Outputs and Operating Environment Factors to be Used in the Economic Benchmarking of Electricity Transmission Network Service Providers

Briefing Notes prepared for
Australian Energy Regulator

21 February 2013

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EXECUTIVE SUMMARY

The AER (2012a) has indicated that economic benchmarking will be one of a suite of assessment techniques to be detailed in its forthcoming expenditure forecast assessment guidelines. The AER is consulting extensively with network service providers in developing its approach to economic benchmarking. This includes conducting a series of workshops to seek feedback on the appropriate outputs, inputs and operating environment variables to be used in economic benchmarking.

The AER has engaged Economic Insights to assist with this consultation process. These briefing notes provide background material for the second workshop on the appropriate outputs and operating environment factors to be used for economic benchmarking of electricity transmission network service providers (TNSPs).

Outputs – issues for discussion

A number of important issues remain to be resolved with regard to the TNSP outputs to be used in economic benchmarking studies. We would welcome input on the following issues discussed at further length in the paper:

1) Should the outputs to be used in economic benchmarking be similar to those the regulator implicitly uses in setting building block revenue requirements rather than what TNSPs actually charge customers for?
2) Are the AER's output selection criteria (of being consistent with the NER objectives, reflecting customer services and being significant) appropriate? Are there other important criteria we should use in selecting TNSP outputs?
3) Should TNSP outputs for economic benchmarking be extended to include 'secondary deliverables' (ie the capacity required to deliver outputs now and in the future) rather than being limited to those reflecting current consumption?
4) Should energy throughput be included as an output even though changes in it have little impact on TNSP costs?
5) TNSPs typically impose fixed charges for connection on generators and downstream users. Is the number of entry and exit points the best quantity measure for this item?
6) Should demand–based quantities users are charged for be included as outputs for economic benchmarking purposes?
7) Is system capacity an appropriate output variable to capture TNSPs' ability to meet expected demand?
8) The capacity of a transmission network to throughput energy depends on both the capacity of the TNSP's lines and the number and size of transformers it has in place. Should a system capacity output include transformer capacity as well as line and cable capacity? If so, is the simple product of downstream bulk supply point transformer capacity and line length a reasonable summary measure?
9) Is there a case for including system peak demand as an output even though reliability at peak times is what affects customers?

10) Is TNSP reliability a key output which should be included in economic benchmarking?

11) Should we make use of the Service Target Performance Incentive Scheme (STPIS) variables as economic benchmarking outputs?

12) Is the STPIS market impact variable the most important reliability indicator to include?

13) Should the loss of supply event frequency and average outage duration from unplanned outages be included as outputs?

14) Is it appropriate to include a measure of circuit availability as an output for economic benchmarking purposes?

15) Is the time scale for new (generation) connection a relevant output? What of possible ensuing constraints and their resolution?

16) If a functional output specification is used, how should output weights be formed? Is the cost function method (where shares of output elasticities in the sum of those elasticities reflect relative estimated cost shares for the outputs) the best way of doing this?

17) How should an output dollar value be formed for economic benchmarking purposes for reliability outputs?

18) Can processes currently in place to demonstrate compliance with regulatory pricing principles or for internal TNSP planning purposes be utilised in forming measures of the relative cost of producing the different outputs?

Operating environment factors – issues for discussion

A number of important issues remain to be resolved with regard to the operating environment factors to be incorporated in TNSP economic benchmarking studies including:

1) Are the AER’s operating environment factor selection criteria (of being material, exogenous to the TNSP and a primary cost driver) appropriate? Are there other important criteria we should use in selecting TNSP operating environment factors?

2) Should allowance be made for climatic differences between TNSPs operating in sub–tropical areas and those operating in temperate areas? What about between those operating in temperate areas?

3) Should adjustment be made for locational climatic effects such as direct lightning effects, resultant fires, snow loading (and difficulty of access), conductor derating in elevated temperatures and variability of vegetation aggression? How could these be measured and adjusted?

4) What is the best summary measure of climatic effects?

5) Is it possible to derive a useable summary measure of the terrain a TNSP faces?

6) Is peak demand exogenous to the TNSP? Would including it as an operating environment factor reduce TNSP incentives to efficiently manage peak demands?

7) The distance a transmission line has to cover and the capacity required to service the end load centre are important TNSP cost drivers and are largely beyond TNSP control. Should these aspects be included as operating environment factors? If so, how?

8) Should adjustment be made for extra construction cost resulting from forced selection of a non–minimal cost line routes and/or use of more costly structure design or construction methods?

9) Economic Insights (2009a) identified differences in coverage of regulated services both across jurisdictions and over time. Should allowance be made for differences in regulated coverage or should the emphasis be on obtaining data on a common basis across all jurisdictions

1 BACKGROUND

The Australian Energy Regulator (AER) has initiated a work stream on expenditure forecast assessment (EFA) guidelines for electricity distribution and transmission as part of its Better Regulation program. This is in response to the Australian Energy Market Commission's recent rule changes for electricity network regulation (AEMC 2012). The rule changes clarify the AER's powers to undertake benchmarking and add a new requirement for the AER to publish annual benchmarking reports on electricity network businesses.

The AER has indicated that economic benchmarking will be one of a suite of assessment techniques to be detailed in the EFA guideline. The AER is consulting extensively with network service providers in developing its approach to economic benchmarking. This includes conducting a series of workshops to seek feedback on the appropriate outputs, inputs and operating environment variables to be used in economic benchmarking and their specification. The workshops will also cover the data necessary for economic benchmarking and how economic benchmarking would be used in assessing NSPs' expenditure proposals.

The AER has engaged Economic Insights to assist with this consultation process. These briefing notes provide background material for the second workshop on the appropriate outputs and operating environment factors to be used for economic benchmarking of electricity TNSPs. They also include a series of questions to help focus discussion at the workshop.

The remainder of this section provides some background on the basics of economic benchmarking and why it is relevant to network regulation. The second section discusses the outputs that should be included in future economic benchmarking of electricity TNSPs and the third section discusses the operating environment factors that should be allowed for in future economic benchmarking of TNSPs.

1.1 What is economic benchmarking?

Economic benchmarking of costs measures the economic efficiency performance of a TNSP by comparing its current performance to its own past performance and to the performance of other TNSPs. All TNSPs use a range of inputs including capital, labour, land, fuel, materials and services to produce the outputs they supply. If the TNSP is not using its inputs as efficiently as possible then there is scope to lower costs and, hence the prices charged to energy consumers, through efficiency improvements. This may come about through the use of:

- better quality inputs including a better trained workforce
- adoption of technological advances
- removal of restrictive work practices
- removal of other forms of potential waste such as 'gold plating', and
- better management through a more efficient organisational and institutional structure.

Overall economic efficiency has several components including:

- technical efficiency which requires that the maximum possible quantity of output is produced from the quantities of inputs the TNSP has available or, alternatively, that the quantity of output required is produced from the minimum possible quantity of inputs
- allocative efficiency which requires that the TNSP use inputs in proportions consistent with minimising costs given current input prices
- cost efficiency which requires that the TNSP produce its outputs at minimum possible cost (ie that it achieves both technical and allocative efficiency), and
- scale efficiency which requires that the TNSP is operating at an optimal size.

Most economic benchmarking techniques compare the quantity of outputs produced to the quantity of inputs used and costs incurred over time and/or across TNSPs. As no two TNSPs operate under exactly the same operating environment conditions, it is important to allow for operating environment differences when comparisons are made across TNSPs to ensure that like is being compared with like to the maximum extent possible.

The main economic benchmarking techniques include:

- total factor productivity (TFP) indexes which calculate growth rates of the total output quantity relative to total input quantity for a TNSP over time
- multilateral TFP indexes which allow productivity levels as well as growth rates to be compared across TNSPs
- econometric cost function models
- data envelopment analysis (DEA) which uses linear programming to construct an efficient production frontier from the included observations, and
- stochastic frontier analysis (SFA) which constructs an efficient production frontier from the included observations using statistical methods which allow for error.

These techniques aim to provide a holistic comparison of TNSP cost performance. They differ from the simple benchmarking techniques currently used in building block reviews which typically examine the relativity between specific activities rather than the efficiency performance of the TNSP as a whole. The economic benchmarking techniques provide a 'top down' perspective on TNSP cost performance using relatively high level data compared to the 'bottom up' item by item comparisons currently used.

1.2 Why the current interest in economic benchmarking?

The AER's electricity TNSP price reviews to date have relied heavily on expert engineering reviews and historical trending of costs based on the assumption that revealed costs are relatively efficient. However, these tools are only a subset of the methods used by other regulators and greater use of benchmarking has been frustrated, among other things, by the lack of consistent data available (see, for example, Economic Insights 2009a).

The AEMC (2012, p.viii) observed that:

> 'The Commission considers that benchmarking is a critical exercise in assessing the efficiency of a NSP and approving its capital expenditure and operating

> expenditure allowances. … The Commission will remove any potential constraints in the NER on the way the AER may use benchmarking.
>
> 'Whilst benchmarking is a critical tool for the regulator, it can also be of assistance to consumers, providing them with relative information about network performance on NSPs.'

In response to the recent rule changes the AER (2012a) has proposed making greater use of two different streams of analysis in future reviews and reporting – category analysis and economic benchmarking. Category analysis is the more detailed of the two and attempts to link disaggregated cost data to a series of 'drivers' thought to influence each expenditure category. As such, it includes some elements of benchmarking (eg examining expenditure per unit of each explanatory variable across TNSPs) and some elements of the trend analysis, revealed costs and modelling methods currently used.

The AER (2012a, p.31) has indicated that it sees the higher level economic benchmarking techniques as an important checking and screening method to be used in conjunction with the more disaggregated category analysis:

> 'We are proposing to … conduct higher level [economic] benchmarking as a useful complement to category based analysis. In particular, we expect this type of analysis to:
>
> - provide an overall and higher–level test of relative efficiency, which may highlight issues that can potentially be overlooked during lower–level and detailed analysis
> - facilitate benchmarking which may not be possible as part of the category analysis due to data availability, including as a transitional measure
> - reinforce findings that are made through other types of analysis, otherwise highlighting potential problems in assessment methods or data.
>
> 'It is hoped that the input/output based economic benchmarking techniques will be sufficient to test whether the largely revealed cost–based category analysis results can be relied upon and areas where further detailed review should occur.'

In practice, economic benchmarking is likely to play an important role in reviewing the relative efficiency of historical TNSP expenditure and whether base year expenditure can be trended forward or whether it may be necessary to make adjustments to base year expenditure to remove observed inefficiencies. Economic benchmarking is also likely to play an important role in quantifying the feasible rate of efficiency change and productivity growth that a business can be expected to achieve over the next regulatory period. This would include splitting costs that are flexible in the short run (eg opex) and costs that will need to be progressively adjusted over the longer term (eg capital inputs). This could also include consideration of how scale efficiencies may change over time. An example of how economic benchmarking methods can be used to calculate the rate of partial productivity growth that should be included in an opex rate of change roll–forward formula can be found in Economic Insights (2012b).

Economic benchmarking is also likely to be central to determining whether the revealed cost approach should be used (if the TNSP is found to be operating efficiently in the economic benchmarking analysis) or whether a more detailed building blocks review will be necessary (if the TNSP is found to be inefficient in the economic benchmarking analysis).

1.3 Broad data requirements for economic benchmarking

Economic benchmarking requires data on the price and quantity (and hence value) of all outputs and inputs and on the quantities of operating environment variables (noting that output prices may be 'shadow', or cost–reflective, prices where the output is not explicitly charged for). This then allows any of the key economic benchmarking methods – TFP indexes, multilateral TFP indexes, econometric models, DEA and SFA models – to be implemented.

The different techniques have different strengths and weaknesses and each offers a different perspective on the relative performance of included NSPs. It is noted that the non–TFP methods all require a larger number of observations to be available before they can be reliably implemented. It should also be noted that the usefulness of the frontier methods (DEA and SFA) reduces as the number of outputs is increased (because these techniques will find progressively more firms 'efficient' simply because they have unique output mixes and no other firms they can be compared with). This highlights the 'tops down' nature of economic benchmarking and why it is important to concentrate on a relatively small number of key outputs.

The availability of robust and consistent data to support a range of likely specifications is a prerequisite for the introduction of economic benchmarking. A key requirement for a robust and consistent database is detailed and consistent definitions of the way key variables have to be reported. Without this, data may have been supplied inconsistently across TNSPs and also through time by each TNSP.

If it proves feasible to 'backcast' data using historical data, once output and input variable lists and definitions are finalised, then it would be possible to use economic benchmarking methods in building blocks reviews in the near future and certainly sooner than if completely new databases have to be established.

2 TNSP OUTPUTS

2.1 Billed or functional outputs?

Measuring the output of network businesses presents a number of challenges, especially where charging formats may not well reflect the cost of producing the various outputs. Outputs can be measured on an 'as billed' basis or on a broader 'functional' basis. This distinction arises because NSP charging practices have typically evolved on an ease of implementation and historical precedent basis rather than necessarily on a network cost reflective basis. Hence, some NSPs charges on energy throughput even though changes in aggregate energy throughput usually have little impact on the costs they face[1] and dimensions that customers may value highly such as reliability are not explicitly charged for at all (although, in the case of TNSPs, the drivers may enter as components of the TNSPs' service quality incentive scheme).

Under building blocks regulation there is typically only an indirect link between the TNSP revenue allowances and how the TNSP structures its prices. The regulator typically sets the revenue requirement based on the TNSP being expected to meet a range of performance standards (including reliability performance) and other deliverables (or functional outputs) required to meet the expenditure objectives set out in clauses 6A.6.6(a) and 6A.6.7(a) of the National Electricity Rules (NER). Transmission determinations also approve TNSP pricing methodologies that regulate the way that TNSPs can charge for their services. Charges are typically only imposed on a subset of the performance dimensions considered in setting the revenue requirement.

This differs significantly from productivity–based regulation where a case can be made that the 'billed' output specification should be used as output (and, hence, productivity) needs to be measured in the same way that charges are levied to allow the NSP to recover its costs over time (see Economic Insights 2010 for an illustration). However, in the case of building blocks, it will be important to measure output (and hence efficiency) in a way that is broadly consistent with the output dimensions implicit in the setting of NSP revenue requirements. This points to using a functional rather than a billed outputs specification. However, we believe it is important to collect data that would support both billed and functional output specifications going forward to allow sensitivity analysis to be undertaken.

Direct functional outputs versus secondary deliverables

Another issue that needs to be considered is whether the functional outputs for TNSPs should be measured in terms of direct customer experience or whether 'secondary deliverables' (ie capacity required to deliver outputs now and in the future) should be used as a measure of TNSP outputs for economic benchmarking purposes. This is because TNSPs have very few outages and must meet strict system security standards. They are also somewhat removed from the final interface with end–consumers. Given the critical role of transmission in the overall electricity supply chain, perhaps what should be measured is the efficiency of TNSPs

1 One justification for this practice could be using throughput as a proxy for customer demand.

in delivering required system security as opposed to their direct impact on customers. The counter argument is that customers might not care about system security directly, and rather are only concerned with the actual service they receive. It could be argued TNSPs should be afforded the flexibility to make investment decisions and should be benchmarked on how these decisions ultimately affect customers. But there is also a risk that, should system security be benchmarked, TNSPs might be provided with an incentive to gold plate their networks.

It is also important to distinguish between outputs and operating environment variables as both will directly affect TNSP costs. Under most economic benchmarking applications a price and quantity are required for outputs but only a quantity is generally needed for operating environment variables. The distinction we draw between outputs and operating environment variables is that outputs reflect services directly (or indirectly in the case of secondary deliverables) provided to customers whereas operating environment variables do not.

2.2 Criteria for selecting TNSP outputs

Given that the outputs to be included in economic benchmarking for building blocks expenditure assessments will need to be chosen on a functional basis, we need to specify criteria to guide the selection of outputs.

The AER (2012a, p.74) proposed the following criteria for selecting outputs to be included in economic benchmarking:

1) the output aligns with the NEL and NER objectives

2) the output reflects services provided to customers, and

3) the output is significant.

The first selection criterion states that economic benchmarking outputs should reflect the deliverables the AER expects in setting the revenue requirement which are, in turn, those the AER believes are necessary to achieve the expenditure objectives specified in the NER. The NER expenditure objectives for both opex and capex are:

- meet or manage the expected demand for prescribed transmission services
- comply with all applicable regulatory obligations or requirements associated with the provision of prescribed transmission services
- maintain the quality, reliability and security of supply of prescribed transmission services, and
- maintain the reliability, safety and security of the transmission system through the supply of prescribed transmission services.

If the outputs included in economic benchmarking are similar to those the TNSPs are financially supported to deliver then economic benchmarking can help ensure the expenditure objectives are met at an efficient cost.

The second selection criterion is intended to ensure the outputs included reflect services provided directly to customers rather than activities undertaken by the TNSP which do not directly affect what the customer receives. If activities undertaken by the TNSP but which do not directly affect what customers receive are included as outputs in economic benchmarking then there is a risk the TNSP would have an incentive to oversupply those activities and not concentrate sufficiently on meeting customers' needs at an efficient cost. However, as noted above, given the characteristics of transmission and its critical role in the electricity supply chain there may be a case for including as outputs in economic benchmarking secondary deliverables which are not directly provided to customers. If this route is taken then the second criterion becomes less relevant.

The third selection criterion requires that only significant outputs be included. TNSP costs are dominated by a few key outputs and only those key services should be included to keep the analysis manageable and to be consistent with the high level nature of economic benchmarking.

2.3 Candidates for inclusion

We focus first on billed outputs before considering broader functional outputs.

2.3.1 Billed outputs

TNSPs usually charge for transmission services on three broad bases:

- throughput charges which reflect the volume of energy passing through the transmission system
- fixed charges which have to be paid by the user regardless of energy throughput, and
- demand–based charges.

Most users pay some combination of these three types of charges.

TNSP charges are also generally disaggregated into four categories (Transgrid 2010, p.5):

- prescribed entry services which are provided by assets that are directly attributable to serving a generator, or group of generators, at a single connection point
- prescribed exit services which are provided by assets that are directly attributable to serving a transmission customer, or group of transmission customers, at a single connection point
- prescribed transmission use of system (TUOS) services which are provided by assets that are shared to a greater or lesser extent by all users, and
- prescribed common transmission services, which are services that benefit all transmission customers and cannot be reasonably allocated on a locational basis.

Energy throughput

Energy throughput is the TNSP service directly consumed by end–customers. However, the case for including energy throughput in economic benchmarking studies is somewhat more arguable. This is because, provided there is sufficient capacity to meet current throughput levels, changes in throughput are likely to have at best a marginal impact on the costs TNSPs face.

Lawrence (2003) noted that a major part of network infrastructure industries' output is providing the capacity to supply the product. This is in addition to the simple measure of the quantity of the product actually delivered to consumers. A number of NSP representatives in Australia have drawn the analogy between an electricity network and a road network. The NSP has the responsibility of providing the 'road' and keeping it in good condition but it has little, if any, control over the amount of 'traffic' that goes down the road. Consequently, they argue it is inappropriate to measure the output of the NSP by a volume of sales or 'traffic' type measure. Rather, the NSP's output should be measured by the availability of the infrastructure it has provided and the condition in which it has maintained it.

One argument for including energy throughput is that it is a useful proxy for the load capacity of the network as the NSP has to make sure it has the system capacity to deliver the throughput demanded (eg Coelli, et al 2010). However, using throughput as a proxy for demand is likely to be more relevant to DNSPs where sophisticated customer metering is not generally available. It is likely to be less relevant for TNSPs where sophisticated customer metering is in place (ie for DNSPs and directly connected large customers) and, hence, demand measurement is available, generally by at least every 15 or 30 minutes. The AER also noted that while it might be argued that energy throughput needs to be considered, a contrary view is that energy networks need to be engineered to manage peak demand rather than energy throughput.

Considering energy throughput against the output selection criteria, it scores well against the second criterion in that it is the service which end–customers see directly. However, it is less clear that it is important with regard to the first criterion of the TNSP meeting or managing expected demand as this is more influenced by peak demand rather than throughput. And, while energy throughput is significant to some TNSPs in terms of revenue, it is unlikely to be directly significant in terms of costs.

Despite the case for including energy throughput as an output in the current context being arguable, we believe it should be included in data collection and sensitivity analysis should be undertaken of the effects of including or excluding it. Throughput data would need to be collected in aggregate, for peak times and off–peak times and by type of user (eg distribution network, other connected transmission networks and directly connected end–users) as well as for those users paying throughput–based charges.

Entry and exit point numbers

Some TNSPs impose fixed charges for users at both entry and exit points from the transmission network. These charges are related to activities the TNSP has to undertake regardless of the level of energy throughput which include metering services and connection related capacity. They can be imposed on generators (upstream users) and downstream users including distribution networks, other connected transmission networks and directly connected end–users. Going back to the road analogy, the TNSP will need to provide and maintain entry and exit ramps to the freeway, regardless of the amount of traffic on the freeway. In economic benchmarking studies, the quantity of these functions could be proxied by the number of TNSP entry and exit points.

Considering entry and exit point numbers against the output selection criteria, entry and exit point numbers are one indicator of the demand for transmission services and provide a proxy for the services the TNSP has to provide at connection points. This is a necessary part of maintaining the quality, reliability and security of supply of both transmission services and the transmission system itself. They do reflect services directly provided to users of the transmission network but may not be a good measure of services provided to end–customers. They could reflect services that can be a significant part of TNSP costs. The entry and exit point numbers output, therefore, scores well against the first and third selection criteria but less so against the second criterion. We believe this output should be considered for inclusion in economic benchmarking studies as it is a billed item for some TNSPs and may be an important secondary deliverable. Data on entry and exit point numbers should be assembled and sensitivity analysis undertaken to determine the effect of using different output specifications on economic benchmarking results.

Demand–based outputs

Most TNSPs impose some demand–based charges – usually on a kW of contracted and/or measured maximum demand per month basis.

This output scores well against the three selection criteria as it relates directly to the TNSP's ability to manage expected demand and maintain the quality, reliability and security of supply and the transmission system itself. It also reflects an important service provided to end–customers and will be significant for most TNSPs in terms of costs.

While not commonly reported in current regulatory data sets, this information should be relatively straightforward for TNSPs to provide as it will be an important component of their charging mechanism for demand tariff customers. The productivity study Economic Insights (2012a) undertook for the Victorian gas distribution businesses includes equivalent measures for gas distribution.

2.3.2 Other functional outputs

In addition to the three billed outputs discussed above, there are a number of other potential functional outputs which are likely to be of particular importance for economic benchmarking of TNSPs in a building blocks context. These include system capacity, peak demand, circuit availability and reliability.

System capacity

A TNSP requires system capacity to provide transmission services to its users and to meet peak demands. Failure to have sufficient system capacity to cover periods of peak demand (which may be of relatively short duration) may lead to loss of reliability or even system failure.

Going back to the road analogy described earlier, including system capacity as an output captures the TNSP's responsibility of providing the necessary 'road' or, in this case, 'freeway' and keeping it in good condition.

Lawrence (2003) used system line capacity as a proxy for overall electricity distribution system capacity. This was measured by MVA–kilometres, an engineering measure which takes account of line length, voltage and the effective capacity of an individual line based on the number, material and size of conductors used, the allowable temperature rise as well as limits through stability or voltage drop. An analogous MVA–kilometres measure could be formed for transmission system capacity. Agreement would need to be reached on the common MVA–kilometre conversion factors to be used and whether different treatment is required for the small point–to–point direct current TNSPs. These issues will be discussed further in the second phase of the project.

Economic Insights (2009c) included a broader measure of electricity distribution system capacity that recognised the role of transformers as well as lines. Electricity transmission output capability also depends on the throughput capacity of the transformers at the downstream end of the transmission system, as well as on the length and capacity of high voltage mains over which throughput is carried.

One measure that recognises the role of transformer capacity as well as mains length is a simple product of the installed downstream–end transmission transformer kVA capacity and the totalled mains length (inclusive of all voltages). The advantage of including such a measure is that it recognises the key dimensions of overall effective system capacity.

Considering the system capacity output against the three selection criteria, system capacity is clearly required to meet expected demand for transmission services and to maintain the quality, reliability and security of supply and the transmission system itself. It is also a significant part of TNSP costs. However, while it reflects a service provided to both users and end–customers, it may not be the ideal measure since it will not distinguish between TNSPs who have provided adequate capacity to meet demands from those who have overinvested in system capacity. Despite these limitations, we consider system capacity to be an important variable to be considered in economic benchmarking. It is one that is readily measurable from robust data in TNSP data systems.

Peak demand

As noted above, the TNSP needs to provide sufficient capacity to meet peak demand wherever and whenever it occurs which raises the issue of whether peak demand itself should be included as an output in economic benchmarking. Meeting peak demand is generally a significant cost to networks, particularly when peak demand may only occur for only very short periods (eg due to widespread air conditioner use on extreme temperature days). However, while its use may be consistent with meeting demand for transmission services as set out in the expenditure objectives, managing peak demand will likely require the use of time–of–use pricing and other demand management methods – many of which will be beyond the control of TNSPs. However, simply including system peak demand as an output in economic benchmarking may not incentivise TNSPs to take actions which are under their control to smooth peaks and reduce the need for costly additional underutilised infrastructure.

System peak demand also tends to be somewhat volatile over time due to the influence of variable climatic conditions. If peak demand were to be included as an output, it may be more appropriate to include either a smoothed series or a 'ratcheted' variable that reduced the effect of climate–related volatility.

With regard to the second selection criterion, system peak demand does potentially reflect a service provided to end–customers but the provision of a high level of reliability at all times – and particularly peak periods when the costs to customers of outages will be highest – will be what individual end–customers observe and are most interested in receiving.

Circuit availability and Reliability

Transmission system reliability is a key component of ensuring a reliable supply of electricity to end–users. Transmission networks are inherently reliable and generally include significant built–in redundancy. Interruptions to supply to end–consumers are relatively rare and generally only occur when there are multiple and significant concurrent events. However, given the interlinked nature of the electricity supply system, transmission line outages can have significant effects on end–customers both directly and indirectly. Even if the loss of supply through a transmission line does not lead to interruptions to end–customers, it can still have a significant impact on the market spot price for electricity in the wholesale market. This is because the market operator will immediately reconfigure the overall supply network and generation sources to get the system back to as close to an *n–1* level of redundancy as possible. This will likely involve having to constrain some generation sources' output while requiring additional higher cost generation from other generators who are not facing network congestion constraints.

Transmission network circuit availability is thus critical to ensuring not only the reliability of supply to end–customers but also to the efficient operation of the market and minimising spikes in the spot price for power. However, to ensure that the transmission system plays its role in ensuring efficient market operation, it is important for TNSPs to maximise circuit availability where and when it is most needed. Thus, it is not just a matter of the TNSP maximising its overall circuit availability but doing so in the locations and at the times which will stop spikes occurring in the wholesale market spot price.

Given the importance of these aspects of TNSP performance to overall market operation, and the fact that these aspects of TNSP service provision are not explicitly charged for, the AER has spent considerable time developing and refining the TNSP Service Target Performance Incentive Scheme (STPIS). AER (2012b) presents the current and fourth iteration of the STPIS. The variables contained in the STPIS should thus be examined for their suitability as potential functional output variables to include in economic benchmarking of TNSPs.

The STPIS now contains three broad components covering service, market impact and network capability. The service component is intended to incentivise TNSPs to reduce the occurrence of unplanned outages and includes four sub–components (for all TNSPs other than the point to point Directlink and Murray link): average circuit outage rate, loss of supply event frequency, average outage duration and proper operation of equipment.

The average circuit outage rate measures the average number of times circuits were unavailable during the relevant time period as a result of unplanned outages. Unplanned outages are concentrated on as a lead indicator of potential reliability issues and to reduce overlap with the market impact component. The source of unplanned outages is further disaggregated into faults and forced outages affecting transmission lines, transformers and reactive plant. Neither the outage duration nor whether the outage led to a loss of supply event for end–customers is identified. This variable supersedes the earlier variable that measured actual circuit hours that transmission circuits were available relative to the total time those circuits could have been available, which was dominated by planned maintenance outages.

The loss of supply event frequency indicator measures the number of unplanned outages when there has been a loss of supply. This is further broken down into small events and large events. It is designed to encourage TNSPs to reduce response times to small and medium customer interruptions and to reduce the number of interruptions to large customers.

The average outage duration measures the average length of unplanned outages where a loss of supply to customers has occurred. It is intended to focus the TNSP on those unplanned outages with the greatest impact on customers.

The proper operation of equipment sub–component measures the number of incidents where a protection or control system has failed or where there has been incorrect operational isolation of equipment during maintenance. It is intended to be a lead indicator of reliability but is included on a reporting basis only.

The second broad component of the STPIS, that relating to market impact, measures the number of dispatch intervals where an outage on the TNSP's network results in a network outage constraint with a marginal value greater than $10/MWh. It is intended to provide an incentive to TNSPs to reduce the impact of planned and unplanned outages on wholesale market outcomes. TNSPs do so by reducing the length of planned outages and scheduling outages to occur during those times when there will be the least impact on the wholesale market. TNSPs are also incentivised to improve reliability on those elements of the network critical to the wholesale market to reduce the incidence of unplanned outages. This variable focuses TNSPs on avoiding those outages which cause the greatest overall costs to end–customers.

The third broad component of the STPIS, that relating to network capability, encourages TNSPs to deliver benefits through increased network capability, availability or reliability through the development of one–off projects that can be delivered through low cost operational and capital expenditure. The TNSP is rewarded if it completes agreed small projects which are prioritised according to their potential benefits for customers or impact on wholesale market outcomes.

Considering the three broad components of the STPIS against the output selection criteria above, the second component (market impacts) scores well against all three criteria. It is important to meeting and managing expected demand and maintaining the quality, reliability and security of both transmission services and the transmission system. Further, it reflects a service provided to end–customers in the form of higher reliability at a time valued the most by them. It can also be expected to have a significant impact on TNSP costs.

Elements of the first broad component of the STPIS also score well against the selection criteria. The loss of supply frequency and average outage duration indicators both reflect the TNSP's success in meeting and managing expected demand and maintaining the quality, reliability and security of both transmission services and the transmission system. They also reflect the quality of the service provided to end–customers and the cost of improving this dimension of performance can be quite significant.

The average circuit outage rate indicator is also an important measure of the TNSP's ability to meet and manage expected demand and maintain the quality, reliability and security of both transmission services and the transmission system. However, it is not a service directly provided to end–customers but rather a lead indicator of potential unreliability. It also lacks the focus of the market impact indicator on improving availability at those places and times likely to be of highest value to customers. The proper operation of equipment indicator may also be a useful measure of secondary deliverables in that it provides a good measure of 'near misses' where transmission outages almost occurred. Along with a range of other more focused technical measures these two measures should certainly form part of the broader suite of benchmarking measures if they are not included in economic benchmarking directly.

The third broad component of the STPIS, that relating to network capability, relates to inputs rather than outputs and is not considered further here.

In summary, we believe the latest version of the STPIS provides some important guidance for the selection of TNSP outputs for use in economic benchmarking. It contains three important reliability measures, one of which is firmly focused on TNSP performance at places and times likely to be of the highest value to end–customers. And it also contains two measures related to unplanned outages that provide guidance on TNSP system capacity but which are not so closely linked to outcomes directly affecting end–customers.

We note that it will be necessary to collect additional data to implement economic benchmarking using outputs based on the latest STPIS variables. Data would need to be collected for those TNSPs not already subject to the latest scheme and it may be necessary to extract or backcast data for previous years to provide a longer time series and to facilitate sensitivity analysis.

As is the case with including reliability results as outputs for economic benchmarking in distribution, some further work will be required on the best way of converting the commonly available measures into a format consistent, where necessary, with economic performance measurement where an increase in the variable represents more output (eg better reliability or less line outages).

Broader obligations

Some overseas regulators have shown an interest recently in including a much wider range of considerations and obligations in NSP output coverage and assessment. Ofgem (2011), for example, has listed the outcomes it expects network companies to deliver as:

- safety
- limited impact on the environment

- customer satisfaction
- delivery of social obligations.
- non-discriminatory and timely connection, and
- reliability and availability.

Three of these six outcomes (environmental, customer satisfaction and social obligations) represent a considerable broadening of (explicit) expectations on the TNSP (although Ofgem is not including social obligations for TNSPs initially). They are also relatively difficult to measure robustly and objectively. At this stage we do not propose to include these broader objectives as TNSP outputs for inclusion in economic benchmarking studies.

Ofgem also proposes to include a suite of 'secondary deliverables' to ensure any risk to the long–term delivery of the primary outputs is managed. These secondary deliverables are:

- asset risk (asset health, criticality and replacement priorities)
- system unavailability and average circuit unreliability (ACU)
- faults, and
- failures.

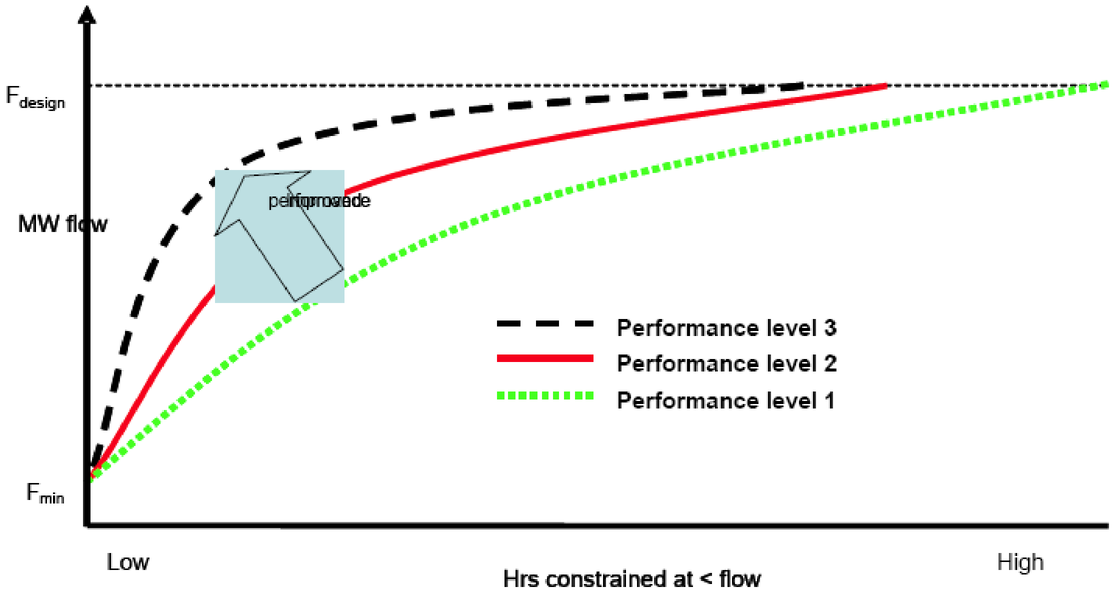
The secondary forward–looking deliverables seek to identify and predict aspects of network performance where the effect would fall beyond the normal (short relative to asset life) regulatory period and seek to address the needs of customers in the longer term. In this broader context, Ofgem noted that 'delays in efficient network investment could undermine progress towards the UK's renewable energy targets, inhibit a competitive and efficient market, and threaten security of supply'. The secondary deliverables are thus related to the outputs that TNSPs should deliver to ensure delivery of primary outputs in future periods and are related to activities such as wider reinforcement works.

Network capability

AEMC (2007, pp.134–5) recognised that network capability cannot be adequately described by a single number and should instead be represented by a constrained flow versus duration curve which plots the level of flow when binding against the number of hours binding at each level of flow. Higher performance levels would be associated with higher flows available (near the design flow) being constrained for short periods, while lower performance would derive from flows constrained at lower level and for greater periods of time (see figure 1).

Further development of this information, its availability and associated reporting of congestion events should assist in the development and assessment of transmission capability output measures that could be used in future economic benchmarking.

Figure 1: **Network capability**



Source: AEMC (2007, p.135)

Outputs weights

Some of the key economic benchmarking techniques aggregate output component quantities into a measure of total output quantity. Others allocate shadow weights to components in forming an efficiency measure so it is useful to have explicit measures of output weights to assess the reasonableness of the shadow weights formed.

Economic benchmarking studies have used one of two alternative approaches to establishing the weights used in combining the various output quantity measures into a measure of total output. Some studies have used simple observed revenue shares while others have used estimated output cost shares on the grounds that pricing structures in many network industries have evolved on the basis of historical accident or convenience rather than on any strong relationship to underlying relative costs. In some cases important dimensions of network output are not explicitly charged for which means these outputs would not be included if only observed revenue shares were used.

In practice economic benchmarking studies using a functional outputs approach have formed estimates of cost–reflective output weights from econometric cost function models. This is done by using the relative shares of output cost elasticities in the sum of those elasticities because the cost elasticity shares reflect the cost of providing relevant output components.

Economic Insights (2009d) developed a detailed theory of productivity–based regulation and examined the issue of appropriate weighting of output components in that context. The report showed that all relevant network outputs – both billed and unbilled – should ideally be included in the productivity measure and that each output should be weighted by the difference between its price and marginal cost in deriving the X factor. However, marginal costs are not readily observable and, given the disconnection between TNSP pricing and the setting of revenue requirements and X factors under building blocks regulation, forming output weights on a cost–reflective basis is likely to provide the most practical option going forward.

If a functional approach to specifying the outputs to be used in economic benchmarking is adopted then forming appropriate weights in an objective way will be an important task going forward. While cost function methods provide one way of doing this (provided sufficient observations are available), other methods may be required to allocate a value to reliability outputs. It may also be necessary to use alternative methods to form output weights for the other TNSP outputs given there are fewer observations available for TNSPs.

2.4 The short list and necessary data

Based on the discussion in section 2.3, Economic Insights recommends that the following short list be considered for use as TNSP outputs in economic benchmarking studies:

- throughput (total or by broad user type or by location)
- number of entry and exit points
- measured maximum demand for those users charged on this basis
- system capacity (taking account of both transformer and line/cable capacity)
- market dispatch intervals with market impact of outages greater than $10/MWh
- loss of supply event frequency
- average outage duration, and
- circuit availability.

While a case can be made for the inclusion of additional output components, most economic benchmarking techniques are limited on practical implementation grounds to a relatively small number of outputs and so the most important ones have to be prioritised for inclusion.

Appendix F of the AEMC (2011) final report for the review into the use of TFP in prices and revenues determinations contains a list of variables considered necessary to support calculation of TFP, including billed output charges. The list is based on the Economic Insights (2009a) data report and was designed to cover the principal energy network productivity study specifications previously used in Australia. While the TNSP lists were compiled in the context of a review of the potential use of productivity–based regulation, they are effectively the same as those required to support the use of economic benchmarking techniques to assess TNSP efficiency in assessing building blocks expenditure forecasts (and in annual benchmarking reports). We therefore suggest that these lists are a useful starting point for consultation on the collection of data to support economic benchmarking.

The lists will need to be supplemented in some areas, eg the availability and reliability indicators are based on an earlier version of the STPIS which had broader outage coverage and which did not include the market impact indicator. It may also be necessary to add additional information needed to allocate weights to functional outputs.

The variables from the AEMC (2011) lists required to support calculation of many of the variables discussed in section 2.3 are presented in Appendix A to these briefing notes.

2.5 Issues for discussion

This section has summarised the main considerations in specifying the outputs to be used in the AER's economic benchmarking of TNSPs. A number of important issues remain to be resolved in practice and we would welcome input on the following issues in particular:

1) Should the outputs to be used in economic benchmarking be similar to those the regulator implicitly uses in setting building block revenue requirements rather than what TNSPs actually charge customers for?

2) Are the AER's output selection criteria (of being consistent with the NER objectives, reflecting customer services and being significant) appropriate? Are there other important criteria we should use in selecting TNSP outputs?

3) Should TNSP outputs for economic benchmarking be extended to include 'secondary deliverables' (ie the capacity required to deliver outputs now and in the future) rather than being limited to those reflecting current consumption?

4) Should energy throughput be included as an output even though changes in it have little impact on TNSP costs?

5) TNSPs typically impose fixed charges for connection on generators and downstream users. Is the number of entry and exit points the best quantity measure for this item?

6) Should demand–based quantities users are charged for be included as outputs for economic benchmarking purposes?

7) Is system capacity an appropriate output variable to capture TNSPs' ability to meet expected demand?

8) The capacity of a transmission network to throughput energy depends on both the capacity of the TNSP's lines and the number and size of transformers it has in place. Should a system capacity output include transformer capacity as well as line and cable capacity? If so, is the simple product of downstream bulk supply point transformer capacity and line length a reasonable summary measure?

9) Is there a case for including system peak demand as an output even though reliability at peak times is what affects customers?

10) Is TNSP reliability a key output which should be included in economic benchmarking?

11) Should we make use of the Service Target Performance Incentive Scheme (STPIS) variables as economic benchmarking outputs?

12) Is the STPIS market impact variable the most important reliability indicator to include?

13) Should the loss of supply event frequency and average outage duration from unplanned outages be included as outputs?

14) Is it appropriate to include a measure of circuit availability as an output for economic benchmarking purposes?

15) Is the time scale for new (generation) connection a relevant output? What of possible ensuing constraints and their resolution?

16) If a functional output specification is used, how should output weights be formed? Is the cost function method (where shares of output elasticities in the sum of those elasticities reflect relative estimated cost shares for the outputs) the best way of doing this?

17) How should an output dollar value be formed for economic benchmarking purposes for reliability outputs?

18) Can processes currently in place to demonstrate compliance with regulatory pricing principles or for internal TNSP planning purposes be utilised in forming measures of the relative cost of producing the different outputs?

3 TNSP OPERATING ENVIRONMENT FACTORS

Operating environment conditions can have a significant impact on network costs and measured efficiency and in many cases are beyond the control of managers. Consequently, to ensure reasonably like–with–like comparisons it is desirable to adjust for at least the most important operating environment differences that are truly exogenous to the TNSP. Likely candidates for incorporation as operating environment factors include climatic and terrain conditions and peak demand.

In practice, the number and type of operating environment factors that can be included in economic benchmarking studies is often limited by data availability, correlation with other included variables and degrees of freedom considerations.

3.1 Criteria for selecting TNSP operating environment factors

The AER (2012a, p.85) has proposed the following criteria for selecting operating environment factors:

1) the variable must have a material impact

2) the variable must be exogenous to the TNSP's control, and

3) the variable must be a primary driver of TNSP costs.

The first criterion concerns prioritising the many factors that affect TNSPs' ability to convert inputs into outputs. Since relatively few operating environment factors can be included in economic benchmarking, it is important to concentrate on those that have the most significant effect and which vary the most across TNSPs.

The second criterion relates to ensuring only factors that are genuinely exogenous to the TNSP (ie beyond management control) are included. Including factors that TNSPs did have some control over could reduce incentives to minimise costs and operate efficiently.

The third criterion relates to ensuring that where a number of factors are correlated, only the one with the most direct impact on TNSPs' costs is included.

3.2 Candidates for inclusion

Climate

Climatic differences can affect TNSP costs both relative to each other and also over time for the one TNSP. TNSPs operating in more tropical climates will generally face higher costs than those operating in temperate climates with the potential for faster vegetation growth, a higher incidence of lightening strikes, higher winds and more flooding.

The incidence of severe storm events can also materially affect a TNSP's costs from year–to–year and make a TNSP look inefficient in those years where it has had to restore services and clean up after severe weather events. Similarly, drier climates are more susceptible to bushfires and this increases required vegetation clearances, design types and recovery costs.

If reliability is to be included as an output it would be important to either include climatic effects as an operating environment factor or to exclude severe weather related impacts from reliability measures and associated restoration costs from the input side.

Climatic effects appear to satisfy the three selection criteria for operating environment factors. They can have a material impact on TNSP costs, are clearly exogenous to the TNSP and can be a primary driver of TNSP costs. Some work remains to be done on what the best summary measure of climatic effects is and whether it is included as an operating environment factor will have to be decided in conjunction with the choice and measurement of outputs.

Terrain

The terrain a TNSP has to traverse can significantly affect its costs. Hilly areas are typically more expensive to traverse than flat areas (although hilly terrain may also allow longer spans and less vegetation clearing if the spans can run from hilltop to hilltop). And forested areas will also incur higher vegetation management costs. The terrain a TNSP faces is clearly exogenous to it and can be a significant driver of TNSP costs. It is also a primary driver of costs and so satisfies the three selection criteria. However, it is often difficult to average terrain conditions in an easily quantifiable way. There is also a dearth of indicators for terrain conditions that lend themselves to use in economic benchmarking.

Peak demand

As discussed in section 2, peak demand can potentially be considered as an operating environment factor. It is a significant driver of TNSP costs and is often a primary driver as well. However, including system peak demand as an operating environment factor in economic benchmarking may not incentivise TNSPs to take actions which are under their control to smooth peaks and reduce the need for costly additional underutilised infrastructure.

Length and capacity

The distance a transmission line has to cover and the capacity required to service the size of the end load centre will, of course, be important drivers of TNSP costs and may also be important drivers of measured TNSP efficiency. Generators have traditionally been located close to coal fields and the main transmission lines have run from those generators to the major cities. Other transmission lines of possibly longer length and generally lesser capacity service regional load centres. The length and capacity of transmission lines required are largely beyond TNSP control and are primary cost drivers. The development of suitable measures for inclusion in economic benchmarking of these potentially important operating environment effects is likely to be a priority for future work.

Other factors

TNSPs also face constraints on their operation from jurisdictional standards, regulations and environmental considerations. In some cases TNSPs may be forced to adopt higher cost routes for new transmission lines in response to environmental lobbying or to underground lines in response to aesthetic considerations. In other cases TNSPs may face different crewing requirements, have to meet different standards and face different environment protection requirements across different jurisdictions. These constraints are exogenous to the TNSP and can have a material impact on costs but they are difficult to quantify robustly and objectively. Given the quantification difficulty we recommend not including these factors at this time.

3.3 The short list

Based on the discussion in section 3.2, Economic Insights recommends that the following short list be considered for use as TNSP operating environment factors in economic benchmarking studies:

- climatic effects
- terrain, and
- length and capacity measure(s).

A satisfactory summary measure will have to be developed for the terrain a TNSP traverses. While challenging, this task is likely to be more achievable for a TNSP than it would be for a DNSP given that TNSP lines are point to point rather than covering a wide and potentially much more diverse service area.

3.4 Issues for discussion

This section has summarised the main considerations in choosing the operating environment factors to be used in the AER's economic benchmarking. A number of important issues remain to be resolved in practice and we would welcome input on the following issues in particular:

1) Are the AER's operating environment factor selection criteria (of being material, exogenous to the TNSP and a primary cost driver) appropriate? Are there other important criteria we should use in selecting TNSP operating environment factors?

2) Should allowance be made for climatic differences between TNSPs operating in sub–tropical areas and those operating in temperate areas? What about between those operating in temperate areas?

3) Should adjustment be made for locational climatic effects such as direct lightning effects, resultant fires, snow loading (and difficulty of access), conductor derating in elevated temperatures and variability of vegetation aggression? How could these be measured and adjusted?

4) What is the best summary measure of climatic effects?

5) Is it possible to derive a useable summary measure of the terrain a TNSP faces?

6) Is peak demand exogenous to the TNSP? Would including it as an operating environment factor reduce TNSP incentives to efficiently manage peak demands?

7) The distance a transmission line has to cover and the capacity required to service the end load centre are important TNSP cost drivers and are largely beyond TNSP control. Should these aspects be included as operating environment factors? If so, how?

8) Should adjustment be made for extra construction cost resulting from forced selection of a non–minimal cost line routes and/or use of more costly structure design or construction methods?

9) Economic Insights (2009a) identified differences in coverage of regulated services both across jurisdictions and over time. Should allowance be made for differences in regulated coverage or should the emphasis be on obtaining data on a common basis across all jurisdictions?

APPENDIX A: ELECTRICITY TNSP OUTPUT VARIABLES[2]

OUTPUTS

TUOS Revenue– $m

From Fixed Customer (Exit Point) Charges
From Variable Customer (Exit Point) Charges
From Fixed Generator (Entry Point) Charges
From Variable Generator (Entry Point) Charges
From Fixed Energy Usage Charges (Charge per day basis)
From Variable Energy Usage charges (Charge per kWh basis)
From Energy based Common Service and General Charges
From Capacity based Common Service and General Charges
From Fixed Demand based Usage Charges
From Variable Demand based Usage Charges

From Other connected transmission networks
From Distribution networks
From Directly connected end–users
From Generators
Total – $m

Revenue/penalties from incentive schemes (eg S factor) – $m

Throughput Energy – GWh

To Other connected transmission networks
To Distribution networks
To Directly connected end–users (please specify voltage)
Total energy delivered – GWh

Maximum demand – MW

Transmission System Capital Quantities and Capacities

Line length by voltage level – km

Network circuit kilometres (route length multiplied by number of circuits per tower at year end) for the following voltage classes:

500 kV
330 kV
275 kV
220 kV
132 kV

Other (please specify)
Total circuit kilometres

Data for each voltage is to be given separately for overhead and underground circuits.

Installed transformer capacity – MVA

Transmission substations (eg 500 kV to 275 kV)

2 Taken from AEMC (2011) and Economic Insights (2009a)

Terminal points
Transformer capacity for directly connected end–users owned by the TNSP
Transformer capacity for directly connected end–users owned by the end–user
Other (please specify)

Transmission circuit availability – hours

Total number of hours for the following (force majeureevents to be excluded):

Circuit hours actually available
Maximum possible number of circuit hours

Number of loss of connection[3] *events by time – no*

The total and planned numbers of loss of connection (outage) events by the following outage lengths:

less than 0.2 minutes (including momentary unavailability pending a reclosure which is successful)
greater than 0.2 minutes
greater than 1 minute.

Excluded events to include circuit interruptions caused by third party systems such as intertrip signals from another party, generator outage or by customer installations, and force majeure events.

Average outage duration – mins

Aggregate minutes of duration of all and planned outages divided by the number of respective outage events.

Excluded events to include circuit interruptions caused by third party systems such as intertrip signals from another party, generator outage or by customer installations and force majeure events.

Line losses – %

[3] Give separated data for total and planned events

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