction is thereby known to the CEER project team, it will not be repeated here.

86. TenneT does not agree with the route chosen in TCB18. TenneT believes that by not including the cost of Wintrack towers in the benchmarking itself, the study deliberately produces a biased result. As efficiency scores from the study will be written down and discussed, even just within the CEER project group, the regulators and the TSOs. This number should be as accurate as possible. Also, fundamentally, a small difference in output and input variables could lead to a previously inefficient TSO becoming fully efficient and vice versa. Thereby, any correction to individual data can have an influence on the frontier and thereby on the score of other TSOs. This means that ex-post corrections to the benchmarking score should be avoided as much as possible.

87. In the case of the additional cost of building Wintrack towers, this is possible by reducing the TOTEX of TenneT by a set amount, as was done after TCB18 to the TCB18 data.

Assessment by CEER

88. From TCB18 it is known that the extra investment per km is at most about 2,1M€. With about 83 km of Wintrack towers, the total extra investment is therefore about 179 M€. With an annuity factor of 2,67% this amounts to about 4,8 M€ of the benchmarked totex of TenneT, which is about 1,36% of that benchmarked totex. As such CEER concludes that the cost impact of the claim is not material enough to include it as a special condition in TCB21.

Claim E6 (APG): Labour cost

Description of the claim (by the TSO)

89. APG notes that, in Austria the energy-supplier branch is according to numbers published by the National Statistical Bureau (STATISTIK AUSRIA) an industry, which pays traditionally high salaries compared to the other industries and also compared to the TSOs in the TCB21 sample. This becomes obvious if costs are divided by FTEs. APG stresses that one should notice and consider though, that FTEs are not the same in all European countries and TSOs.

90. APG recalls from senior staff that at APG in the 1970s (during the energy-crises) an extraordinary high adjustment was achieved through trade unions negotiations for the collective agreements of our branch, which of course is still represented in our nowadays labour costs.

91. APG already claimed/submitted this issue towards its NRA in TCB18 but is not aware if this proposal was forwarded or even considered by the PSG back then.

92. APG continues that Austria has a very long and unique tradtion of the so-called “Sozialpartnerschaft“ (social partnership). The Austrian social partnership is a voluntary cooperation of the most important employers' and employees' organizations and the federal government. The tasks and objectives of the social partnership are the following: Collective agreements are concluded by the chamber of commerce and by trade unions. The social partners strive to solve problems and challenges through dialog (i.e., without openly airing conflicts) and to achieve solutions that are acceptable for all parties. The social partnership was founded after the Second World War and has undoubtedly made a major contribution to social peace in the second half of the 20th century in Austria. The "island of the blessed" image that one can/could have of Austria is largely due to the work of the social partnership this is represented through rather low numbers of strike-days and social freedom. Social partnership is a very good concept – unfortunately, due to the reason that the TCB aims at minimizing cost we qualify our issue as country-specific condition.

93. Austria posesses a very well recognized statistical bureau (STATISTIK AUSTRIA) which has been published data on labour costs for a long time. On the other hand APGs work councils has still information dating back into the 1970s on the development of collective agreements. The extraordinary raise in collective agreement is still present in todays labour-costs.

94. APG expects that this impacts its benchmarked total personnel expenses (Input OPEX) between 5 and 10 %.

Assessment by CEER

95. CEER and E-Control consider that in Austria the representation of employee interests is quite good due to the described social partnership, which leads to good wages in highly organized industries such as the energy industry. In TCB21, however, a correction for differences in national salary cost levels are already made. CEER and E-Control believe that this is sufficient to determine the influence of the cost of labour on total costs, especially since many jobs can and are outsourced.

96. Furthermore, CEER and E-Control consider that the energy crisis of the 1970s affected not only Austria but rather all of Europe and the "Western world". Furthermore, the strong bargaining position of the unions in the 1970s does not determine the current salary distribution of TSOs by itself. European countries also differ in other aspects of labour law, such as dismissal protection or severance pay. However, CEER and E-Control believe that these differences are sufficiently covered by controlling for the general wage level and cannot be eliminated.

97. Also, the circumstance that APG points out does not significantly distinguish Austria from other European countries. Wages are rising there as well, see the earlier section on Opex-super growth.

Claim E7 (TSO-Cyprus): Asset separation

Description of the claim (by the TSO)

98. TSO-Cyprus explains that unlike the majority of TSOs in the benchmark, TSO-Cyprus does not own any transmission system assets. Transmission System asset ownership is with a different company. The TSO defines the needs for the transmission system based on load growth and connection applications and operates the transmission system; the transmission system owner builds and maintains the transmission system.

99. TSO-Cyprus mentions that this is the first time that TSO-Cyprus participates in such a benchmark, so the claim has not made before by TSO-Cyprus.

100. TSO-Cyprus remarks that an asset-separated TSO is non-comparable to the majority of the sample, which comprises of TSOs which are also owners of the infrastructure. This is something that has already been identified by the consultants.

- *Due to the accounting rules for collecting financial data, it is possible that some of the costs that are in this benchmark are not adequately captured.*
- *It is structurally different to the other TSOs, which may mean that it has a different cost base due to the way that it has to operate. This could be thought of as an "environmental condition" created by legislation.*
- *A TSO that is not the owner of the transmission system assets does not have any control over the majority of the costs that are in the TCB21 benchmark. Therefore, even if it were possible to calculate an efficiency score in a manner that is comparable to the majority of the sample, it wouldn't reflect the efficiency of the TSO.*

101. TSO-Cyprus explains that the condition is a result of the legal framework in Cyprus, which imposes an ownership and operation structure that is different from that of the rest of the TSOs in the benchmark. As such it is objectifiable and structural.

102. TSO-Cyprus expects the consultants, who are specialists in their field, to quantify the impact of this special condition on the results, and to provide justification for the validity of the results/comparisons in the final report.

103. TSO-Cyprus concludes that it is important that underlying assumptions and implications of this special condition on the comparisons that can be drawn with the rest of the TSOs are made clear in the final report.

Assessment by CEER

104. There are a few TSOs in the sample that have a structure in which asset ownership and operation are separated, one of which is TSO-Cyprus. Indeed, this is a situation that warrants special attention.

105. From analysis and model development so far CEER notes that it is not likely that the asset-separated TSOs will come out as peers for other TSOs. This protects the integrated TSOs from being compared directly to non-asset integrated TSOs.

106. The question then remains if asset-separated can (also) be compared directly to integrated TSOs. The projection of asset-separated operators on a frontier formed by integrated operators seems feasible, although the results such be evaluated with care since the performance concerns a virtual unit constituted by two independent structures. CEER will pay special attention to this in its reporting to avoid misinterpretation of results.

Claim E8 (TSO-Cyprus): Lack of GIS cable data

Description of the claim (by the TSO)

107. TSO-Cyprus explains that the GIS database used by the consultants did not have location data for the vast majority of the cables on the Cyprus transmission system. Moreover, it did not have any information at all for the cables in the cities. We already made a comment during the environmental parameters consultation, under the post "Response: Cyprus - Issues with Environmental parameters ELEC X0.7".

108. In Cyprus most of the transmission network within the cities comprises of underground cables. Furthermore, it is likely that this urban network will be a bigger proportion of the total network when compared to most countries in the benchmark, because of the small distances between the cities on the small island of Cyprus.

109. TSO-Cyprus continues that from the model specification document, it precipitated that the most important factor increasing the costs for cables is urban environment. TSO-Cyprus remarks that this shouldn't be a surprise; it is expensive and time consuming to design and build in a dense urban environment, where there are other buried services, and where permissions to close roads are difficult to obtain and special conditions may be imposed for such works. Access to these cables for repairs is equally difficult.

110. TSO-Cyprus mentions that this is the first time that TSO-Cyprus participates in such a benchmark, so the claim has not made before by TSO-Cyprus.

111. TSO-Cyprus mentions that this condition is special and objectifiable as the GIS database used by the consultants did not have data for the cables on the Cyprus transmission system. This situation is result of the GIS database used to extract environmental information in this benchmark not having the necessary data for Cyprus and is outside the control of the TSO. TSO-Cyprus mentions that claim is structural as the condition is a result of the GIS database used in this benchmark.

112. As to materiality, TSO-Cyprus expects that, given that:

- urban environment is the most important factor that increases cable costs,
- a significant proportion of the Cyprus network is underground cables in cities, and
- there is no GIS data for cables in Cyprus in the database used in this benchmark,

the Consultants justify how they will proceed, so as not to unfairly penalize TSO-Cyprus by not considering that a significant part of its network is made of underground cables in an urban environment. TSO-Cyprus asks the Consultants to be mindful that, due to the asset separation, it would be time consuming to obtain and provide accurate location data ourselves; if such a data collection were to be requested now, it would probably delay this project.

Assessment by CEER

113. The TCB21 data collection for environmental factors is based on EUROSTAT GIS-data mapped using satellite data for asset locations. Naturally, cable locations are only partially present in the asset data. As a consequence, the cable locations are only used in a single environmental correction (model E2388 for circuits), the other correction factors are based on line-level data. This approach is equitable as cable installations normally are found in city locations with high density, the normgrid output for cables is higher than for lines and no bias is introduced.

114. TSO-Cyprus is not unduly penalized by this procedure and there is no reason to collect more data as this would not address shortcomings for other TSOs in the same dimension. Thus, the claim is not unique; the cable location data is a shared condition.

115. Urban conditions are represented in the environmental analysis through the landcover parameter, also correctly reproducing other challenges for TSO-Cyprus and the other TSOs.

116. For these reasons and referring to claim E9, CEER finds that specific attention to TSO-Cyprus will be made through its status as asset-separated and the general exclusion of cable-location data (except for E2388V2.4). See also claim E9 below.

Claim E9 (TSO-Cyprus): Small isolated system

Description of the claim (by the TSO)

117. TSO-Cyprus notes that Cyprus is a small isolated system (EU Directive 2019/944). As such, it presents a different environment within which the TSO has to operate, with different design considerations when compared to a TSO of a large interconnected system.

118. TSO-Cyprus mentions that this is the first time that TSO-Cyprus participates in such a benchmark, so the claim has not made before by TSO-Cyprus.

119. TSO-Cyprus further notes that it is the only TSO in the sample that operates a small, isolated system and that the condition is due to geography. As such the condition is special, objectifiable, and structural.

120. Regarding materiality TSO-Cyprus says that, being the TSO of a small, isolated system, presents different design considerations. For example:

- Additional redundancy may be required to be built into the system to ensure continuity of supply, as there are fewer alternative supply paths in the system.
- The design may have to accommodate a worse load factor (= average annual load / peak annual load), when compared to a bigger system with a larger number of customers and a wider spread of energy usage types. In Cyprus, the system has to be designed for the peak summer load (air-conditioning) that can be encountered in an extreme heatwave.
- Furthermore, the big distance and the sea between Cyprus and Europe may require the system owner to be more self-sufficient (eg. spares policy, in-house maintenance, etc.). Additionally, the TSO and system owner are likely to suffer from lack of the benefits of economies of scale, due to their small size. This won't be captured through the Constant Returns to Scale method adopted in the modelling.

121. Thus, TSO-Cyprus expects the consultants, who are specialists in their field, to quantify the impact of this special condition on the results, and to provide justification for the validity of the results/comparisons in the final report.

122. TSO-Cyprus concludes that it is important that underlying assumptions and implications of this special condition on the comparisons that can be drawn with the rest of the TSOs are made clear in the final report.

Assessment by CEER

123. The network of TSO-Cyprus is a small isolated system that warrants special attention. This kind of system tends to have a relatively high unit cost profile. As such it is a-priori not likely that TSO-Cyprus will come out as a peer for other TSOs, which is indeed suggested by preliminary analysis and model development. Like with Claim E7 (asset separation), CEER notes that model E2388.V2.4 is the only metric that fully represents the performance dimensions and data availabilities of TSO Cyprus. Finally, the DEA scores in TCB21 are calculated under non-decreasing returns to scale (NDRS) which compensates for suboptimal scale (cf. 120/3)

Claim G1 (Enagás): Soil rockiness

Description of the claim (by the TSO)

124. In this claim Enagás presents a condition, related to an environmental factor that in Enagás' opinion hasn't been properly included in the benchmarking, at least for the company, and will affect the outcome of the study.

125. In Enagás' opinion this special condition doesn't derive because new information has arisen, but for the new approach in the use of environmental factors.

126. Enagás remarks that one of the factors that most impact in the cost of a gas pipeline, is the presence of rock in the soil, (in former pipelines projects, the rock excavation overrun in the pipeline installation cost, can increase their costs in more than 40% as explained below). In 2016 and 2018 studies, the impact of the rockiness was indirectly included by the analysis of the slope, (as both rockiness and slope are expected to be correlated). However, in TCB21 neither of both parameters are used in the study, being the gravel content used instead.

127. In Enagás' opinion, unlike the majority of TSOs, for Enagás this parameter is not a valid factor to represent the difficulty of the terrain and the impact on the cost of the pipelines construction, because if the soil is composed of rock and not gravel, it is not being considered. For this reason, Enagas deems that another environmental factor should be used instead for Enagás. Enagás proposes 2 different options that take into account the higher costs incurred due to the difficulty in the excavatability of the ground:

- Option A) Use of an alternate methodology to the environmental correction based on Gravel_T + Gravel_S, applying the parameter Depth to rock combined with z-gravel topsoil and subsoil (instead of just z-gravel) for all TSOs instead.
- Option B) Apply to Enagás the Special Condition for being the TSO with higher level of volume of stones, which is the variable that has the greatest impact on project investment costs, applying the Option A methodology to quantify the extra costs of pipelines due to the rockiness of the subsoil.

128. Enagás continues with a further, more detailed description of the claim:

129. In Enagás' understanding, according to the last workshop, the option chosen for environmental corrections is LLG, i.e. the combination of land use and Gravel_T + Gravel_S, being Gravel parameters, the ones chosen for the characterisation of the subsoil structure.

130. Unlike other soil parameters analysed, like zSoil.vs and zSoil.dr, zGravel parameter distinguishes between top soil (up to 30 cm deep) and subsoil (from 30 cm until 100 cm deep).

131. With such a small difference in depth, (less than 1 meter), one would expect that the two parameters show equivalent levels of gravel content in both layers and that the subsoil level of gravel is higher than the topsoil, as this layer is closer to the rock bed.

132. In the following figure, Enagás presents the differences for each TSO between the top soil and subsoil zGravel mean values, using the data provided in the env_Gas Excel File. In the figure is also presented the mean differences and the 95% confident lines (+- 2*standard deviation).

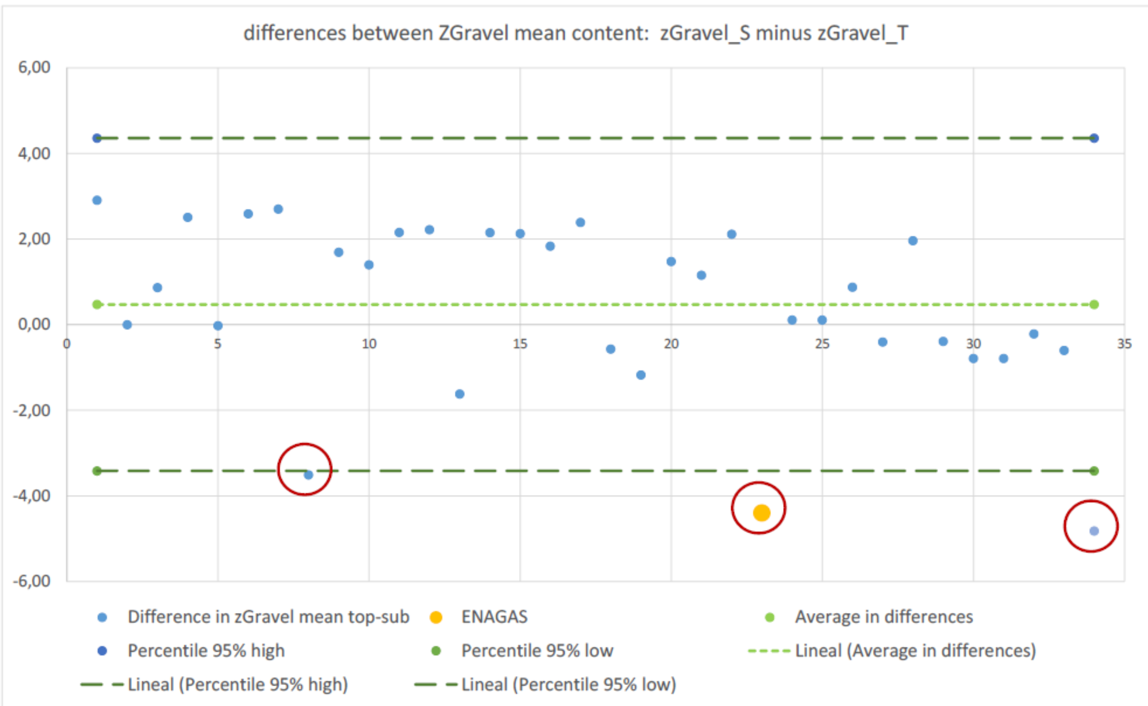


Figure 3: Differences in zGravel mean subsoil and topsoil values *(Source: Internal development from Enagás)*

133. As can be seen in the graph, for the majority of TSOs, the differences between subsoil and topsoil mean zGravel values, are less than 2% approximately. Also, as it was expected, on average, subsoil values are higher than topsoil values.

134. However, there are three TSOs, one of them is Enagás (two of them, Spanish TSO and the other one, Greek TSO), that don't follow this pattern. The differences between subsoil the mean zGravel value and the

topsoil mean value fall outside the confidence limits and, more outstanding, the subsoil mean zGravel content is much lower than the topsoil zGravel content.

135. Enagás mentions that the reason for this anomaly for these three TSOs, with a high probability, is that the rock bed is closer to the surface than in the rest of TSOs. As a result, the subsoil layer could be thinner, i.e., the gravel content could be lower, not because the volume of small particles is low, but because the rock volume is much higher.

136. Looking at the zSoil.vs data, although this parameter lacks of detail (there is only one value for volumes of stones higher than 20%), Enagás notes that Enagás has the highest “≥20% stones” value of all TSOs. This would support the previous interpretation for this particular behaviour.

137. Option A) Due to this special condition, Enagás requests not the use of the zGravel parameters alone for identifying the subsoil structure. Enagás proposes the use of these zGravel parameters with the zSoil.dr, (depth to rock). Enagás considers this parameter as the fairest to measure the overrun cost of digging trenches to instal the pipeline for all TSOs, rather that volume of stones that can be correlated to zGravel. Enagás prepared an analysis that combines zGravel and deep to rock parameters and explains the methodology the followed for the analysis: […see the original claim…].

138. Enagás summarizes that volume of rock has been found to be one of the most impacting factors in countries with rocky terrain, and can increase up to 40% over the initial price. However, the volume of stones parameter alone can be incomplete, and combined with the gravel volume can lead to duplicate results[3]. Therefore, Enagás believes that the best parameter that can measure the volume of rock and gravel in the pipeline trench is the combination of Z-gravel for topsoil and subsoil and the Depth to rock from which it is assumed that there will be rock to the end of the trench. In Enagás’ opinion, this combination could be applied to all TSOs, instead of the combination Z_Gravel parameters. According to this Option A, Enagás estimates that the new complexity factor for Enagás would be 1,78.

139. Enagás notes that it hasn’t claimed before, as it’s the first time this zGravel parameters are used.

[3] Enagás remarks that the volume of stones parameter measures the amount of rock in the first meter of depth. The depth of the trench hosting the pipelines is greater, so the volume of rock below one meter depth would be disregarded until the depth of the trench is reached. In addition, it must be correlated with the topsoil.

140. Regarding the impact of the claim, Enagás states that for countries with rocky soils, there is a very relevant impact on costs when excavating the terrain to construct and install a gas pipeline network. In this regard, they have estimated how the volume of rock in the ground influences the construction costs of gas pipelines.

141. Option B) In the contracts Enagás signed with the different contractors[4], a base price for construction and installation was included, to which cost supplements were added depending on the difficulty of the terrain. The most significant was the case of excavation in rocky terrain, which, according to their calculations, it increased significantly the cost.

142. The average diameter of gas pipelines is 24 inches. Compared to the base price, rock excavation represents a maximum cost overrun of 42% in the case of considering all the excavated terrain as 100% rocky (19% of total CAPEX, since 46% of total Investment costs for Pipelines construction project corresponds to Installation). This increase is due to special excavation required (breakers, drills and even blasting), not contemplated in the normal production line, and therefore in the base price, in order to extract the rocky material from the trench and even from the work track.

143. Volume of rock in the pipeline trench has been estimated based on the values of the depth to rock parameter. From this data, it is possible to calculate the cost overrun for each of the rock % values, as can be seen in the figure, and the final result of the total cost overrun of excavating in rocky ground (in absolute and relative terms).

144. So, due to the rocky soils, the Enagás's pipelines overall costs are 10,71% higher. In case of Option B, Enagás proposes to exclude this investment percentage of every year Enagas's pipeline investment costs.

145. Enagás is of the opinion that zGravel is not a valid parameter for characterising the rockiness of the soil for Enagás and in consequence wouldn't properly explain the differences in pipeline costs and that their use could be misleading. Enagás thinks that this could be due to the higher volume of stones or rock in Enagás' subsoil compared to the rest of TSOs.

[4] In Enagás' assessment, Enagás has taken as a reference the prices included in contracts with national and international contractors in previous years (2008) and the impact of excavation in rocky areas on costs.

146. In Enagás' opinion, the analysis of Enagás clearly shows that its claim is objectifiable as it falls outside the 95% confidence limits of the mean differences all TSOs

147. Enagás continues that the condition is durable as it affects directly to the costs (CAPEX) of the pipelines.

148. Regarding materiality, Enagás notes that the rockiness in the subsoil can lead to a 40-45% increase in the construction and installation costs of the pipelines, (max 19%-21% of total CAPEX with 100% volume of stones). According to option A, Enagás estimates that the new complexity factor for Enagás would be 1,78, that's it 38% higher than the complexity factor for Enagás resulting to apply the mean for z-gravel subsoil and z-gravel topsoil. According to option B, the extra cost due to rocky soils is estimated in a 10,71% of overall pipelines investment costs.

Assessment by CEER

149. CEER understands that rockiness increases the costs of pipes' CAPEX and a correction should be investigated.

150. As shown in the environmental´s excel file, 27,53% of Enagas pipelines are in areas where the volume of stones > 20%. Also, 23,85% of Enagas pipelines are in areas where the volume of stones > 15%, and 6,03% in areas where the volume of stones is > 10%.
Also, 24,86% of Enagas pipelines are in areas where the depth to rock is shallow (< 40 cm), 26,08% in areas where the depth to rock is moderate (40-80 cm), and 34,60% in areas where the depth to rock is deep (80-120 cm).
Although these values show the relevance of rockiness in the service area of Enagas, it can also be seen, from the data of the same excel file, that rockiness is also relevant in the service area of a few other TSOs as well.

To investigate the most suitable environmental correction for rockiness, the explanatory power of Gravel (topsoil and subsoil), volume of stones and depth to rock is important, as well as the correlation with other variables (such as slope, for example).

151. For the calculation of the cost impact of the special condition, Enagás has considered the following data:

- An average trench of 175 cm, according to their construction pipelines procedures (100 cm above pipeline + 61 cm average pipeline diameter + 15 cm sand bed under the pipeline).
- The depth of the different layers (topsoil, subsoil and rock) is allocated using the environmental data provided by the TCB21 team: z-gravel topsoil, z-gravel subsoil and depth to rock.

- The surplus in cost for excavating in rocky terrain is obtained from Enagás contract´s prices.

152. Enagás has provided in their specific folder (due to confidentiality) extracts of contracts in which the contractor applies higher prices for excavation in rocky soils. This is reflected in the contracts as surplus from a base price.

153. The surplus has been documented in the public version of the claim as a percentage (10,71% of overall pipelines investment costs).

154. The claim had not been previously submitted, as in previous (E2gas, 2016) and (TCB18, 2018) benchmarking studies, the rockiness was indirectly included into the 'slope' parameter.

155. The claim complies with some of the criteria for special conditions treatment, as shown in the following table, but not with all of them:

Criteria	Description
Uniqueness	Enagas service area is affected by rockiness, as it can be seen in the parameters "volume of stones" "depth to rock" and "gravel". However, rockiness is also relevant in the service area of a few other TSO as well. Therefore, the condition can´t be seen as unique.
Objectification	The claim is objective as it can be seen from the environmental data provided in TCB21 and the extracts of contracts provided by Enagas. Nevertheless, its quantification is difficult, as it would need one of the following actions: - to build a new complexity factor that has not been included in the environmental note. - to look for data from other TSO' contracts, not only from Enagas.
Durability (structural)	The condition is clearly structural.
Materiality	The impact in construction costs is higher than 5% of the benchmarked investment stream. It is 10,71% of pipelines investment costs according to Enagas calculations.
Complementarity	Rockiness is correlated with slope, as slope terrain is mostly rocky, and it is not clear the complementarity between rockiness and gravel.
Transparency	The claim is based on data provided by the TCB21 team, except for the cost of excavation in rock, which is based on Enagás' contract prices and is marked as confidential.

156. The claim cannot be accepted as it does not fully comply with the criteria of Uniqueness and Complementarity and as there are difficulties associated to its quantification. However, the claim is well supported and

CEER understands that rockiness increases the costs of pipes´ CAPEX. In consequence, CEER has decided that environmental corrections associated to this claim should be investigated (gravel, slope, volume of stones …), considering their explanatory power on costs and the correlations within each other and with other parameters as well. Several environmental corrections have been analysed and included in the sensitivity analysis in the public and individual report.

Claim G2 (GTS): Network age differences

Description of the claim (by the TSO)

157. GTS mentions that participating TSOs in TCB21 differ in age of assets and that age has an impact on the maintenance of assets. Simply said by GTS, older assets need more maintenance and therefore incur higher cost. Moreover, maintaining assets can be a more economically viable option compared to replacing the entire asset. TCB18 attempted to accommodate for the age effect by introduction of the concept of 'significant rehabilitations' in the Normgrid factor. But in the final version of the benchmark model, assets that are 'over age' or economically fully depreciated, did not count as output in the Normgrid factor. TCB21 seems to maintain this approach. As a result the TCB21 model does not reflect reality with respect to the cost-output relationship of specific TSOs in a balanced way. TSOs with a larger share of old (over age) assets have a disadvantage because of this approach.

158. GTS states that this is not a re-claim.

159. GTS further motivates its claim by noting that the benchmark model should count the output for a given in-scope cost level. In particular the Normgrid factor should account for 'over age' assets when these assets are still in use.

160. For GTS, many assets built in the 1970s are still in place and provide output for the network. Even though the economic lifetime might have been passed, the assets are still in place and upgraded on a component level from time to time. To GTS this is easily objectifiable as the investment years of assets are known.

161. GTS states that from the above it follows that the condition is durable.

162. Regarding materiality of the claim, GTS points at the motivation of the claim in the above. Materiality of the condition will also depend on the final model chosen.

Assessment by CEER

163. In TCB21 an age analysis was carried out that empirically tested whether TSOs with older assets indeed face higher costs. No such relation was found, implying that GTS is not at a disadvantage due to relatively older assets. The results for mean-age test are given in Appendix C: Tobit test for age parameters / GAS, Table 3 for TSOG and in Appendix D: Tobit

test for age parameters / ELEC Table 4 below for TSOE. The proxies used are the following:

- agem_YY: Mean age for assets in asset category YY
- ageL10_YY: Share of YY-assets (NG) younger than 10 years
- ageL05_YY: Share of YY assets (NG) younger than 5 years.
- shareold_YY: Share of overage YY-assets (NG)
- Sharem_young10: Overall share of (≤ 10 years) assetvalue (NG)
- Sharem_young05: Overall share of (≤ 5 years) assetvalue (NG)
- Sharem_old: Overall share of overage assetvalue (NG)
- Age_all_mean: mean of asset ages (across categories, unweighted)

164. As seen, the only effect that is significant and efficiency decreasing is a marginal effect for control rooms. Thus, there is a general age pattern to control for in the gas asset data for the given models. This is natural considering that the outputs in G1445.V3 and G4450.V3 are measured as age-independent physical quanta (pipeline-km and compressor stations), there is, therefore, no penalty for older assets as outputs.

Claim G3 (GTS): Differences in functionality of TSO networks

Description of the claim (by the TSO)

165. GTS discusses heterogeneity of TSOs: TSOs differ in terms of functionality, ranging from single-pipeline TSOs (transit-function), to meshed networks (distribution-function). Some TSOs in the sample can be characterized as one of the two types. Other TSOs, including GTS, have a mix of both functionalities: a transit function (providing transit capacity from TSO to TSO) and a distribution network (providing capacity to end users or DSOs). Having both functionalities increases the complexity of developing and operating a network and also results in a higher cost base.

166. GTS mentions that this claim has in part been submitted before by GTS under the heading 'complexity'.

167. GTS further motivates its claim: The primary method in this benchmark methodology drafts a frontier based on corner point combinations of efficient input-output combinations. TSOs that have a relatively high score on a certain output parameter due to the nature of their services provisions might have an advantage and receive a 100% score based on this condition. For all the other TSOs, the DEA model assumes that any TSO can be a linear combination of the corner points of input-output combinations as defined by the DEA model. Given the heterogeneity of TSOs in the sample it is questionable that any TSO can be a linear combination of corner points or that a TSO might optimize its production function by changing its output combinations.

168. GTS continues that the benchmark model should accommodate for all TSOs in the sample such that all TSOs have an equal opportunity to score on the input-output combinations shaped by the DEA model. In essence, the benchmark model should cater for all types of TSOs.

169. As to durability of the claim, GTS notes that TSOs are largely bound to the characteristics of the services area and legal conditions. Both factors are relatively stable over time.

170. Regarding materiality of the claim, GTS notes that the impact depends ultimately on the final model and the plausibility of the combinations that constitute the efficient frontier with which inefficient TSOs are compared. The issue might also play a role in the validation of the data, the selected correction factors, outlier analyses and the construction and validation of the DEA model. In essence, the starting point must be a dataset of structurally comparable TSOs.

Assessment by CEER

171. CEER assessed this claim in multiple ways. Firstly, it is checked that GTS is not directly compared with pipe-to-pipe or highly meshed distribution TSOs. It was found that this isn't the case.

172. Secondly, a test was done if a proxy of the network structures, defined as number of connection points divided by km pipeline (ntw.structure below), is related to (a) high unit costs or (b) efficiency scores. A similar analysis was done in TCB18. No such relation could be found, implying that the network structure is not a good predictor for overall cost (in)efficiency. The statistical results are found below

```
structure test: crossection G1445.V2

Residuals:
     Min       1Q   Median       3Q      Max
-0.35424 -0.20401  0.00076  0.21674  0.24078

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)       0.75723    0.06004  12.612 1.59e-13 ***
ntw.structure.20  0.31536    0.49563   0.636    0.529
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.2201 on 30 degrees of freedom
Multiple R-squared:  0.01332,	Adjusted R-squared:  -0.01957
F-statistic: 0.4049 on 1 and 30 DF,  p-value: 0.5294

structure test: crossection G1445.V2.env4

Residuals:
     Min       1Q   Median       3Q      Max
-0.39012 -0.18871 -0.02284  0.22124  0.24855

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)       0.75109    0.05975   12.57 1.73e-13 ***
ntw.structure.20  0.33531    0.49325    0.68    0.502
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.219 on 30 degrees of freedom
Multiple R-squared:  0.01517,	Adjusted R-squared:  -0.01766
F-statistic: 0.4621 on 1 and 30 DF,  p-value: 0.5018

structure test: crossection G4450.V3

Residuals:
     Min       1Q   Median       3Q      Max
-0.48839 -0.14801  0.07785  0.12240  0.24208

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)       0.92936    0.04475  20.767   <2e-16 ***
ntw.structure.20 -0.63337    0.36943  -1.714   0.0968 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.164 on 30 degrees of freedom
Multiple R-squared:  0.08924,	Adjusted R-squared:  0.05888
F-statistic: 2.939 on 1 and 30 DF,  p-value: 0.09676
```

```
structure test: crossection G4450.V3.env3

Residuals:
    Min      1Q  Median      3Q     Max 
-0.4840 -0.1481  0.0480  0.1264  0.2427 

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)    
(Intercept)       0.91759    0.04389  20.908   <2e-16 ***
ntw.structure.20 -0.59208    0.36229  -1.634    0.113    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1609 on 30 degrees of freedom
Multiple R-squared:  0.08175,	Adjusted R-squared:  0.05114 
F-statistic: 2.671 on 1 and 30 DF,  p-value: 0.1127
```

173. Hence, CEER concludes that GTS’ network structure does not put GTS at a disadvantage.

Claim G4 (GTS): Network complexity (legal obligations)

Description of the claim (by the TSO)

174. GTS mentions that TSOs operate networks that differ in terms of complexity of transported gas qualities. Unlike many other TSOs in the sample, GTS accommodates different gas qualities in its network. This also leads to additional assets (such as valves), nodes, intersection, and complex control centre structures, to ensure a clear separation of the various gas qualities. Therefore, accommodating different gas qualities also leads to a higher TOTEX.

175. GTS states that this condition has been claimed before as special to GTS.

176. GTS further motivates its claim as follows. Catering for multiple gas qualities requires GTS to invest more in the entire network including complex configurations, a decentralized complex control centre network to arrange all different flows (and qualities), many intersections/nodes/bends, etc. Therefore, the benchmark model should differentiate between TSOs of varying levels of complexity to ensure comparability because these factors are beyond the control of GTS because the TSO is bound to a service area.

177. As to objectifiablity, GTS adds that service areas differ in their characteristics which are beyond the control of a TSO (external factors).

178. Regarding durability, GTS remarks that complexity issues should be assessed at the time of benchmarking. Service area complexities tend to be stable but might change over time.

179. GTS mentions that the quantification of the claim is not straightforward and requires a good understanding of relative differences across TSOs in the sample of TCB21. Often, the costs for added complexity in the network are not easy to separate in specific asset types. For instance a control center can be complex or more simple depending on the circumstances but still count as one control center. GTS notes that at this stage of the project, GTS did not receive any information on the analysis of comparability of transported gas qualities among TSOs in the sample for TCB21.

Assessment by CEER

180. CEER notes that the condition that GTS points out is not unique to GTS or only a small group of TSOs in the sample. There are several German TSOs who also transport different gas qualities.

Claim G5 (GTS): Obligation to connect

Description of the claim (by the TSO)

181. GTS remarks that the Dutch political landscape is different from the political landscapes in other countries. Over the past decades, the Dutch government and other national authorities have set several demands for GTS that require GTS to deliver additional outputs compared to other TSOs. In order to provide the additional outputs, GTS has to make additional investments and has higher OPEX.

182. A specific example is that GTS has the legal obligation to connect all parties that request a connection to the network of GTS (Article 10 of the Dutch Gas Act). This legal obligation does not hold for all countries in the TCB21 sample. It implies that GTS has to accommodate these highly complex connections to the grid. This requires laying connection pipelines which are relatively more expensive than laying regular pipelines in the network.

183. GTS states that this condition has been claimed before as special to GTS.

184. GTS further motivates its claim as follows. Connections tend to be more complex compared to regular pipeline routes, due to for instance many bends instead of straight routes, special procedures, higher safety standards, many nodes (with valves), interdependencies, etc.

185. As mentioned in the above, several other TSOs do not have this obligation to connect all parties. In other words, being faced with these additional demands by the Dutch government (and other Dutch national authorities) inevitably comes with a disadvantage compared to other TSOs, since dealing with the demands leads to additional TOTEX. Therefore, in order to deal with this heterogeneity in TCB21, these additional demands have to be controlled for.

186. GTS remarks that the claim is objectifiable as the amount of the relevant connections and the average length of the connection pipelines can be separated.

187. GTS remarks that the claim is also durable as it concerns hundreds of cases of connection pipelines which have been in place.

188. GTS offers a quantification of the claim on request as this involves confidential unit cost prices.

Assessment by CEER

189. The TCB21 benchmark measures outputs on several dimensions: grid provision, capacity, and customer service. Connections generate output on several of these dimensions, regardless of the reason for building the connections. CEER concludes that GTS is not disadvantaged in this respect.

Claim G6 (GTS): Obliged security of supply standard

Description of the claim (by the TSO)

190. GTS notes that it is obliged to meet particular standards with regard to the security of supply for these connections. This decision, part of the Dutch Gas Act, determines that GTS is obliged to able to secure the peak-supply of end-users from -9 °C to -17 °C. This equals a winter in the Netherlands with a probability of occurring once in fifty years. The network of GTS therefore is designed for -17 °C, to be able to fulfil its legal/political obligation.

191. The Dutch situation differs from other countries, often based on one (or a combination) of the following arguments:

- In most countries, the design temperature of the security of supply obligation is based on the European regulation (Art. 8 Vo. 994/2010). This article describes that all member states are obliged to supply end users ´for a day of extraordinary demand, with a statistical probability of occurring once in 20 years'.
- Due to climate differences between participating countries in this benchmark, design temperature of the gas networks differ.

192. Peak supply conditions will vary from country to country based on climatological differences. Nordic countries might be at a disadvantage vis-à-vis countries on a lower degree of latitude. As such, providing a level of security of supply of -17 °C inevitably comes with a disadvantage, compared to TSOs with a security of supply obligation above -17 °C. This is because significant investments have to be made to ensure a network that can fulfil this peak-obligation. Without correction, this will lead to incomparable input/output ratios.

193. GTS states that this condition has been claimed before as special to GTS.

194. GTS further motivates its claim as follows. At this stage it is not clear how the final benchmark model will look like. Any final model should properly cater for the design characteristics of the network.

195. GTS remarks that the claim is objectifiable as design characteristics are often prescribed by European or national law and can be verified.

196. As to durability GTS notes that once a network has been developed according to specific design characteristics, it is often not possible or very limitedly to withdraw any of these choices.

197. GTS mentions that materiality depends on the data normalization, model specification and peer analysis. At this stage of the project GTS did not receive any information on the analysis of comparability of design criteria among TSOs in the sample for TCB21.

Assessment by CEER

198. In previous benchmarks GTS made a similar claim. In discussions about that with ACM, GTS explained that to meet the supply standards, three additional compressors were built. As compressors are assets that generate output in TCB21, CEER does not see how GTS is put at a disadvantage regarding its claim. Also, BNetzA declared that in practice German TSOs have to supply gas in similar conditions.

Appendix A: OLS results for density test model E4099.V1

Dependent variable: DEA(ndrs,2020)

```
OLS: model E4099.V1

Residuals:
       Min         1Q     Median         3Q        Max 
-104478581  -25514240    1655079   22699687  101015579 

Coefficients:
                            Estimate Std. Error t value Pr(>|t|)    
(Intercept)               -2.268e+06 9.529e+06  -0.238 0.812527    
yLines_tot                 5.017e+03  1.213e+03   4.135 9.60e-05 ***
yTransformers.power        3.749e+03  3.976e+02   9.430 3.79e-14 ***
yNGCex_lines.trafo        -5.336e-01  3.436e+00  -0.155 0.877023    
zDensityNGop.circuits.nuts 6.467e+00  1.744e+00   3.707 0.000412 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 47190000 on 71 degrees of freedom
Multiple R-squared:  0.9069,	Adjusted R-squared:  0.9017 
F-statistic:   173 on 4 and 71 DF,  p-value: < 2.2e-16
```

Appendix B: Tobit test for substations

Test ratio: ySubstations.pc/(ySubstations+yTransformers.pc)

Dependent variable: DEA(ndrs,2020)

Model	t.value	p.value
E3GRID2013	0.51	0.61
TCB18E	-0.05	0.96
E3395.V2.4	-1.59	0.11
E3395.V2.4.env2	-0.90	0.37
E3395.V2.4.env2.cLGC	-1.61	0.11
E3395.V2.4.env2.WGC	-1.35	0.18

Appendix C: Tobit test for age parameters / GAS

Test parameters: agem_XX

Dependent variable: DEA(ndrs,exo,2020)

Sign = statistically significant at level <0.05

Neg.sign = coefficient <0, ie factor decreases score (bias)

Table 3 Tobit, GAS, mean proxy per asset category), dea.ndrs.2020.exo.

Model	Test	t.value	p.value	sign.var	neg.sign.var
G1445.V3	agem_10	0.26	0.80	0	0
G1445.V3	agem_20	0.61	0.54	0	0
G1445.V3	agem_30	0.79	0.43	0	0
G1445.V3	agem_40	0.16	0.88	0	0
G1445.V3	agem_50	-0.12	0.90	0	0
G1445.V3	agem_60	-1.18	0.24	0	0
G1445.V3	Age_all_mean	-0.06	0.95	0	0
G1445.V3	ageL10_10	-0.56	0.58	0	0
G1445.V3	ageL10_20	1.34	0.18	0	0
G1445.V3	ageL10_30	0.26	0.80	0	0
G1445.V3	ageL10_40			0	0
G1445.V3	ageL10_50			0	0
G1445.V3	ageL10_60	-0.40	0.69	0	0
G1445.V3	ageL05_10	0.27	0.79	0	0
G1445.V3	ageL05_20	-1.44	0.15	0	0
G1445.V3	ageL05_30	1.36	0.17	0	0
G1445.V3	ageL05_40			0	0
G1445.V3	ageL05_50			0	0
G1445.V3	ageL05_60			0	0
G1445.V3	shareold_10			0	0
G1445.V3	shareold_20	0.41	0.68	0	0
G1445.V3	shareold_30	0.88	0.38	0	0
G1445.V3	shareold_40	-0.03	0.98	0	0
G1445.V3	shareold_50			0	0
G1445.V3	shareold_60	-0.87	0.38	0	0
G1445.V3	Sharem_young10	-0.30	0.76	0	0
G1445.V3	Sharem_young05	0.48	0.63	0	0
G1445.V3	Sharem_old	-0.11	0.91	0	0
G1445.V3.env4	agem_10	0.22	0.82	0	0
G1445.V3.env4	agem_20	0.62	0.53	0	0
G1445.V3.env4	agem_30	0.73	0.46	0	0
G1445.V3.env4	agem_40	0.17	0.87	0	0
G1445.V3.env4	agem_50	-0.14	0.89	0	0
G1445.V3.env4	agem_60	-1.24	0.22	0	0
G1445.V3.env4	Age_all_mean	-0.10	0.92	0	0
G1445.V3.env4	ageL10_10	-0.51	0.61	0	0
G1445.V3.env4	ageL10_20	1.38	0.17	0	0
G1445.V3.env4	ageL10_30	0.28	0.78	0	0
G1445.V3.env4	ageL10_40			0	0
G1445.V3.env4	ageL10_50			0	0
G1445.V3.env4	ageL10_60	-0.41	0.69	0	0
G1445.V3.env4	ageL05_10	0.28	0.78	0	0
G1445.V3.env4	ageL05_20	-1.37	0.17	0	0
G1445.V3.env4	ageL05_30	1.38	0.17	0	0
G1445.V3.env4	ageL05_40			0	0
G1445.V3.env4	ageL05_50			0	0
G1445.V3.env4	ageL05_60			0	0
G1445.V3.env4	shareold_10			0	0
G1445.V3.env4	shareold_20	0.42	0.67	0	0
G1445.V3.env4	shareold_30	0.81	0.42	0	0
G1445.V3.env4	shareold_40	-0.02	0.99	0	0
G1445.V3.env4	shareold_50			0	0
G1445.V3.env4	shareold_60	-0.87	0.39	0	0
G1445.V3.env4	Sharem_young10	-0.25	0.80	0	0
G1445.V3.env4	Sharem_young05	0.50	0.62	0	0
G1445.V3.env4	Sharem_old	-0.12	0.90	0	0

Model	Test	t.value	p.value	sign.var	neg.sign.var
G4450.V3	agem_10	0.51	0.61	0	0
G4450.V3	agem_20	0.39	0.69	0	0
G4450.V3	agem_30	0.14	0.89	0	0
G4450.V3	agem_40	0.43	0.67	0	0
G4450.V3	agem_50	-1.08	0.28	0	0
G4450.V3	agem_60	-2.37	0.02	1	1
G4450.V3	Age_all_mec	-0.48	0.63	0	0
G4450.V3	ageL10_10	0.41	0.68	0	0
G4450.V3	ageL10_20	0.94	0.35	0	0
G4450.V3	ageL10_30	1.89	0.06	0	0
G4450.V3	ageL10_40			0	0
G4450.V3	ageL10_50			0	0
G4450.V3	ageL10_60	0.60	0.55	0	0
G4450.V3	ageL05_10	0.54	0.59	0	0
G4450.V3	ageL05_20	-1.00	0.32	0	0
G4450.V3	ageL05_30	0.00	1.00	0	0
G4450.V3	ageL05_40			0	0
G4450.V3	ageL05_50			0	0
G4450.V3	ageL05_60			0	0
G4450.V3	shareold_10			0	0
G4450.V3	shareold_20	0.59	0.55	0	0
G4450.V3	shareold_30	0.92	0.36	0	0
G4450.V3	shareold_40	0.81	0.42	0	0
G4450.V3	shareold_50			0	0
G4450.V3	shareold_60	-1.86	0.06	0	0
G4450.V3	Sharem_you	1.13	0.26	0	0
G4450.V3	Sharem_you	0.90	0.37	0	0
G4450.V3	Sharem_old	-0.18	0.86	0	0
G4450.V3.en	agem_10	0.35	0.72	0	0
G4450.V3.en	agem_20	0.47	0.64	0	0
G4450.V3.en	agem_30	-0.20	0.84	0	0
G4450.V3.en	agem_40	0.59	0.55	0	0
G4450.V3.en	agem_50	-1.22	0.22	0	0
G4450.V3.en	agem_60	-2.94	0.00	1	1
G4450.V3.en	Age_all_mec	-0.72	0.47	0	0
G4450.V3.en	ageL10_10	-0.23	0.82	0	0
G4450.V3.en	ageL10_20	1.16	0.25	0	0
G4450.V3.en	ageL10_30	1.09	0.28	0	0
G4450.V3.en	ageL10_40			0	0
G4450.V3.en	ageL10_50			0	0
G4450.V3.en	ageL10_60	-0.46	0.64	0	0
G4450.V3.en	ageL05_10	0.47	0.64	0	0
G4450.V3.en	ageL05_20	-0.75	0.45	0	0
G4450.V3.en	ageL05_30	0.00	1.00	0	0
G4450.V3.en	ageL05_40			0	0
G4450.V3.en	ageL05_50			0	0
G4450.V3.en	ageL05_60			0	0
G4450.V3.en	shareold_10			0	0
G4450.V3.en	shareold_20	0.64	0.52	0	0
G4450.V3.en	shareold_30	0.58	0.56	0	0
G4450.V3.en	shareold_40	0.91	0.36	0	0
G4450.V3.en	shareold_50			0	0
G4450.V3.en	shareold_60	-2.03	0.04	1	1
G4450.V3.en	Sharem_you	0.23	0.82	0	0
G4450.V3.en	Sharem_you	0.85	0.40	0	0
G4450.V3.en	Sharem_old	-0.30	0.77	0	0

CEER

Appendix D: Tobit test for age parameters / ELEC

Test parameters: agem_XX

Dependent variable: DEA(ndrs,exo,2020)

Sign = statistically significant at level <0.05

Neg.sign = coefficient <0, ie factor decreases score (bias)

Table 4 Tobit, ELEC, mean proxy per asset category), dea.ndrs.2020.exo.

model	name.coef1	t.value	p.value	sign	neg.sign
E3395.V2.4	agem_10	-1.216	0.224	0	0
E3395.V2.4	agem_20	-0.680	0.496	0	0
E3395.V2.4	agem_30	-0.713	0.476	0	0
E3395.V2.4	agem_40	-0.832	0.406	0	0
E3395.V2.4	agem_50	-0.388	0.698	0	0
E3395.V2.4	agem_60	-2.080	0.037	1	1
E3395.V2.4	agem_70	0.001	0.999	0	0
E3395.V2.4	agem_80	-1.513	0.130	0	0
E3395.V2.4	Age_all_mean	-2.097	0.036	1	1
E3395.V2.4	ageL10_10	1.874	0.061	0	0
E3395.V2.4	ageL10_20	0.819	0.413	0	0
E3395.V2.4	ageL10_30	0.095	0.925	0	0
E3395.V2.4	ageL10_40	1.350	0.177	0	0
E3395.V2.4	ageL10_50	-0.789	0.430	0	0
E3395.V2.4	ageL10_60	1.549	0.121	0	0
E3395.V2.4	ageL05_10	1.977	0.048	1	0
E3395.V2.4	ageL05_20	0.473	0.636	0	0
E3395.V2.4	ageL05_30	0.155	0.877	0	0
E3395.V2.4	ageL05_40	1.749	0.080	0	0
E3395.V2.4	ageL05_50	0.150	0.880	0	0
E3395.V2.4	ageL05_60	0.001	0.999	0	0
E3395.V2.4	shareold_10	-0.333	0.739	0	0
E3395.V2.4	shareold_20	-1.079	0.281	0	0
E3395.V2.4	shareold_30	-0.777	0.437	0	0
E3395.V2.4	shareold_40	1.307	0.191	0	0
E3395.V2.4	shareold_50	-0.916	0.360	0	0
E3395.V2.4	shareold_60	-0.422	0.673	0	0
E3395.V2.4	shareold_70	-0.726	0.468	0	0
E3395.V2.4	shareold_80	-1.939	0.053	0	0
E3395.V2.4	Sharem_young10	2.070	0.038	1	0
E3395.V2.4	Sharem_young05	1.962	0.050	1	0

E3395.V2.4	Sharem_old	-1.731	0.083	0	0
E3395.V2.4.env2	agem_10	-0.607	0.544	0	0
E3395.V2.4.env2	agem_20	-0.950	0.342	0	0
E3395.V2.4.env2	agem_30	-0.847	0.397	0	0
E3395.V2.4.env2	agem_40	-0.757	0.449	0	0
E3395.V2.4.env2	agem_50	-0.333	0.739	0	0
E3395.V2.4.env2	agem_60	-2.050	0.040	1	1
E3395.V2.4.env2	agem_70	0.569	0.569	0	0
E3395.V2.4.env2	agem_80	-1.774	0.076	0	0
E3395.V2.4.env2	Age_all_mean..s..	-1.995	0.046	1	1
E3395.V2.4.env2	ageL10_10	1.431	0.152	0	0
E3395.V2.4.env2	ageL10_20	0.440	0.660	0	0
E3395.V2.4.env2	ageL10_30	0.436	0.663	0	0
E3395.V2.4.env2	ageL10_40	1.350	0.177	0	0
E3395.V2.4.env2	ageL10_50	-0.362	0.718	0	0
E3395.V2.4.env2	ageL10_60	1.440	0.150	0	0
E3395.V2.4.env2	ageL05_10	1.571	0.116	0	0
E3395.V2.4.env2	ageL05_20	0.178	0.859	0	0
E3395.V2.4.env2	ageL05_30	0.281	0.779	0	0
E3395.V2.4.env2	ageL05_40	1.789	0.074	0	0
E3395.V2.4.env2	ageL05_50	0.904	0.366	0	0
E3395.V2.4.env2	ageL05_60	0.002	0.999	0	0
E3395.V2.4.env2	shareold_10	0.533	0.594	0	0
E3395.V2.4.env2	shareold_20	-1.293	0.196	0	0
E3395.V2.4.env2	shareold_30	-0.904	0.366	0	0
E3395.V2.4.env2	shareold_40	1.193	0.233	0	0
E3395.V2.4.env2	shareold_50	-0.988	0.323	0	0
E3395.V2.4.env2	shareold_60	-0.627	0.531	0	0
E3395.V2.4.env2	shareold_70	-0.141	0.888	0	0
E3395.V2.4.env2	shareold_80	-2.112	0.035	1	1
E3395.V2.4.env2	Sharem_young10	1.757	0.079	0	0
E3395.V2.4.env2	Sharem_young05	1.600	0.110	0	0
E3395.V2.4.env2	Sharem_old	-1.830	0.067	0	0
E2388.V2.4	agem_10	-0.962	0.336	0	0
E2388.V2.4	agem_20	1.030	0.303	0	0
E2388.V2.4	agem_30	-0.238	0.812	0	0
E2388.V2.4	agem_40	0.043	0.966	0	0
E2388.V2.4	agem_50	-0.108	0.914	0	0
E2388.V2.4	agem_60	0.265	0.791	0	0
E2388.V2.4	agem_70	-0.440	0.660	0	0
E2388.V2.4	agem_80	-1.480	0.139	0	0
E2388.V2.4	Age_all_mean	-0.311	0.756	0	0
E2388.V2.4	ageL10_10	0.272	0.785	0	0
E2388.V2.4	ageL10_20	-1.085	0.278	0	0

E2388.V2.4	ageL10_30	-0.470	0.638	0	0
E2388.V2.4	ageL10_40	-0.265	0.791	0	0
E2388.V2.4	ageL10_50	-0.617	0.537	0	0
E2388.V2.4	ageL10_60	1.291	0.197	0	0
E2388.V2.4	ageL05_10	0.445	0.656	0	0
E2388.V2.4	ageL05_20	-1.599	0.110	0	0
E2388.V2.4	ageL05_30	-0.940	0.347	0	0
E2388.V2.4	ageL05_40	0.950	0.342	0	0
E2388.V2.4	ageL05_50	-0.062	0.950	0	0
E2388.V2.4	ageL05_60	0.002	0.999	0	0
E2388.V2.4	shareold_10	-0.635	0.526	0	0
E2388.V2.4	shareold_20	-0.169	0.866	0	0
E2388.V2.4	shareold_30	-0.400	0.689	0	0
E2388.V2.4	shareold_40	0.966	0.334	0	0
E2388.V2.4	shareold_50	-0.383	0.702	0	0
E2388.V2.4	shareold_60	1.116	0.264	0	0
E2388.V2.4	shareold_70	-0.738	0.460	0	0
E2388.V2.4	shareold_80	-1.807	0.071	0	0
E2388.V2.4	Sharem_young10	-0.099	0.921	0	0
E2388.V2.4	Sharem_young05	0.107	0.915	0	0
E2388.V2.4	Sharem_old	-0.032	0.975	0	0
E2388.V2.4.env2	agem_10	-0.053	0.958	0	0
E2388.V2.4.env2	agem_20	0.469	0.639	0	0
E2388.V2.4.env2	agem_30	-0.377	0.706	0	0
E2388.V2.4.env2	agem_40	-0.025	0.980	0	0
E2388.V2.4.env2	agem_50	-0.783	0.433	0	0
E2388.V2.4.env2	agem_60	0.281	0.779	0	0
E2388.V2.4.env2	agem_70	-0.002	0.998	0	0
E2388.V2.4.env2	agem_80	-1.668	0.095	0	0
E2388.V2.4.env2	Age_all_mean	-0.346	0.730	0	0
E2388.V2.4.env2	ageL10_10	-0.155	0.877	0	0
E2388.V2.4.env2	ageL10_20	-1.057	0.290	0	0
E2388.V2.4.env2	ageL10_30	-0.287	0.774	0	0
E2388.V2.4.env2	ageL10_40	-0.024	0.981	0	0
E2388.V2.4.env2	ageL10_50	-0.576	0.565	0	0
E2388.V2.4.env2	ageL10_60	1.136	0.256	0	0
E2388.V2.4.env2	ageL05_10	0.168	0.866	0	0
E2388.V2.4.env2	ageL05_20	-1.384	0.166	0	0
E2388.V2.4.env2	ageL05_30	-0.859	0.390	0	0
E2388.V2.4.env2	ageL05_40	0.957	0.339	0	0
E2388.V2.4.env2	ageL05_50	0.826	0.409	0	0
E2388.V2.4.env2	ageL05_60	0.002	0.999	0	0
E2388.V2.4.env2	shareold_10	0.390	0.697	0	0
E2388.V2.4.env2	shareold_20	-0.698	0.485	0	0

E2388.V2.4.env2	shareold_30	-0.591	0.554	0	0
E2388.V2.4.env2	shareold_40	0.703	0.482	0	0
E2388.V2.4.env2	shareold_50	-1.115	0.265	0	0
E2388.V2.4.env2	shareold_60	1.016	0.310	0	0
E2388.V2.4.env2	shareold_70	-0.182	0.855	0	0
E2388.V2.4.env2	shareold_80	-1.904	0.057	0	0
E2388.V2.4.env2	Sharem_young10	-0.376	0.707	0	0
E2388.V2.4.env2	Sharem_young05	-0.101	0.920	0	0
E2388.V2.4.env2	Sharem_old	-0.271	0.787	0	0