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

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EXECUTIVE SUMMARY

The AER (2012) 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 first workshop on the appropriate outputs and operating environment factors to be used for economic benchmarking of electricity distribution network service providers (DNSPs).

Outputs – issues for discussion

A number of important issues remain to be resolved with regard to the DNSP 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 DNSPs 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 DNSP outputs?

3) Should energy delivered be included as an output even though changes in it have little impact on DNSP costs?

4) Not all components of energy delivered and customer numbers will cost the same to supply, their shares may very across DNSPs and they may be growing at different rates. Should the customer number and energy delivered outputs be disaggregated to better capture DNSP performance? If so, should this disaggregation be by type of customer (eg residential, commercial, farm, industrial) or by geographic location (eg CBD, suburban, rural, remote)?

5) Does customer class energy delivered represent a reasonable proxy for the demand/capacity associated with that customer class?

6) Industrial customers are usually charged by DNSPs based on their actual maximum demand or a contracted (or reserved) maximum demand. Should these demand–based quantities industrial customers are charged for be included as DNSP outputs?

7) The capacity of a distribution network to deliver energy depends on both the capacity of the DNSP's lines and the number and size of transformers it has in place. Is distribution system capacity an appropriate output variable to capture DNSPs' ability to meet expected demand? If so, how should system capacity be measured?

8) Early studies including system capacity outputs measured system capacity based on the MVA–kms of the DNSP's lines and cables. Should a system capacity output include

transformer capacity as well as line and cable capacity? If so, is the simple product of distribution transformer capacity and line length a reasonable summary measure?

9) Is it feasible to allow for DNSPs' demand management and embedded generation solutions in forming a system capacity variable? If so, how could this be done so that DNSPs adopting these solutions are not penalised relative to DNSPs who simply expand capacity (at likely higher cost)?

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

11) Is reliability a key output which should be included in DNSP economic benchmarking?

12) Are SAIDI and SAIFI the best summary measures for a reliability output?

13) What is the most effective way of including reliability as an output given that the common reliability indexes measure better reliability by a decrease in their value rather than an increase? To what extent is this a problem for economic benchmarking?

14) Is it important to include dimensions of service quality other than reliability as outputs?

15) Efforts to improve network system security can involve significant cost but may not be reflected in different reliability outcomes if adverse events being guarded against do not occur. But the improved system security has provided insurance by minimising the impacts of those events, should they occur. Can a satisfactory measure of the insurance output associated with increased system security be developed?

16) Nearly all DNSPs achieve very high levels of electricity quality of supply and safety and this is effectively a prerequisite for DNSP operation. Since only the most important DNSP outputs affecting consumers directly can be included in economic benchmarking, does this preclude using electricity quality and safety as outputs for economic benchmarking?

17) 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?

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

19) Can processes currently in place to demonstrate compliance with regulatory pricing principles or for internal DNSP 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 DNSP economic benchmarking studies. We would welcome input on the following issues discussed at further length in the paper:

1) Apart from having a material impact, being exogenous to DNSP control and being a primary driver of DNSP costs, are there other important criteria we should consider in selecting operating environment factors?

2) Can a reduction in customer density generally be expected to lead to a reduction in measured DNSP efficiency, all else equal? Are there instances where an increase in customer density may actually increase DNSP costs per customer?

3) Is customer density the most important density variable affecting measured DNSP efficiency?

4) Can a meaningful measure of DNSP service area be formed?

5) Should energy density be included as an operating environment factor?

6) Is energy density a better operating environment factor to include than customer mix?

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

8) How should the effect of climatic differences over time be allowed for?

9) What is the best summary measure of climatic effects impacting on DNSPs?

10) Is it possible to derive a useable summary measure of the overall average terrain a DNSP faces in its service area? If so, how should such an average measure be weighted?

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

12) Economic Insights (2009a) identified differences in coverage of standard control services both across jurisdictions and over time. Should allowance be made for differences in standard control 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 responding 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, putting necessary data reporting mechanisms in place, 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 first workshop on the appropriate outputs and operating environment factors to be used for economic benchmarking of electricity DNSPs. 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 DNSPs and the third section discusses the operating environment factors that should be allowed for in future economic benchmarking of DNSPs.

1.1 What is economic benchmarking?

Economic benchmarking of costs measures the economic efficiency performance of a DNSP by comparing its current performance to its own past performance and to the performance of other DNSPs. All DNSPs use a range of inputs including capital, labour, land, fuel, materials and services to produce the outputs they supply. If the DNSP 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 and 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 DNSP 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 DNSP use inputs in proportions consistent with minimising costs given current input prices
- cost efficiency which requires that the DNSP produce its outputs at minimum possible cost (ie that it achieves both technical and allocative efficiency), and
- scale efficiency which requires that the DNSP 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 DNSPs. As no two DNSPs operate under exactly the same operating environment conditions, it is important to allow for operating environment differences when comparisons are made across DNSPs 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 DNSP over time
- multilateral TFP indexes which allow productivity levels as well as growth rates to be compared across DNSPs
- 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 DNSP 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 DNSP as a whole. The economic benchmarking techniques provide a ‘top down’ perspective on DNSP 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 DNSP 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 (2012) 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 DNSPs) and some elements of the trend analysis, revealed costs and modelling methods currently used.

The AER (2012, 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 DNSP 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 DNSP is found to be operating efficiently in the economic benchmarking analysis) or whether a more detailed building blocks review will be necessary (if the DNSP 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 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 DNSPs and also through time by each DNSP.

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 DNSP 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 on a network cost reflective basis. Hence, many NSPs levy a high proportion of charges on energy throughput even though changes in aggregate energy throughput usually have little impact on the costs they face and dimensions that customers may value highly such as reliability, continuity or speedy restoration after any interruption are not explicitly charged for at all.

Under building blocks regulation there is typically not a direct link between the revenue requirement the DNSP is allowed by the regulator and how the DNSP structures its prices. Rather, the regulator typically sets the revenue requirement based on the DNSP 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 6.5.6(a) and 6.5.7(a) of the National Electricity Rules (NER). DNSPs then set prices that have to be consistent with broad regulatory pricing principles but this is a separate process from 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.

It is also important to distinguish between outputs and operating environment variables as both will directly affect DNSP 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 provided to customers whereas operating environment variables do not.

2.2 Criteria for selecting DNSP 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 (2012, 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 standard control services
- comply with all applicable regulatory obligations or requirements associated with the provision of standard control services
- maintain the quality, reliability and security of supply of standard control services, and
- maintain the reliability, safety and security of the distribution system through the supply of standard control services.

If the outputs included in economic benchmarking are similar to those the DNSPs 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 DNSP which do not directly affect what the customer receives. If activities undertaken by the DNSP but which do not directly affect what customers receive are included as outputs in economic benchmarking then there is a risk the DNSP would have an incentive to oversupply those activities and not concentrate sufficiently on meeting customers' needs at an efficient cost.

The third selection criterion requires that only significant outputs be included. DNSPs provide a wide range of services but DNSP 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. For instance, call centre operation is not normally a large part of DNSP costs and so call centre performance is not normally included as an output in DNSP economic benchmarking studies.

2.3 Candidates for inclusion

Most economic benchmarking studies to date have included either all or a subset of billed outputs in their output coverage. However, the weights applied to billed components have typically varied between studies adopting a billed outputs only approach and those adopting a broader functional outputs approach. Those studies that have adopted the broader functional outputs approach have included additional outputs such as system capacity and reliability and attention has been drawn to the possible need to develop measures of system security (see, for example, Economic Insights 2009b). We focus first on billed outputs.

2.3.1 Billed outputs

DNSPs usually charge for distribution services on three broad bases:

- throughput charges which reflect the volume of energy used by the customer
- fixed charges which have to be paid by the customer regardless of energy use, and
- maximum demand–based and/or contracted reserved capacity charges which guarantee the user a given amount of capacity, even at peak times, and which are normally only applied to relatively large (usually industrial) customers.

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

Energy delivered

Energy delivered is the service directly consumed by customers and has been included in nearly all economic benchmarking studies to date. However, in the current context, the case for including energy delivered 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 very marginal impact on the costs DNSPs face.

Lawrence (2003a) 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 DNSP representatives in Australia have drawn the analogy between an electricity distribution system and a road network. The DNSP 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 distribution business by a volume of sales or 'traffic' type measure. Similarly, DNSPs act passively in distributing energy over their systems as they do not decide the amount of energy distributed and short–run changes in load only trivially affect the DNSP's costs. Rather, the DNSP's output should be measured by the availability of the infrastructure it has provided and the condition in which it has maintained it.

Other studies have included energy delivered because they argue it is a useful proxy for the load capacity of the network as the DNSP has to make sure it has the system capacity to deliver the throughput demanded (eg Coelli, et al 2010). This approach was supported by a recent study by Kuosmanen (2010) who found a high correlation between energy delivered and peak demand in Finland. The AER (2012, p.78) has questioned whether this would apply to Australia where growth in annual peak demand has outstripped growth in energy delivered in recent years. The AER also noted that while it might be argued that energy delivered needs to be considered when considering a DNSP's ability to meet or manage expected demand under the expenditure criteria, a contrary view is that energy networks need to be engineered to manage peak demand rather than energy delivered.

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

Despite the case for including energy delivered 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. While a case can be made for its inclusion, it is likely that the weight that it should be accorded in forming a total output measure will be considerably less than its revenue share (as its impact on DNSP costs is likely to be small). We also note that previous studies have included either only aggregate energy delivered or aggregate peak energy delivered and aggregate off–peak energy delivered. As will be discussed in the following section, there is a need to collect consistent energy delivered data on a more disaggregated basis as disaggregation can make a material difference if there are significant differences in load factors, growth rates and in per unit costs or revenues between categories (eg residential, commercial and industrial).

Customer numbers

Customers typically face some fixed charges on their energy distribution bills. These charges are related to activities the DNSP has to undertake regardless of the level of energy delivered which include metering services, customer connections, customer calls and, more importantly, connection related capacity (eg having more residential customers may require more local distribution transformers and low voltage mains). Going back to the road analogy, the DNSP will need to provide and maintain local access roads for its customers, regardless of the amount of traffic on those roads. In previous economic benchmarking studies, the quantity of these functions has been proxied by the number of DNSP customers or, more specifically, the number of connections. The connection component recognises that some distribution outputs are related to the very existence of customers rather than either throughput or system capacity. And the connection of new customers could be a significant cost driver.

Considering customer numbers against the output selection criteria, customer numbers are one indicator of the demand for distribution services and, in most cases, DNSPs have an obligation to supply customers. They also reflect services directly provided to the customer and can be a significant part of DNSP costs. The customer numbers output, therefore, scores well against the three selection criteria and should be included in economic benchmarking studies.

Previous studies have generally used the total number of customers to proxy the quantity of this output. It may be necessary to include more disaggregation of customer numbers to obtain a better proxy of the services DNSPs provide and their costs. For example, supply to a unit in a block of flats may be more costly if the block is regarded as a single ‘customer supply point’, or less costly if the connection is regarded and charged as a multitude of individual ‘residential customers’.

In other industries moving from very aggregated output measures to more disaggregated measures has proven to be quite material. For example, a study of Australia Post’s TFP growth by Lawrence (2002) included price and quantity data for 7 outputs (reserved letters, other addressed mail, unaddressed mail, money orders, agency services, accommodation and other outputs). Significant improvements in Australia Post's information systems allowed Lawrence (2007) and Economic Insights (2009c) to include considerably more detail on the outputs provided by Australia Post, particularly with regard to postal items carried. The number of output categories increased from 7 to 25, allowing the construction of more accurate output indexes.

The effect of this increased level of disaggregation was to increase Australia Post's measured TFP growth rate as higher valued items carried have been increasing at a much faster than average rate. Applying a higher weight to these faster growing items carried in recognition of their higher value (and higher costs) – instead of the same weight to all items carried – had a material impact on measured productivity growth.

A similar result may be observed in energy distribution if those throughput categories and customer types that have higher per unit costs or charges have been increasing faster than those that have lower per unit costs or charges. Increasing the detail included on throughput and fixed output components should be a relatively straightforward improvement to make to current specifications. Disaggregation could be by customer type (eg residential, farm, commercial, industrial) or customer location (eg CBD, suburban, rural, remote).

Demand–based outputs

The treatment of the third billed output – demand–based and/or contracted reserved capacity charges – has been more variable in previous economic benchmarking studies. These charges mainly apply to large industrial customers. The appropriate quantities to use for this billed output are the (non–coincident) peak demands (in MW or MVA) for those customers that are charged on the basis of their actual observed peak demand and the MW or MVA of reserved capacity for those industrial customers that are subject to reservation charges.

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

While not commonly reported in current regulatory data sets, this information should be relatively straightforward for DNSPs 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.

Attempts to proxy this output quantity by non–coincident system peak demand are likely to be problematic as this measure represents the peak energy entering the network at the bulk supply points and is likely to be a poor proxy for the contracted demands that large customers pay for. This is because diversification of demand within the network means that the total peak energy entering the network at any one time will be less than the sum of maximum demands at the final customer level (which will all occur at different times and which may determine local system capacity requirements). System peak demand is also generally quite volatile with erratic movements from year to year which are unlikely to reflect the costs of providing necessary system capacity in any one year. Contracted reserved capacity (and, to a lesser extent, actual peak demand from customers charged on this basis) is likely to move in a relatively smooth and monotonic fashion rather than to shift erratically from year to year. Annual climatic factors affecting residential and commercial demand may be a more significant contributor to observed volatility in system–wide peak demands.

2.3.2 Other functional outputs

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

System capacity

A DNSP requires system capacity to provide distribution services to its customers (which may be spread over a large geographic area) 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.

Many analysts have considered the provision of system capacity to be a key output of DNSPs. For instance, Turvey (2006) notes:

> ‘what the enterprise provides is not gas, electricity, water or messages; it is the capacity to convey them. It follows that, to compare efficiencies, it is necessary to compare differences in capacities with different costs.’

Going back to the road analogy described earlier, including system capacity as an output captures the DNSP’s responsibility of providing the necessary ‘road’ and keeping it in good condition.

Lawrence (2003a) 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.

Economic Insights (2009d) included a broader measure of electricity distribution system capacity that recognised the role of transformers as well as lines. Electricity distribution output capability to serve consumers depends on the throughput capacity of the distribution transformers at the final level of transformation to utilisation voltage, as well as on the length and capacity of high and low voltage mains over which supply is delivered.

One measure that recognises the role of transformer capacity as well as mains length is a simple product of the installed distribution transformer kVA capacity of the last level of transformation to the utilisation voltage and the totalled mains length (inclusive of all voltages but excluding streetlighting and communications lengths). 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 distribution services and to maintain the quality, reliability and security of supply and the distribution system itself. It is also a significant part of DNSP costs. However, while it reflects a service provided to customers, it may not be the ideal measure since it will not distinguish between DNSPs who have provided adequate capacity to meet demands from those who have overinvested in system capacity. It may also penalise those DNSPs who have sought out new ways of managing demand (eg through demand management or embedded generation) compared to simply investing in more capacity which may be a more costly option. 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 DNSP data systems.

Peak demand

As noted above, the DNSP 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 distribution 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. Simply including either coincident or non–coincident system peak demand as an output in economic benchmarking may not incentivise DNSPs to take actions to smooth peaks and reduce the need for costly additional underutilised infrastructure.

System peak demand also tends to be quite 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 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 customers observe and are most interested in receiving.

Reliability

Reliability is an important dimension of DNSP output and receives some prominence in the NER expenditure objectives where maintaining the reliability of both supply and the system itself are explicitly mentioned. Improving (or maintaining) reliability is generally a significant part of DNSP costs and it reflects an important part of the service directly provided to customers (although customers are not typically charged for reliability explicitly).

Outputs in efficiency studies have generally been measured in such a way that an increase in the measured quantity of an output represents more of the output and, hence, a desired result. But both the frequency and duration of interruptions are measured by indexes where a decrease in the value of the index represents an improvement in service quality. It would be necessary to either include the indexes as 'negative' outputs (ie a decrease in the measure represents an increase in output) or else to convert them to measures where an increase in the converted measure represents an increase in output. Some of the key economic benchmarking techniques cannot readily incorporate negative outputs and inverting the measures to produce an increase in the measure equating to an increase in output can lead to non–linear results. And, since most systems are interrupted for a relatively small number of minutes each year, using the number of minutes the system is uninterrupted effectively produces a constant variable that is of limited use.

A priority for future work in this area is finding a practical way of incorporating reliability measures as outputs in those benchmarking techniques that require improved performance to be represented by an increase in the included variable rather than a decrease in it as is the case with the commonly used reliability indexes.

The key reliability indexes of SAIDI and SAIFI have been the main reliability measures used in economic benchmarking studies to date. They have mainly been included in econometric models where the need for more output to be represented by an increase in the variable is less of an issue. Some econometric studies have transformed the indexes into a more convenient form by multiplying them by total customer numbers (eg Coelli et al 2010).

If reliability is not included as an additional output variable, there will be no recognition or 'credit' on the output side for the better quality service provided while higher input usage is recognised leading to an underestimate of the efficiency of DNSPs that have invested in improving measured reliability. It also needs to be recognised that there is usually a time lag between changes in expenditure on reliability–related initiatives and changes in observed reliability performance. This applies in both directions with increases in reliability–related expenditure often taking a year or two to be reflected in improved reliability performance and, conversely, reductions in reliability–related expenditure often taking some time to feed through into worsened reliability as the system is allowed to run down.

Some economic benchmarking studies have included reliability as an input rather an output in recognition of a DNSP's ability to substitute between using opex and capital, on the one hand, and reduced reliability and associated penalties on the other (see Coelli et al 2008).

Although more development work needs to be done on the most effective way of incorporating reliability in economic benchmarking models, we believe reliability should be recognised as an important DNSP output in the current context. The measures of reliability used should relate to distribution–related causes rather than including outages originating from other parts of the overall electricity supply system.

System security

Security of supply and security of the distribution system receive explicit mention in the NER expenditure objectives. They refer to the DNSP's management of the system to reduce the probability of network assets failing or being overloaded. In some cases DNSPs are being required to meet higher statutory system security benchmarks (eg moving from n–1 to n–2 redundancy levels). While system security is a significant cost to DNSPs, it is not necessarily an output that reflects services provided to customers as customers are concerned about the reliability of the system as it affects them directly. As such, reliability may be the more appropriate measure to include as an output in economic benchmarking.

System security can also be quite difficult to quantify in a summary measure. Ofgem (2009) has attempted to form several different measures of system security based on the load on network assets, a health index reflecting asset age and condition and asset fault rates.

The system security issue is somewhat problematic. Some DNSPs have spend large amounts to strengthen their systems and provide higher levels of redundancy but current measures of output do not show any corresponding increase in 'output'. It should also be noted that reliability measures may not reflect any change in output either. Rather, improving system security is providing an 'insurance' output that customers may value but which it is very hard to measure. One option could be to give DBs a score depending on what redundancy level they achieved (eg 1 for n–1, 2 for n–2, etc). This would be similar to the Ofgem approach. But if the event being insured against by the system strengthening does not come to pass then the extra output would not be reflected in different reliability performance but insurance against such an event would have been provided nonetheless.

In the current context, system security measures are best considered descriptors of input condition and are not sufficiently close to reflecting services directly provided to customers to be included as an output in economic benchmarking. A further practical difficulty is the lack of comprehensive high level summary measures of system security that could be used in economic benchmarking.

Electricity quality and safety

The quality and safety of electricity supply and of the distribution system also receive explicit mention in the NER expenditure objectives. Electricity quality and safety is of obvious importance to customers so that their physical safety is protected and their equipment and appliances are not damaged. There are a number of specific measures of electricity quality and safety but no overall summary measure. While efforts to maintain quality and safety overall may have a significant impact on DNSP costs, we assume that achieving these safety and quality standards are a basic requirement of DNSP operation and are unlikely to be substantially different across DNSPs. As only a limited number of outputs can be included in an economic benchmarking study, we believe it is more important to prioritise the inclusion of other key outputs ahead of electricity quality and safety measures.

Broader obligations

Some overseas regulators have shown an interest recently in including a much wider range of considerations and obligations in DNSP output coverage and assessment. Ofgem (2012, p.7), 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 DNSP. They are also relatively difficult to measure robustly and objectively. At this stage we do not propose to include these broader objectives as DNSP outputs for inclusion in economic benchmarking studies.

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. For example, Lawrence (2003a) estimated a simple cost function using data for 28 DNSPs over 7 years which produced output cost share estimates for the three outputs included of 22 per cent for throughput, 32 per cent for network line capacity and 46 per cent for connections.

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 disconnect between DNSP 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.

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 DNSP outputs in economic benchmarking studies:

- customer numbers (total or by broad class or by location)
- measured maximum demand and contracted maximum demand for those customers charged on these bases
- system capacity (taking account of both transformer and line/cable capacity)
- reliability (SAIDI and/or SAIFI), and
- throughput (total or by broad customer class or by location).

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. Consequently, most studies would use only a subset of the output variables on the short list.

A study using a billed outputs specification would use three outputs as follows:

- customer numbers
- measured maximum demand and contracted maximum demand for those customers charged on these bases, and
- throughput.

Output weights under this approach would reflect actual revenue shares.

A functional outputs only specification might include:

- system capacity (taking account of both transformer and line/cable capacity), and
- reliability.

In this case output weights would typically be determined on the basis of estimates of the relative cost shares of the two outputs.

Economic Insights (2012a, section 5.6) presents a detailed comparison of Victorian gas distribution business productivity results using a billed outputs specification (with outputs of: Tariff V throughput; number of Tariff V customers; and, non–coincident Tariff D, L and M maximum hourly demands) and a functional outputs specification (with outputs of: total throughput; total customer numbers; and, system capacity).

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. The list is based on the Economic Insights (2009a) data report and was designed to cover the principal DNSP productivity study specifications previously used in Australia. While the DNSP 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 DNSP 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 may need to be supplemented in some areas, eg the lists include key reliability indicators such as SAIDI and SAIFI but more detailed reliability indicators may need to be added if reliability is considered to be a key functional output. 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 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. 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 DNSPs 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 DNSP outputs?

3) Should energy delivered be included as an output even though changes in it have little impact on DNSP costs?

4) Not all components of energy delivered and customer numbers will cost the same to supply, their shares may very across DNSPs and they may be growing at different rates. Should the customer number and energy delivered outputs be disaggregated to better capture DNSP performance? If so, should this disaggregation be by type of customer (eg residential, commercial, farm, industrial) or by geographic location (eg CBD, suburban, rural, remote)?

5) Does customer class energy delivered represent a reasonable proxy for the demand/capacity associated with that customer class?

6) Industrial customers are usually charged by DNSPs based on their actual maximum demand or a contracted (or reserved) maximum demand. Should these demand–based quantities industrial customers are charged for be included as DNSP outputs?

7) The capacity of a distribution network to deliver energy depends on both the capacity of the DNSP's lines and the number and size of transformers it has in place. Is distribution system capacity an appropriate output variable to capture DNSPs' ability to meet expected demand? If so, how should system capacity be measured?

8) Early studies including system capacity outputs measured system capacity based on the MVA–kms of the DNSP's lines and cables. Should a system capacity output include transformer capacity as well as line and cable capacity? If so, is the simple product of distribution transformer capacity and line length a reasonable summary measure?

9) Is it feasible to allow for DNSPs' demand management and embedded generation solutions in forming a system capacity variable? If so, how could this be done so that DNSPs adopting these solutions are not penalised relative to DNSPs who simply expand capacity (at likely higher cost)?

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

11) Is reliability a key output which should be included in DNSP economic benchmarking?

12) Are SAIDI and SAIFI the best summary measures for a reliability output?

13) What is the most effective way of including reliability as an output given that the common reliability indexes measure better reliability by a decrease in their value rather than an increase? To what extent is this a problem for economic benchmarking?

14) Is it important to include dimensions of service quality other than reliability as outputs?

15) Efforts to improve network system security can involve significant cost but may not be reflected in different reliability outcomes if adverse events being guarded against do not occur. But the improved system security has provided insurance by minimising the impacts of those events, should they occur. Can a satisfactory measure of the insurance output associated with increased system security be developed?

16) Nearly all DNSPs achieve very high levels of electricity quality of supply and safety and this is effectively a prerequisite for DNSP operation. Since only the most important DNSP outputs affecting consumers directly can be included in economic benchmarking, does this preclude using electricity quality and safety as outputs for economic benchmarking?

17) 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?

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

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

3 DNSP 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 DNSP. Likely candidates for incorporation as operating environment factors include customer density (customers per kilometre of main), energy density (energy delivered per customer), customer mix, 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 DNSP operating environment factors

The AER (2012, 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 DNSP's control, and
3) the variable must be a primary driver of DNSP costs.

The first criterion concerns prioritising the many factors that affect DNSPs' 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 DNSPs.

The second criterion relates to ensuring only factors that are genuinely exogenous to the DNSP (ie beyond management control) are included. Including factors that DNSPs 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 DNSPs' costs is included.

3.2 Candidates for inclusion

Customer density

A DNSP with lower customer density will generally require more poles and wires to reach its customers than will a DNSP with higher customer density but the same consumption per customer making the lower density DNSP appear generally less efficient unless the differing densities are allowed for. Some economic benchmarking studies incorporate customer density effects by including line length and customer numbers explicitly as outputs. This means that DNSPs who have low customer density, for instance, receive credit for their longer line lengths whereas this would not be the case if output was measured by only one output such as throughput. Other studies have included customer density explicitly as an operating environment factor.

The DNSP's service area is also sometimes suggested as another way of picking up customer density effects. However, in our experience the inclusion of service area is problematic as a remote DNSP may only provide coverage to a few centres in a largely uninhabited region. Rather than counting the whole area, it would be more appropriate to only measure areas within a certain distance of distribution lines. Difficulties in objectively measuring the area actually serviced preclude using service area.

DNSPs have no control over the spread of customers over their network area and, hence, the customer density they face, so this factor satisfies the second selection criterion. It is also a significant driver of DNSP costs with DNSPs with low customer density generally having to provide considerably more infrastructure per customer than a DNSP with high customer density. DNSPs with low customer density may also face opex disadvantages with, for example, one field crew being able to cover fewer customers than would be the case for a DNSP with high customer density. Since customer density is a more fundamental driver of DNSP costs than line length, there would appear to be a strong case for including customer density as an operating environment factor although that decision has to be made in conjunction with the choice of outputs.

Energy density and customer mix

Being able to deliver more energy to each customer means that a DNSP will usually require fewer inputs to deliver a given volume of electricity as it will require less poles and wires than a less energy dense DNSP would require to reach more customers to deliver the same total volume. Offsetting this to some degree may be the requirement for the higher energy density DNSP to have larger transformers to service its higher consumption customers but again it will require a smaller number of transformers than its less dense counterpart.

Energy density will be influenced by a number of factors including climatic conditions in the distribution area, customer affluence and customer mix. Areas that have hotter summers and colder winters will generally have higher energy density than areas with a more moderate climate, all else equal. DNSPs operating in more affluent areas might be expected to have higher consumption per customer than those operating in poorer areas. And those DNSPs with a higher proportion of industrial customers will have higher overall energy density, all else equal. The latter effect could also be captured by including customer mix as an operating environment factor but this would not capture the climatic or affluence effects. Customer mix effects might also be captured on the output side by including a higher level of throughput and customer number disaggregation. Including both customer numbers and energy delivered in aggregate as outputs will also partly capture energy density differences.

As with customer density, the energy density a DNSP faces will be largely beyond its control and so satisfies the second selection criterion. It is also a potentially significant driver of DNSP costs although this is perhaps less clear cut than in the case of customer density. And, being a more comprehensive measure, it takes in more effects than a customer mix variable. But whether it is appropriate to include energy density as an operating environment factor will again have to be decided in conjunction with the choice of output variables to be included.

Climate

Climatic differences can affect DNSPs costs both relative to each other and also over time for the one DNSP. DNSPs 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. Corrosion and termite attacks can also take a higher toll on DNSP assets in more tropical areas (see Lawrence 2003b for estimates of the higher costs associated with tropical DNSP operations).

The incidence of severe storm events can also materially affect a DNSP's costs from year–to–year and make a DNSP look inefficient in those years where it has had to restore services and clean up after severe weather events. 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 DNSP costs, are clearly exogenous to the DNSP and are a primary driver of DNSP 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 again have to be decided in conjunction with the choice and measurement of outputs.

Terrain

The terrain a DNSP has to operate in can significantly affect its costs. Hilly areas are typically more expensive to service than flat areas and forested areas will also incur higher vegetation management costs. The terrain a DNSP faces is clearly exogenous to it and can be a significant driver of DNSP costs. It is also a primary driver of costs and so satisfies the three selection criteria. However, all DNSPs face a range of terrain conditions over their service areas and it is often difficult to average these 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 DNSP costs and is often a primary driver as well. However, it is not clear cut whether peak demand is totally exogenous to the DNSP as peak demand can be influenced by demand management initiatives and peak load pricing. Allowing peak demand to be included as an operating environment factor may also reduce the incentives DNSPs have to find cost effective ways of reducing the peak demands they face.

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 DNSP operating environment factors in economic benchmarking studies:

- customer density
- energy density, and
- climatic effects.

While terrain effects are also a potential candidate for inclusion, it is unlikely a satisfactory summary measure can be developed reflecting the overall effect on costs for a DNSP.

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) Apart from having a material impact, being exogenous to DNSP control and being a primary driver of DNSP costs, are there other important criteria we should consider in selecting operating environment factors?

2) Can a reduction in customer density generally be expected to lead to a reduction in measured DNSP efficiency, all else equal? Are there instances where an increase in customer density may actually increase DNSP costs per customer?

3) Is customer density the most important density variable affecting measured DNSP efficiency?

4) Can a meaningful measure of DNSP service area be formed?

5) Should energy density be included as an operating environment factor?

6) Is energy density a better operating environment factor to include than customer mix?

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

8) How should the effect of climatic differences over time be allowed for?

9) What is the best summary measure of climatic effects impacting on DNSPs?

10) Is it possible to derive a useable summary measure of the overall average terrain a DNSP faces in its service area? If so, how should such an average measure be weighted?

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

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

APPENDIX A: ELECTRICITY DNSP OUTPUT VARIABLES[1]

DUOS Revenue– $m

From Fixed Customer Charges
From On–Peak Energy Deliveries
From Off–Peak Energy Deliveries
From Contracted Maximum Demand
From Measured Maximum Demand

From Domestic Customers
From Commercial Customers
From Small Industrial Customers
From Large Industrial Customers
From Other Customers
Total – $m

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

Total Energy delivered – GWh

On–Peak Energy Deliveries – GWh
Off–Peak Energy Deliveries – GWh
Summated Contracted Maximum Demand[2] – MW
Summated Measured Maximum Demand[3] – MW
Domestic Customer Energy Deliveries – GWh
Commercial Customer Energy Deliveries – GWh
Small Industrial Customer Energy Deliveries – GWh
Large Industrial Customer Energy Deliveries – GWh
Other Customer Energy Deliveries – GWh

Non–coincident System Annual Peak Demand – MW

Coincident System Annual Peak Demand – MW

Total Distribution Customer Numbers– no

Domestic Customer Numbers
Commercial Customer Numbers
Small Industrial Customer Numbers
Large Industrial Customer Numbers
Other Customer Numbers
Total – no

Distribution System Capacities Variables

O/H network circuit length – km
Low voltage distribution

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1 Taken from AEMC (2011) and Economic Insights (2009a)
2 For customers charged on this basis
3 For customers charged on this basis

HV 11 kV
HV 22 kV
HV 33 kV (if used as distribution voltage)
SWER
S/T 44/33 kV (if used as subtransmission)
S/T 66 kV
S/T 132 kV
(Other voltages)
Total overhead circuit km

U/G network circuit length – km
Low voltage distribution
HV 11 kV
HV 22 kV
HV 33 kV (if used as distribution voltage)
S/T 66 kV
S/T 132 kV
(Other voltages)
Total underground circuit km

Transformer Total Installed Capacity – MVA
Distribution transformer capacity owned by utility
Distribution transformer capacity owned by HVCs

Reliability
Distribution–related SAIDI
Distribution–related SAIFI

Line losses – %

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