

Industry and market monitoring

Reliability and efficiency Information paper

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Executive summary

This paper explains the Authority's approach to monitoring reliability and efficiency. An earlier information paper addressed competition issues.

The Authority is monitoring reliability and efficiency in accordance with its statutory objective to 'promote competition in, reliable supply by, and the efficient operation of, the electricity industry for the long-term benefit of consumers'.

The objective in monitoring reliability and efficiency is to promote or facilitate industry behaviour which minimises costs of services to consumers, while ensuring the industry is robust enough to withstand adverse events. This objective will be met mainly by using monitoring to identify, assess and support appropriate improvements to the Electricity Industry Participation Code 2010. The process for this includes bespoke reviews and investigations, with the results being made publicly available.

Monitoring will also improve the functioning of the industry by increasing transparency and access to quality information. To promote this goal, statistics, analysis and analytical tools will be made publicly available.

The Authority's approach to monitoring reliability and efficiency has three interrelated parts:

- indicators organised according to an extended application of the Structure-Conduct-Performance framework used to monitor competitiveness;
- bespoke use of benchmarking models; and
- a 'reliability-centred monitoring regime' to identify systemic issues or failures affecting reliability, which extends widely used 'reliability-centred (asset) maintenance' approaches to considering industry-wide reliability.

The Authority is aware that its monitoring activities are similar to those of other organisations such as the Commerce Commission and the system operator. The Authority is seeking to leverage relevant work rather than duplicating it. It will then be able to use its perspective across the industry to add value to other more focused monitoring work.

Glossary of abbreviations and terms

Act	Electricity Industry Act 2010
Authority	Electricity Authority
Code	Electricity Industry Participation Code 2010
FTRs	Financial Transmission Rights
GEM	Generation Expansion Model
GWh	Giga Watt Hours
MWh	Mega Watt Hours
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SPD	Scheduling, Pricing and Dispatch
vSPD	Vectorised Scheduling, Pricing and Dispatch
vSPD	Vectorised Scheduling, Pricing and Dispatch

1 Introduction

- 1.1 This paper explains how the Electricity Authority (the Authority) is monitoring the industry and market for reliability and efficiency. The Electricity Industry Act 2010 (the Act) requires the Authority to undertake industry and market monitoring. This represents a new function: one that the Authority's predecessor, the Electricity Commission, did not carry out.
- 1.2 Monitoring activities cover all aspects of the electricity sector – from generation and key associated input markets, to the wholesale and related ancillary and forward markets, through to system operation, transmission, distribution and retail markets.
- 1.3 Ultimately, this monitoring function will help the Authority to 'promote competition in, reliable supply by, and the efficient operation of, the electricity industry for the long-term benefit of consumers'.¹
- 1.4 This is a companion paper to the earlier information paper released by the Authority on 31 August 2011, which discussed monitoring in terms of competition.²
- 1.5 This paper sets out:
- (a) the Authority's objectives in fulfilling its monitoring function;
 - (b) examples of applied frameworks and metrics that will be used to examine the performance of the industry and how the Authority is achieving its statutory objective in relation to reliability and efficiency;
 - (c) the outputs it will produce while conducting its monitoring activities; and
 - (d) how the Authority's activities relate to those of other organisations monitoring reliability and efficiency in the electricity industry.

2 Objectives

- 2.1 The overall purpose of industry and market monitoring is to promote the Authority's statutory objective.³ Figure 1 summarises the Authority's interpretation of its statutory objective. The Authority interprets its role as promoting reliable supply and efficient operation, rather than prescribing optimal levels of reliability or efficiency.
- 2.2 In practical terms, the purpose of the Authority's monitoring activities is to promote reliability and efficiency by:
- (a) improving transparency and access to quality information; and
 - (b) informing development of the Electricity Industry Participation Code 2010 (Code) or market-facilitation measures.⁴

¹ The Authority has published a paper which clarifies how the Authority interprets its statutory objective. See <http://www.ea.govt.nz/document/12803/download/about-us/documents-publications/foundation-documents/>.

² 'Industry and market monitoring: Competition' available at <http://www.ea.govt.nz/industry/monitoring/reports-publications/>.

³ There is a more direct purpose, which is to fulfil a legislated requirement (i.e. the Act prescribes it), but this is subsidiary to the broader statutory objective. Section 16 of the Act lists the functions of the Authority. In particular, section 16(1)(g) of the Act requires the Authority: 'to undertake industry and market monitoring, and carry out and make publicly available reviews, studies, and inquiries into any matter relating to the electricity industry'. Section 16(1)(f) sets out the requirements for market-facilitation measures: 'to undertake market-facilitation measures (such as providing education, guidelines, information, and model arrangements), and to monitor the operation and effectiveness of market-facilitation measures'.

⁴ Improving and administering the Code in accordance with subpart 3 of part 2 of the Act is a central function of the Authority.

Promoting reliability

- 2.3 Promoting reliability means encouraging minimised costs to consumers while ensuring that the industry is robust enough to withstand adverse events.⁵ These costs include costs to the industry from supply interruptions and quality deterioration, as well as the direct costs of ensuring reliability and security through, for example, supplying reserve capacity and transmission assets.

Figure 1 Interpretation of the statutory objective



Source: Electricity Authority

- 2.4 Conventionally, being robust to adverse events has meant system redundancies – e.g. sufficient dry year firming plant or N-1 grid security. The Authority takes a broader view, that 'robust to adverse events' also means:
- (a) sufficient flexibility in the industry to respond to and manage costs during adverse events;

⁵ The objective of promoting reliability includes security of supply as well as quality of supply (more usually referred to as reliability).

- (b) ensuring that participants have incentives to manage risks of adverse events before they happen; and
 - (c) minimising the resource costs of reliability.
- 2.5 This view of reliability monitoring is necessary because the Authority's statutory objective places end reliability for consumers at the centre of any monitoring regime. Reliability, or any investment in it, is only valuable because of the benefits for consumers, and isn't valuable in its own right.
- 2.6 A key objective of monitoring is to improve system reliability by developing and monitoring indicators that make industry behaviour transparent and identify any emerging risks. This requires paying attention to the functions, incentives and processes that affect reliability.

Promoting efficiency

- 2.7 There is substantial overlap between efficiency and the other two limbs of the statutory objective. Efficiency is part of the objective of promoting competition, and promoting efficient levels of reliable supply is clearly an efficiency objective. The efficiency limb can thus be considered a residual as it focuses on those aspects of industry efficiency that are not captured in the reliability and competition limbs.
- 2.8 The 'efficient operation' limb of the statutory objective is particularly relevant to non-competitive parts of the electricity industry. This includes transmission and distribution. In these parts of the industry pro-competition measures cannot be used to promote efficient outcomes that benefit consumers.
- 2.9 Promoting efficiency also extends to regulatory, resource and production efficiencies in workably competitive segments of the electricity industry. For example, resource and productive efficiency in generation and elsewhere in the industry must be considered because many resource efficiency issues are connected directly to regulatory frameworks, whether environmental (consent-related) or related to the energy market (such as scarcity pricing). As a result, they demonstrate the efficiency of regulatory frameworks, and also the efficiency of decisions by producers.

3 Outputs

- 3.1 The Authority's monitoring activities will produce two distinct kinds of results:
- (a) **Reports of routine monitoring and annual market performance reviews:**
 - (i) reports of periodic reviews of industry performance against specified benchmarks and thresholds;
 - (ii) informational documents and educational initiatives (e.g. via the *Information on the market* segments of the weekly 'Market Brief'); and
 - (iii) tools to improve market participants' own monitoring capacity and understanding of the Authority's work.
 - (b) **Results of bespoke enquiries, investigations and in-depth reviews:**
 - (i) in-depth studies of particular topics that arise and/or are requested by the Minister of Energy and Resources; and
 - (ii) enquiries, reports and investigations into events that may require Code amendment or other actions to improve the functioning of the market.

3.2 The relationship between these different products and how they fit into the overall monitoring process is summarised in Figure 2.⁶

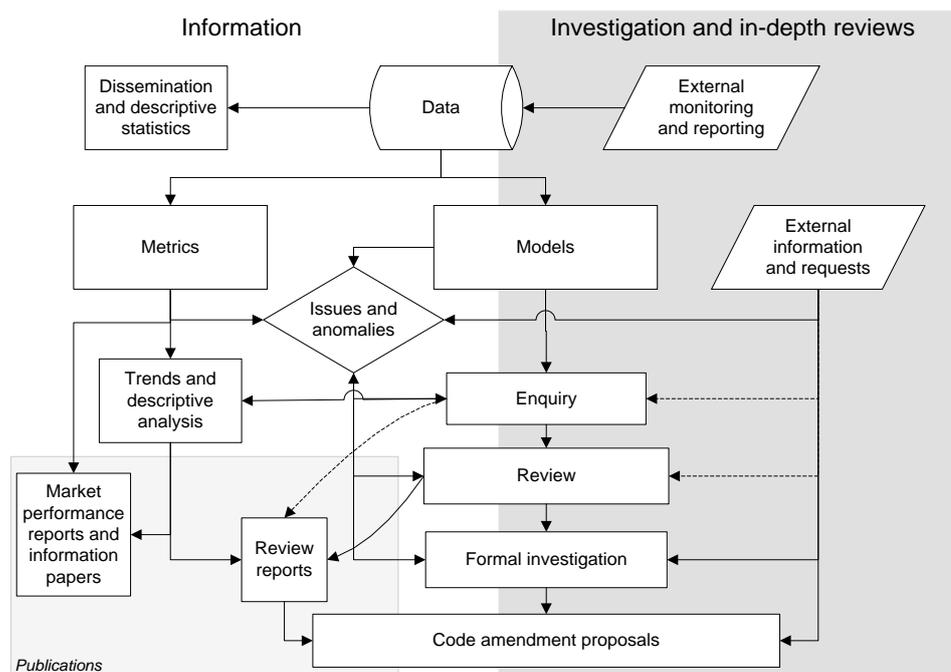
Routine monitoring and annual market performance reports

3.3 Routine monitoring uses standardised measures and metrics, such as descriptive statistics that summarise supply capacity and interruptions. It also uses analytical information on the state of supply-side risks (e.g. hydro risk) and trends in reliability and efficiency.

3.4 Statistics are produced automatically and distributed via a customisable web interface. Analysis, plots and metrics are also available in written reports such as the ‘Market statistics and reports’ on the Authority’s website.

3.5 The Authority publishes a comprehensive ‘State of the market’ report annually, and produced a high-level market performance report in December 2011 after its first year of operation. Future reports will include more technical content and in-depth analyses as well as evaluating overall market performance. These reports will focus on metrics of industry reliability and efficiency (as well as competition), while in-depth reviews, enquiries and investigations will use more sophisticated model-based analyses.

Figure 2 Information flows and outputs



Source: Electricity Authority

Bespoke enquiries, investigations and in-depth reviews

3.6 Enquiries, investigations and in-depth reviews are undertaken as required, usually using bespoke analysis rather than relying on simple descriptive statistics. These normally result in recommendations for possible Code amendments or facilitation measures to improve market performance.

⁶ The appendices to this paper include further detail on the scope and range of the Authority’s monitoring activities and market monitoring infrastructure.

- 3.7 Investigations work on gathering sufficient information to decide whether a Code amendment or market facilitation measure should be considered. An in-depth investigation is typically the final step of a sequence of escalating stages, as described below:
- (a) **Market performance enquiry (Stage I):** At the first stage, routine monitoring identifies circumstances that require follow-up. This stage may entail designing low-cost ad hoc analysis, using existing data and resources, to better characterise and understand what has been observed. The Authority would not usually announce it is doing this work.

No further action may be needed if the enquiry is unlikely to have any implications for the competitive, reliable and efficient operation of the electricity industry. The Authority would publish its enquiry only if industry participants were likely to be interested in it.
 - (b) **Market performance review (Stage II):** A second stage of investigation occurs if insufficient information is available to understand the issue and it could be significant for the competitive, reliable or efficient operation of the electricity industry. Relevant service providers and industry participants are asked for information, followed by a period of iterative information-gathering and analysis. The Authority would usually publish the results of these reviews, but wouldn't publicise its investigation unless there was a high level of stakeholder or media interest.
 - (c) **Market performance investigation (Stage III):** The Authority may exercise statutory information-gathering powers under section 46 of the Act to acquire the information it needs to fully investigate an issue. The Authority would generally announce early in the process that it was undertaking the investigation, with its expected completion date. Draft reports go to the Board of the Authority for publication approval.
- 3.8 The outcome of any of the three stages of investigation can be: a recommendation for a Code amendment; information provided to a Code amendment process already under way; a brief report provided to industry as a market facilitation measure; or no further action.
- 3.9 Market facilitation measures include educational initiatives and disseminating tools to improve market participants' own monitoring capacity and understanding of the Authority's work.
- 3.10 From the participants' point of view, information is usually requested during Stage II, when trying to understand the issue well enough to make a decision about materiality.

4 Monitoring framework and metrics

- 4.1 The Authority draws on three analytical frameworks for monitoring reliability and efficiency:
- Structure-Conduct-Performance (SCP);
 - benchmarking; and
 - reliability-centred monitoring.

Structure-Conduct-Performance

- 4.2 SCP is an organising framework for thinking about influence on market performance. It starts from the idea that the market structure determines the conduct of participants. This conduct drives outcomes. In the context of competition, a more competitive structure leads to more competitive participant conduct, which makes their performance more efficient.⁷
- 4.3 This is a useful framework for considering reliability and efficiency. It underscores the need to consider the context in which industry participants conduct themselves, as well as the outcomes

⁷ Further information on the SCP framework, including a diagram of its interrelated components, can be found in the 'Industry and market monitoring: Competition' information paper.

resulting from their conduct. As discussed in the earlier paper on monitoring competition, the SCP framework has the benefit of emphasising that outcomes are a function of many related influences and actions, so no single measure provides definitive information on market performance.

4.4 Some of the elements of market and industry structure that are important for reliability and efficiency are summarised in Table 1.

Table 1 Structural measures

Issue	Relevance	Potential indicators
Intermittent generation	<p>Reliability: High shares of intermittent generation raise challenges for managing quality of supply.</p> <p>Efficiency: Increasing intermittent generation tends to require a higher degree of coordination amongst market participants than other forms of generation.</p> <p>Industry segments: Generation; transmission; wholesale and hedge markets.</p>	Ratio of generation capacity which is intermittent as a proportion of total capacity (MW); ratio of output to potential under 'normal conditions' (MWh); theoretical contribution to peak as proportion of installed capacity; potential rate of change of output at various risk levels; quantity of fast response firm generation (MW); exposure of the system to high load, low wind scenarios.
Embedded generation	<p>Efficiency: Growth in embedded generation affects market-wide trading conditions by altering the amount of energy available for trade and affecting the value of transmission assets.</p> <p>Industry segments: Generation; transmission; distribution.</p>	Share of embedded generation in total supply (MWh).
Diversity of supply	<p>Reliability: System reliability is enhanced by geographic and technological (especially fuel-based) diversity, although efficiency may be undermined if there is duplication.</p> <p>Industry segments: Generation, transmission, wholesale and hedge markets.</p>	Fuel diversification measures such as fuel shares; regional net import and export. Peaking plant capacity and availability.
Hydro capacity and risk	<p>Reliability and efficiency: Increasing or declining water storage and generating capacity in hydro systems, measured in energy stored, affects supply reliability and potentially efficiency.</p> <p>Reliability: In the short and medium term (over months) reliability is significantly affected by hydro inflows and risks of shortage.</p> <p>Efficiency: This can also have implications for efficiency, to the extent that it affects water use and price volatility.</p> <p>Industry segments: Generation; wholesale and hedge markets.</p>	Water storage capacity (GWh), maximum and mean potential in 'normal' conditions (accounting for actual, regulation dependent, as opposed to physical capacity); 'Minzone' measures. Winter energy and capacity margins.
Line length	<p>Efficiency: The length of transmission and distribution lines reflects location decisions of consumers and New Zealand geography, which can limit the productive efficiency of distribution and transmission systems.</p> <p>Industry segments: Transmission; distribution.</p>	Customers per kilometre of line. MW per kilometre of line. Transport (MWh km), transport distance (km), and penetration of distributed generation (share of local network or consumption).

Source: Electricity Authority

4.5 These issues and the related indicators will not always have an obvious upside or downside. In most cases they are simply contextual. However, they provide important information about industry trends and 'exogenous' risks that need to be managed or may promote particular kinds of conduct. Table 2 summarises the conduct measures.

Table 2 Conduct measures

Issue	Relevance	Potential indicators
Forward contracts	<p>Reliability: Robust and transparent long-term pricing incentivises coordinated investment, which matches consumer willingness to pay for reliability.</p> <p>Industry segments: Consumers; wholesale and hedge market; retail.</p>	Robust hedge market prices; contract pricing trends; number of sellers and buyers of long-term traded contracts; average months to maturity.
Investment	<p>Reliability: Persistently low investment (especially in critical reliability equipment) signals potential reliability concerns.</p> <p>Efficiency: Both low and high levels of investment can signal inefficiency.</p> <p>Industry segments: Transmission; distribution.</p>	Investment trends on their own and relative to overseas benchmarks.
Overheads	<p>Efficiency: High or increasing overheads can be an indicator of inefficient management or market arrangements, especially in non-competitive segments of the industry.</p> <p>Industry segments: Transmission; distribution.</p>	Opex benchmarks (\$/MWh, \$/MW).
Demand response	<p>Reliability and efficiency: Increased use of demand response, or advanced metering which facilitates demand response, will enhance the efficiency of the overall system. It may also support low-cost reliability.</p> <p>Industry segments: Consumers; wholesale and hedge market; retail.</p>	Penetration of advanced metering or time of use meters (% of ICPs). Availability (number and variety) and uptake of consumer contracts incorporating incentives for demand response. Proportion of load exposed to prices which signal scarcity; uptake of substitutes.
Water management	<p>Reliability and efficiency: 'Optimal' use of stored water (shifting generation between high inflow-low demand periods to low inflow-high demand periods) affects productive efficiency and security of supply.</p> <p>Industry segments: Generation; wholesale and hedge markets</p>	Trend/index-based measures, e.g. correlation between stored hydro generation and net inflows or high demand periods; model-based assessment of 'optimal' dispatch. Implied market values of stored water (based on market offers).
Maintenance	<p>Reliability and efficiency: Large changes in maintenance expenditure by transmission or distribution asset owners may reflect inefficiencies or signal problems with managing security and reliability.</p> <p>Industry segments: Generation; wholesale and hedge markets.</p>	Annual maintenance expenditure as a share of asset base. Speed of response to faults.
Planned outages	<p>Reliability and efficiency: It is important that participants manage planned outages efficiently,</p>	Planned outage ratio; ⁸ number of planned outages; duration and time of day of planned maintenance; system availability

⁸ E.g.: $[(f \times \text{planned outage hours}) + (\text{equivalent planned derated hours} - \text{equivalent planned derated hours during reserve shutdown}) \times 100] / [\text{service hours} + (f \times \text{planned outage hours})]$, where $f = (1/r + 1/T) / (1/r + 1/T + 1/D)$, where r = average planned outage duration = planned outage hours/number of planned outages, T = average reserve shutdown time/number of attempted starts, D = average demand time = service hours/number of successful starts.

Issue	Relevance	Potential indicators
	<p>particularly to ensure that outages are balanced against the costs to the overall system and to consumers. Planned outages can have significant impacts on system reliability when they put stress on the system.</p> <p>Industry segments: Generation; transmission; distribution.</p>	<p>measures (% of theoretical maximum).</p>

Source: Electricity Authority

- 4.6 The most important element of the SCP framework is measures of conduct. This is as much about monitoring incentives that drive industry behaviour as it is about measuring conduct itself. Thinking about the industry as a whole, this point is particularly acute for monitoring dynamic efficiency, where there are many possible investment and innovation paths and it is very difficult to determine whether a chosen path could be improved upon. So for dynamic efficiency it is critical to ensure that participants have strong incentives to choose an efficient path. With respect to productive and static efficiency it is easier to use benchmarks and other techniques to assess efficiency.
- 4.7 In the case of reliability, this means focusing on whether price signals for investment are operating efficiently, or whether there are adequate incentives for consumers to respond to signals of scarcity. Monitoring reliability in the workably competitive parts of the industry therefore takes in a number of the issues which are important when monitoring competitive pressure.
- 4.8 Measuring conduct in the non-competitive parts of the industry is generally much easier than in the workably competitive parts, though it is by no means straightforward. In the competitive parts of the market, monitoring needs to account for the fact that firms respond to a range of competitive pressures, so what may seem inefficient behaviour or a risk to supply security may reflect the actions of other participants – whether competing producers’ or consumers’ decisions. This is not the case for non-competitive parts of the industry, where conduct is a function of observable behaviours such as investment trends and asset management plans.
- 4.9 Complications do arise, however: it is not always possible to accurately gauge the efficiency of observed behaviours to the extent that they reflect an organisation’s proprietary view of demand and supply conditions as well as the strictures of regulation. Indeed, it is these kinds of complications which commend the ‘reliability-centred monitoring’ discussed below.
- 4.10 In terms of overall industry performance it is important to account for trade-offs and complementarities across each limb of the Authority’s statutory objective. For example, capacity constraints raise questions about reliability and how well the supply system operates under stress. However, participants’ behaviour in response to those constraints is also a question of efficiency, especially for those parts of the market that are not workably competitive. This raises questions about competitive pressure, as participants’ response to constraints in the transmission system or in water availability may result in transient periods where they can influence prices. Similarly, reliability can only be assessed by balancing the trade-off between the cost of additional reliability and the benefits to consumers (in aggregate) of the additional reliability. Taking this approach requires consideration of costs and prices, which adds complexity to the otherwise straightforward physical measurement of reliability levels.

- 4.11 Ultimately, this means that performance measurement ought to be consistent across each of the three limbs of the statutory objective, even though the particular relevance of some structure and conduct performance measures will vary.

Table 3 Performance measures of competition, reliability and efficiency

Measure	Relevance	Potential indicators
Allocative efficiency	Value maximisation: where resource is scarce consumer benefit is maximised by allocating resource to its highest value use.	Extent to which seasonal and diurnal variances in production costs are reflected in prices; correlation between scarcity and prices, particularly during crisis and shortage.
Production efficiency	Cost minimisation.	Trend in reserve margin; actual less risk-rated reserve margins; ratio of energy production to total average capacity; single factor efficiency ratios (e.g. FTEs per MWh); Total Factor Productivity; Loss ratios. Price separation. Constrained-off generation, energy margins, constraints (number occurring). Periods of reserve shortfall. Benchmark analysis of productive efficiency (e.g. stochastic frontier analysis).
Dynamic efficiency	Changes to production processes and resource allocation are required to ensure that allocative and production efficiency are maintained over time.	Measures of retail and wholesale product innovation and investment; rates of adoption of new technology (products and processes).
Technical reliability (and security)	Essential measures of technical performance against which efficiency needs to be measured and risks need to be evaluated.	Supply interruptions (system minutes, SAIDI, SAIFI), loss ratios, reserve margin, energy margin, capacity margin.
Pricing trends	Can compare with own-market forecasts and trends in other markets to check for unusual patterns that might indicate a lack of competition or ineffective incentives for efficient and reliable supply.	Nodal price comparisons; actual vs. forecast comparisons; market load vs. price; forward contract and hedge market prices, bid-ask spreads and correlation with spot market developments. Number of pricing periods where market prices approach estimated value of lost load.

Source: Electricity Authority

- 4.12 Indeed, the Authority's statutory objective can be thought of as having the sole performance metric of minimising resource cost for a given level of service with:

- (a) resource cost measured in terms of prices or costs associated with:
- (i) generation;
 - (ii) ancillary services;
 - (iii) market and system operation;
 - (iv) risk management (e.g. the hedge market);
 - (v) transmission and distribution; and
 - (vi) metering and retailing.
- (b) a 'given level of service' measured in terms of:
- (i) energy served;
 - (ii) 'un-served energy'; and

(iii) likelihood of supply interruptions (i.e. risk).

4.13 In practical terms, more than one performance measure is needed to monitor this overall objective. Table 3 summarises the range of measures the Authority will apply across all three limbs to monitor the overall performance of the industry and market and meet its statutory objective.

Benchmarking

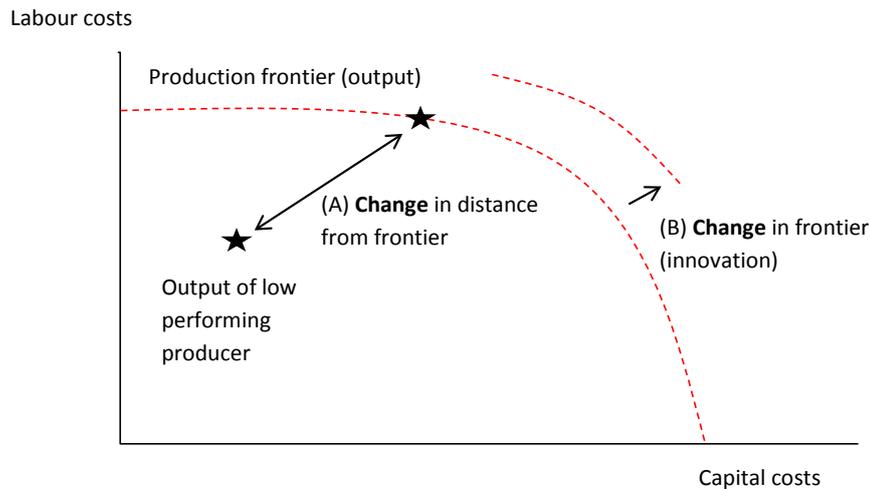
4.14 The information paper on monitoring competition noted that a premium is needed on underlying market conditions that are conducive to competition. This is less so for monitoring efficiency (and reliability). Here the focus includes evaluating actual outcomes and conduct. The main reason for this is that so much of the industry's reliability and efficiency depends on sectors that are not workably competitive.

4.15 Efficiency monitoring is thus concerned with results obtained relative to a specified benchmark (such as in the case of efficiency of resource use), as opposed to 'conditions' for efficiency, which are largely a matter for competition monitoring. The main implication of this is that monitoring performance in terms of reliability and efficiency relies on establishing a benchmark or counterfactual.⁹

4.16 A generalised framework for understanding and measuring efficiency is described in Figure 3. It depicts the frontier of possible production levels with existing technology and management strategies. Production is shown as combinations of capital and labour inputs, and output can only expand beyond the production frontier if there is innovation. In workably competitive markets, processes of improvement (points A and B) result from competitive pressure, which drives efficiency and innovation. Thus the position of firms relative to the production 'frontier' (and indeed the position of the frontier itself) matter less than the incentives that drive efficiency. Conversely, efficiency monitoring, particularly in non-competitive parts of the industry, is concerned with where firms are relative to the frontier. However, when considering performance benchmarks the Authority focuses on improvements in efficiency rather than existing **levels** of efficiency.

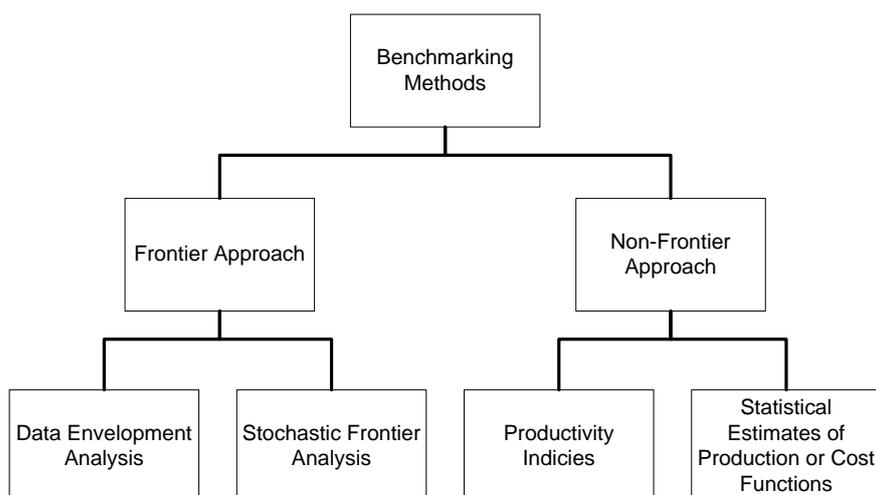
4.17 The dimensions of the production frontier shown in Figure 3 can also be changed from a firm level trade-off between capital (bottom axis) and labour (left axis) costs to, for example, the trade-off between hydro and thermal dispatch as a measure of productive efficiency of generation.

⁹ Thus, the Authority is employing benchmarks and model-based performance estimates that include benchmarks (implicitly or explicitly).

Figure 3 Measuring efficiency

Source: Electricity Authority

- 4.18 There are several approaches to analytical benchmarking. Figure 4 below describes some of the most popular methods used around the world to assess performance in both the public and private sector.
- 4.19 Broadly speaking, these different methods can be divided into frontier and non-frontier methods. Frontier methods attempt to measure how far actual output is from an estimated production frontier(s) and how technological frontiers have shifted over time.
- 4.20 Frontier methods have the advantage that they can be used to distinguish between efficiency improvement and technological advance, and to specify less restrictive assumptions. Frontier methods are particularly useful for comparing or benchmarking performance improvements across an entire industry. This is because they can help to account for differences in operational environments across the industry.
- 4.21 Non-frontier methods measure relative performance across firms or over time with no reference to an 'idealised' frontier. The advantage of non-frontier methods is that they are less data-intensive. In the extreme case, only two observations of one firm at two different time periods are required. Note that 'non-frontier' approaches include productivity indices that are also a central part of other performance measures in terms of market outcomes.

Figure 4 Benchmarking: analytical methods

Source: Electricity Authority

- 4.22 Due to data intensity, explicit frontier-based approaches will therefore be more amenable to in-depth reviews and investigations, while routine reporting is much more likely to monitor changes in simpler measures such as productivity indices. These indices are simpler and easier to understand, and can also be compared against measures used in the context of competition and across market segments.
- 4.23 Implementing any benchmark analysis of productive efficiency will also include using models that can simulate the kind of conduct and outcomes expected from a competitive market, or some other theoretical metric for 'optimal' production efficiency.

Reliability-centred monitoring

- 4.24 The Authority is borrowing from 'reliability-centred maintenance' (RCM) frameworks to create a 'Reliability-Centred Monitoring Regime' (RCMR) to guide bespoke enquiries, in-depth reviews and investigations. Importantly, this framework places functionality for the user at the centre of any maintenance regime. RCM also emphasises the need to:
- clarify the functional components of a system (as opposed to the assets);
 - analyse the potential for failures and consequent effects (formally known as 'failure modes and effects analysis' or FMEA); and
 - design maintenance regimes that reduce functional failures to acceptable rates given maintenance costs and the impacts of failure.
- 4.25 An exhaustive functional analysis of the electricity sector delivery of reliable supply is not intended: the RCMR will be the conceptual framework employed when investigating particular reliability issues. Extending RCM to outcome-focused monitoring of industry reliability can be illustrated in an example such as the under-frequency event of 13 December 2011, which resulted in 560MW of load being shed as a result of Automatic Under-Frequency Load Shedding (AUFLS).¹⁰
- 4.26 At a micro (RCM) level, it is apparent that the protection function 'to protect unit 5 generator, generator transformer, and bus work against over-current' was incorrectly set, and therefore failed. Extending this to the industry (RCMR) level means considering the extent to which the

¹⁰ This event has been reviewed by the Authority (see <http://www.ea.govt.nz/industry/monitoring/enquiries-reviews-investigations/2011/>) and by Transpower.

event represented a hidden failure in industry functions such as ‘coordination and approval of protection settings for connecting generators’. Periodic audit by an independent agency can identify hidden failures in this industry function, or re-design may be needed to provide clear accountability and responsibility, or stronger financial incentives.

5 Relationship to other organisations’ activities

5.1 The Authority is aware that its monitoring activities are similar to those of other organisations. The Authority:

- works with other organisations and regulatory bodies, wherever appropriate, drawing on information and analysis from any pre-existing monitoring processes and focusing on extending or interpreting this information (i.e. adding value rather than duplicating work); and
- seeks to distinguish its activities by focusing on monitoring rather than compliance, particularly where other bodies monitor for compliance with regulatory and statutory requirements.

Drawing on existing monitoring efforts

5.2 The Authority’s monitoring will use pre-existing monitoring, reports and other information already provided periodically. Table 4 summarises existing monitoring activities of other organisations, with examples of relevant publications and data sources.

5.3 The Authority will add value by scrutinising information provided by others, interpreting the information, and helping to ensure consistency and comparability in reporting. The Authority’s industry-wide perspective will also add to the more narrowly focused monitoring activities of others.

Transmission system monitoring

5.4 Transpower provides extensive information about reliability and efficiency in the performance of the transmission system. This information is useful and the Authority will not seek to replicate it. Transpower’s Quality Performance Reports include metrics on, for example: capacity utilisation, duration of supply interruptions, causes of interruptions, financial and cost metrics, and benchmarks of cost and supply quality relative to overseas transmission providers (results from the International Transmission Operations and Maintenance Study – ITOMS). This information is provided transparently even where the results are not favourable to Transpower (i.e. where performance has deteriorated).

5.5 The Authority will, however, compile information provided by Transpower over the years, to ensure comparability amongst reporting periods and to ensure that monitoring is conducted as frequently as feasible.¹¹

5.6 The Authority also reviews existing reporting and analysis by Transpower from a wider industry perspective, including impacts of transmission outages and costs on other parts of the industry. This is necessary because Transpower reports on supply interruptions and costs of reliability as a guide to whether the organisation’s objectives are being met, and also to meet regulatory reporting requirements. This is different to the Authority’s objective.

¹¹ Reliability and costs are currently benchmarked by Transpower every two years and by the Commerce Commission every four years.

Table 4 External monitoring and information sources

Organisation/agency	Monitoring activities	Publications and data sources
Commerce Commission	Distribution business productive efficiency	Electricity information disclosure database
	Distribution business service quality	Electricity information disclosure database
	Grid upgrade approvals	Major capital proposals/approvals
System operator	Hydro risk	Security of supply (weekly) updates; Annual security assessment
	Supply security	Annual security assessment
	Supply quality	System performance reports; operational performance reports
Transpower	Productive efficiency	Annual reports; annual 'Quality Performance Reports'; ITOMS benchmarking studies; Information for disclosure.
	System security	Annual 'Quality Performance Reports'
	Service quality	Annual 'Quality Performance Reports'
Ministry of Economic Development	Long-term demand and investment trends	Electricity demand and generation scenarios; Energy Outlook.

Source: Electricity Authority

- 5.7 The Authority's monitoring is more frequent, which does not mean that the results of its monitoring differ from those of Transpower or the Commerce Commission. However, the broader industry perspective does require monitoring that is differentiated and more frequent in order to understand overall industry development and analyse industry events.

System-wide reliability and supply risks

- 5.8 The system operator provides daily, weekly, monthly, quarterly and annual information on supply events, resource availability (e.g. hydro risk and reserve availability) and supply (capacity and energy) margins. This information is also valuable and the Authority does not see any need for additional primary monitoring. However, the Authority has tools that can be used to further the analysis of the system operator, whose reporting is often limited to primary sources. Models of market and generator behaviour, for example, may be used to determine whether changes in hydro storage or generator offers reflect efficient resource use in the context of current or potential capacity constraints. The Authority will also review adverse supply events that have been investigated by the system operator.¹²
- 5.9 Although the quality of service provided by transmission and distribution systems is a key component of reliability, reliability-centred monitoring may not adequately address issues such as whether regulatory frameworks promote efficient investment patterns.
- 5.10 Monitoring efficiency and reliability takes in aspects of industry performance that are currently regulated by the Commerce Act and overseen by the Commerce Commission. The Authority will

¹² This sort of review will focus on the events in question rather than the performance of the system operator. Monitoring service provider performance is not part of the industry and market monitoring function, at least not in practical terms. The Authority has contracts with a number of service providers for system operation, reconciliation, clearing, pricing, and the provision of a registry and the wholesale information and trading system. The Authority's Operations Development team monitors the performance of these providers.

use the work of the Commerce Commission to inform its own monitoring function and, in particular, will rely on Commerce Commission data compiled from information disclosures on distribution business costs and supply quality.

Efficiency and quality of supply

- 5.11 The Authority needs to extend some of the analysis and monitoring that is conducted by the Commerce Commission, because the Authority has a different perspective.¹³ For example, the Authority:
- (a) is concerned primarily with overall industry performance as opposed to individual organisational performance;
 - (b) is concerned with technical or physical efficiency, at least in the case of reliability monitoring, and is thus concerned with organisational management of technical systems; and
 - (c) is more focused on changes over time and gauging improvements or deficiencies in industry performance.
- 5.12 The Authority may also adopt bespoke benchmark measures that differ from those used by the Commerce Commission and other organisations. This is not to provide alternative absolute measures of performance and efficiency, but rather to determine if measured improvements of service quality are sensitive to alternative benchmarks.
- 5.13 For example, in terms of reliability, the Commerce Commission has decided to gauge Transpower's performance based on quality of service provided during the period 2006-2011. The Authority may consider alternative benchmarks and the sensitivity of performance measurement relative to different benchmarks.

Information exchange

- 5.14 The Authority can also improve its own analyses of industry performance by taking account of other relevant analyses. The Commerce Commission and Ministry of Economic Development also report on long-term reliability and efficiency, by analysing demand and investment trends and investment approvals.
- 5.15 Indeed, all three entities have interests in the kinds of information obtained from market monitoring. They also have an interest in ensuring that monitoring activities are coordinated to avoid unnecessary duplication. The Authority has Memoranda of Understanding with the Commerce Commission and with the Ministry of Economic Development, to coordinate their respective roles. Each entity is required to be independent and must fulfil its own statutory objectives and functions.

Distinguishing monitoring and compliance

- 5.16 The Authority conducts its monitoring independently of compliance functions. This is a key distinction between the Authority's monitoring activities and those of the Commerce Commission and organisations complying with regulatory requirements.
- 5.17 The Authority does have a compliance function under the Act, which requires it to monitor compliance with the Act, regulations under the Act, and the Code. However, industry and market monitoring operate separately and independently from the Authority's compliance monitoring

¹³ The Commerce Commission's role is to promote competition in markets for the long-term benefit of consumers within New Zealand by ensuring compliance with the Commerce Act. This includes investigating conduct that may breach the restrictive trade practices and business acquisitions provisions in the Commerce Act and enforcing compliance with them.

function. Information obtained under the Authority's information-gathering powers for industry and market monitoring will not be used in its compliance function unless the Authority identifies a serious compliance issue that needs to be referred to its compliance function.

- 5.18 The Authority's Chief Executive must authorise the referral of any information from industry and market monitoring to the Authority's compliance monitoring function. In such circumstances, the Authority will notify the relevant person(s) of the referral.
- 5.19 Information and analytical tools used for market monitoring may be used by the Authority's Compliance team, as well as by its Market Operations and Market Design teams.

Appendix A Scope of monitoring activities

- A.1 The main monitoring activities include:
- (a) collecting, processing, storing and disseminating data;
 - (b) building market monitoring infrastructure;
 - (c) routine monitoring;
 - (d) routine screening and testing to identify and quantify potential issues;
 - (e) developing benchmarks and indices to measure and report on all aspects of industry performance;
 - (f) developing and maintaining open source modelling tools and expertise to support quantitative analysis and to automate processes to the maximum extent possible;
 - (g) analysing topics of interest to the Authority in depth; and
 - (h) publishing findings for a range of audiences.
- A.2 The performance of the entire supply chain serving the final electricity consumer is subject to monitoring. This includes:
- (a) the wholesale spot market;
 - (b) the instantaneous reserves markets;
 - (c) other ancillary services markets;
 - (d) transmission services market;
 - (e) distribution services market;
 - (f) the metering market; and
 - (g) the hedge and retail markets.
- A.3 The Authority will prioritise the entries on the Code amendment register and advance specific projects to the annual work plan. A project will then be progressed by either the Market Design or Operations Development teams. Participants will be consulted, and eventually the Code will be amended if a proposal satisfies the Authority's Code amendment principles.
- A.4 On some occasions, matters raised during market monitoring may also be referred to the Ministry of Economic Development; for example, if a policy improvement is indicated.

Appendix B Market facilitation and monitoring infrastructure

Data warehouse project

- B.1 A major initiative that has just been launched is the design and construction of a comprehensive data warehouse. This will enable the Market Performance team to have access to data that is timely, reliable, consistently defined over time, and accessible in a format that can be used in further analysis. In addition, data that is not confidential will be accessible to the general public via a web browser interface.
- B.2 The web browser interface can be used to query, view and download data, and also provides a gateway to extensive reporting capabilities. Many of the simple metrics that can be computed mechanically (i.e. without requiring model-based analysis) are accessible from the data warehouse's reporting facilities. For example, interested parties can request and instantly receive reports and plots on retail switching, generator offers, and many other market performance measures.
- B.3 Basic half-hourly market data such as final nodal prices, demand quantities, network topology, branch flows, and generator offers going back to the establishment of the market in New Zealand are currently being loaded into the data warehouse. Monthly data related to retail has already been loaded. The various ad hoc databases will continue to be incorporated so that the data warehouse becomes the primary repository for data held by the Authority. The data warehouse will supersede the centralised dataset.

Open source modelling tools

- B.4 The Market Performance team develops and maintains a suite of models to support its industry and market monitoring work, as well as the broader Authority work programme. GEM and vSPD are two such models familiar to the sector. Other tools recently developed include:
- (a) 'back-of-the-envelope' Excel-based versions of GEM and vSPD, which can illustrate central concepts in newly designed policies (e.g. scarcity pricing) without all the complexity and realism of the fully functional model; and
 - (b) a visualisation tool for analysing generator offer data.
- B.5 The Authority will continue to make these tools available to interested parties. In the case of vSPD, the data warehouse will automatically produce the daily input file to enable the previous day's final pricing cases to be replicated (and experimented with) within minutes of the pricing manager publishing final prices.
- B.6 Making these tools available fits the Authority's statutory objective to serve the long-term benefit of consumers. It means that a powerful analytical and monitoring capability can be used by parties that could not otherwise access it.

Education and outreach

- B.7 Section 16(1)(f) of the Act requires education and outreach activities to be undertaken as part of the market facilitation function. Accordingly, plain language 'fact sheets' will periodically be prepared and published. These will generally cover enduring concepts and ideas. For example, topics such as the derivation and role of long-run marginal cost or the operation of FTRs are likely candidates for fact sheets to be prepared by the Market Performance team.

Human resources

- B.8 The Market Performance team is led by a General Manager, reporting directly to the Authority's Chief Executive. Nine staff report to the General Manager, Market Performance. Of the nine:
- (a) three work on data acquisition, data cleaning and integrity checking, storage, and dissemination;
 - (b) three provide analytical support to other teams in the Authority – for example, the current scarcity pricing and FTR projects being undertaken by the Authority's Market Design team; and
 - (c) three work full-time on industry and market monitoring.
- B.9 As other work groups build up their own analytical capability, the requirement to have three full-time members of the Market Performance team providing support should diminish. As that occurs, the freed-up capacity will be redeployed in the monitoring function.