APPENDIX: NETWORK OUTPUT MEASURES METHODOLOGY
Author: National Grid

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1.0 PURPOSE AND SCOPE

1.1 Document Purpose

1. A 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 (SPTL) and Scottish Hydro-Electricity (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. The Network Output Measures Methodology describes the common framework (concepts and principles) which will be followed by the three Electricity Transmission Licensees in producing the Network Output Measures in each of the following areas:
    a. The requirements in the Licence Condition
    b. The Specified Amendments to the Network Output Measures Methodology 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

4. In addition to the Network Output Measures Methodology, each individual Transmission Licensee has produced a Specific Appendix to describe how each will produce the Network Output Measures using the common framework described in the Network Output Measures Methodology.

5. National Grid's Specific Appendix is referred to from this point as the Implementation Document. This Implementation Document describes the framework National Grid are using (supporting data and models) to generate the Network Output Measures.

6. This Implementation Document references internal business documentation (attached) which describes:
    a. The data (including the data categories) used to produce the Network Output Measures
    b. The methods, calculations and models used to transform this data into the Network Output Measures
    c. Analysis and reports used to develop the Network Output Measures, including supporting data and models
    d. Availability of historical data
    e. National Grid's use of the Network Output Measures

7. In implementing the Network Output Measures framework, National Grid has sought to utilise existing activities and embed any new activities required to meet this framework within its Asset Management System (e.g. documents, processes). For this reason, much of the content of this Implementation Document is contained in the attached Policy Statements, Technical Guidance Notes and Technical Reports.

8. Following production of Issue 2 of this document on 30 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).

9. The Specified Amendments from The Authority's condition approval decision letter 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

10. This Issue of National Grid's Implementation Document (Issue 3) specifically highlights the additions and changes that have been made to the Policy Statements, Technical Guidance Notes and Technical Reports to address the Specified Amendments within The Authority's condition approval decision letter (18 December 2008).

11. The changes made to National Grid's Policy Statements, Technical Guidance Notes and Technical Reports to address the Specified Amendments are summarised within Table 1 and Table 2.

Table 1: Changes to Existing National Grid Policy Statements and Technical Guidance Notes

Document	Change	The Authority's Specified Amendment
[redacted]	Calibration of Replacement Priorities across equipment types and between Transmission Licensees	1 – Ensuring consistency between remaining useful life scales
[redacted]	Inclusion of further deterioration evidence	2 – Validity of the remaining useful life calculation 2 & 4 – Rate of deterioration assumptions (used in derivation of future Network Risk)
[redacted]	Criticality scoring for safety, system and environment	3 – Breakdown of Network Risk into its three constituent Criticalities and derivation and application of Criticality grading
[redacted]	Comparability of Safety, System and Environment Criticality scoring and deriving an overall Criticality Score	3- Breakdown of Network Risk into its three constituent Criticalities and derivation and application of Criticality grading
[redacted]	Criticality scoring for individual equipment types	3 – Derivation and application of Criticality grading

Table 2: New Technical Guidance and Technical Reports

Document	Reason	The Authority's Specified Amendment
[redacted]	Description of modeling of asset lives, rates of deterioration and asset replacement volumes	2 – Rate of deterioration assumptions
[redacted]	Description of rate of deterioration assumptions, including worked examples	2 – Validity of the remaining useful life calculation 2 & 4 – Rate of deterioration assumptions (used in derivation of future Network Risk)
[redacted]	Description of the relationship between loss of supply, network availability, network reliability and asset condition and forecast network unreliability.	5 - Measures of Network Reliability correlated with asset condition and age

12. Table 3 shows the specific additions to National Grid's Implementation Document to address the specific requirements placed upon the individual Transmission Licensee under the Specified Amendments.

Table 3: Signposting How the Specified Amendments have been Addressed in National Grid's Implementation Document

Specified Amendment	Where Addressed in Implementation Document
Specified Amendment 1	Transmission Licensees' Network Output Measures Methodology National Grid's Implementation Document: Sections 3.2, 4.1.2
Specified Amendment 2	Sections 4.1.2, 4.1.8, 4.1.14, 4.1.15, 4.1.16, 4.1.17,
Specified Amendment 3	Sections 3.2, 4.2.1, 4.2.2, 4.2.3, 4.2.4, 4.2.5
Specified Amendment 4	Section 3.5, 4.2.11
Specified Amendment 5	Sections 3.6, 3.7, 4.3, 4.3.2
Specified Amendment 6	Sections 4.4.2

13. It can be expected that this Implementation Document and all associated documentation will continue to undergo review and revision as part of continuous improvement of National Grid's Asset Management processes and practices and as the Network Output

Measures are regularly reviewed and updated to ensure they continue to meet the objectives of the Licence Condition.

2.0 SUBMISSION OF NETWORK OUTPUT MEASURES

14. The first full set of Network Output Measures will be reported to The Authority for the 2009/10 financial year by 31 July 2010 as part of the Transmission Regulatory Reporting Pack.

15. However, in agreement with the Authority National Grid has already reported the Network Asset Condition and Network Risk measures including the requirements of Specified Amendment 3 ahead of the licence requirement. The submitted Network Output Measures tables and accompanying narrative were sent to The Authority on 30 September 2009. The submitted tables that formed part of the Transmission Regulatory Reporting Pack were:
    - Table 4.28 – Network Asset Condition
    - Table 4.29 – Network Risk
    - Table 4.30 – Criticality

16. Table numbers for the 2009/10 Transmission Regulatory Reporting Pack will be different, as the Network Output Measures tables have different numbering.

3.0 USING NETWORK OUTPUT MEASURES WITHIN NATIONAL GRID

17. This section of the document provides an explanation of how the Network Output Measures are embedded in National Grid's Asset Management System in the following areas:
    a. Using technical asset lives to assess longer term network expenditure requirements
    b. Using Asset Health Priorities and Replacement Priorities to understand medium to shorter term network expenditure requirements
    c. Using volume modelling to assess Network Risk
    d. Using performance metrics in the form of losses of supply, defects, faults, failures and Average Circuit Unreliability to understand and monitor Network Performance and forecast network unreliability
    e. Using boundary information within its system design decision making process

3.1 Long term Asset Replacement Planning

18. Long-term asset replacement forecasts are developed for lead assets using a probabilistic (Monte Carlo simulation) asset replacement model called ALERT. ALERT models the technical requirement for asset replacement. The rate of asset deterioration is encoded in the technical asset lives which form a primary input to ALERT. In the short to medium

term (within a ten year period) National Grid uses the asset replacement volume outputs from ALERT to understand how the Capital Plan compares with expected volumes from the technical asset lives. In the longer term, the need for asset replacement is considered over a 20-year time horizon to ensure that decisions in the short term maintain a sustainable network, thus protecting both current and future stakeholder interests.

19. Given the above, in the longer term (greater than a ten year period), the need for asset replacement investment is based on equipment specific technical asset lives, which represent the probability the lead assets need to be replaced. These technical asset lives have been developed and used within the business over a long period of time and are based on an in-depth understanding of asset condition and asset deterioration.

20. The technical lives incorporate a significant body of asset health information including outputs from research and development, condition monitoring, condition assessment, forensic examinations, fault and failure investigations and knowledge of equipment design. Depending on the equipment type, condition information may be available for specific assets (where condition information is collected as part of routine processes) and/or based on known asset family deterioration mechanisms.

21. The Asset Health process collates and assesses asset data, information and knowledge from across the Electricity Transmission business to ensure a full understanding of asset performance, asset condition and criticality. A review of asset lives will also be triggered based on analysis of performance and condition information undertaken as part of the Asset Health process.

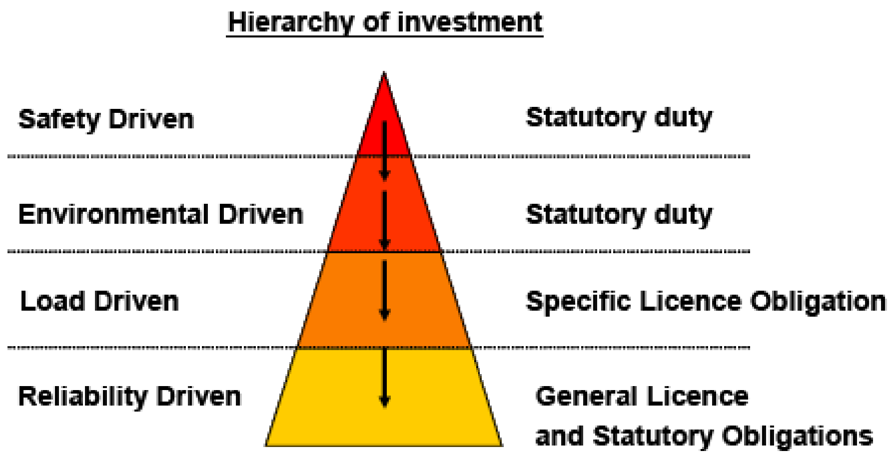
3.2 Short to Medium Term Asset Replacement Planning

22. Each lead asset is assessed and categorised with an Asset Health Index (Asset Health Priority). Asset Health Indices describe the condition and performance of the lead assets and are assigned against a common set of definitions. The criteria used to define the Asset Health Indices include asset condition (specific and family), design weaknesses and asset performance. Criteria used to assess Network Asset Condition are shown in Appendix A in the Network Output Measures Methodology and this forms a summary of the work that has been undertaken by the Transmission Licensees to address Specified Amendment 1 to ensure consistency between their assessments of Asset Health Priorities.

23. Each lead asset is also assigned a Replacement Priority. The Replacement Priorities are derived using the Asset Health Indices and an overall Criticality Score derived from System Criticality, Safety Criticality and/or Environmental Criticality as appropriate. The distinction between Asset Health Indices and Replacement Priorities recognises that two assets, both with the same Asset Health Index can have a different Replacement Priority because of the consequences of asset failure.

24. The derivation of an overall Criticality Score for safety, system and environment considers the comparability of these elements taking into account National Grid's Hierarchy of Investment (Figure 1).

Figure 1: Hierarchy of investment



25. Asset Health Priorities and Replacement Priorities are reviewed annually or as part of the Asset Health process.

26. Replacement Priorities provide a set of priority ranked asset replacement candidates which are used to initiate and develop schemes which form the Capital Plan. This process will involve either asset replacement being brought forward or deferred to:
    a. Bundle asset replacement into economic packages of work
    b. Align asset replacement with load related network requirements
    c. Recognise the practicalities of delivering schemes in terms of outages, resources, lead time to achieve asset replacement and interaction with other schemes

    The development of the Capital Plan allows assessment of future network expenditure requirements.

27. National Grid has in place a company wide investment management process which establishes a methodology for assessing investment risk on a common basis across all of the National Grid's Lines of Business. The Asset Health Indices, Criticality Scores and Replacement Priorities provide an input to this process.

28. Condition assessments acquire specific asset related condition information (i.e. detailed condition information on the particular asset being considered for replacement) to inform the Asset Health Indices and Replacement Priorities and to understand the required scope of works (e.g. scope of civil work required) and intervention options (e.g. refurbish, replace).

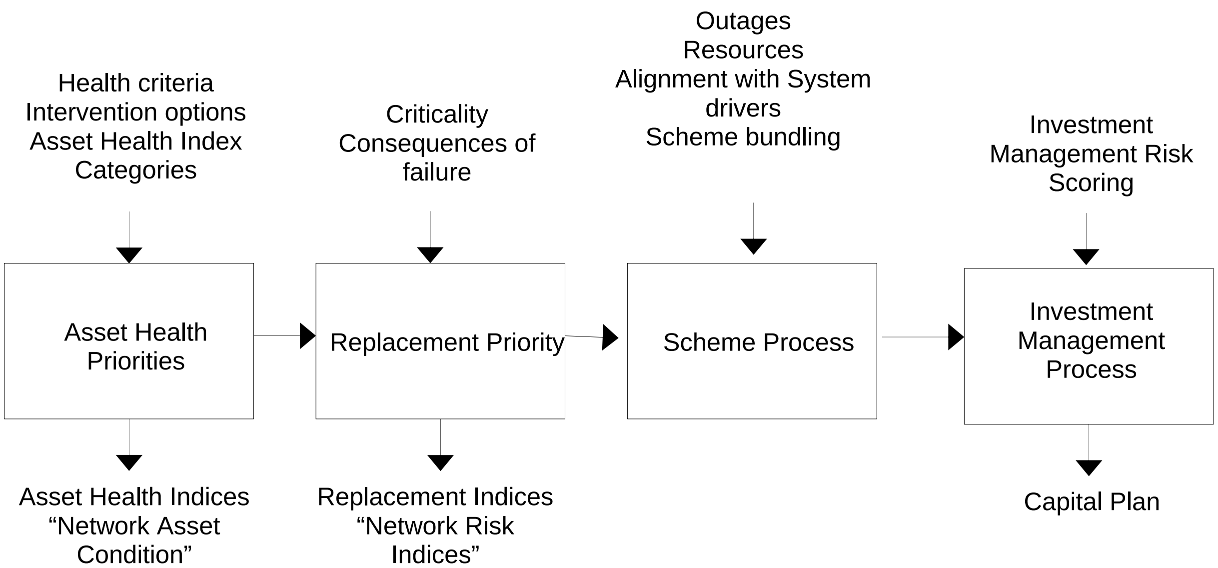
29. Updated information received from condition assessments, asset failures and performance trends is monitored through the Asset Health process. This may result in changes to the Asset Health Indices and Replacement Priorities leading to either asset replacement being brought forward or asset replacement being deferred.

30. Criticality will be reassessed following significant enhancement to the transmission system infrastructure, the introduction of Risk Mitigation measures which reduce the consequence of asset failure or the discovery of a new failure mechanism associated with an equipment type which changes the materiality of the consequence of failure. This may also result in changes to Replacement Priorities leading to either asset replacement being brought forward or asset replacement being deferred.

31. Figure 1 in the Network Output Measures Methodology shows how Asset Health Priorities and Replacement Priorities are used in development of the Capital Plan.

32. Figure 2 shows the relationship between National Grid's Asset Health Indices, Replacement Priorities, Scheme process and Investment Management process as depicted in [redacted], National Grid's Policy Framework for Equipment Replacement and Refurbishment.

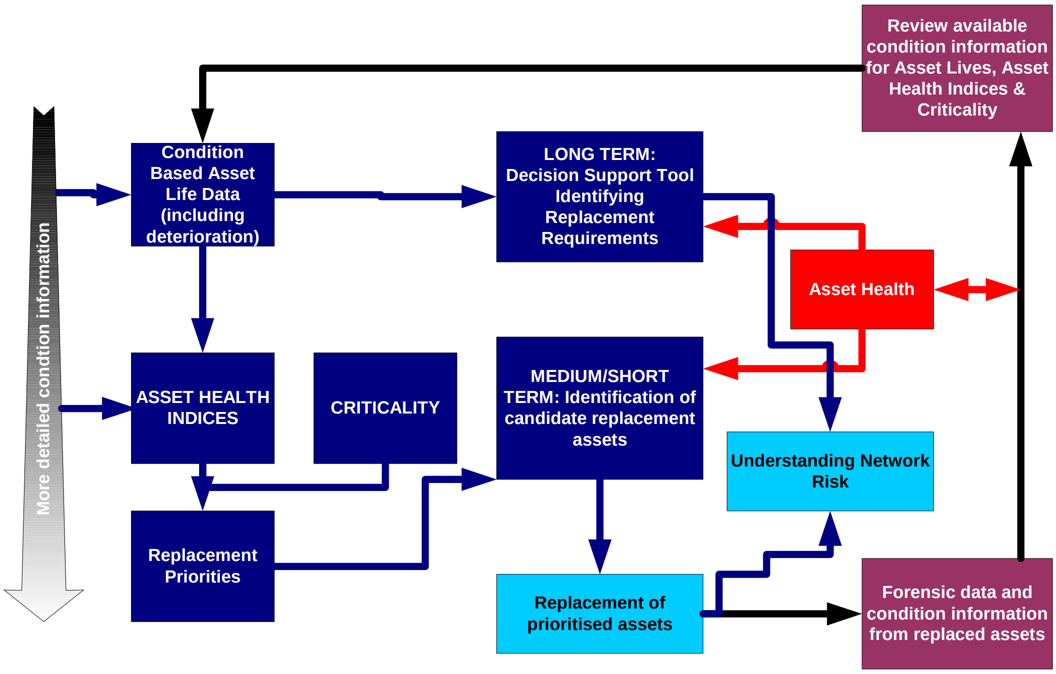
Figure 2: Understanding Network Expenditure for National Grid



33. As schemes are completed, opportunities are taken to gather forensic evidence. This forensic evidence is used to validate the technical asset lives used in long term modelling and to inform the Asset Health Priorities and Replacement Priorities as part of the Asset Health process.

34. Figure 3 below summarises National Grid's approach to identifying the requirements for asset replacement network expenditure, progressing from long term modelling based on statistical models and technical asset life data, through to condition, performance and Criticality based identification of asset replacement candidates.

Figure 3: Asset Replacement: High Level Process



35. Figure 4 shows the maturity of Asset Management Capability. The following sections describe how this increasing maturity is being implemented within National Grid.

Figure 4: Increasing maturity of Asset Management

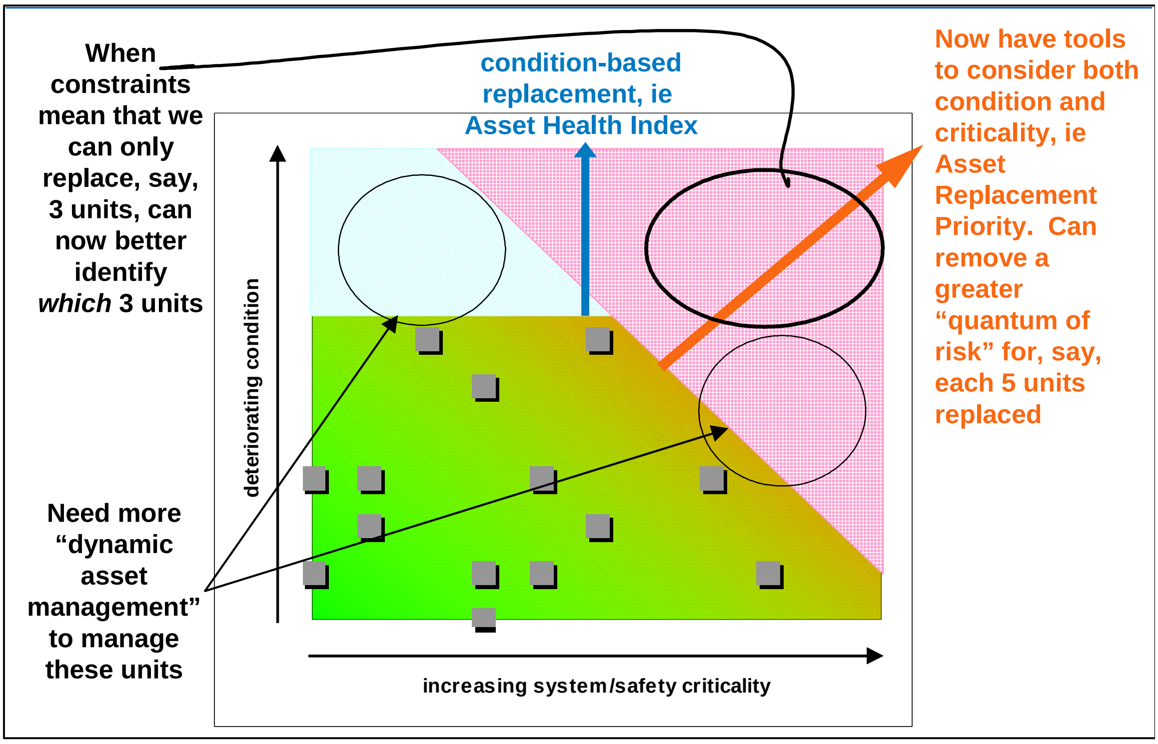
'Reactive based' (e.g. repair/replace on fail	'Interval based' (e.g. maintain at a set interval, replace at asset life)	'Condition based' (e.g. maintain/replace based on condition)	'Risk & Criticality based' (e.g. maintain/replace assets with the highest risk and greatest importance)

Increasing maturity of asset management

3.3 Determining Appropriate Asset Management Strategies

36. Figure 5 shows how a combined view of Asset Health Indices (Network Asset Condition) and Criticality (i.e. Replacement Priorities) is used within National Grid to determine the appropriate asset management strategy.

Figure 5: Using Asset Health Indices and Criticality to Determine the Appropriate Asset Management Strategy



37. Different Asset Health Indices and Criticality may result in differing asset management strategies. Assets with a high Criticality and poor Asset Health Indices will have a high Replacement Priority. Assets with the same poor Asset Health Index but a low Criticality will have a lower Replacement Priority and the risk that the asset poses with having a poor Asset Health index will be managed through alternative intervention options (e.g. enhanced maintenance) or condition monitoring to ensure an acceptable and sustainable balance between performance, costs and risk.

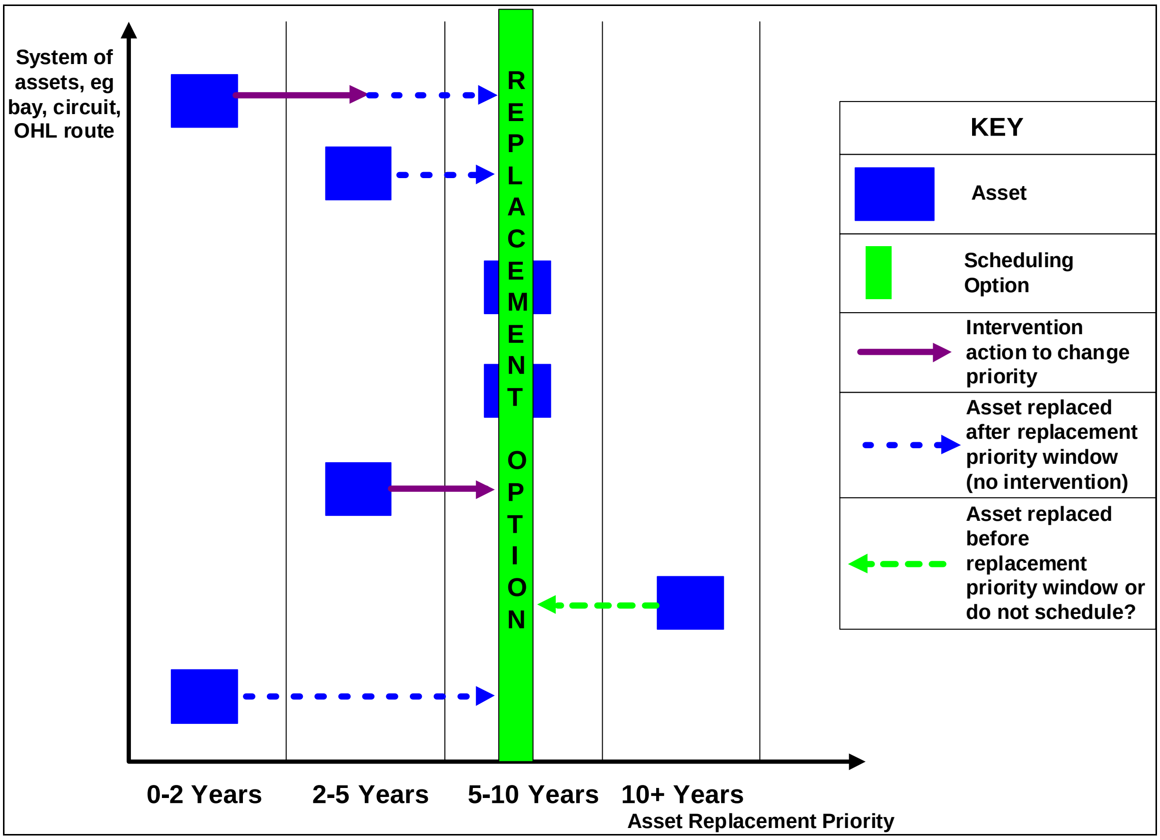
38. For example, the development of new refurbishment options for certain types of circuit breaker enables management of the condition and performance of the assets (i.e. management of the Asset Health Indices) and thus management of the Replacement Priorities and extension of the technical lives.

3.4 Optimised Approach to Scheduling Replacement Across a System of Assets

39. Replacement Priorities are used to bundle lead asset replacement candidates into economic packages of work which feed into schemes and to inform prioritisation of these schemes. These bundling opportunities are available for a system of assets such as a substation bay, a conductor system or a cable system and enable optimisation of the elements of a scheme which are common across assets (e.g. outages, resources, set up arrangements and costs). Intervention options (e.g. refurbishment or reconditioning) can also be considered to enable efficient and effective bundling (e.g. to extend the life of certain assets in the system to align with longer life assets). This may lead to new options, which may not currently be available, being investigated and developed (e.g. research and development to develop new intervention options, new risk mitigation options).

40. Figure 6 shows an example of how this bundling can be applied for a system of assets.

Figure 6: Replacement Options for a System of Assets



3.5 Understanding Network Risk Using Asset Replacement Volumes

41. The asset replacement volumes generated from the ALERT model are used in conjunction with the volumes from the Capital Plan to understand Network Risk. [redacted]

42. For the period under consideration, cumulative Capital Plan asset replacement volumes are calculated by summating the asset replacement volumes from the first year (e.g. 2000/1) up to and including the year for which the cumulative volume is being calculated. This gives a set of cumulative Capital Plan asset replacement volumes for the period studied. A set of cumulative ALERT asset replacement volumes is calculated using the same method.

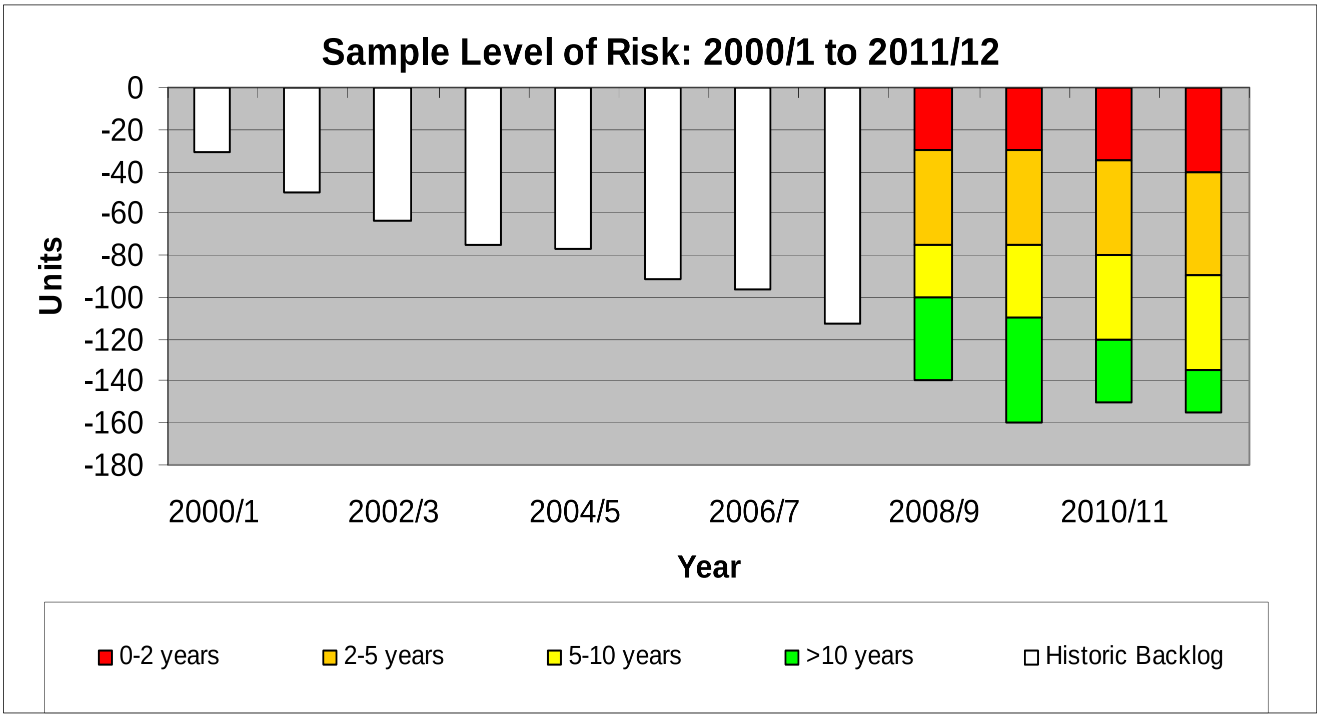
43. For each year, the difference between the cumulative Capital Plan volumes and cumulative ALERT volumes is calculated and this difference is plotted on a graph.

44. Using the known replacement years, expected deterioration of asset health generated via a forward projection of Asset Health Indices and a forward view of Criticality, Network Risk can be assessed. The difference in cumulative Capital Plan volumes and cumulative ALERT volumes can be sub-categorised using a forward projection of Replacement Priorities of assets yet to be replaced based on the forward projection of Asset Health Index and Criticality.

45. For each year, this volume difference is sub-categorised by assessing the forward projection of Replacement Priorities (see example graph in Figure 7) in the following order:
    a. 0-2 Years – Red
    b. 2-5 Years – Orange
    c. 5-10 Years – Yellow
    d. >10 Years - Green

46. Not all the sub-categories may be shown for any particular year if only a few sub-categories are required to meet the volume difference. For example, it is possible that the graph shows no volume for the >10 year Replacement Priority category if the volume difference is fulfilled by the other categories or all the volume difference is categorised as 0-2 years (with zero volume in the other categories).

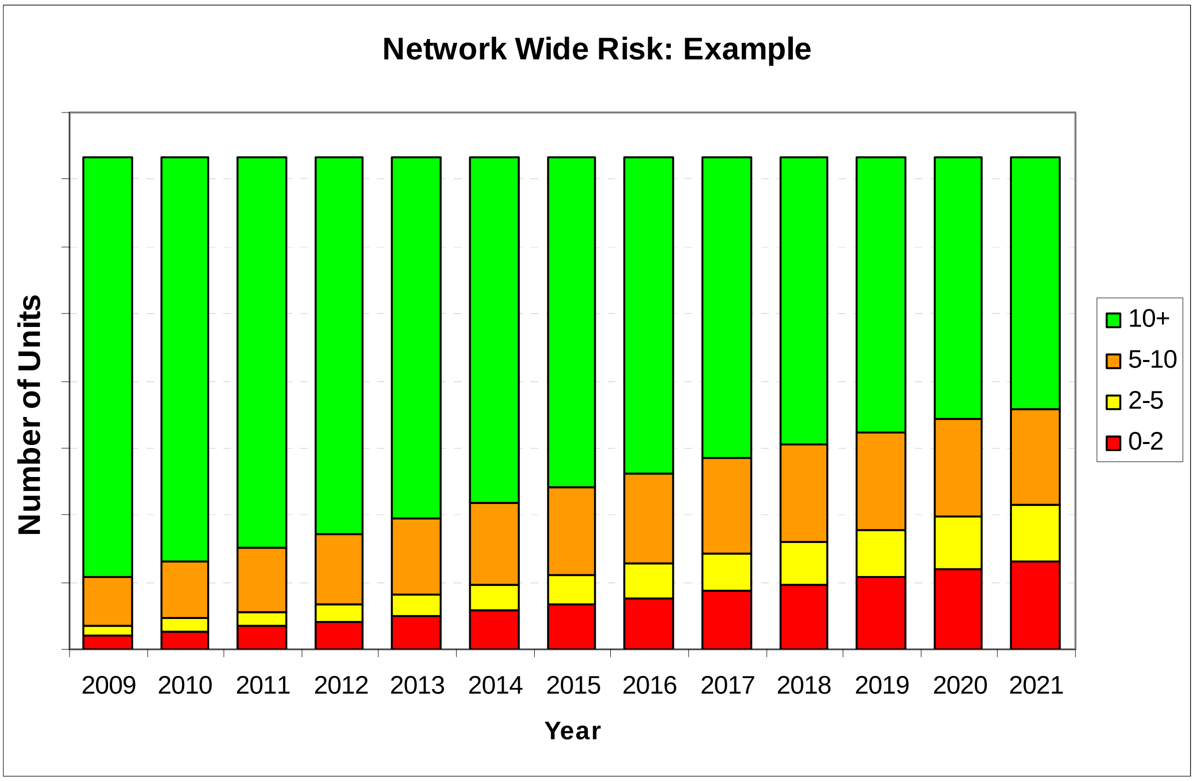
Figure 7: Network Risk - Difference volumes by Replacement Priority (Example)



47. These graphs allow National Grid to understand the level of Network Risk associated with any Capital Plan scenario. By assessing the individual assets to be replaced and assessing the volume at risk (shown on the graph) against historic volumes, National Grid can evaluate the reliability risk compared with historic levels and understand specific areas of the network at risk. This is a key process for National Grid to ensure an acceptable and sustainable balance between performance, costs and risk.

48. A further aid to understand the level of Network Wide Risk is to understand the forward profile of Replacement Priorities across the main transmission asset groups. This is achieved by projecting forward the Asset Health Indices and combining a future view of Criticality to obtain a forward projection of Replacement Priorities using the approach in Figure 2. The Capital Plan details which assets are planned to be replaced and where assets are replaced, the Asset Health Index is reset to 4 (health at the beginning of life) and deterioration begins from age zero. An example output is shown below in Figure 8.

Figure 8: Network Risk – Example Forward Projection of Replacement Priorities Against A Specific Asset Replacement Investment Scenario



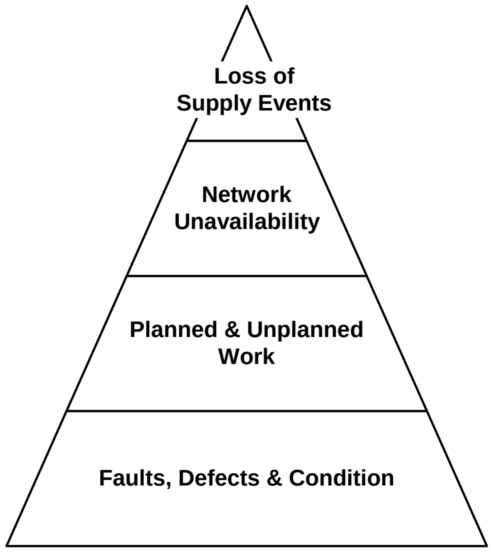
3.6 Understanding Asset and Network Performance

49. National Grid undertakes a wide variety of asset and network performance monitoring activities with particular emphasis placed on monitoring 'leading' measures to provide advance warning of key issues. National Grid monitors the element of network unavailability associated with circuit unreliability as a 'leading' measure of network performance.

50. It is possible to show the relationship between loss of supply events and other network performance metrics in a 'Network Performance Triangle' (Figure 9). This 'Network

Performance Triangle' is analogous to Heinrich's Safety Triangle[1] widely used to describe the relationship between fatalities and near misses.

Figure 9: Performance Triangle



51. A mathematical relationship between the elements in the triangle cannot be demonstrated in the same way as the safety triangle; the relationship is purely conceptual.

52. The key metrics National Grid uses to understand asset and network performance are:
    a. Loss of supply
    b. Average Circuit Unreliability including Unplanned Unavailability
    c. Failures
    d. Faults
    e. Defects

53. Asset and network performance monitoring is a key activity for National Grid. Changes in performance impact the customer in terms of reliability of supply and the costs of the services that National Grid provides. This information is used in conjunction with other data, information and knowledge to determine the appropriate proactive and reactive Asset Management actions.

3.6.1 Loss of Supply

[1] Heinrich, H.W., "Industrial Accident Prevention: A Scientific Approach", 1959, McGraw-Hill, New York

54. All loss of supply events are investigated to understand the sequence of events that led to the loss of supply and its root cause, as well as identifying learning points which could avoid future events. Losses of supply are reported, investigated and analysed but due to the very small number of events each year (average of 10 incidents in total with an average of 5 incidents where more than 3 customers are affected) this provides very sparse information to enable identification of any emerging trends.

3.6.2 Average Circuit Unreliability

55. Average Circuit Unreliability (ACU) is used within National Grid to understand the impact of asset unreliability on the network. Average Circuit Unreliability has been reported monthly as a Key Performance Indicator (KPI) within National Grid since autumn 2001. This KPI is used to identify trends in asset and network unreliability and in-depth analysis is undertaken to understand the causes of these trends and identify appropriate Asset Management actions to manage asset and network performance.

56. Average Circuit Unreliability is a measure of asset functional failure. Using functional failure as a key measure provides consistency with other industries who aim to understand trends in network reliability.

57. Average Circuit Unreliability is reported at an equipment level for the major asset types, namely transformers, cables, switchgear and overhead lines. [redacted]

[redacted]

[redacted]

3.6.3 Failures

58. Failures are defined for each equipment group but essentially a failure is a disruptive event that results in either a major sub-component or the whole asset being replaced.

59. The number of failures experienced each year is very small (e.g. a few in each equipment category). As failures are often disruptive in nature, they often result in a risk of significant safety and/or environmental impact. In addition, failures can have a significant impact on the network because they often result in long periods of time when the assets are out of service (e.g. months for transformer and cable failures). A catastrophic failure may also result in collateral damage other assets that are located close by and these may also need to be taken out of service.

3.6.4 Faults

60. Within National Grid, a fault is defined as ‘an event which causes equipment to be automatically disconnected from the HV system for investigation and further action if required’.

61. National Grid typically has a small number of faults (200-300) per annum and the number is highly dependent on weather conditions. Given this, faults are not a good measure for tracking overall network performance or benchmarking but fault analysis is routinely undertaken as part of the Asset Health process to identify issues with particular assets or asset families. Faults are used to feed into the asset health assessment of specific equipment groups.

3.6.5 Defects

62. Within National Grid, a defect is defined as ‘a non-conformance from specified requirements, which is identified from maintenance, inspection, observation or alarm and requires investigation, possibly involving planned disconnection of equipment, and/or further remedial action’.

63. Typically, approximately 20,000 defects are identified on National Grid’s network each year. Defects in isolation are not a good measure for tracking overall network performance, as aggregating the total number of defects is not sensible as the severity and impact of defects may vary greatly. Defects are used to track asset performance at a detailed equipment design level taking account of equipment design, defect severity and defect impact. Defects are used to feed into the asset health assessment of specific equipment groups.

3.7 Understanding the Relationship between Asset Condition, Asset Age and Network Reliability

64. National Grid has undertaken a substantial piece of analysis to understand the link between asset condition, asset age and network reliability. [redacted]

65. Failures and faults have been analysed with the aim of being able to use these metrics to understand the relationship between asset condition, asset age and network reliability and forecast network reliability. However, with these metrics there is a lack of data with which to produce a strong statistical link between asset performance and age/condition. In contrast, Average Circuit Unreliability as a measure of functional failures, provides a substantive set of data with which to understand the relationship between asset condition, asset age and network reliability and can also be used to forecast network unreliability. [redacted]

66. [redacted]

4.0 IMPLEMENTATION

4.1 Network Asset Condition

4.1.1 Required Individual Documentation

67. In additional to the Network Output Measures Methodology, the following items are included within this Implementation Document:
    a. A description of the information used to determine the Asset Health Indices and technical asset lives including availability of historical information
    b. An explanation of how National Grid determines Asset Health Indices
    c. An explanation of how National Grid determines technical asset lives
    d. An explanation of how calibration and consistency is being ensured across the equipment types and between National Grid and the two other Transmission Licensees.

4.1.2 Understanding Network Asset Condition

68. Over many years of operation of its transmission assets National Grid has established a thorough understanding of the condition of its assets and the consequences of asset failure through a variety of mechanisms including:
    a. Research and development into degradation mechanisms
    b. Condition monitoring information where condition monitoring is defined within National Grid as 'the acquisition, recording and [automatic] analysis of parameters which indicate the state of equipment (generally online and in real-time) and commonly look for changes of state or trends in these parameters'

c. Condition assessment information where condition assessment is defined within National Grid as ‘the activity of reviewing the available condition information offline by an engineer to evaluate the health of equipment, with a view to recommending a particular course of action’
d. Failure investigations
e. Performance information (e.g. faults, defects, Average Circuit Unreliability)
f. Forensic examinations
g. Feedback from intervention activities (e.g. maintenance)

69. This information is used to determine the Asset Health Indices, the states requiring replacement and the technical asset lives for different equipment types/families. [redacted].

[redacted]

[redacted]

70. [redacted]

71. The equipment specific Replacement and Refurbishment Policies and supporting Technical Guidance Notes also document the rate of deterioration assumptions which describe how the Asset Health Indices change with age. This addresses the first part of Specified Amendment 2. National Grid has also developed technical reports for each lead equipment group which provide worked examples of the rate of deterioration assumptions, specifically addressing the second part of Specified Amendment 2.

72. These documents also include the developments since Issue 2 of this Implementation Document to address the Specified Amendments:
    - Specified Amendment 1:
        - Take account of calibration of asset condition criteria across the equipment types and across the Transmission Licensees
        - Take account of calibration of Replacement Priorities across the equipment types and across the Transmission Licensees
    - Specified Amendment 2:
        - Include further deterioration evidence which provides the foundation for the technical asset lives (i.e. remaining useful life calculation)
        - Changes to the technical asset lives for some equipment families as part of the continuous improvements of National Grid's Asset Management capability reflecting enhanced understanding of asset condition and deterioration mechanisms and developments in intervention options (e.g. refurbishment)

73. [redacted]

4.1.3 Framework for Developing Asset Health Indices (Short to Medium Term Assessment)

74. [redacted]

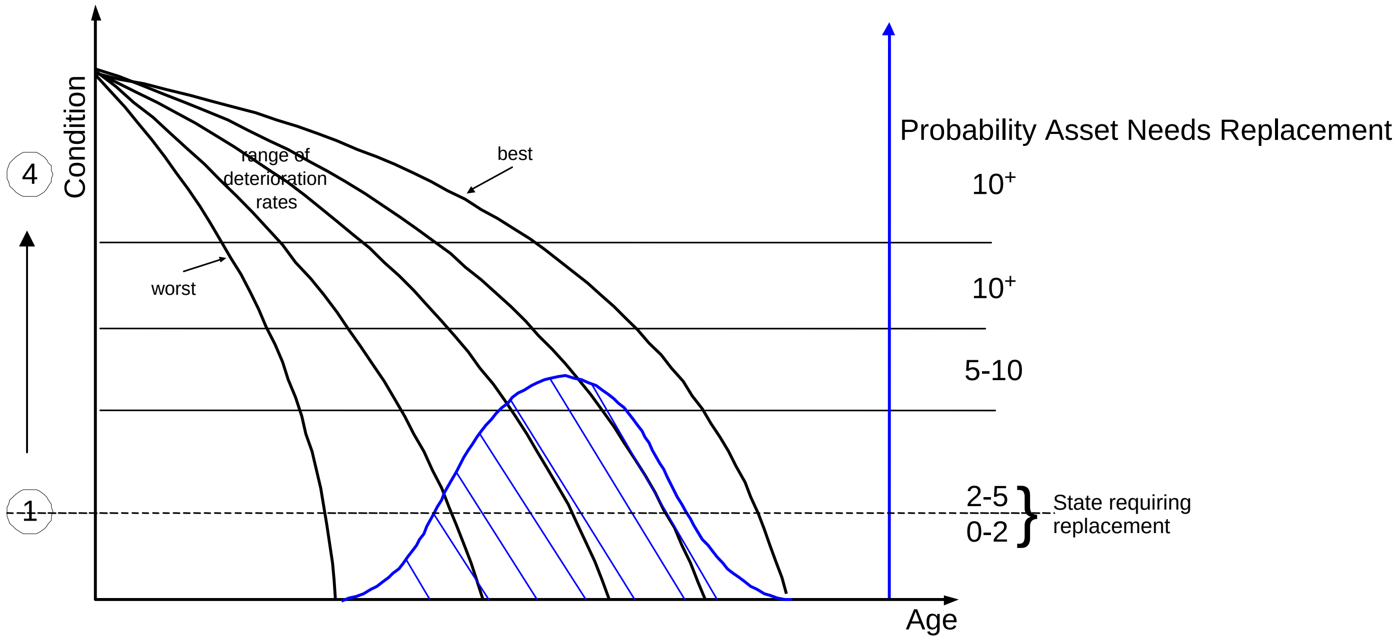
75. Within National Grid, the generic Asset Health Index categories are defined over a numeric scale. This Implementation Document includes a description of the mapping

from the National Grid numeric equipment specific Asset Health Index to the Network Output Measures Asset Health Index categories:

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

76. Figure 12 shows the relationship between Asset Health Indices and technical asset lives.

Figure 12: Link between Asset Health Indices and Asset Lives



77. Asset Health Indices against the National Grid categorisation were reported in Table 4.7 in the 2006/7 and 2007/8 Transmission Regulatory Reporting Pack for transformers and switchgear. In addition, Asset Health Indices against the National Grid categorisation for overhead lines and cables were also reported in Table 4.7 in the 2007/8 Transmission Regulatory Reporting Pack. Historic information for transformer Asset Health indices was reported in Table 4.7 in the 2007/8 Transmission Regulatory Reporting Pack back to 2000/1. A commentary on the Asset Health Indices is included in the narratives which form part of the 2006/7 and 2007/8 Transmission Regulatory Reporting Packs.

78. Following discussion and agreement with Ofgem, in September 2009, National Grid reported Network Asset Condition in the form of Asset Health Indices against the Network Output Measures categorisation in Table 4.28 as part of an additional submission of the Transmission Regulatory Reporting pack.

79. Since Issue 2 of the Implementation Document, the Replacement and Refurbishment Policy Statements and associated Technical Guidance Notes have been enhanced to further explain how the comparability and consistency of Asset Health Indices and remaining useful life criteria across the equipment types and across the Transmission Licensees has been achieved (Specified Amendment 1).

80. The Asset Health Index general criteria [redacted] have been reviewed and the specific Asset Health Index definitions for each of the equipment types have been reviewed against this general criteria to ensure consistency. In addition, the criteria used in assigning Asset Health Indices for the specific equipment types have been discussed and agreed with the Transmission Licensees. The National Grid processes used to assess Asset Health Indices have been reviewed against these agreed criteria. The changes made as a result of these various reviews are reflected in the equipment specific Replacement and Refurbishment Policy Statements and Technical Guidance Notes.

81. No changes have been made to the common technical asset life definition [redacted] which has been an established definition for many years.

4.1.4 Overhead Lines Asset Health Indices

82. [redacted]

Table 4: Asset Health Index Mapping to Network Asset Condition Indices (Overhead Lines)

Overhead Line Asset Health Index	Asset Health Condition
1	Remaining Useful Life 0-2 years
	Remaining Useful Life 2-5 years
2	Remaining Useful Life 5-10 years
3, 4	Remaining Useful Life > 10 years

83. [redacted]

84. Asset Health Indices for overhead lines were developed in 2007. Overhead line refurbishment prioritisation was undertaken in the past on a different basis and so the information is not available to calculate historic Asset Health Indices prior to 2007.

85. Ahead of reporting for 2009/10 the Asset Health Indices will be mapped across to all four remaining useful life categories as stated within the proposed Network Output Measures Methodology. National Grid's internal documentation will also be changed to reflect these changes.

4.1.5 Cables Asset Health Indices

86. [redacted]

Table 5: Asset Health Index Mapping to Network Asset Condition Indices (Cables)

Cable Asset Health Index	Asset Health Condition
1 and 1R	Remaining Useful Life 0-2 years
	Remaining Useful Life 2-5 years
2	Remaining Useful Life 5-10 years
3, 4	Remaining Useful Life > 10 years

87. [redacted]

88. Asset Health Indices for cables were developed in 2007. Cable replacement and refurbishment prioritisation was undertaken in the past on a different basis and so the information is not available to calculate historic Asset Health Indices prior to 2007.

89. Ahead of reporting for 2009/10 the Asset Health Indices will be mapped across to all four remaining useful life categories as stated within the proposed Network Output Measures Methodology. National Grid's internal documentation will also be changed to reflect these changes.

4.1.6 Circuit Breakers Asset Health Indices

90. [redacted]

Table 6: Asset Health Index Mapping to Network Asset Condition Indices (Circuit Breakers)

Circuit Breaker Asset Health Index	Asset Health Condition
1, 2a	Remaining Useful Life 0-2 years
	Remaining Useful Life 2-5 years
2b	Remaining Useful Life 5-10 years
3, 4	Remaining Useful Life > 10 years

91. A detailed description of the data used to define the Asset Health Indices [redacted] along with an explanation of how this data is combined to derive the Asset Health Index category.

92. Asset Health Indices for circuit breakers were developed in 2007. Switchgear replacement and refurbishment prioritisation was undertaken in the past on a different basis and so the information is not available to calculate historic Asset Health Indices prior to 2007.

93. Ahead of reporting for 2009/10 the Asset Health Indices will be mapped across to all four remaining useful life categories as stated within the proposed Network Output Measures Methodology. National Grid's internal documentation will also be changed to reflect these changes.

4.1.7 Transformers Asset Health Indices

94. [redacted]

Table 7: Asset Health Index Mapping to Network Asset Condition Indices (Transformers)

Transformer Asset Health Index	Asset Health Condition
1, 2a	Remaining Useful Life 0-2 years
	Remaining Useful Life 2-5 years
2b & 2c	Remaining Useful Life 5-10 years
3 & 4	Remaining Useful Life > 10 years

95. An Asset Health Index 1 or 1s transformer is allocated to 0-2 years remaining useful life if it is either in the Capital Plan for replacement within the next 2 years (work or replacement has already commenced) or a rapidly escalating problem is detected, sufficiently serious to trigger an immediate replacement with a spare unit otherwise the remaining useful life is 2-5 years.

96. [redacted]

97. Ahead of reporting for 2009/10 the Asset Health Indices will be mapped across to all four remaining useful life categories as stated within the proposed Network Output Measures Methodology. National Grid's internal documentation will also be changed to reflect these changes.

98. Historical data for transformer Asset Health Indices is available from 2000/1. From 2000/1 to 2002/3 there was no subdivision of Category 2 into a, b and c and information is not available to split the Category 2 transformers into these sub-categories.

4.1.8 Framework for Understanding the Rates of Deterioration

99. A set of rate of deterioration distributions describing how asset health is expected to change with age has been developed for each equipment group. A 'wear out' range is

defined at a sub-component level, appropriate for that equipment group, detailing the earliest age at which the component is expected to start deteriorating and the latest predicted occurrence of wear out. Using this information deterioration ranges are used to define the worst and best case rates of deterioration showing how the asset moves through the Asset Health Indices.

100. This information is based on a combination of forensic analysis, asset condition information and predicted performance in conjunction with engineering experience.

101. [redacted]

4.1.9 Overhead Lines Deterioration

102. [redacted]

103. [redacted]

4.1.10 Cable Deterioration

104. [redacted]

105. [redacted]

4.1.11 Circuit Breaker Deterioration

106. [redacted]

107. [redacted]

4.1.12 Transformer Deterioration

108. [redacted]

109. [redacted]

4.1.13 Framework For Developing Technical Asset Lives (Longer Term Assessment)

110. [redacted] includes a common definition for technical asset lives in terms of key statistical parameters to enable derivation of technical asset life probability density curves which are used as input to ALERT. [redacted] details how these probability density curves are produced using the technical asset life parameters defined in the equipment specific Replacement and Refurbishment Policies and also includes information on how the ALERT model is used to generate asset replacement volumes. [redacted] also defines the relationship between Asset Health Indices and technical asset lives.

111. Technical asset life parameters and the state requiring replacement are defined in each equipment's specific Replacement and Refurbishment Policy Statement. Further detail on the derivation of technical asset lives is contained in the supporting equipment specific Technical Guidance Notes. The probability distributions which are derived from these technical asset lives are reported to The Authority on Table 4.16: Asset Lives in the annual Transmission Regulatory Reporting Pack according to the Price Control Review Instructions and Guidance.

4.1.14 Overhead Lines Technical Asset Lives

112. [redacted]

113. [redacted] Since August 1999 additional asset families and further categorisation has been added into the technical asset lives table so not all current technical asset lives will be comparable with historic information. Technical asset lives do exist before August 1999 but the definitions used do not align with the current definition.

114. [redacted] In addition, technical asset lives for fully greased and core only greased Zebra conductor in benign environmental operating conditions (e.g. categories B and C) have been extended based on forensic evidence and operational data.

4.1.15 Cables Technical Asset Lives

115. [redacted]

116. [redacted] Since August 1999, further categorisation has been added into the technical asset lives table so not all current technical asset lives will be comparable with historic information. Technical asset lives do exist before August 1999 but the definitions used do not align with the current definition.

117. [redacted]

4.1.16 Circuit Breakers Technical Asset Lives

118. [redacted]

119. [redacted] Since August 1999 additional asset families and further categorisation has been added into the technical asset lives table so not all current technical asset lives will be comparable with historic information. Technical asset lives do exist before August 1999 but the definitions used do not align with the current definition.

.

120. [redacted]

4.1.17 Transformers Technical Asset Lives

121. [redacted]

122. Historical data on technical asset lives using the common definition [redacted] exists since August 1999. Since August 1999 additional asset families and further categorisation has been added into the asset lives table so not all current asset lives will be comparable with historic information. Technical asset lives do exist before August 1999 but the definitions used do not align with the current definition.

123. [redacted]

4.1.18 Continuous Improvement

124. Asset Health Indices and technical asset lives are continuously being developed and updated using condition and performance information collected during Asset Management activities and specific activities to develop further understanding of asset health (e.g. forensics, research and development). These developments will be incorporated in National Grid's Policy Statements and Technical Guidance Notes and will be reflected in the regular review of the Transmission Licensees' Network Output Measures Methodology and National Grid's Implementation Document.

125. In additional to the development of Asset Health Indices and technical asset lives, National Grid is also sharing information with the other two Transmission Licensees to ensure that the developed Asset Health Indices are calibrated and consistent.

126. National Grid will continue to develop its understanding of the rates of asset deterioration. As assets age and reach a state requiring replacement more information about the assets will become available which will be used develop the rates of deterioration distributions.

4.2 Network Risk

4.2.1 Required Individual Documentation

127. Additional to the Network Output Measures Methodology the following items are included within this Implementation Document:
    a. A description of the definitions and criteria for deriving System, Safety and Environmental Criticality
    b. An explanation of the approach used in comparing System, Safety and Environmental Criticality and combining these constituent elements to derive an overall Criticality Score
    c. The common approach to mapping overall Criticality Scores and Asset Health Indices against each other to derive Replacement Priorities
    d. An explanation of the derivation and application of Criticality Scores by equipment type
    e. An explanation of the application of Asset Health Indices and Criticality Scores to assign a Replacement Priority by equipment type

4.2.2

4.2.3

4.2.4 Understanding Network Risk

128. For many years, National Grid has prioritised schemes in the Capital Plan based on lead assets. This prioritisation process included Criticality factors for System, Safety and Environmental. Recent changes in the development of the Replacement Priorities have combined System, Safety and Environmental Criticality with the Asset Health Indices. This has led to developments in the methods used to determine the priorities for asset replacement.

4.2.5 Criticality

129. The framework which National Grid uses to derive an overall Criticality Index has been developed across the UK electricity transmission business and is utilised to prioritise Asset Management actions.

130. During development of the Network Output Measures Methodology, extensive work has been undertaken to address The Authority's Specified Amendment 3 associated with the breakdown of Network Risk into its three constituent Criticalities and derivation and application of the Criticality grading. This work can be broadly summarised as:
    - The framework for deriving System Criticality has been reviewed and updated in conjunction with the GB System Operator. This review and update has involved discussion across the three Transmission Licensees as well as discussions between the Transmission Licensees and the GB System Operator. This utilises the agreed definitions included in the Network Output Measures Methodology
    - The framework for deriving Safety and Environmental Criticality has been developed. This utilises the agreed definitions included in the Network Output Measures Methodology
    - The framework for comparing and combining the constituent elements of Criticality (System, Safety and Environmental Criticality) into an overall Criticality Score has been developed. This utilises the agreed definitions included in the Network Output Measures Methodology
    - A common matrix has been defined for deriving Replacement Priorities from Asset Health Indices and Criticality Indices. Further definition of National Grid's timescales for Replacement Priorities is provided within this document
    - The replacement and refurbishment Policy Statements and Technical Guidance Notes have been enhanced to include the derivation of equipment specific Safety and Environmental Criticality Indices and the application of Asset Health Indices and Criticality Indices in deriving Replacement Priorities

131. The Criticality scoring framework derives Criticality Scores for each of the three constituent elements of system, safety and environmental. These constituent elements of Criticality are defined against four comparable categories:
    a. Very High
    b. High

c. Medium
d. Low

132. Using these comparable categories, these constituent elements of Criticality are combined to derive an overall Criticality Score [redacted]

133. [redacted]

[redacted]

4.2.6 System Criticality

134. National Grid has worked jointly with the GB System Operator to develop a consolidated overall view on System Criticality. This overall view of System Criticality includes a number of key data items which have been available for some considerable time but until

very recently these key data items have not been combined together to form an overall System Criticality Score. The overall System Criticality Score is applied consistently across all the equipment types.

135. [redacted]

136. A high, medium or low categorisation is derived from the application of this process. To allow comparability across the criticality component parts of System, Safety and Environment there is no very high category scored for System Criticality.

137. Elements that are included within the definition of System Criticality are:
   a. Vital Infrastructure:
      i. Support England and Wales Traffic Infrastructure
      ii. Substations that support Control of Major Accident Hazards (COMAH) Sites
      iii. Economic Key Points
      iv. Circuits and Substations that affect reliability of connection to a nuclear power station
      v. Circuits and substations that support the operation of black start sites
   b. Impact on customers - The National Grid definitions for impact on customers in terms of MWs at risk are:
      i. High - >600MW
      ii. Medium - >300MW, <600MW
      iii. Low - <300MW
   c. System Security:
      i. Local Group Demand Security
      ii. Generation Concentration
      iii. Demand Concentration
      iv. Constraint Boundaries

4.2.7 Safety and Environmental Criticality

138. [redacted]

139. Safety and Environmental Criticality are both equipment specific. In order to ensure comparability between the equipment types, Safety and Environmental Criticality is assigned where it is believed that there is a material risk from failure or unreliability of the assets.

Figure 14: Safety and Environmental Criticality Impact by Equipment Type

	Safety Impact?	Environmental Impact?
Overhead Line	✓	X
Cable	✓ *	✓
Switchgear	✓	X
Transformer	✓	✓ (minor)
Protection	X	X

✓ Significant impact from failure of equipment (* applies to cables with specific ancillaries/accessories)
✓ (minor) Minor impact from failure of equipment
X No impact from failure of equipment (where equipment considered in isolation)

140. Safety Criticality is based on the risk of direct harm to personnel/public as a result of asset failure.

141. A very high, high, medium or low categorisation is derived from application of this process.

142. Safety Criticality is derived using a combination of:
- **Exposure** – The level of personnel or public activity within the vicinity of the asset
- **Vulnerability** – The impact of equipment failure that has the potential to cause harm to an individual or member of the public

143. [redacted].

144. 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.

145. A very high, high, medium or low categorisation is derived from application of this process. To allow comparability across the Criticality component parts of System, Safety and Environment Criticality there is no very high category scored for Environmental Criticality.

146. Environmental Criticality is derived using a combination of:
   - **Exposure** – The proximity of the asset to an environmentally sensitive area
   - **Vulnerability** – The environmental impact of unreliability or failure of the asset

147. [redacted]

148. The specific application of the Safety and Environmental Criticality framework and criteria for deriving the equipment specific Safety and Environmental Criticality Indices is described for each equipment type in the Replacement and Refurbishment Policy Statements and associated Technical Guidance Notes.

149. Addressing Specified Amendment 3, Table 4.29 reporting the constituent elements of Criticality (System, Safety and Environmental Criticality) for circuits and substations has been included in the Electricity Transmission Regulatory Reporting Pack. The highest Criticality is reported as the overall substation or circuit Criticality. The constituent elements which are used to produce System Criticality (see Paragraph 132), Safety Criticality and Environmental Criticality are also reported in this table.

150. As agreed with The Authority, National Grid provided Table 4.29 for the first time on 30 September 2009 as part of an additional submission of the Transmission Regulatory Reporting Pack. As agreed with The Authority Table 4.29 was issued on a secure memory stick due to the confidential nature of the data contained in the table.

4.2.8 Replacement Priorities

151. The National Grid matrix for combining Asset Health Index and Criticality Indices to produce Replacement Priorities is [redacted] shown in Figure 15. This is based on the agreed matrix contained in the Network Output Measures Methodology and so provides comparability both across equipment types as Replacement Priorities are derived for each asset based on the same matrix and across the Transmission Licensees as the National Grid Replacement Priority matrix is based on the agreed Replacement Priority matrix contained in the Network Output Measures Methodology.

Figure 15: Replacement Priority Mapping

	Criticality			
AHI	**Very High**	**High**	**Medium**	**Low**
1	0-2	0-2	2-5	2-5
High category 2	0-2	2-5	5-10	5-10
Medium/Low category 2	5-10	5-10	5-10	10+
3	10+	10+	10+	10+
4	10+	10+	10+	10+

152. National Grid maps the Replacement Priorities accordingly:
    a. Category 1 = Replacement Priority = 0-2 Years
    b. Category 2 = Replacement Priority = 2-5 Years
    c. Category 3 = Replacement Priority = 5-10 Years
    d. Category 4 = Replacement Priority = 10+ Years

153. As agreed with The Authority, National Grid provided Replacement Priorities against the definitions above in Table 4.30 for the first time on 30 September 2009 as part of an additional submission of the Transmission Regulatory Reporting Pack.

4.2.9 Overhead Lines Replacement Priorities

154. [redacted]

155. [redacted]

156. Replacement Priorities for overhead lines were developed in 2008. Overhead line Refurbishment Prioritisation was undertaken in the past on a different basis and so the information is not available to calculate historic Replacement Priorities.

4.2.10 Cables Replacement Priorities

157. [redacted]

158. [redacted].

159. Replacement Priorities for cables were developed in 2008. Cable Replacement and Refurbishment Prioritisation was undertaken in the past on a different basis and so the information is not available to calculate historic Replacement Priorities.

4.2.11 Circuit Breakers Replacement Priorities

160. [redacted]

161. [redacted]

162. Replacement Priorities for circuit breakers were developed in 2008. Switchgear Replacement and Refurbishment Prioritisation was undertaken in the past on a different basis and so the information is not available to calculate historic Replacement Priorities.

4.2.12 Transformers Replacement Priorities

163. [redacted] mapped using the Replacement Priority mapping in Figure 15.

164. [redacted]

165. Transformer Replacement Prioritisation was undertaken in the past on a different basis and so the information is not available to calculate historic Replacement Priorities.

4.2.13 Network Wide Risk Measure

166. To address Specified Amendment 4 a model has been developed which provides a future view of Network Risk in the form of a forward projection of Replacement Priorities by combining a forward projection of Asset Health Indices and a future view of Criticality consistent with approach in Section 4.2.8. The forward projection of Asset Health Indices is produced using the substantial amount of work undertaken defining rates of deterioration and thus how Asset Health Indices change with age to address Specified Amendment 2.

167. It is intended this measure of Network Wide Risk (in the form of a forward projection of Replacement Priorities) will be produced against different Capital Planning scenarios to determine how the measure changes under these scenarios. Two scenarios which it will be possible to provide are:

   a. Assuming no network expenditure – i.e. zero volume
   b. Assuming current Capital Planning volumes

168. [redacted]

169. [redacted]. This will take into account a view on the level of strategic investment on the system and future load related network expenditure as agreed with The Authority.

4.3 Network Performance

4.3.1 Required Individual Documentation

170. Additional to the Network Output Measures Methodology the following items are included within this Implementation Document:
   a. In the short term – a rule set for defining the outages included within the definition of Average Circuit Unreliability. In the long term – this will be a common agreed definition across the three Transmission Licensees
   b. Explanation of the process undertaken to capture and analyse information for reporting purposes
   c. Availability of historic information
   d. Specific detail of how National Grid is addressing Specified Amendment 5 with regard to correlating age and condition data with network reliability and provision of future forecasts.

4.3.2 Production of Network Performance Measures

171. National Grid calculates Unavailability and Unreliability statistics from National Grid's outage planning database TOGA (Transmission Outage and Generator Availability), as this records the reasons for outages taken.

172. Outages in TOGA are assigned codes when the outage is entered in the system. An example of a TOGA code is Ad Hoc Repair (unplanned unreliability related outage). Outages in TOGA do not include transient or non-damage faults (faults cleared in seconds by tripping and auto-reclosing).

173. The process for producing Average Circuit Unreliability is as follows:
    a. A general report of all outages in TOGA for the time period is downloaded
    b. This report is then queried to search for outages assigned ADR (ad hoc repair) codes
    c. Outages not assigned ADR codes are also queried to search for unreliability related keywords in the job description
    d. All unreliability related outages are then analysed to determine whether they are actually unreliability related outages, which equipment item requires repair and an equipment marker is placed in TOGA to indicate that the outage is unreliability related

174. A report which queries all outages containing equipment marker codes for the specified time period is then calculated in TOGA. Unreliability related outage durations are extracted from TOGA for each plant type, according to the marker allocated to the outage.

175. The total unreliability related outage duration for the period is determined for each equipment type and is converted into a percentage unavailability (for unreliability related reasons) figure based on the number of circuits on the Main Interconnected System (MIS). The equation for calculating Average Circuit Unreliability is:

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

176. The MIS comprises all 400kV and 275kV circuits plus all Supergrid Transformer feeder circuits, connections to Generators and those parts of lower voltage systems that are controlled by National Grid as defined in the substation Site Responsibility Schedules.

4.3.3 Rule Set for outages included within Average Circuit Unreliability

177. It is not always obvious from TOGA what constitutes a repair outage. Sometimes repairs can be synchronised with other planned work on the circuit. If, under these circumstances, the repair is not the work element that governs the outage placement or duration, then the outage is not regarded as a repair outage. If, however, the repair governs the outage pattern duration, then the outage is regarded as a repair outage.

178. Outages **not** included in Average Circuit Unreliability:
    a. Capital Works: Indicated by Pier Code
    b. Maintenance Activity: Indicated by MAJOR/BASIC[2]/IMED codes
    c. Written scheme examination: WSE Code
    d. Inspections
    e. Refurbishment connected with asset replacement and third party outages (whether they affect our equipment or not)

179. Outages included in reliability statistics:
    a. Fault and defect outages, weather trips, overhead line clearance, third party effects, proximity outages (if the outage is related to National Grid 's unreliable equipment) and theft are included in the Average Circuit Unreliability

180. Search terms include:
    a. Defect, Leak, Fault, Repair, Problem, Fail, Damage, Broken, Mend, Emergency, Urgent, Top Up, Tree and Fix
    b. Some search terms are designed to capture multiple forms of a word that may be reported: 'Rectif' captures rectify/rectification, 'Invest' captures investigate/investigation, 'Remed' captures remedy/remedial, 'Tripp' captures tripping/tripped, 'Sampl' captures sampling/sample, 'Inspect' captures inspection/inspection ('Inspect' is often used for investigating unreliable equipment. If the outage is purely inspection it is excluded)

181. It should be noted Average Circuit Unreliability for Compensation equipment is very small because Reactive Compensation equipment rarely causes outages on the MIS. In addition, Average Circuit Unreliability for Substations, Protection and Telecoms is minor compared with the main plant types and makes a very small contribution to the overall unavailability statistics. For reporting purposes, these are grouped into an Other Equipment category.

182. Equipment codes marked in TOGA comprise the following equipment groups:
    a. Overhead Lines
    b. Cables
    c. Switchgear
    d. Transformers, Quad Boosters and Reactors
    e. Other: Combination of
        i. Substations
        ii. Compensation
        iii. Protection

[2] Generally, outages with a BASIC code are excluded from Average Circuit Unreliability; however, on occasion there may be a significant amount of unreliability related work taking place during the outage whereby the outage would be included.

iv. Telecoms

4.3.4 Availability of Historical Information

183. Average Circuit Unreliability has been produced since April 1998. In 2001/02, the number of search criteria was expanded from 4 keywords to 20. For this reason, historical data produced on the same basis is available from 2001/02.

184. It will not be possible to report historical data from TOGA, because only a limited amount of validated historical data (from April 2008) has been imported into TOGA.

4.3.5 Correlating Performance with Age and Condition and Forecasting Network Performance

185. National Grid uses a number of different metrics to assess asset performance. Due to the relatively low number of faults and failures on the National Grid system it is difficult to use these particular metrics to derive strong statistical links between reliability and asset age and condition.

186. The Average Circuit Unreliability metric has been used by National Grid for many years. It measures functional failure, a reliability-related event which results in the unavailability of the asset. ACU identifies all reliability issues, including catastrophic failures as well as defect repairs and fault investigation and is a function of both event and duration. Hence it is a good measure of network reliability that can be correlated with asset condition and age.

187. The ACU also provides a sufficiently large dataset to be able to develop a forecast technique. This data can also be disaggregated to provide detailed information about the major equipment groups. Average Circuit Unreliability and the disaggregated ACU charts for the major equipment groups provide the best metrics available to correlate with asset condition and age and have been used to forecast future ACU.

188. The forecasts of performance are based on maintaining the current backlogs for asset replacement, refurbishment and maintenance, i.e. that the risk profile is unchanged.

189. As Asset Health Indices become established further, more data will become available to establish clearer statistical links between ACU and asset condition.

190. Details of the work undertaken on correlating reliability metrics with asset condition and age and forecasting reliability metrics [redacted] includes analysis of network performance metrics correlated with asset condition and age and specifically addresses Specified Amendment 5.

4.3.6 Reporting of Other Asset and Network Performance Metrics

191. Losses of supply are captured by the GB System Operator and are recorded [redacted]

192. Faults are recorded in the Ellipse Work Management System by the GB System Operator. Faults are analysed through the Asset Health process.

193. Defects are recorded in the Ellipse Work Management System by the Network Operators Centre (if generated from an alarm) or by Field Staff via Office in the Hand (handheld device) if identified on site. Defects are analysed as part of the Asset Health process.

194. Failures are identified from a subset of faults and in rare cases from defects through the Asset Health process.

195. Asset and network performance metrics are reported annually to The Authority in the Transmission Regulatory Reporting Pack. Loss supply information and Average Circuit unreliability is reported in Table 4.3, Faults are reported in Table 4.5 and Failures are reported in Tables 4.6. A commentary on these asset and network performance metrics including identifying any changes in trends is included in the narrative which forms part of the Transmission Regulatory Reporting Pack. In addition, a commentary is included in the narrative on each of the failures identifying the cause and impact. As agreed with The Authority (letter to Stuart Cook 30 March 2009), Defects (Table 4.4) are no longer reported as part of the Transmission Regulatory Reporting Pack as these feed into the Asset Health Indices (Table 4.28).

4.3.7 Continuous Improvement

196. National Grid is continuously developing its ability to report and analyse asset and network performance information collected during Asset Management activities. In particular, since 2003 National Grid has introduced a number of process changes to improve the capture of defects. This has led to a marked increase in the number of defects reported. As further developments are undertaken, these will be incorporated into Asset Management activities and will be reflected in the regular review of the Network Output Measures Methodology and Implementation Documents.

197. 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.

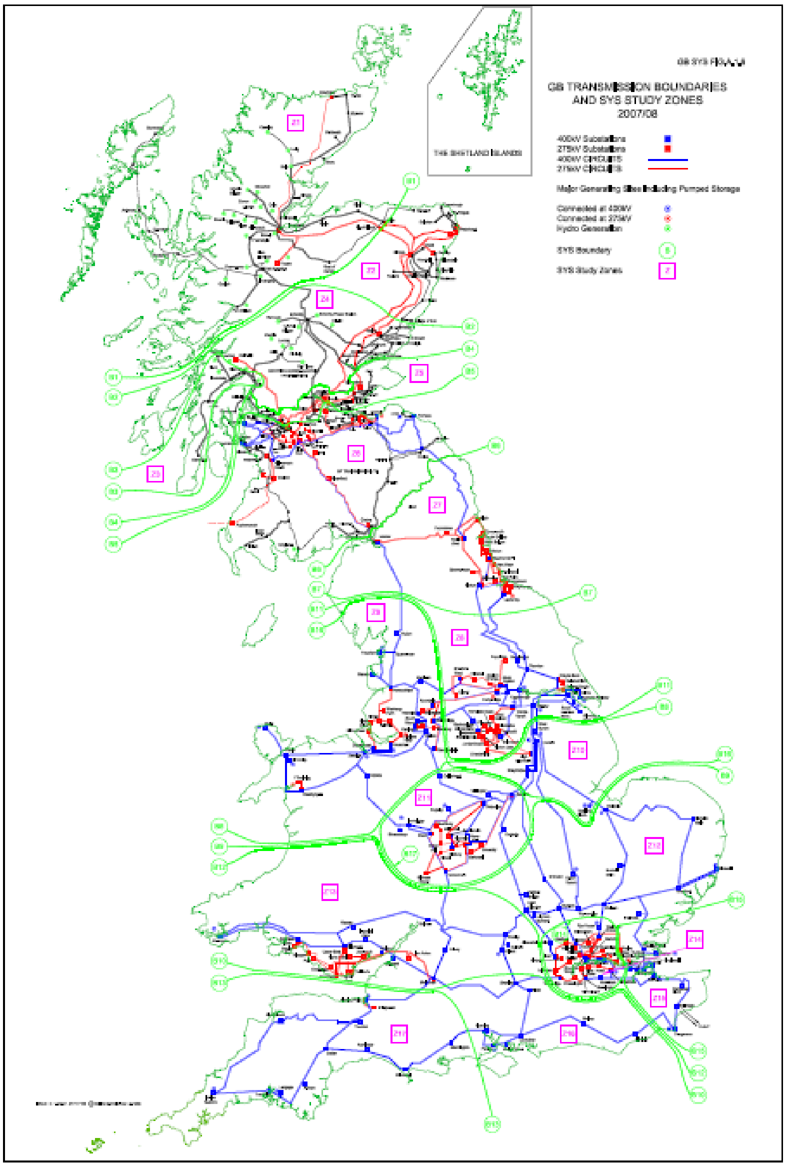
4.4 Network Capability

198. Additionally to the Network Output Measures Methodology the areas covered in this section are:
    a. A description of the data used to determine the inputs in Table 4.8 and Table 4.9 in Transmission Regulatory Reporting Pack
    b. Additional measures on voltage capability and historic flow across boundaries to address Specified Amendment 6.

4.4.1 Network Capability

199. Figure 16 shows the transmission network split into zones which define boundaries across which transfer capabilities are assessed. The capabilities of these boundaries are calculated using DC and AC analysis (FLOP and OPFLO packages) and are tabulated in Table 4.8 in the Transmission Regulatory Reporting Pack.

Figure 16: The Transmission Network Split into Zones



200. The actual capability of a boundary is the current and predicted GW power transfer capability, based on a best view background.

201. The required capability is the current and future requirement to transfer power in GW, based on a best view background.

202. The best view background is made up of the following:
   a. Demand Background: The demand backgrounds are based upon user submissions as governed by the Grid Code. Demands are corrected for the average cold spell and modified to consider demand usage seen and predicted by National Grid
   b. Generation Background: A best view of the generation pattern is based upon market behaviour and contracted positions
   c. Network Background: The existing network and those future transmission developments, which are considered ‘firm’ in that they are least likely to be varied or cancelled as the needs of the evolving system change

203. The required power transfer values must satisfy the National Electricity Transmission System Security & Quality of Supply Standards (NETSSQSS). An interconnection allowance, as defined in Appendix D of the NETSSQSS, is included in the capability calculations. The interconnection allowance is an additional margin to take into account non-average conditions such as severe winters as well as variations in generator availability.

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204. If the forecast for required capability is greater than the ability of the network to transfer the power (required capability > actual capability) then mitigating action is required. Identified shortfalls allow National Grid to plan solutions for ensuring continuing compliance with the NETSSQSS. The solutions may take the form of capital reinforcement or action such as intertripping contracts.

4.4.2 Network Utilisation

205. Table 4.9 in the Transmission Regulatory Reporting Pack shows the number of sites within percentage bands of Utilisation at demand exit points.

206. Capacity is defined as ‘non Supergrid Transformer (SGT) capacity’ and takes into account:
   a. SGT capacity, utilising cyclic rating for post fault conditions
   b. Low voltage interconnection capacity as provided by the DNO (Distribution Network Operator)
   c. Embedded generation where it is appropriate to consider a contribution

207. Table 4.9 considers substation utilisation for three network conditions:
   a. Winter peak, intact system compared with intact SGT capacity
   b. Seasonal Peak demand (most onerous of summer, winter or autumn demand) compared against n-1 capacity, typically loss of one SGT at the site
   c. Demand at maintenance period (summer demand), compared against n-2 capacity, typically one SGT on maintenance and loss of a second SGT. This comparison is only valid for substations where the demand is greater than 300MW, as defined in Table 3.1 of the NETSSQSS

208. Table 4.9 in the Transmission Regulatory Reporting Pack identifies sites where present or future demand (in MVA) is close to or greater than the capacity of the substation. Together with the DNO companies, National Grid uses this type of information to identify where there is a need for future infrastructure investment or other mitigating action.

209. Substation Utilisation can be limited by complex issues which it is difficult to tabulate. These factors still require consideration by the appropriate companies and can be summarised as follows:
    a. Insufficient low voltage switchgear fault rating means that the site must be operated split, restricting the way the transformers are able to supply the load
    b. Uneven transformer sharing due to differences in impedance, restricting the ability of the site to utilise the full capacity of an SGT
    c. Heavy loaded sites that have been split to manage fault levels can experience high voltage step changes following the loss of a transformer

210. In reference to Specified Amendment 6, qualitative commentary on voltage is provided within the narrative in the Transmission Regulatory Reporting Pack associated with Table 4.8. Furthermore, the GB Seven Year Statement: Chapter 8 provides qualitative commentary on stability.

211. Entry point utilisation and capability is a function of the generators connection requirements and operating regime and as such is not reported.

4.4.3 Voltage and Stability Capability for the Seven Year Statement (SYS) Boundaries:

212. National Grid proposes providing additional information on voltage capability for the Seven Year Statement Boundaries using the approach as outlined in the NETSSQSS.

213. 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.

4.4.4 Historical Information

214. National Grid has historic information for Network Capability Output (Table 4.8 in Transmission Regulatory Reporting Pack) from 2000/01. This was reported to The Authority in 2007.

215. National Grid has historic information for Network Utilisation Output (Table 4.9 in Transmission Regulatory Reporting Pack) from 2001/02. This was reported to The Authority in 2007.

4.5 Deliverability of Capital Plan

216. National Grid is currently in the process of developing measures associated with deliverability of the Capital Plan e.g. resources, supplier capability, outages. These measures are being discussed with The Authority during the meetings held to understand National Grid's Capital Plan for this Price Control Period. The development of the deliverability measures will incorporate feedback from these meetings.

5.0 REFERENCES

217. This Implementation Document has referenced National Grid's internal Policy Statements, Technical Guidance Notes and Technical Reports. National Grid has submitted these documents as part of its Implementation Document. These Policy Statements, Technical Guidance Notes and Technical Reports contain confidential material (e.g. references to specific manufacturer's equipment, sensitive information regarding physical security) and these documents should not be made public. Table 8 summarises these documents.

Table 8: Summary of Documentation

Document Title	Reference	Meeting Licence Condition	Meeting Specified Amendments	Issue Number
[redacted]	[redacted]	• Network Asset Condition • Network Risk	1, 2	6
[redacted]	[redacted]	• Network Asset Condition • Network Risk	1, 2	8
[redacted]	[redacted]	• Network Asset Condition • Network Risk	1, 2	5
[redacted]	[redacted]	• Network Asset Condition • Network Risk	1, 2	6

Document Title	Reference	Meeting Licence Condition	Meeting Specified Amendments	Issue Number
[redacted]	[redacted]			
[redacted]	[redacted]	• Network Asset Condition • Network Risk	1,2	5
[redacted]	[redacted]	• Network Risk	3	2
[redacted]	[redacted]	• Network Risk	3	1
[redacted]	[redacted]	• Network Risk	3	1
[redacted]	[redacted]	• Network Asset Condition • Network Risk	1, 2	5
[redacted]	[redacted]	• Network Asset Condition • Network Risk	1, 2	5
[redacted]	[redacted]	• Network Asset Condition • Network Risk	1, 2	5
[redacted]	[redacted]	• Network Asset Condition • Network Risk	1, 2	5
[redacted]	[redacted]	• Network Risk	3	2

Document Title	Reference	Meeting Licence Condition	Meeting Specified Amendments	Issue Number
[redacted]	[redacted]			
[redacted]	[redacted]	• Network Risk	3	1
[redacted]	[redacted]	• Network Asset Condition • Network Risk	2	1 (New document)
[redacted]	[redacted]	• Network Performance	5	1 (New document)
[redacted]	[redacted]	• Network Asset Condition	1, 2	1 (New document)
[redacted]	[redacted]	• Network Asset Condition	1, 2	1 (New document)
[redacted]	[redacted]	• Network Asset Condition	1, 2	1 (New document)
[redacted]	[redacted]	• Network Asset Condition	1, 2	1 (New document)