NETWORK OUTPUT MEASURES METHODOLOGY

Authors: National Grid, SP Transmission Limited, Scottish Hydro Electric Transmission Limited

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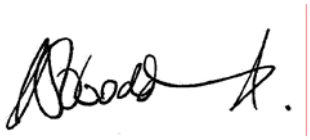

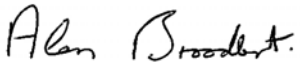

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1.0 PURPOSE AND SCOPE

1.1 Methodology Purpose

1. This Network Output Measures Methodology has been produced in accordance with standard Electricity Transmission Licence Condition B17, which is applicable to the three Electricity Transmission Licensees (National Grid, Scottish Power Transmission Limited (SPTL) and Scottish Hydro Electric Transmission Limited (SHETL)).

2. The Licence Condition requires the GB Transmission Licensees to jointly develop a set of Network Output Measures in four areas:
    a. Network Asset Condition
    b. Network Risk
    c. Network Performance
    d. Network Capability

3. This Network Output Measures Methodology describes:
    a. The requirements in the Licence Condition
    b. The Specified Amendments to the Network Output Measures required by The Authority as set out in their conditional approval decision (18 December 2008)
    c. The Transmission Licensees' collective understanding of the Licence Condition requirements and The Authority's Specified Amendments
    d. The process the Transmission Licensees have followed in developing the Network Output Measures
    e. The common framework (concepts and principles) behind the Network Output Measures
    f. The proposed Network Output Measures
    g. Comparisons of the Network Output Measures with measures produced by other Asset Management organisations
    h. Confidentiality issues surrounding publishing the content of this Network Output Measures Methodology to external (outside The Authority) parties
    i. How the Network Output Measures will be regulatory reviewed and continuously improved by the Transmission Licensees

4. In addition to this Network Output Measures Methodology, there is a Specific Appendix for each Transmission Licensee describing how each will produce the Network Output Measures using the common framework described in this Network Output Measures Methodology. These Specific Appendices include the supporting data categories and models used to generate the Network Output Measures.

5. Following production of Issue 2 of this document on 30th January 2009, the Transmission Licensees have jointly developed their proposals and have incorporated feedback directly from The Authority on the Issue 2 documents, from The Authority's consultation process (consultation letter, PB Power consultant's report and responses) and from The Authority's condition approval decision letter (18 December 2008).

6. Final amendments to the documentation reflect the agreed tables to be included in the Regulatory Reporting Packs.

2.0 DEVELOPMENT PROCESS

2.1 Licence Requirements

7. Within this section the Transmission Licensees have considered Part B of the B17 Licence Condition:
    a. The Transmission Licensee shall, in consultation with other 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")

2.2 Development Process

8. The development phase of Issue 1 of the Network Output Measures Methodology included a number of internal and external meetings:
    a. Internal Transmission Licensee meetings
    b. Meetings with the Gas Transmission Licensee
    c. Meetings with the GB System Operator
    d. Cross Transmission Licensee meetings
    e. Meetings with The Authority
    f. Workshop with interested parties (including customers)

9. The Transmission Licensees presented the Network Output Measures Methodology to The Authority throughout the Issue 1 development phase to receive feedback on the Network Output Measures Methodology.

10. Using feedback from these meetings with The Authority, the Transmission Licensees worked together to develop and agree a common framework (concepts and principles) which became Issue 1 of the Network Output Measures Methodology.

11. A workshop was held on 8 May 2008 with interested parties to consult with them on the proposed Network Output Measures. Of the approximately 150 companies (customers and stakeholders) invited, 11 participants attended the workshop and feedback received was incorporated into the proposed Network Output Measures contained in this Network Output Measures Methodology. Material from the workshop can be accessed on the external National Grid's website. This can be found at the following link (http://www.nationalgrid.com/uk/Electricity/Info/TO_Initiatives).

12. Following submission by the Transmission Licensees of Issue 1 of the Network Output Measures Methodology dated 30 May 2008, The Authority consulted on the submitted Network Output Measures Methodology. This can be accessed on The Authority's website at the following link:

(http://www.ofgem.gov.uk/Pages/MoreInformation.aspx?file=Tx%20Ntwk%20Output%20Measures.pdf&refer=Networks/Trans/RegReporting)

13. In developing Issue 2 of the Network Output Measures Methodology further meetings were held with The Authority to understand which areas of the Issue 1 Network Output Measures Methodology should be enhanced.

14. Issue 2 of the Network Output Measures Methodology, dated 30 January 2009, was updated to reflect the outcome of The Authority's consultation process and to address some of the Specified Amendments from The Authority's condition approval decision letter (18 December 2008). The Authority's condition approval decision letter including a development timeline (Appendix C) can be accessed via its website at the following link: (http://www.ofgem.gov.uk/Networks/Trans/RegReporting/Documents1/20081218B17.pdf)

15. The Specified Amendments from The Authority's condition approval decision letter which should be resolved to The Authority's satisfaction by 1 December 2009 are:
    - **Specified Amendment 1** - The Licensees should ensure consistency between their remaining useful life scales
    - **Specified Amendment 2** - Each Licensee should provide sufficient detail of their rate of deterioration assumption to demonstrate the validity of the remaining useful life categorisation. The Licensees should provide worked examples that illustrate how for a given asset category how the rate of deterioration policy for that asset category has been applied to derive the categorisation of the asset population by remaining useful life
    - **Specified Amendment 3** - The proposed measure of Network Risk should also be broken down and reported against its three constituent Criticalities; safety, environmental, system in each case the derivation and application of the Criticality grading should be clear
    - **Specified Amendment 4** - The Licensees should develop a measure of longer term Network Wide Risk
    - **Specified Amendment 5** - The Licensees should report on measures of Network Reliability that can be correlated with asset condition and age including on a forecast basis e.g. expected fault and failure trends
    - **Specified Amendment 6** - The Licensees should develop further measures of Capability and Utilisation that measure factors other than thermal capacity at boundaries e.g. voltage and stability performance which could be impacted by changes in generation connecting to the network

16. During the development of Issue 3 of the Network Output Measures Methodology further meetings have been held with The Authority to understand the requirements of these Specified Amendments. The Transmission Licensees have worked together to develop the Network Output Measures to meet both the Licence requirements and the Specified Amendments. The final proposal of the Network Output Measures Methodology describes these developments and states how they meet both the Licence requirements and the Specified Amendments.

17. To enable easy identification of these developments, this document includes 'signposting' to highlight how these Licence requirements and Specified Amendments have been addressed.

18. Throughout the development of Issue 1, 2 and 3 of the Network Output Measures Methodology, consultation has taken place with the Gas Transmission Licensee to ensure the Electricity Transmission Network Output Measures are, where practicable, consistent with those being developed for Gas Transmission.

19. In addition, throughout the development of Issue 1, 2 and 3 of the Network Output Measures Methodology, discussions have taken place with the GB System Operator to both obtain information to feed into the development of the Network Output Measures and gain their feedback on the approach being adopted as a customer of the Transmission Licensees.

20. Table 1 is a summary of how the Licence Condition has been addressed within the Network Output Measures Methodology.

Table 1: Signposting How the Licence Conditions have been Addressed in the Network Output Measures Methodology

Licence Requirement	Where Addressed in Network Output Measures Methodology
Network Asset Condition	Sections 5.1.3, 5.1.4, 5.1.5, 5.1.9, 5.1.7
Network Risk	Sections 5.2.3, 5.2.4 Including Network Asset Condition Sections 5.1.3, 5.1.4, 5.1.5, 5.1.9, 5.1.7
Network Performance	Sections 5.3.3, 5.3.5
Network Capability	Sections 5.4.3, 5.4.4, 5.4.5

21. Table 2 is a summary of the where the enhancements made to the Network Output Measures Methodology have been described.

Table 2: Signposting How the Specified Amendments have been Addressed in the Network Output Measures Methodology

Specified Amendment	Where Addressed in Network Output Measures Methodology	How Continuous Improvement will be Ensured
Specified Amendment 1	Added Text: Paragraphs 46, 47, 48, 51, 54 Added Sections: Appendix A, Appendix D	Paragraphs 57, 58
Specified Amendment 2	Added Section: Section 5.1.5.2	Paragraph 57, 58 and 71
Specified Amendment 3	Added Text: Paragraph 116	As per Network Output Measures

	Added Sections: Appendix B	review process
Specified Amendment 4	Added Sections: Section 5.2.5	As per Network Output Measures review process
Specified Amendment 5	Added Sections: 5.3.4, Paragraph 155	As per Network Output Measures review process
Specified Amendment 6	Added Sections: 5.4.4	As per Network Output Measures review process

3.0 APPLICATION OF NETWORK OUTPUT MEASURES

3.1 Licence Requirements

22. Within this section the Transmission Licensees have considered the following parts of the Licence Condition:
    a. The Network Output Measures shall be designed to facilitate:
        i. The monitoring of the Transmission Licensee's performance in relation to the development, maintenance and operation of an efficient, co-ordinated and economical system of Electricity Transmission
        ii. The assessment of historical and forecast network expenditure on the Licensee's Transmission System

23. Remaining requirements of Licence Condition Part B: Paragraph 4 are addressed elsewhere within this document.

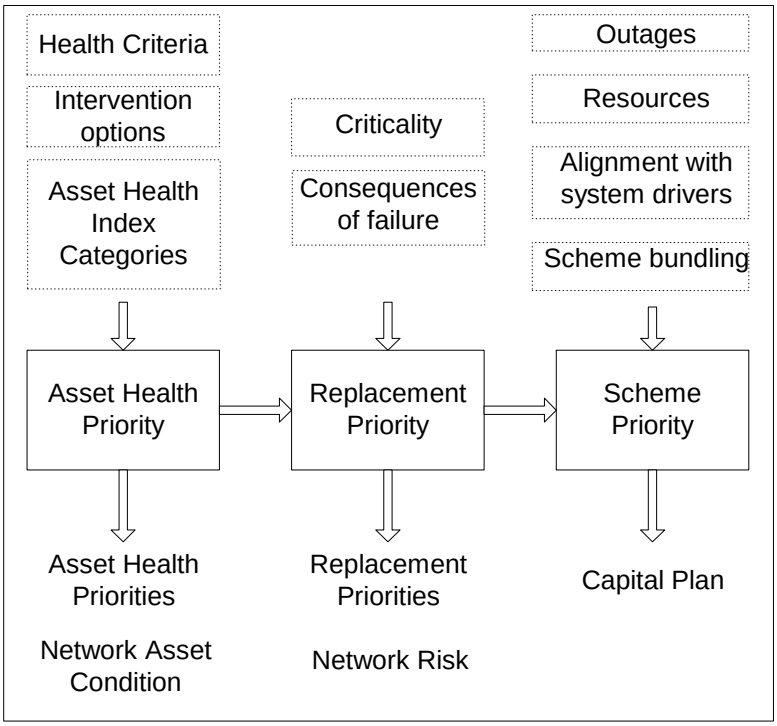
3.2 Using the Network Output Measures

24. The Transmission Licensees are committed to developing Network Output Measures that can be used internally to enhance current Asset Management Processes and understanding of business drivers. This is especially in relation to the development, maintenance and operation of our networks and in assessing future network expenditure.

25. The Transmission Licensees have included in their Specific Appendix a description of how they are using the Network Output Measures within their respective businesses.

26. Figure 1 shows how elements of the Network Output Measures feed into a Capital Plan. Health criteria (e.g. Condition, Performance) categorised into Asset Health Indices are used with knowledge of intervention options (e.g. Refurbishment) to determine Asset Health Priorities. These Asset Health Priorities are combined with information about Criticality to determine Replacement Priorities. These Replacement Priorities are combined with other factors (e.g. Outages, Resources) to determine scheme priority which is used to determine the Capital Plan.

Figure 1: Understanding Network Expenditure Requirements



27. It should be noted that the inclusion of Criticality may or may not have the impact of bringing forward/pushing back the Replacement Priority when compared with the corresponding Asset Health Priority. In addition outages, resources, alignment with system drivers and scheme bundling may or may not bring forward/push back the actual asset replacement when compared with the corresponding Replacement Priority.

4.0 REPORTING TO THE AUTHORITY

4.1 Licence Requirements

28. Within this section the Transmission Licensees have considered the following parts of the Licence Condition:
    a. The Transmission Licensee shall in consultation with other Transmission Licensees and interested parties, before 31 May 2008, submit a Network Output Measures Methodology for approval by The Authority:
        i. The Transmission Licensees will submit an annual report on the Network Output Measures to The Authority by 31 July of every subsequent year once the Methodology has been agreed
    b. Once the Network Output Measures Methodology has been approved by The Authority the Transmission Licensee shall:
        i. 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

ii. Provide historical data, where reasonably practicable, for a period of the last 10 years from the submission of the Network Output Measures Methodology

4.2 Reporting Timescales

29. Once the Network Output Measures Methodology has been agreed with The Authority, the first recording of the Network Output Measures is required to start on 1 April 2009 and the first annual report is required to be submitted to The Authority by 31 July 2010.

30. Transmission Licensees may have provided Network Output Measures Tables for 2008/09. This will be made clear within the individual Specific Appendices.

31. The Transmission Licensees will include information on the availability of historical data in the individual Specific Appendices.

32. The Transmission Licensees propose that:
    a. Network Output Measures are incorporated into the Transmission Regulatory Reporting Packs because the Network Output Measures will be reported in July each year coincident with Transmission Regulatory Reporting Packs submission
    b. Information provided in these consolidated Transmission Regulatory Reporting Packs is rationalised to avoid overlaps and duplication and is made consistent with other reporting to The Authority (e.g. GB Transmission System Performance report)

5.0 METHODOLOGY

5.1 Network Asset Condition

5.1.1 Licence Requirements

33. Paragraph 2(a) of the Licence Condition requires the Transmission Licensees 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')

34. The key elements from this Licence Condition are:
    a. Current condition of the assets
    b. Reliability of network assets
    c. Predicted rate of deterioration in condition

d. Present/future ability of network assets to perform their function

35. Table 3 shows the where the Transmission Licensees have met the Specified Amendments.

Table 3: Meeting Requirements of Network Asset Condition Licence Condition

Licence Requirement	Where Addressed in Network Output Measures Methodology
Network Asset Condition	**Sections 5.1.3, 5.1.4, 5.1.5, 5.1.9, 5.1.7**

5.1.2 Specified Amendments

36. The Specified Amendments in the area of Network Asset Condition are:
    a. **Specified Amendment 1** - The Licensees should ensure consistency between their remaining useful life scales
    b. **Specified Amendment 2** - Each Licensee should provide sufficient detail of their rate of deterioration assumption to demonstrate the validity of the remaining useful life categorisation. The Licensees should provide worked examples that illustrate how for a given asset category how the rate of deterioration policy for that asset category has been applied to derive the categorisation of the asset population by remaining useful life

Table 4: Response to Specified Amendments 1 & 2

Specified Amendment	Where Addressed in Network Output Measures Methodology	How Continuous Improvement will be Ensured
Specified Amendment 1	Added Text: Paragraphs 46, 47, 48, 51, 54 Added Sections: 5.1.6, Appendix A, Appendix D	Paragraphs 57, 58
Specified Amendment 2	Added Sections: Sections 5.1.5.2, 5.1.6	Paragraphs 57, 58 and 71

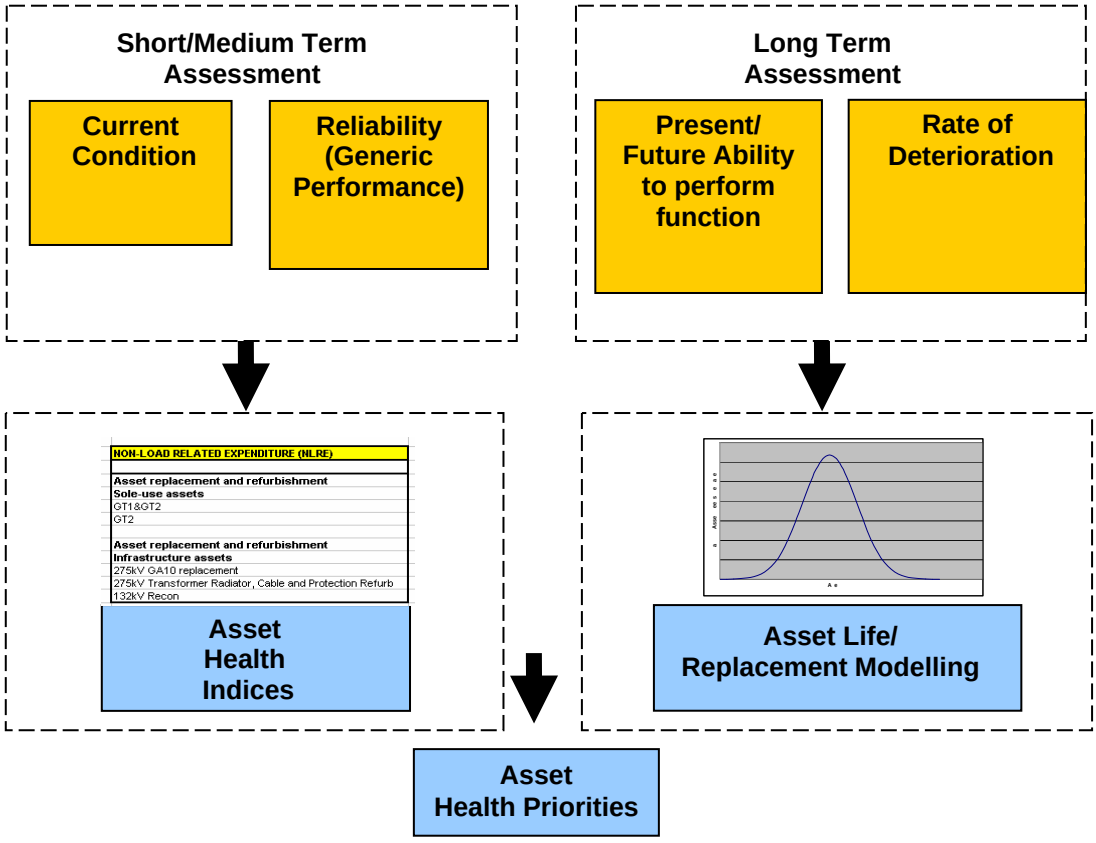
5.1.3 Methodology

37. The Licence Condition requirement can be summarised as the need to enable the evaluation of Asset Health Prioritisation of the Transmission Licensee's assets.

Figure 1 describes how Asset Health Prioritisation feeds into the assessment of the Capital Plan.

38. Figure 2 presents how the key elements of asset condition combine to determine the number and category of assets to be replaced within specific timescales (i.e. Asset Health Priorities). Each section of the diagram is described in the proceeding paragraphs.

Figure 2: The development of the Asset Health Priorities from short, medium and long term assessment



39. This assessment approach to determine the Asset Health Priorities can be described in two separate timescales:
    a. Short and medium term assessment
    b. Long term assessment

5.1.4 Short and Medium Term Assessment

40. Asset condition is the main factor in determining asset health and correspondingly remaining useful life of the asset. Asset Health Indices are categorised as follows:
    a. Remaining Useful Life 0-2 Years
    b. Remaining Useful Life 2-5 Years
    c. Remaining Useful Life 5-10 Years
    d. Remaining Useful Life >10 Years

41. The asset would not be expected to adequately perform their function outside of remaining useful life.

42. The Asset Health Indices do not represent a requirement for all intervention options including maintenance, repair or inspection. The deterioration mechanism managed by maintenance, repair or inspection generally does not impact on the asset life and so Asset Health Indices do not represent a requirement for these intervention options.

43. The above categorisation gives a common and consistent definition that the Joint Transmission Licensees are using to represent Network Asset Condition and ensure that remaining useful life is calibrated across Transmission Licensees.

44. Asset Health Priorities are based on a number of objective factors, examples of which are noted in Table 5. This table was included in all previous issues of the Network Output Measures Methodology.

Table 5: Example Factors used to determine Asset Health Indices

No	Factor	Measure
1.	External Condition	Photographic comparison by graded comparators
2.	Fault Rate	Using national fault database – collated view of faults
3.	Internal Condition	Dissolved Gas Analysis (BS EN 60567)
4.	Issues Arising	Specific to asset types – ENA NEDeRs, Operational Restrictions

45. Asset performance information (e.g. fault rate, failure information), which provides a measure of the reliability of network assets is factored into the Asset Health Priorities.

46. Addressing the requirements in Specified Amendment 1, the experts in the Transmission Licensees have shared information on the derivation of Asset Health Priorities and Asset Lives and have agreed a consistent set of factors which is contained within Appendix A. Appendix A contains information to ensure consistency and comparability across the Transmission Licensees.

47. Addressing the requirements in Specified Amendment 1, Appendix D lists the deterioration mechanisms for each equipment group which have been agreed by the experts in the Transmission Licensees – these are the mechanisms which result in changes in condition and thus the Asset Health Indices. This information will be reviewed on a continual basis.

48. Addressing the requirements in Specified Amendment 1 and 2, information will continue to be shared during the regular reviews of Network Output Measures to ensure consistency and calibration of the assessment of the remaining useful life scales and demonstrate validity of the remaining useful life categorisation across the Transmission Licensees.

49. Due to the differing asset portfolios and differing asset management strategies across the Transmission Licensees, there will be some differences in the assessment of Asset Health Priorities. An example of these differences is:

- Assessment of tape corrosion and sheath failure on cables. National Grid has experienced significant unreliability from cables which are subject to a design fault on certain types of oil-filled cables. SPTL and SHETL do not have these cable types and so are not experiencing these failure mechanisms

50. Asset Health Priorities will be produced for the following:
    a. Circuit Breakers
    b. Transformers
    c. Reactors
    d. Overhead Lines – Split into the three following categories
        i. Line conductors
        ii. Line fittings
        iii. Towers
    e. Underground Cables

51. Addressing the requirements in Specified Amendments 1 and 2, the classification of Asset Health Indices by remaining useful life scales is determined based on condition, performance and other relevant information (e.g. family design factors, duty) as included within Appendices A and D.

5.1.5 Long term Assessment

5.1.5.1 Asset Life / Replacement Profiles

52. The long term assessment is based on asset life/replacement profiles. This allows the review of historical/forecast capital expenditure and is an established process used by The Authority and the Transmission Licensees for all four Transmission Price Control Reviews.

53. Determining asset life profiles requires an understanding of the rate of deterioration of asset health. The volume of assets identified from replacement modelling provides a measure of the volume of assets in the future that are no longer able to perform their function.

54. Asset life profiles are determined based on agreed condition, performance and other relevant criteria, which are consistent across the Transmission Licensees, as included within Appendices A and D.

5.1.5.2 Projection of Asset Health Indices

55. Addressing the requirements in Specified Amendment 2, the Transmission Licensees will define the rate of deterioration by of the age at which a typical asset will be at a particular Asset Health Index. An example of the minimum information required to define this rate of deterioration is shown in Table 6.

Table 6: Example of Minimum Information Provided for Asset Health Index Progression

Asset Health Index	AHI 3	AHI 2	AHI 1
Average Age	30 years	42 years	50 years

56. Using this rate of deterioration, Asset Health Indices can be determined from when assets are new or first installed (i.e. Asset Health Index 4). This rate of deterioration can then be used to predict future Asset Health Indices at a particular asset age using the current Asset Health Index.

57. The rate of deterioration assumptions and modelling undertaken to predict the Asset Health Indices is documented in the individual Transmission Licensees Specific Appendices.

58. In developing the rates of deterioration, the Transmission Licensees have shared information in how they determine how their profile of Asset Health Indices will change with time.

59. The remaining Specified Amendment 2 requirement for worked examples will be included within the individual Transmission Licensees' Specific Appendices.

5.1.6 Ensuring Consistency and Calibration between Transmission Licensees

60. In addition to regular meetings between the Transmission Licensees to discuss the development of Network Output Measures, other things have been done to ensure consistency and calibration between Transmission Licensees.

61. Transmission Licensees have shared relevant internal documentation to share information regarding processes for assessing Asset Health Indices. The Specific Appendices have been shared at each stage of the process.

62. A three-day session was organised to allow the technical experts to come together and share the information used in determining information used in the assessment of Network Expenditure. Also information was shared regarding the development of information to meet the Specified Amendments.

63. The experts in the Transmission Licensees have shared information on the derivation of Asset Health Priorities and Asset Lives and have agreed a consistent set of factors which is contained within Appendix A. This information will be reviewed on a continual basis.

64. Appendix D lists the deterioration mechanisms for each equipment group which have been agreed by the experts in the Transmission Licensees – these are the mechanisms which result in changes in condition and thus the Asset Health Indices. This information will be reviewed on a continual basis.

5.1.7 Reporting

65. The above short, medium and long term assessments result in the delivery of Asset Health Priorities which measure the overall condition of assets. The proposed table for Network Asset Condition is shown in Figure 3 This will become part of the Transmission Regulatory Reporting Pack (Table 4.28). This information will be reported for the 400 kV, 275 kV and 132 kV transmission networks. The information will be further split into criticality (see section 5.2.3).

Figure 3: Proposed Network Asset Condition Regulatory Report Table

Asset categories		Criticality	Units	Asset distribution based on estimated remaining useful life in current reporting year				Asset Register
				Remaining useful life				31-Mar-10
				0-2 Yrs	2-5 Yrs	5-10 yrs	>10 Yrs	
400KV Network								
1	Circuit Breaker	Very high	No. CB					
		High	No. CB					
		Medium	No. CB					
		Low	No. CB					
2	Transformer	Very high	No. TX					
		High	No. TX					
		Medium	No. TX					
		Low	No. TX					
3	Reactors	Very high	No. Reactors					
		High	No. Reactors					
		Medium	No. Reactors					
		Low	No. Reactors					
4	Underground Cable	Very high	Km					
		High	Km					
		Medium	Km					
		Low	Km					
5	OHL line conductor	Very high	Km					
		High	Km					
		Medium	Km					
		Low	Km					
6	OHL line fittings	Very high	Km					
		High	Km					
		Medium	Km					
		Low	Km					
7	OHL towers	Very high	No.					
		High	No.					
		Medium	No.					
		Low	No.					

66. Additionally using the asset deterioration modelling as part of Specified Amendment 2, the Transmission Licensees will produce the information in Figure 3 for future periods as agreed with The Authority. This will include volumes additive changes to the populations consistent with the Transmission Licensee's business plans, addressing both asset replacement (non-load) and customer driven (load) related volumes. As part of this forecast the Transmission Licensees will produce:

a. Best view forecast of asset condition across the population of assets
b. A range covering a 50% expectation of asset condition.

5.1.8 Continuous Improvement

67. There is no additional development work proposed for Network Asset Condition.

68. Addressing the requirements in Specified Amendment 1 and 2, and as part of continuous improvement, the Transmission Licensees will continue to develop their understanding of the asset health, performance and condition of their transmission assets and consequently the methods for determining Asset Health Priorities and rates of deterioration. These enhancements will be reflected in the reissue of the Transmission Licensees' Specific Appendices as required as part of the Network Output Measures Review process.

69. Addressing the requirements in Specified Amendment 1 and 2, and as part of the Network Output Measures Review process, the Transmission Licensees will continue to share information about the processes and factors which feed into the assessment of Network Asset Condition to ensure that the Network Output Measures are consistent and comparable across the Transmission Licensees.

5.1.9 Additional Material Included within Transmission Licensees' Specific Appendices

70. Each Transmission Licensee will cover how the framework set out in this section on Network Asset Condition is implemented within their Specific Appendix.

71. Each Transmission Licensee will provide information within their Specific Appendix which will support the Network Output Measures Methodology on how the rate of deterioration is included in the asset life/replacement profiles and Asset Health Indices, including worked examples.

5.1.10 External Publication of Network Output Measures

72. There are no confidentiality issues that surround the external publication of the proposed Methodology for Network Asset Condition. The summary tables as shown in Figure 3 will form part of the Transmission Regulatory Reporting Packs and should not be published externally.

5.2 Network Risk

5.2.1 Licence Requirement

73. Paragraph 2(b) of the Licence Condition requires the Transmission Licensees to enable the evaluation of:
    a. 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')

74. The key elements from this Licence Condition are:
    a. Overall level of risk
    b. Inclusion of Network Asset Condition
    c. Interdependence between network assets

75. The Transmission Licensees have carefully considered this Licence Condition and in the development of the proposed measures have used the following definition for Network Risk:

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

76. Table 7 shows the where within the Network Output Measures Methodology, the Transmission Licensees have met the requirements of the Network Risk Licence Condition.

Table 7: Meeting Requirements of Network Risk Licence Condition

Licence Requirement	Where Addressed in Network Output Measures Methodology
Network Risk	Sections 5.2.3, 5.2.4 Including Network Asset Condition Sections 5.1.3, 5.1.4, 5.1.5, 5.1.9, 5.1.7

5.2.2 Specified Amendments

77. The Specified Amendments in the area of Network Risk are:
    a. **Specified Amendment 3** - The proposed measure of Network Risk should also be broken down and reported against its three constituent Criticalities; safety, environmental, system in each case the derivation and application of the Criticality grading should be clear.
    b. **Specified Amendment 4** - The Licensees should develop a measure of longer term Network Wide Risk

78. Table 8 shows the where the Transmission Licensees have met the Specified Amendments.

Table 8: Meeting Requirements of Specified Amendments 3 & 4

Specified Amendment	Where Addressed in Network Output Measures Methodology	How Continuous Improvement will be Ensured
Specified Amendment 3	Added Text: Paragraph 116 Added Sections: Appendix B	As per Network Output Measures review process
Specified Amendment 4	Added Sections: Section 5.2.5	As per Network Output Measures review process

5.2.3 Methodology

79. When evaluating Network Risk, the Transmission Licensees include information used in the development of their optimised Capital Plans.

80. When developing of an optimised Capital Plan, prioritised candidates for asset replacement are produced for the will be produced for the following:
    a. Circuit Breakers
    b. Transformers
    c. Reactors
    d. Overhead Lines – Split into the three following categories
        i. Line conductors
        ii. Line fittings
        iii. Towers
    e. Underground Cables

81. Replacement Priorities provide the prioritised candidates for asset replacement. Figure 1 shows how Replacement Priorities feed into the development of the Capital Plan.

82. Replacement Priorities allow the Transmission Licensees to consider:
    a. The operation of the transmission system and the impacts of asset unavailability
    b. The impact on the business and its stakeholders of asset management decisions across the whole life-cycle (short, medium and long term)

83. This allows the Transmission Licensees to economically and efficiently target assets which pose the greatest Network Risk and thus manage the impact of Network Risk upon the customer.

84. Replacement Priorities are determined through three activities:
    a. Assessment of Asset Health Priorities – already defined as part of Network Asset Condition
    b. Assessment of Criticality
    c. Derivation of Replacement Priorities

85. Replacement Priorities are a measure of the priority ordering of the replacement of assets. There are four categories:
    a. Priority 1 (Very High)
    b. Priority 2 (High)
    c. Priority 3 (Medium)
    d. Priority 4 (Low)

86. Criticality is a representation of the risk to the stakeholders in terms of safety, environment and reliability. More specifically Criticality has three elements:
    a. Safety Criticality
    b. Environmental Criticality
    c. System Criticality

87. Safety Criticality is based on the risk of direct harm to personnel/public as a result of asset failure (e.g. conductor drop, asset fire or explosion).

88. Safety Criticality will be scored using a consistent methodology (i.e. Very High, High, Medium and Low) which considers the impact of failure/unreliability and the location of the asset.

89. High level criteria for determining Safety Criticality are described in the Table 9.

Table 9: High Level criteria for determining Safety Criticality

Safety Criteria	Very High	High	Medium	Low
Location	Constant personnel/public activity within vicinity of asset	High levels of personnel/public activity within vicinity of asset	Regular personnel/public activity within vicinity of asset.	Limited personnel access. No likely public access.
Impact of Failure/ unreliability	Failure of asset may result in fatality.	Failure of asset may result in permanently incapacitating injury.	Failure of asset may result in reportable injury.	Failure of asset results in minor injury or no consequence.

90. Environmental Criticality is based on the environmental impact caused by asset unreliability or failure, taking into account the sensitivity of the geographical area local to the asset.

91. High level criteria for determining Environmetal Criteria are described in Table 10. Criteria are not included for the Very High category for Environmental Criticality to ensure comparability with Safety Criticality.

Table 10: High level criteria for determining Environmental Criticality

Environmental Criteria	Very High	High	Medium	Low
Location		Asset located within proximity of environmentally sensitive area	Asset located in controlled area which may be close to an environmentally sensitive area or distributed asset not within proximity of sensitive environment	Asset located in controlled area
Impact of Failure/ Unreliability		Failure of asset may lead to reportable environmental incident which may result in prosecution.	Failure of asset may lead to significant environmental incident with agency visibility.	Failure of asset may lead to minor environmental incident (without agency visibility) that can be managed locally or no environmental consequence.

92. Safety and Environmental Criticality need to be assessed on an individual asset basis as the safety or environmental impact of asset failure or unreliability will depend on the asset type and its location. For this reason whilst Safety Criticality and Environmental Criticality will be categorised using a consistent scale (i.e. Very High, High, Medium, and Low), the assessment of Safety and Environmental Criticality will be documented separately for each Transmission Licensee in the Specific Appendices.

93. Safety and Environmental criticality scoring depends upon the asset type and the unreliability or failure mode. For a circuit comprising several asset types (e.g. and overhead line and a cable), each asset is scored individually. The impact of unreliability or failure will vary from asset type to asset type and a safety or environmental consequence may not apply for some assets.

94. Figure 4 shows where safety and environmental criticality affects equipment groups. This Figure has been discussed and agreed across the Transmission Licensees.

Figure 4: Safety and Environmental Criticality Impact by Equipment Type

	Safety Impact?	Environmental Impact?
Overhead Line	✓	X
Cable	✓*	✓
Switchgear	✓	X
Transformer	✓	✓

✓ Significant impact from failure of equipment (* applies to cables with specific ancillaries/accessories)

✓ Minor impact from failure of equipment

X No impact from failure of equipment (where equipment considered in isolation)

95. System Criticality covers the impact of the transmission system not delivering services to the customers of the Transmission Licensees and any impact to the safety to the public (indirectly through unavailability to a directly connected customer) or the smooth operation of the UK services and economy.

96. The Transmission Licensees have held discussions with the GB System Operator to determine a System Criticality methodology. The proposals have been developed by the System Operator ensuring sign-on from the Transmission Licensees.

97. System criticality can be defined at both a circuit and substation level. It is built up of a number of elements with specific examples (not exhaustive) highlighted in Figure 5.

Figure 5: Elements of System Criticality

Impact on Vital Infrastructure	• Directly connected customers which impact on public safety • Directly connected suppliers providing key services to the public	• Transport issues • Support Nuclear Generation Safety • Economic key points
Impact on Customers	• Deliverability of electricity to areas in order of density (numbers of customers)	• MWs at risk
System Security	• Delivery of electricity to consumers • Delivery of the most flexible network to the electricity market (accessibility of maximum generation)	• Infrastructure essential for transport of power or voltage stability reasons

98. System Criticality will be scored using a consistent methodology (i.e. Very High, High, Medium, and Low).

99. The parameters which are used by the individual Transmission Licensees will be reflective of the differing sizes of their Transmission Network. The methodology used for System Criticality which is used by the Joint Transmission Licensees is shown in Figure 6.

Figure 6: Definition of System Criticality

Criticality	Criteria: Vital Infrastucture		Impact on Customers		System Security
Very High	N/A	OR	N/A	OR	N/A
	IF NONE OF THE ABOVE ARE APPLICABLE				
High	Vital Infrastructure: {Economic Key Point; Supporting Major Traffic Hub; COMAH Site; Black Start Site; Supports Nuclear Generation}	OR	Substation Demand = [x] MW+	OR	System Security = High
	IF NONE OF THE ABOVE ARE APPLICABLE				
Medium	N/A	OR	Substation Demand = [y]-[x] MW	OR	System Security = Medium
	IF NONE OF THE ABOVE ARE APPLICABLE				
Low	N/A	AND	Substation Demand [y] MW-	AND	System Security = Low

100. Criteria are not included for the Very High category for System Criticality to ensure comparability with Safety Criticality.

101. Vital infrastructure represents the infrastructure which is crucial to our stakeholders.

102. Substation demand is taken from the submissions from customers rather than the assessments by the individual Transmission Licensees. Substation demand is defined as the required demand at the yearly peak as submitted by customers as part of P2/6 (historically P2/5) process. This demand data is reported in the GB Seven Year Statement. Using the customer submitted demand ensures customer requirements are being taken into account in defining System Criticality.

103. The general principles used to determine System Security are:
    - Local Group Demand Criteria: Determined by the unsupplied demand at peak for an N-2 loss taking into account the demand transfer capability within switching time (assume 30 minutes) and a contribution from fully embedded generation: The greater the unsupplied demand, the greater the assigned Criticality

- For the Main Interconnected Transmission System:
  a. Generation Concentration: Areas where there is a high concentration of net generation and little supporting infrastructure to transport the energy away to demand centres. The higher the concentration relative to the supporting infrastructure, the higher the assigned Criticality
  b. Demand Concentration: Areas where there is a high concentration of net demand and little supporting infrastructure to transport the energy required to meet demand. The higher the concentration relative to the supporting infrastructure, the higher the assigned Criticality
  c. Zonal/Boundary Issues: These are generally constraint boundaries where for the intact system or the first outage there may be a significant volume of generation constrained and/or a significant cost. The higher the expectation of constrained volume/costs, the higher the assigned Criticality

104. The actual scoring mechanisms will be detailed within the Transmission Licensees Specific Appendices.

105. The Transmission Licensees investigated using financial consequences to provide the comparison of the safety, system and environmental Criticality elements. However, using financial values to balance investments which address safety and environmental statutory duties against reliability investments would not be a justifiable or challengeable defence if the resultant failure to act resulted in a breach of the law.

106. In addition to the immediate consequences (e.g. loss of life, pollution of water courses), a breach of the law may result in wider impacts than just financial penalties (where for some offences there is no upper limit on the fine) including individual prosecution and damage to the company reputation. As such the Very High Criticality Scoring is only attributable to the Safety elements of Criticality to reflect the safety statutory duties specifically concerning fatalities.

107. Figure 7 shows how the System, Safety and Environmental Criticality elements map against each other to determine the overall Criticality Score.

Figure 7: Criticality Mapping across Safety, System and Environment

Criticality	Criteria: System		Safety		Environment
	N/A	OR	Failure of asset may result in fatality. Constant personnel/public activity within vicinity of asset	OR	N/A
	IF NONE OF THE ABOVE CRITERIA ARE APPLICABLE				
High	Vital Infrastructure: {Economic Key Point; Supporting Major Traffic Hub; COMAH Site; Black Start Site; Supports Nuclear Generation} or Substation Demand ≥ 600MW; System Security = High	OR	Failure of asset may result in permanently incapacitating injury. High levels of personnel/public activity within vicinity of asset	OR	Failure of asset may lead to reportable environmental incident which may result in prosecution. Asset located within proximity of environmentally sensitive area
	IF NONE OF THE ABOVE CRITERIA ARE APPLICABLE				
Medium	Substation Demand = 300-600MW or System Security = Medium	OR	Failure of asset may result in reportable injury. Regular personnel/public activity within vicinity of asset.	OR	Failure of asset may lead to significant environmental incident with agency visibility. Asset located in controlled area or distributed asset not within proximity of sensitive environment
	IF NONE OF THE ABOVE CRITERIA ARE APPLICABLE				
Low	Substation Demand ≤ 300MW and System Security = Low	AND	Failure of asset results in minor injury or no consequence. Limited personnel access. No likely public access.	AND	Failure of asset may lead to minor environmental incident (without agency visibility) that can be managed locally or no environmental consequence. Asset located in controlled area

108. The table indicates that the overall Criticality Score is derived from the greatest impact identified from the three individual Criticality Scores. This ensures that assets with a high score in just one Criticality category can be equally assessed with those containing high scores in two or three categories.

109. A method of weighting and combining Criticalities was considered but rejected on the basis that there was a possibility that the combination process might result in the 'cancelling' out of Criticality Scores, potentially resulting in an important Criticality factor being overlooked.

110. Figure 8 shows how Asset Health Priorities and Criticality are mapped to obtain a Replacement Priority category.

Figure 8: Mapping of Replacement Priorities

Criticality

Asset Health Index

	Very High	High	Medium	Low
0 - 2	Priority 1	Priority 1	Priority 2	Priority 2
2 - 5	Priority 1	Priority 2	Priority 3	Priority 3
5 - 10	Priority 3	Priority 3	Priority 3	Priority 4
10 +	Priority 4	Priority 4	Priority 4	Priority 4

111. In the development of the Replacement Priorities across the Transmission Licensees, a comparable and consistent approach has been reached by categorising the Replacement Priorities from Priority 1 to 4; Priority 1 will be replaced ahead of Priority 2's and so on.

112. By sharing approaches to deriving and applying Criticality and assigning Replacement Priorities, the Transmission Licensees have reached this common approach (Specified Amendment 3).

113. The Transmission Licensees provide further information on how Figure 8 is used to assign Replacement Priorities within the Specific Appendices.

114. To ensure the Network Risk outputs are consistent and comparable across the Transmission Licensees, As part of the Network Output Measures Review process, the Transmission Licensees will continue to share information about:
    a. The processes and factors which feed into the assessment of the Replacement Priorities
    b. Experiences with delivering the Network Risk Measure

5.2.4 Reporting

115. The Replacement Priorities are summarised and included within the Transmission Regulatory Reporting Pack (Table 4.28) in a table agreed with Ofgem as shown in Figure 9. This allows the Transmission Licensees to show the overall level of

Network Risk and the potential impact to their customers in terms of reliability of services, safety performance and environmental performance.

Figure 9: Network Risk Regulatory Reporting Table

Asset categories			Units	Asset distribution based on replacement priority in current reporting year				Asset Register
				Replacement priority				31-Mar-10
				1	2	3	4	
400KV Network								
1	Circuit Breaker		No. CB	0	0	0	0	0
2	Transformer		No. TX	0	0	0	0	0
3	Reactors		No. Reactors	0	0	0	0	0
4	Underground Cable		Km	0	0	0	0	0
5	OHL line conductor		Km	0	0	0	0	0
6	OHL line fittings		Km	0	0	0	0	0
7	OHL towers		No.	0	0	0	0	0
275KV Network								
1	Circuit Breaker		No. CB	0	0	0	0	0
2	Transformer		No. TX	0	0	0	0	0
3	Reactors		No. Reactors	0	0	0	0	0
4	Underground Cable		Km	0	0	0	0	0
5	OHL line conductor		Km	0	0	0	0	0
6	OHL line fittings		Km	0	0	0	0	0
7	OHL towers		No.	0	0	0	0	0
132KV Network								
1	Circuit Breaker		No. CB	0	0	0	0	0
2	Transformer		No. TX	0	0	0	0	0
3	Reactors		No. Reactors	0	0	0	0	0
4	Underground Cable		Km	0	0	0	0	0
5	OHL line conductor		Km	0	0	0	0	0
6	OHL line fittings		Km	0	0	0	0	0
7	OHL towers		No.	0	0	0	0	0

116. To meet Specified Amendment 3, the Transmission Licensees have agreed an intermediate table with Ofgem which reports the constituent elements of Criticality on a circuit and substation basis (Specified Amendment 3). This table can be seen in Appendix B. It is likely this table will require further refinement based on the practicalities of producing and reporting the information in a transparent manner.

5.2.5 Longer Term Network Wide Risk

117. To address the development of a longer term Network Wide Risk Measure (Specified Amendment 4), the Transmission Licensees consider the following principles are important:
    a. Consistency with the current Network Risk information i.e. Asset Condition and Criticality
    b. Can be determined under different investment scenarios (e.g. planned network expenditure, no replacement investment)
    c. Is used internally within the Transmission Licensees' businesses
    d. Is consistent with the proposals to meet the requirements of Specified Amendment 2

118. For this longer term Network Wide Risk Measure (Specified Amendment 4), the Transmission Licensees propose a forward projection is made of the Network Risk Measure predicting the Replacement Priorities at the end of each price control cycle. It is further proposed this can be made under different investment scenarios(e.g. planned network expenditure within each Transmission Licensees' business, no network expenditure).

119. This forward projection of Network Risk (i.e. a forward projection of the Replacement Priorities) is produced by combining:
    a. Forward projection of Asset Health Indices using the rates of deterioration developed to meet the requirements of Specified Amendment 2
    b. Forward view of Criticality which takes future network investment in account

120. This proposed longer term Network Wide Risk Measure is similar to the DNO DPCR5 proposals for reporting Asset Health Indices but incorporates additional information when compared with the DNO proposals as the Network Risk Measure reported by the Transmission Licensees incorporates Criticality information on the basis of no network expenditure and with the planned capital expenditure.

121. The detailed approaches used by the Transmission Licensees to forecast Replacement Priorities into the future is contained within the Transmission Licensees' Specific Appendices.

122. The detailed approaches used by the Transmission Licensees to forecast Replacement Priorities have been shared to ensure consistency and comparability across the reported longer term Network Risk Measure.

123. The proposed output for Specified Amendment 4 is the production of the data required for Network Risk (Figure 9) at the end of the Price Control Period assuming the planned Network Expenditure is actioned and completed. This will include volumes additive changes to the populations consistent with the Transmission Licensees' business plans, addressing both asset replacement (non-load) and customer driven (load) related volumes. As part of this forecast the Transmission Licensees will produce:

    a. Best view forecast of asset condition across the population of assets
    b. A range covering a 50% expectation of asset condition

5.2.6 Continuous Improvement

124. As part of continuous improvement, the Transmission Licensees will develop their understanding of the Criticality of their transmission assets and consequently further enhancements will be made to the Replacement Priorities.

5.2.7 Additional Material Included within Transmission Licensees' Specific Appendices

125. The parameter values for System Criticality for each Transmission Licensee will be documented within their Specific Appendix.

126. A more detailed approach for determining System Security (part of System Criticality Methodology) will be documented for each Transmission License within their Specific Appendix.

127. Each Transmission Licensee will cover how Network Risk will be implemented within their Specific Appendix.

128. The detailed approaches used by each Transmission Licensee to forecast Replacement Priorities (the longer terms Network Wide Risk Measures) into the future is contained within their Specific Appendix.

5.2.8 Ensuring Consistency and Calibration between Transmission Licensees

129. In addition to regular meetings between the Transmission Licensees to discuss the development of Network Output Measures, other activities have been undertaken to ensure consistency and calibration of the Network Output Measures between the Transmission Licensees.

    a. The Specific Appendices to this Network Output Measure Methodology have been shared at each stage of the process

    b. The Transmission Licensees have shared relevant internal documentation regarding processes for determining Replacement Priorities

    c. Technical experts from the three Transmission Licensees attended a three-day session to share the information used in the assessment of Network Expenditure. Information was also shared regarding the development of information to meet the Specified Amendments

5.2.9 External Publication of Network Output Measures

130. The information on System Criticality at an asset level is highly sensitive in terms of physical security and so information on the methodology used to derive the categories or any of the outputs from applying this methodology should not be published. In addition, the methodology used to derive Safety or Environmental Criticality or any of the outputs from applying this methodology should not be published as this information could cause public concern if taken out of context. The summary tables as shown in Figure 9 and Appendix B will form part of the Transmission Regulatory Reporting Packs and should not be published externally.

5.3 Network Performance

5.3.1 Licence Requirement

131. Paragraph 2(c) of the Licence Condition requires the Transmission Licensees to enable the evaluation of:
    a. 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 Transmission Licensee as part of its transmission business ('network performance')

132. The key elements from this Licence Condition are:
    a. Performance of the Licensee's transmission system
    b. Direct Impact on the reliability and cost of the services

133. Table 11 shows the where the Transmission Licensees have met the Specified Amendments.

Table 11: Meeting Requirements of Network Asset Condition Licence Condition

Licence Requirement	Where Addressed in Network Output Measures Methodology
Network Performance	**Sections 5.3.3, 5.3.5**

5.3.2 Specified Amendments

134. The Specified Amendments in the area of Network Performance are:

    a. **Specified Amendment 5** - The Licensees should report on measures of Network Reliability that can be correlated with asset condition and age including on a forecast basis e.g. expected fault and failure trends

Table 12: Response to Specified Amendments 5

Specified Amendment	Where Addressed in Network Output Measure Methodology	How Continuous Improvement will be Ensured
Specified Amendment 5	Added Sections: 5.3.4, Paragraph 155	As per Network Output Measures review process

5.3.3 Methodology

135. Network Performance is a key output for the customers of the Transmission Licensees.

136. To provide a full picture on Network Performance it is necessary to consider a number of complementary performances measures. This is because some measures consider events only and some consider a combination of event and duration. The Transmission Licensees already report a comprehensive set of Network Performance Measures in the form of unavailability, faults and failure information with associated commentary through the Transmission Regulatory Reporting Packs. It is proposed the Transmission Licensees will draw on the existing reporting supplemented by consistent reporting of Average Circuit Unreliability to address the Licence Condition and Specified Amendment 5.

137. Reduced reliability of the transmission network increases the risk of loss of supply for directly connected customers and increases costs to market participants which impacts the consumer. An increased number of loss of supply events creates a cost of inconvenience to the general consumer and in extreme cases will result in a significant impact upon the economy.

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

$$\frac{\textbf{Total Duration of Repair (cumulative across circuits)}}{\textbf{Number of Circuits * Duration of reported time period}}$$

139. Duration in the context of Average Circuit Unreliability is a continuous number and is not rounded or truncated at any stage of the calculation, thus no errors are introduced into the calculation. The monthly duration will be calculated using a differing number of days in a month and so any calculation to derive a yearly number will require a suitable weighting of monthly values to account for this.

140. The outages which are classified as being included within the definition of Average Circuit Unreliability are:
    a. Enforced unreliability outages taken at less than 24 hours notice (otherwise known as unplanned unavailability)
    b. Planned unreliability outages taken after 24 hours notice

141. All unreliability related outages are included within the definition of Average Circuit Unreliability. The definition above assumes that no outages are planned with less than 24 hours notice as any such outage would fall into part (a) in the definition above.

142. Currently the outage planning tool TOGA (Transmission Outage and Generator Availability) does not contain the reporting categorisation required to produce Average Circuit Unreliability for the Transmission Licensees. There are additional modifications required to reduce the process time associated with derivation of Average Circuit Unreliability which are being progressed but were not in place for April 2009. These further modifications to both processes and TOGA software will be delivered during 2009/10.

143. SPTL will continue to use reports out of OPD (Outage Planning Diary) to report this data until satisfactory delivery of both GB System Operator and Transmission Licensees processes and TOGA software.

144. As SHETL are solely reliant on TOGA (i.e. SHETL do not maintain a specific system) no interim reports will be available until a TOGA software solution is available.

5.3.4 Forecasting Network Reliability on the basis of asset condition and asset age

145. To provide a forecast of Network Reliability on the basis of asset condition and asset age it is important to have an underlying data set that has a statistically significant data size when broken down into equipment group and asset age or asset condition. Detection of correlations and accuracy of forecasting on the basis of asset age profile or asset condition profile is critically dependent on having a statistically significant data set.

146. The Transmission Licensees have investigated whether the Fault and Failure data provides a statistically significant dataset to derive correlations between asset age and asset condition. The actual number of faults and failures is very small across all the Transmission Licensees. This is as a result of:

    a. Actual population sizes of the assets – The population of assets is not large enough to experience a great number of reliability related faults and failures
    b. Asset management approach within our businesses – the Transmission Licensees maintain assets to manage the number of faults experienced and aim to replace before failure using asset condition and criticality to prioritise asset replacement candidates (see Figure 1). This means many faults and failures that would occur are avoided.

147 [redacted]

148. The number of faults and failures have proven insufficient to enable accurate correlations and forecasting with asset age and asset condition. Further detail of the investigations undertaken by each Transmission Licensee is included in the Transmission Licensees' Specific Appendices.

149. By looking at "Functional Failures" i.e. those assets which have been removed from service (on a temporary basis) as a result of a unreliability related event there is a greater set of data which can be used for correlation and forecasting with asset age and asset condition.

150. 'Functional Failures' are the same as those unreliability related outages which are used to determine Average Circuit Unreliability.

151. The Transmission Licensees have an agreed definition of Average Circuit Unreliability and agreed definition of Network Asset Condition in the form of Asset Health Indices thus any correlations or forecasting of Average Circuit Unreliability with asset condition and age are provided on a comparable basis.

152. Each Transmission Licensee has varying historical datasets with which to produce correlation and forecasting of Average Circuit Unreliability with asset condition and asset age. In addition, given the recent introduction of Asset Health Indices on a consistent basis across the Transmission Licensees, there is limited historical condition information to provide correlation with 'Functional Failures' in the form of Average Circuit Unreliability. These historical datasets will grow with time and thus the accuracy of the correlations and forecasting will improve.

153. The investigations undertaken by each Transmission Licensee including the analysis undertaken to identify correlations between Average Circuit Unreliability ('Functional Failures') and asset age and asset condition and to forecast Average Circuit Unreliability are detailed in the Transmission Licensees' Specific Appendices.

5.3.5 Reporting

154. Average Circuit Unreliability is a network related measure. Outages taken for unreliability reasons whether planned or enforced have an impact on the reliability of service.

155. To further address Specified Amendment 5, National Grid will provide a breakdown of Average Circuit Unreliability into Asset Condition categories for the health of the asset which drives the requirement for the unreliability related outage. This will not be provided by the Scottish Transmission Licensees.

156. Figure 10 shows the proposed revised Average Circuit Unreliability table for inclusion in the Transmission Regulatory Reporting Packs as part of the Network Output Measures for Network Performance which will be sent to The Authority by 31 July each year. This will be included within the Transmission Regulatory Reporting Pack (Table 4.3).

Figure 10: Proposed Average Circuit Unreliability Submission

Average Circuit Unreliability (ACU) (unavailability due to functional failures) (%)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
April									
May									
June									
July									
August									
September									
October									
November									
December									
January									
February									
March									
ACU (%)									
Transformers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AH1									
AH2									
AH3									
AH4									
Unclassified									
Switchgear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AH1									
AH2									
AH3									
AH4									
Unclassified									
Overhead Lines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AH1									
AH2									
AH3									
AH4									
Unclassified									
Underground Cables	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AH1									
AH2									
AH3									
AH4									
Unclassified									
Protection and control									
Other									
Total functional fa lures unavailability	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Functional failures (planned and unplanned reliability outages) (#)									
Transformers	0	0	0	0	0	0	0	0	0
AH1									
AH2									
AH3									
AH4									
Unclassified									
Switchgear	0	0	0	0	0	0	0	0	0
AH1									
AH2									
AH3									
AH4									
Unclassified									
Overhead Lines	0	0	0	0	0	0	0	0	0
AH1									
AH2									
AH3									
AH4									
Unclassified									
Underground Cables	0	0	0	0	0	0	0	0	0
AH1									
AH2									
AH3									
AH4									
Unclassified									
Protection and control									
Other									
Total functional fa lures	0	0	0	0	0	0	0	0	0
Number of monitored circuits for ACU (#)									
Number of monitored circuits (year end)									

157. The total number of circuits used in this calculation varies by Transmission Licensee and will vary from year to year as the networks are modified. For this reason it is proposed to report the number of circuits used as part of the Average

Circuit Unreliability calculation as at 31 March each year in the proposed Regulatory Reporting table.

158. Reporting of Unplanned Unavailability is already included in the GB Transmission System Performance Report and the Transmission Regulatory Reporting Pack and Average Circuit Unreliability is included in National Grid's Transmission Regulatory Reporting Pack. It is the intention of all Transmission Licensees to produce Average Circuit Unreliability following acceptance of the Network Output Measures Methodology and availability of the information from TOGA.

159. The Transmission Licensees propose that the reporting of Unplanned Unavailability and Average Circuit Unreliability is rationalised across the various reports (e.g. Transmission Regulatory Reporting Packs, GB Transmission System Performance) to ensure consistency, and avoid overlaps and duplication including modification and removal of existing tables (particularly Table 4.3 in the National Grid pack) in the Transmission Regulatory Reporting Packs and ensuring definitions are consistent.

160. Network Performance reporting also includes a number of tables already reported in the Transmission Regulatory Reporting Packs e.g. faults (Table 4.5), failures (Table 4.6).

161. The Transmission Licensees will develop a forecast of Average Circuit Unreliability into the future as agreed with Ofgem. This will be done be producing technical reports which detail this work.

5.3.6 TOGA Developments

162. Developments to both the system and the processes, essential for reporting data from TOGA to allow the production of Average Circuit Unreliability are currently being made to TOGA and are due to be implemented from February 2010. These developments are essential to the Scottish Transmission Licensees' ability to use TOGA to produce Average Circuit Unreliability.

5.3.7 Additional Material Included within Transmission Licensees' Specific Appendices

163. Each Transmission Licensee will cover how Network Performance will be implemented within their Specific Appendix including specific detail regarding the classification of circuits which are included within the calculation of Average Circuit Unreliability.

164. Further information regarding the forecasting of Average Circuit Unreliability an addition to the methodology to meet Specified Amendment 5.

5.3.8 External Publication of Network Output Measures

165. There are no issues with the external publication of the proposed Network Output Measure Methodology. The summary tables as shown in Figure 10 which will form part of the Transmission Regulatory Reporting Packs and the other Network Performance tables which already form part of the Transmission Regulatory Reporting Packs should not be published externally.

5.4 Network Capability

5.4.1 Licence Requirements

166. Paragraph 2 (d) requires the Transmission Licensees to enable the evaluation of:
    a. The level of the Capability and Utilisation of the Licensee's Transmission System at entry and exit points and other Network Capability and Utilisation factors ('network capability')

167. The key elements from this Licence Condition are:
    a. Information about Transmission System Capability
    b. Information about Transmission System Utilisation

168. Table 15 shows the where the Transmission Licensees have met the Licence Condition requirements for Network Capability and Utilisation.

Table 15: Meeting Requirements of Network Asset Condition Licence Condition

Licence Requirement	Where Addressed in Network Output Measures Methodology
Network Capability	Sections 5.4.3, 5.4.4, 5.4.5

5.4.2 Specified Amendments

169. The Specified Amendments in the area of Network Capability are:
    a. **Specified Amendment 6** - The Licensees should develop further measures of Capability and Utilisation that measure factors other than thermal capacity at boundaries e.g. voltage and stability performance which could be impacted by changes in generation connecting to the network

170. Table 16 shows the where the Transmission Licensees have met Specified Amendment 6.

Table 16: Response to Specified Amendments 6

Specified Amendment	Where Addressed in Network Output Measure Methodology	How Continuous Improvement will be Ensured
Specified Amendment 6	Added Sections: 5.4.4, Added Paragraph 177	As per Network Output Measures review process

5.4.3 Methodology

171. The Transmission Licensees currently report on transmission system capability as part of the Transmission Regulatory Reporting Pack. It is intended that the capability sections from Table 4.8 'Boundary Transfers and Capability' will be used to meet the requirements of the Licence Condition. This measures the existing and future transmission capacity being provided by the Transmission Operators on the main interconnected transmission system.

172. Likewise, the Transmission Regulatory Reporting Pack requires the individual Transmission Licensees 'to collect information relating to more localised demand driven need for developing transmission infrastructure'. This is presented in Table 4.9 'Demand and Supply Capacity at Substations' with Utilisation being represented as demand as a percentage of Capacity. This shows the relationship between localised demand and Capacity and hence provides a proxy measure for Utilisation.

173. Where data is available the Transmission Licensees will provide forecasts into the future as agreed with Ofgem. This will be incorporated into the Transmission Regulatory Reporting Table (Table 4.8).

174. Adopting these measures ensures:
    a. Consistency in reporting and interpretation of requirements across all Transmission Licensees
    b. Prevention of duplication in reporting on Capability and Utilisation Measures

5.4.4 Provision of Information on Voltage & Stability

175. Information is reported in the GB Seven Year Statement at a boundary level and the boundary capability is reported. This boundary capability is calculated based on the most onerous limitation whether this is thermal or voltage. It is proposed to meet the specified amendment 6 voltage capabilities across all boundaries are reported consistent with the information reported in the GB Seven Year Statement.

176. The reported thermal and voltage capabilities when reported together give a more complete view of the capabilities across Seven Year Statement boundaries.

177. As additional information to address specified amendment 6, where stability constrains boundary capability this data will be provided where this information is applicable and available.

178. Where data is available the Transmission Licensees will provide forecasts into the future as agreed with Ofgem. This will be incorporated into the Transmission Regulatory Reporting Table (Table 4.8).

5.4.5 Reporting

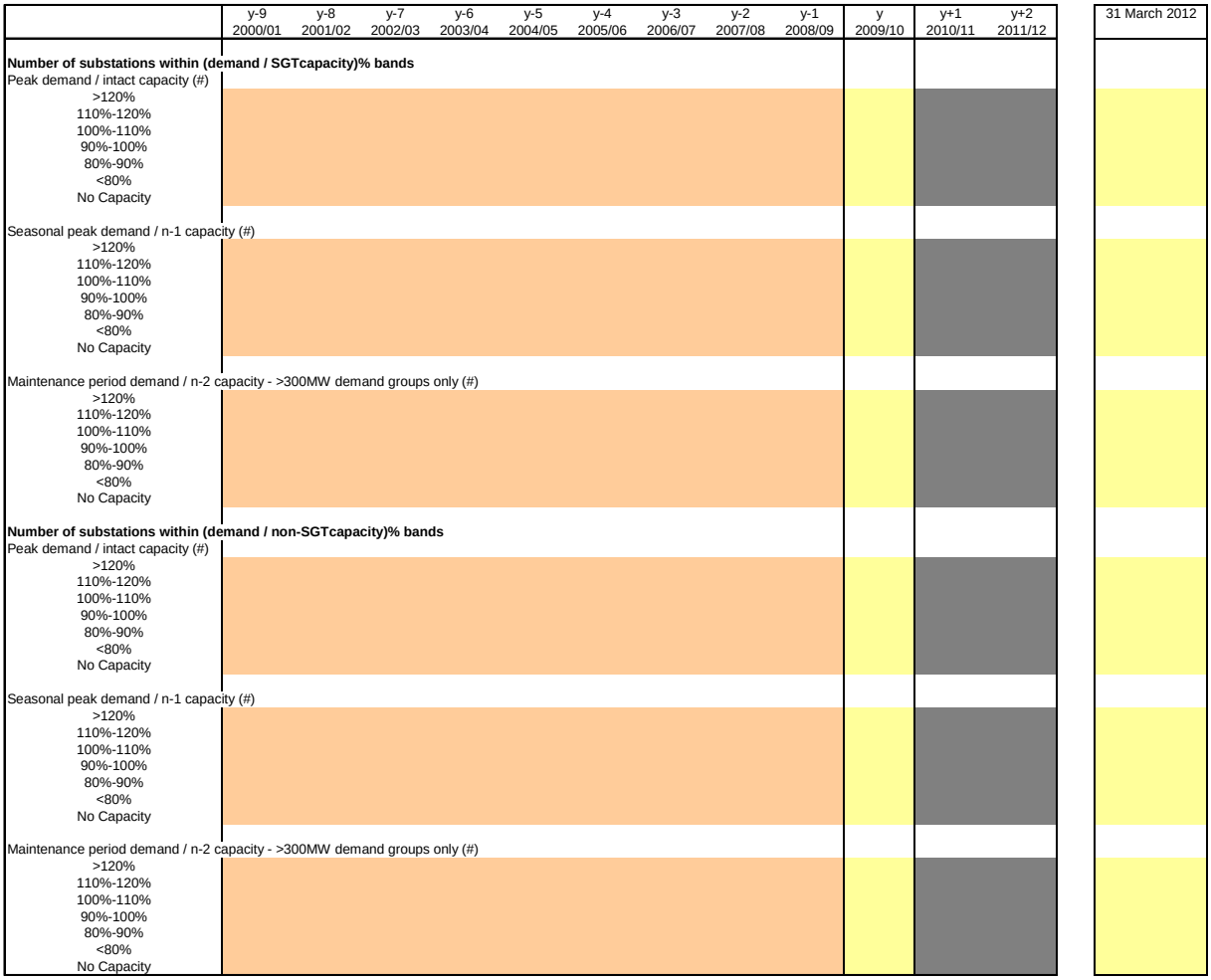
179. Figure 11 shows the existing Transmission Regulatory Reporting Pack table which will be submitted to reflect the 'Capability' requirement.

Figure 11: Network Capability Reporting Table

	y-9 2000/01	y-8 2001/02	y-7 2002/03	y-6 2003/04	y-5 2004/05	y-4 2005/06	y-3 2006/07	y-2 2007/08	y-1 2008/09	y 2009/10	y+1 2010/11	y+2 2011/12
Planned Transfer (GW)												
Boundary 1 North West												
Boundary 2 North South												
Boundary 3 South West												
Boundary 4 SHETL-SPT												
Boundary 5 SPT North - South												
Boundary 6 SPTL - NGC Boundary												
Boundary 7 Upper North - North												
Boundary 8 North to Midlands												
Boundary 9 Midlands to South												
Boundary 10 South coast												
Boundary 11 North East & Yorkshire												
Boundary 12 South & South West												
Boundary 13 South West												
Boundary 14 London												
Boundary 15 Thames Estuary												
Boundary 16 North East, Trent & Yorkshire												
Boundary 17 West Midlands												
Required Capability (GW)												
Boundary 1 North West												
Boundary 2 North South												
Boundary 3 South West												
Boundary 4 SHETL-SPT												
Boundary 5 SPT North - South												
Boundary 6 SPTL - NGC Boundary												
Boundary 7 Upper North - North												
Boundary 8 North to Midlands												
Boundary 9 Midlands to South												
Boundary 10 South coast												
Boundary 11 North East & Yorkshire												
Boundary 12 South & South West												
Boundary 13 South West												
Boundary 14 London												
Boundary 15 Thames Estuary												
Boundary 16 North East, Trent & Yorkshire												
Boundary 17 West Midlands												
Actual thermal capability (GW)												
Boundary 1 North West												
Boundary 2 North South												
Boundary 3 South West												
Boundary 4 SHETL-SPT												
Boundary 5 SPT North - South												
Boundary 6 SPTL - NGC Boundary												
Boundary 7 Upper North - North												
Boundary 8 North to Midlands												
Boundary 9 Midlands to South												
Boundary 10 South coast												
Boundary 11 North East & Yorkshire												
Boundary 12 South & South West												
Boundary 13 South West												
Boundary 14 London												
Boundary 15 Thames Estuary												
Boundary 16 North East, Trent & Yorkshire												
Boundary 17 West Midlands												
Actual voltage capability (GW) (for all boundaries where voltage is most onerous constraint and where available for other boundaries)												
Boundary 1 North West												
Boundary 2 North South												
Boundary 3 South West												
Boundary 4 SHETL-SPT												
Boundary 5 SPT North - South												
Boundary 6 SPTL - NGC Boundary												
Boundary 7 Upper North - North												
Boundary 8 North to Midlands												
Boundary 9 Midlands to South												
Boundary 10 South coast												
Boundary 11 North East & Yorkshire												
Boundary 12 South & South West												
Boundary 13 South West												
Boundary 14 London												
Boundary 15 Thames Estuary												

180. Figure 12 shows the Transmission Regulatory Reporting Pack table which will be submitted to reflect the 'Utilisation' requirement.

Figure 12: Network Utilisation Regulatory Reporting Table



181. The rules for creating Table 4.8 are taken from the 'Price Control Review Reporting Rules: Instruction and Guidance'. Further rules are as follows:
    a. Boundaries: A system boundary splits the network into two parts across which transfer capabilities can be assessed
    b. Planned Transfer: This is defined within the GB Security and Quality of Supply Standard (SQSS)
    c. Boundary Capability: Assessed according to the GB SQSS
    d. Boundary Transfer Capacity: As defined in the GB SQSS if the two parts either side of the boundary are of applicable sizes, otherwise apply an equivalent scaling to the generation and demand

182. The rules for creating Table 4.9 are taken from the 'Price Control Review Reporting Rules: Instruction and Guidance'. Information will be used from the most recent business planning studies. Further rules are as follows:
    a. Supply Capacity: Assessed according to the GB SQSS in two separate ways – limited by Supergrid Transformer (SGT) capacity or limited by any other factors
    b. Peak Demand: The maximum demand of the demand group at the substation
    c. Seasonal Peak Demand: Equal to peak demand or if more onerous conditions arise with lower demand and the accompanying relevant rating
    d. Maintenance Period Demand: As defined in the GB SQSS
    e. Intact Capacity: The capacity with no local outages
    f. n-1 Capacity: The first circuit outage condition as defined in the GB SQSS
    g. n-2 Capacity (300MW demand groups only): The second circuit outage condition as set out in the GB SQSS – only applicable for substations where the peak group demand is greater than 300MW

5.4.6 Continuous Improvement

183. The Transmission Licensees will continue to review the submitted information for Network Capability. This will also consider the parallel work which is being undertaken at the time to ensure a consistency of approach, for instance Transmission Access Review.

5.4.7 Additional Material Included within Transmission Licensees' Specific Appendices

184. Any additional relevant measures which the individual Transmission Licensee considers useful for internal business use and addressing the Licence requirement and Specified Amendment 6 will be reported within the individual Transmission Licensee's Specific Appendix.

5.4.8 External Publication of Network Output Measures

185. There are no issues with the external publication of the proposed Network Output Measure Methodology. The summary tables as shown in Figure 11 and Figure 12, which already form part of the Transmission Regulatory Reporting Packs and should not be published externally.

6.0 COMPARATIVE ANALYSIS

6.1 Licence Requirements

186. Within this section the Transmission Licensees have considered the following parts of the Licence Condition:
    a. The Network Output Measures shall be designed to facilitate 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

6.2 Geographic areas of, and Network Assets within the Licensee's Transmission System

187. The Network Output Measures Methodology has been designed to enable comparability of network assets e.g. common Asset Health Index definitions, common Replacement Priority definitions. The constituent elements of Criticality recognise geographic differences.

6.3 Transmission Systems within Great Britain

188. By developing the Network Output Measures Methodology across the Transmission Licensees, the Network Output Measures will be produced in the same format and allow comparative analysis across Transmission Licensees.

189. By continually sharing information across the Transmission Licensees with the aim of calibrating the Network Output Measures this will enable comparison across the Transmission Licensees.

6.4 Transmission Systems within Great Britain and Other Countries

190. The names of specific companies have not been included within this Network Output Measures Methodology to enable external publication of these comparisons.

191. In addition to the development of the Network Output Measures, the three Transmission Licensees have researched methods used to report similar measures within Great Britain and other countries. Examples of these systems are Condition Based Risk Management, Asset Health Indices and Criticality Indices. Whilst adopting a Methodology used by other Transmission Companies would indicate the outputs will have the same definitions, the evidence collected shows these methodologies are highly configurable so the companies using them can align the measures to their asset base and statutory, regulatory and business requirements.

192. National Grid supported the establishment of and is representing the UK on the recently convened CIGRE working group C1.16, which has been set up to develop Electricity Transmission thinking on Transmission Asset Risk Management. The working group has found that companies are not reporting on elements of Network Risk due to:
    a. Lack of complete data
    b. Information being retained by specialists

6.5 Transmission Systems and Distribution Systems within Great Britain

193. Throughout the development of the Network Output Measures Methodology, the Transmission Licensees have reviewed the Distribution Regulatory Reporting Pack templates to ensure consistency in reporting across transmission and distribution.

194. In addition the Transmission Licensees have been closely following the development of the Distribution Network Output Measures during DPCR5. For example, the approach adopted for addressing Specified Amendment 4 as outlined in this Network Output Measures Methodology has similar features to the forward projection of Asset Health Indices (purely based on asset health) based on no network expenditure and planned network expenditure developed during DPCR5. In addressing Specified Amendment 4, the Transmission Licensees have proposed a future projection of the Network Risk Measure (requiring the future projection of both asset condition in the form of Asset Health Indices combined with a forward view of Criticality) which contains the additional Criticality element compared to the DPCR5 proposal. It has also been proposed this future projection of Network Risk can be provided against different investment scenarios as for the DNO Network Output Measures.

195. The Transmission Licensees have worked together to share information regarding the definition of Asset Health Indices to ensure consistency of underlying principles and approach where applicable.

6.6 Additional Comparative Analysis

196. The names of specific companies have not been included within this Network Output Measures Methodology to enable external publication of these comparisons.

197. In rail a process has been developed for the optimisation of maintenance regimes for safety critical assets. This takes into account financial and safety risk associated with the assets. The process follows five key steps:
    a. Identify failure modes/root cause and analyse how deterioration occurs
    b. Assess and quantify maintenance and failure costs
    c. Link failure modes directly with mitigating maintenance tasks
    d. Use software tools to model cost-risk optimisation maintenance intervals
    e. Provide an ALARP (As Low As Reasonably Practicable) safety justification for the new maintenance regime

198. In rail an Asset Stewardship Index (ASI) has been developed which provides an overall measure on all aspects of asset stewardship, including:
    a. Safety
    b. Quality (Condition and Capability)
    c. Performance

The measures provide coverage across most of the asset types and have been weighted to reflect the importance of the assets to the overall ASI measure. This is then used to determine if the Asset Stewardship is improving or deteriorating. This measure is used as an incentive where the incentive is only positive.

199. In highways Performance Indicators have been developed to monitor performance over time and measure the effectiveness of processes. These are set every year.

200. The 'Capital Maintenance Planning: Common framework' for the UK water industry, is based on the analysis of risk (specifically the probability and consequences of asset failure) and encompasses an economic approach which allows the trade-off between capital and operational cost options. The forward looking risk based aspect of the framework encourages consideration of the optimal balance between proactive and reactive maintenance as well as Opex and/or Capex solutions and assists in identifying the economic level of capital maintenance.

201. This additional comparative analysis highlights that the Transmission Licensees are covering the main areas identified from other relevant industry sectors.

7.0 ONGOING REVIEW AND DEVELOPMENT OF NETWORK OUTPUT MEASURES

7.1 Licence Requirements

202. Within this section the Transmission Licensees have considered the following parts of the Licence Condition:
    a. The Transmission Licensee shall at all times keep the approved Network Output Measures Methodology under review to ensure that it facilitates the objectives
    b. The Transmission Licensee shall make such modifications to the approved Network Output Measures Methodology as may be required to better facilitate the objectives
    c. The Transmission Licensee 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

7.2 Process to Modify Network Output Measures

203. Once the initial development phase of the Network Output Measures is concluded (by December 2009 as defined in the Ofgem Decision letter of 18 December 2008), the Transmission Licensees will jointly review the Network Output Measures Methodology to ensure they are still meeting the objectives of the Licence Condition and propose further developments of the measures as required through a series of regular review sessions (one annual face-to-face session and three teleconferences).

204. The Network Output Measures Methodology will be jointly agreed and re-issued each year following the annual face-to face review to reflect any proposed

changes or further developments to ensure it facilitates the objectives of the Licence Condition. The Transmission Licensees will also conduct three other teleconferences during the year (probably at 3 monthly intervals in between the annual face-to-face meeting) to discuss common areas with the Network Output Measures.

205. The terms of reference of these review meetings are – "The Transmission Licensees will meet to discuss the appropriateness of the current Network Output Measures in meeting the requirements of Licence Condition B17; Share information to ensure consistency and calibration across the Transmission Licensees and to discuss and resolve common issues with the implementation of Network Output Measures"

Appendix A: Factors used in determining Asset Health Indices

Equipment Type	Factors to determine AHI	Additional Factors
Overhead Lines	Condition assessment score - including conductor condition Environmental – including galloping, sub-conductor oscillation, industrial environment, % of route 150m above sea level, coastal location (distance from coast) Conductor corrosion and forensic results	Service experience of other circuits of similar design/age in similar environment Historic and projected defects
Cables	Historic and projected environmental performance Risk of tape corrosion Risk of sheath failure	Historic unreliability Results of condition assessment where applicable Service experience of cable systems
Switchgear	Forensic evidence from targeted condition assessment and known deterioration modes Historic number of defects and significant NEDERS (National Equipment Defect Reporting Scheme) issues pointing to safety or environmental issues. Likelihood of failure – trends for individual and family type	Unplanned revenue costs Technical sustainability – evaluation of original equipment manufacturers' or National Grid support in terms of technical knowledge and availability of spares.
Transformers	Condition assessment Design family performance Chemical analysis of oil for dissolved gas or other ageing tests Site testing and/or continuous monitoring Scrapping Reports of replaced transformers	Oil quality – acidity, breakdown voltage and resistivity

	Condition scores: Dielectric condition assessed using DGA (dissolved gas analysis Thermal condition assessed using DGA Mechanical condition assessed using FRA (frequency response analysis) External condition of transformer (e.g. corrosion)	

Appendix B: Criticality – Constituent Elements for Circuits and Substations (Example)

4.29A Criticality - substation

Demand criticality	Demand greater than (MW)	Demand less than or equal to (MW)
High	600	
Medium	300	600
Low	0	300

Asset	System criticality								Safety criticality			Environmental
Substation	Nuclear	Traffic Hub	COMAH	EKP	Black Start	Demand	Security	Overall system criticality	Transformer safety	Switchgear safety	Overall substation safety criticality	Transformer environ.

Appendix C: Timeline for work on Transmission Network Output Measures

2009	
January	Licensees submit revised Network Output Measures Methodology with any amendments being implemented for 1 April 2009
February to March	Network Output Measures tables/pro-formas for 2009/10 published and incorporated into the TRRP
April to December	Licensees continue to work on Specified Amendments directed as part of The Authority's approval to the deadline in December Subject to the Licensees resolving the reliability incentive remains symmetrical or becomes penalty only Licensees record data for 2009/10 Network Outputs Measures
2010	
January to March	Incorporate developments in Network Output Measures after April 2009 into the TRRP for 2010/11
July	Licensees submit report on 2009/10 Network Output Measures

Appendix D: Deterioration Mechanisms & Factor which bring about Deterioration

Equipment Type	Deterioration Mechanism	Factors Affecting Mechanism
Transformers	Thermal Ageing of Paper Insulation	Transformer operating temperature, moisture content of the insulation and acidity of the insulating oil
	Localised Overheating due to induced currents flowing in the transformer core bolts and steel	Integrity of core bolt and core to frame insulation
	Thermal Fault	High resistance winding connections or restricted oil flow in windings due to poor thermal design or deterioration of the dielectric resulting in restricted oil flow
	Winding Movement	Vibration associated with normal operation or forces within the winding resulting from through fault conditions
	Dielectric Fault	High moisture content of the dielectric or transient overvoltages
	Corrosive Oil – dielectric failure due to deposition of copper sulphide in the paper insulation.	High operating temperature combined with insulating oil containing corrosive compounds
Cables	Tape corrosion	Family design weakness Installation environment
	Sheath failure	Often associated with installation (cables cleated in air) where cable subject to thermal cycling and bending
	Environmental performance (oil leaks)	Numerous factors – weak joint plumbs, tape corrosion, lead sheath failure
	Failure of old-style link boxes (refurbishment)	Ingress of water Design
	Failure of old-style SVLs (refurbishment)	Ingress of water Design
	Condition of joint plumbs (refurbishment)	Design – weak plumbs lead to oil leaks

Switchgear	Seals	Loss of elasticity giving moisture/water ingress and/or oil leakage Pressure induced deformation and wear Loss of sealing ability Wear and Tear O-Ring Embrittlement
	Porcelain to metal joints - cement	Frost/Oxide Jacking Loss of mechanical strength Chemical ageing of cement, weakening flange joints
	Drive Rods, Glassfibre rods	Shearing or bending Age related shearing of glass fibre rods Separation of end pieces Bearing wear
	Tension Components	Relaxation of tension tubes, increased vibration and loosening of assemblies
	Mechanisms, Linkages and Air Cubicle Components	Mechanism linkage weakness (duralloy) Torsion springs Dash pot – Poor design Pressure Switches deterioration Piston corrosion/wear Poor settings, loss of adjustment
	Contacts and PTFE Nozzles	Poor settings, loss of adjustment Duty related wear
	Grading Capacitors	Capacitor pack punctures Corrosion leading to water ingress or oil leakage
	Resistors	Corrosion leading to moisture ingress
	Electronic Control & Monitoring Systems	Sub-component failure
	Oil filled Bushings	Water ingress Poor oil quality
	OCB Tanks	Corrosion leading to water ingress
	Steel housing of drive mechanism	Corrosion leading to water ingress
	Paint/Coatings	Corrosion

Overhead Lines	Conductor corrosion	Local pollution levels (coastal/industrial)
	Conductor fatigue	Topography, wind induced vibration (i.e. Aeolian vibration, sub-conductor oscillation, galloping, ice-loading)
	Conductor fittings	Topography, local pollution levels (coastal/industrial), wind induced vibration
	Conductor joints	Poorly cleaned installation of new to old conductor, inadequately compressed joint
	Dowel pins	Corrosion of split pin leading to dowel pin migration
	Insulators (Glass)	Corrosion of steel pin caused by local pollution levels (coastal/industrial)
	Insulators (Porcelain)	Expansive corrosion of steel pin at the air-cement-steel interface caused by local pollution levels (coastal/industrial)
	Spacers	Vibration fatigue
	Dampers	Vibration fatigue
	Tower steelwork corrosion	Topography, local pollution levels (coastal/industrial), painting quality at first installation
	Tower foundations	Construction quality, soil type, ground water level/change in level
	Tower foundation muffs	Corrosion at foundation/muff interface due to construction quality