



ELECTRICITY COMMISSION

Discussion Paper

Core Grid Determination

June 2005

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1. Introduction

Background

- 1.1 Part F of the Electricity Governance Rules 2003 (the “EGRs” or “the Rules”) requires the Commission to determine the most appropriate grid reliability standards (GRS). In April 2005, in accordance with Part F, the Electricity Commission (“the Commission”) made its recommendation to the Minister of Energy (the “Minister”) regarding the GRS.
- 1.2 In developing the GRS, the Commission signalled its commitment to pursuing an economic approach to grid reliability, strongly linking the GRS with the application of the Grid Investment Test (GIT), a related Part F construct. However, the Commission acknowledged that there is concern amongst a number of stakeholders about the uncertainties and implementation issues associated with moving to such an approach at this time. The Commission therefore developed a two-limb grid reliability standard, consisting of an economic standard for the whole grid, underpinned by a “safety net” of an N-1 standard for contingencies on the Core Grid.
- 1.3 The Minister accepted the recommended GRS, and the associated package of rules was gazetted in late April 2005.
- 1.4 The GRS gives rise to the need to determine the Core Grid for the purposes of giving effect to the second limb of the grid reliability standard. As part of the GRS drafting package, a set of rules relating to the determination of the Core Grid was incorporated in Part F. In essence, the Commission is required to develop a draft Core Grid Determination, invite submissions on this, then make a final Core Grid Determination recommendation to the Minister, having considered the submissions received. Once approved, the Core Grid is appended as a schedule to Part F of the EGRs.
- 1.5 Determining the Core Grid is an important step in the process of completing the GRS framework. Once the Core Grid is determined, the capability of the grid to meet the GRS can be fully assessed. Such an assessment is a key aspect of a number of Part F processes, particularly:
 - the Statement of Opportunities (SOO), a draft initial version of which was prepared against Interim GRS and published in May 2005 for submissions;
 - the Grid Upgrade Plan (GUP), the first of which is to be prepared by Transpower and submitted to the Commission for its consideration by mid 2006¹; and
 - the assessment of any Reliability Investments proposed by Transpower pursuant to a GUP.
- 1.6 In view of these relationships there is a pressing need to finalise the Core Grid and thus complete the implementation of the GRS in a practical sense.

¹ This timeframe was originally set out in the Government Policy Statement as being September 2005, however the Minister revised this date to mid 2006 in a recent announcement. Although the Core Grid Determination is not yet complete, the Commission has expressed the view this does not hinder progression of issues relating to the Auckland transmission situation, as it is likely that the Core Grid would include the main 220kV transmission circuits feeding Auckland.

- 1.7 The Commission has prepared this consultation paper with input from System Studies Group NZ (SSG) and Concept Consulting Group (Concept), and from advice received through discussions with the Transmission Advisory Group (TAG). Where relevant, the Commission has also drawn on:
- material prepared as part of the development of the GRS; and
 - submissions received as part of the GRS process that related to Core Grid definition.

Purpose of this paper

- 1.8 The purpose of this discussion paper is to set out the Commission's proposed approach to the determination of the Core Grid, together with its draft Core Grid Determination, as required by rule 5A of section III of Part F. A draft Core Grid schedule has been prepared consistent with the proposed approach to the Core Grid Determination. This draft is attached as Appendix 1 to this discussion paper.
- 1.9 The Commission is publishing this discussion paper to provide an opportunity for stakeholders (including potential designated transmission customers) to comment on the Commission's proposed approach and draft Core Grid Determination.
- 1.10 Since the Core Grid, once approved by the Minister, becomes a schedule to the EGRs, it constitutes a rule change and is therefore subject to the rule change requirements set out in the Electricity Act 1992 (the "Act"). To assist stakeholders, and in recognition of the requirements on the Commission under the Act, this paper also sets out, the Commission's rationale for proposing the draft Core Grid Determination, other options considered, and the Commission's assessment of its proposal against the Core Grid objectives² under Part F, and the overall objectives under the Act. This is set out as a Statement of Proposal, and forms part of this discussion paper.

Submission requirements

- 1.11 The Commission invites submissions on the proposal and in answer to the specific questions in this paper by **5pm on 20 July 2005**. Please note that, because of the statutory timing obligations of the Commission, submissions received after this date may not be able to be considered. For the same reason, there will be no opportunity for cross-submissions.
- 1.12 The Commission's preference is to receive submissions in electronic form (Microsoft Word format and pdf). These should be emailed with the phrase "Submission on draft Core Grid" in the subject header to info@electricitycommission.govt.nz. Hard copies of submissions can be posted to the address below:

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² Rule 5A.3.1 of section III of part F

- 1.13 The Commission will acknowledge receipt of all submissions electronically. Please contact Jenny Walton if you do not receive electronic acknowledgement of your submission within two business days.
- 1.14 *Submissions should be provided in the format shown in Appendix 5.* Your submission is likely to be made available to the general public on the Commission's website. Submitters should indicate any documents attached in support of the submission in a covering letter, and clearly indicate any information that is provided to the Commission on a confidential basis. All information provided to the Commission is subject to the Official Information Act 1982.

2. Overview of the GRS

Introduction

- 2.1 The need to define the Core Grid arises from the form of GRS adopted in Part F. As background to discussing options for defining the Core Grid, this section summarises the GRS and associated arrangements now included in Part F.
- 2.2 For a more detailed description and further background information, interested parties are referred to the rules of Part F, as well as the following documents on the Commission's website:
- GRS Discussion Paper, December 2004
 - GRS Explanatory Paper, March 2005
 - GRS Supplementary Explanatory Paper, March 2005

GRS in the context of Part F

- 2.3 Part F defines the purpose of the GRS, and also sets out guidelines for the development of the GRS in the form of principles that should be followed and content that must be provided. The GRS purpose, principles and content are prescribed in rule 4 of section III, and set out here in Table 1 for reference.

Table 1: Part F Requirements for GRS

<p>Purpose Part F section III rule 4.2</p>	<p>The purpose of grid reliability standards is to provide a basis for:</p> <ul style="list-style-type: none"> • the Commission to publish Statements of Opportunities (other than the Initial Statement of Opportunities) • Transpower to prepare Grid Upgrade Plans • other parties to appraise opportunities for transmission investments and transmission alternatives
<p>Principles Part F section III rule 4.3</p>	<p>Grid reliability standards should:</p> <ul style="list-style-type: none"> • take into account the Grid Investment Test • take into account that transmission investments are long-lived assets and require a long-term planning perspective • reflect the public interest in reasonable stability in planning, having regard to the long term nature of investment in transmission assets • be consistent with good electricity industry practice • provide flexibility to allow the form of the standards to evolve over time, reflecting changes in good electricity industry practice

Content Part F section III rule 4.4	<p>Grid reliability standards:</p> <ul style="list-style-type: none"> • must contain one or more standards for reliability of the grid which may include without limitation a primary reliability standard and other reliability standards • may differ to reflect differing circumstances in different regions supplied by the grid • may include one or more standards for reliability of the Core Grid • may contain supporting information, such as information summarising economic assessments balancing different levels of reliability and the expected value of energy at risk
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2.4 For the purpose of this paper, references to rules are references to rules in Section III of Part F, unless otherwise specified.

Approach to Grid Reliability

2.5 The key role for GRS is to provide a basis, in conjunction with the Grid Investment Test (GIT), for planning and development of the national transmission grid.

2.6 The development of transmission networks has, until recently, been largely undertaken according to “deterministic” standards based on network redundancy criteria, often referred to as “N-k”. Transpower has applied an “N-1” criterion to its planning for the main interconnected transmission network, typically seeking to maintain supply during single credible contingencies.

2.7 The alternative to this is to adopt a “probabilistic” approach to grid planning and development. This typically involves estimating the probability of contingencies, estimating the expected loss of supply that could occur, and estimating the costs of the loss of supply. Within this probabilistic framework, investments are made in the grid when there is a clear net economic benefit.

2.8 The processes set out in Part F articulate a key role for both the GRS and the GIT in the transmission planning process and the approval of grid investments. The GIT must also be taken into account when setting GRS. The GIT is essentially an economic test to be applied to all grid upgrade plans and investment proposals. A key component of the GIT is the value of Unserved-Energy (USE), which is set at \$20,000/MWh as a default figure.

2.9 Although there is a distinction in Part F between reliability investments and economic investments, the GIT must be applied to both types of investment.

2.10 This has implications for transmission planning and grid reliability levels. The Commission has concluded that transmission planning should be undertaken using a probabilistic framework and applying an economic test to all investments, and that reliability levels on the grid should accordingly be determined by economic considerations, taking into account the cost to consumers of losses of supply, while meeting technical and safety requirements.

2.11 This approach is likely to lead to different levels of reliability, at different points on the grid, reflecting the economics of each situation.

The two-limb GRS

- 2.12 In developing the GRS, the Commission signalled its commitment to pursuing an economic approach to grid reliability, strongly linking the GRS with the application of the GIT. A number of parties endorsed the economic approach in their submissions on the draft GRS.
- 2.13 It should be noted that, in adopting an economic approach to grid reliability, the Commission does not expect a degrading of reliability, and expects that in many cases reliability levels of N-1 and higher will be economic.
- 2.14 However, the Commission acknowledged that there is concern amongst a number of stakeholders about the uncertainties and implementation issues associated with moving to such an approach at this time. These concerns were expressed in a number of submissions.
- 2.15 The Commission therefore developed a two-limb grid reliability standard, consisting of an economic standard (linked to the GIT) for the whole grid, underpinned by a “safety net” of an N-1 standard for contingencies on the Core Grid. Thus the GRS has at its heart the two limbs set out in Table 2 which is drawn from clause 4 of the GRS schedule to Part F (Schedule F3). A practical description of each of the limbs is also included in Table 2.

Table 2: The two-limb GRS

GRS Excerpt	Commentary
4. <i>For the purposes of clause 3 the list of purposes of grid reliability standards, the grid satisfies the grid reliability standards if:</i>	<ul style="list-style-type: none"> the purpose is clearly limited to the purposes of the GRS as set out in rule 4.2 of section II of part F, and repeated in clause 3 of the GRS Schedule (F3)
4.1 <i>the power system is reasonably expected to achieve a level of reliability at or above the level that would be achieved if all economic reliability investments were to be implemented; and</i>	<ul style="list-style-type: none"> the “economic limb” through the definition of “economic reliability investments”, this in effect means the level of reliability that would result from application of the GIT expressed another way, this is an economic assessment balancing the cost of investment in reliability with the cost of unreliability, underpinned by application of the GIT there is the possibility of a higher than N-1 standard for some parts of the grid if the economic assessment supports this

GRS Excerpt	Commentary
<p>4.2 <i>with all assets that are reasonably expected to be in service, the power system would remain in a satisfactory state during and following any single credible contingency event occurring on the Core Grid.</i></p>	<ul style="list-style-type: none"> the “N-1 safety net” through the definition of “satisfactory state” and “single credible contingency event”, the effect of this limb is that the power system must also meet a minimum N-1 standard for certain defined contingencies on the Core Grid there is no such minimum standard for contingencies on any part of the Grid that is not part of the Core Grid ('non-Core Grid')
<p>5. <i>For the purpose of clause 4.1, the expected level of reliability of the power system must be assessed at each and every grid exit point and grid injection point (wheresoever located on the grid).</i></p>	<ul style="list-style-type: none"> the economic limb relates to all GXPs and GIPs, and has implications for reliability on the Core Grid as well as the non-Core Grid
<p>6. <i>For the purposes of clause 4.1 and 4.2, the expected level of reliability, and state, of the power system must be assessed using the range of operating conditions that could reasonably be expected, having regard to the possible future scenarios set out in the SOO.</i></p>	<ul style="list-style-type: none"> this links the GRS (both the economic limb and the safety net) to the possible future scenarios on the SOO these scenarios relate to the Commission’s expectation as to future supply and demand scenarios this is consistent with a similar link in the GIT

2.16 The “N-1” limb of the GRS means that it is possible for investments to be made in the transmission grid that have the effect of restoring “N-1” reliability, that might otherwise have failed the economic test established in the GIT. Accordingly, the GIT provides for investments that are required to meet the GRS to be assessed by minimising the expected net market cost. The process of establishing whether an investment to restore “N-1” reliability satisfies the GIT involves comparing the investment with a number of alternative projects that would also potentially restore “N-1” reliability. The project with the lowest expected net market cost should be chosen.

2.17 As further explanation of the GRS, several key definitions from the GRS Schedule (Schedule F3 of Part F) and Part A of the EGRs are set out in Table 3.

Table 3: Key GRS terms

defined term	definition
economic reliability investments	<p>means investments in the grid and transmission alternatives that would satisfy the GIT:</p> <ul style="list-style-type: none"> a) reading each reference to a proposed investment in the GIT as a reference to the grid investment or transmission alternative (as the case may be); and b) having regard to part C of the rules including the policy statement set out in schedule C4.

defined term	definition
single credible contingency event	<p>means an individual credible contingency event comprising any one of the following:</p> <ul style="list-style-type: none"> a) a single transmission circuit interruption b) the failure or removal from operational service of a single generating unit c) an HVDC link single pole interruption d) the failure or removal from service of a single bus section e) a single inter-connecting transformer interruption f) the failure or removal from service of a single shunt connected reactive component
satisfactory state	<p>means that none of the following occur on the power system:</p> <ul style="list-style-type: none"> a) insufficient supply of electricity to satisfy demand for electricity at any GXP b) unacceptable overloading of any primary transmission equipment c) unacceptable voltage conditions d) system instability

- 2.18 It is important to note that the only reference to the Core Grid in the GRS schedule is in the second “N-1” limb. When determining the recommended GRS, the Commission considered that this second limb should be included as a “safety net” for the Core Grid in view of the possible uncertainties. The Commission expressed its expectation that the safety net would have a narrow scope; that is, that the Core Grid would be comparatively tightly defined.
- 2.19 Although the Core Grid may be comparatively tightly defined, that does not imply that those parts of the transmission system outside the Core Grid will have reliability of less than N-1. The nature of the Core Grid determination is to ensure that those parts of the transmission system that are critical to reliability will have an N-1 safety net. For those parts of the transmission system outside the Core Grid an economic standard will apply. In many case this will justify an N-1 level of reliability. The Commission also notes that some parts of the existing transmission system do not currently enjoy a level of reliability consistent with N-1.
- 2.20 As part of its GRS recommendation, the Commission also signalled its intent to set in train a number of key work streams aimed at removing some of the uncertainties identified, with a view to revisiting within five years’ time its decision regarding the form of GRS, in particular, the possible removal of the N-1 “safety net”. Thus, the definition of Core Grid may not be required beyond an initial period of a few years.

Related arrangements

- 2.21 In order for the GRS to be given effect, a related set of arrangements was also implemented as part of the rule change package. These included the following:
- provisions relating to the nature of the Core Grid and the process by which the Core Grid Determination is undertaken

- amendments to the GIT in order to allow investments required for the “N-1” limb that wouldn’t otherwise pass the GIT
- new obligations on Transpower to prepare and publish a Grid Reliability Report within six months of a SOO.

2.22 The Part F requirements relating to the Core Grid are the focus of this discussion paper, and are described in Section 3 as background to the possible options for defining the Core Grid. Interested parties are also referred to the rules of Part F and the background material (listed here in paragraph 2.2) on the Commission’s website for a description of the other aspects of the GRS package.

3. Core Grid Determination process

Overview

- 3.1 A “Core Grid Determination” is defined in the Rules to be the determination specifying the assets forming part of the Core Grid, developed in accordance with the rules of Part F.
- 3.2 The process for determining the Core Grid Determination now included as rules 5A and 5B was modelled on that for developing the GRS and GIT. It includes the following key steps:
- the Commission develops a proposed Core Grid, taking into account the purpose and objectives of Core Grid Determination and the principles for GRS
 - the Commission publishes its draft Core Grid Determination, notifies registered participants and allows a minimum of 15 business days for submissions
 - the Commission considers submissions received and makes a recommendation to the Minister for the Core Grid Determination to be included as a schedule to Part F (within a maximum of 20 business days after submissions close, or other such time agreed by the Minister).
- 3.3 As with the GRS and the GIT, the Rules provide for interested parties to request a review by the Commission of the Core Grid Determination. The Commission itself may also initiate a review.
- 3.4 The focus of this section is the description of the matters the Commission is required by the Rules to have regard to in determining on the most appropriate Core Grid Determination, and their implications for identifying possible options for defining the Core Grid. These matters relate to scope, purpose, objectives and principles.

Matters relevant to the Core Grid Determination

Scope

- 3.5 The Rules set out upper and lower boundaries on the scope of the Core Grid³.
- 3.6 At most, the Core Grid may include “*all assets that form part of the grid and operate at nominal voltages of 66kV and above*”. This requirement sets an unambiguous upper bound on the Core Grid, and the Commission’s approach must take account of this.
- 3.7 At a minimum it must include “*those assets that comprise the main elements of the grid*”. It is important to note that “main elements” is not defined, however the Core Grid needs to be consistent with a reasonable interpretation of this lower bound on scope.
- 3.8 The Commission has considered what constitutes the “main elements” of the grid (and therefore the minimum Core Grid) and has reached the conclusion that it would

³ Rule 5A.1.2

be reasonable to consider that the “main elements” comprise the transmission circuits that:

- interconnect the major geographic areas of generation with the main load centres; and
- are necessary for the short-term reliability of supply to those main load centres.

3.9 The Commission has applied this interpretation to the South Island network and concluded that the following elements comprise the minimum Core Grid in the South Island:

- all 220kV circuits Twizel – Islington
- the 220kV circuit Livingstone – Islington
- all 200kV circuits North Makarewa – Invercargill

3.10 The Commission has applied the interpretation outlined in paragraph 3.8 to the North Island network and concluded that the following elements comprise the minimum Core Grid in the North Island:

- All 220kV circuits Haywards – Bunnythorpe
- All 220kV circuits Bunnythorpe – Whakamaru
- All 220kV circuits Whakamaru – Otahuhu
- All 220kV circuits Huntly – Otahuhu
- All 220kV circuits Otahuhu – Henderson

3.11 The Commission has also considered whether the “main elements” should include the HVDC transmission link between Benmore and Haywards. The main function of the link is to transmit surplus South Island production to North Island load centres. While the HVDC link arguably interconnects South Island production and North Island load centres, it is not necessary to ensure the short-term reliability of supply to those North Island load centres. The primary role of the HVDC link is an economic one rather than a reliability one. The link is designed to transmit electricity north when there is a surplus in the South Island, and south when storage in the South Island lakes is low. This is essentially a matter of optimising the use of resources in an effort to minimise overall cost and deliver medium-term security of supply, rather than short-term reliability.

3.12 The Commission has therefore decided that the HVDC transmission link is not part of the “main elements” of the grid, for the purpose of defining the Core Grid.

3.13 Thus the Commission views the scope of the Core Grid, for the purpose of rule 5A.1.2, as lying between the two extremes of, *all assets that form part of the grid and operate at nominal voltages of 66kV and above*, on the one hand, and the grid elements listed in paragraphs 3.9 and 3.10, on the other hand.

Purpose

3.14 The Rules set out the purpose of the Core Grid Determination, and require the Commission to have regard to this amongst other things⁴. The purpose of the Core

⁴ Rules 5A.2 and 5A.1.3.1

Grid Determination is largely drawn from the purpose of the GRS. It is to provide a basis for:

- the Commission to determine the GRS;
- the Commission to publish SOOs;
- Transpower to prepare GUPs;
- other parties to appraise opportunities for transmission investment and transmission alternatives.

3.15 The Commission considers this purpose to be self-explanatory, and that a clear unambiguous definition of a Core Grid that is defined in a manner that is consistent with the other requirements discussed in this section, will meet this purpose.

Objectives

3.16 The Commission must have regard to the following objectives in determining the most appropriate Core Grid Determination⁵:

- avoiding the failure or removal from service of any asset forming part of the Core Grid, where the failure or removal from service of that asset may result in cascade failure ('first objective' or 'cascade failure objective')
- providing flexibility to allow the Core Grid to evolve over time, reflecting any changes in the grid ('second objective' or 'flexibility objective')
- reflecting the public interest in reasonable stability in planning for transmission ('third objective' or 'planning stability objective').

3.17 The first objective provides a strong direction for determining which transmission links form the Core Grid. The Commission has considered several means of identifying the Core Grid that best meets this objective. This has involved consideration of a methodology for assessing whether cascade failure would occur in the event of removing a particular asset from service, as well as an interpretation of cascade failure itself. These matters give rise to a number of options for defining the Core Grid, and the issues are discussed further in section 4.

3.18 There is an inherent tension between the second and third objectives in developing the Core Grid Determination. The second objective of providing flexibility to allow the Core Grid to evolve over time might imply that the Core Grid Determination should set out some formula to determine at a given point in time which assets were core and which assets were non-core. As the grid evolved over time, assets could move in and out of the Core Grid to reflect any change in circumstances. However, such a Core Grid Determination could result in an unstable planning environment and so be inconsistent with the third objective. Further, the Core Grid Determination is required to specify the assets making up the core grid (rule 5A.1.2).

3.19 The Commission has had regard to the second objective in developing the most appropriate Core Grid Determination. In so doing, the Commission has also had regard to the rule 5B.2 provisions and the fact that these provisions provide a means for facilitating the second objective of providing flexibility to allow the evolution of the Core Grid over time may also be achieved.

⁵ Rules 5A.3 and 5A.1.3.3

3.20 The third objective suggests that in determining the most appropriate Core Grid Determination, the Commission should take into account that the determination should be forward-looking, should allow for the lifetime of transmission assets, and should take into account the transmission planning process. This is discussed further in the sub-section starting at paragraph 4.14.

Principles

3.21 In determining the most appropriate Core Grid Determination, the Commission must also have regard to the principles for the GRS⁶. These are that the GRS should:

- take into account the GIT;
- take into account that transmission investments are long-lived assets and require a long-term planning perspective;
- reflect the public interest in reasonable stability in planning, having regard to the long term nature of investment in transmission assets;
- be consistent with good electricity industry practice;
- provide flexibility to allow the form of the standards to evolve over time, reflecting changes in good electricity industry practice.

3.22 Several of these principles are reflected in the objectives for the Core Grid Determination. In particular, the requirements for stability in planning, and the flexibility to evolve over time, are incorporated in the objectives for the Core Grid Determination.

3.23 The requirement to take into account the GIT was reflected in the determination of the GRS, and the Commission has again taken into account the GIT in developing the proposed Core Grid Determination.

Primacy of the Economic Limb of the GRS

3.24 Taking into account the principles for the GRS set out in rule 4.3, and the GIT, the Commission proposed in developing the GRS that the economic limb of the GRS would be the primary limb of the GRS for the reasons outlined in its *Grid reliability standards: Supplementary Explanatory Paper* of 31 March 2005. By virtue of the strong link to the GIT, this incorporates an economic assessment balancing the cost of investment in reliability with the cost of unreliability. A probabilistic assessment of the expected un-served energy, combined with the value of Unserved-Energy, yields the cost of unreliability. In the design of the GRS, it is the economic limb that is intended to be the primary focus, encompassing the comprehensive analysis required for determining the reliability of the grid and considering whether an investment is required to meet the standards defined. In contrast, it was contemplated that the secondary “N-1” limb of the test would operate as a safety net in view of possible uncertainties associated with the application of the primary economic limb.

3.25 As discussed at paragraphs 3.21 to 3.23 above, the Commission must again take into account the principles of the GRS, and in particular the GIT, in determining on the most appropriate Core Grid Determination. The Core Grid specified in the Core Grid Determination will be determinative of the balance struck between the economic limb

⁶ Rules 4.3 and 5A.1.3.2

and the "N-1" limb of the GRS in its application and operation. Not surprisingly, the Commission is of the view that regard to the principles for the GRS, and in particular the GIT, in developing the Core Grid Determination favours defining a Core Grid that strikes a balance between the two limbs of the GRS that gives the economic limb primacy. The reasoning referred to above in the Commission's *Grid reliability standards: Supplementary Explanatory Paper* is equally applicable in support of this conclusion based on the principles for the GRS. The Core Grid Determination needs to be one which strikes an appropriate balance between providing the "safety net" of the "N-1" limb and ensuring the primacy of the economic limb of the GRS.

Other uses of a "Core Grid"

- 3.26 Some submissions in response to the GRS consultation paper promoted the concept of consistency between the determination of the Core Grid for GRS purposes and the definition of a set of inter-connection assets for the purposes of the transmission pricing arrangements under section IV of Part F. Those submissions suggested there would be merit in a single common determination for both purposes. The Commission has considered this issue because at least some interested parties appear to consider that it may be a relevant consideration in determining the most appropriate Core Grid Determination.
- 3.27 The Commission acknowledges that there is some appeal to the simplicity of a single uniform definition of Core Grid and interconnection assets. However, the Commission has concluded that this would not be appropriate because:
- different criteria need to apply to the two determinations – the determination of the Core Grid is intended to identify the assets that are critical for reliability for the purposes of the GRS, while the determination of interconnection assets is intended to identify the assets that are provided for "common good" purposes, rather than specifically for individual participants, for the purposes of the pricing methodology;
 - these different criteria are likely to lead to a Core Grid Determination for the GRS that is quite different from what may be appropriate for the collective "interconnection" assets for pricing purposes;
 - in attempting to align the Core Grid Determination with the interconnection assets determination, inevitable compromises would need to be made that are likely to be inconsistent with the purpose and objectives of either one or the other determination. The result could be an application of the "N-1" limb of the GRS in transmission planning to parts of the transmission system that are not appropriate, and a risk of more investment than is economic.
- 3.28 The Commission has therefore concluded that achieving consistency between the definition of the Core Grid and the determination of interconnection assets for transmission pricing is not a relevant consideration in determining the most appropriate Core Grid Determination.

Q1: *Do you agree with the Commission's interpretation of the Part F requirements and wider design issues for the Core Grid Determination?*

4. Approach to Determining the Core Grid

The cascade failure objective

- 4.1 The first objective for the Core Grid Determination provides a strong direction about the importance of avoiding cascade failure. The objective, repeated here for convenience, is:

“avoiding the failure or removal from service of any asset forming part of the Core Grid, where the failure or removal from service of that asset may result in cascade failure”

- 4.2 The Commission has considered this objective and concluded that what was intended was a Core Grid comprising the transmission links⁷ which would need to have N-1 reliability in order to avoid cascade failures. This led the Commission to the following interpretation of the first objective.

“If a grid link was operating at less than “N-1” reliability and a single credible contingent event on that link would result in cascade failure, then that link should be part of the Core Grid.”

- 4.3 In order for the Commission to properly have regard to the first objective, it is necessary to determine an approach for assessing each possible transmission link of the grid to determine whether it would cause cascade failure. It is also necessary to define what constitutes a cascade failure for the purposes of the first objective.

Interpretation of Cascade Failure

- 4.4 The term cascade failure is normally used by power system engineers to describe a situation in which a system contingency (either the loss of a generator or a transmission link) triggers a series of further losses, ultimately resulting in voltage collapse and widespread loss of load. This is a relatively extreme outcome, but is consistent with the view of the Commission, formed having regard to the principles for the GRS, and in particular the GIT, that an appropriate Core Grid definition would operate to give the economic limb of the GRS primacy. For further discussion of the considerations on which the Commission has formed this view, refer to paragraphs 3.21 to 3.25 above.
- 4.5 To undertake an analysis of the grid and establish which transmission links would result in cascade failure, applying this concept of cascade failure, it would be necessary to undertake detailed simulation studies to assess the transient and dynamic stability of the power system under various contingencies. This would be a complex and time consuming task that is beyond what the Commission considers appropriate to establish the limits of operation of the “safety net” limb of the GRS.
- 4.6 The Commission has therefore considered an alternative approach in order to simplify the analysis and inform the decision making process. A simplifying concept that the Commission has found useful as an indicator of “cascade failure” is the loss of a substantial quantum of load for a duration of at least several minutes (a loss of load criterion). If a contingency in the network is likely to cause a loss of load above

⁷ For the purpose of this paper “transmission link” refers to the collective transmission assets that join one “node” in the network to another “node”. Thus a “transmission link” could comprise one or more transmission lines, or one or more transformers, for example.

a certain threshold, then that loss could be considered as a “cascade failure”. The Commission considered a range of possibilities for the loss of load criterion from 150MW to 600MW.

- 4.7 In considering which loss of load criterion to adopt as indicative of cascade failure, the Commission concluded that the likely cost of the loss of supply was a useful input that could be considered.
- 4.8 To consider the likely cost of the loss of supply it is necessary to estimate the likely duration of outages. In general, when load is lost, it cannot be immediately reconnected. The typical restoration procedure involves progressively re-livening the disconnected area. As more of the transmission network is re-livened, load can gradually be restored by the distribution utilities. Table 4 outlines the Commission’s approximate assessment of the likely range of cost for outages of 150MW, 300MW and 600MW, taking into account the likely duration of outages and the restoration process, and using the value for Unserved-Energy that is specified in the GIT.

Table 4: Cost of Lost Load – Cascade Failure

Loss of Load	Likely Duration	Cost at \$20,000 per MWh
150MW	40 to 80 min	\$1m to \$2m
300MW	60 to 120 min	\$3m to \$6m
600MW	90 to 150 min	\$9m to \$15m

- 4.9 The Commission considers that, having regard to the first objective, it is appropriate for the Core Grid Determination to strike a balance between the two limbs of the GRS such that the “N-1” limb of the GRS operates to ensure contingency costs of the order of \$3m to \$6m are avoided. The Commission considers that it is appropriate for the economic limb of the GRS to apply to transmission links which would likely result in costs that are below this level, rather than the “N-1” limb. It has therefore concluded that, for the purposes of the first objective, a “cascade failure” should be defined by reference to a loss of load criterion of 300MW. In order to demonstrate the sensitivity to this factor, the Commission has tested the composition of the Core Grid for each of 150MW, 300MW and 600MW.
- 4.10 The application of this approach, while simpler than attempting to simulate true cascade failure, could also involve complex analysis. The Commission has therefore used the loss of load criterion as a guide, rather than as a definitive criterion, in having regard to the first objective and has sought expert advice about likely outcomes, rather than undertaking complex and detailed system analysis. The Commission has concluded that determination of the Core Grid that would be consistent with the first objective using this approach requires a series of judgements, based on experience and supported by analysis.

Approach to consideration of the cascade failure objective

- 4.11 Large tracts of the current system have been designed to an N-1 standard and therefore provide for a level of redundancy to survive contingencies without loss of supply. However, the Commission’s obligation to have regard to the cascade failure objective in determining the Core Grid Determination gives rise to the need to consider each link in the grid as if it was operating at less than “N-1” immediately prior

to a single credible contingency, and then consider what the outcome would be, in terms of loss of load, if a contingency occurred.

- 4.12 The Commission engaged System Studies Group NZ (SSG) to undertake an analysis of the Core Grid by applying this approach. SSG found that the proposed approach, while conceptually straightforward, was extremely difficult to apply to the existing transmission grid in a rigorous manner. Following several attempts to apply this approach, it became clear that a more practical and pragmatic approach was required.
- 4.13 The final approach adopted involved developing a set of rules, based on analysis and experience, to determine whether a particular transmission link should have N-1 reliability, in order to avoid cascade failure leading to a loss of load greater than A (where A could be 150MW, 300MW or 600MW). Table 5 describes this set of rules.

Table 5: Practical approach to assessing cascade failure objective

Transmission Link	Description	Core Grid Determination that would be consistent with cascade failure objective
Radial Feed	Radial transmission link feeding an area without generation.	Transmission link is part of Core Grid if peak load in the area is greater than A ⁸ .
Radial Feed with generation	Radial transmission link feeding an area with generation.	Transmission link is part of Core Grid if peak load in the area, minus reliable generation ⁹ , is greater than A.
Radial Generation	Radial transmission link providing a connection to generation.	Transmission link is part of Core Grid if loss of the generation in-feed would lead to loss of load greater than A.
Parallel Link	Transmission link running in parallel with other transmission links	Transmission link is part of Core Grid if loss of the link would lead to loss of load greater than A.
Meshed Link	Transmission link in a meshed part of the grid	If the load at a node minus the reliable generation at the node is greater than A, then there must be at least one Core Grid link connected to that node.
HVDC Link	HVDC transmission between the islands	HVDC is part of Core Grid if loss of the link would result in a loss of load greater than A.

The flexibility and planning stability objectives

- 4.14 The GRS represent a planning standard, and as such involve an assessment of the capability of the grid into the future. The Commission is required to set out in the SOO its expectation as to the credible future scenarios for supply and demand, and it is these scenarios that the GRS assessment needs to take into account.

⁸ In this table, "A" is the loss of load criterion – 150MW, 300MW or 600MW.

⁹ Reliable generation excluded intermittent generation such as wind and run-of-river hydro, except to the extent that diversity of supply would provide a reliable supply. Thermal power stations were assumed to have full fuel availability.

- 4.15 The future capability of the grid is likely to vary through time and across scenarios. It is quite conceivable that changes in the supply and demand situation and, in particular, grid investment and reconfiguration, would result in changes over time as to which transmission links should comprise the Core Grid.
- 4.16 As discussed above at paragraph 3.18, the second and third objectives for the Core Grid Determination are the competing objectives of *'providing flexibility to allow the core grid to evolve over time, reflecting any changes in the grid'* and *'reflecting the public interest in reasonable stability in planning for transmission'*.
- 4.17 The Commission has considered these competing objectives, and whether the Core Grid Determination should include a time dimension. The purpose of the GRS is to enable the Commission to publish SOOs, Transpower to prepare GUPs, and other parties to appraise opportunities for transmission investment and transmission alternatives. All of these involve a forward-looking purpose for the GRS.
- 4.18 The Commission has considered three possible approaches to addressing the competing flexibility and planning stability objectives:
- (a) Undertake the Core Grid Determination on the basis of the current state of the power system (in terms of generation, transmission and demand), and rely on the economic limb of the GRS to address timing issues, coupled with the provisions allowing a Core Grid re-determination.
 - (b) Undertake the Core Grid Determination on the basis of the expected state of the power system (in terms of generation, transmission and demand) in ten years time, using the scenarios set out in the SOO. If it would likely be appropriate for a transmission link to form part of the Core Grid in that timeframe, then it should be included in the Core Grid now. As with (a), the economic limb of the GRS and the provisions allowing a Core Grid re-determination are also relevant.
 - (c) Undertake the Core Grid Determination on the basis of the expected state of the power system (in terms of generation, transmission and demand), at intervals over the 20 year horizon using the scenarios set out in the SOO. As part of the Core Grid Determination, each transmission link would be tagged with the period during which it would form part of the Core Grid. Thus some transmission links might enter, and others exit, the set of transmission links comprising the Core Grid during the period in which the Core Grid Determination applied. As with (a), the economic limb of the GRS and the provisions allowing a Core Grid re-determination are also relevant.
- 4.19 The Commission considers that the approach outlined in (b) is most consistent with the principles of the GRS to which the Commission must have regard, and strikes an appropriate balance between the competing objectives of *"flexibility to evolve over time"* and *"public interest in stability in planning"*. Approach (a) does not adequately account for the likely future state of the power system and is thus not meaningful as a planning standard or defining the operational limits of such a standard. Approach (c) is overly complex and introduces the prospect of instability in planning.
- 4.20 Accordingly, the Commission proposes to consider the expected state of the power system in 2015, using the scenarios set out in the SOO, when determining on the most appropriate Core Grid Determination, and identifying which transmission links should comprise the Core Grid for this purpose.

Assessing Core Grid Determination consistent with objectives

4.21 The approach to cascade failure outlined in Table 5 was applied to the power system as it is expected to be configured in 2015. The approach was applied to the transmission network using a mixture of load flow analysis and expert judgement, in order to determine the Core Grid consistent with the cascade failure objective for each loss of load criterion (150MW, 300MW and 600MW). The resulting Core Grid outcomes are outlined in Table 6 and Table 7 for each island.

4.22

Table 6: Core Grid Determination for different loss of load criteria – North Island

600MW Loss of Load	300MW Loss of Load	150MW Loss of Load
220kV Otahuhu-Henderson	All 600MW Core Grid links plus	All 300MW Core Grid links plus
220kV Otahuhu-Southdown	220kV Huapai-Henderson	220kV Huapai-Marsden
220kV Southdown-Henderson	220kV Henderson-Albany	220kV Huapai-Bream Bay
220kV Huntly-Takanini	220kV Albany-Huapai	220kV Bream Bay-Marsden
220kV Otahuhu-Takanini	220kV Otahuhu-Penrose	220kV Wairakei-Redclyffe
220kV Huntly-Glenbrook	220kV Wairakei-Ohakuri	220kV Wairakei-Whirinaki
220kV Glenbrook-Takanini	220kV Ohakuri-Atiamuri	220kV Whirinaki-Redclyffe
220kV Otahuhu-Whakamaru	220kV Atiamuri-Whakamaru	110kV Marsden-Maungatapere
220kV Otahuhu-Huntly	220kV Atiamuri-Tarukenga	110kV Henderson-Hepburn Rd
220kV Huntly-Hamilton	220kV Bunnythorpe-Brunswick	110kV Mangare-Roskill
220kV Hamilton-Whakamaru	220kV Brunswick-Stratford	110kV Otahuhu-Roskill
220kV Tokaanu-Whakamaru	110kV Otahuhu-Mangere	110kV Wilton-Central Park
220kV Bunnythorpe-Tokaanu	220/110kV interconnection Tarukenga	110kV Haywards-Takapu Rd
220kV Bunnythorpe-Tangiwai		220/110kV interconnection Marsden
220kV Rangipo-Tangiwai		220/110kV interconnection Albany
220kV Rangipo-Wairakei		220/110kV interconnection Henderson
220kV Wairakei-Poihipi		220/110kV interconnection Penrose
220kV Poihipi-Whakamaru		220/110kV interconnection Hamilton
220kV Bunnythorpe-Haywards		220/110kV interconnection Wilton
220kV Haywards-Wilton		
220kV Wilton-Linton		
220kV Bunnythorpe-Linton		
220/110kV interconnection Otahuhu		
220/110kV interconnection Haywards		

Table 7: Core Grid Determination for different loss of load criteria – South Island

600MW Loss of Load	300MW Loss of Load	150MW Loss of Load
220kV Twizel-Tekapo B	All 600MW Core Grid links plus	All 300MW Core Grid links plus
220kV Tekapo B-Islington	220kV Islington-Kikiwa	220kV Kikiwa-Stoke
220kV Twizel-Ashburton	220kV Benmore-Ohau B	220kV Roxburgh-Three Mile Hill
220kV Ashburton-Bromley	220kV Ohau B-Twizel	220kV Three Mile Hill-Half Way Bush
220kV Bromley-Islington	220kV Benmore-Twizel	220kV Three Mile Hill-Sth Dunedin
220kV Twizel-Islington	220kV Benmore-Ohau C	220kV Sth Dunedin-Half Way Bush
220kV Livingstone-Islington	220kV Ohau C-Twizel	66kV Islington-Addington
220kV Manapouri-Invercargill	220kV Benmore-Aviemore	220/66kV interconnection Bromley
220kV Manapouri-Nth Makarewa	220kV Clyde-Cromwell	
220kV Nth Makarewa-Invercargill	220kV Cromwell-Twizel	
	220kV Roxburgh-Clyde	
	220kV Roxburgh-Naseby	
	220kV Naseby-Livingstone	
	220kV Invercargill-Roxburgh	
	220kV Invercargill-Tiwai Pt	
	220kV Nth Makarewa-Tiwai Pt	
	220/66kV interconnection Islington	

- 4.23 Single-line diagrams illustrating the three Core Grid definitions consistent with the cascade failure objective that emerge from this analysis are included in Appendix 4.

Alternative approaches considered

- 4.24 Because of the complexity of the analysis involved in applying the cascade failure approach, the Commission has considered a number of alternative approaches to defining the Core Grid based upon the application of potentially more straightforward analysis. These are described in Table 8.

Table 8: Other approaches considered

Possible approach	Description/Commentary
Meshed network	<ul style="list-style-type: none"> • Those bits of the network that are meshed tend to be shared by many users, since some portion of users' power supply flows through the meshed elements. On the other hand, radial networks supply power to certain loads and tend to be shared by just a few users. Meshed networks could therefore be considered more critical and deserving of a higher level of reliability. Accordingly, meshed networks could be defined as core under this approach. • The Commission considered that there was no obvious link between the shared meshed network and reliability. Just because network elements are shared does not imply that they are necessary to provide a reliable supply. Similarly, a particular radial network may supply a sizeable load, where loss of that load might be regarded as "cascade failure". • It was therefore considered unlikely that a Core Grid Determination developed using the meshed network approach would be appropriate having regard to the objectives for the Core Grid Determination or the principles for the GRS.
Transmission of Bulk Energy	<ul style="list-style-type: none"> • It is possible to take the view that the parts of the system associated with the transmission of bulk energy should be more reliable than the parts of the system associated with the transmission of small amounts of energy. The Core Grid could therefore be defined as comprising the parts of the network associated with transmitting more than a certain threshold of energy (150MW, 300MW and 600MW could be possible thresholds to consider). • The Commission considered that this approach was unlikely to discriminate effectively between network transmission links that would result in cascade failure and other transmission links. For example, bulk transmission network elements linking generation into the grid are likely to be less critical than bulk transmission network elements supplying major load centres. • It was therefore considered unlikely that a Core Grid Determination developed using the transmission of bulk energy approach would be consistent with the objectives for the Core Grid Determination or the principles for the GRS.
Inter-regional Links	<ul style="list-style-type: none"> • The transmission network tends to link together geographic areas of generation with geographic areas of demand. It may be helpful to consider the reliability of the links between these geographic regions. Appendix 3 explores this option by dividing New Zealand into 17 geographic regions and considering the reliability of the inter-regional links between those regions. • The Commission considered this approach in some detail because it appeared to offer a simplified approach that focussed on the key arterial routes that carry most of the critical power flows. • Ultimately the Commission concluded that the approach did not offer sufficient discrimination and yielded a result that was perhaps best suited to defining the "main elements" of the grid for the purpose of Rule 5A.1.2 .

Possible approach	Description/Commentary
Voltage-based Heuristic	<ul style="list-style-type: none"> • It is possible to define the Core Grid by selecting transmission links that meet a simple heuristic voltage requirement, on the basis that higher voltage parts of the system tend to carry more power and tend to be more critical than lower voltage parts of the system. For instance, the Core Grid could be defined as those transmission links that operate at 220kV or higher, including interconnecting transformers. • The Commission considered that such a definition was an overly simplistic approach that did not adequately reflect whether the loss of any particular element would result in cascade failure. • It was therefore considered unlikely that a Core Grid Determination developed using the voltage-based heuristic approach would be appropriate having regard to the objectives for the Core Grid Determination or the principles for the GRS.

HVDC Transmission Link

- 4.25 The Core Grid outcomes set out in Table 6 and Table 7 above are consistent with the Core Grid Determination objectives, in particular the cascade failure objective. However, it does not necessarily follow that any one of these Core Grid outcomes is the most appropriate Core Grid Determination having regard to:
- the objectives for the Core Grid Determination set out in rule 5A.3.1;
 - the purposes of the Core Grid Determination set out in rule 5A.2.1;
 - the principles for the GRS set out in rule 4.3; and
 - all other relevant considerations.
- 4.26 For example, as discussed at paragraph 4.9, the Commission concludes that, having regard to the cascade failure objective and the principles for the GRS, it is appropriate for the Core Grid Determination to be developed with the objective of avoiding a loss of load of 300MW or more. Thus, the Commission does not consider either of the Core Grid outcomes for a loss of load criterion of 150MW or 600MW set out in Tables 6 and 7 to be the most appropriate Core Grid Determination.
- 4.27 Similarly, the Commission does not consider that the most appropriate Core Grid Determination would specify the HVDC transmission link as part of the Core Grid, having regard to the principles for the GRS.
- 4.28 As already discussed, the primary role of the link is to export surplus South Island hydro power to the North Island, when it is available. When it is not available, because South Island hydro storage is low (for example), the North Island must meet demand from power stations within the island. Thus the power system has been designed to provide sufficient supplies within each island, to meet demand for extended periods.
- 4.29 Application of the cascade failure approach indicates that, with loss of the HVDC transmission, under most circumstances the loss of load is likely to exceed 300MW and may exceed 600MW under some circumstances.
- 4.30 However, the Commission considers that, because of the HVDC link's unique role within the transmission system, and because its physical characteristics distinguish it

from other transmission links, the link is not necessary to ensure short-term reliability of supply to main load centres. That is, the Commission considers that the HVDC transmission needs to be considered as a special case in determining the most appropriate Core Grid Determination.

- 4.31 As discussed at paragraphs 3.24 to 3.25 above, the Commission considers that, having regard to the principles for the GRS set out in rule 4.3, the Core Grid Determination should strike an appropriate balance between the primacy of the economic limb and the "safety net" to address the possible uncertainties associated with the application of the primary economic limb provided by the "N-1" limb. The possible uncertainties associated with the application of the primary economic limb, which the "N-1" limb operates to address, will not arise in respect of the HVDC link, in contrast to other transmission links. This is a consequence of the HVDC link's unique role within the transmission system and its physical characteristics.
- 4.32 As a result, the Commission considers that any proposals to refurbish replace or expand the HVDC link should be considered under the economic limb of the GRS rather than the "safety net" provisions. The role of the N-1 safety net applying to the Core Grid is to ensure that uncertainties and complexities in the application of the GIT do not lead to a degradation of reliability on the Core Grid. The Commission is confident that this should not be the case with the application of the economic limb to options for replacing, refurbishing or expanding the HVDC link.
- 4.33 The Commission therefore considers that the principles for the GRS are best served by applying the economic limb of the GRS to the HVDC link and excluding it from the Core Grid in the Core Grid Determination.

Q2: *Do you agree with the approach the Commission has adopted to determine the Core Grid Determination? What are your reasons?*

5. Draft Core Grid Determination

Proposed Core Grid

- 5.1 The Commission has determined on the proposed Core Grid Determination having regard to:
- The objectives set out in rule 5A.3.1, including the objective in rule 5A.3.1.1 and the analysis set out in section 4 in relation to the meaning and operation of that objective;
 - The purposes set out in rule 5A.2.1;
 - The principles for the GRS set out in rule 4.3; and
 - All other relevant considerations.
- 5.2 This determination is for a Core Grid Determination comprising the assets that constitute the transmission links listed in Table 9. A draft Core Grid Schedule corresponding to this proposal is included as Appendix 2 to this paper.

Table 9: Proposed Core Grid

North Island Core Grid Links	South Island Core Grid Links
220kV Otahuhu-Henderson	220kV Twizel-Tekapo B
220kV Otahuhu-Southdown	220kV Tekapo B-Islington
220kV Southdown-Henderson	220kV Twizel-Ashburton
220kV Huntly-Takanini	220kV Ashburton-Bromley
220kV Otahuhu-Takanini	220kV Bromley-Islington
220kV Huntly-Glenbrook	220kV Twizel-Islington
220kV Glenbrook-Takanini	220kV Livingstone-Islington
220kV Otahuhu-Whakamaru	220kV Manapouri-Invercargill
220kV Otahuhu-Huntly	220kV Manapouri-Nth Makarewa
220kV Huntly-Hamilton	220kV Nth Makarewa-Invercargill
220kV Hamilton-Whakamaru	220kV Islington-Kikiwa
220kV Tokaanu-Whakamaru	220kV Benmore-Ohau B
220kV Bunnythorpe-Tokaanu	220kV Ohau B-Twizel
220kV Bunnythorpe-Tangiwai	220kV Benmore-Twizel
220kV Rangipo-Tangiwai	220kV Benmore-Ohau C
220kV Rangipo-Wairakei	220kV Ohau C-Twizel
220kV Wairakei-Poihipi	220kV Benmore-Aviemore
220kV Poihipi-Whakamaru	220kV Clyde-Cromwell
220kV Bunnythorpe-Haywards	220kV Cromwell-Twizel
220kV Haywards-Wilton	220kV Roxburgh-Clyde
220kV Wilton-Linton	220kV Roxburgh-Naseby
220kV Bunnythorpe-Linton	220kV Naseby-Livingstone

North Island Core Grid Links	South Island Core Grid Links
220kV Huapai-Henderson	220kV Invercargill-Roxburgh
220kV Henderson-Albany	220kV Invercargill-Tiwai Pt
220kV Albany-Huapai	220kV Nth Makarewa-Tiwai Pt
220kV Otahuhu-Penrose	220/66kV interconnection Islington
220kV Wairakei-Ohakuri	
220kV Ohakuri-Atiamuri	
220kV Atiamuri-Whakamaru	
220kV Atiamuri-Tarukenga	
220kV Bunnythorpe-Brunswick	
220kV Brunswick-Stratford	
110kV Otahuhu-Mangere	
220/110kV interconnection Otahuhu	
220/110kV interconnection Haywards	
220/110kV interconnection Tarukenga	

- 5.3 In the North Island, the Core Grid provides a continuous 220kV link extending from Wellington through the Central North Island up to North Auckland, and branching out to New Plymouth. Key interconnectors in Wellington and Auckland are also included, along with an important 110kV link between Otahuhu and Mangere.
- 5.4 In the South Island, the Core Grid provides a continuous 220kV link extending from Manapouri through Invercargill to the Waitaki area, up to Christchurch, and extending to Kikiwa, near the top of the South Island. A key interconnector in Christchurch is also included.
- 5.5 This set of transmission links is more than the minimum requirements outlined in paragraph 3.7 and less than the maximum requirements outlined in paragraph 3.6. Therefore, it is the Commission's view that this Core Grid Determination meets the requirements of rule 5A.1.2.

Possible alternatives

- 5.6 The main reasonably practicable alternatives to this Core Grid Determination are to consider either a smaller or larger loss of load criterion than the recommended 300MW as indicative of "cascade failure".
- 5.7 It is obvious that there is a spectrum of possible criteria that could be tested and that the range of possible criteria is large. However, it is not reasonably practicable to test the full spectrum of options. The Commission considers that the reasonable bounds of possible criteria is encompassed within the 150MW to 600MW range evaluated in section 4, and that it is reasonable to choose three points from within that range to evaluate.
- 5.8 Choosing a smaller loss of load criterion than 300MW would reflect a view that the Core Grid "N-1" limb should be widened to cover more of the transmission network. A 150MW loss of load criterion, for example, would suggest that the safety net should cover contingencies with indicative costs as low as \$1m to \$2m.

- 5.9 Choosing a larger loss of load criterion than 300MW would reflect a view that the Core Grid “N-1” limb should be tightened to cover less of the transmission network. A 600MW loss of load criterion, for example, would suggest that the safety net should only cover contingencies with indicative costs as high as \$9m to \$15m.
- 5.10 Table 10 illustrates the overall effect of both wider and narrower definitions on the transmission links comprising the Core Grid.
- 5.11

Table 10: Possible alternatives

Option	North Island Transmission Links	South Island Transmission Links
Wider Core Grid	A wider definition would extend the Core Grid beyond North Auckland to encompass supply to Whangarei, and out to the Hawkes Bay. It would also bring in several interconnectors and parallel 110kV links in the Wellington and Auckland regions.	A wider definition would extend the Core Grid further towards Nelson and Dunedin and include further interconnecting transformers in Christchurch.
Narrower Core Grid	A narrower definition would reduce the Core Grid to the main 220kV links between Wellington and Auckland.	A narrower definition would reduce the Core Grid to the main 220kV links between Manapouri and Christchurch.

- Q3:** *Do you agree with the Core Grid proposed by the Commission in this Core Grid Determination?*
- Q4:** *What transmission links, if any, do you consider should be excluded from the Core Grid Determination? What are your reasons?*
- Q5:** *What transmission links, if any, do you consider should be included in the Core Grid Determination? What are your reasons?*
- Q6:** *What comments do you have on the proposed drafting of the Core Grid Schedule included in draft form as Appendix 2 to this discussion paper?*

6. Process to Amend Rules

- 6.1 The Core Grid Determination process is set out in rule 5A of section III of Part F of the Rules. Since the Core Grid Determination, once recommended by the Commission and approved by the Minister, becomes a Schedule to the Rules, it constitutes a rule change and it is therefore subject to the rule change requirements set out in the Act.
- 6.2 Accordingly, this discussion paper includes a statement of proposal, which includes an assessment of the proposed Core Grid, prepared in accordance with the requirements of the Act.

Legislative requirements

- 6.3 The Minister may make a rule for all or any of the purposes for which an electricity governance regulation may be made.¹⁰ A rule is made by publishing a notice in the Gazette¹¹.
- 6.4 If the Minister makes, or the Commission recommends, a rule for a purpose for which an electricity governance regulation may be made, the Minister and the Commission must comply with the same conditions and process that would apply under section 172D(3)¹², section 172E, or section 172F of the Electricity Act 1992 (Act) if they were making recommendations on that electricity governance regulation, and those sections apply (with all necessary modifications) accordingly.
- 6.5 Sections 172X to 172Z of the Act also apply.¹³ The Commission must, in formulating recommendations, give effect to the principal objectives and specific outcomes and the Government Policy Statement on electricity governance (GPS) objectives and outcomes.¹⁴ The Minister must have regard to a recommendation by the Commission in exercising any of his functions or powers in relation to the Rules.¹⁵
- 6.6 Under section 172E(2)(b), before making a recommendation, the Commission must:
- undertake an assessment under section 172F;
 - consult with persons that the Commission thinks are representative of the interests of persons likely to be substantially affected by the proposed rules;
 - give those persons an opportunity to make submissions; and
 - consider those submissions.
- 6.7 Under section 172F(1), before making a recommendation, the Commission must:

¹⁰ Section 172H of the Electricity Act 1992.

¹¹ Section 172I.

¹² Section 172D(3) provides that the Commission and the Minister must ensure, before making a recommendation for any rules under section 172D(1)(2), that those rules do not provide for undue discrimination between electricity generators.

¹³ Section 172E(2)(a).

¹⁴ Section 172X.

¹⁵ Section 172Z.

- seek to identify all reasonably practicable options for achieving the objective of the rule;
- assess those options by considering the benefits and costs of each option, the extent to which the objective would be promoted or achieved by each option, and any other matters the Commission considers relevant;
- ensure that the objective of the rule is unlikely to be satisfactorily achieved by any reasonably practicable means other than the making of the rule (for example, by education, information, or voluntary compliance);
- prepare a statement of the proposal for the purpose of consultation under section 172E(2)(b)(ii)¹⁶.

Statement of proposal

- 6.8 As set out above, as the Commission's proposed draft Core Grid Determination (proposal) constitutes an amendment to the Rules, the process set out in the Act must be followed.
- 6.9 The Commission has prepared a statement of proposal, including the assessment, as required under section 172F of the Act, for the purposes of consultation under section 172E(2)(b)(ii). As such, it is required to set out a detailed statement of the proposal, a statement of the reasons for it, provide an assessment of the reasonably practicable options, and any other information that the Commission considers relevant.

Proposal - Proposed Core Grid Determination

- 6.10 The Commission is required under rule 5A.1 of section III of Part F of the Rules to determine the most appropriate Core Grid Determination. The Commission's Core Grid Determination must meet the requirements set out in rule 5A.
- 6.11 The Commission considers that the objective of the rule proposal is to determine the most appropriate Core Grid Determination that meets the requirements in Part F for the Core Grid Determination and the relevant aspects of the Part F requirements for the GRS. In particular, the Core Grid Determination needs to be one which strikes the appropriate balance between providing the "safety net" of the "N-1" limb of the GRS and ensuring the primacy of the economic limb of the GRS.
- 6.12 Specifically, the proposal is that the Core Grid should consist of those assets that comprise the transmission links listed in Table 9 (Proposed Core Grid) of this paper, which are derived from a loss of load criterion of 300MW. This constitutes the Draft Core Grid Determination required under rule 5A.4 of section III of Part F. A draft schedule to Part F, consistent with this Draft Core Grid Determination, is attached as Appendix 2 to this paper.

¹⁶ Section 172 provides that the statement of proposal must contain a detailed statement of the proposal, a statement of the reasons for the proposal and an assessment of the reasonably practicable options, including the proposal, and other information that the Commission considers relevant. Under section 172E(2)(b)(ii), the Commission must consult with persons that it thinks are representative of the interests of persons likely to be substantially affected by the proposed rule.

Statement of the reasons for the proposal

- 6.13 As set out above, the Commission is required under rule 5A.1 of section III of Part F of the Rules to determine the most appropriate Core Grid Determination, which meets the requirements set out in rule 5A. This proposal has been made to meet the Commission's obligations and the requirements of the Rules.
- 6.14 The Commission acknowledges that the development of the Core Grid involves judgements, both in interpreting the requirements of the Rules, and then in applying that interpretation in order to identify the Core Grid Determination that best meets those requirements. The Commission's interpretation of the requirements and of other information it considers relevant is discussed in sections 3 and 4 of this discussion paper.
- 6.15 The Commission's reasons for determining the Core Grid Determination in the form that it has are also set out in sections 3 and 4. However, a summary of those reasons is set out below.
- 6.16 The Commission considers that the matters relevant to the Core Grid Determination are:
- scope (the upper and lower boundaries);
 - purpose;
 - objectives;
 - principles for the GRS; and
 - primacy of the economic limb of the GRS.
- 6.17 The Commission's interpretation and assessment of these relevant matters led it to conclude:
- that the scope for the purposes of rule 5A1.2 lies between the two extremes of "all assets that form part of the grid and operate at nominal voltages of 66kV and above" and "those assets that comprise the main elements of the grid" (ie the minimum elements of the core grid listed in paragraphs 3.9 and 3.10);
 - that a clear unambiguous definition of Core Grid, defined in a manner consistent with the other requirements, will meet the purpose;
 - that the most appropriate interpretation and application of the cascade failure objective is to adopt an approach to identifying Core Grid elements based on a loss of load criterion of 300MW;
 - that the most appropriate interpretation and application of the flexibility and planning stability objectives is to consider, when identifying Core Grid elements, the expected state of the power system in 2015 using the scenarios set out in the SOO;
 - that the principles are encapsulated in the objectives and/or the form of the GRS; and
 - that the Core Grid Determination needs to be one which strikes an appropriate balance between providing the "safety net" of the "N-1" limb and ensuring the primacy of the economic limb of the GRS.

- 6.18 The Commission then applied these conclusions and a set of rules, based on analysis and experience, to determine whether a particular transmission link should have N-1 reliability in order to avoid cascade failure leading to a loss of load greater than 300MW.
- 6.19 This is the approach that the Commission considers best meets the requirements of Part F for the Core Grid Determination and the relevant aspects of the Part F requirements for the GRS.
- 6.20 In preparing this proposed Core Grid Determination, the Commission also considered a range of other possible approaches to its preparation, in addition to the loss of load factor approach. A description of each of these and a commentary as to why they were not pursued is set out in Table 8 (Other approaches considered) of this paper. In each case the Commission considers that the approach was unlikely to result in a Core Grid Determination that would meet the requirements of Part F and/or the objective of the rule proposal. Accordingly, a Core Grid determination based on any of these approaches was not regarded as a reasonably practicable option.

Identification of reasonably practicable options

- 6.21 Section 172F(1) of the Act requires the Commission to seek to identify all reasonably practicable options for achieving the objective of the rule (including the proposed rule).
- 6.22 The Commission has concluded that the only reasonably practicable options involve options derived from variations on the 300MW loss of load criterion. Paragraphs 5.6 to 5.10 of this discussion paper outline that there is a full spectrum of feasible options within a range of 150MW to 600MW. However, it is not reasonably practicable to test the full spectrum of those options. Accordingly, the Commission has considered the effect of applying loss of load criteria of 150MW and 600MW as representative of the reasonably practicable options to the proposal which is derived from a loss of load criterion of 300MW.
- 6.23 The Core Grid Determination based on a 600MW loss of load criterion gave rise to a narrower Core Grid Determination. The Core Grid Determination based on a 150MW loss of load criterion gave rise to a wider Core Grid Determination. The grid elements that might be included (excluded) under the wider (narrower) Core Grid are set out in Table 6: Core Grid Determination for different loss of load criteria – North Island and Table 7: Core Grid Determination for different loss of load criteria – South Island.
- 6.24 The Commission considers that these represent the reasonable bounds to the Core Grid, in view of the Commission's interpretation of the Part F requirements and its approach to identifying the Core Grid that meets these. The Commission considers that the narrower core grid and wider core grid are reasonably practicable options for achieving the objective of the rule proposal.

Assessment of the proposal and reasonably practicable options

- 6.25 Section 172F(1) of the Act requires the Commission to assess each reasonably practicable option, including the proposal by considering:
- the benefits and costs of each reasonably practicable option, including the proposal;

- the extent to which the objective would be promoted or achieved by each option; and
- any other matters that the Commission considers relevant.

6.26 Table 11 sets out the Commission’s assessment, for all three of these aspects, of the proposal and two reasonably practicable options.

Table 11: Assessment of the proposed Core Grid

Aspect	Proposed Core Grid	Practicable Options
Costs and benefits	<ul style="list-style-type: none"> • The 300MW loss of load criterion would involve investing for “N-1” reliability in order to avoid contingency costs of between \$3m and \$6m. The Commission assesses this as an appropriate level for a safety net. • Investment proposals for transmission links that are part of the Core Grid may be made on the basis of restoring N-1 reliability. The Commission considers that uneconomic investments are unlikely with the proposed Core Grid. • The proposal has the benefit of offering some certainty to the minimum level reliability on the Core Grid. • Investment proposals for transmission links that are outside the Core Grid will be subject to the economic limb of the GRS ensuring that only economic investments occur. 	<ul style="list-style-type: none"> • The 150MW loss of load criterion would involve investing for “N-1” reliability in order to avoid contingency costs of between \$1m and \$2m. The Commission considers this to be too low for a safety net. • While a wider Core Grid would extend the safety net to more transmission links, the risk of uneconomic investment would rise. • The 600MW loss of load criterion would involve investing for “N-1” reliability in order to avoid contingency costs of between \$9m and \$15m. The Commission considers this to be too high for an effective safety net. • While a narrower Core Grid would reduce the safety net to fewer transmission links and reduce the risk of uneconomic investment, it would increase the uncertainty of reliability outcomes during the period that probabilistic techniques are being developed.

Aspect	Proposed Core Grid	Practicable Options
Objectives	<ul style="list-style-type: none"> The 300MW loss of load criterion used in the assessment methodology meets a reasonable interpretation of the cascade failure objective. The proposed Core Grid strikes an appropriate balance between the competing objectives of “<i>flexibility to evolve over time</i>” and “<i>public interest in stability in planning</i>”. The proposed Core Grid strikes an appropriate balance between operating as a meaningful safety net while not unduly interfering with operation of the primary, economic limb of the GRS. 	<ul style="list-style-type: none"> A 150MW loss of load criterion extends beyond what the Commission considers is a reasonable interpretation of the cascade failure objective. A 150MW loss of load criterion would extend the Core Grid safety net across most of the 220kV transmission network and into the 110kV network in the North Island. The Commission considers that it would be inconsistent with the intent of the safety net provisions for the Core Grid to extend this far A 600MW loss of load criterion would mean that many contingent events that lead to cascade failure would not be covered. A 600MW loss of load criterion would reduce the Core Grid to a short backbone of 220kV transmission in each island. The Commission considers that it would be inconsistent with the intent of the safety net provisions for the Core Grid to be this narrow.
Other matters	<ul style="list-style-type: none"> As part of the GRS decision, the Commission signalled its intent to set in train a number of key work streams aimed at removing some of the uncertainties of an economic standard. This was with a view to revisiting the form of GRS within five years and considering the removal the N-1 safety net. The proposal is designed to provide a safety net and reduce uncertainty about reliability, while allowing the economic limb of the test to apply in some areas. 	<ul style="list-style-type: none"> A wider Core Grid may restrict the development of the techniques to apply probabilistic planning by restricting the extent to which the economic test can be applied. A narrower Core Grid could mean that the economic approach based on probabilistic planning may be applied before the techniques are fully developed.

Other means to achieve the objective

- 6.27 The Commission must ensure that the objective of the rule is unlikely to be satisfactorily achieved by any reasonably practicable means other than the making of the rule (for example, by education, information, or voluntary compliance).
- 6.28 The Rules require the making of a Core Grid Determination which is to be included as a schedule to the Rules. Accordingly, the Commission considers that the objective of the rule is unlikely to be satisfactorily achieved by any reasonably practicable means

other than the making of the rule. The Commission, Transpower as grid owner, and participants need certainty as to what assets form the Core Grid. The Commission considers that this can only be achieved if those assets are clearly identified and set out formally as part of the Rules, with any changes to the Core Grid being subject to the rigour of the rule change process. Furthermore, the GRS are set out in the Rules, but would be incomplete without the Core Grid also being defined.

- 6.29 Accordingly, the Commission considers that alternatives such as education, information or voluntary compliance would not satisfactorily achieve the objectives of the rule proposal, nor the requirements of Part F that the Core Grid, once determined be incorporated as a schedule to Part F and therefore take the form of a rule.

Assessment against objectives and outcomes

- 6.30 Table 12 sets out the Commission's assessment of the draft Core Grid Determination against the principal objectives and specific outcomes of the Commission (s 172N of the Act), and against the objectives for the provision of transmission services specified in the GPS (paragraph 80).

Summary

- 6.31 The Commission has concluded that the Core Grid proposed in Table 9: Proposed Core Grid is the most appropriate, and this is set out in the draft Core Grid Schedule included as Appendix 2.
- 6.32 The Commission has based its assessment of the proposed Core Grid primarily with reference to the wider and narrower Core Grids described in Table 10: Possible alternatives¹⁷, and considers that:
- the qualitative assessment supports the proposed Core Grid relative to the wider or narrower options identified, in particular its use as part of the application of the GRS will yield more appropriate outcomes.
 - the proposed Core Grid best meets the objective of the proposed rule amendments, in particular:
 - it best meets the requirements of rule 5A and the relevant aspects of the Part F requirements for the GRS, as interpreted by the Commission;
 - it best achieves the appropriate balance between providing the "safety net" of the "N-1" limb and ensuring the primacy of the economic limb of the GRS;
 - the proposed Core Grid also gives effect to the Act and the GPS objectives and outcomes.
- 6.33 This assessment is based on the Commission's interpretation of the requirements and the exercise of some judgement in the application of the approach to identify the Core Grid that best meets those requirements. Accordingly, the Commission acknowledges that some parties may hold a different view of the requirements, and exercise different judgements about the application of the requirements.

¹⁷ Table 6: Core Grid Determination for different loss of load criteria – North Island) and Table 7: Core Grid Determination for different loss of load criteria – South Island) set out the core grid elements for the different loss of load criteria.

- 6.34 The Commission has concluded that the only reasonably practicable options involve options derived from variations on the 300MW loss of load criterion. However, it is not reasonably practicable to test the full spectrum of those options. Accordingly, the Commission has considered the effect of applying loss of load criteria of 150MW and 600MW as representative of the reasonably practicable options to the proposal. The Commission considers that these represent the reasonable bounds to the Core Grid, in view of the Commission's interpretation of the Part F requirements and its approach to identifying the Core Grid that meets these.

Q7: *Do you agree with the Commission's assessment of the proposal? If not, what alternative assessment would you make and why?*

Submissions

- 6.35 The Commission welcomes submissions on the material presented in this discussion paper, on the questions posed, and in particular on the proposed rule change to include the Core Grid Schedule as set out in Appendix 2 as a schedule to section III of Part F of the Rules. The requirements for submissions are set out in Section 1 of this paper. In particular, submissions must be received by **5pm on 20 July 2005**.

Table 12: Assessment against Commission and GPS objectives and outcomes

Objectives	Response
Objectives: Under s172N of the Act, the principal objectives of the Commission are:	
<ul style="list-style-type: none"> To ensure that electricity is produced and delivered to all classes of consumers in an efficient, fair, reliable, and environmentally sustainable manner; and To promote and facilitate the efficient use of electricity 	<p>The proposed Core Grid contributes to ensuring that electricity is delivered in a reliable manner by ensuring that, in combination with the GRS to which it relates, there is a minimum standard of N-1 on the Core Grid, so that the grid is able to withstand a single credible contingency on the Core Grid without loss of load.</p> <p>The proposed Core Grid contributes to ensuring that electricity is delivered in an efficient manner by ensuring that its effect is to not unduly interfere with operation of the economic limb of the GRS which balances the cost of reliability investments against the benefits of reliability investments using the GIT.</p>
Outcomes Under the s172N of the Act , the Commission's specific outcomes are as follows:	
<ul style="list-style-type: none"> Energy and other resources are used efficiently 	The proposed Core Grid promotes efficient use of energy and transmission resources by not adversely impacting on the primacy of the economic limb of the GRS, thereby enabling resources to be generally applied to increase reliability where the reliability benefits are greater than the costs.
<ul style="list-style-type: none"> Risks (including price risks) relating to security of supply are properly and efficiently managed 	The proposed Core Grid contributes to the proper and efficient management of risks relating to security of supply by providing a minimum standard of N-1 on the Core Grid, so that the grid is able to withstand a single credible contingency on the Core Grid without loss of load.
<ul style="list-style-type: none"> Barriers to competition in the electricity industry are minimised for the long-term benefit of end-users 	n/a
<ul style="list-style-type: none"> Incentives for investment in generation, transmission, lines, energy efficiency, and demand-side management are maintained or enhanced and do not discriminate between public and private investment 	<p>The GRS ensure that all reliability investments are evaluated according to economic criteria and, generally, only proceed where there is a clear net benefit. This maintains appropriate incentives for investment in transmission and alternatives. However, the minimum standard of N-1 on the Core Grid may limit, to some extent, the opportunities for alternatives to compete. By not specifying a wide Core Grid, this effect is reduced. Furthermore, the Commission has signalled its intent to review the need for the N-1 minimum (and therefore the need to define the Core Grid) within 5 years.</p> <p>The proposed Core Grid does not discriminate between public and private investment.</p>
<ul style="list-style-type: none"> The full costs of producing and transporting each additional unit of electricity are signalled 	N/A

Objectives	Response
<ul style="list-style-type: none"> Delivered electricity costs and prices are subject to sustained downward pressure 	<p>The proposed Core Grid contributes to this objective by not adversely impacting on the primacy of the economic limb of the GRS, thereby enabling resources to be generally applied to increase reliability where the reliability benefits are greater than the costs.</p>
<ul style="list-style-type: none"> The electricity sector contributes to achieving the Government's climate change objectives by minimising hydro spill, efficiently managing transmission and distribution losses and constraints, promoting demand-side management and energy efficiency, and removing barriers to investment in new generation technologies, renewables and distributed generation 	<p>The minimum standard of N-1 on the Core Grid may limit, to some extent, the opportunities for distributed generation, demand-side management and energy efficiency to compete with transmission. By not specifying a wide Core Grid, this effect is reduced. Furthermore, the Commission has signalled its intent to review the need for the N-1 minimum (and therefore the need to define the Core Grid) within 5 years.</p>
<p>Transmission Objectives: Under paragraph 80 of the GPS, the Government's objectives for the provision of transmission services are that:</p>	
<ul style="list-style-type: none"> the services are provided in a manner consistent with the Government's policy objectives for electricity 	<p>The proposed Core Grid is consistent with the policy objectives (see section in this table on objectives).</p>
<ul style="list-style-type: none"> the services should be provided at the standards of power quality and grid reliability required by grid users and consumers as determined by the Commission 	<p>The economic limb of the GRS includes the use of a value of Unserved-Energy in the evaluation that is intended to recognise the value of reliability required by consumers. The proposed Core Grid supports this objective by not adversely impacting on the primacy of the economic limb of the GRS.</p> <p>The proposed Core Grid supports this objective by providing a minimum standard of N-1 on the Core Grid, so that the grid is able to withstand a single credible contingency on the Core Grid without loss of load.</p>
<ul style="list-style-type: none"> the efficiency of transmission services should be continuously improved so as to produce the services grid users and consumers want at least cost, and 	<p>The Commission intends to review whether the minimum N-1 standard on the Core Grid is necessary within 5 years. Fundamental to this review will be the need to better recognise consumer requirements.</p>
<ul style="list-style-type: none"> the services are priced in a manner that: <ul style="list-style-type: none"> is transparent fully reflects their costs including risk facilitates nationally efficient supply, delivery and use of electricity promotes efficient investment in transmission or transmission alternatives promotes nationally efficient use of transmission services by grid users and consumers. 	<p>N/A</p>

Appendix 1. Commonly Used Terms

This explanatory paper uses a number of terms and acronyms from the Rules (especially Part F and Part C) and relevant literature. Commonly used terms are set out here for ease of reference.

CCE	Credible Contingent Event
EGRs	Electricity Governance Rules
EUE	Expected Un-served Energy
GIP	Grid Injection Point
GIT	Grid Investment Test
GPS	Government Policy Statement
GRS	Grid Reliability Standards
GUP	Grid Upgrade Plan
GXP	Grid Exit Point
HVDC	High Voltage Direct Current link between the North and South Islands
PPOs	Principal Performance Obligations under Part C
SOO	Statement of Opportunities
SOPS	System Operator Policy Statement under Part C
SSG	System Studies Group NZ
TAG	Transmission Advisory Group
USE	Un-served Energy

Appendix 2. Draft Core Grid Schedule

Schedule F Core Grid Determination

Making of Electricity Governance Rules

1. In accordance with rule 5A.6 in section III of part F of the **rules**, and the provisions of the **Act**, the **Minister**, on the recommendation of the **Board**, makes this **core grid determination** a schedule to section III of part F of the **rules** with effect from *[insert date here]*.

Background

2. Rule 5A.1, in section III of part F of the **rules**, requires the **Board** to determine the most appropriate **core grid determination** and in so doing must have regard to the purposes set out in rule 5A.2, the principles set out in rule 4.3 for the **grid reliability standards** and the objectives set out in rule 5A.3, as required by rule 5A.1.

The core grid determination

3. The purpose of this **core grid determination** is to define the **core grid** for the purposes of the **grid reliability standards** and so provide a basis for:
 - 3.1 the **Board** to determine the **grid reliability standards**;
 - 3.2 the **Board** to **publish statements of opportunities**;
 - 3.3 **Transpower** to prepare **grid upgrade plans**; and
 - 3.4 other parties to appraise opportunities for transmission investment and **transmission alternatives**.
4. For the purpose set out in clause 3, those assets comprising the following transmission links form part of the core grid:

North Island Core Grid Links	South Island Core Grid Links
220kV Otahuhu-Henderson	220kV Twizel-Tekapo B
220kV Otahuhu-Southdown	220kV Tekapo B-Islington
220kV Southdown-Henderson	220kV Twizel-Ashburton
220kV Huntly-Takanini	220kV Ashburton-Bromley
220kV Otahuhu-Takanini	220kV Bromley-Islington
220kV Huntly-Glenbrook	220kV Twizel-Islington
220kV Glenbrook-Takanini	220kV Livingstone-Islington
220kV Otahuhu-Whakamaru	220kV Manapouri-Invercargill
220kV Otahuhu-Huntly	220kV Manapouri-Nth Makarewa
220kV Huntly-Hamilton	220kV Nth Makarewa-Invercargill
220kV Hamilton-Whakamaru	220kV Islington-Kikiwa
220kV Tokaanu-Whakamaru	220kV Benmore-Ohau B
220kV Bunnythorpe-Tokaanu	220kV Ohau B-Twizel

North Island Core Grid Links	South Island Core Grid Links
220kV Bunnythorpe-Tangiwai	220kV Benmore-Twizel
220kV Rangipo-Tangiwai	220kV Benmore-Ohau C
220kV Rangipo-Wairakei	220kV Ohau C-Twizel
220kV Wairakei-Poihipi	220kV Benmore-Aviemore
220kV Poihipi-Whakamaru	220kV Clyde-Cromwell
220kV Bunnythorpe-Haywards	220kV Cromwell-Twizel
220kV Haywards-Wilton	220kV Roxburgh-Clyde
220kV Wilton-Linton	220kV Roxburgh-Naseby
220kV Bunnythorpe-Linton	220kV Naseby-Livingstone
220kV Huapai-Henderson	220kV Invercargill-Roxburgh
220kV Henderson-Albany	220kV Invercargill-Tiwai Pt
220kV Albany-Huapai	220kV Nth Makarewa-Tiwai Pt
220kV Otahuhu-Penrose	220/66kV interconnection Islington
220kV Wairakei-Ohakuri	
220kV Ohakuri-Atiamuri	
220kV Atiamuri-Whakamaru	
220kV Atiamuri-Tarukenga	
220kV Bunnythorpe-Brunswick	
220kV Brunswick-Stratford	
110kV Otahuhu-Mangere	
220/110kV interconnection Otahuhu	
220/110kV interconnection Haywards	
220/110kV interconnection Tarukenga	

Interpretation

- For the purposes of this **core grid determination**, unless the context calls for another interpretation, a term has the meaning given to that term in the **grid reliability standards**.

Appendix 3. Inter-Regional Link Approach

The transmission network tends to link together geographic areas of generation with geographic areas of demand. It may be helpful to consider the reliability of the links between these geographic regions. This appendix explores this option by dividing New Zealand into 17 geographic regions and considering the reliability of the inter-regional links between those regions. These links can be considered to be arterial routes that carry most of the critical power flow. A possible approach is to divide the network into the following regions :

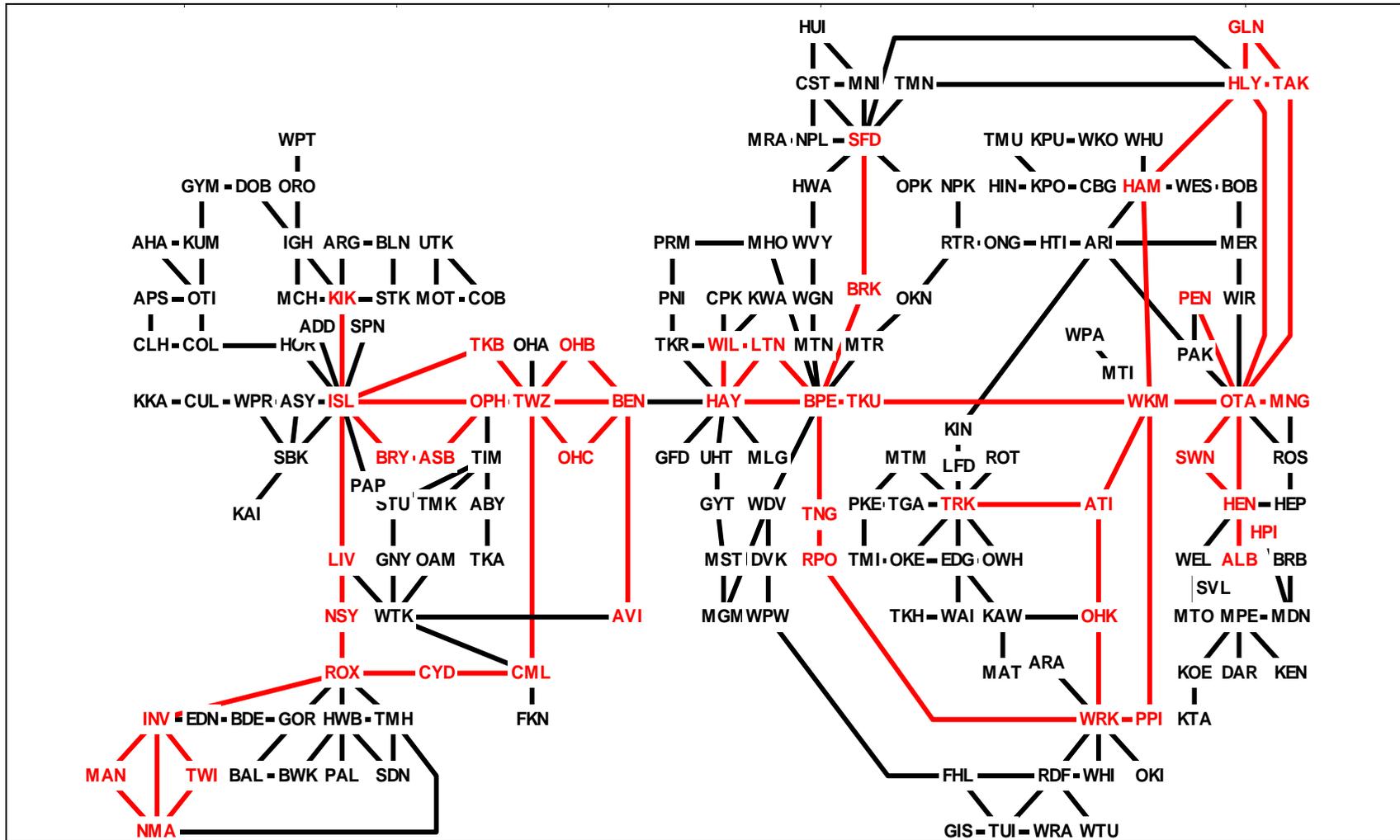
- a) Northland
- b) Auckland
- c) Waikato
- d) Bay of Plenty
- e) Central
- f) Taranaki
- g) Hawkes Bay
- h) Bunnythorpe
- i) Wellington
- j) Nelson / Marlborough
- k) West Coast
- l) Christchurch
- m) Waitaki
- n) Clutha
- o) Dunedin
- p) Southland
- q) Fiordland

Each group of circuits linking these regions forms an inter-regional link. Each inter-regional link may also be sub-divided into different voltage levels (220 kV, 110 kV, or 66 kV) with the 220 kV links being the most significant.

The loss of some of these 220 kV links would be expected to cause cascade failure and widespread loss of load, depending on the generation and load pattern at the time. Consequently these links would warrant a greater degree of reliability than other parts of the network. Under this approach it is expected that the following inter-regional links would be included in the Core Grid based on common generation and load patterns;

- a) 220 kV circuits Waikato – Auckland
- b) 220 kV circuits Central – Waikato
- c) 220 kV circuits Waitaki – Christchurch
- d) 220 kV circuits Clutha – Waitaki
- e) 220 kV circuits Manapouri – Southland

Core Grid (shown in red) for 300MW loss of load criterion



Appendix 5. Format for Submissions

To assist the Commission in the orderly and efficient consideration of stakeholders' responses, a suggested format for submissions has been prepared. This is drawn from the questions posed in the body of this consultation document.

Respondents are also free to include other material in their responses.

Question	Comment
1. Do you agree with the Commission's interpretation of the Part F requirements and wider design issues for the Core Grid Determination?	
2. Do you agree with the approach the Commission has adopted to determine the Core Grid Determination? What are your reasons?	
3. Do you agree with the Core Grid proposed by the Commission in this Core Grid Determination?	
4. What transmission links, if any, do you consider should be excluded from the Core Grid Determination? What are your reasons?	
5. What transmission links, if any, do you consider should be included in the Core Grid Determination? What are your reasons?	
6. What comments do you have on the proposed drafting of the Core Grid Schedule included in draft form as Appendix 2 to this discussion paper?	
7. Do you agree with the Commission's assessment of the proposal? If not, what alternative assessment would you make and why?	