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27 March 2026

Ms Kami Kaur
General Manager
Australian Energy Regulator
GPO Box 3131
Canberra, ACT 2601

Dear Kami,

Thank you for the opportunity to provide feedback on Phase 2 of the Australian Energy Regulator's (**AER's**) review to investigate potential options for the operating expenditure (**opex**) benchmarking cost function models.

We continue to support the AER's objective of strengthening the reliability and credibility of its econometric benchmarking framework, given the central role the models play in setting base-year opex allowances and in creating reputational incentives for efficiency.

The importance of reliable econometric benchmarking models

Ausgrid commends the AER in continuing its consultation on improvements to the opex benchmarking cost function models.

Our submission builds on the position we set out in response to the AER's Phase 1 consultation. Ausgrid's key point was that the current models' assumption of constant efficiency over time is no longer credible, particularly since some Distribution Network Service Providers (**DNSPs**), including Ausgrid, have become materially more efficient over time. We also submitted that the alternative Jurisdictional Time Trend (**JTT**) and Australian Time Trend (**ATT**) specifications were useful in diagnosing the problem, but should not themselves be adopted as replacements for the current models, and that the AER should instead explore model specifications that allow for time-varying inefficiency.

Phase 2 of the consultation progresses the review of the benchmarking models with the AER's advisers, Quantonomics, expanding the range of candidate models that it considers perform well against its selection criteria:

- Two stochastic frontier analysis (**SFA**) models: a Battese and Coelli (1995) (**BC95**) model, and one Kumbhakar (1990) (Kumb90) model; and
- Two time-varying least squares econometrics (**LSE**) models.

We have identified, with assistance from Frontier Economics, a number of issues with Quantonomics' analysis that need to be addressed before the time-varying inefficiency models could be fully assessed, including:

- From our review, the approach to modelling the efficiency time trend in the BC95 models appear to be done inconsistently;

- The fact that expected inefficiency in the preferred BC95 model was effectively invariant over time - meaning that the model was not, for practical purposes, a time-varying inefficiency model;
- The efficiency time trend imposed in the Kumb90 models is highly restrictive and often results in efficiency estimates over time that are difficult to reconcile with observed outcomes;
- The time-varying LSE models tested by Quantonomics do not allow for different rates of catch-up over the historical benchmarking period;
- Quantonomics' concerns about the apparent lack of convergence of some models, which resulted in some models being excluded, can be achieved for all the models investigated when more appropriate starting values are adopted; and
- Quantonomics' concerns that efficiency scores could not be computed for some DNSPs in some models, was in fact possible.

These issues were addressed as part of the testing of the models considered by Quantonomics. We also expanded the set of models investigated.

Having estimated 18 time-varying inefficiency models in total, and the time-invariant SFA and LSE models currently used by the AER, we evaluated all 20 models against selection criteria very similar to those used by Quantonomics. Our key conclusions from that exercise are as follows:

1. **The time-invariant inefficiency models currently used by the AER are materially mis-specified and we recommend the AER consider alternative approaches.**
   Their assumption of constant efficiency is inconsistent with observed data and leads to unreliable outcomes.

2. **Three time-varying SFA models satisfy all selection criteria and materially outperform all others tested:**
   - These are two BC95 models (SFA-BC95-JTT-HN-GTC and SFA-BC95-AGEC-HN-GTC) and one Kumb90 model (SFA-Kumb-AGECJUR-HN-GTC). Ausgrid proposes that the AER use all three of these models instead of its existing benchmarking models, and that all three models should, by default, receive equal weight.
   - These models allow the estimated cost time trends to vary between each three-year historical period; the SFA-BC95-AGEC-HN-GTC and SFA-Kumb-AGECJUR-HN-GTC models also allow the estimated efficiency time trend to vary for each three-year historical period— an option not considered by Quantonomics.
   - The models identified by Quantonomics as satisfying the evaluation criteria are not considered to perform satisfactorily.
   - LSE specifications should be excluded. These models are overly restrictive and perform unambiguously worse than the preferred SFA models.

3. **The AER should give primacy to translog specifications**, using the Cobb-Douglas versions of the models only as a fallback. This is because formal statistical tests show clearly that the Cobb-Douglas specifications fit the data more poorly than the translog specifications. For the avoidance of doubt, it is not that the Cobb-Douglas specifications of the recommendations are mis-specified. Rather, the statistical tests show that the Cobb-Douglas versions explain the data less well than the translog versions of the same models. If reliable estimates can be obtained using the translog specification,

there is no need for the AER to use poorer-fitting models (i.e., the Cobb-Douglas specifications). Translog models are more flexible and therefore can be more prone to statistical problems such as monotonicity violations. If for unanticipated reasons the translog models cannot be estimated reliably in future, the less flexible Cobb-Douglas specifications could be a useful fallback option.

We also note that Quantonomics did not assess whether current benchmarking models capture new DNSP services linked to consumer energy resources (**CER**) and grid stability, despite DNSPs incurring costs to deliver them. As a result, these models may wrongly interpret higher costs as inefficiency rather than the cost of providing unmeasured outputs.

Ausgrid considers that adoption of these recommendations would materially improve the robustness, credibility, and regulatory usefulness of the AER's opex benchmarking framework.

If the AER were to adopt time-varying inefficiency models, Ausgrid's preference is to retain the use of the benchmarking roll-forward model from the middle of the benchmarking period (rather than using the final year estimates of efficiency to estimate efficiency base year opex), but applying the average time-varying efficiency estimates over the benchmarking period to estimate the average efficient opex over the period. This process is familiar to DNSPs and the Quantonomics report does not suggest that a change is needed.

Should the AER wish to make material changes to its approach to estimating efficient base year opex, it should undertake sufficiently extensive consultation. This should occur after the time-varying inefficiency models have been established as the basis for the estimation.

The attached submission explains these matters in greater detail.

Ausgrid would also be pleased to provide the AER with Frontier Economics' modelling files, to assist the AER and Quantonomics in understanding the analysis that has underpinned our submission.

Should you have any questions, please contact [redacted], Economic Regulation Manager, at [redacted]

Regards,

[redacted]

Fiona McAnally
Head of Regulation

Attachment – Response to AER Phase 2 consultation on econometric benchmarking models

Ausgrid commends the AER in continuing its consultation on improvements to the opex benchmarking cost function models. The AER's opex benchmarking analysis plays two important roles in the regulatory framework:

- Firstly, it is used to determine the efficiency of DNSPs' base-year opex which, in turn, is used to forecast DNSPs' efficient opex over a regulatory control period. In other words, the AER's benchmarking models have a direct influence on DNSPs' revenue allowances. If the benchmarking models produce unreliable estimates of efficiency, this could result in DNSPs' revenue allowances being set either above or below the efficient level.
- Secondly, the results from the benchmarking models are published in the Annual Benchmarking Reports and play an important role in driving reputational incentives for DNSPs to become more efficient over time. Consumers ultimately benefit from such efficiency improvements, because the regulatory framework shares these efficiencies with consumers. However, the AER's benchmarking analysis will only be effective in driving efficiencies if all stakeholders have confidence that the benchmarking models produce reliable results.

Whilst the AER's benchmarking models may have once been fit-for-purpose, in recent years we have expressed concern that the models are becoming less reliable. The AER and its advisers Quantonomics have noted that the models routinely suffer from material statistical problems, such as excessive monotonicity violations, resulting in those models being excluded from the Annual Benchmarking Reports and the process for estimating efficient base year opex in regulatory determinations. Some models also produce unusually low estimates of efficiency for Ausgrid (and other DNSPs) that are inconsistent with the estimates produced by other models and with the opex Multilateral Partial Factor Productivity (**MPFP**) indices.

In Phase 1 of the AER's consultation on opex benchmarking cost function models, Quantonomics investigated concerns regarding model mis-specification. Quantonomics concluded that the existing models are mis-specified because they assume efficiency remains constant over time and apply a uniform time trend across all jurisdictions (Australia, New Zealand, and Ontario). By testing more flexible Jurisdictional and Australian Time Trend models (**JTT** and **ATT**), Quantonomics proved that time trends differ significantly across jurisdictions. However, Quantonomics noted that these alternative models still conflate industry-wide technical change with individual network "catch-up" efficiency, ultimately recommending that the AER explore models that allow explicitly for time-varying inefficiency.

Ausgrid's submission strongly supported Quantonomics' diagnosis, noting that the constant inefficiency assumption risks penalising distribution networks, such as Ausgrid, that have made material and genuine efficiency improvements over time. While validating the mis-specification problem, Ausgrid recommended against adopting the JTT or ATT models as replacements, arguing that they would overstate technical change and miscalculate efficient base year opex.

Instead, Ausgrid proposed that Phase 2 of the AER's consultation rigorously explore models that accurately account for time-varying efficiency, urging the AER to prioritise fit-for-purpose accuracy over rushed timelines.

Our submission to the AER's Phase 2 review of its opex benchmarking econometric models is structured as follows:

- Section 1 summarises the time-varying inefficiency models investigated by Quantonomics.
- Section 2 discusses the issues identified in Quantonomics' Phase 2 analysis.
- Section 3 explains the models we have investigated when preparing this response to the AER's Phase 2 consultation.
- Section 4 explains how we evaluated the models we investigated, identifies the models we recommend the AER use for future benchmarking analysis, and explains how Ausgrid considers those models should be used to estimate efficient base year opex.

1. Summary of models assessed by Quantonomics in Phase 2 report

In Phase 2 of the consultation process, Quantonomics examined several classes of econometric models that allow for time-varying inefficiency. Five model classes were considered in total:

- Battese and Coelli (1995) (**BC95**) stochastic frontier analysis (**SFA**) models;
- Kumbhakar (1990) (**Kumb90**) SFA models;
- Least squares econometrics (**LSE**) fixed effects panel models;
- Colombi et al. (2014) four-components models; and
- Cornwell, Schmidt and Sickles (1990) (**FECSS**) models.

Quantonomics focused primarily on the BC95, Kumb90 and LSE models, concluding that the four-components and FECSS models did not perform adequately and should not be pursued further.

Ausgrid engaged Frontier Economics to independently assess the robustness and suitability of the econometric models selected by Quantonomics for regulatory benchmarking purposes, and the positions set out in this submission reflect Frontier Economics' advice.

Battese and Coelli (1995) models

Comparison with the AER's existing SFA model

The BC95 model extends the AER's existing SFA model by allowing expected inefficiency to vary over time rather than assuming time-invariant inefficiency at the firm level. The AER's current approach assumes each DNSP draws a single inefficiency term that remains constant across the sample period. By contrast, the BC95 model allows inefficiency to vary over time, with an inefficiency term drawn each year from a distribution featuring a time-varying pre-truncation mean.

Ausgrid considers this to be a material conceptual improvement, as it better reflects the reality that DNSP efficiency can change over time in response to managerial effort, regulatory incentives, and operating conditions.

Quantonomics' implementation

Quantonomics implemented the BC95 model using a normalisation that sets the intercept of the inefficiency pre-truncation mean to zero. This simplifies estimation, mitigates convergence issues, and effectively imposes a half-normal distribution for inefficiency when efficiency drivers are zero.

Efficiency trends were modelled using either:

- jurisdictional time trends (**JTT**), where each jurisdiction has a common linear efficiency trend; or
- Australian DNSP specific time trends combined with jurisdictional trends for overseas DNSPs (**AJTT**).

Quantonomics modelled cost/frontier movements using either a linear time trend or a general technical change (**GTC**) specification with step changes every three years. Quantonomics found that the JTT specification with a linear cost trend was the most tractable and reliable BC95 variant.

Kumbhakar (1990) models

Model characteristics

The Kumb90 model also allows for time-varying inefficiency but does so in a more restrictive manner. Inefficiency is decomposed into a time-invariant, firm-specific component that is scaled deterministically over time by a function of observable drivers. As a result, DNSPs differ in the level of inefficiency but are constrained to follow a deterministic time path.

As discussed later, Ausgrid notes that a “common trend” restriction may limit the model’s ability to capture heterogeneous efficiency improvements across DNSPs, particularly where firms undertake materially different efficiency initiatives over time.

Quantonomics’ implementation

Quantonomics implemented the Kumb90 model using the same JTT and AJTT specifications for efficiency trends and the same linear and GTC specifications for cost trends as applied in the BC95 analysis. Similar to the BC95 results, Quantonomics found that the JTT specification with a linear cost trend performed best.

Least squares econometrics models

Standard LSE approach

The LSE model differs fundamentally from SFA models in that it does not explicitly decompose the error term into inefficiency and noise. Instead, it estimates firm specific fixed effects that are interpreted as permanent cost differences, with inefficiency inferred from those effects. A key assumption of the LSE approach is that at least one DNSP is fully efficient in each period.

Quantonomics’ implementation

Quantonomics extended the standard LSE framework by allowing efficiency to vary over time through DNSP-specific or jurisdiction-specific time trends. It examined four specifications combining alternative efficiency trend assumptions with linear or GTC cost trends.

Quantonomics highlighted the relative simplicity and computational stability of the LSE models compared to SFA approaches and concluded that two LSE variants performed among the best overall models assessed.

Models rejected by Quantonomics

Quantonomics rejected both the Colombi et al. four-components model and the FECSS model. Although Quantonomics considered these models to be theoretically appealing, it concluded that the models produced implausibly high efficiency scores, suffered from significant monotonicity violations, and exhibited poor statistical performance. Ausgrid agrees with Quantonomics that these models are not suitable for regulatory benchmarking purposes.

Key variants of the BC95, Kumb90 and time-varying LSE models

Half-normal inefficiency assumption

Quantonomics restricted inefficiency distributions to be half-normal rather than truncated normal with a freely estimated mean. Although the assumption of a half-normal efficiency distribution is more restrictive than the assumption of a truncated normal distribution, Ausgrid considers this a pragmatic trade-off because it simplifies the numerical process for estimating the models, reduces the risk of non-convergence and improves model identification.

General technical change

The GTC specification relaxes the assumption of a smooth linear cost trend by allowing step changes every three years. Ausgrid agrees that this approach has merit and notes that extending similar flexibility to efficiency trends, as explored by Frontier Economics, in the analysis presented below is conceptually appealing.

Omitted variables and heteroscedasticity

Quantonomics examined the inclusion of additional outputs and input prices, as well as heteroscedastic error structures. It found that these extensions did not materially improve model performance and often worsened monotonicity outcomes. Ausgrid supports the decision not to pursue these extensions further at this stage.

However, Quantonomics did not examine whether the existing models omit potentially important outputs associated with the evolving role of DNSPs, particularly those related to the growth in consumer energy resources (**CER**) and grid stability. Over the past decade, the role of DNSPs has shifted significantly from passively transporting electricity from the transmission network to end users, to actively providing a broader set of services. These include:

- facilitating two-way power flows as rooftop solar penetration has increased;
- undertaking active system management and load control; and
- enabling new forms of end-user participation in the energy system, such as electric vehicle charging.

DNSPs have made substantial investments in their networks to deliver these services and continue to incur operating and maintenance costs associated with these assets. While these costs are included in the opex that the AER seeks to benchmark, the benchmarking models currently used by the AER reflect only the outputs historically delivered by DNSPs. The models do not adequately capture the expanded range of services that DNSPs now provide to support the modern energy system. As a result, the models risk attributing higher costs to inefficiency rather than to the provision of unmeasured outputs.

Ausgrid acknowledges that identifying measurable outputs that comprehensively reflect these evolving services may be challenging. It is also likely to be difficult to find consistent data to measure these outputs across Australia, New Zealand and Ontario. Nevertheless, it is critical that the benchmarking analysis appropriately reflect the full range of DNSP outputs. Ausgrid therefore encourages the AER to undertake further industry consultation to broaden the set of relevant outputs incorporated into its benchmarking framework.

Quantonomics' assessment criteria

Quantonomics assessed model performance against a comprehensive set of criteria, including:

- statistical significance and plausibility of output coefficients;
- frequency of monotonicity violations;
- reasonableness of implied output weights;
- convergence and estimation stability;
- goodness of fit;
- performance in specification tests;
- robustness to sample changes; and
- consistency of efficiency scores across methods.

Ausgrid considers this multi-criteria approach to be appropriate and consistent with good practice for selecting between econometric models.

Key takeaways from Quantonomics' Phase 2 report

Quantonomics identified four models as performing best overall: one BC95 model, one Kumb90 model, and two LSE models. While these models outperformed the AER's existing approaches on several criteria, Quantonomics characterised its findings as preliminary and recommended further analysis before any replacement of the current framework.

Quantonomics observed that time-varying inefficiency models may reduce reliance on the benchmarking roll-forward process currently employed by the AER by enabling more direct estimation of efficient base-year opex when the base year aligns with the end of the sample or, alternatively, rolling forward minimally from the final year of the benchmarking period to the base year.

Ausgrid cautions against adopting an alternative approach to estimating efficient base year opex without further testing and consultation.

Ausgrid supports the AER's continued exploration of time-varying inefficiency models as part of its opex benchmarking framework. The Quantonomics analysis provides a valuable foundation for this work.

Ausgrid agrees that time-varying inefficiency models provide promising results which warrant further consideration. As discussed below, Frontier Economics has explored, refined and extended the models examined by Quantonomics, and has identified a set of models—different from those proposed by Quantonomics—that it considers to be viable replacements for the time-invariant inefficiency models currently used by the AER. Ausgrid therefore encourages the AER to discontinue use of the existing models, which are no longer fit for purpose, and to give serious consideration to adopting the models recommended by Frontier Economics.

2. ISSUES WITH THE ANALYSIS IN THE PHASE 2 REPORT

The Phase 2 report represents a significant expansion in the use of econometric techniques, including SFA and LSE models, to derive comparative efficiency estimates. Ausgrid supports the continued development of benchmarking approaches that are empirically robust and economically meaningful. However, for benchmarking to be used appropriately in regulatory decision-making, the underlying models must be capable of reflecting genuine efficiency differences and changes over time, and their limitations must be clearly understood.

This section explains a number of key issues that Frontier Economics identified in the Phase 2 report that needed to be addressed before the models presented by Quantonomics could be evaluated properly. In Ausgrid's view, the Quantonomics Phase 2 report should be viewed as an informative starting point for improving the reliability of the AER's benchmarking models, rather than a definitive position on the matter.

Our recommendations – based on the advice from Frontier Economics – are intended to address the key issues identified as part of this review and are presented in subsequent sections of this submission.

Treatment of efficiency time trends in BC95 models

Conceptual background

A central feature of the BC95 class of SFA models is the treatment of inefficiency as a latent component that may vary over time. In principle, this framework allows efficiency to improve or deteriorate in response to managerial effort, technological change, scale effects, or external operating conditions. Therefore, when appropriately specified, BC95-type models can provide useful insights into both relative efficiency levels and efficiency change over time.

In practice, however, the behaviour of estimated efficiency scores depends critically on how the time dimension of inefficiency is parameterised. Seemingly minor choices - such as the definition of the time index or the normalisation of time trend variables - can have large effects on the implied evolution of efficiency.

Specification adopted in the Phase 2 report

Ausgrid notes that Quantonomics defines the efficiency time trend variables inconsistently across different BC95 specifications. In some cases, the models are specified in a way where the expected level of inefficiency is essentially invariant over time - which is contrary to the objective of specifying models that can account for changes in DNSP inefficiency over time.

For example, in the BC95-JTT-HN model (the BC95 model that Quantonomics identified as one of the four best-performing models overall), the pre-truncation mean of the inefficiency term, μ_{it}, is calculated as $\beta_1 \times 2006$ for Australian observations in 2006, $\beta_1 \times 2007$ for Australian observations in 2007… $\beta_1 \times 2023$ for observations in 2023. All DNSPs are assumed to have $\mu_{it} = 0$ (a half-normal distribution of inefficiency) in year 0, which is over 2,000 years prior to the start of the benchmarking sample.

This implies that the ratio of μ_{it} in 2023 and 2006 is:

$$\frac{\mu_{i,2023}}{\mu_{i,2006}} = \frac{\beta_1 \times 2023}{\beta_1 \times 2006} \approx 1.$$

That is, there is almost no difference in expected inefficiency between the end of the benchmarking sample (i.e., 2023) and the start of the benchmarking sample (i.e., 2006).

The problem with the way Quantonomics defined the efficiency time trend in the BC95-JTT-HN model is illustrated in Figure 1 below. The blue dots can be considered (for illustrative purposes) the true efficiency of DNSPs, increasing considerably over the benchmarking period 2006 to 2023. When attempting to fit the data, the Quantonomics specification is essentially constrained to finding the best slope, with the intercept (year 0) set to 77%. Because $t = 0$ is defined to be more than 2,000 years before the start of the benchmarking period, the slope of the line-of-best-fit is almost flat over the benchmarking period. Due to the restrictive way in which the efficiency time trend is defined, the BC95 model that Quantonomics identifies as one of the top-performing models is unable of estimating the trend in inefficiency accurately (i.e., the line-of-best-fit is almost horizontal, but the true efficiency is trending upwards steeply over the benchmarking period).[1]

Several other versions of the BC95 models investigated by Quantonomics suffered from the same mis-specification problems.

For the avoidance of doubt, the issue identified here is not a problem with the BC95 model per se. Rather, our concern is with the way Quantonomics has chosen to specify the efficiency time trend in some of the BC95 models (including the BC95 model Quantonomics identifies as one of the four best-performing models). Quantonomics' chosen specification of the efficiency time trend results in the expected efficiency remaining almost constant over the benchmarking period. This renders those particular versions of the BC95 model time-invariant, for all practical purposes.

Empirical testing undertaken by Frontier Economics confirms that, despite being presented as time-varying, these specifications generate estimates of the cost function that are almost indistinguishable from time-invariant results. In Ausgrid's view, this outcome reflects model mis-specification.

This defeats the objective of specifying time-varying inefficiency models that are capable of accounting for changes in DNSP efficiency over time.

Other BC95 specifications investigated by Quantonomics did not suffer from this problem, but none of those models were identified by Quantonomics as either feasible or performing well against Quantonomics' selection criteria.

As explained below, we propose a treatment of the efficiency time trend term that is consistent across all BC95 models, and which allows the models to be truly time-varying.

[1] Although the efficiency time trend is defined differently in the BC95-JTT-HN-hY model, it too is essentially a model in which expected inefficiency is time-invariant.

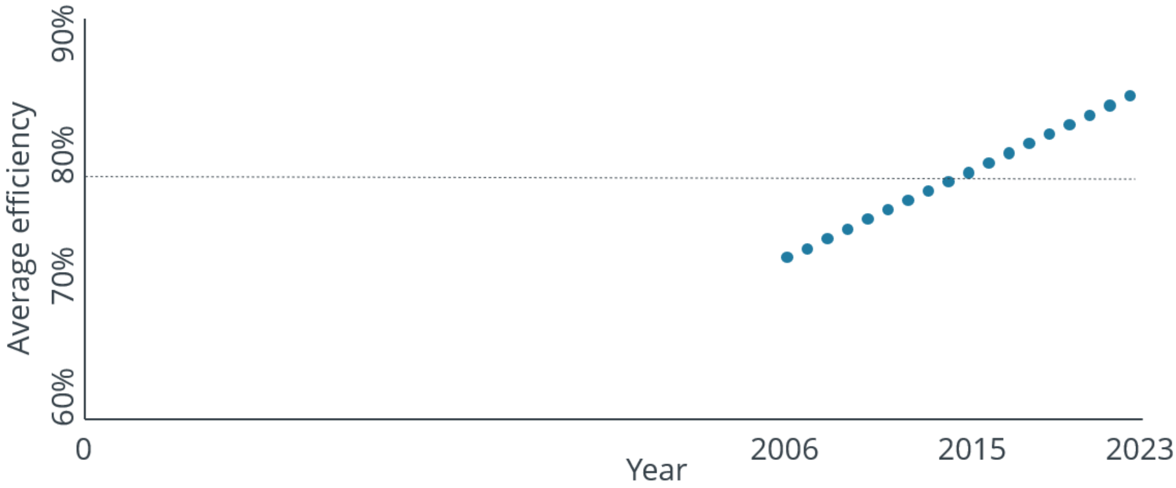


Figure 1: Illustrative comparison of efficiency paths under time-invariant and Phase 2 BC95 time-varying specifications

Regulatory implications

The specification of these models means that they are unable to reflect material efficiency changes over time. This undermines their suitability for assessing base year efficiency since the efficiency of a number of DNSPs, including Ausgrid, has changed over time. If expected efficiency is effectively fixed by construction, the estimated cost functions will be unreliable and so the models cannot provide meaningful evidence on whether a DNSP has become more or less efficient, over time, relative to its peers.

Ausgrid's position

Ausgrid proposes that the efficiency time trend term should be defined consistently across all BC95 models as follows: The efficiency time trend for Australian DNSPs would be defined as the observation year minus the final year of the benchmarking period if the DNSP is Australian, and zero otherwise. The efficiency time trend for New Zealand and Ontarian DNSPs would be defined analogously.

For example, if the benchmarking period was 2006 to 2023, then the time trend term for an Australian DNSP would be:

- -17 (i.e., 2006 – 2023) for the first year in the benchmarking period;
- -16 (i.e., 2007 – 2023) for the first year in the benchmarking period;
- …
- 0 (i.e., 2007 – 2023) for the final year in the benchmarking period.

The efficiency time trend term would be defined similarly for the New Zealand and Ontarian DNSPs.

Because the time trend term changes meaningfully from one year to the next under this specification, expected efficiency is allowed to vary meaningfully from year to year. This makes the model properly time-varying.

Another benefit to this specification of the time trend is that all DNSPs would be assumed to have efficiency that is half-normally distributed in the final year of the benchmarking period. That is, all DNSPs can be compared on a like-with-like basis in the final year of the benchmarking period, because they would all be assumed to be drawn from the same efficiency distribution. One purpose of the Annual Benchmarking Reports is to provide the latest view on the relative efficiency of DNSPs. Requiring that all Australian DNSPs be drawn from the same efficiency distribution in the final year of the benchmarking period allows fair comparisons of the latest efficiency scores in each Annual Benchmarking Report.

Assuming that all DNSPs (from a particular jurisdiction) are drawn from the same efficiency distribution in the final year is supported by evidence from the opex MPFP indices, which suggest that the efficiency scores of the Australian DNSPs have converged over time, and are more clustered together in the latter years of the benchmarking period than in the earlier years.

Over-restrictive efficiency dynamics in Kumb90 models

Model structure and imposed restrictions

In the versions of Kumb90 models examined by Quantonomics, each DNSP draws a single, time-invariant inefficiency term. In the JTT versions, efficiency in each year is then determined by applying a deterministic adjustment factor that is common across all Australian DNSPs.

While this structure simplifies estimation, it imposes several strong and implausible restrictions, including:

- mechanical convergence of efficiency scores over time, regardless of underlying performance;
- a systematic tendency for efficiency scores to converge towards 100%; and
- invariance in relative efficiency rankings across the entire sample period.

These properties are not empirical findings but mechanical implications of the model specification.

Inconsistency with observed performance patterns

Observed productivity and cost performance across DNSPs exhibit substantial heterogeneity, including periods of divergence as well as convergence. A model that precludes changes in relative rankings or forces convergence by construction is therefore poorly suited to capturing real-world dynamics.

For example, Figure 2 compares the efficiency scores obtained from the translog Kumb90-JTT-HN model (estimated over the long benchmarking period) against the opex MPFP indices published in the 2024 Annual Benchmarking Report.

As the figures below show, the opex MPFP indices (Figure 3) change non-monotonically over time, with the relative rankings of DNSPs changing from year to year. By contrast, the efficiency scores under the Kumb90-JTT-HN (Figure 2) rise continuously, such that all DNSPs' efficiency scores would rapidly converge to 100% - an outcome that appears unrealistic.

While the AJTT specifications did not suffer from the constraint of invariance in relative efficiency rankings, Frontier Economics found the resulting efficiency time trends to be equally implausible, with rapid convergence towards 100% efficiency for most DNSPs.

Figure 2: Comparison of efficiency scores from a Kumb90 model presented by Quantonomics and the Opex MPFP indices presented in the 2024 Annual Benchmarking Report

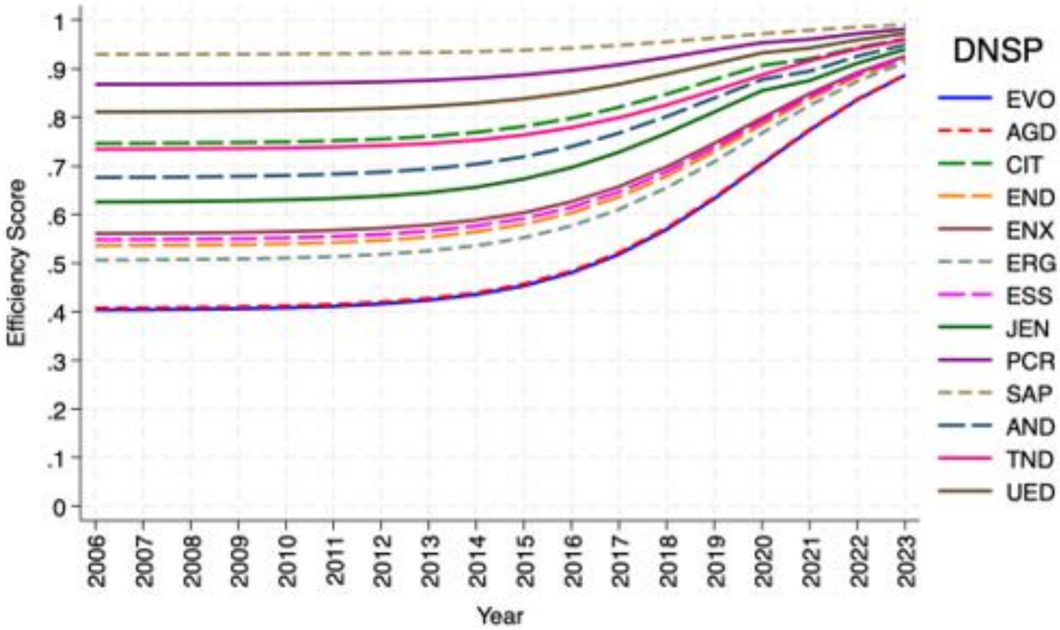


Figure 3: Opex MPFP indices presented in the 2024 Annual Benchmarking Report

Source: Figure 4.4.2 in the Quantonomics Phase 2 report and Figure 3.2 of the 2024 Annual Benchmarking Report. Note: The estimated Kumb90 model is the Kumb90-JTT-HN-TL model.

Regulatory Implications

The highly deterministic way in which inefficiency is assumed to evolve over time in the Kumb90 models tested by Quantonomics means that adoption of models specified in that way may result in DNSPs' efficiency scores being modelled in a highly unrealistic way over time, with those scores failing to match observed outcomes. This could result in some DNSPs being judged to be more or less efficient than they in fact are, and opex allowances being driven by implausible model assumptions, rather than genuine efficiency.

Ausgrid's position

Ausgrid supports the use of more flexible general efficiency change specifications, under which efficiency adjustment factors are allowed to vary across multi-year periods rather than following a single deterministic functional form. This approach avoids guaranteed convergence to extreme efficiency values (e.g. 100%), allows for non-linear efficiency paths, and improves the responsiveness of efficiency estimates to actual performance changes from period to period.

Limitations of LSE time-varying efficiency models

Key assumptions

The LSE models adopted by Quantonomics assume that efficiency catch up occurs at a constant rate over the entire benchmarking period. This assumption implies smooth and linear efficiency trajectories, irrespective of changes in operating conditions, investment cycles, or regulatory incentives.

Ausgrid considers this assumption to be problematic in the context of DNSPs, because it does not match the available evidence, which suggests that the rate of catch up has varied over the historical period. For example, it seems that several DNSPs (including Ausgrid) implemented major efficiency initiatives that delivered rapid catch up efficiency after 2015, when the AER introduced its current benchmarking regime. This can be seen in the opex MPFP indices, shown in Figure 3 above. There was much less pressure on DNSPs to deliver catch up efficiency prior to 2015.

Empirical performance

Frontier Economics found statistical evidence that indicates that the LSE models exhibit poor residuals and signs of mis-specification, raising concerns about the reliability of the estimated cost functions. While LSE models are simpler to estimate, simplicity alone is not a sufficient justification when it comes at the expense of economic realism.

Regulatory implications

Given the statistical evidence that the LSE models do not fit the data as well as the SFA models, adoption of the LSE time-varying inefficiency models would likely result in less reliable estimates of efficiency and efficient base-year opex than would be produced by the SFA specifications.

Ausgrid's position

Ausgrid considers that, in light of these findings, the AER should discard the LSE time-varying inefficiency models and instead adopt well-specified SFA models.

Model convergence and starting values

Nature of the convergence issues

Quantonomics reports that a number of time-varying SFA model specifications failed to converge, and excludes those models from further consideration. Frontier Economics' assessment is that these convergence failures primarily reflect the use of inappropriate starting values rather than inherent infeasibility of the models.

More appropriate starting values can be obtained by estimating the simple time-invariant SFA models, and then using all the estimated coefficients from that model as starting values to estimate the time-varying inefficiency SFA models. By adopting this more structured estimation approach, convergence can be achieved across all the SFA models investigated.

Regulatory implications

Quantonomics is careful to note that failure of models to converge does not necessarily mean that the model solution is unsatisfactory. Nevertheless, Quantonomics notes that lack of convergence warrants "caution". Elsewhere, Quantonomics states more clearly that "Models that do not converge are not considered reliable".[2] In addition, Quantonomics proposes the adoption of a half-normal (rather than the less restrictive truncated normal) assumption for the efficiency distribution on the grounds that this makes the models more computationally tractable, thus reducing the risk of non-convergence. Quantonomics clearly (and correctly) views lack of model convergence as problematic.

Ausgrid agrees that genuine failure of a model to converge during the estimation process would be a reason to treat the estimates from that model as unreliable. However, in this particular case, Quantonomics' concerns about lack of convergence are unwarranted as the models do in fact converge when appropriate starting values are used; the lack of convergence observed by Quantonomics resulted from inappropriate starting values being used to perform the estimation of the models.

Ausgrid's position

None of the models tested should be discarded because they fail to converge since convergence can be achieved for all models by adopting more appropriate starting values than those employed by Quantonomics.

Calculation of efficiency estimates

Quantonomics expressed concern that efficiency scores for some DNSPs could not be calculated under some models using standard postestimation routines and considered this a possible limitation of those models. This issue arose because of limitations with the numerical routines chosen by Quantonomics, rather than any inherent problem with the underlying models.

Frontier Economics found that alternative, but equivalent, calculation methods can generate valid efficiency estimates for all DNSPs in all models investigated by Quantonomics. Consequently, the inability to calculate

[2] Quantonomics Phase 2 Memorandum, 26 November 2025, p.22.

efficiency scores using default software commands is not, of itself, sufficient grounds for rejecting a model specification.[3]

Summary of models estimated by Quantonomics

Table 1 below summarises the variations of the BC95, Kumb90 and LSE models investigated by Quantonomics.

*Table 1: Differences in BC95, Kumb90 and LSE models*Model	Type	Efficiency trend	Cost trend
SFA-BC95-JTT-HN	BC95	Linear	Linear
SFA-BC95-JTT-HN-GTC	BC95	Linear	GTC
SFA-BC95-AJTT-HN	BC95	Linear, individual Aus DNSPs	Linear
SFA-BC95-AJTT-HN-GTC	BC95	Linear, individual Aus DNSPs	GTC
SFA-Kumb-JTT-HN	Kumb90	Linear	Linear
SFA-Kumb-JTT-HN-GTC	Kumb90	Linear	GTC
SFA-Kumb-AJTT-HN	Kumb90	Linear, individual Aus DNSPs	Linear
SFA-Kumb-AJTT-HN-GTC	Kumb90	Linear, individual Aus DNSPs	GTC
LSE-ADTT	LSE	Linear, individual Aus DNSPs (no trend for NZ/Ont)	Linear
LSE-ADTT-GTC	LSE	Linear, individual Aus DNSPs (no trend for NZ/Ont)	GTC
LSE-AJTT-NZ	LSE	Linear, individual Aus DNSPs (no trend for Ont)	Linear
LSE-AJTT-NZ-GTC	LSE	Linear, individual Aus DNSPs (no trend for Ont)	GTC

[3] Quantonomics, Electricity Distribution Benchmarking Opex Model Development, 26 November 2025, p. 50.

Key takeaways

There are several issues in the approach and findings of the Quantonomics Phase 2 report:

- inconsistent and restrictive treatment of efficiency time trends in BC95 models, which in practice prevents material changes in estimated expected efficiency over time;
- overly restrictive assumptions in the Kumb90 models tested by Quantonomics that mechanically force convergence of efficiency scores and constrain movements in relative rankings;
- strong and unrealistic assumptions in LSE models that efficiency catch-up occurs at a constant rate over the entire benchmarking period;
- illusory model convergence problems that arise because inappropriate starting values were adopted, rather than due to inherent infeasibility of more complex SFA specifications; and
- technical limitations in the calculation of efficiency scores under some models, which can be addressed without rejecting otherwise potentially valid models.

Taken together, these issues suggest that the Phase 2 benchmarking results should be interpreted with caution. In Ausgrid’s view, the Quantonomics Phase 2 report should be viewed as an informative starting point for improving the reliability of the AER’s benchmarking models, rather than a definitive position on the matter.

3. MODELS IDENTIFIED FOR FURTHER INVESTIGATION

This section sets out the SFA and LSE models investigated by Frontier Economics on behalf of Ausgrid in response to the modelling undertaken by Quantonomics in its Phase 2 report. The purpose of this section is to:

- document the alternative specifications that are tested to address known limitations in the Phase 2 analysis;
- explain the methodological refinements adopted to ensure numerical convergence and the derivation of efficiency estimates for all DNSPs; and
- explain the models considered as part of our review.

Consistent with the preceding section of this submission, Ausgrid has:

- proposed improved specifications of the BC95, Kumb90 and time-varying LSE models relative to those estimated by Quantonomics;
- implemented a robust approach to selecting starting values that ensures convergence across all SFA models, including models that Quantonomics reported as failing to converge; and
- applied a post-estimation routine that allows efficiency scores to be obtained for all Australian DNSPs under every model tested.

Unless otherwise stated, all models are estimated using the same benchmarking dataset employed in the AER's 2024 Annual Benchmarking Report, comprising historical observations from 2006 to 2023 (inclusive). This ensures comparability with the Phase 2 results and isolates the impact of alternative modelling choices.

Scope of models considered

This review focuses on time-varying inefficiency models within three established classes of models:

- the BC95 stochastic frontier models;
- the Kumb90 stochastic frontier models; and
- time-varying LSE models.

These models were selected because they are:

- feasible to estimate using existing benchmarking datasets;
- relatively incremental extensions to the models currently used by the AER, while explicitly allowing for time-varying efficiency; and
- well-established in the academic and applied literature, with practical implementations available (including through the **Stata *sfpanel*** package).

While many alternative time-varying inefficiency specifications could be contemplated in principle, the scope of testing was limited to refinements and extensions of the Phase 2 models. This reflects the objective of identifying robust and implementable improvements, rather than proposing entirely new benchmarking frameworks.

For consistency with the AER's historical experience, testing of the models was restricted to:

- translog functional forms; and
- the long benchmarking period from 2006 to 2023.

The focus on translog specifications over the long benchmarking period is significant because these specifications have historically proven most challenging for the AER, often exhibiting severe monotonicity violations or numerical instability. Highly flexible models (such as the translog specifications) that perform well over the full period provide a stronger basis for concluding that the model specification is appropriate for regulatory use.

BC95 models

Model variants investigated

The following BC95 variants were considered:

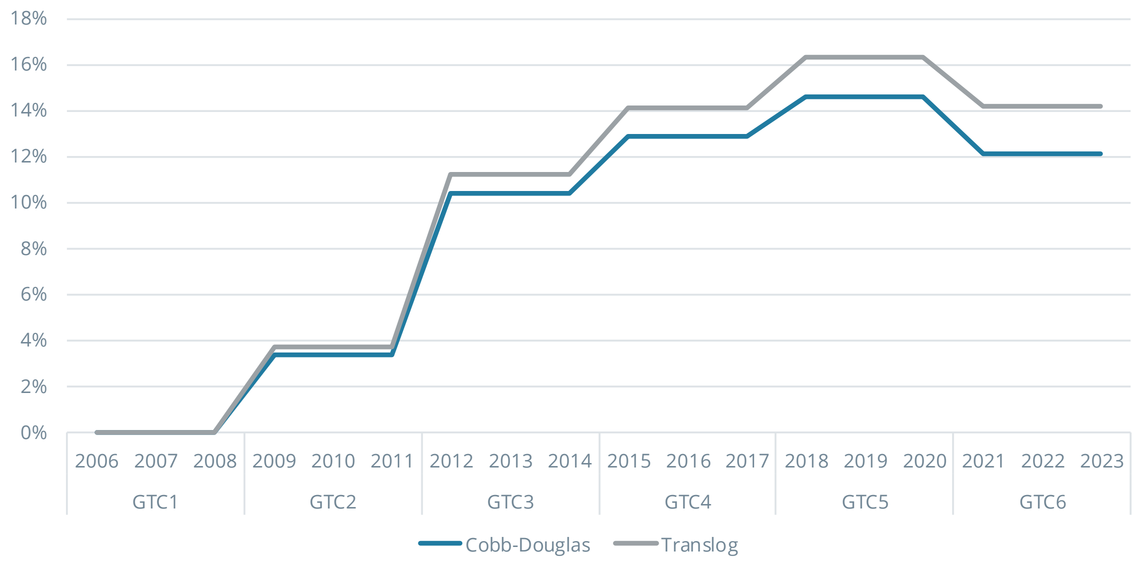
- BC95-JTT-HN;
- BC95-JTT-HN-GTC;
- BC95-AJTT-HN; and
- BC95-AJTT-HN-GTC.

Consistent with the approach taken in the Phase 2 report, these specifications adopt a half-normal inefficiency distribution by omitting the constant term from the mean of the non-truncated inefficiency distribution. While this is more restrictive than the truncated-normal specification used in the AER's existing SFA models, this approach is considered to be a reasonable compromise given the substantial gains in numerical stability and convergence.

Additionally, the analysis supported Quantonomics' inclusion of a general technical change (**GTC**) specification for the cost function. Empirical estimates indicate that the relationship between time and costs is unlikely to be well approximated by a single linear trend. In particular, GTC estimates suggest a period of strong real cost growth in the early part of the sample, followed by slower growth and eventual cost reductions in later years.

This pattern is illustrated in Figure 4, which shows estimated cost time trends under the LSE-ADTT-GTC model. Both the Cobb-Douglas and translog specifications of this LSE model indicate that the rate of increase in costs varied, rather than increased linearly, over the benchmarking period. This indicates that the simple linear cost trend assumption is not consistent with the observed data, and is therefore an overly simplistic assumption.

Figure 4: Estimated cost time trends under a GTC specification



Source: Frontier Economics analysis.

Efficiency time trends

Within the BC95 class of models, the JTT and AJTT specifications for inefficiency were considered. The JTT specification provides a parsimonious starting point for modelling time-varying efficiency, while the AJTT extension allows individual Australian DNSPs to follow distinct efficiency trajectories.

However, the efficiency improvements of the Australian DNSPs do not appear to have followed a simple linear path over time. In particular, the evidence indicates little sustained efficiency improvement prior to the introduction of formal economic benchmarking, but that there were more pronounced improvements after 2015 when the formal benchmarking regime was introduced by the AER. To capture this pattern, Frontier Economics developed a more flexible General Efficiency Change (**GEC**) specification for Australian DNSPs.

Under this approach:

- efficiency for Australian DNSPs is allowed to vary across six three year periods, analogous to Quantonomics' GTC treatment of technical change;
- New Zealand and Ontario DNSPs retain a simple linear efficiency time trend; and
- the final period is omitted as the reference category, ensuring comparability with other BC95 specifications.

This extended specification is referred to as the BC95-AGEC-HN-GTC model.

Kumb90 models

Model variants investigated

Frontier Economics investigated the following Kumb90 variants considered by Quantonomics:

- Kumb90-JTT-HN;
- Kumb90-JTT-HN-GTC;
- Kumb90-AJTT-HN; and
- Kumb90-AJTT-HN-GTC.

These models allow the efficiency adjustment factor to vary over time, with the AJTT specification introducing DNSP-specific trends for Australian businesses. However, results reported by Quantonomics reveal implausible efficiency paths for several DNSPs over the long benchmarking period, suggesting that the functional form may be overly restrictive.

To address this concern, GEC variants of the Kumb90 models were developed that allow efficiency changes for Australian DNSPs to vary flexibly across discrete three-year time periods. Frontier Economics considered two further extensions :

- inclusion of jurisdiction-specific efficiency adjustments for New Zealand and Ontario; and
- estimation under both linear and GTC cost trend specifications.

These extensions resulted in four additional models:

- Kumb90-AGEC-HN;
- Kumb90-AGEC-HN-GTC;
- Kumb90-AGECJUR-HN; and
- Kumb90-AGECJUR-HN-GTC.

All Kumb90 specifications were estimated under a half-normal inefficiency assumption, with DNSPs drawing from a common pre-adjustment inefficiency distribution.

Treatment of time trends

For linear efficiency adjustments, a centred time trend (set to zero at the midpoint of the sample) was adopted, consistent with Quantonomics' JTT specifications. This approach improves numerical behaviour and yields more stable estimates relative to alternatives that anchor the trend at the start or end of the sample.

For GEC specifications, the final efficiency period is omitted as the reference category. Where jurisdictional dummy variables are included, the choice of omitted category does not affect model fit.

LSE models

Model variants investigated

The following LSE models were investigated:

- LSE-ADTT;
- LSE-ADTT-GTC;
- LSE-AJTT-NZ; and
- LSE-AJTT-NZ-GTC.

In these specifications, the base time trend corresponds to that of the Ontarian DNSPs, with an additional New Zealand-specific trend. However, the basis for preferring a New Zealand rather than Ontario time trend is unclear, and alternative specifications are therefore also examined in which the Ontario trend is explicitly modelled:

- LSE-AJTT-Ont; and
- LSE-AJTT-Ont-GTC.

While linear time trend specifications are equivalent across these alternatives, small but meaningful differences emerge under GTC formulations. Ausgrid therefore recommends that these distinctions be examined carefully if LSE models are to be considered further by the AER.

Nonlinear efficiency trends

While the suite of LSE models can accommodate more flexible efficiency trends, fixed-effects models suffer from an incidental parameters problem. The fixed-effects models assign a dummy variable for each DNSP, which soaks up much of the cross-sectional variation in the data. As a result, the model has difficulty in distinguishing reliably between the effects of the output variables. To balance flexibility and feasibility, a spline-based efficiency trend with a single structural break in 2015 was estimated, reflecting both institutional changes (the introduction of formal benchmarking) and empirical evidence from residual diagnostics. This specification allows efficiency growth rates to differ before and after 2015 while maintaining continuity in the efficiency path.

The resulting model, estimated only with a GTC cost trend, is referred to as LSE-AJTTBREAK-NZ-GTC.

Summary of models

Table 2 summarises the full set of models investigated. Models originally considered by Quantonomics are distinguished from the extended and alternative specifications introduced by Frontier Economics.

Table 2: Summary of models investigated

Model	Type	Efficiency trend	Cost trend	Investigated by Quantonomics?
SFA-BC95-JTT-HN	BC95	Linear	Linear	Yes
SFA-BC95-JTT-HN-GTC	BC95	Linear	GTC	Yes
SFA-BC95-AJTT-HN	BC95	Linear, individual Aus DNSPs	Linear	Yes

Model	Type	Efficiency trend	Cost trend	Investigated by Quantonomics?
SFA-BC95-AJTT-HN-GTC	BC95	Linear, individual Aus DNSPs	GTC	Yes
SFA-BC95-AGEC-HN-GTC	BC95	3-year step change, Australian	GTC	No
SFA-Kumb-JTT-HN	Kumb90	Linear	Linear	Yes
SFA-Kumb-JTT-HN-GTC	Kumb90	Linear	GTC	Yes
SFA-Kumb-AJTT-HN	Kumb90	Linear, individual Aus DNSPs	Linear	Yes
SFA-Kumb-AJTT-HN-GTC	Kumb90	Linear, individual Aus DNSPs	GTC	Yes
SFA-Kumb-AGEC-HN	Kumb90	3-year step change, Australian	Linear	No
SFA-Kumb-AGEC-HN-GTC	Kumb90	3-year step change, Australian	GTC	No
SFA-Kumb-AGECJUR-HN	Kumb90	3-year step change, Australian; jurisdiction-specific efficiency adjustments for NZ/Ont	Linear	No
SFA-Kumb-AGECJUR-HN-GTC	Kumb90	3-year step change, Australian; jurisdiction-specific efficiency adjustments for NZ/Ont	GTC	No
LSE-ADTT	LSE	Linear, individual Aus DNSPs (no trend for NZ/Ont)	Linear	Yes
LSE-ADTT-GTC	LSE	Linear, individual Aus DNSPs (no trend for NZ/Ont)	GTC	Yes
LSE-AJTT-NZ	LSE	Linear, individual Aus DNSPs (no trend for Ont)	Linear	Yes

Model	Type	Efficiency trend	Cost trend	Investigated by Quantonomics?
LSE-AJTT-NZ-GTC	LSE	Linear, individual Aus DNSPs (no trend for Ont)	GTC	Yes
LSE-AJTTBREAK-NZ-GTC	LSE	Structural break in 2015 for Aus DNSPs (no trend for Ont)	GTC	No

Source: Frontier Economics analysis.

4. EVALUATION OF MODELS INVESTIGATED BY AUSGRID

Overview

This section assesses the econometric model selection process applied in Quantonomics' Phase 2 report and presents Ausgrid's views on the models that should be adopted by the AER for electricity distribution opex benchmarking going forward.

The choice of econometric models is a critical regulatory decision. Models adopted by the AER are not only used in the Annual Benchmarking Reports, but also directly influence the estimation of efficient opex and therefore the setting of revenue allowances for DNSPs. Given the likelihood that selected models will be relied upon for an extended period and applied as new data are added, it is essential that those models are robust, well-specified, and capable of producing reliable efficiency estimates over time.

This section draws on detailed econometric analysis undertaken by Frontier Economics and applies a comprehensive set of selection criteria to a broad suite of SFA and LSE models.

Model selection criteria

Ausgrid agrees with Quantonomics that models should be assessed based on their statistical and economic properties, rather than on whether they produce results that align with historical DNSP rankings. The focus should be on selecting models that are capable of generating reliable estimates as new data become available.

Frontier Economics applied a set of model selection criteria that overlaps substantially with those used by Quantonomics, but differs in emphasis and application in several important respects.

Reasonableness of output elasticities

Ausgrid agrees that it is appropriate to assess the sum of output elasticities, as an indicator of returns to scale, and to test whether the implied scale properties are economically plausible.

However, we do not place significant weight on assessing the reasonableness of individual output elasticities by reference to:

- output weights used in index based MPFP or MTFP analysis; or
- output weights derived from previous econometric benchmarking studies.

As some DNSPs have previously identified,[4] the output weights used in index analysis are unreliable, having been estimated using a flawed approach. Further, prior econometric models used by the AER were mis-specified, and output elasticities derived from those models are therefore not a reliable benchmark. In addition, collinearity between output variables limits the precision with which individual elasticities can be estimated.

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[4] SA Power Networks, Feedback on Quantonomics' update of non-reliability output weights, 22 September 2025.

Accordingly, emphasis is placed on assessing whether the aggregate scale properties of each model are reasonable, rather than attempting to anchor individual coefficients to unreliable priors.

Reasonableness of efficiency and cost time trends

Quantonomics implicitly considers this issue through correlations between model based efficiency scores and the opex MPFP index. While this is necessary, we do not consider it is sufficient.

Our analysis examines:

- whether estimated efficiency paths over time are economically plausible; and
- whether cost function specifications are capable of capturing non-linear cost trends observed in the data.

As discussed later in this section, certain time-varying specifications (notably some Kumb90 models) produce implausibly rapid convergence of efficiency scores towards 100%, undermining their credibility for regulatory use.

Specification testing

Quantonomics relies on the *linktest* to assess specification of the SFA models. Frontier Economics has identified that this test was misapplied, as the requisite options (specifying the structure of the time-varying model) were omitted from the *linktest* command. As a consequence, the *linktest* command defaulted to consideration of the BC92 time-varying decay model rather than the model being tested.[5] When implementing the *linktest* command, the user should specify the model being tested.

The test should be applied by specifying the options used in estimating the original model (i.e. BC95 or Kumb90, and the variables used in the efficiency trends).[6] Without doing so, the *linktest* command would test the specification using the wrong model, resulting in incorrect conclusions about the specification of the model. That is what occurred in Quantonomics' analysis.

Stability to sample changes

Ausgrid considers model stability under sample expansion to be a critical criterion.

Quantonomics tests stability by estimating models over subsets of historical data. This approach is not considered to be sufficient, as it does not test how models behave when new data are added—which is the primary concern in a forward-looking regulatory framework.

Instead, stability is tested by:

- generating additional data beyond the historical period under known efficiency assumptions; and
- examining whether models are able to recover those known efficiency paths when re-estimated on the expanded dataset.

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[5] Battese, G. E., and T. J. Coelli. 1992. Frontier production functions, technical efficiency and panel data: With application to paddy farmers in India. Journal of Productivity Analysis 3: 153–169.

This form of out-of-sample testing is standard in econometric practice and directly addresses the key regulatory risk associated with model instability.

Parsimony

Relatively limited weight is placed on parsimony.[6] All models assessed were either those tested by Quantonomics or involved only minor extensions. Provided models converge reliably, are estimable using standard software, and achieve a reasonable fit, Ausgrid considers the parsimony criterion to be satisfied.

Evaluation of models against the selection criteria

Selection criteria were applied to:

- 18 time-varying inefficiency models (five BC95 models, eight Kumb90 models, and five LSE models); and
- two standard time-invariant inefficiency models currently used by the AER.

A summary assessment is provided in Table 3, with detailed discussion below. Cells shaded green indicate that the model performed satisfactorily under the relevant criteria; amber indicates a moderately poor performance and red indicates severely poor performance.

[6] A parsimonious model is one that is not more complex than it needs to be.

Table 3: Summary of assessment

Model	Sign/significance of output coefs	Monotonicity	Reasonableness of weights	Share UGC	Reasonableness of efficiency/cost trend	Convergence
SFA-BC95-JTT-HN	Green	Amber	Green	Green	Amber	Green
SFA-BC95-JTT-HN-GTC	Green	Green	Green	Green	Green	Green
SFA-BC95-AJTT-HN	Green	Amber	Green	Green	Amber	Green
SFA-BC95-AJTT-HN-GTC	Green	Green	Green	Green	Green	Green
SFA-BC95-AGEC-HN-GTC	Green	Green	Green	Green	Green	Green
SFA-Kumb-JTT-HN	Green	Green	Green	Green	Amber	Green
SFA-Kumb-JTT-HN-GTC	Green	Green	Green	Amber	Amber	Green
SFA-Kumb-AJTT-HN	Green	Red	Amber	Green	Amber	Green
SFA-Kumb-AJTT-HN-GTC	Green	Red	Amber	Amber	Amber	Green
SFA-Kumb-AGEC-HN	Green	Green	Green	Green	Amber	Green
SFA-Kumb-AGEC-HN-GTC	Green	Green	Green	Amber	Green	Green
SFA-Kumb-AGECJUR-HN	Green	Green	Green	Green	Amber	Green
SFA-Kumb-AGECJUR-HN-GTC	Green	Green	Green	Green	Green	Green
LSE-ADTT	Green	Amber	Green	Green	Amber	Green
LSE-ADTT-GTC	Green	Green	Green	Green	Green	Green
LSE-AJTT-NZ	Green	Green	Green	Green	Amber	Green
LSE-AJTT-NZ-GTC	Green	Green	Green	Green	Green	Green
LSE-AJTTBREAK-NZ-GTC	Green	Green	Green	Green	Green	Green
LSE-TL (existing model)	Green	Amber	Green	Green	Red	Green
SFA-TL (existing model)	Green	Red	Amber	Green	Red	Amber

Model	Goodness of fit	Specification	Residuals	Stability	Consistent efficiency	Parsimony
SFA-BC95-JTT-HN	Green	Green	Green	Green	Green	Green
SFA-BC95-JTT-HN-GTC	Green	Green	Green	Green	Green	Green
SFA-BC95-AJTT-HN	Green	Green	Green	Red	Amber	Green
SFA-BC95-AJTT-HN-GTC	Green	Green	Green	Red	Amber	Green
SFA-BC95-AGEC-HN-GTC	Green	Green	Green	Green	Green	Green
SFA-Kumb-JTT-HN	Green	Green	Amber	Red	Green	Green
SFA-Kumb-JTT-HN-GTC	Green	Green	Amber	Red	Green	Green
SFA-Kumb-AJTT-HN	Green	Green	Green	Red	Green	Green
SFA-Kumb-AJTT-HN-GTC	Green	Green	Green	Red	Green	Green
SFA-Kumb-AGEC-HN	Green	Green	Green	Green	Amber	Green
SFA-Kumb-AGEC-HN-GTC	Green	Green	Green	Green	Amber	Green
SFA-Kumb-AGECJUR-HN	Green	Green	Green	Green	Green	Green
SFA-Kumb-AGECJUR-HN-GTC	Green	Green	Green	Green	Green	Green
LSE-ADTT	Amber		Amber	Amber	Green	Green
LSE-ADTT-GTC	Amber		Amber	Amber	Green	Green
LSE-AJTT-NZ	Amber		Amber	Amber	Green	Green
LSE-AJTT-NZ-GTC	Amber		Amber	Amber	Green	Green
LSE-AJTTBREAK-NZ-GTC	Amber		Green	Amber	Green	Green
LSE-TL (existing model)	Red		Red	Green	Green	Green
SFA-TL (existing model)	Red	Amber	Red	Red	Red	Green

Sign and significance of output coefficients

All models tested produce positive and statistically significant coefficients on key output variables (customer numbers, circuit length, and ratcheted maximum demand). Ausgrid therefore considered that all time varying models satisfy this criterion.

Monotonicity

Several models - most notably the AJTT Kumb90 models and the time-invariant SFA model currently used by the AER - exhibit excessive monotonicity violations, rendering them unsuitable for benchmarking purposes. Ausgrid therefore submits that these models should not be used by the AER.

Other models exhibit moderate violations that warrant caution but do not preclude their use. A number of models display either no violations or only an immaterial number of violations.

Output elasticities and returns to scale

Most models imply moderate returns to scale, consistent with economic expectations for DNSPs. However:

- the AJTT Kumb90 models imply slight diseconomies of scale; and
- the existing SFA model used by the AER implies unrealistically large economies of scale.

These results raise concerns about the reliability of those specifications. For example, the benchmarking data indicates for the Australian DNSPs that outputs have increased, but this has not been accompanied by a one-for-one increase in costs. The most likely explanation for this that at least some DNSPs have delivered material catch-up efficiency, even as their outputs have increased. However, the existing SFA model used by the AER interprets the data incorrectly to mean that there are strong returns to scale, because it is incapable of accounting for time-varying inefficiency (i.e., it is fundamentally mis-specified).

Undergrounding coefficient

With limited exceptions, estimated coefficients on underground share are negative and economically plausible. Where coefficients are positive, they are statistically insignificant and do not materially affect model performance.

Efficiency and cost time trends

Ausgrid finds that:

- JTT and AJTT Kumb90 models impose implausible convergence of efficiency scores;
- LSE models are overly restrictive but do not exhibit extreme convergence; and
- BC95 models produce smoother and more plausible efficiency trajectories that align with observed improvements since the introduction of the current benchmarking regime.

Linear cost time trend specifications are found to be unsatisfactory given the nonlinear cost patterns evident in the data.

Convergence and goodness of fit

All time-varying models converge successfully when appropriate starting values are used. However, the standard SFA model has failed to converge in the 2025 Annual Benchmarking Report, indicating an ongoing practical limitation.

SFA models consistently outperform LSE models on goodness-of-fit measures. Within the SFA class, BC95 models perform particularly well.

Specification tests and residual diagnostics

When specification tests are applied correctly, the preferred SFA models show no evidence of mis-specification. Residual diagnostics further support the exclusion of the standard models and certain Kumb90 specifications.

Stability to new data

The out of sample testing identifies:

- material instability in BC95 AJTT models and Kumb90 JTT models;
- marginal but defensible performance by LSE models; and
- strong performance by selected BC95 and Kumb90 AGEC-type models.

Consistency and plausibility of efficiency scores

The standard SFA model produces implausibly low efficiency estimates for some DNSPs, including Ausgrid, and should be treated as a material concern for regulatory use.

While some time-varying models produce materially higher or lower average efficiency levels, Ausgrid considers that only models meeting all other selection criteria should be relied upon.

Cobb-Douglas versus translog specifications

We found that formal statistical testing strongly favours the translog specification over the Cobb Douglas specification across the vast majority of models tested.

Ausgrid agrees that translog specifications should be preferred wherever they do not give rise to severe statistical problems (e.g., an unacceptable number of monotonicity violations). The historical justification for retaining Cobb-Douglas models—namely, to mitigate monotonicity violations—no longer applies to the preferred models identified in this section.

Recommended models

Ausgrid's key conclusions are as follows:

1. **The time-invariant inefficiency models currently used by the AER are materially mis-specified and we recommend the AER consider transitioning away from them.**
   Their assumption of constant efficiency is inconsistent with observed data and leads to unreliable outcomes.

2. **Three timevarying SFA models satisfy all selection criteria and materially outperform all others tested:**
    - SFA-BC95-JTT-HN-GTC;
    - SFA-BC95-AGEC-HN-GTC; and
    - SFA-Kumb-AGECJUR-HN-GTC.
3. **LSE specifications should be excluded.**
   These models are overly restrictive and perform unambiguously worse than the preferred SFA models.
4. **The AER should give primacy to translog specifications**, using Cobb-Douglas variants only as a fallback where severe statistical problems arise.

Ausgrid considers that adoption of these recommendations would materially improve the robustness, credibility, and regulatory usefulness of the AER's opex benchmarking framework.

How should the time-varying inefficiency models be used to estimate efficient base year opex?

If the AER were to adopt the time-varying inefficiency models, Ausgrid's preference is to retain the use of the benchmarking roll-forward model from the middle of the benchmarking period (rather than using final year estimates of efficiency to estimate efficient base year opex), but applying the average time-varying efficiency estimates over the benchmarking period to estimate the average efficient opex over the period. The process is familiar to DNSPs and the Quantonomics report does not suggest that a change is needed.

Should the AER wish to make material changes to the approach to estimating efficient base year opex, a sufficiently extensive consultation should be undertaken, having already established the time-varying inefficiency models to form the basis for the estimation.

Key takeaways

Ausgrid submits that:

- The existing time-invariant inefficiency models used by the AER should be discontinued and replaced by the following SFA models:
    - SFA-BC95-JTT-HN-GTC;
    - SFA-BC95-AGEC-HN-GTC; and
    - SFA-Kumb-AGECJUR-HN-GTC.
- The LSE time-varying models should not be pursued.
- The AER should use only the translog specifications of the three models above since these fit the data better than the Cobb-Douglas specifications. The Cobb-Douglas specifications should be used only in the event that the translog models cannot be estimated reliably, or exhibit serious statistical problems (e.g. an unacceptable level of monotonicity violations).
- The AER should continue to roll forward estimates of efficient opex from the middle of the benchmarking period to the base year, but applying the average time-varying efficiency estimates over the benchmarking period to estimate the average efficient opex over the period.
- The AER should consult broadly before altering the process for estimating efficient base-year opex to ensure that there are no unintended consequences arising from a change of approach.