OFGEM

REVIEW OF ELECTRICITY TRANSMISSION OUTPUT MEASURES

FINAL REPORT

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PB POWER

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APPENDICES:

EXECUTIVE SUMMARY

Introduction (Section 1)

Licence Condition B17: Network Output Measures sets out the requirements of developing an appropriate methodology to enable the evaluation of electricity transmission network output measures for the transmission systems of the three Transmission Licensees, National Grid Electricity Transmission (NGET), ScottishPower Transmission Limited (SPTL) and Scottish Hydro-Electric Transmission Limited (SHETL). Paragraph 2 of the Licence Condition requires the network output measures to be designed to enable evaluation of:

- network asset condition
- network risk
- network performance and
- network capability.

Paragraph 4 of the Licence Condition sets out the objectives to be facilitated thereby, namely the monitoring, comparison of performance and assessment of expenditure.

A copy of Licence Condition B17 is included in Appendix D for reference.

PB Power has been commissioned to review the:

- present practice and capabilities of the Transmission Licensees
- international practice
- practice in relevant commercial industries and
- Transmission Licensees' draft methodologies.

Review of Electricity Transmission Licensees' Present Practice and Capabilities (Section 2)

The electricity transmission and distribution licensees in Great Britain (GB) presently report by:

- an annual GB Transmission System Performance Report
- quality of supply information subsequently complied by Ofgem into the annual Distribution Quality of Service Report
- Transmission Regulatory Reporting Package (TRRP), 2006/7 being the first reporting year; we understand that the 2007/8 TRRP has been delivered by the Licensees and
- Distribution Regulatory Reporting Package (DRRP), 2006/7 being the third consecutive reporting year.

We observe that on the transmission networks few causes of losses of supply appear to be related to the condition of the plant. The annual unsupplied energy could readily be normalised into the internationally used comparator of Cigré "System Minutes" although both NGET's and SPTL's System Minutes are likely to be an order of magnitude lower than most international comparators reflecting compliance with the Great Britain Security and Quality of Supply Standard (SQSS) and the highly integrated configuration of the two Transmission Licensees' networks.

We note that the TRRP requires more detailed breakdowns of system unavailability data and the provision of data on defects, faults and failures and the grading of assets by condition.

We are however unaware of any systematic compilation by the Transmission Licensees of fault rates, restoration times or trends thereof by asset type and nor does there appear to be any sharing of such data between Transmission Licensees although 132 kV data has been shared between the two Scottish Transmission Licensees and the Distribution Network Operators, at least in the past. There may be merit in formalising systematic compilation of these statistics at the transmission level. The National Fault and Interruption Reporting Scheme (NaFIRS®), as administered by the Energy Networks Association (ENA), compiles distribution reliability data on a systematic basis and may therefore be regarded as a suitable precedent for the comparison of transmission reliability data.

Review of International Electricity Transmission and Distribution Practice (Section 3)

System performance related metrics. A number of international transmission system operators disaggregate availability and unavailability further than in the annual GB Transmission System Performance Report, and even further than the more detailed disaggregation in the TRRP. In Australia the Service Target Performance Incentive Scheme is a practical method of providing an incentive to the Electricity Transmission Network Service Providers to minimise network outages. We consider that there may be a merit in adopting a more disaggregated approach than currently proposed by the Transmission Licensees.

Asset related fault and interruption reporting. Good examples exist of definitions of the type of data required (Cigré surveys (occasional), Canada's ERIS five yearly reporting on the Forced Outage Performance of Transmission Equipment, Nordel's annual Grid Disturbance and Fault Statistics) and of standard definitions (FERC's Transmission Availability Data System (TADS), IEEE and IEC). As already mentioned NaFIRS is also a good example of the compilation of distribution fault data suitable for reliability modelling.

Asset management techniques specific to the planning of asset strategies. Limited information is in the public domain on the variation of failure rates with asset condition and, separately, with asset age although the modelling of failure rates against asset age and/or condition is the subject of a number of recent papers however. Cigré Technical Brochure, Asset Management of Transmission Systems and Associated Cigré Activities, December 2006, expands the concept of risk in terms of probabilities of asset failures, their consequences and relationship with the business values of the transmission owner. Cigré Technical Brochure 248, Guide on Economics of Transformer Management, June 2004, is recommended as a reference for methodologies for a "Risk-Based Decisions Process for

Investment in Power Transformer Replacement" including economic/financial analysis of net present values in monetary terms taking into account cost of energy not supplied; the brochure also contains outline data of failure rate by age and failure rate by condition. Asset Health Index based processes for risk management are available, principally in the United Kingdom and in Canada, and are being developed further, principally for distribution assets, although coverage within a given distribution network operator's asset base may not be complete (Appendix B). Nevertheless no standardised methodology or terminology for asset health indices exists and the processes require appreciable data on the condition of assets.

Review of relevant commercial industries practice (Section 4)

In the water industry Ofwat has adopted a "capital maintenance planning common framework" (CMPCF) which has been subject to recent review identifying the most and least successful approaches in carrying out asset deterioration and prioritisation modelling; Service Performance indicators and guaranteed standards of service to customers are important in output measurement. For road networks, the Government has created Best Value Performance Indicators, supported by the internal Key Performance Indicators that a highway agency may adopt. The Network Rail Monitor is a balanced scorecard produced by the ORR of some eleven high-level key performance indicators used in the rail industry. Network Rail has also upgraded its asset data management and related modelling processes.

Review of the Licensees' draft methodologies (Section 5)

We have reviewed both the Joint Methodology Statement (JMS), which has been jointly drafted by the three Transmission Licensees, and the Transmission Licensees' Specific Appendices.

In formulating comments from the review the following is of note:

- The comments made are relevant to all of the Transmission Licensees unless a specific Licensee is named

- It is the Transmission Licensees themselves who have the necessary information to establish the materiality or otherwise of output measures applicable to their systems. PB Power has sort to make suggestions where it considers the output measures proposed by the Transmission Licensees warrant supplementing to meet the requirements of the Licence Condition

- It is recognised by Ofgem, the Transmission Licensees and PB Power that work needs to continue to evolve the output measures and this may include the development of measures that require business processes and the monitoring of information that may only become available in the future.

- It is recognised that in attempting to define output measures that collectively meet the objectives outlined in Section 4 of the Licence Condition compromises between the constituent objectives 4(a) to 4(e) may be required. However, for the purposes of this document Objectives 4(a) to 4(e) are individually assessed to highlight any deficiencies in meeting these.

- There is a the need that the proposed output measures are proportionally applied to the Licensees in view of their different characteristics.

Asset condition

In paragraph 26 of the JMS (JMS paragraph 26) the Transmission Licensees have proposed a metric for “network asset condition” based on estimated remaining useful life, being Asset Health Indices generally categorised as follows:

Item	Remaining Useful Life (Years)	PB observation – historic interpretation
a.	0-2 Years	Projects in train – now - will be done unless there are problems - definite
b.	2-5 Years	Remainder of Price Control – soon – may be done but good chance of being reprioritised/deferred
c.	5-10 Years	Next Price Control – medium term – likely to be reprioritised/deferred – not likely to be brought forward
d.	>10 Years	Beyond Next Price Control – longer term – uncertain when it will be done

NGET has further proposed its own Asset Health Indices, generally classified in supporting documents as Priority 1 (clear case for short-term replacement) to Priority 4 (no known technical/condition issues with the asset or its family). The proposals for Asset Health Indices are derived from condition based Priority Groups as developed initially in previous versions of Engineering Policy Statement (EPS) 12.7, Transformer Replacement and Refurbishment, and transformers appear to be the only asset category for which historic condition grade data may exist. Another point is that NGET’s Asset Health Index 2 (Developing Problems) may be further sub-divided, the sub-divisions varying between asset category.

Our principal observations are as follows.

- the categorisation of Asset Health Indices into four principal categories:
    - o a four-grade scale is proposed with sub-divisions which differ between asset categories[1]. While this categorisation might be as good as could be expected given existing asset condition reporting processes and data any analysis undertaken would be limited by the discontinuous and discrete intervals of the grading scale; future refinement may permit a finer scale so as to enable more meaningful further analysis, including calibration of remaining useful lives
    - o corresponding Asset Health Indices are identified for four asset groups only, circuit breakers, transformers, overhead line conductors and underground cables but no mention is made of other major asset groups such as overhead line fittings and towers or protection and control
    - o reflects the reporting format in the DRRP (with the intention of enabling comparison with the reporting by the Distribution Network Operators (DNOs)), namely 0-2 years, 2-5 years, 5-10 year and >10 years; this format may suffice for reporting but
    - o does not facilitate (external) qualitative analysis or modelling including calibration against existing fault rates and analysis of faults based on asset health progression and/or prediction of replacement requirements on an annual basis
- no proposals are provided for calibrating Asset Health Indices against either fault rates or remaining useful lives (predicted rate of deterioration) - the Transmission Licensees need to explain how residual lives are determined in the first instance (for example, would the residual lives be the number of years the plant may remain in service before the level of deterioration becomes unacceptable regardless of where it is located on the network, its geographical location or the importance of its function (i.e. its criticality)?
- the expected time intervals for the migration from one Asset Health Index to another are large, reflecting the reporting format and the limited number of grades of Asset Health Indices
- processes for the scoring of asset condition to derive Asset Health Indices appear to be limited and
- no mention is made in the JMS of how (efficiency of) historical and forecast expenditure

[1] A four-grade scale represents fewer grades than are being adopted by other workers in this field albeit for distribution assets. Work on the application of Asset Health Indices to transmission assets is however proceeding, notably the work of the Transmission Underground Cables Interest Group of CEATI International covering oil insulated pipe type cables to 225kV (see Cigre Osaka Symposium 2007 Paper 227).

would be assessed, from the viewpoint of condition amongst other things; the Transmission Licensees acknowledge that such historical data may not exist, as acknowledged in Licence Condition B17, paragraph 5c

- without calibration and normalisation, the asset health indices will not allow 'the objectives' (comparative analysis over time as per Licence Condition B17, paragraph 4 c), to be met; i.e. Ofgem would need to know that, for example, NGET's assessment of '2-5 years residual life' carried the same level of risk of failure or the same onset of significant deterioration as SPTL's. (It could, of course, be arranged for NGET and SPTL to assess the health indices for a sample of each other's plant to see if the assessments are aligned.) and
- we therefore consider that it is crucial that the assessment of residual life is uniformly applied across the three Transmission Licensees as a first step.

Network risk

Transmission Licensees' proposal. In Section 5.2 of the JMS, Network Risk – paragraph 39, the Transmission Licensees have proposed the following definition of Network Risk:

"The likelihood and consequence of a potential negative impact to the network, as a result of a future event."

In paragraphs 37 to 57, the Transmission Licensees have also proposed using the concept of criticality (defined as system, safety and environmental criticality) to establish "Replacement Priorities" by modifying some of the remaining useful lives indicated by the Asset Health Indices. The modification to the remaining useful lives would be based on a "Criticality Index" (low, medium or high) and the effect would be to bring forward or delay some of the asset replacement. The quantities of assets thus modified would be known as "Replacement Priorities" and would be quantities of assets to be replaced in discrete time intervals, namely 0 to 2 years, 2 to 5 years, 5 to 10 years and beyond 10 years (the intervals lining up with the Asset Health Indices).

We consider the proposed definition of Network Risk in the JMS to require supplementing and our main observations of the Replacement Priority approach are that:

- the Replacement Priority approach is an application of risk mitigation to prioritise asset replacement but the Network Risk itself is not quantified or defined thereby, nor is a risk profile with time indicated
- life cycle costing techniques, as advocated in Cigré Technical Brochure 248 - Guide on Economics of Transformer Management, are not considered at all
- bringing forward of replacement of assets of a given health index is at discrete intervals (e.g. from 2 to 5 years to 0 to 2 years) and is therefore discontinuous and a coarse adjustment, instead of, say, a methodology which allowed adjustments to be made a year at a time
- it should be made clear by the Transmission Licensees that replacement could equally

either be brought forward, not changed or delayed.

- a process for combining of system, safety and environmental criticalities on a common basis is not provided and is essential if criticality is to be addressed; in JMS paragraph 86 the Transmission Licensees have listed the development of a comparable scale for System, Safety and Environment Criticality as being subject to future development work

- system criticality, as described in NGET's document TGN(E) 226:

    - would appear to be concerned with delivery points only

    - does not indicate how connecting circuits would be treated

    - does not indicate the proportions of substations and circuits in each criticality category overall and

    - does not appear to take account of risk mitigation already provided by GB Security and Quality of Supply Standard (SQSS).

The Transmission Licensees acknowledge that further work is required on the concept of Replacement Priorities and to Network Risk in general, including the delivery of criticality as an intermediate step.

Influence of criticality. Criticality is very site/geography specific and so the corresponding quantification and comparison of risk is complex. In practice these considerations may preclude the assessment by third parties of network risk on large networks.

Furthermore, in our view, criticality should only be an issue for short range expenditure planning otherwise the definition of residual life would become inappropriate. At a price review, therefore, we consider that it is important that the Transmission Licensees provide details of residual lives per asset category (before criticality-based prioritisation) and the forecast for residual life art the end of the incoming regulatory period to see the proposed movement (if any). Could it be anticipated that criticality should not re-prioritise significant asset replacement from more than seven years away to bring it inside the next period? (The forecast for the period, i.e. the Price Review submission, is made approximately seven years before the end of the period.) Any prioritisation from outside the new regulatory period to within the period should be specifically identified in terms of location, quantities and numbers of years of advancement.

Supplementary approaches for consideration for a network risk index. We propose that the following supplementary approaches for a network risk index be considered. If these approaches are not currently possible, it is proposed that these be considered in the future:

a. weighted average remaining life (WARL) index would have the advantage of being readily calculable but would be only an indirect indicator of risk and would not take account of criticality

b. a WARL index modified to reflect criticality, in which the residual lives would be weighted further by an (empirical) factor to take account of criticality, thereby indicating the sensitivity of the index to criticality

c. weighted index based on availability, in the manner of the Australian Service Target Performance Incentive Scheme, including weightings of availabilities of critical circuits; one of the elements of unplanned unavailability, namely fault rate could be related to asset condition and furthermore interruption durations could be related to (arguably) finite availability of resources (in the event of numbers of faults increasing) and

d. a network (weighted) risk index in terms of economic worth at risk be considered (Appendix C), noting that such an index would be criticality dependant, our caveats on the modelling of criticality and its being more applicable to short term planning.

Network performance

In paragraph 62 of the JMS the Transmission Licensees have proposed the following principal measure of Network Performance:

“Average Circuit Unreliability is derived from the unavailability of the network due to outages occurring as a result of reliability reasons which cannot be deferred until the next planned intervention and is defined as:

$$\frac{\text{Total number of Repair Days (cumulative across circuits)}}{\text{Number of Circuits x Days in reported time period}}$$”

We comment that:

- a further explanation is required of the proposal to adopt NGET’s Key Performance Indicator (KPI) of Average Circuit Unreliability in addition to availability/unavailability (planned and unplanned) as in the GB Transmission System Performance Report and the TRRP Table 4.3; there are differences between the definitions (weighting by “Repair Days” instead of by hours; there are also exclusions of certain outages from Average Circuit Unreliability); one possibility would be for the Transmission Licensees to provide a reconciliation between the two methods

- the unavailability data as provided in TRRP Table 4.3 is insufficient and further data is required, by asset type and voltage level, corresponding fault rates, restoration times provided by time bands (and not just simple averages), faults disaggregated either into condition/non-condition related , urgent/non-urgent and/or capex/opex; the data should also permit the view of trends

- data on hazard rates (fault rates of remaining population) should similarly be compiled

- the Transmission Licensees should state the effectiveness of the proposed measures in providing an early indication of significant asset deterioration

- the increase in NGET's transformer unavailability in the year 2007/8 could be a useful test case for indicating the onset of significant asset deterioration, if that indeed be the case in this instance and

- clarification is required of the term "circuits" in calculating unavailability/unreliability.

Network capability

The Transmission Licensees have proposed two metrics for "network capability", namely for assessing the:

- Main Interconnected Transmission System (MITS) capability: Required boundary transfer capability relative to actual capability and

- exit point capability: Number of substations within (demand/non-SGT capacity)% bands for intact, N-1 and N-2 (>300MW) conditions, in effect providing an indication of the utilisation of the network at exit points.

The following output measures should also be considered to meet the objectives of the Licence Condition:

- effectiveness of measures to release additional capacity or change the generation mix to provide an understanding of the extent and cause of constraints

- Transfer distance (MW.km)

- zonal capability

- power factor and reactive power margin

Recommendations (Section 6)

The recommendations of this report are that the Transmission Licensees should be asked to expand their submission in general to meet the requirements of Paragraphs 5(a) and 5(b) of Licence Condition B.17 (analysis and reports relevant to the development of the network output measures … to indicate how the proposed methodology facilitates the objectives) in detail as per the headings in Licence Condition B.17 paragraph 2 as indicated below.

1) **Network Asset Condition**

   Short/medium Term Assessment

   a) **Current condition of assets**

      A (future) refinement of the proposed four-grade scale, if practical, may include a finer scale enabling further analysis, including calibration of remaining useful lives.

   b) **Reliability of network assets**

      Proposals should be submitted for the calibration of the Asset Health Indices in terms either of fault rate, remaining useful lives and/or predicted rate of deterioration; the relationship between Probability of Failure and Asset Health Index should be determined thereby to enable analysis; specifically fault (hazard) rates should be complied as functions of (separately) condition and age, these being essential for normalisation and validation purposes.

c) **Predicted rate of deterioration**

i) A justification should be provided for statements to the effect that an asset with a particular Asset Health Index would be expected to deteriorate to lower (condition) Asset Health Index within a given interval; measurements of key condition indicators than would support such statements including calibration.

ii) Proposals are required for key indicators of deterioration in asset condition (e.g. variation in hazard rate (i.e. the rate at which the remaining items fail) or "upturn of the bathtub curve"); details of the definition of rate of deterioration and policy for each major asset category.

d) **Present and future ability to perform function**

It would appear that if requirements a) to c) are met then d) is implicitly met.

Long Term Assessment

a) **Current condition of assets**

The reporting of asset age profiles and asset lives should be retained to enable the assessment of replacement asset quantities in the longer term.

b) **Reliability of network assets**

As short term assessment a).

c) **Predicted rate of deterioration**

As short term assessment a).

d) **Present and future ability to perform function**

As short term assessment a).

2) **Network risk**

Short/medium term assessment

a) Firstly the Licensees' process should have the Asset Health Indices (calibrated and normalised) generated as base data per asset category; secondly then an assessment of how these assets are classified as critical, subject to agreement between the Licensees on definitions (calibration) of criticality

b) An Intermediate Step, delivery of criticality, is therefore required to amplify the proposed definition of Network Risk in JMS paragraph 39 and to quantify Network Risk as such; consideration should be given to further quantifying the relationship between Network Risk and variation in expenditure

c) As the proposed Replacement Priority process is a prioritisation process and does not provide either a definition of network risk or a risk profile (with time) i.e. variation of risk (however defined) with time, further consideration should be given to the adoption of a risk definition in terms of the frequency of an event occurring compared with its consequence; paragraph 40 in the Joint Methodology Statement (JMS) needs to expanded to explain why optimised replacement is a proxy for risk and what the nature of risk is

d) the proposed Replacement Priority process should in any case be reviewed to:

   i) reduce the step changes in Replacement Priorities with Criticality Index

   ii) combine the system, safety and environmental criticalities

e) techniques for prioritising asset replacement should include an element of life cycle costing and/or cost/benefit analysis

f) The output measure of network risk should provide a high level indication of the relationship between network asset condition (remaining lives) and network performance and, in so doing, provide an early indication of the possibility of a “spiral of decline” if asset replacement/refurbishment/repair was insufficient

g) We would consider a criticality based approach to be a short term risk management issue; accordingly we would suggest that a network (weighted) risk index in terms of economic worth at risk be considered (Appendix C), noting that such an index would be criticality dependant and our caveats on the modelling of criticality and its being more applicable to short term planning,

   whereby the Network Risk Index would be related to

   - asset condition and the interdependence between network assets (Licence Condition B17, paragraph 2b)
   - unserved energy
   - reliability worth of supply (Value of Lost Load (VOLL)/System Customer Outage Cost (SCOC)
   - monetary equivalents of safety and environmental criticalities, or where there are qualitative elements within the definition of criticality a means whereby qualitative and quantitative elements can be compared and

h) If a scoring system for assessment of criticality (ScottishPower) is proposed instead, then the methodology for allocating the scores should be provided.

Long term assessment

i) We propose that the following supplementary approaches for a network risk index be considered. If these approaches are not currently possible, it is proposed that these be considered in the longer term:

- weighted average remaining life (WARL) index,
- criticality modified WARL index, indicating the sensitivity of the index to criticality and
- weighted index based on availability, in the manner of the Australian Service Target Performance Incentive Scheme, and also weighted for safety and environmental considerations.

3) **Network performance**

a) In addition to declaring the annual Estimated Unsupplied Energy and related incidents, the corresponding “System Minutes” index should also be declared, including major incidents where this index is greater than one minute, so as to enable comparison with other transmission networks worldwide.

b) an explanation should be provided of the proposal to adopt the output measure of Average Circuit Unreliability instead of planned/unplanned availability as at present; a reconciliation between the two methods should also be provided.

c) further disaggregation of the unavailability data is required, by asset type and voltage level, restoration times provided by time bands, faults disaggregated either into condition/non-condition related, urgent/non-urgent and/or capex/opex; the data should also permit the view of trends; NaFIRS provides a suitable precedent for the compilation of such fault data.

d) NGET should provide a reconciliation between the number of unplanned circuit outages in TRRP Table 4.3 (System Performance) and the number of faults in TRRP Table 4.5 (Fault Reporting); noting that the system unavailability data in TRRP Table 4.3 is from the Transmission Outage Planning and Monitoring (TOPAM) database and the fault data in Table 4.5 is from the MIMS work management system; furthermore the information provided in the TRRP is insufficient to say whether there is a direct correlation between the number of unplanned circuit outages in 2006/7 (280 in TRRP Table 4.3) and the number of faults in that year (275 in TRRP Table 4.5) – clarification should be provided - and

e) NGET should provide an amplification of TRRP Table 4.3 in which average durations and fault/interruption rates of planned and unplanned interruptions are derived from the unavailability and number of circuit outages data already provided; particular clarification is required on the asset quantities (e.g. from TRRP Table 4.12 (Asset Age)) that would be used to derive the fault rates and the interpretation of the term “circuits” in respect of transformers and reactors, switchgear, overhead lines and cables in calculating average durations of outages (for example a reconciliation of "circuits" with either asset quantities in TRRP Table 4.12 or with Tables B.2.1 in the Seven Year Statement).

4) **Network capability**

Additional output measures should be considered in respect of Network Capability, namely effectiveness of measures to release additional capacity and the effect of generation mix in order to provide an understanding of the extent and cause of constraints, the reactive power margin within each zone that is associated with boundary transfer metric suggested by the Licensees, the transfer distance (MW.km), and the within zone capability of each zone (Cigré Technical Brochure 24 - Planning against voltage collapse - refers). In addition, given the rise in reactive power consumption reported in the last TPCR, it is recommended that power factor is also reported on a zonal basis.

5) **SPTL**

As SPTL has provided only a relatively brief high level description of its asset management processes (largely unchanged from the Main TPCR) but with little detail of proposed output measures, SPTL should therefore be asked to provide details of its proposed output measures as these are developed.

PB Power recognise that there is a the need to ensure that the proposed output measures are proportionally applied to SPTL, particularly when compared to NGET. How this will be achieved will only become clearer when the high level description provided is supplemented.

6) **SHETL**

As SHETL has also provided only a brief description of its specific implementation details regarding each of the elements of the Network Output Measures, SHETL too should therefore be asked to provide details of its proposed output measures as these are developed.

In a similar way to SPTL, there is a need to ensure the proposed output measures are proportionally applied to SHETL.

Table E1 – Comparison of output measures proposed by Transmission Licensees and recommendations by PB Power

Condition B17 Category	**Output measure proposed by Licensee**	**Output measure recommended by PB Power (where these are not currently possible they should be considered in the future)**
Network asset condition	**Short/Medium Term Assessment:** Asset Health Indices based on estimated remaining useful life (0-2 yrs, 2-5yrs, 5-10yrs, >10yrs) **Long Term Assessment:** Age based modelling	As per Licensee proposal plus: **Short/Medium Term Assessment:** If practical, finer and more consistent scale of Asset Health Indices; Calibration of Asset Health Indices; asset hazard rates
Network risk	Replacement Priorities based on modifying Asset Health Priorities according to System/Safety/Environmental criticality of assets	As per Licensee proposal plus: **Short/Medium Term Assessment:** Frequency versus consequence definition Life cycle costing for prioritisation **Long Term Assessment:** WARL, Availability or Network (weighted) Risk Index
Network performance	Average Circuit Unreliability	As per Licensee proposal plus: Average Circuit Unreliability (Unavailability) by major asset category and voltage, restoration times by time bands, faults disaggregated into: condition/non-condition related, urgent/non-urgent/capex/opex; trends System Minutes.
Network capability	MITS: Required boundary transfer capability relative to actual capability Exit: Number of substations within (demand/non-SGT capacity)% bands for intact, N-1 and N-2 (>300MW) conditions	As per Licensee proposal plus: Expansion of boundary transfer capability metric Zonal assessment (Revenue Driver Values) Transfer distance (MW.km) Power factor and reactive power margin

1. INTRODUCTION

Ofgem's Final Proposals for the 2006 Transmission Price Control Review introduced a licence obligation for the electricity and gas transmission licensees of Great Britain (GB) (the Transmission Licensees) to develop a methodology to enable evaluation of the following:

a) the current condition of the assets which collectively form the licensee's transmission system (including the condition of the principal components of those assets) (collectively, "network assets"), the reliability of network assets, and the predicted rate of deterioration in the condition of network assets which is relevant to making assessment of the present and future ability of network assets to perform their function ("network asset condition");

b) the overall level of risk to the reliability of the licensee's transmission system as a result of network asset condition and the interdependence between network assets ("network risk");

c) those aspects of the technical performance of the licensee's transmission system which have a direct impact on the reliability and cost of services provided by the licensee as part of its transmission business ("network performance");

d) the level of the capability and the utilisation of the licensee's transmission system at entry and exit points and other network capability and utilisation factors ("network capability");

These obligations are set out in Condition B17: Network Output Measures.

National Grid Electricity Transmission Ltd (NGET), SP Transmission Ltd (SPTL) and Scottish Hydro-Electric Transmission Ltd (SHETL) are collectively developing proposed output measures and a methodology for their determination.

PB Power has been commissioned, with respect to output measures, to:

- Review the electricity transmission and distribution licensees' present practice and capabilities. This is considered in Section 2 of this report.
- Review international electricity transmission and distribution practice. This is considered in Section 3 of this report.
- Review relevant commercial industries practice. This is considered in Section 4 of this report.
- Review the licensees' draft methodologies. This is considered in Section 5 of this report.

Conclusions are presented in Section 6.

2. REVIEW OF ELECTRICITY TRANSMISSION AND DISTRIBUTION LICENSEES' PRESENT PRACTICE AND CAPABILITIES

2.1 General

The electricity transmission and distribution licensees in GB have historically reported on a number of metrics. The recently introduced Regulatory Reporting Packages for both the transmission and distribution further developed some of the thinking on output measures. These are discussed for transmission and distribution respectively in the following sub-sections.

2.2 Transmission

The GB Transmission System Performance Report[2] that is produced annually by National Grid as GB System Operator[3] includes the following metrics:

1. GB System Availability
    - Monthly System Availability
    - Annual` System Availability
    - Annual Winter Peak System Availability
    - Monthly Planned & Unplanned Unavailability
2. Interconnector Availability
    - Annual Availability
    - Monthly Unavailability
3. GB System Security
    - Overall Reliability of Supply
    - Number of Incidents
    - Estimated Unsupplied Energy
    - Incident Details

[2] Report to the Gas & Electricity Markets Authority, GB Transmission System Performance Report, 2006 - 2007

[3] Prior to 2005/06 and the implementation of BETTA, the three transmission licensees reported separately to Ofgem on system performance.

4. GB Quality of Service

    - Voltage
    - Frequency
    - Frequency Standard Deviation

The document presents the metrics for each of the Transmission Licensees (NGET, SPTL and SHETL) and also as a whole GB. The document also includes details of incidents that resulted in loss of supply and it is of note that these incidents largely resulted from:

- Non-damage faults, typically lightning or snow storms
- Protection and control issues
- Operational conditions (inadvertent operation of protection during a planned outage)
- SHETL's losses of supply are predominantly due to storms affecting the relatively sparse 132kV network in the Highlands and Islands Region of Scotland
- Few causes of losses of supply appear to be related to the condition of the plant as addressed in Licence condition B 17 (historic expenditure may have been sufficient to prevent the average condition of plant from deteriorating – or historic expenditure has been driven by safety and environmental considerations – or both of these – and the security of supply standards are effective).

The nature of the incidents suggests that there may be a need for the metrics to focus on the supporting assets (secondary assets) as well as primary assets and operational issues.

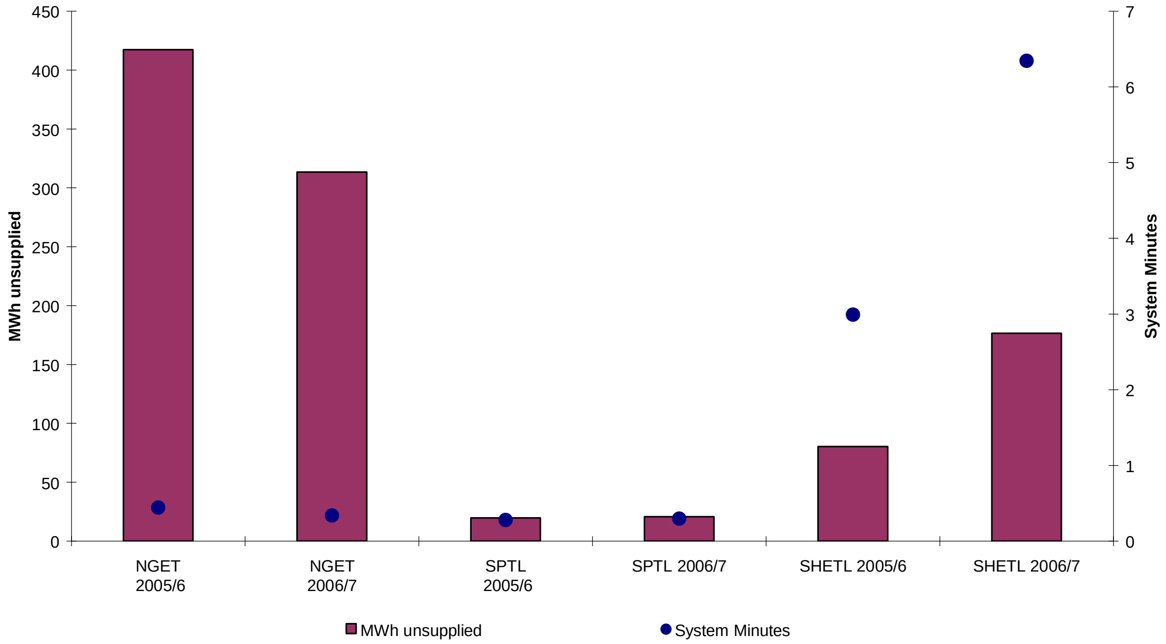
Figure 3.1 presents the un-supplied energies for the years 2005/06 and 2006/07, both as MWh unsupplied and normalised as "System Minutes" to the Cigré convention[4].

The unsupplied energy figures are total including those incidents where three or less customers are affected. Both NGET's and SPTL's levels of System Minutes are an order of magnitude lower than other published comparators due to compliance with the SQSS and highly integrated configurations of their networks.

[4] System Minutes (SM) where:

SM	=	(ENS/PL) x 60	(minutes/year)
ENS	=	Energy Not Supplied/year, transmission losses excluded (MWh/year)	
PL	=	Peak Load (MW).	
Source:		Unipede: Availability of Supply, Ref: 04000Ren9706, April 1997 and Cigré (www.cigre.org) defines a major system disturbance as having a system-minute equal to or greater than one.	

Figure 2.1 - Unsupplied Energy of NGET, SPTL and SHETL for 2005/6 and 2006/7



Furthermore the transmission operators are also subject to a transmission network reliability penalty / incentive scheme, an example being Special Condition D5 of NGET's licence, whereby NGET receives an incentive payment if the unsupplied energy is less than the target level and vice versa. It is understood that this incentive scheme was introduced to address operational measures following the London blackout in August 2003.

Since the 2006 Main Transmission Price Control, Ofgem has embarked on a number of initiatives to consider the matter of reporting further. In addition to the performance indicators detailed above, the Transmission Licensees report in the annual TRRP, by main asset category (transformers, overhead lines, cables, switchgear)[5], on:

- Defects – a non-conformance from specified requirements, which is identified from maintenance, inspection, observation or alarm and requires investigation, possibly involving planned disconnection of plant, and/or further remedial action.
- Faults – an event which causes plant to be automatically disconnected from the HV system for investigation and further action if required.
- Failures – as defined in Instructions and Guidance but essentially where asset/component has to be replaced.
- Condition – according to Transmission Licensees' condition grading categories.

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[5] Ofgem: Electricity Transmission Price Control Review, Price Control Review Reporting Rules: Instruction and Guidance, April 2008.

- Boundary transfers relative to their capability
- Demand and supply capacities at substations under intact, N-1 and N-2 conditions
- System utilisation (MW.km)

The above metrics therefore provide a basis from which to embark on meeting the objectives of Licence condition B.17.

We are however unaware of any systematic compilation of fault rates, restoration times or trends thereof by asset type and nor does there appear to be any sharing of such data between Transmission Licensees although 132 kV data has been shared between the two Scottish Transmission Licensees and the DNOs, at least in the past. **There may be merit in formalising systematic compilation of these statistics at the transmission level.**

2.3 Distribution

In a similar manner to transmission, the Distribution Network Operators (DNOs) are required to report on performance. This information is published annually by Ofgem[6] and includes:

- the number and duration of interruptions to supply per year
- the quality of telephone response
- the number of short interruptions to supply per year
- disaggregated information on interruptions by source, voltage and HV circuit.

There is also a Distribution Regulatory Reporting Package in which Ofgem requests similar items to those requested in the TRRP including quantities of assets due for replacement within given time frames e.g. remaining life <2 years, 2 to 5 years, >5 years.

We understand that most DNOs participate in the National Fault and Interruption Reporting Scheme (NaFIRS®), administered by the Energy Networks Association (ENA). NaFIRS reports, which are confidential to participating members of the ENA, include detailed breakdowns, for each of the preceding five years, of fault causes for each principal distribution asset type. Fault rates (including five year trends) and urgent/non-urgent mean restoration times are also provided. NaFIRS data is essential to the reliability modelling carried out by the DNOs[7].

In addition the ENA also operates the National Equipment Defect Reporting System (NEDeRS®) whereby ENA members (transmission and distribution licensees) are alerted to

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[6] Electricity Distribution Quality of Service Report, Ofgem

[7] ENA; ER G43, Instructions for Reporting to the National Fault and Interruption Reporting Scheme

any major defect, generally with operating and safety implications, being encountered on plant and equipment (i.e. operating “embargos”).

3. REVIEW OF INTERNATIONAL ELECTRICITY TRANSMISSION AND DISTRIBUTION PRACTICE

A review of international electricity transmission and distribution practice, limited to “best practice”, in output measures and asset management has been undertaken.

In Table 3.1 included towards the end of this section, examples of published system performance related metrics are presented for a number of utilities around the world. In Table 3.2 examples of asset related fault and interruption reporting are presented. Table 3.3 reviews asset management techniques specific to the planning of asset strategies.

3.1 System performance related metrics

Regarding Table 3.1 the main findings are that:

- a number of international transmission system operators disaggregate availability and unavailability further than in the annual GB Transmission System Performance Report, by cause and in particular by asset type – an example of good practice is EirGrid's Transmission System Performance Report 2007. **At this early stage in the development of metrics for the Transmission Licensees there may be merit in adopting a more disaggregated approach than currently proposed by the Transmission Licensees**

- a number of utilities declare System Minutes as a metric in accordance with the Cigré convention discussed in Section 2. This metric normalises unsupplied energy (MWh lost) by GW maximum demand to enable comparison with other transmission systems. **To permit international comparisons there would be merit in adopting a metric of System Minutes in GB**

- as a particular example, the Service Target Performance Incentive Scheme in Australia provides a practical method of providing an incentive to the Electricity Transmission Network Service Providers to minimise network outages; the performance metric parameters for SP AusNet in Victoria are[8]:

    1) total circuit availability, and

       the transmission circuit availabilities of:

       - critical circuits at peak load
       - non-critical circuits at peak load
       - critical circuits at intermediate load

[8] Australian Energy Regulator (AER); Final decision, SP AusNet transmission determination 2008-9 to 2013-14, January 2009, www.aer.gov.au

- non-critical circuits at intermediate load

2) loss of supply event frequency, number of events per annum where the system minutes incurred are respectively greater than 0.05 minutes and 0.3 minutes per annum

3) average outage duration of transmission lines and transformers,

where the metric parameters are weighted in the "service" or "s" factor formula and then applied to the maximum allowed revenue, some 1 per cent of the annual revenue being at risk (the amount of the incentive or penalty is subject to limits). **As half of the incentive weighting is in respect of availabilities alone, and as these include planned outages, much of the revenue at risk is under the control of the Transmission Network Service Provider.**

3.2 Asset related fault and interruption reporting

Regarding Table 3.2, the main findings are:

- good examples exist of definitions of the type of data required (Cigré surveys (occasional), Canada's ERIS five yearly reporting on the Forced Outage Performance of Transmission Equipment, Nordel's annual Grid Disturbance and Fault Statistics) and of standard definitions (FERC's TADS, IEEE and IEC).

- The Transmission Licensees do not appear to have reported on fault rate, fault cause and repair time information in a systematic manner in contrast to the long established reporting by most of the DNOs under the National Fault and Interruption Reporting Scheme (NAFIRS) administered by the Energy Network Association (ENA). **As suggested previously, there may be advantages in so doing on a common basis to allow comparison with internationally sourced data.**

3.3 Asset management techniques specific to asset strategies

Regarding Table 3.3, the main findings are:

- Cigré Technical Brochure 309, Asset Management of Transmission Systems and Associated Cigré Activities, December 2006, expands the concept of risk in terms of probabilities of asset failures, their consequence and relationship with the business values of the transmission owner; the Brochure discusses the:

    - key performance indicators of asset health (e.g. mechanical integrity of overhead lines)

    - distinction between Major Failures (or simply failures) and minor failures (defects)

    - derivation of Asset Health Indices

    - criticality, being the impact of outages and failures on important delivery points

   - existing practices and identifies areas for future investigation by Cigré Study Committees

   - Asset Risk Management example, from Nuon in the Netherlands, including risk evaluation procedures for prioritisation of expenditure

- limited information is in the public domain on the variation of failure rates with asset condition and, separately, with asset age; modelling of failure rates against asset age and/or condition is the subject of a number of recent papers however

- Cigré Technical Brochure 248, Guide on Economics of Transformer Management, June 2004, is recommended as a reference for methodologies for a "Risk-Based Decisions Process for Investment in Power Transformer Replacement" including economic/financial analysis of net present values in monetary terms taking into account cost of energy not supplied; the Brochure also contains outline data of failure rate by age and failure rate by condition

- Asset Health Index based processes for risk management are becoming established and are being developed further, principally for distribution assets, although coverage within a given distribution network operator's asset base may not be complete and

- no standardised methodology or terminology for asset health indices exists however and the processes require appreciable data on the condition of assets (where data collection is dependent on intrusive maintenance, the data collection period may extend to 12 to 15 years; nevertheless prioritisation of data collection may facilitate worthwhile analysis in a shorter period).

Considerable work is being undertaken in the United Kingdom, Canada and elsewhere to relate fault rate with asset condition category and (for a given asset condition category) with age. Most of this work however relates to distribution assets where quantities are larger and analysis more amenable to statistical techniques although Hydro One in Ontario, Canada, is applying asset health indexing to its transmission as well as distribution assets. In general the establishment of trends takes both time and the availability of consistent statistical records[9].

Figure 3.1 illustrates an example of an age dependent modelling of component failure rate with age where the fault rate is assumed to vary exponentially with age. The dependency would be adapted according to available statistical information and the parameters also varied with asset condition. Modelling could then be undertaken, say, to determine the level of asset replacement/refurbishment to keep the fault rate constant for a given asset type. Examples from Germany and France of the application of such approaches have recently been presented by Cigré. The approaches are, however, in relatively early stages of development. Similarly the availability of adequate statistical data for transmission assets needs to be ascertained.

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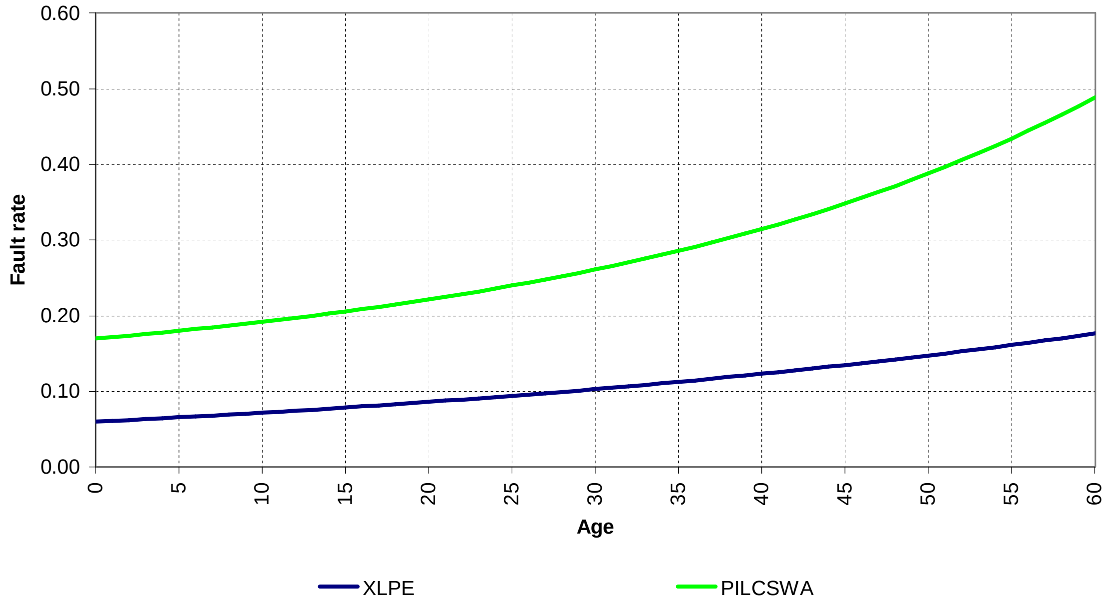
[9] An example of an international collaborative programme is Annex III "Infrastructure Asset Management Phase 1 – Distribution Systems" of the IEA ENARD project, for which EA Technology is the operating agent.

Figure 3.1 - Example of cable fault rate trend with age



3.4 Duration of outages

Examples of alternative conventions for reporting durations of outages are:

- (as is reported by EirGrid) the declaration of numbers of outages by the following time bands ≤ 10 minutes, ≤ 1 hour, ≤ 1 day, ≤ 1 week, ≤ 2 weeks, ≤ 3 weeks, ≤ 4 weeks, > 5 weeks
- (NaFIRS) Average interruption duration/restoration time (urgent/non-urgent)
- Other methods of outage classifications may be considered. e.g. in North America NERC's TADS requires the reporting of:

  a) outage frequency per element (sustained, momentary (< 1 minute), total)

  b) for circuits, outage frequency per 100 miles

  c) for sustained outages:

     i) outage duration per element

     ii) Mean time between failures (MTBF)

     iii) Mean time to repair (MTTR)

     iv) Median availability

  d) per cent availability

e) per cent of elements with zero outage

f) per cent of element outages associated with disturbance report

g) 2008 is the first year of reporting, of automatic outages only; reporting of planned or deliberate outages is to follow in a second phase

Table 3.1 – Examples of Published System Performance Related Metrics

Country	Utility	Metric								
		System Availability Planned/unplanned by outage type	**System Availability Planned/unplanned by equipment type**	**Outage durations, number & type**	**Unsupplied energy (MWh lost)**	**Incidents of unsupplied energy (details)**	**Energy not supplied by voltage level & asset type**	**System Minutes Lost**	**Fault clear-ance rate, by distance zone**	**Long and short outage frequencies**
Australia	TransGrid[10]	X	✓	✓	X	X	X	✓	X	X
	SP AusNet[11]	✓	X	✓	X	X	X	✓	X	X
France	RTE[12]	X	X	X	X	✓	X	✓	X	✓
Great Britain	NGET/SPTL/ SHETL[13]	✓	X	X	✓	✓	X	X	X	X
Ireland	EirGrid[14]	✓	✓	✓	✓	✓	X	✓	✓	X
New Zealand	Transpower[15]	✓	✓	✓	X	✓	X	✓	X	X
Nordic Grid (Nordel)[16]	Energinet (DK) Fingrid (FI) Landsnet (IS) Statnett (NO) Svenska Kraftnät (SE)	X	X	✓	✓	X	✓	X	X	✓

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[10] TransGrid, Electricity Network Performance Report 2006/7, www.transgrid.co..au

[11] SP AusNet; Performance Against AER Service Standards Year Ending 31 December 2007, www.sp-ausnet.com.au. and AER; Final decision, SP AusNet transmission determination 2008-9 to 2013-14, January 2009, www.aer.gov.au

Similar (limited) information on the performance of other Australian Transmission Network Service Providers (TNSP) is presented by the Australian Energy Regulator (AER) in the TNSP Electricity Regulatory Report for 2005/06, www.aer.gov.au

[12] RTE; Technical Results French Electricity Supply Industry 2007 and French Power System Reliability Report 2006 (more detailed RTE quality indices are internal indicators only), www.rte-france.com

[13] National Grid; GB Transmission System Performance Report, www.nationalgrid.com

[14] EirGrid; Transmission System Performance Report 2007, www.eirgrid.com

[15] Transpower, Quality Performance Report 2006/07, www.transpower.co.nz

[16] Nordel, Grid Disturbance and Fault Statistics 2006, www.nordel.org

Table 3.2 – Examples of asset related fault and interruption reporting

Country	Organisation	Description	Metric: No. of failures	Failures with forced outage	Failures by sub-assembly	Failure rates	Restoration / repair time	Definitions	Comments
International	Cigré[17]	Electra No 88 1983 "An international survey on failures in large transformers in service."	✓	✓	X	✓	✓	✓	Includes UK data.
International	Cigré	1994 Session, Paper 13-202, "A Summary of the Final Results and Conclusions of the Second International Enquiry on the Reliability of High Voltage Circuit Breakers"	✓	X	✓	✓	X	X	Importantly distinguishes between major and minor failures; includes UK data.
International	Cigré	Technical Brochure 150: Report on the Second International Survey on High Voltage Gas Insulated Substations (GIS) Service Experience; WG 23.02, February 2000.	✓	✓	✓	✓	✓	✓	Includes UK data; very comprehensive survey
Great Britain	Energy Networks Association (ENA Confidential)[18]	NAFIRS, including analysis by fault causes and 5-year trends in fault rates and restoration times, for equipment up to 66 kV (In 1998/90 a 132kV system supplement was issued but the status of this document subsequent to Vesting in 1990 is uncertain.)	✓	✓	X	✓	✓	✓	Under NaFIRS®, information on electricity supply interruptions is distilled into annual reports of national and company performance; 2007 reports were issued to member companies in October[19]. – possibly superseded (to a limited extent) by Ofgem's distribution IIS.

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17 www.cigre.org

18 NAFIRS (National Fault and Interruption Reporting Scheme) was previously the responsibility respectively of the Electricity Council, subsequently by the Electricity Association and now the Energy Networks Association. http://2008.energynetworks.org/ . NAFIRS is available only to participating members of the ENA.

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Country	Organisation	Description	Metric: No. of failures	Failures with forced outage	Failures by sub-assembly	Failure rates	Restoration / repair time	Definitions	Comments
Canada	Canadian Electricity Association[20]	Equipment Reliability Information System (ERIS); Forced Outage Performance of Transmission Equipment covering overhead lines, cables, transformers and reactive compensation plant	✓	✓	✓	✓	✓	✓	Includes information by fault causes as well as unavailabilities – long established system but report entitled “Forced Outage Performance of Transmission Equipment” is available by purchase only.
Nordic Grid (Nordel)[21]	Energinet (DK) Fingrid (FI) Landsnet (IS) Statnett (NO) Svenska Kraftnät (SE)	Grid Disturbance and Fault Statistics 2006 covering overhead lines, cables, transformers, and reactive compensation plant	✓	✓	X	✓	✓	✓	Annual report which prior to 2006 was in Swedish.
North America (USA, Canada, (Baja) Mexico	North America Electric Reliability Council (NERC)[22] and Transmission Owners (TOs)	Transmission Availability Data System (TADS)						✓	Present benchmarking survey is conducted by SGS[23] – information available to participants only. TADS reporting commencing in 2008.
USA	IEEE[24]	IEEE Std 859-1987 (R2002) IEEE Standard Terms for Reporting and Analyzing Outage Occurrences and Outage States of Electrical Transmission Facilities						✓	Systematic precise definitions.
International	International Electrotechnical Commission (IEC)[25]	IEC 50(191-05-01): International Electrotechnical Vocabulary, Dependability and quality of service						✓	Available for purchase.

[20] www.canelect.ca

[21] Nordel, Grid Disturbance and Fault Statistics 2006, www.nordel.org

[22] www.nerc.com; Transmission Availability Data System Revised Final Report and TADS Definitions, 26 September 2007. Comments by TOs, including National Grid US, are also posted.

[23] www.sgsstat.com

[24] www.ieee.org

[25] www.iec.ch

Table 3.3 – Examples of asset management techniques specific to asset strategies

Country	Organisation	Description	Metric Survey of asset management activity	Asset Health Indices	Fault rate by asset age data	Fault rate by asset condition data	Risk	Criticality	Comments
International	Cigré[26]	Technical Brochure 309: Asset Management of Transmission Systems and Associated Cigré activities; WG C1.1, December 2006	✓	✓	X	X	✓	✓	High level overview of asset management processes applied to transmission systems
Netherlands	Nuon	Risk Management (Appendix 2 to Cigré Technical Brochure 309)	X	X	X	X	✓	✓	Good methodology for quantification of risk and criticality
International	Cigré	Technical Brochure248: Guide on Economics of Transformer Management	X	X	✓	✓	✓	✓	Flow charts of Risk-Based Decisions process, including NPV analysis; data on failure rates by both asset age and condition
United Kingdom	EA Technology	Condition Based Risk Management (CBRM)	✓	✓	✓	✓	✓	✓	Process widely adopted by DNOs, as well as by some overseas operators
France	RTE	R Blanc et al; Transformer refurbishment Policy at RTE Conditioned by the Residual Lifetime Assessment, Cigré 2008, Paper A2-204	X	X	✓	X	X	X	Trends of serious failures (outage > 8 days) and forced outage anomalies against age for 225 kV and 400 kV transformers
Germany	RWE/EnBW	C. Neumann (RWE) et al; Strategy for End of Life Assessment for High Voltage Circuit Breakers; Cigré 2008, Paper A3-101	✓	X	✓	X	X	✓	Methodology for supporting the decision making process for the end of life of equipment
Germany	Siemens/ RheinEnergie/ RWE Energy	M Schwan et al; Risk-based Asset Management for Substations in Distribution Networks considering Component Reliability; Cigré 2006, Paper B3-104	✓	✓	✓	X	✓	X	Proposes methodology for modelling asset health indices against age

[26] www.cigre.org

Country	Organisation	Description	Metric Survey of asset management activity	Asset Health Indices	Fault rate by asset age data	Fault rate by asset condition data	Risk	Criticality	Comments
France	EdF (Distribution)	E. Dorison, F Lesur; A Tool for Ageing Underground Links Management: The Health Index; Cigré Osaka Symposium 2007, paper 227	X	✓	X	X	X	X	Discussion of theoretical derivation of asset health indices for cables
Canada	Hydro One, Ontario	I. Bradley, J. Ciufo, A. Cooperberg, C. Tavener; Life-cycle management for System Protection, T&D World, June 2007	X	✓	X	X	X	X	Practical application of condition ratings to obtain asset health indices for protection assets. Hydro One has a well developed asset based process for considering asset condition, risk, functionality, criticality to derive asset programmes.
Canada	BC Hydro	BC Hydro; Report on (distribution) Performance 2005	X	✓	X	X	✓	X	Asset Health Risk Index is the percentage of Distribution Assets rated in fair or poor condition through an annual assessment of asset health; achieved target as increased maintenance spending helped to prevent asset health from declining

4. REVIEW OF RELEVANT COMMERCIAL INDUSTRIES PRACTICE

4.1 General

An essential part of understanding the output measures employed by regulators in other industries is the lessons of experience it provides. Best practice examples that can be gained from this exercise is in its potential to guide in establishing relevant and more effective measures of output, specific to the activity or sector rather than a prescribed measure that is employed for all activities across the board.

In view of this, section 4 examines key industries such as water, rail and roads to form a better understanding of how the performances, output of organisations that are part of their individual sectors are measured by the regulators.

4.2 Water

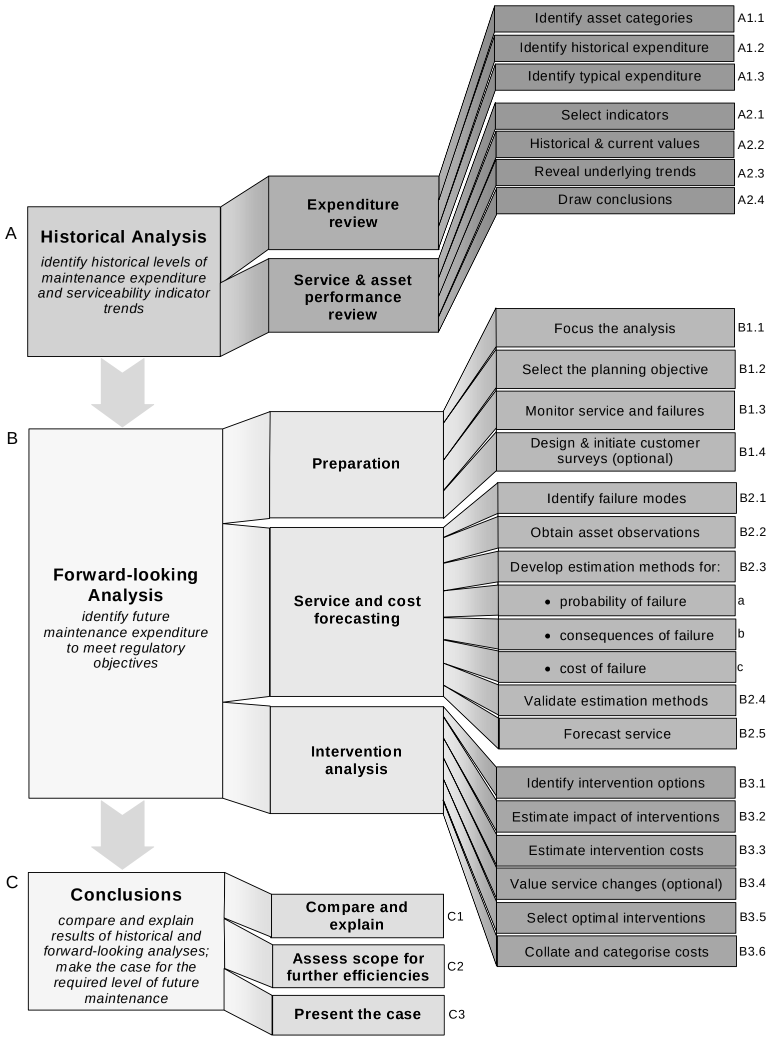
Ofwat, the Water Services Regulatory Authority is the economic regulator of the water and sewerage industry in England and Wales, tasked with regulating the industry ‘in a way that provides incentives and encourages the companies to provide quality service and value for customers’. The regulator does this by:

- setting limits on what companies can charge the customers;
- ensuring companies are able to carry out their responsibilities under the Water Industry Act 1991 as updated by section 39 of the Water Act 2003;
- protecting the standard of service customers receive;
- encouraging companies to be more efficient;
- meeting the principles of sustainable development; and
- helping to encourage competition where appropriate.

In doing so, the metrics by which the regulator measures output and service provided by companies (licensees) is water and sewerage services serviceability indicators and guaranteed standards of service for the customers of the companies.

The regulator also requires of the licensees to set out their approach to asset management planning to identify outputs and expenditure plans for capital maintenance. The proposed plan must ensure that serviceability to customers is at least stable at minimum levels of expenditure necessary for the delivery of the outputs. It is also emphasised that the capital maintenance planning 'common framework' (CMPCF, as set out in UKWIR report, reference 02/RG/05/3 and outlined in the diagram below) provides a robust basis for companies to plan their future capital maintenance requirements.

Figure 4.1 –The Common Framework for Capital Maintenance Planning:



Source: UKWIR Report Ref: No. 02/05/3

In a forward looking analysis, the regulator looks at both water and sewerage sectors individually in assessing the serviceability in each sector.

Maintaining service and serviceability
Water service
1 Planning objectives, direction and delivery
2 Approach to asset management planning by sub-service
3 Business case by asset group
4 Further table commentaries
Sewerage service
5 Planning objectives, direction and delivery
6 Approach to asset management planning by sub-service
7 Business case by asset group
8 Further table commentaries

1 and 5: Planning objectives, direction and delivery

The common framework provides for companies to estimate their future capital maintenance requirements to meet two possible objectives:

- a cost effective objective, to provide steady or improving service, to be used to justify base service provision;
- a cost benefit objective, to be used to justify a changed level of service in terms of targeted serviceability and an associated change to capital maintenance requirements.

All companies are obliged to meet the cost effectiveness objective.

In setting out its objectives for each sub-service (i.e. infrastructure and non-infrastructure for both water and sewerage) the company should explain:

- how the planning objectives have been influenced by stakeholder views (e.g. through willingness to pay surveys) and the long term company strategy (e.g. with reference to their strategic direction statement); and
- how the overall objectives relate to both current performance and the projected outputs. The company should review service and asset performance and selected indicators, including but not limited to, those used by Ofwat.

2 and 6: Approach to asset management planning

The company should set out its approach to asset management planning, specifically relating to capital maintenance planning. The commentary should make it clear where the processes and systems are applied across the entire programme or where aspects only relate to planning in particular sub-services. The commentary must be provided in the context of how the processes and systems are used to inform asset management planning and should be split into three sub-sections: management, processes and systems.

3 and 7: Business case by asset group

The company should describe the data it has used and analysis it has carried out to identify the future maintenance expenditure needed to meet the planning objectives and stated outputs. It should also present the case for all capital maintenance expenditure, including any 'exceptional' or 'atypical' items within the business case for the appropriate asset group. This overall to capital maintenance planning is then to be integrated across the business by the company which then is expected to set out the business case for expenditure according to the asset groups.

4 and 8: Further commentary

The company then can provide any additional commentary (not covered before) that is needed to fully explain its business plan for maintaining service and serviceability such as the historic levels of expenditure as well as operating expenditure figures summarised.

Customer Service Standards

Customers of water and sewerage companies are entitled to guaranteed standards of service, as set by the Government. If a company fails to meet any of the guaranteed standards, customers are entitled to a compensation payment. The standards include targets on making and keeping appointments, responding to account inquiries and dealing with planned or unplanned interruptions to the water supply.

As part of its guaranteed standards scheme to customers of the companies, the regulator identifies three categories of guaranteed standards of service scheme by which the companies must adhere to and customer related outputs are measured according to these standards.

Guaranteed Standards Scheme (GSS): payments made in full accordance with the provisions of the 'Water Supply and Sewerage Services (Customer Service Standards) Regulations 1989' (SI 1989:1159), as amended by SI 1989:1383, SI 1993:500, SI 1996:3065 and S1 2000: 2301. NB:

These standards are not the same as the levels of service performance criteria.

Where a standard GSS payment is made within a larger unrelated payment, only the GSS payment should be recorded in the GSS line. For example, a GSS payment may be included within a cheque for a rebate of charges;

Enhanced Guaranteed Standards Scheme: payments made for standards that, whilst based on the statutory GSS, go beyond the provisions of that scheme; for example, an increase in the level of payment made; a reduction in the qualifying period triggering a payment; or automatic payment made where the GSS requires the customer to make a claim for payment.

Company Customer Service Standards/Charters: payments made for company standards that fall outside of the provisions of the statutory GSS or go beyond an enhanced GSS. Also includes ex gratia payments.

This information enables Ofwat to identify the areas for improvement for both the sector and the companies in particular, analyse the trends, which may indicate declining asset condition at treatment works. This adds to the basket of indicators that together inform an assessment of serviceability to customers.

4.3 Road

Over the last decade, the way UK highway networks have been managed has been undergoing important changes. The UK Roads Liaison Group document 'Maintaining a Vital Asset' states that: "Continuing growth in traffic and its attendant problems has brought an increasingly widespread recognition of the importance of highway maintenance, and the high value placed on it both by users and the wider community. Conversely, public concern is increasing about failure to invest adequately and effectively in highway maintenance and the implications of this for safety and journey reliability. Inadequate maintenance only stores up even greater problems for the future. Recent increases in investment have been welcome and effective, but a sustained long term programme of investment in maintenance of the local highway network is crucial. This investment needs to be planned, efficiently managed and supported by effective technical and management systems.[27]

Led by central government efforts, local authorities are being urged to adopt asset management led approach to maintaining existing roads and infrastructure, as a precursor to more formal Transport and Highway Asset Management Plans.

As Transport and Highway AMPs are done at regional or local levels, useful lessons can be learned by looking at Transport for London's (TfL) Highways AMP (HAMP). (September 2007).

One of TfL's roles is to serve as the highway authority for the Transport for London Road Network (TLRN), the capital's 580km network of main roads which constitute about five per cent of the total length of London's roads, yet carry one third of the Capital's vehicle traffic. Most are key bus routes, red routes and all are important thoroughfares for pedestrians, cyclists and freight. Proper maintenance of the TLRN – including proper management of the various physical assets – is the bedrock upon which all other road transport improvement projects on that network rely, and is essential to facilitate efficient travel across the Capital. The TLRN is among the most valuable parts of TfL's portfolio, with the latest network valuation approximately £5bn.[28]

TfL's HAMP covers management of existing assets of the following types:

a. Carriageway and footway

b. Highway structures, including bridges, footbridges, retaining walls, subways and culverts

c. Tunnels

d. Lighting and lighting columns

e. Other assets, including traffic signs, road markings and studs; drainage; street furniture; and the green estate

Efficiency gains of such an approach to management of nation's highways infrastructure lie in their full implementation and utilisation in prioritising future maintenance. Coupled with the

[27] Roads Liaison Group, Maintaining a Vital Asset, 2005, p3.
[28] Transport for London, Highways Asset Management Plan, September 2007.

efficiency gains, effective asset management provides

a. practical solutions highlighting the best practice in realising the Asset Management Plans (AMP)

b. maximising their benefits in contributing to the long term sustainability of the nation's road networks through maintenance and investment in infrastructure, leading to improvements in

    - quality of the roads
    - journey times, average speeds
    - congestion
    - road availability

c. assistance in enhancing the

    - Economic outcomes by developing and delivering optimal whole of life cost solutions
    - Social outcomes by proactively seeking safer transport corridors and better transport outcomes
    - Environmental outcomes by actively seeking solutions minimising the impact of noise, storm water and storm events and improving habitat in the surrounding greenfields.

For road users the most visible part of the maintenance process is the roadworks. Whilst necessary to deliver safer and more reliable journeys, roadworks are often seen by road and highway users as annoyance for they create delays, albeit in short-term. TfL's HAMP focuses on the level of service delivered by the highway assets rather than the transport system that it supports.

The plan also develops high level outcomes relevant to management of TLRN. These are grouped by category and responds to respective service statements explaining what the TfL will aim to do.

A selected outcomes and level of service statements are given below

Category	Outcome	Level of Service Statement
Surface (Policy 4G.1)	A smooth surface	TfL will maintain the surface so as to minimise (within reason) uneven surfaces, rutting and cracking, based on information collected from visual and machine-driven inspections to identify necessary works. Any deformity likely to cause personal injury or damage to property will be repaired as a matter of urgency.
Lighting (Policy 4G.1)	Well-lit carriageways	TfL will monitor the lighting stock by means of visual inspections, including in the hours of darkness. Any lighting outages likely to cause loss of quality of driver vision will be repaired as a matter of urgency.
Accessibility (Policy 4I.10)	Footways that are clear and accessible for disabled people and those with mobility difficulties	TfL will maintain footways and pedestrian crossings and public space to optimise with due regard to cost, practicality and the needs of other users their convenience of movement for disabled people and those with mobility difficulties.
Congestion (Policy 4G.20)	Road available and not interrupted by roadworks	TfL will undertake carriageway and other repairs in such a way to minimise occupation of road space.
Investment (Policy 4G.25)	Optimal decision in terms of when and how much money is spent on highway maintenance	TfL will determine its investment budgets and programmes based on removing the backlog of repairs and minimising whole-life costs.
Information	Well-informed customers	TfL will keep its customers informed about its activities and respond promptly to queries and complaints.

Source: Transport for London, Highways Asset Management Plan, September 2007, p.45.

The desired outcomes listed above are measured through 'customer outcomes,' which cover a specific and measurable aspect of an asset or of the maintenance activity performed on it. Measuring outcomes through customer outcomes allows TfL to monitor and demonstrate its performance.

Delivery of the customer outcomes is measured and reported externally by each TfL directorate by means of key performance indicators (KPIs). In some cases these reference Best Value Performance Indicators (BVPIs). Both BVPIs and KPIs are measures currently used to measure the performance of the TLRN asset itself and of aspects of TfL's management of it, such as workforce safety and environmental sustainability.

BVPIs are measures created by central Government as part of the Best Value initiative to create a scorecard for local and highway authorities, encouraging efficiency and performance and allowing comparison among localities. KPIs are calculated internally and reported either four-weekly, quarterly or annually, as appropriate.

Two additional types of indicators are used to measure performance in more detail, within the supply chain management process or within an individual directorate:

a. Service performance indicators (SPIs) are used to measure outcomes relating to how the highway maintenance service is carried out by the supply chain. SPIs measure programme delivery as well as aspects such as the environmental sustainability of contractors' vehicles or the diversity of the workforce involved. Like KPIs, they have explicit targets and are not nationally benchmarked. SPIs feed into KPIs, allowing TfL not only to measure contractors' compliance with the HMW contract and other supply chain contracts, but also to collect the information that can be used in aggregate to determine overall performance against KPI targets.

b. In addition to monitoring service delivered by the supply chain, the Directorate of Road Network Management also monitors its own performance through the use of business performance indicators (BPIs) which are reported internally.

4.4 Rail

Established in 2004, The Office of Rail Regulation (ORR) is an independent statutory safety and economic regulatory body tasked:

- to ensure that Network Rail, the owner and operator of the national railway infrastructure - the track and signalling - manages the network efficiently and in a way that meets the needs of its users;
- to encourage continuous improvement in health and safety performance;
- to secure compliance with relevant health and safety law, including taking enforcement action as necessary;

- to develop policy and enhance relevant railway health and safety legislation; and
- to license operators of railway assets, setting the terms for access by operators to the network and other railway facilities, and
- to enforce competition law in the rail sector.

Monitoring Network Rail's performance is a key role for ORR

- against targets in the most recent access charges review (2003),
- against obligations in its network licence, and
- against forecasts in its own business plan.

This monitoring is done through regular reports from the company, annual returns by 1 July of each year to be made public by 31 July each year subject to independent audit of the annual returns. ORR also produces an 'annual stewardship statement' to give Network Rail's customers, funders, members, railway users and other stakeholders, an assessment of how well the company is managing this asset.

To complement this annual assessment, consultation is being carried on the proposed publication of the Network Rail Monitor, a balanced scorecard of high-level key performance indicators (KPIs) together with a commentary.

The key performance indicators (KPIs) currently used in the Network Rail Monitor are set out below. KPIs 5, 6 and 7 will change in the future when new, more meaningful measure have been introduced.

- KPI-1 Safety Risk - RSSB train accident pre-cursor measure
- KPI-2 Train performance - SRA public performance measure (PPM)
- KPI-3 Network Rail delay minutes - number of delay minutes attributed to Network Rail causes
- KPI-4 Asset failures - number of infrastructures
- KPI-5 Asset quality - the Asset Stewardship Index (ASI) is to be used pending the development of an asset quality measure
- KPI-6 Activity volumes - limited to track renewal volumes until a composite measure of activity volumes is developed
- KPI-7 Unit cost efficiency gain - the Financial Efficiency Index is to be used pending the development of a more robust measure of efficiency
- KPI-8 Expenditure variance - variation to Network Rail annual budget
- KPI-9 Financing - Debt to Regulatory Asset Base (RAB) ratio

- KPI-10 Customer satisfaction - train operator satisfaction
- KPI-11 Supplier satisfaction - major supplies satisfaction

Investments in the network

Capital expenditure in infrastructure improvements is key to develop a better rail service to meet the needs of passengers and freight users, and the growth in demand. ORR is instrumental in setting out an effective framework for delivering infrastructure investments such as increasing track capacity or building new stations. The authority (ORR) also ensures that the relevant parts of the regulatory and contractual framework provide clear and effective processes for agreeing investment schemes and then ensuring that they are delivered on time and to budget.

Investment schemes, some proposed by train operators, other rail users (such as freight services) or rail service funders, while others are identified by Network Rail. Network Rail also generally takes the lead in promoting, planning, facilitating and, in most cases, delivering and financing schemes, ensuring that improvements are delivered.

2005 ORR Policy Framework for Investment sets out a framework in facilitating the efficient provision of investment schemes. The framework seeks to clarify Network Rail's role in enhancements and the terms on which it engages with its customers, rail users and funders in facilitating and delivering them.

Here, the regulator monitors whether the framework is delivering the objective of facilitating efficient and appropriate investment in the rail network. Key factors (measures of performance) determining success of this framework are set out as:

- Network Rail pro-actively identifying value for money investments, either through the route utilisation strategy (RUS) process or through incremental improvements in capacity and/or capability,
- Network Rail fostering a culture throughout its organisation to respond positively and consistently to investment proposals identified by others (such as appointing Route Enhancement Managers);
- Network Rail establishing a code of practice (enforceable by ORR) setting out the terms of its engagement with its customers and funders,
- All parties striving for continuous improvements in efficiency, thus reducing year by year the cost of improvements to the rail network;
- For third party investments, clarity of legal, economic and financial obligations set out in templated contracts, including who bears what risks, the prices of provision of different services, and the remedies following any breach of contract;
- ORR's monitoring of the framework and acting swiftly but proportionately on any failings; and

- Effective streamlining of other industry processes related to investment, in particular the reform of network change part of the Network Code.

Asset management

Another way the regulator measures performance of Network Rail is by way of monitoring Network Rail through the year as it completes tasks detailed in the compliance framework of the Guidelines to Licence Condition 24, the Asset Register.

ORR acts as observers to some of the tasks such as the consultation with external stakeholders and the development of processes that ensure asset information is kept up to date. Network Rail on its part identifies the key areas where its information is inadequate and how it will tackle this. Based on this information, ORR together with the Independent Reporter review the identified gaps to ensure that everything is in order before auditing the asset information to ensure that it is fit for purpose.

Network Rail further explores ways for enhancing overall business performance. In this endeavour, its strategy of employing Intelligent Infrastructure is talked of being instrumental in providing a new proactive approach to the management of infrastructure assets.[29] It is explained that this will be based on a continuous understanding of asset condition and will make delivering railway of future that is safe, reliable and affordable. This approach sees effective asset management as key to the future success in meeting expectations of an efficient rail service which requires an integrated approach to asset management and a change in maintenance philosophy from ‘Find and Fix’ to a ‘Predict and Prevent’. The Intelligent Infrastructure approach to condition monitoring uses specialist mobile vehicles such as the New Measurement Train (NMT) to measure infrastructure condition or to constantly monitor infrastructure at fixed locations. Through Increased frequency of monitoring, improved data management and use, the new approach is expected to yield the following benefits:

- Safety benefits
  - Improved network and staff safety
  - Reduced risk catastrophic failures
  - Elimination/ reduction of human-based examination
  - Maintain infrastructure at the safest time.
- Improved Asset Management
  - Enhances reliability, availability and fault management
  - Positive assurance of fitness of purpose in real time

[29] Ollier, B.D., “Intelligent Infrastructure, The Business challenge”, Network Rail, London. http://ieeexplore.ieee.org/Xplore/login.jsp?url=/iel5/4126717/4126718/04126725.pdf?isnumber=4126718&prod=&arnumber=4126725&arSt=1&ared=6&arAuthor=Ollier%2C+B.+D

- Understand the effect of varying maintenance regimes on rate of asset degradation

- Trending information to determine optimum asset life cycles.

The key to an effective management of network assets requires fit-for-purpose information about these assets. Network Rail's Asset Information Strategy (AIS) and Asset Register April 2008 progress report reports on the progress made on the quality of the wide range of information on its large and diverse asset base. AIS reports that the organisation has now reached a stage where:

a. All infrastructure asset disciplines have systems in place that are populated with the core data necessary to support primary decisions on the maintenance and renewal of the infrastructure.

b. Asset Data Management (ADM) procedures have been developed for all disciplines and an assurance regime has been developed and implemented.

c. The Corporate Network Model (CNM), which includes a geospatial representation of the railway infrastructure, has been identified, and is being developed, as the primary mechanism for providing easy and intuitive access to infrastructure information for both internal and external users.

5. REVIEW OF THE LICENSEES' DRAFT METHODOLOGIES

5.1 Introduction

The Draft Methodologies are the subject of a submission by the Transmission Licensees on 30 May 2008 and comprise a:

- Covering letter
- Joint Methodology Statement (JMS) and
- Transmission Licensees' Specific Appendices.

The statement was also made that these documents would address all the requirements in Standard Licence Condition B17, Part B.

In addition NGET forwarded copies of the policy statements referred to in NGET's company specific appendices.

For the purposes of this review we assume that the Draft Methodologies supersede previous presentations by the Transmission Licensees.

5.2 General

We are not reviewing the:

- Transmission Licensees' previous presentations (Initial Proposals)
- Presentations at the Network Output Measures Workshop on 8 May 2008 or
- Regulatory Reporting by the Transmission Licensees for the year 2006/7 (TRRP) or the 2007/8 TRRP that we understand has been delivered

as such but may instead refer to them where such reference illustrates the review of the Draft Methodologies.

The review has focused on the ability of the proposed output measures in the Draft Methodologies to meet the objectives set out in Licence Condition B17, paragraph 4, namely:

a) the monitoring of the licensee's performance in relation to the development, maintenance and operation of an efficient, co-ordinated and economical system of electricity transmission;

b) the assessment of historical and forecast network expenditure on the licensee's transmission system;

c) the comparative analysis over time between:

   (i) geographic areas of, and network assets within the licensee's transmission system;

   (ii) transmission systems within Great Britain;

   (iii) transmission systems within Great Britain and within other countries;

   (iv) transmission systems and distribution systems within Great Britain;

d) the communication of relevant information regarding the licensee's transmission system between the licensee, the Authority and interested parties in a transparent manner; and

e) the assessment of customer satisfaction derived from the services provided by the licensee as part of its transmission business;

In undertaking the review, PB Power has been mindful of ensuring the proposed output measures avoid:

- regulation to a model rather than promoting efficiency within the licensed activities recognising diversity of approach and the different characteristics of the different transmission networks and
- micro-management of the Licensees.

In formulating comments from the review the following is of note:

- The comments made are relevant to all of the Transmission Licensees unless a specific Licensee is named
- It is the Transmission Licensees themselves who have the necessary information to establish the materiality or otherwise of output measures applicable to their systems. PB Power has sort to make suggestions where it considers the output measures proposed by the Transmission Licensees warrant supplementing to meet the requirements of the Licence Condition
- It is recognised by Ofgem, the Transmission Licensees and PB Power that work needs to continue to evolve the output measures and this may include the development of measures that require business processes and the monitoring of information that may only become available in the future.
- It is recognised that in attempting to define output measures that collectively meet the objectives outlined in Section 4 of the Licence Condition compromises between the constituent objectives 4(a) to 4(e) may be required. However, for the purposes of this document Objectives 4(a) to 4(e) are individually assessed to highlight any deficiencies in meeting these. The individual assessments are summarised in Table 5.1 to 5.4.

- There is a the need that the proposed output measures are proportionally applied to the Licensees in view of their different characteristics.

In undertaking the review we appreciate that the scope of work is at the forefront of a regulatory review of asset management processes. Accordingly we have followed an appreciation of a:

- phased approach
- initial concentration on the gathering of information
- understanding of the information so gathered for use at a later date and
- potential for gathering data trends over an interval of time.

We comment on the proposed output measures by the Transmission Licensees and make suggestions for their enhancement to more fully meet the objectives below.

5.3 Comments on the Joint Methodology Statement (JMS)

In the sub-sections that follow we comment on the JMS and the company specific appendices.

5.4 Network asset condition

Condition B17, 2(a)	the current condition of the assets which collectively form the licensee's transmission system (including the condition of the principal components of those assets) (collectively, "network assets"), the reliability of network assets, and the predicted rate of deterioration in the condition of network assets which is relevant to making assessment of the present and future ability of network assets to perform their function ("network asset condition");

In paragraph 26 of the JMS (JMS paragraph 26) the Transmission Licensees have proposed a metric for "network asset condition" based on estimated remaining useful life, being Asset Health Indices generally categorised as follows:

Item	Remaining Useful Life (Years)	PB observation – historic interpretation
a.	0-2 Years	Projects in train – now - will be done unless there are problems - definite
b.	2-5 Years	Remainder of Price Control – soon – may be done but good chance of being reprioritised/deferred

Item	Remaining Useful Life (Years)	PB observation – historic interpretation
c.	5-10 Years	Next Price Control – medium term – likely to be reprioritised/deferred – not likely to be brought forward
d.	>10 Years	Beyond Next Price Control – longer term – uncertain when it will be done

We comment as follows.

5.4.1 Condition B17, 4 (a) - monitoring of Licensee's performance

5.4.1.1 Current condition of network assets

We consider that the categorisation of Asset Health Indices into four categories (sometimes with sub-divisions) in JMS paragraph 26:

- a four-grade scale is proposed with sub-divisions which differ between asset categories[30]. While this categorisation might be as good as could be expected given existing asset condition reporting processes and data any analysis undertaken would be limited by the discontinuous and discrete intervals of the grading scale; future refinement may permit a finer scale so as to enable more meaningful further analysis, including calibration of remaining useful lives

- corresponding Asset Health Indices are identified for four asset groups only, circuit breakers, transformers, overhead line conductors and underground cables but no mention is made of other major asset groups such as overhead line fittings and towers or protection and control

- reflects the reporting format in the DRRP (with the intention of enabling comparison with the reporting of the DNOs), namely 0-2 years, 2-5 years, 5-10 year and >10 years; this format may suffice for reporting but

- does not facilitate (external) qualitative analysis including calibration against existing fault rates and analysis of faults based on asset health progression and/or prediction of replacement requirements on an annual basis.

JMS paragraph 27 provides examples of factors used to determine Asset Health Indices but does not indicate a systematic process for deriving Asset Health Indices from, say, weighted

[30] A four-grade scale represents fewer grades than are being adopted by other workers in this field albeit for distribution assets. Work on the application of Asset Health Indices to transmission assets is however proceeding, notably the work of the Transmission Underground Cables Interest Group of CEATI International covering oil insulated pipe type cables to 225kV (see Cigre Osaka Symposium 2007 Paper 227).

grades of the condition of a particular asset and its key components.

An auditable trail is required between key condition monitoring measures (e.g. transformer dissolved gas analysis (DGA), furfural analysis (FFA)) and asset condition categories (asset health indices). Slide 11 of the Initial Proposals (slightly modified as Table 1 in the JMS) lists factors for asset health indices and the requirement is stated for a "Decision Support Tool" based on 'weighted' scores of measures by experts. Slides 12 and 13 of the Initial Proposals provide examples of condition reports but the process of consolidation into condition categories requires stating. An example of a condition scoring system for transformers, reactors and switchgear is provided in Figure 1 of National Grid Electricity's Regulatory Reporting for Year 2006/7 (TRRP). However a Transmission Licensee would also be expected to have yet more detailed supporting procedures providing a systematic methodology of assigning condition grades.

Although JMS paragraph 34 states that no additional development work is proposed for Network Asset Condition (presumably in the JMS), further work in enhancements to the development of Asset Health Indices would be reflected in the Transmission Licensees Specific Appendices - which we comment on later in this report.

5.4.1.2 Reliability of network assets

No specific reporting measures are proposed, other than circuit availability in JMS paragraph 88. Unplanned unavailability is mentioned in JMS paragraph 68. We would expect the Transmission Licensees at least to jointly compile fault rate, duration and cause statistics similar to NAFIRS.

The term "reliability" requires defining in the context of network assets. International standards for terminology exist (e.g. IEC 50(191-05-01) and IEEE Std 859-1987 (R2002)). In the past Ofgem defined the overall reliability of distribution system performance as faults per unit length of network i.e. fault rate.[31]

One method of defining reliability is in the reporting in the TRRP:

- Table 4.3 - Transmission System Performance (availability, outages)
- Table 4.4 - Defect reporting
- Table 4.5 – Fault reporting
- Table 4.6 – Failure reporting (In paragraph 32 of NGET's Electricity Regulatory Reporting for the Year 2006/7, the recommendation is made that a "holistic view" be taken of the information in Tables 4.3 to 4.7, but without much further amplification of how such a "holistic" view would be undertaken.)

Nevertheless the information requested in the TRRP is incomplete for the purposes of say, modeling unavailability trends as information on corresponding (damage) fault rates and restoration or repair times is also required.

[31] Ofgem; Report on distribution and transmission system performance 2000/2001, January 2002.

Other established systems for reporting reliability of network assets are listed in Table 3.2 of this report.

We would therefore expect to see:

- proposals for a demonstration of the calibration of the Asset Health Indices in terms either of fault rate, remaining useful lives and/or predicted rate of deterioration - the Transmission Licensees need to explain how residual lives are determined in the first instance (for example, would the residual lives be the number of years the plant may remain in service before the level of deterioration becomes unacceptable regardless of where it is located on the network, its geographical location or the importance of its function (i.e. its criticality)?

- relationship between Probability of Failure and Asset Health Index being determined thereby to enable analysis and

- specifically fault (hazard) rates being complied as functions of (separately) condition and age.

5.4.1.3 Predicted rate of deterioration of network assets

JMS paragraph 26 categorises the proposed four Asset Health Indices in terms of Remaining Useful Life. However no indication is provided at this stage in the JMS as to how a given Asset Health Index might be expected to vary over time and how such variation might be determined, for example for modelling purposes.

We therefore consider that:

- a justification should be provided for statements to the effect that an asset with a particular Asset Health Index would be expected to deteriorate to lower (condition) Asset Health Index within a given interval

- measurements of key condition indicators than would support such statements including calibration

- proposals are required for key indicators of deterioration in asset condition (e.g. variation in hazard rate (i.e. the rate at which remaining items fail) or “upturn of the bathtub curve”) and

- details of the definition of rate of deterioration and policy for each major asset category

5.4.1.4 Present/future ability to perform their function

As it would appear that if the licence requirements of current condition, reliability and predicted rate of deterioration of condition of network assets are met then implicitly the assessment of present/future ability to perform their function is met.

5.4.2 Condition B17, 4 (b) - Assessment of historical and forecast expenditure

5.4.2.1 Current condition of network assets

No mention is made in the JMS of how (efficiency of) historical and forecast expenditure would be assessed, from the viewpoint of condition. JMS paragraph 30 implies that the review of historic/forecast capital expenditure would be base on asset live/replacement profiles, as for long term assessment.

The Short and Medium Terms (Condition based assessment) and Long Term (age based assessment) should be indicated. We would however agree that in short to medium term asset condition is main factor whereas in longer term (and for high level review), age based modelling is appropriate. One key factor is the length of validity of information on asset condition and on previous occasions NGET has indicated that this would be about five years. We would also comment that the length of validity may depend on intervals between inspections.

5.4.2.2 Reliability of network assets

No mention is made in the JMS of how (efficiency of) historical and forecast expenditure would be assessed, from the viewpoint of reliability.

A key policy decision is whether to replace on condition or on failure - Transmission Licensees' policy is the former. A second point is the need to establish a relationship between (un)availability, defects, faults and/or failures and necessary and efficient opex and capex.

5.4.2.3 Predicted rate of deterioration of network assets

The Asset Health Indices to be used in the proposed short and medium term assessment would be based on asset condition, however this would only be an intermediate stage and furthermore but does not necessarily indicate a required remedial measure e.g. maintain/refurbish/replace. It is not clear how a remaining useful life would be assigned to a particular asset condition category. JMS paragraph 31 proposes that asset life profiles assist in the assessment of deterioration of condition – if so, the calibration process is not clear.

There may be some subjectivity in the determination of remaining useful life. For instance an operator may decide that there is a slight risk that a component may fail in say 3 years time, so that operator would determine remaining useful life as 0 - 2 years, i.e. the operator would want the asset replaced before there was any risk of failure. Another operator may decide that the equipment will not fail inside the next 2 years and determine a remaining useful life of 2 - 5 years. Health Indices of different companies therefore require calibration and one such method is to relate the failure rate of a given group of assets with known asset health indices to their corresponding fault rate where this rate is known.

5.4.2.4 Present/future ability to perform their function

If the present/future ability to perform their function (e.g. within the next [5] years was a defined asset condition category then this would simplify matters and aid the assessment of expenditure. The JMS is not clear on this point.

5.4.3 Condition B17, 4 (c) - Comparative analysis over time and between utilities

Section 7, paragraphs 89 to 100, of the JMS does not provide any specific proposals as to how the Transmission Licensees intend to provide network output measures to meet this particular requirement of Condition B17. We note that JMS paragraph 87 c i and paragraph 88 state that further development work is required for the reporting of average circuit unreliability statistics, particularly across the four equipment groups in JMS paragraph 20 (circuit breakers, transformers, overhead line conductors and underground cables).

We would have expected to have received, for example, a critique of the TRRP at this point.

5.4.3.1 Current condition of network assets

We note that in the TRRP returns for 2006/7 from the three Transmission Licensees the definitions of Asset Health Indices all differed. We presume that JMS paragraph 26 represents a common definition and that the respective asset management processes will be revised accordingly. Such a revision may however have implications for the two Scottish Transmission Licensees as they may also, and for good reason, wish to maintain commonality with their distribution network operations. This aspect is alluded to in the final sentence in JMS paragraph 92 and should be explored further with the Transmission Licensees.

5.4.3.2 Reliability of network assets

Section 5.3, paragraphs 58 to 73, of the JMS concentrates on Average Circuit Unreliability as the network performance output measure, indicating that improvements in present data recording facilities would be required. The JMS notes that planned and unplanned unavailabilities are output measures that are also presently reported. At this point in the JMS the distinction between Average Circuit Unreliability and unavailability is not explained. In JMS paragraph 61 mention is made of some measures (faults, failures) considering events only and some considering a combination of event and duration, but no explicit indication is given of any resulting output measure that would indicate the type of fault and range of durations. In order to calibrate Asset Health Index models, information similar to that in NAFIRS would also be required, namely mean fault rate, mean restoration times (urgent, non-urgent) and faults disaggregated by condition and non-condition related. Furthermore fault data would also need to be disaggregated by main asset type.

During the briefings on the Main TPCR in 2006, NGET indicated that unplanned unavailability, for a given asset type, could be a suitable indicator of deteriorating asset condition (there were indications of rising trends in unplanned unavailability of certain asset groups at the time). We consider that this indicator would be of considerably more informative if the events could be disaggregated by duration, asset type, and also whether the consequent remedial action incurs capex or opex.

5.4.3.3 Predicted rate of deterioration of network assets

The compilation of fault and interruption reporting data on a similar basis to NAFIRS would permit comparative analysis over time and should be regarded as a sine qua non of an asset condition reporting system to comply with Licence Condition B17. No proposals for such a system were presented in the JMS, however.

In EPS 12.4, Overhead Line Replacement and Refurbishment, NGET distinguishes asset lives by environmental locations (e.g. proximity to coast/pollution, exposure to wind). We would consider such classifications as a meaningful application of analysis between geographical areas. Reporting by operating regions (and offering the possibility of benchmarking between them) no longer appears possible because data is not compiled in this way.

Comparisons between the three Transmission Licensees would be possible provided fault and interruption performance data is compiled in the same way although any comparison of overhead line performance would have to take account of local weather patterns.

Comparison on an international basis is less likely to be fruitful due to differences in reporting arrangements and plant and equipments construction as well as operating histories. If such comparisons were to be made, starting points would be the Cigré surveys and the Canadian ERIS system described in Section 3. Published information of fault rate against age is sparse[32] and against condition almost negligible.

5.4.4 Condition B17, 4 (d) - Communication between parties

We would refer to our earlier comments regarding limited sharing of fault and interruption reporting data between the Transmission Licensees.

Furthermore without calibration and normalisation, the asset health indices will not allow ‘the objectives’ (comparative analysis over time as per Licence Condition B17, paragraph 4 c), to be met; i.e. Ofgem would need to know that NGET’s assessment of ‘2-5 years residual life’ carried the same level of risk of failure or the same onset of significant deterioration as SPTL’s. (It could, of course, be arranged for NGET and SPTL to assess the health indices for a sample of each other’s plant to see if the assessments are aligned.)

We therefore consider that it is crucial that the assessment of residual life is uniformly applied across the three Transmission Licensees as a first step.

5.4.5 Condition B17, 4 (e) - Assessment of customer satisfaction

The customers, presumably generators, distributors and large users would need to be defined. Furthermore consideration would need to be taken of the required level of security

[32] J Steed, “Life management of electrical plant”, Chapter 23 of High Voltage Engineering and Testing, IET Power and Energy Series 32, ISBN 0 85296 775 6.

of supply, which differs between these customers as is noted in the annual GB Transmission System Performance Report (connections of three customers or less).

Table 5.1 - Network Asset Condition

Evaluation of:		**Designed to facilitate:**				
		Monitoring of Licensee's performance	**Assessment of historical and forecast expenditure**	**Comparative analysis over time between transmission networks**	**Communication between parties**	**Assessment of Customer Satisfaction**
		4(a)	**4(b)**	**4(c)**	**4(d)**	**4(e)**
Licensees' proposal:						
Current condition of network assets	2(a)	Qualified JMS 26 Categorisation of Asset Health Indices into only 4 categories; future refinement may permit a finer scale, enabling further analysis including calibration	× JMS 30 No mention of how (efficiency of) historical expenditure would be assessed, from the viewpoint of condition	× JMS 92 Adoption of methodologies used by other transmission companies – but which?	✓ JMS 92 Requirement for common reporting framework identified, to which we would agree in principle.	Qualified Customers (generators, distributors and large users) would need to be defined
Reliability of network assets		× JMS 88 No specific reporting measures proposed other than circuit availability – we would expect Licensees at least to jointly compile fault rate, duration and	× No mention in JMS of relationship between expenditure and reliability	Qualified JMS 58 to 73 ACU proposed as network performance output measure. Reconciliation with unavailability required. Also require NAFIRS type fault rate and	Qualified Only planned and unplanned availability data shared to date, in contrast to DNOs sharing fault data through NAFIRS	Qualified Required (contracted) level of security at load points should be considered

Evaluation of:		**Designed to facilitate:**				
		Monitoring of Licensee's performance	**Assessment of historical and forecast expenditure**	**Comparative analysis over time between transmission networks**	**Communication between parties**	**Assessment of Customer Satisfaction**
		4(a)	**4(b)**	**4(c)**	**4(d)**	**4(e)**
		cause statistics similar to NAFIRS; JMS 68 -Unplanned unavailability mentioned but no specific proposal		restoration time data, by asset group		
Predicted rate of deterioration of network assets		✗ JMS 26 does not indicate how AHI would vary over time	✗ JMS 31 Asset life profiles assist in assessment of asset condition – calibration process not clear	No specific proposals provided	Crucial that the assessment of residual life is uniformly applied across the three Transmission Licensees as a first step.	–
Present/future ability to perform their function		✗	PB query on intended output measure	–	–	–
Suggested additional metrics:						
Fault rate, duration and cause statistics similar to NaFIRS.		✓	-	✓	✓	-

Evaluation of:		**Designed to facilitate:**				
		Monitoring of Licensee's performance	**Assessment of historical and forecast expenditure**	**Comparative analysis over time between transmission networks**	**Communication between parties**	**Assessment of Customer Satisfaction**
		4(a)	**4(b)**	**4(c)**	**4(d)**	**4(e)**
Reconciliation of Average Circuit Unreliability and unavailability		✓	-	✓	✓	-

JMS = Joint Methodology Statement e.g. JMS 54 = paragraph 54 of the Joint Methodology Statement

5.5 Network risk

Condition B17, 2 (b)	the overall level of risk to the reliability of the licensee's transmission system as a result of network asset condition and the interdependence between network assets ("network risk");

5.5.1 Short/medium term assessment

In Section 5.2 of the JMS, Network Risk – paragraph 39, the Transmission Licensees have proposed the following definition of Network Risk:

"The likelihood and consequence of a potential negative impact to the network, as a result of a future event."

The Transmission Licensees however acknowledge that further work is required on the concept of Replacement Priorities and to Network Risk in General.

We nevertheless comment as follows:

- in paragraphs 37 to 57, the Transmission Licensees have proposed using the concept of criticality (defined as system, safety and environmental criticality) to establish "Replacement Priorities" by modifying some of the remaining useful lives indicated by the Asset Health Indices; the modification to the remaining useful lives would be based on a "Criticality Index" (low, medium or high) and the effect would be to bring forward or delay some of the asset replacement; the quantities of assets thus modified would be known as "Replacement Priorities" and would be quantities of assets to be replaced in discrete time intervals, namely 0 to 2 years, 2 to 5 years, 5 to 10 years and beyond 10 years (the intervals lining up with the Asset Health Indices); we have concerns over the proposals in the JMS, principally definitions of risk and criticality are vague and differ from those used elsewhere within the industry

- approach is in effect a method of prioritisation but is discontinuous and operates at discrete intervals

- as the proposed Replacement Priority process is a prioritisation process and does not provide either a definition of network risk or a risk profile (with time), further consideration should be given to the adoption of a risk definition in terms of the frequency of an event occurring compared with its consequence;

- paragraph 40 in the Joint Methodology Statement (JMS) needs to expanded to explain why optimised replacement is a proxy for risk and what the nature of risk is.

- the proposed Replacement Priority process should in any case be reviewed to

    - reduce the step changes in Replacement Priorities with Criticality Index

    - combine the system, safety and environmental criticalities

- there is uncertainty as to whether the proposed methodology reflects the actual decision making process
- the proposed methodology of projecting replacement priorities forward on the basis of risk is subject to challenge as none of the priorities seem to go backward
- proposed application of risk is qualitative and
- there does not appear to be any scope for ranking of replacement by life cycle costing including costs to the system, safety and environmental costs, a method advocated in Cigré Technical Brochure 248, for example - techniques for prioritising asset replacement should include an element of life cycle costing and/or cost/benefit analysis.

We comment on the JMS in detail later in the report and initially review other concepts of risk.

We would firstly suggest that a definition of risk be considered. To whom is the risk addressed – Transmission Licensee, regulator or customer? Alternatively risk may be expressed as the probability of a certain (outage based) performance measure not exceeding a given level in a year. One approach might be to consider the following:

- Risk = frequency x consequence and
- Consequence, which can be evaluated on a points system, comprises:
    - Repair cost.
    - Performance (reliability, energy not supplied).
    - Safety.
    - Compliance (statutory) and
    - “shine” (complaints, corporate reputation)

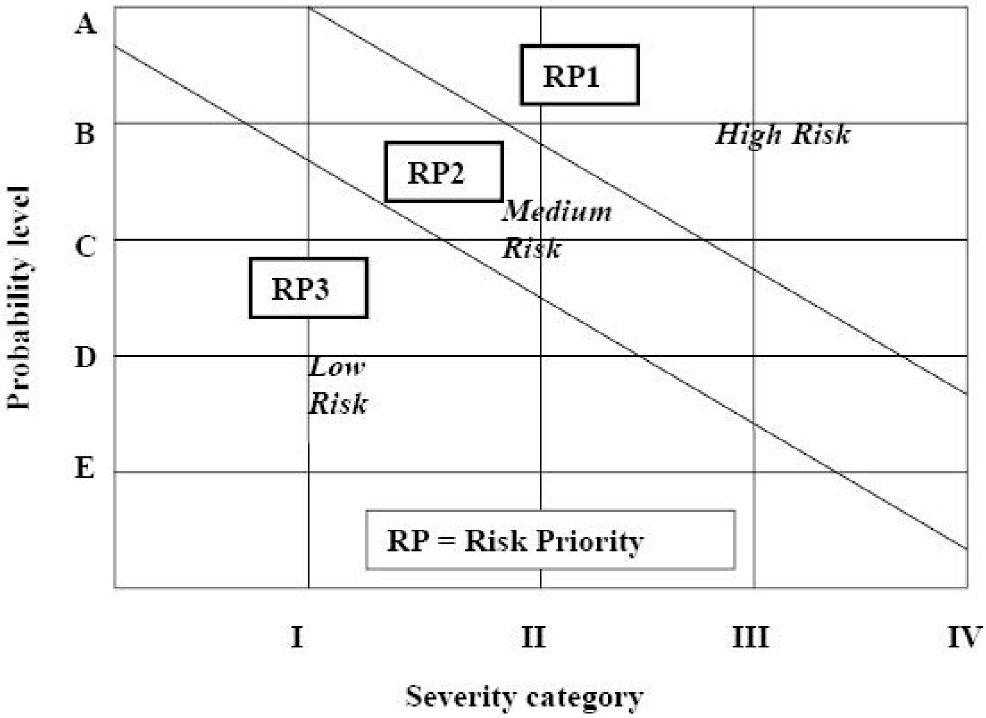
A risk matrix with hard and/or soft values is generally derived where the risk expressed in absolute or relative terms. Essentially this is a prioritisation aide to establish invest/do not invest boundaries[33].

An example of a risk matrix is presented in Figure 5.3.[34]

As similar approach in assessing risk to the network business is presented in Appendix 2 of Cigré Technical Brochure 309, Asset Management of Transmission Systems and Associated Cigré Activities, December 2006.

[33] R. Gilbert (NIE), “Asset Replacement and Investment Criticality Modelling”, Utilities Asset Management Conference, 26 February 2002.
[34] IEE; “Quantified Risk Assessment Techniques (Part 1)”, Health and Safety Information, No. 26 (a) October 1999.

Figure 5.2 – Asset risk matrix



Criticality. Criticality may then be regarded as the sum of risk and operating and capital expenditures and the results can be optimized in an investment criticality modelling approach. One major obstacle is in the complexity of assessing risk. Criticality may not be modellable by outside parties. It may be measurable but again there would be different weightings for risks/events by different operators. Criticality depends on network configuration, supplied load, historic network performance, geography, etc. Criticality may even change due to non-network reasons, e.g. closure or opening of a factory/shopping centre or negotiation for a disconnectable load. It may be difficult to assure a regulator of movement in criticality within a regulatory period for a single operator let alone make comparisons between operators. Residual life alone may be a better indicator of medium term risk whereas criticality is more useful to an operator in prioritising expenditure short term.

5.5.2 Long term assessment

We consider that the output measure of network risk should provide a high level indication of the relationship between network asset condition (remaining lives) and network performance and, in so doing, provide an early indication of the possibility of a "spiral of decline" if asset replacement/refurbishment/repair was insufficient.

Supplementary approaches for consideration for a network risk index. We propose that the following supplementary approaches for a network risk index be considered. If these approaches are not currently possible, it is proposed that these be considered in the future:

- weighted average remaining life (WARL) index, as calculated but not taken further at the time of the Main Transmission Price Review in 2006; a WARL index would have the advantage of being readily calculable but would be only an indirect indicator of risk and, as proposed in 2006, would not take account of criticality

- a WARL index modified to reflect criticality, in which the residual lives would be weighted further by an (empirical) factor to take account of criticality; this weighting would require the declaration by the Transmission Licensees of assets by Asset Health Index (e.g. TRRP Table 4.7) and/or by asset age (e.g. TRRP Table 4.12) to be further disaggregated according to the criticality index (high/medium/low) of the corresponding circuits; the residual lives of high criticality assets would be shortened and vice versa; the criticality modified WARL index would thereby indicate the sensitivity of the index to criticality

- weighted index based on availability, in the manner of the Australian Service Target Performance Incentive Scheme, including weightings of availabilities of critical circuits; one of the elements of unplanned unavailability, namely fault rate could be related to asset condition and furthermore interruption durations could be related to (arguably) finite availability of resources (in the event of numbers of faults increasing), and also weighted for safety and environmental considerations and

- a network (weighted) risk index in terms of economic worth at risk be considered (Appendix C), noting that such an index would be criticality dependant, our caveats on the modelling of criticality and its being more applicable to short term planning

  whereby the Network Risk Index would be related to

  - asset condition and the interdependence between network assets (Licence Condition B17, paragraph 2b)

  - unserved energy

  - reliability worth of supply (Value of Lost Load (VOLL)/System Customer Outage Cost (SCOC)

  - monetary equivalents of safety and environmental criticalities or

If a scoring system for assessment of criticality (ScottishPower) is proposed instead, then the methodology for allocating the scores should be provided.

5.5.3 Condition B.17. 4 (a) - Monitoring of Licensee's performance

We would consider the proposed definition of risk in JMS paragraph 39 as being vague and would prefer a more tangible definition based on the above approaches. In particular the matter of consequence would need clarifying.

5.5.4 Condition B.17.4 (b) - Assessment of historical and forecast expenditure

The criticality indices in JMS paragraph 47 would need to be scored, most usefully in monetary terms to enable cost/benefit analysis and prioritisation. Furthermore the System, Safety and Environmental Criticalities in JMS paragraphs 45 to 50 are discussed in qualitative terms only. It would appear that they could only be brought together (compared) if expressed in monetary or economic terms (hard or soft) – for example the HSE provides guidance for assessing safety criteria and costs to meet these and so we would expect the Transmission Licensees to take account of such guidance. Environmental criticality could be assessed in terms of financial penalties for non-compliance. Operational risks such as DAR inhibits and RMHZs could be assigned a monetary value for comparison with the costs of remedial measures – this aspect should be explored further.

JMS Paragraph 51 (Figure 5, Potential Mapping of Replacement Priorities) presents a possible assessment approach whereby the remaining useful life, as determined by the asset health index approach, is modified according to criticality i.e. risk, to derive ”Replacement Priorities”. JMS Paragraph 53 (Figure 6, Proposed Network Risk Regulatory Reporting Table) presents the output, namely asset replacement volumes, based on a Network Risk Index. These proposals require further clarification.

5.5.5 Condition B.17. 4 (c) - Comparative analysis over time and between utilities

A worked example of the proposed definitions of the elements of criticality would be beneficial (JMS paragraph 45).

JMS Paragraph 53 (Figure 6, Proposed Network Risk Regulatory Reporting Table) provides the Volumes per year Based on Network Risk Index arranged in intervals of 0-2 years, 2-5 years, 5-10 years and > 10 years. Figure 6 presents a preliminary stage in deciding actual projects and expenditure as the final stage is one of scheme prioritisation (JMS Figure 1, Understanding Network Expenditure Requirements). Some transmission projects, such as replacement of a cable route in tunnels, replacement of air insulated switchgear (AIS) with gas insulated switchgear (GIS) or refurbishment of a long overhead line are of their nature bundled as schemes and also are major items of expenditure in their own right. In monetary terms therefore the actual expenditures may vary from those that might be indicated by a purely condition based approach.

5.5.6 Condition B.17. 4 (d) - Communication between parties

JMS paragraph 47 and JMS paragraph 86 b ii state that a common approach to the assessment of system criticality is yet to be developed.

5.5.7 Condition B.17. 4 (e) - Assessment of customer satisfaction

No account appears to be taken of the cost to the customer of asset performance.

The strongly worded statement in JMS Paragraph 57 that criticality should not be published appears to miss the point of overall network criticality – we would, however, agree to not publishing details of key critical network installations.

Publication of safety and environmental criticalities is for consideration.

Table 5.2 - Network Risk

Evaluation of:		**Designed to facilitate:**				
		Monitoring of Licensee's performance	**Assessment of historical and forecast expenditure**	**Comparative analysis over time between transmission networks**	**Communication between parties**	**Assessment of Customer Satisfaction**
		4(a)	**4(b)**	**4(c)**	**4(d)**	**4(e)**
Licensees' proposal:						
Network Risk Definition	2(b)	× JMS 39 Definition of Risk is vague; consequence is not quantified				Qualified No account taken of cost to customer of network performance
Criticality		× JMS 45 Concept of criticality appears to differ from that adopted elsewhere within electricity supply industry.	× JMS 45 to 50 No mention of cost element e.g. NPV or life cycle cost[35]; criticality should be scored in monetary terms to enable cost/benefit analysis and prioritisation	Qualified JMS 45	Qualified JMS 47 & JMS 86 b ii Mention further development of a comparative commonplace scale for criticality – this should be a monetary scale, but to be comprehensive may	Qualified JMS 57 Strong statement that criticality should not be published appears to miss the point of overall network criticality – would agree however in respect of details of

[35] For an example of a comprehensive risk-based decision process regarding repair or refurbishment, refer to Cigré Technical Brochure 248, Guide on Economics of Transformer Management, WG A2.20, June 2004

Evaluation of:		**Designed to facilitate:**				
		Monitoring of Licensee's performance	**Assessment of historical and forecast expenditure**	**Comparative analysis over time between transmission networks**	**Communication between parties**	**Assessment of Customer Satisfaction**
		4(a)	**4(b)**	**4(c)**	**4(d)**	**4(e)**
					require a value of lost load (Transmission Reliability Incentive scheme refers).	key critical network installations. Publish safety and environmental criticalities?
Replacement Priorities		✓ JMS 86 b iii Identified for further development work	Qualified JMS 51 Replacement Priority methodology to be modified to show that replacement could equally either be brought forward, not changed or delayed.			
Suggested additional metrics:						
Weighted average remaining life (WARL) index		✓	-	✓	✓	-
Criticality modified WARL index		✓	-	✓	✓	-

Evaluation of:		**Designed to facilitate:**				
		Monitoring of Licensee's performance	**Assessment of historical and forecast expenditure**	**Comparative analysis over time between transmission networks**	**Communication between parties**	**Assessment of Customer Satisfaction**
		4(a)	**4(b)**	**4(c)**	**4(d)**	**4(e)**
Weighted index based on availability		✓	-	✓	✓	-

5.6 Network performance

(c)	those aspects of the technical performance of the licensee's transmission system which have a direct impact on the reliability and cost of services provided by the licensee as part of its transmission business ("network performance");

In paragraph 62 of the JMS the Transmission Licensees have proposed the following principal measure of Network Performance:

"Average Circuit Unreliability is derived from the unavailability of the network due to outages occurring as a result of reliability reasons which cannot be deferred until the next planned intervention as is defined as:

$$\frac{\text{Total number of Repair Days (cumulative across circuits)}}{\text{Number of Circuits x Days in reported time period}}$$

We comment as follows:

5.6.1 Condition B.17. 4 (a) - Monitoring of Licensee's performance

The metric proposed provides a high level and easy to understand single composite method of indicating the performance of the respective Transmission Licensee's network. We would however comment that it does not permit understanding of:

a. whether there are problems with particular asset categories

b. whether the unavailability is being driven by fault rates (related to condition) or outage duration times (type of asset and/or resources available to repair/replace)

c. whether the unavailability is associated with a number of key circuits or whether it is more widespread.

At this early stage in the development of metrics for the Transmission Licensees there may be merit in adopting a more disaggregated approach than currently proposed, particularly given the age of the network. **This could include disaggregation of the proposed circuit unavailability metric by cause and in particular by asset type.**

We would also comment that care will need to be exercised in the use of average circuit unreliability as an output measure as this is a better measure for an operator with a large number of circuits. It can be quite volatile for an operator with a few circuits.

The difference between the above metric and those of "System Availability" and "planned and unplanned unavailability" as stated in the annual GB Transmission System Performance Report and in Table 4.3 of the TRRP are not explicitly clear in the JMS (although further information is provided in NGET's Appendix, reviewed later). Furthermore the latter is subject to detailed definitions in Ofgem's Price Control Review Reporting Rules and is by hours of unavailability whereas the proposed Average Circuit Unreliability metric is in terms of "Repair Days" and hence needs further explanation. It is also not clear how the Average Circuit Unreliability would be disaggregated (planned/unplanned unavailability).

We comment further:

- NGET should provide a reconciliation between the number of unplanned circuit outages in TRRP Table 4.3 (System Performance) and the number of faults in TRRP Table 4.5 (Fault Reporting); noting that the system unavailability data in Table 4.3 is from the Transmission Outage Planning and Monitoring (TOPAM) database and the fault data in TRRP Table 4.5 is from the MIMS work management system; furthermore the information provided in the TRRP is insufficient to say whether there is a direct correlation between the number of unplanned circuit outages in 2006/7 (280 in TRRP Table 4.3) and the number of faults in that year (275 in TRRP Table 4.5) – clarification should be provided - and

- NGET should provide an amplification of TRRP Table 4.3 (System Performance) in which average durations and fault/interruption rates of planned and unplanned interruptions are derived from the unavailability and number of circuit outages data already provided; particular clarification is required on the asset quantities (e.g. from TRRP Table 4.12, Asset Age) that would be used to derive the fault rates and the interpretation of the term "circuits" in respect of transformers and reactors, switchgear, overhead lines and cables in calculating average durations of outages (for example a reconciliation of "circuits" with either asset quantities in TRRP Table 4.12 or with Tables B.2.1 in the Seven Year Statement).

We also note the lack of an equivalent to NAFIRS at the transmission level. We note that prior to vesting (April 1990) a supplement to NAFIRS was complied in respect of 132 kV system fault data (Scottish companies and the then Area Boards in England and Wales) – the present status of such information is uncertain. (NAFIRS is administered by the Energy Networks Association (ENA) and the data is confidential to participating members of the ENA). No comparable sharing of data in respect of British 275 kV and 400 kV networks appears to have been undertaken however. The following NAFIRS data would also be particularly useful in a transmission context:

- mean fault rate, data series over time for each principal asset group

- mean restoration times, urgent and non-urgent and

- faults grouped by condition and non-condition related.

5.6.2 Condition B.17. 4 (b) - Assessment of historical and forecast expenditure

No mention is made in the JMS as to how the proposed output measure will be used to assess historical and forecast expenditure. However, the metrics considered above will indirectly permit the assessment of historical and forecast expenditure as it is expected to be an input to the requirements for replacement of assets based on the condition/risk assessment discussed previously.

5.6.3 Condition B.17. 4 (c) - Comparative analysis over time and between utilities

The metrics considered above, much like those currently reported in GB Transmission System Performance Report, lend themselves to reporting over time. **To permit international comparisons there would be merit in adopting a normalised metric of System Minutes in GB.**

5.6.4 Condition B.17. 4 (d) - Communication between parties

Information included in the GB Transmission System Performance Report and the TRRP will enable this to be communicated between parties. As discussed above, this may however require to be supplemented.

5.6.5 Condition B.17. 4 (e) - Assessment of customer satisfaction

The proposed definition of Average Circuit Unavailability may mean a change to the corresponding reporting in the GB Transmission System Performance Report.

Table 5.3 - Network Performance

Evaluation of:		**Designed to facilitate:**				
		Monitoring of Licensee's performance	**Assessment of historical and forecast expenditure**	**Comparative analysis over time between transmission networks**	**Communication between parties**	**Assessment of Customer Satisfaction**
		4(a)	**4(b)**	**4(c)**	**4(d)**	**4(e)**
Licensees' proposal:						
Average Circuit Unavailability	2(c)	✓ JMS 62 to 69 Needs to be developed further to provide disaggregation by: • Asset type • Event and duration[36]	Indirectly No mention is made in the JMS as to how the proposed output measure will be used to assess historical and forecast expenditure, together with disaggregated Opex and Capex against incidents required.	× Changes to reporting may mean that correlation with historic data is lost	✓ JMS 70 to 71 Further development required.	✓ Affects GB Transmission System Performance Report and TRRP

[36] Clarification would be provided by a breakdown of individual entries by event, duration and asset type – this requirement is acknowledged in part in JMS 88 but nevertheless an illustrative detailed breakdown would be appreciated.

Evaluation of:		Designed to facilitate:				
		Monitoring of Licensee's performance	**Assessment of historical and forecast expenditure**	**Comparative analysis over time between transmission networks**	**Communication between parties**	**Assessment of Customer Satisfaction**
		4(a)	**4(b)**	**4(c)**	**4(d)**	**4(e)**
Suggested additional metrics:						
System Minutes		✓	Indirectly	✓	✓	✓

5.7 Network capability

(d)	the level of the capability and the utilisation of the licensee’s transmission system at entry and exit points and other network capability and utilisation factors (“network capability”);

The Transmission Licensees have proposed two metrics for “network capability”, namely for assessing the:

- **Main Interconnected Transmission System (MITS) capability:** Required boundary transfer capability relative to actual capability and
- **exit point capability:** Number of substations within (demand/non-SGT capacity)% bands for intact, N-1 and N-2 (>300MW) conditions, in effect providing an indication of the utilisation of the network at exit points.

We comment as follows:

5.7.1 Condition B.17. 4 (a) - Monitoring of Licensee's performance

The metrics proposed again provide a high level and easy to understand single composite method of indicating the capacity and utilisation of the respective Licensees network. We would however note that:

a. **General:** The determination of metrics associated with capability and utilisation of transmission networks is not easy as a result of:

   i. The specific characteristics of the respective transmission system (transmission distances, transfer requirements, load density, etc)

   ii. the “lumpy” nature of transmission capacity additions and their associated costs

   iii. the effect the planning and operational standard (GB SQSS) has on the way the transmission system is designed and augmented

b. **Risk:** It is of note that while condition B.17 introduces the concept of a risk metric for asset condition related issues, no such metric is proposed for load related issues.

c. **Entry:** No metrics are presented by the Transmission Licensees, however, this is considered reasonable from the perspective of metrics for a Transmission Operator (TO) in that the TO’s are largely responding to customer requirements for the connection or disconnection of generation plant from the network which can be considered outside of the TO’s control. It will however be important that output measures associated with the MITS provide understanding of how changes in generation background influence network capability, particularly as a result of the expected changes to generation mix.

d. **MITS:** The metric proposed by the Transmission Licensees provides an indication of the capability and utilisation of the grid for bulk transfer. Although it has not been stated, it is hoped that the methodology to be developed by the Transmission Licensees will also:

i. Provide an understanding of the extent and cause of constraints.

ii. Provide an understand of the effectiveness of measures to release additional capacity.

iii. Provide an understanding of how swing and voltage stability (reactive power margin) of the system will be affected as the generation mix changes, particularly in relation to intermittent generation.

The metric will also ensure transparency and consistency of approach at the boundaries between NGET, SPTL and SHETL. We would comment that the output metric based on boundary capability does not permit understanding of some of the more local issues that occur within the transmission network including load churn and changes in generation background. For example, in Scotland, SPTL have embarked on a process of establishing "collector" networks to optimise the connection of several small generation schemes. **It would therefore be appropriate to develop "zonal capability" to understand the effects of within zone changes in the generation/demand balance, in addition to the wider effects of such changes that can be captured by the already proposed boundary transfer metric already proposed. The proposed revenue driver mechanism introduced in the 2006 TPCR and due to be presented as a joint Ofgem and Transmission Licensee paper at Cigre in 2008[37] could be the starting point for such an output measure.**

The Transmission Licensees also report within the TRRP on system utilisation in terms of MW.km. It may be appropriate to introduce that as a metric. In respect of reactive power margin in each zone and the zonal capabilities and, given the rise in reactive power consumption reported in the last TPCR, it is recommended that power factor is also reported on a zonal basis.

It will be important to understand the basis by which the boundary and zonal capabilities are determined. It is expected that this will require an understanding of the data, assumptions and methodology used by the Transmission Licensees in calculating the boundary and zonal capabilities.

[37] R. Hull. M. Zhu., L.A. Dale, D. Densley, S. Mathieson; Network Investment Incentive Developments in the 4th GB Transmission Price Control Review – Regulator & Licensee Perspectives, Cigré 2008, paper C5-206.

e. **Exit:** During the 2006 TPCR, PB explored the relationship between exit point utilisation and capital investment as proposed by the Transmission Licensees for a metric associated with this category. As can be seen by reference to Appendix A, while one can draw subjective conclusions, it is difficult to draw quantified solutions. We also consider that any meaningful conclusions may only become apparent in the longer term, say when there is 10-20 years of data. That said, we would find it difficult to propose an alternative metric. Indeed, during the 2006 TPCR when we proposed such analysis, NGET were critical of us. It appears that the Transmission Licensees cannot find anything either.

We would also add that during the 2006 TPCR it became evident that while average load growth was comparatively small, there was a high growth in reactive power consumption. **It would therefore be appropriate to monitor this as a power factor metric on a zonal basis although it may well be that DNO measures are put in place to mitigate against this.**

It will also be necessary to understand the basis of the definition of utilisation, i.e.: does the definition capture circuit/fault level constraints as for the distribution equivalent?

5.7.2 Condition B.17. 4 (b) - Assessment of historical and forecast expenditure

No mention is made in the JMS as to how the proposed output measure will be used to assess historical and forecast expenditure. The boundary transfer metric proposed by the Transmission Licensees will provide an indication the expenditure requirements. However, it is unlikely that this will supersede scheme based assessments in the determination of expenditure requirements. It is assumed, however, that this will permit :

a. Understanding measures, and hence costs, to release additional capacity

b. Understanding of the extent and cause of constraints, and hence costs

The number of substations within (demand/non-SGT capacity)% bands for intact, N-1 and N-2 (>300MW) conditions metric is likely to only be able to be used subjectively. In any event, a long period of time is likely to be required before any patterns possibly become evident that permit interpretation of this metric.

Given the level of reactive compensation proposed by NGET and SPTL in the current price control, a metric associated with reactive power margin and the influence of expenditure on the transfer margin is suggested[38].

[38] Cigré Technical Brochure 24; Planning against voltage collapse, Task Force 38-01-03 of Study Committee 38, October 1986.

5.7.3 Condition B.17. 4 (c) - Comparative analysis over time and between utilities

The metrics are presented in a manner that permits comparative analysis over time. However, it is difficult to see how these metrics can be used to make comparisons between utilities.

5.7.4 Condition B.17. 4 (d) - Communication between parties

Information included in the TRRP will enable this to be communicated between parties. As discussed above, this may however require to be supplemented.

5.7.5 Condition B.17. 4 (e) - Assessment of customer satisfaction

See Section 5.4.5.

Table 5.4 - Network Capability Metrics and their Ability to Meet Licence Condition Objectives

Evaluation of:	**Designed to facilitate:**				
	Monitoring of Licensee's performance	**Assessment of historical and forecast expenditure**	**Comparative analysis over time**	**Communication between parties**	**Assessment of Customer Satisfaction**
Licensees proposal:					
Required boundary transfer capability relative to actual capability	✓	✗ No mention is made in the JMS as to how the proposed output measure will be used to assess historical and forecast expenditure but unlikely to supersede scheme based assessment	✓	✓ expand to provide an understanding of the extent and cause of constraints, effectiveness of measures to release additional capacity, and effect of generation mix.	
Number of substations within (demand/non-SGT capacity)% bands for intact, N-1 and N-2 (>300MW) conditions	✓	✗	✓	✓	
Suggested additional metrics:					
Zonal capability	✓	✗ Unlikely to supersede scheme based assessment	✓	✓	

Evaluation of:	**Designed to facilitate:**				
	Monitoring of Licensee's performance	**Assessment of historical and forecast expenditure**	**Comparative analysis over time**	**Communication between parties**	**Assessment of Customer Satisfaction**
Transfer distance (MW.km)	✓	✗	✓	✓	
Power factor	✓	✓ and optimisation between TO and DNO solutions	✓	✓ and optimisation between TO and DNO solutions	
Reactive power margin	✓	✓	✓		

5.8 NGET specific appendix

5.8.1 Introduction

The NGET Appendix (NGA) on Network Output Measures Methodology, also referred to as NGET's Implementation Document, applies the proposals in the JMS and is supported by:

- Policy Statement (Transmission – PS(T)) and Technical Guidance Note (Electrical) 226 (TGN (E)226) on System Criticality
- Engineering Policy Statements (EPSs) on asset replacement and refurbishment – general, overhead lines, cables, switchgear and transformers and
- TGNs – Guidance on the priority ranking of candidates of overhead lines, cables, switchgear and transformers.

The EPSs and TGNs are revisions of long standing documents, updated to include methodology on Asset Health Indices and Replacement Priorities. These methodologies follow on from the statements in the JMS.

NGA 7 states that further work is required to develop the framework around Network Risk and Network Performance.

We review the NGA and supporting documents (EPS, TGN) under the headings in Licence Condition B17, 2.

5.8.2 Current condition of network assets

NGA 10 and 11 refer to the use of the ALERT asset replacement model use to determine asset replacement quantities in the longer term (greater than a ten year period) and to compare the volumes based on asset lives with those in the capital plan in the short to medium term (up to ten years). Whilst NGET's views of asset lives have been developed over a period of many years, there is limited information in the EPS and TGN as to how the asset lives would be calibrated. (The only stated instance of the basis of asset life is in EPS 12.7, Transformer Replacement and Refurbishment, where the anticipated (average) lifetime of a transformer of 55 years is based on a theoretical assessment of ageing of paper with winding temperature; no NGET transformers are aged more than 54 years although there is an age-independent random failure rate of 0.3 per cent per year i.e. some 2 units per year. NGET comments that its end-of-life model (for transformers) is necessarily an extrapolation (TGN (AR) 007 section 2).)

NGET has long maintained a "replace before fail policy" and acknowledges that one consequence of this policy is that it is often not possible to derive strong statistical links between experienced failures and declared asset lives (EPS 12.0, section 1).

The Asset Health Indices, generally classified as Priority 1 (clear case for short-term replacement) to Priority 4 (no known technical/condition issues with the asset or its family) are broad, arguably simplistic, and do not appear to allow calibration against fault rates as is done elsewhere in established asset health index based methodologies, albeit mainly for distribution assets. The proposals for Asset Health Indices are based on condition based Priority Groups as developed initially in previous versions of EPS 12.7. Asset Health Index Priority 2 may be further sub-divided. The Asset Health Indices are mapped to Network Asset Condition Indices, expressed in bands of Remaining Useful Lives (RUL) – NGA 49.

Table 5.5 – Review of NGET's processes for assessment of asset condition

Asset	**Overhead Lines**	**Cables**	**Switchgear**	**Transformers and Reactors**
EPS	12.4	12.5	12.6	12.7
TGN (AR)	4	5	6	7
Asset Health Indices (AHIs)				
1	Serious problem; RUL < 5 years	Serious problem; RUL < 10 years	Serious problem; RUL < 5 years	Serious problem; RUL< 5 years.
2	Developing problems – expected to deteriorate to AHI of 1 within 5 years.	Developing problems – expected to deteriorate to AHI of 1 within 5 years.	2a. Developing problems – expected to deteriorate to AHI of 1 within 5 years. 2b. To deteriorate to AHI of 1 within 10 years.	2a. Developing problems – expected to deteriorate to AHI of 1 within 5 years. 2b. To deteriorate to AHI of 1 within 5-10 years. 2c. Long term uncertainty.
3	Low level of faults and defects	Low level of faults and defects	Low level of faults and defects	Problems in family.
4	Good condition.	Good condition.	Good condition.	Good condition.
Condition Scoring Methodology	One point for each defect. Circuit scoring e.g. 1200 = AHI of 1; >500 = AHI of 4	None stated	None stated	1 (good) to 100 (poor) for each category (e.g. DGA).
End of Life Criteria	Quantitative; mechanical strength	Qualitative	Qualitative	Quantitative (DGA, FFA, FRA, Oil quality)
Linkage between AHIs and Remaining Useful Life	Yes, NGA 49 & TGN(AR) 4, section 5	Yes, NGA 52 & TGN(AR) 005, section 6	Yes, NGA 56 & TGN(AR) 006, section 6	Yes; NGA 59 & TGN(AR) 007, section 5
Fault rate vs AHI	No	No	No	No
Failure rate vs Age (other than retirement profiles for ALERT modelling) i.e. hazard rate	No	No	No	Yes; TGN (AR) 007, section 4

There appear therefore to be inconsistencies in the detail between the Asset Health Indices proposed in JMS 26 and those in Table 5.5. The table above also indicates that quantitative condition scoring methodologies to establish Asset Health Indices appear to exist only for overhead lines and transformers. We consider that it would be useful if NGET was to provide sight of the underlying process by presenting actual worked examples.

We note, however that NGA 51 (overhead lines), 55 (cables) and 58 (circuit breakers) state that the corresponding Asset Health Indices were developed only in 2007 to 2008 and that there is not enough information available to back-calculate the historic Asset Health Indices on the same basis. For transformers, however, there is historic data available from 2000/1 (NGA 62). As it would appear therefore that the methodology is not yet established in practice, NGET should be asked to provide information on any trials that may have been conducted.

Our principal observation of NGET's proposals for the output measures relating to asset condition are that:

- the proposed Asset Health Index grading is simplistic, not uniform between assets (only 4 grades, albeit with sub-divisions) and impedes the development of a mathematical Asset Health Index model – which could be used to Asset Health indices, fault and/or failure rates against alternative replacement scenarios, as is being done elsewhere and

- there do not appear to be quantitative end-of-life criteria or condition scoring processes for cables and switchgear.

5.8.3 Reliability of network assets

No correlation is provided between reliability (fault or failure rate) and Asset Health Index which itself raises the question of how the Asset Health Indices are quantified. With the limited exception of transformers failure rates are not stated.

5.8.4 Predicted rate of deterioration of network assets

An indication is given of the expected time interval for the migration from Asset Health Index 2 (Remaining Useful Life 5 to 10 years) to Asset Health Index 1 (Remaining Useful Life less than 5 years). It is for consideration whether a more precise indication should be given, such as typical degradation rates for:

- mechanical strengths of overhead line components,

- Asset Health Indices of circuit breakers with time and with number of operations (fault, non-fault, if known) and

- condition of transformers as indicated by DGA, FFA levels and FRA tests

particularly those nearing end-of-life limits.

5.8.5 Assessment of present and future ability of network asset to perform their function

See 5.8.4.

5.8.6 Network risk

NGET firstly compares the asset replacement volumes generated from the ALERT model (age based model) with those in the capital plan. Where the latter are the lower a “backlog volume” provides an indicator of risk and a means is derived of projecting forward the Replacement Priorities (as indicated by the Asset Health Indices) although Replacement Priorities could similarly remain unchanged or be delayed. We find this concept to be curious since such backlogs could equally well be indicated if the assumed asset lives for modelling are shorter than those indicated by asset condition (NGA 21 to 28).

NGA Section 3.2, Network Risk, indicates that the Asset Health Priorities (Remaining Useful Lives corresponding to the Asset Health Indices) would be brought forward as Replacement Priorities (time intervals within which the assets are to be replaced) according to whether the criticality is Low (criticality score = 3), Medium (2) or High (1). The details of the Replacement Priority /Criticality Scoring matrices are presented in the respective TGNs. We note also the statements made that as Replacement Priorities were developed in 2008 and that there is not enough information to back-calculate the historic Replacement Priorities on the same basis. Our main observations of the Replacement Priority approach are that:

- it is an application of risk mitigation to prioritise asset replacement but the Network Risk itself is not quantified thereby, nor is a risk profile with time indicated
- life cycle costing techniques, as advocated in Cigré Technical Brochure 248 - Guide on Economics of Transformer Management, are not considered at all
- bringing forward of replacement of assets of a given health index is at discrete intervals (e.g. from 2 to 5 years to 0 to 2 years) and is therefore discontinuous and a coarse adjustment
- no assets appear to have their replacement correspondingly delayed, and it should be made clear that replacement could equally either be brought forward, not changed or delayed
- system criticality only is considered in the NGA whereas the JMS includes safety and environmental criticalities – it is not clear how these criticalities could be combined (in our view this could be in monetary terms and then the cost of unavailability would have to be known)
- system criticality, as described in TGN(E) 226:
    - would appear to be concerned with delivery points only
    - does not indicate how connecting circuits would be treated
    - does not indicate the proportions of substations and circuits in each criticality category overall and
    - does not appear to take account of risk mitigation already provided by GB Security and Quality of Supply Standard (SQSS)

We consider that NGET should be asked to present a worked example of the Replacement Priority process and to explain the omission of life cycle costing techniques as a means of prioritisation.

NGET should also indicate the extent to which the quantities of assets identified for replacement by Replacement Priorities would be modified by the Scheme Prioritisation process (JMS 16).

5.8.7 Network performance

Further to our comments in 5.6.1 we comment that:

- In NGA Section 3.3, Network Performance, statements are provided of inclusions and exclusions within the “Rule set for outages included within Average Circuit Unreliability”; NGET should be asked to provide a reconciliation between the Average Circuit Unreliability Measure and:
    - the system performance data (system availability/system unavailability due to planned/unplanned outages) in Table 4.3 of NGET’s TRRP return
    - corresponding Average Circuit Unreliability calculated using hours instead of ”Repair Days” and
    - an explanation for apparently having two dissimilar output measures ostensibly measuring the same network performance and in effect thereby proposing an apparent change from the established annual Report on Transmission System Performance and the TRRP returns
- the system unavailabilities in the system performance data in Table 4.3 of NGET’s TRRP return are disaggregated by planned and unplanned outages and that the latter are further disaggregated by asset type (transformers, switchgear, overhead lines and underground cables); we would propose that further disaggregation by voltage level and outage duration be provided
- NGET should be asked to confirm whether its unavailability data includes transient or non-damage faults (faults cleared in seconds by tripping and auto-reclosing) as these faults are normally not condition-related
- NGET should be asked to clarify the derivation of the number of “circuits” used in the calculation of the respective unavailabilities in TRRP Table 4.3 by asset type
- comparative data on asset fault rates and repair times could then be readily derived from the Table 4.3 data which would allow comparison between the Transmission Licensees in a manner similar to that offered by NAFIRS to participating DNOs
- NGA 36, Figure 4, Average Circuit Unreliability of Transformers April 2002 to March 2008, indicates a sharp upturn in “% unavailability due to reliability outages” during the year 2007/8; in PB’s opinion it would be in accordance with Licence Condition B.17, paragraph 5 if NGET was to explain whether this upturn marks a deterioration in asset

condition, preferably by providing an analysis of the data and comment how this output measure could show changes in

- o asset condition
- o fault rate
- o repair times
- o resources to undertake remedial work and/or
- o condition/non-condition related faults (NGA 103 refers)
- o other relevant factors such as weather and

- NGA 39 to 40, Faults – the data in TRRP return Table 4.5 Fault Reporting could usefully be disaggregated into capex and opex related faults and corresponding expenditures provided.

5.8.8 Network capability

The methodology should be expanded to include:

- effectiveness of measures to release additional capacity or change the generation mix to provide an understanding of the extent and cause of constraints
- Zonal analysis[39].
- Power factor.

5.9 SPTL specific appendix

5.9.1 Introduction

SPTL has provided only a relatively brief high level description of its asset management processes but with little detail of proposed output measures. SPTL also states that further work is required in respect of Network Risk and Network Performance. As far as can be seen SPTL's processes reflect those presented to us during the Main Transmission Price Control (TPCR) over two year's ago and are little changed to meet the requirements of Licence Condition B17.

PB Power recognise that there is a the need to ensure that the proposed output measures are proportionally applied to SPTL, particularly when compared to NGET. How this will be achieved will only become clearer when the high level description provided is supplemented.

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[39] R. Hull. M. Zhu., L.A Dale, D. Densley, S. Mathieson; Network Investment Incentive Developments in the 4th GB Transmission Price Control Review – Regulator & Licensee Perspectives, Cigré 2008, paper C5-206.

5.9.2 Current condition of network assets

SPTL has adopted an age-based asset replacement model to model the long term planning of the principal network assets, namely cables, transformers, overhead lines and switchgear. SPTL describes this as a top-down modelling process. In planning replacement in the short to medium term SPTL states that it considers asset condition and prioritises assets according to either substation or circuit criticality.

SPTL provides an outline description of its routine asset inspection and detailed asset condition assessment processes but does not give any details as to how condition would be scored or graded. There is no mention of Asset Health Indices, Asset Hazard Priorities and only a one line mention of remaining useful life but this is purely descriptive. Hazard rectification instructions are graded into immediate, earliest or programme priorities as described during the Main TPCR although these instructions are likely to apply to low-cost repair and maintenance measures.

5.9.3 Network risk

SPTL states that it has adopted an asset criticality framework, as was noted at the Main TPCR, in which the asset importance of substations and circuits is assessed and assets assigned to three bands of criticality (high, medium and low) and replacement priorities assigned accordingly. Technical and financial activities include a comprehensive range of costs (capex, opex, safety, customer service) SPTL also ranks criticality by consequence, cost and by business drivers using a scoring methodology.

We would consider SPTL's methodology on respect of Network Risk to be in accordance with good practice elsewhere, subject to the qualification that a high proportion of the transmission assets are classified as being of “High” criticality (Figure 5 of SPTL's specific appendix refers). SPTL should be asked to provide more details, however in particular tangible proposals for the quantification of Network Risk.

5.9.4 Network performance

SPTL has provided a brief description of its present methodology for assessing unavailability due to outages. There is no reference to Average Circuit Unreliability as proposed in the JMS. Furthermore no mention is made of derivation of fault rates or restoration times. It would appear that further work is required to provide a common approach between the Transmission Licensees.

5.9.5 Network capability

SPTL reports on network capability as per Table 4.8 (Boundary transfers) and Table 4.9 (Demand and supply capacity at substations) of the TRRP.

5.10 SHETL specific appendix

5.10.1 Introduction

SHETL has provided a brief description of its specific implementation details regarding each of the elements of the Network output measures. SHETL also refers to its standing procedures, the review of its asset management processes which was carried out during the Main TPCR and which was found to align with the international leading practices of transmission companies. SHETL also points out that the specific network output measures are new to SHETL and that, other than the information provided with the 2006/7 TRRP return, it would not be possible to report for past years.

PB Power recognise that there is a the need to ensure that the proposed output measures are proportionally applied to SHETL, particularly when compared to NGET. How this will be achieved will only become clearer when the high level description provided is supplemented.

5.10.2 Network asset condition

Although SHETL lists its processes for short and medium term assessment of assets and their condition, no indication is provide of any condition scoring or Asset Health Index derivation process. (The condition grades in Tables 4.7 of each Transmission Licensee's TRRP return each differ.)

SHETL makes reference to assessing fault rates against NaFIRS but it is unclear whether this assessment applies to its 275kV assets. Predicted rates of deterioration relay on asset replacement profiles in age-based modelling.

It would therefore appear that SHETL's processes would have to be modified in order to line up with the proposals in the JMS.

5.10.3 Network risk

SHETL has an established asset risk scoring system in which consequence of failure is compared with likelihood of failure in order to establish replacement timescales.

5.10.4 Network performance

SHETL states that its network performance reporting within the TRRP is derived from figures published within the annual GB Transmission System performance Report. As SHETL has not provided data on system unavailability by asset type, clarification should be sought as to what outage information is available and how this could be processed to provide the level of detailed reporting proposed elsewhere in this report.

5.10.5 Network capability

SHETL reports Boundary transfers and capabilities as per TRRP Table 4.8 and Demand and supply capacity at substations as per TRRP Table 4.9.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

6.1.1 Section 2 – review of transmission and distribution licensees present practice and capabilities

The conclusions of Section 2 of the report are:

- reporting is presently through the GB Transmission System Operator Performance Report and TRRP returns; we identify gaps in reporting required for Licence Condition B17 in later sections of this report

- few causes of loss of supply appear to be related to the condition of plant

- SHETL's losses of supply are predominantly due to storms affecting the relatively sparse 132 kV network in the Highlands and Islands Region of Scotland

- the nature of the incidents suggest that there may be a need for the metrics to focus on the supporting assets (secondary assets) as well as primary assets and operational issues

- NGETs' and SPTL's normalised (Cigré) System Minutes are of an order of magnitude lower than other international comparators, reflecting the highly integrated configurations of the two networks and compliance with the SQSS

- we are however unaware of any systematic comparison, across the Transmission Licensees, of fault rates, restoration times or trends thereof by asset type and nor does there appear to be any sharing of such data between Transmission Licensees although 132 kV data has been shared between the two Scottish Transmission Licensees and the DNOs under the auspices of NaFIRS, at least in the past.

6.1.2 Section 3 – Review of International Electricity Transmission and Distribution Practice

The conclusions of Section 3 of the report are:

- there may be merit in adopting a more disaggregated approach in reporting availability and unavailability than currently proposed by the Transmission Licensees

- the adoption of System Minutes as a metric would readily enable comparison with international transmission system operators although we would expect NGET's and SPTL's values to be of an order of magnitude lower than most available comparators

- in Australia the Service Target Performance Incentive Scheme is a practical method of providing an incentive to the Electricity Transmission Network Service Providers to minimise network outages; the scheme includes the reporting of transmission circuit availabilities by critical circuits and also according to peak, intermediate and off-peak loads; much of the revenue at risk is under the control of the Transmission Network Service Providers

- good examples of reporting of reliability and outage statistics of transmission plant exist (Cigré surveys (occasional), Canada's ERIS five yearly reporting on the Forced Outage Performance of Transmission Equipment, Nordel's annual Grid Disturbance and Fault Statistics) and of standard definitions (FERC's TADS, IEEE and IEC)

- consideration should be given to adopting the reporting of transmission plant fault and outage data in a manner similar to NaFIRS

- Cigré Technical Brochure 309, Asset Management of Transmission Systems and Associated Cigré Activities, December 2006, expands the concept of risk in terms of probabilities of asset failures, their consequences and relationship with the business values of the transmission owner

- limited information is in the public domain on the variation of failure rates with asset condition and, separately, with asset age; modelling of failure rates against asset age and/or condition is the subject of a number of recent papers however

- Cigré Technical Brochure 248, Guide on Economics of Transformer Management, June 2004, is recommended as a reference for methodologies for a "Risk-Based Decisions Process for Investment in Power Transformer Replacement" including economic/financial analysis of net present values in monetary terms taking into account cost of energy not supplied; the brochure also contains outline data of failure rate by age and failure rate by condition

- Asset Health Index based processes for risk management are established and are being developed further, principally for distribution assets, although coverage within a given distribution network operator's asset base may not be complete (Appendix B)

- no standardised methodology or terminology for asset health indices exists however and the processes require appreciable data on the condition of assets.

- considerable work is being undertaken, albeit on distribution assets, in the United Kingdom, Canada and elsewhere to relate fault rate with asset condition category and (for a given asset condition category) with age.

6.1.3 Section 4 – Review of Relevant Commercial industries Practice

The conclusions of Section 4 of the report are:

- serviceability indicators (or Service Performance Indicators, SPI) and guaranteed standards of service (GSOS) for the customers are important in output measurement and can be taken as an example of best practice from the water and sewerage industry

- the necessity of identifying outputs and expenditure plans for asset maintenance that ensure serviceability to customers and travellers are commensurate with the required levels of expenditure necessary for the output delivery

- Asset Management (or Maintenance) Plans are key ingredients to measuring outputs of sectors that require constant and detailed upkeep and investment

6.1.4 Section 5 – Review of Licensees' Draft Methodologies

The conclusions of Section 5 of the report are that:

6.1.4.1 Network asset condition

- the categorisation of Asset Health Indices into four principal categories:
    - a four-grade scale is proposed with sub-divisions which differ between asset categories[40]. While this categorisation might be as good as could be expected given existing asset condition reporting processes and data any analysis undertaken would be limited by the discontinuous and discrete intervals of the grading scale; future refinement may permit a finer scale so as to enable more meaningful further analysis, including calibration of remaining useful lives
    - corresponding Asset Health Indices are identified for four asset groups only, circuit breakers, transformers, overhead line conductors and underground cables but no mention is made of other major asset groups such as overhead line fittings and towers or protection and control
    - reflects the reporting format in the DRRP (with the intention of enabling comparison with the reporting by the DNOs), namely 0-2 years, 2-5 years, 5-10 years and >10 years; this format may suffice for reporting but
    - does not facilitate (external) qualitative analysis or modelling including calibration against existing fault rates and analysis of faults based on asset health progression and/or prediction of replacement requirements on an annual basis
- no proposals are provided for calibrating Asset Health Indices against either fault rates or remaining useful lives (predicted rate of deterioration) – the Transmission Licensees need to explain how residual lives are determined in the first instance
- the expected time intervals for the migration from one Asset Health Index to another are large, reflecting the reporting format and the limited number of grades of Asset Health Indices
- processes for the scoring of asset condition to derive Asset Health Indices appear to be limited

[40] A four-grade scale represents fewer grades than are being adopted by other workers in this field albeit for distribution assets. Work on the application of Asset Health Indices to transmission assets is however proceeding, notably the work of the Transmission Underground Cables Interest Group of CEATI International covering oil insulated pipe type cables to 225kV (see Cigre Osaka Symposium 2007 Paper 227).

- no mention is made in the JMS of how (efficiency of) historical and forecast expenditure would be assessed, from the viewpoint of condition amongst other things; the Transmission Licensees acknowledge that such historic data may not exist, as acknowledged in Licence Condition B17, paragraph 5c

- without calibration and normalisation, the asset health indices will not allow the objectives of Licence Condition B17 paragraph 4 c) to be met

6.1.4.2 Network risk

We find the proposed definition of Network Risk to be requires supplementing and propose that either a weighted average remaining life (WARL) index, a criticality modified WARL index, a network (weighted) risk index in terms of economic worth at risk be considered (Appendix C) or a weighted index based on availability. In our view criticality should only be an issue for short range expenditure planning otherwise the definition of residual life would become inappropriate.

Our main observations of the Replacement Priority approach are that:

- the Replacement Priority approach is an application of risk mitigation to prioritise asset replacement but the Network Risk itself is not quantified or defined thereby, nor is a risk profile with time indicated

- life cycle costing techniques, as advocated in Cigré Technical Brochure 248 - Guide on Economics of Transformer Management, are not considered at all

- bringing forward of replacement of assets of a given health index is at discrete intervals (e.g. from 2 to 5 years to 0 to 2 years) and is therefore discontinuous and a coarse adjustment, instead of, say, a methodology which allowed adjustments to be made a year at a time

- it should be made clear by the Transmission Licensees that replacement could equally either be brought forward, not changed or delayed.

- a process for combining of system, safety and environmental criticalities on a common basis is not provided and is essential if criticality is to be addressed; in JMS paragraph 86 the Transmission Licensees have listed the development of a comparable scale for System, Safety and Environment Criticality as being subject to future development work

- system criticality, as described in NGET's TGN(E) 226:

    - would appear to be concerned with delivery points only

    - does not indicate how connecting circuits would be treated

    - does not indicate the proportions of substations and circuits in each criticality category overall and

  - o does not appear to take account of risk mitigation already provided by GB Security and Quality of Supply Standard (SQSS)

6.1.4.3 Network performance

- a further explanation is required of the proposal to adopt NGET's Key Performance Indicator (KPI) of Average Circuit Unreliability in addition to availability/unavailability (planned and unplanned) as in the GB Transmission System Performance Report and the TRRP Table 4.3; there are differences between the definitions (weighting by "Repair Days" instead of by hours; there are also exclusions of certain outages from Average Circuit Unreliability); one possibility would be for the Transmission Licensees to provide a reconciliation between the two methods

- the unavailability data as provided in TRRP Table 4.3 is insufficient and further data is required, by asset type and voltage level, corresponding fault rates, restoration times provided by time bands (and not just simple averages), faults disaggregated either into condition/non-condition related , urgent/non-urgent and/or capex/opex; the data should also permit the view of trends

- data on hazard rates (fault rates of remaining population) should similarly be compiled

- The Transmission Licensees should state the effectiveness of the proposed measures in providing an early indication of significant asset deterioration

- the increase in NGET's transformer unavailability in the year 2007/8 could be a useful test case for indicating the onset of significant asset deterioration, if that indeed be the case in this instance and

- clarification is required of the term "circuits" in calculating unavailability/unreliability.

6.1.4.4 Network capability

The following output measures should also be considered to meet the objectives of the Licence Condition:

- effectiveness of measures to release additional capacity or change the generation mix to provide an understanding of the extent and cause of constraints

- zonal capability

- Transfer distance (MW.km)

- power factor and reactive power margin

6.1.4.5 SPTL specific appendix

SPTL has provided only a relatively brief high level description of its asset management processes (largely unchanged from the Main TPCR) but with little detail of proposed output measures. Although SPTL's asset criticality framework, taking account of Network Risk, appears to be in accordance with good practice elsewhere, no tangible proposals for quantification of Network Risk have been provided. SPTL's Network Performance measures are as exist at present and do not reflect the proposals in the JMS. SPTL should therefore be asked to provide details of its proposed output measures as these are developed.

6.2 Recommendations

The recommendations of this report are that the Transmission Licensees should be asked to expand their submission in general to meet the requirements of paragraphs 5 (a) and 5 (b) of Licence Condition B.17, (analysis and reports relevant to the development of the network output measures … to indicate how the proposed methodology facilitates the objectives) in detail as per the headings in Licence Condition B.17.paragraph 2 as indicated below.

Network asset condition

Short/medium term assessment

a) **Current condition of assets**

A (future) refinement of the proposed four-grade scale, if practical, may include a finer scale enabling further analysis, including calibration of remaining useful lives.

b) **Reliability of network assets**

Proposals should be submitted for the calibration of the Asset Health Indices in terms either of fault rate, remaining useful lives and/or predicted rate of deterioration; the relationship between Probability of Failure and Asset Health Index should be determined thereby to enable analysis; specifically fault (hazard) rates should be complied as functions of (separately) condition and age, these being essential for normalisation and validation purposes.

c) **Predicted rate of deterioration**

i) A justification should be provided for statements to the effect that an asset with a particular Asset Health Index would be expected to deteriorate to lower (condition) Asset Health Index within a given interval; measurements of key condition indicators than would support such statements including calibration.

ii) Proposals are required for key indicators of deterioration in asset condition (e.g. variation in hazard rate (i.e. the rate at which the remaining items fail) or "upturn of the bathtub curve"); details of the definition of rate of deterioration and policy for each major asset category.

d) **Present and future ability to perform function**

It would appear that if the requirements of a) to c) above are met then d) is implicitly met.

Long term assessment

a) **Current condition of assets**

The reporting of asset age profiles and asset lives should be retained to enable the assessment of replacement asset quantities in the longer term.

b) **Reliability of network assets**

As short term assessment a).

c) **Predicted rate of deterioration**

As short term assessment a).

d) **Present and future ability to perform function**

As short term assessment a).

2) **Network risk**

Short/medium term assessment

a) Firstly the Licensees' process should have the asset health indices (calibrated and normalised) generated as base data per asset category; secondly then an assessment of how these assets are classified as critical, subject to agreement between the Licensees on definitions (calibration) of criticality

b) An Intermediate Step, delivery of criticality, is therefore required to amplify the proposed definition of Network Risk in JMS paragraph 39 and to quantify Network Risk as such; consideration should be given to further quantifying the relationship between Network Risk and variation in expenditure

c) as the proposed Replacement Priority process is a prioritisation process and does not provide either a definition of network risk or a risk profile (with time) i.e. variation of risk (however defined) with time, further consideration should be given to the adoption of a risk definition in terms of the frequency of an event occurring compared with its consequence; paragraph 40 in the Joint Methodology Statement (JMS) needs to expanded to explain why optimised replacement is a proxy for risk and what the nature of risk is

d) the proposed Replacement Priority process should in any case be reviewed to

   i) reduce the step changes in Replacement Priorities with Criticality Index

   ii) combine the system, safety and environmental criticalities

e) techniques for prioritising asset replacement should include an element of life cycle costing and/or cost/benefit analysis

f) The output measure of network risk should provide a high level indication of the relationship between network asset condition (remaining lives) and network performance and, in so doing, provide an early indication of the possibility of a "spiral of decline" if asset replacement/refurbishment/repair was insufficient

g) We would consider a criticality based approach to be a short term risk management issue; accordingly we would suggest that a network (weighted) risk index in terms of economic worth at risk be considered (Appendix C), noting that such an index would be criticality dependant and our caveats (site/geography specific, quantification and comparison of risk is complex) on the modelling of criticality and its being more applicable to short term planning,

whereby the Network Risk Index would be related to:

- asset condition and the interdependence between network assets (Licence Condition B17, paragraph 2b)
- unserved energy
- reliability worth of supply (Value of Lost Load (VOLL)/System Customer Outage Cost (SCOC)
- monetary equivalents of safety and environmental criticalities, or where there are qualitative elements within the definition of criticality, a means whereby qualitative and quantitative elements can be compared and

h) If a scoring system for assessment of criticality (ScottishPower) is proposed instead, then the methodology for allocating the scores should be provided.

Long term assessment

i) We propose that the following supplementary approaches for a network risk index be considered. If these approaches are currently not possible, it is proposed that these be worked to in the longer term:

- weighted average remaining life (WARL) index, using remaining useful lives and not being criticality dependent
- a criticality modified WARL index, indicating the sensitivity of the index to criticality and
- weighted index based on availability, in the manner of the Australian Service Target Performance Incentive Scheme, and also weighted for safety and environmental considerations.

3) **Network performance**

a) In addition to declaring the annual Estimated Unsupplied Energy and related incidents, the corresponding "System Minutes" index should also be declared, including major incidents where this index is greater than one minute, so as to enable comparison with other transmission networks worldwide

b) an explanation should be provided of the proposal to adopt the output measure of Average Circuit Unreliability as well as planned/unplanned availability as at present; a reconciliation between the two methods should also be provided

c) further disaggregation of the unavailability data is required, by asset type and voltage level, restoration times provided by time bands, faults disaggregated either into condition/non-condition related, urgent/non-urgent and/or capex/opex; the data should also permit the view of trends; NaFIRS provides a suitable precedent for the compilation of such fault data

d) NGET should provide a reconciliation between the number of unplanned circuit outages in TRRP Table 4.3 (System Performance) and the number of faults in TRRP Table 4.5 (Fault Reporting); noting that the system unavailability data in TRRP Table 4.3 is from the Transmission Outage Planning and Monitoring (TOPAM) database and the fault data in Table 4.5 is from the MIMS work management system; furthermore the information provided in the TRRP is insufficient to say whether there is a direct correlation between the number of unplanned circuit outages in 2006/7 (280 in TRRP Table 4.3) and the number of faults in that year (275 in TRRP Table 4.5) – clarification should be provided - and

e) NGET should provide an amplification of TRRP Table 4.3 in which average durations and fault/interruption rates of planned and unplanned interruptions are derived from the unavailability and number of circuit outages data already provided; particular clarification is required on the asset quantities (e.g. from TRRP Table 4.12 (Asset Age)) that would be used to derive the fault rates and the interpretation of the term "circuits" in respect of transformers and reactors, switchgear, overhead lines and cables in calculating average durations of outages (for example a reconciliation of "circuits" with either asset quantities in TRRP Table 4.12 or with Tables B.2.1 in the Seven Year Statement).

4) **Network capability**

Additional output measures should be considered in respect of Network Capability, namely effectiveness of measures to release additional capacity and the effect of generation mix in order to provide an understanding of the extent and cause of constraints, the reactive power margin within each zone that is associated with boundary transfer metric suggested by the Licensees, the transfer distance (MW.km),and the within zone capability of each zone (Cigré Technical Brochure 24 - Planning against voltage collapse - refers). In addition, given the rise in reactive power consumption reported in the last TPCR, it is recommended that power factor is also reported on a zonal basis.

5) **SPTL**

As SPTL has provided only a relatively brief high level description of its asset management processes (largely unchanged from the Main TPCR) but with little detail of proposed output measures, SPTL should therefore be asked to provide details of its proposed output measures as these are developed

PB Power recognise that there is a the need to ensure that the proposed output measures are proportionally applied to SPTL, particularly when compared to NGET. How this will be achieved will only become clearer when the high level description provided is supplemented.

6) **SHETL**

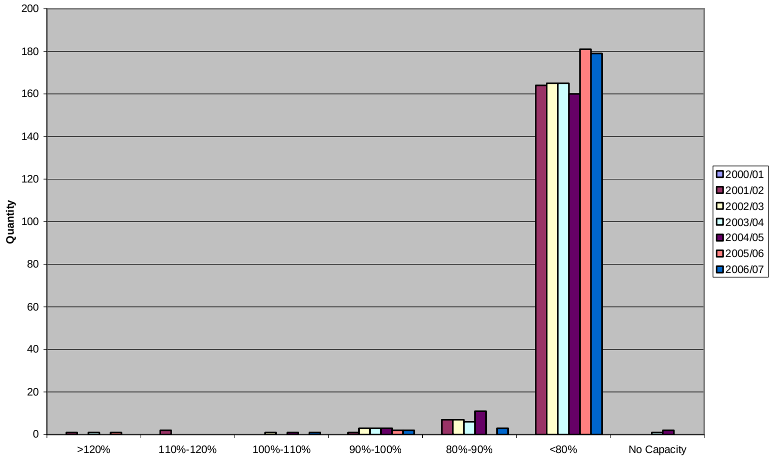
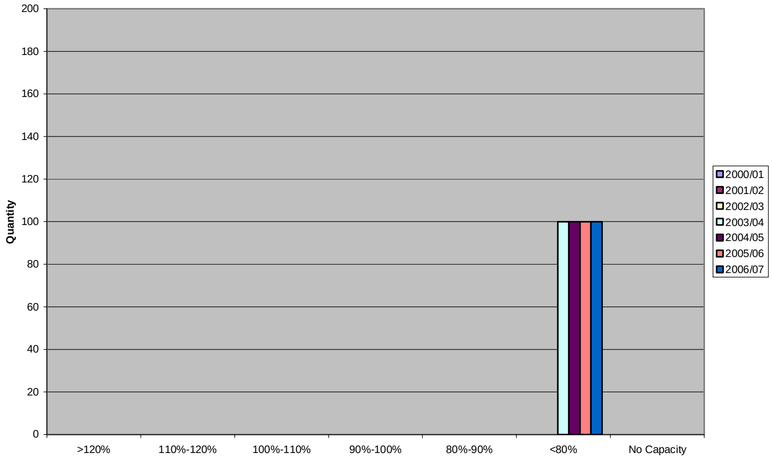
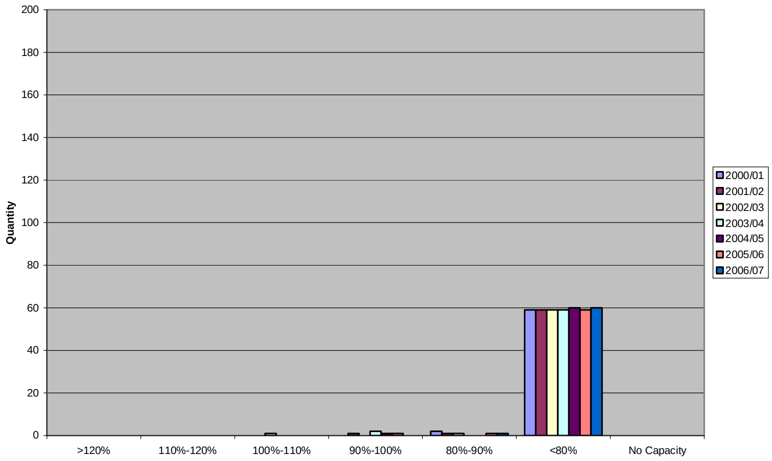
As SHETL has also provided only a brief description of its specific implementation details regarding each of the elements of the Network Output Measures, SHETL too should therefore be asked to provide details of its proposed output measures as these are developed.

In a similar way to SPTL, there is a need to ensure the proposed output measures are proportionally applied to SHETL.

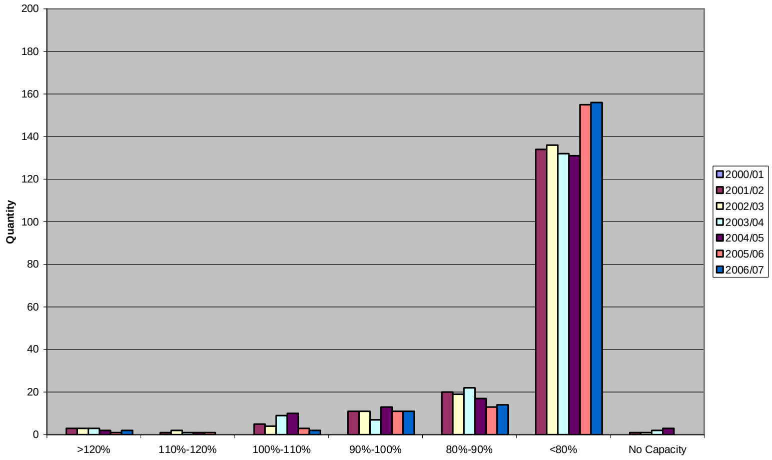
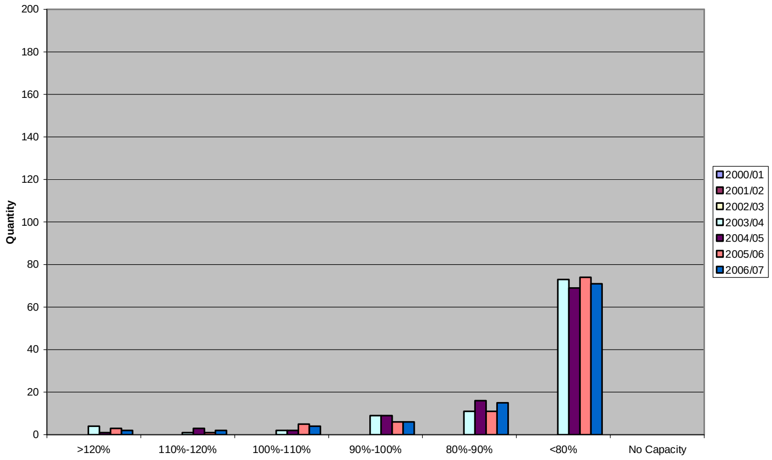
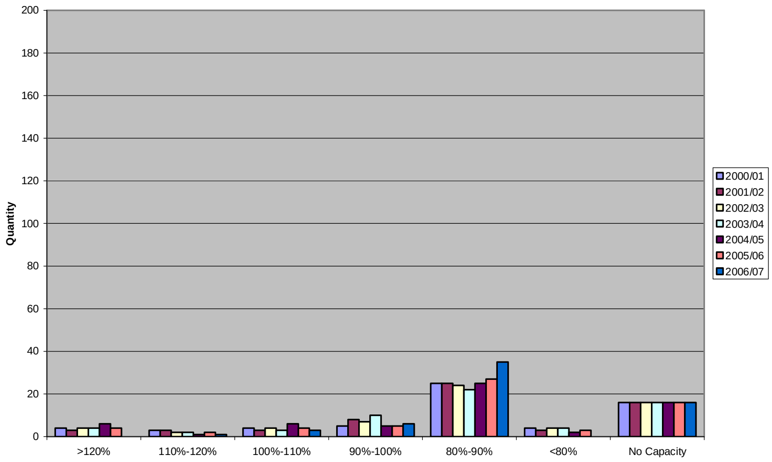
APPENDIX A

NUMBER OF SUBSTATIONS WITHIN (DEMAND/NON-SGT CAPACITY)% BANDS FOR INTACT, N-1 AND N-2 (>300MW) CONDITIONS

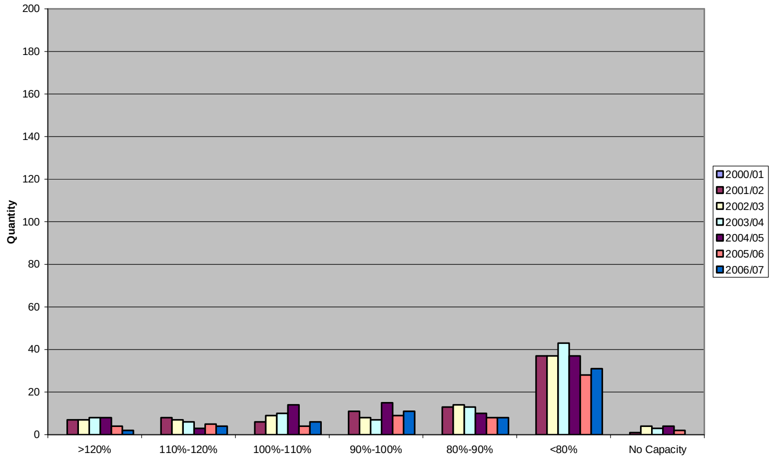
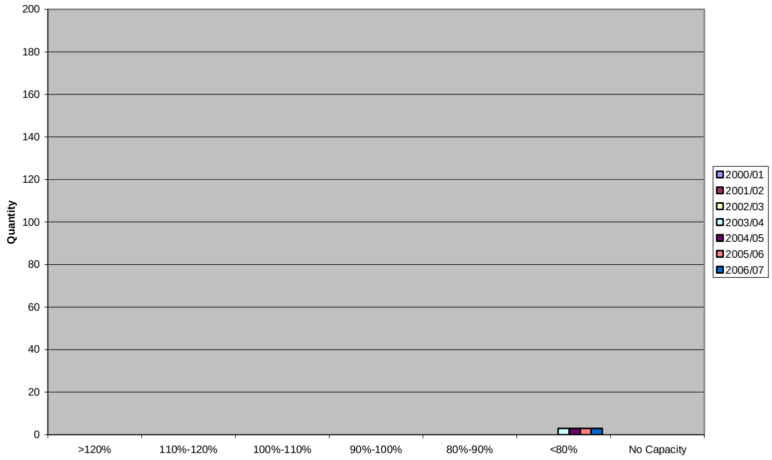
APPENDIX A - NUMBER OF SUBSTATIONS WITHIN (DEMAND/NON-SGT CAPACITY)% BANDS FOR INTACT, N-1 AND N-2 (>300MW) CONDITIONS

NGET	
SPTL	
SHETL	

N-1 conditions

NGET	
SPTL	
SHETL	

N-2 (>300MW) conditions

NGET	
SPTL	
SHETL	Not applicable

APPENDIX B

ASSET HEALTH INDICES – EXAMPLES OF ESTABLISHED PRACTICE

APPENDIX B – ASSET HEALTH INDICES – EXAMPLES OF ESTABLISHED PRACTICE

General

Examples of the use of a fine and uniform scale for Asset Health Indices are the approaches used by EA Technology Ltd in the United Kingdom and by Hydro One and other electricity utilities in Canada. An important feature is the derivation of probability of failure (PoF) as a function of the Asset Health Index.

EA Technology Ltd – Condition Based Risk Management™ (CBRM)

Sources:

D.T Hughes, D.S. Russell; Condition Based Risk Management (CBRM), A Vital Step in Investment Planning for Asset Replacement, 3rd IEE International conference on Reliability of Transmission and Distribution, London, February 2005.

D. T. Hughes; Presentation at IAM conference 20 June 2006

D. Hughes, T. Pears; Condition Based Risk Management (CBRM), A Process to Link Engineering Knowledge and Practical Experience to Investment Planning – An Update, CIRED, 19th International Conference on Electricity Distribution, Vienna, May 2007.

Condition	Health Index	Remnant Life (years)	Probability of Failure
	10		
Bad		At End of Life(EoL) (< 5 years)	High
Poor		5 to 10	Medium
Fair		10 to 20	Low
Good		> 20	Very Low
	0		

CBRM process:

- Use existing information to define present condition of assets, supplemented by surveys as necessary
- Assign Condition Ratings (CR – CR1 = good, CR4 = worst, requires remedial action) to components and

- Weight Condition Ratings according to importance of component to derive normalised asset health indices for individual assets and build asset health index profiles for asset groups
- Calibrate health index against probability of failure (e.g. using existing fault rate data – distinguish between condition and non-condition related) – exponential type function for condition related failures
- Estimate future condition and performance – calculate future failure rates i.e. change of health index with time – exponential type function
- Evaluate potential interventions in terms of probability of failure and failure rates
- Define and weight consequences of failure
- Build a risk model, taking asset criticality into account (the importance of one asset relative to the others of its category)
- evaluate potential interventions in terms of risk (evaluated in monetary terms, taking into account system, safety and environmental aspects)

Canada

Typical Asset Health Index Results

Sources:

T. Hjartarson, Program Planning Using Health and Risk, CIRED/ENARD Workshop, Managing and Ageing Infrastructure, Vienna, May 2007

G. Anders, S. Otal, T. Hjartarson, Deriving Asset Probabilities of Failure; Effect of Condition and Maintenance levels, IEEE, 2006

Health Index	Condition	Life Remaining	Probability of Failure (PoF)	Equivalent status on life curve	Requirements
85 - 100	Very Good	As new	Low	First half of mean life	Normal Maintenance
70 - 85	Good	More than 15 years	Low but slightly increasing	Second third of mean life	Normal Maintenance
50 - 70	Fair	5 to 15 years	Rapidly increasing but lower than PoF at mean life	Final third of mean life	Increase diagnostic testing, possible remedial work or replacement needed depending on criticality
30 - 50	Poor	Less than 5 years	Higher than PoF at mean life and increasing	First third after mean life	Start planning process to replace or rebuild considering risk and consequences of failure

Health Index	Condition	Life Remaining	Probability of Failure (PoF)	Equivalent status on life curve	Requirements
0 - 30	Very Poor	At end-of - life	Very High, more than double the PoF at mean life	Second third after mean life	Immediately assess risk; replace or rebuild based on assessment

- Asset Health Index technique used mainly on distribution assets
- Asset Health Indices, scale 0 to 100, are the totals of condition scores weighted according to the importance of the measure that is being scored and on a normalised scale
- Failure rates of station transformers are found to have a closer correlation with condition category than with age
- Lives remaining according to condition grades can vary e.g. Toronto:

  h) Very Poor = replace next year

  i) Poor = Replace in 2 to 3 years

  j) Fair = Replace in years 4 to 10; expected to deteriorate to Very Poor in 10 years

- Probability of failure against Health Index score derived (exponential type function)
- Canadian regulatory authorities require a condition-based business case for asset replacement

APPENDIX C

REQUIREMENT FOR A NETWORK (WEIGHTED) RISK INDEX

APPENDIX C - REQUIREMENT FOR A NETWORK (WEIGHTED) RISK INDEX

Introduction

Weighted Average Remaining Life (WARL), as assessed in the Main Transmission Price Control Review in 2006 but not taken further at that time, however does not relate to the criticality of the particular assets concerned, namely the impact of their not delivering the required level of service. Such impact would be dependent on the function and location of the asset, configuration of the network, demand that is dependent on the correct functioning of the asset as well as the fault rate and restoration time of the asset concerned.

WARL is therefore only an indirect indicator of network risk although one which can be readily calculated using age-based modelling techniques. WARL could similarly be assessed from remaining useful lives (from asset health indices). As the remaining useful life decreases the fault (hazard) rate would be expected to increase. Remaining useful life can (should) be related to asset health index (condition) and thence to probability of failure.

For a transmission system, however, the network risk profile should be skewed towards the system critical elements (however classified). Furthermore the risk that is considered here should be the risk to the customer as distinct from the risk to the network business. These mean that location and its criticality (reflecting importance) should be taken into account.

Reliability worth of supply

The risk to the customer could be further quantified by considering the value to the customer of lost energy and by applying a monetary value (such as a value of lost load (VOLL)) as previously used in the British Pool Price formula and as presently used in Australia as a price cap to be applied to the dispatch price and to establish the reliability worth of measures as part of the “Regulatory Test”.

A higher value of customer reliability has recently been used to justify reinforcements to the supply to the central business district of Melbourne, for security of supply reasons. An alternative approach to VOLL is to consider the concept of System Customer Outage Costs (SCOC) taking into account the costs of interruptions of supply to commercial, industrial as well as domestic customers - Annex 4 to OFFER: Review of Public Electricity Suppliers 1998-2000, Distribution Price Control Review, Consultation paper, May 1999, refers.

VOLL or SCOC are economic values which are considerably greater than, say, the corresponding direct tariff-related cost, or financial value, of the energy not supplied.

Definition of network risk

Risk is generally defined as:

frequency x consequence

where:

- frequency = probability of relevant outage

- consequence = energy at risk (function of demand, outage duration) and
- risk = expected energy not supplied

By applying a monetary value to the energy not supplied, the Network Risk could be stated in terms such that the

probability of an interruption to supply of a given economic worth shall not exceed a certain sum over a given interval.

The Network Risk Index would accordingly be the particular probability corresponding to the state of the network.

Criticality

Joint Methodology Statement (JMS) paragraph 45 states that criticality has three elements, system, safety and environmental criticalities. These should be combined by attributing monetary values to them.

National Grid's TGN (E) 226 identifies three high level factors used to determine system criticality, namely impact on vital infrastructure, impact on customers and system security. Vital infrastructure includes sites identified as critical network infrastructure by government. It is for consideration whether these sites could be quantified with a (high) value of customer reliability.

The adoption of monetary values could be an alternative to the proposed simplistic classifications of high, medium and low criticalities.

Recommendation

The output measure of network risk should be an index corresponding to probability of an interruption to supply of a given economic worth not exceeding a certain sum over a given interval.

Accordingly the Transmission Licensees should propose a methodology whereby the Network Risk Index would be related to

- asset condition and the interdependence between network assets (Licence Condition B17, paragraph 2b)
- unserved energy
- reliability worth of supply (Value of Lost Load (VOLL)/System Customer Outage Cost (SCOC)
- monetary equivalents of safety and environmental criticalities.

If a scoring system for assessment of criticality (ScottishPower) is proposed instead, then the methodology for allocating the scores should be provided.

APPENDIX D

LICENCE CONDITION B17

Electricity Transmission Licence: Standard Conditions

Condition B17: Network Output Measures

Part A: Purpose

1) The purpose of this condition is to ensure the development and maintenance of an appropriate methodology to enable the evaluation of network output measures (as defined in paragraph 2) for the licensee's transmission system.

Part B: Development of the network output measures methodology

2) The licensee shall, in consultation with other transmission licensees and interested parties, before 31 May 2008 or such later date as the Authority may direct, submit a methodology (the "network output measures methodology") for approval by the Authority in accordance with paragraphs 7, 8 and 9. The network output measures methodology shall be designed to enable the evaluation of:

   a) the current condition of the assets which collectively form the licensee's transmission system (including the condition of the principal components of those assets) (collectively, "network assets"), the reliability of network assets, and the predicted rate of deterioration in the condition of network assets which is relevant to making assessment of the present and future ability of network assets to perform their function ("network asset condition");

   b) the overall level of risk to the reliability of the licensee's transmission system as a result of network asset condition and the interdependence between network assets ("network risk");

   c) those aspects of the technical performance of the licensee's transmission system which have a direct impact on the reliability and cost of services provided by the licensee as part of its transmission business ("network performance");

   d) the level of the capability and the utilisation of the licensee's transmission system at entry and exit points and other network capability and utilisation factors ("network capability");

collectively the "network output measures".

3) The licensee shall set out in its proposed network output measures methodology the categories of data to be used and the methodology to be applied to such data to derive the network output measures.

4) The network output measures shall be designed to facilitate:

   a) the monitoring of the licensee's performance in relation to the development, maintenance and operation of an efficient, co-ordinated and economical system of electricity transmission;

b) the assessment of historical and forecast network expenditure on the licensee's transmission system;

c) the comparative analysis over time between:

i) geographic areas of, and network assets within the licensee's transmission system;

ii) transmission systems within Great Britain;

iii) transmission systems within Great Britain and within other countries;

iv) transmission systems and distribution systems within Great Britain;

d) the communication of relevant information regarding the licensee's transmission system between the licensee, the Authority and interested parties in a transparent manner; and

e) the assessment of customer satisfaction derived from the services provided by the licensee as part of its transmission business;

collectively the "objectives".

5) Save where the Authority otherwise consents, when submitting its network output measures methodology proposal for approval by the Authority in accordance with paragraph 2, the licensee shall also provide the Authority with:

a) analysis and reports relevant to the development of the network output measures methodology, including supporting data and models to indicate how the proposed methodology facilitates the objectives;

b) a description of the data and treatment applied to that data used in the network output measures methodology; and

c) historical data which was used in the network output measures methodology. Historical data should, where reasonably practicable, be provided for a period of at least ten years preceding the year in which the proposal is submitted.

6) The Authority shall review the proposed network output measures methodology submitted to it under paragraph 2 and shall consult with the transmission licensees and where appropriate other interested parties.

7) If the Authority is satisfied that the network output measures methodology proposed by the licensee in accordance with paragraph 2 facilitates the objectives, the Authority shall approve the proposed network output measures methodology.

8) If the Authority is satisfied that the network output measures methodology proposed by the licensee in accordance with paragraph 2 would, if amended, facilitate the

objectives, the Authority may approve such proposed network output measures methodology with such amendments as the Authority shall direct.

9) If the Authority is not satisfied that the network output measures methodology proposed by the licensee in accordance with paragraph 2 facilitates the objectives or if the Authority is not satisfied that the proposed methodology would facilitate the objectives if amended, the Authority shall issue a notice of disapproval of such proposed network output measures methodology. The Authority shall, in such a notice, provide reasons for such disapproval. The Authority shall also, after consulting with the transmission licensees and other interested parties, direct the areas in which the licensee shall make improvements to the network output measures methodology that it has proposed and the date by which the licensee shall propose to the Authority such an improved network output measures methodology.

Part C: Implementation of the network output measures methodology

10) Where the network output measures methodology has been approved by the Authority under paragraph 7 or 8 the licensee shall:

a) from 1 April 2009, or such later date as the Authority may direct, record the data required for the application of the network output measures methodology together with the network output measures derived pursuant to it;

b) in respect of the relevant year commencing on 1 April 2009 (or such later date as the Authority may direct) and each subsequent relevant year, submit a report on the network output measures to the Authority by 31 July (or such later date as the Authority may direct) in the year immediately following the end of the relevant year to which the network output measures relate. The Authority will propose any corresponding specific reporting arrangements applicable to the network output measures in accordance with standard condition B15 (Price Control Review Information).

11) Where the network output measures methodology has been approved by the Authority under paragraph 8 the licensee shall also provide the Authority as soon as is reasonable practicable with the relevant data specified in paragraph 5(c) reflecting the amendments to the proposed network output measures methodology directed by the Authority.

Part D: Modification to the network output measures methodology

12) The licensee shall at all times keep the approved network output measures methodology under review to ensure that it facilitates the objectives.

13) The licensee shall, subject to paragraphs 14, 15 and 16, make such modifications to the approved network output measures methodology as may be required to better facilitate the objectives.

14) Except with the consent of the Authority, before making a modification to the network

output measures methodology the licensee shall:

a) consult with the transmission licensees and other interested parties and allow them a period of not less than 28 days within which to make written representations;

b) furnish the Authority with a report setting out:

   i) the proposed modification to the approved network output measures methodology;

   ii) the representations (if any) made to the licensee and not withdrawn;

   iii) any changes to the modification proposed to the approved network output measures methodology proposed as a consequence of such representations;

   iv) how the proposed modification better facilitate the objectives;

   v) the data used to develop the modification to the network output measures methodology. Historical data should, where reasonably practicable, be provided for a period of at least ten years preceding the year in which the modification was proposed;

   vi) a timetable for implementation of the modification, provided that no such modification may be implemented earlier than the date on which the period referred to in paragraph 15 expires; and

c) where the Authority has given a direction that sub-paragraphs 14(a) and/or 14(b) should not apply, comply with such other requirements that the Authority may specify in the direction in respect of proposals to modify the network output measures methodology.

15) Where the licensee has complied with the requirements of paragraph 14, it shall, unless the Authority has within 28 days of the report being furnished to it given a direction that the modifications may not be made, implement the modifications to the network output measures methodology. The Authority shall propose any corresponding changes to the specific reporting arrangements in accordance with standard condition B15 (Price Control Review Information).

16) The Authority may review the network output measures methodology (in consultation with the transmission licensee and/or interested parties) and revisions to the network output measures methodology may be directed by the Authority in a manner specified in the directions and the licensee shall forthwith comply with any such directions. The Authority shall propose any corresponding changes to the specific reporting arrangements in accordance with standard condition B15 (Price Control Review Information).