COMMISSIONING OF

GENESIS ENERGY'S

HUNTLY UNIT 5

COMBINED CYCLE GAS TURBINE

POWER PLANT

This report has been prepared by the Transpower New Zealand Ltd (as System Operator) in conjunction with Genesis Power Limited.

COMMISSIONING OF GENESIS ENERGY'S HUNTLY UNIT 5 COMBINED CYCLE GAS TURBINE POWER PLANT

Background and overview

Genesis Power Limited (Genesis) and Transpower's System Operator (System Operator) have been jointly involved in commissioning Genesis' new Huntly 5, combined cycle gas turbine power plant. Shortly after completion of the commissioning Genesis and the System Operator conducted a workshop to review how the commissioning process went. The objective of the workshop was to capture the key observations and learnings (both good and not so good) for the benefit of future power plant commissionings. This report includes a necessarily brief account of key aspects of the process as well as identifying the main learnings.

This report is not a comprehensive technical review of the plant commissioning nor of the complete process under the Electricity Governance Regulations and Rules (together 'the Rules'). The interests of other parties, such as the Electricity Commission and other generator/retailers were not represented at the workshop and so their views of the Huntly 5 commissioning are not included. The workshop also focussed on the interactions between Genesis and Transpower as the System Operator, not as Grid Owner.

It should be emphasised the term commissioning in this report in large measure refers to that part of plant commissioning that is of relevance to the System Operator which in particular, involves synchronising of the new plant to the national grid. There are, of course, many aspects of a plant commissioning that are of little or no interest to the System Operator but which are of very great interest and importance to a plant owner and the manufacturer (and associated contractors). Many plant commissioning tests of interest only to the plant owner are carried out at times coincident with or concurrent to tests that are of relevance to the System Operator.

Summary of learnings

The post-commissioning debriefing workshop was a valuable means of capturing key learnings and will undoubtedly be beneficial for commissioning future power plants.

Without diminishing in any way the successful outcomes of the Huntly Unit 5 commissioning, the key learnings. Specific learnings for the commissioning of new large complex generating units are summarised under (e) to (j) as follows:

a) The System Operator should have a commissioning plan template that includes all matters relevant to the needs of the party responsible for power system synchronisation and assurance of plant capability required by the System Operator.

b) The template might contain detailed guidance on the objectives of commissioning tests (being those relevant to the System Operator), the type of tests that should or might be carried out (for different types of plant) and matters such as megawatt profiles, ramp rates and technical details the System Operator will require to assess the potential impact of various tests on the grid and system operations.

c) Asset owner should prepare for commissioning as early as possible. An early project overview document is helpful to the System Operator.

d) Asset owners should? provide more guidance in plant purchase contract documents regarding the nature and purpose of plant operation tests that can be expected during commissioning (a draft Commissioning Plan should be available for use at the earliest appropriate stage of the procurement process).

e) Commissioning parties should carefully assess the resources likely to be required from project start to finish, especially for the commissioning of large complex single generating units including any specialist expertise pertinent to the specific type of power plant being commissioned

f) Consider the level of on-site representation by the System Operator that would be desirable both leading up to and during commissioning for large complex generator commissioning projects where regular System Operator input required.

g) Consider appointing a mutually agreed independent commissioning project manager/facilitator for large complex generator commissioning work

h) Arrange an informal function for all key participants at the outset of detailed planning to get to know each other and, critically, to understand their respective operational environments.

i) Have available the Commissioning Plan, a reasonably tailored draft, or at least a detailed template for the generator/owner of the proposed plant to use at the earliest appropriate stage of contract negotiations with the builder.

j) Prepare a firm policy and agreement on risk sharing in advance, including sanctions for breach of the Commissioning Plan.

k) Asset owners should appreciate and plan for the System Operator's caution in the treatment of risk in relation to commissioning plant. In particular, the System

Operator is unlikely to feel the same level of confidence about plant capabilities that the owner or manufacturer might have.

l) Agree the criteria for when the generating plant will, if at all, be considered a Contingent Event risk or an Extended Contingent Event (ECE) risk during the planned commissioning. This might, for example be:

- CE until demonstrated otherwise
- pass[1] the system ride through test (SRT) [deviation to be defined]
- pass the 100% drop load test
- pass governor response tests
- pass automatic voltage regulator (AVR) injection tests
- obtain confirmation of asset capability from the manufacturer's experts.

These and other minimum prescriptive requirements for commissioning merit further consultation, explanation and agreement with the generation industry.

m) Agree key pre-requisites in advance of commencement of commissioning:

- reserves policy (if required)
- policy on dispensation for under-frequency performance
- commissioning management structure with key personnel having demonstrated commissioning experience
- communications protocol for both the project management team and 'real-time' operations
- the expected test programme (and the purpose of expectations from each test), critical path items and key contractual milestones
- criteria for risk transition (CE-ECE-Normal).

n) Define in the commissioning template when commissioning completion will be regarded as having occurred and include some form of final check list. The definition should be agreed in consultation with industry.

o) Anticipate and recognise in planning – as between the System Operator and the participant – that the expected sequence of plant testing will likely vary considerably and at short notice from that which might be anticipated prior to testing getting underway and that as much flexibility as is possible should be offered by each party.

[1] The agreement should indicate what is expected to constitute a 'pass'

Some of the background contextual issues revealed during the commissioning which were important but largely (if not entirely) outside of the control of Genesis and the System Operator were:

- the location of the CCGT power plant in New Zealand having regard to the region of greatest growth and demand, grid asset capability, and security of supply
- whether more favourable commercial arrangements could and should be able to be obtained during commissioning in respect of procuring instantaneous reserve cover from the market
- how Transpower and the System Operator should be supported given the not inconsiderable resources (circa $0.5M) required to assist in commissioning
- whether the Rules are as helpful as they might be to support commissioning of new power plant of various types and sizes.

Background

Genesis successfully completed commissioning its new combined cycle gas turbine (CCGT) at its Huntly power station in July of 2007. Now known as Huntly Unit 5, but during the project as 'e3p' (Energy Efficiency Enhancement Project), the plant uses a natural gas fired turbine coupled with a heat recovery boiler and steam turbine to generate 385 megawatts of electricity. Unit 5's output with its "cutting edge technology" is expected to meet three years of New Zealand's demand growth and to supply electricity for the equivalent of 350,000 households. It is the largest single shaft generating plant ever commissioned in New Zealand at one time.

A detailed and thorough commissioning process encompassing a series of checks and tests is obviously required before any power plant is permitted to commence full normal operations to supply energy through the national grid. Commissioning therefore involved close cooperation between Genesis and its contractors as the suppliers of the new plant, and Transpower's System Operator as the controller of the national electricity system having the dual roles of facilitating commissioning tests whenever the plant was connected to the grid and fulfilling its regulatory obligations to maintain system security.

Once the commissioning had been largely completed Genesis' and System Operator's main participants in the commissioning process met in August 2007 for a debriefing workshop. The objective of the workshop was to critically review the commissioning

process (in relation to synchronisation of the plant to the power system) from start to finish and to capture the main learnings so that:

- future commissioning projects can start from a better knowledge base
- key aspects of commissioning projects can be managed more effectively.

Project beginnings

The possibility of a combined cycle power plant was first considered by the Electricity Corporation of New Zealand shortly before that organisation disbanded in 1999. Genesis having just become a State Owned Enterprise took the investigation further with a number of technical studies. Tenders were called in 2001, and in 2002 Genesis applied for dispensation for under-frequency performance in anticipation of commissioning its new power plant.

System Operator was consulted during early studies which Genesis and the preferred tenderer carried out. Transpower's Grid Owner[2] had a prominent role in assisting with the precursor project for the building a 220kV grid connection point at Genesis' Huntly switchyard.

Work on constructing the e3p power plant at the Huntly power station site started in 2004, at which time the start of commissioning was scheduled for around August 2006.

Preparing for Commissioning

Genesis prepared a project overview document in 2005 and in February 2006, together with the System Operator, stepped up its preparations for commissioning. Both Genesis and the System Operator formed a team to manage the commissioning process, each party nominating a commissioning manager for coordinating effort and communications. Preparations centred on producing a Commissioning Plan to record all arrangements agreed between Genesis and the System Operator. Genesis submitted a Commissioning Schedule (to form part of the Commissioning Plan) which had been prepared by its main contractor Mitsubishi Heavy Industries Limited (Mitsubishi). Mitsubishi's schedule consisted of a list of the principal commissioning activities and tests with their respective expected durations and overall timeframe. Only a relatively small number of the commissioning tests were relevant to the System Operator's security interests.

[2] The Grid Owner's involvement in the commissioning, while essential, is outside the scope of this report.

Initial commissioning involved the steam turbine and gas turbine. Prior to first admission of steam into the turbine, plant operational commissioning tests involved a process of 'steam blows'. Initially this activity was completed with the unit disconnected from the grid. However, in preparation for first admission of steam, higher pressure and temperature steam was needed for the 'steam blow' process. This required the gas turbine to be synchronised to the grid and lightly loaded for the purpose of producing the required steam.

The milestone of initial synchronisation was significant both technically and commercially as, following this point in the project, all commissioning activities (when connected to the grid) were completed within the electricity market. This required the offering, scheduling and dispatching of e3p into the market in a normal manner. At times when planned commissioning tests were not being carried out, and the plant was running, it was available for production into the power system.

Following initial synchronisation to the grid, turbine tests included combustion tuning at various load steps. The second phase of the process involved generator commissioning, again with synchronisation to the grid. Following commissioning of the combined cycle plant and governor testing the final phase of the commissioning entailed full power performance tests, including a 96 hour full output endurance test and further sustained reliability tests. The System Operator was particularly interested in the possible impact of the following tests on the power system:

- combustion tuning at 25, 50, 75 and 100% of plant output
- load rejection testing at 50, 75 and 100%
- load rejection to house load
- full load runbacks
- generator excitation system load test at 50, 75 and 100%
- demonstration tests for backup systems – e.g. pump failover, UPS, gas compressor trips and such like.

Risk Assessments

Much of the discussion and effort in preparing for commissioning between the parties concerned understanding exactly what the various commissioning tests in the Commissioning Plan entailed, and which of these tests were relevant to the interests of the System Operator so any associated risks could be assessed as best as possible. Genesis carried out a formal risk assessment and risk rated each of the tasks in the schedule. The System Operator carried out its own risk assessment but from the point of view of the impact that the various tests could have on system security.

Risk reviews enabled Genesis and the System Operator to understand and consider ways of mitigating those risks with significant adverse consequences. This allowed adjustments to be made to the test schedule to manage risk. For example, tests such as the 100% load rejection which could threaten security of supply were scheduled for such times as there were sufficient reserves and resilience available in the system.

Under the EGRs, the System Operator in its role of maintaining system security is required to manage events that may lead to under frequency load shedding and ultimately to cascade failure. Thus it has obligations for managing the consequences of events such as the tripping of a relatively large power plant undergoing commissioning. The System Operator actively plans to manage the consequences of such events by making an assessment of likely events in accordance with certain event categories defined in the Policy Statement. This empowers and obligates the System Operator to apply risk mitigation measures by means of the scheduling and dispatch processes, in anticipation of events commensurate with the applicable risk category. Nonetheless, there is an expectation of the generation industry that wherever such risk mitigation measures are called upon by the System Operator they should be clear and justifiable – even if not necessarily agreed with - and because of this, further discussion with the industry to agree the minimum requirements for risk mitigation is merited.

The two risk categories relevant to the Huntly Unit 5 commissioning process were: a ‘Contingent Event’ (CE), where the probability of occurrence and consequences (operation of AUFLS and/or cascade failure) of the event justify cautious pre-event risk management strategies, and an ‘Extended Contingent Event’ (ECE), where the probability of occurrence and consequences of the event do not justify the same level of planning applicable to Contingent Events.

It was anticipated that the primary risk of trip during commissioning could arise from a fault in the e3p power plant or its operation. However, a secondary trip could also occur if the new plant was not resilient to an event caused by another source on the grid. Credible event situations with the potential for serious consequences of concern to the System Operator were:

- loss of the largest other generating unit plus e3p
- loss of the single HVDC pole presenting the greatest risk plus e3p
- loss of the HVDC bipole plus e3p.

There was vigorous debate as to whether and when e3p would pose an ECE or a CE risk during the various tests and stages of the commissioning. ECE or CE status was contentious because the principal planning mitigation involved acquiring instantaneous reserves from other generating sources to protect the power system in the event e3p tripped while connected to the grid during commissioning.

Genesis were understandably most concerned about the times at which the plant would be regarded (by the System Operator) as having CE and ECE status while running and connected. These concerns were held for a number of reasons, not the least of which was that:

- the EGRs (including the Policy Statement) were not in existence when the plant purchase and build contract was let, meaning the requirements of the System Operator at commissioning and synchronisation time were unknown
- the availability and cost of reserves offered through the electricity market was unable to be assured ahead of planned test dates.

There was also an important and material difference of opinion between Genesis and the System Operator as to when ECE or CE status applied. Describing and understanding the reasons for the difference of opinion are not the purpose of this report. Suffice to say each party had materially different views on the risk of trip – especially the secondary risk of trip - and the potential power systems consequences.

The System Operator's views (and the external professional advisor it sought assistance from[3]) were undeniably more cautious than those of Genesis and its contractors. Genesis' view is that consultants may not (unlike the owner or contractor) have sufficient experience in the totality of the commissioning process to gauge operational risk, implying that the

[3] The System Operator's advisor was employed specifically to assist with and to review its approach to the commissioning work (throughout the project) and to provide an international perspective on the commissioning of generic combined cycle gas turbines.

System Operator in being influenced by its advisors was more risk averse than Genesis believed was necessary.

Organisational environment

The operational environments in which Genesis and the System Operator were working within at the time of commissioning, as well as and their respective EGR responsibilities, had an important influence on the parties different views concerning plant risk status. Although sharing the same goal of completing successful commissioning as soon as possible, each organisation had some significantly different responsibilities and drivers. Genesis' strong drivers included commercial and contractual factors in addition to the primary need to demonstrate the plant as being fit for purpose, reliable and meeting the owner's operational requirements. While there was common ground on the need (for the System Operator) to maintain system security throughout the commissioning process, there was less common ground on the evaluation of the risks arising from the commissioning process (and impact on system security)..

The synchronisation and related system commissioning phase was an important part of the e3p project, but for Genesis it was just one relatively small part of a very large and complex project.

The System Operator understood the commercial need to ensure the commissioning was completed as soon as possible. However, at the same time it could not, as a reasonable and prudent system operator, compromise[4] on its strong regulatory imperatives to maintain security of supply. A number of commissioning tests, such as combustion tuning and open loop governor tests on single shaft equipment had, from the System Operator's own experience and that of its advisors, been identified as particular risks from the System Operator's perspective.

The System Operator also had regard to a lack of information about the performance of the model (M701F) of CCGT plant being used for Huntly Unit 5, particularly on an electricity grid with characteristics comparable to New Zealand's grid. This absence of information strengthened System Operator caution regarding the ability of the plant to 'ride through' frequency disturbances of the magnitude experienced in New Zealand.

[4] This is not to say that Genesis asked the System Operator to compromise its views on system security; Genesis acknowledged the absolute need for system security. The debate during the project between the System Operator and Genesis was essentially regarding the degree to which the commissioning plant presented a security risk and how that risk was to be treated.

These considerations along with the System Operator's own detailed knowledge of the grid with its increasingly tighter margins, together with its experience of earlier major plant commissionings and its power system management responsibilities, resulted in the System Operator taking a cautious approach to the commissioning. At the review Genesis reported co-ordination difficulties during the commissioning created a need to convince its commissioning engineers of the System Operator's needs, some of which Genesis itself could not understand and believed were overly conservative.

In agreeing the scheduling of tests many factors had to take into account. From the System Operator's perspective it had to take into account other things happening and scheduled to happen on the system, the forecast load and predicted availability of reserves, the need to fit in urgent scheduled and unscheduled grid outages and other plant commissionings. Amongst other things, Genesis needed to consider the availability of its contractor's staff, preferred test sequencing, market conditions and a variety of other commercial considerations.

To help manage risk Genesis and the System Operator worked together to match the load profiles of the various commissioning tests against models of demand profiles expected on the grid for when the tests were scheduled. Matching these profiles was useful to confirm when grid conditions were likely to be suitable for certain tests to be carried out and to adjust test schedules if needed. Profile matching helped to minimise dependence on reserves.

Commissioning Plan

The e3p Commissioning Plan was agreed between the parties in January 2007 around the time the commissioning tests relevant to the System Operator actually commenced. The plan required Genesis to provide the System Operator with a week-ahead schedule setting out its intentions for commissioning tests in the ensuing period. The week-ahead schedule was reviewed by the System Operator and checks were made for variations from the Commissioning Schedule which was included in the plan. Any changes in the risk profiles of the proposed tests were also checked for. A day-ahead schedule was required to be provided to the System Operator. Although tests could be deferred, a four hour advance cut-off point was agreed so that no changes to proposed tests or any additional tests were permitted where an increase in unit loading was required. This four hour cut-off was found to be about the minimum time required for realistically ensuring reserves would be available, if needed.

The System Operator set up an internal communications procedure amongst the members of its commissioning team which included real time coordinator staff at its National Control Centre, support services staff and other technical specialists. On the day prior to scheduled tests (involving the System Operator) a 'day-ahead' review was undertaken and a preparatory 'Go / No-Go' approval was agreed for Genesis to proceed with the tests. The day-ahead review of proposed testing was done against the backdrop of any other considerations that may have emerged, such as forecast overall grid conditions, planned and unplanned asset outages and the like. If changes to the previously agreed schedule were required on the day of testing, a change request was submitted for consideration by the System Operator. All requests for change were evaluated and actioned by the System Operator commissioning team.

Once the commissioning was underway it was found that major variances occurred between the week-ahead schedules and the day-ahead schedules, notwithstanding the very detailed project planning work Genesis and its contractors had undertaken (and carried out throughout the e3p project). Given how often the week-ahead schedules changed and the effort involved in assessing them, the variations became a source of some stress. But for the fact that the week-ahead schedules helped the System Operator and Grid Owner to plan activities in relation to grid outages reviewing them might have become unworthwhile as they ceased to serve the main purpose for which they had been prepared. In retrospect it became clear the testing programme depended on many things and, to the System Operator, was inherently more changeable than it had expected. Such variability should be anticipated for future commissionings of similar plant.

It appears the Commissioning Schedule provided by Mitsubishi for a typical project was not, as the System Operator believed at the time, one specifically tailored for e3p. The schedule supposed the plant commissioning would take place within a power system that was more flexible and resilient than in New Zealand. Actual plant commissioning tests were planned and carried out by the contractor to demonstrate all of the required plant capabilities. The tests needed for demonstrating certain capabilities for the System Operator were only one part (and a relatively small part at that) of the overall tests required. Further, the tests of interest to the System Operator were not often ones of relevance to the contractor. Thus, while there was no doubt the tests of interest to the System Operator would be carried out, their lack of importance to the contractor meant the scheduling was not always able to best suit the planning and operational needs of the System Operator. This situation plus Genesis' need to consider wider plant commissioning

issues, while perfectly understandable, did result in some planning difficulties between Genesis and System Operator, all of which were overcome.

Furthermore the timing and extent of the System Operator's involvement in the commissioning (essentially well after the plant construction was underway) meant that specific commissioning requirements continued to be negotiated years after the construction contract had been signed. This made the inclusion of commissioning matters relevant to the System Operator less easily achieved. There was, however, no lack of effort by Genesis to achieve the programming of tests to demonstrate plant capability for Part C purposes. .

Thus, changes in commissioning plans should be expected and planned for when commissioning future power plants. Not the least of the reasons for expecting changes in commissioning plans is the relatively small scale of New Zealand power projects for key international suppliers whose stature and overseas experience involve power systems that are larger and more robust than New Zealand's and where less rigid and detailed commissioning schedules can probably be agreed. An understanding of what tests and test outcomes will be of interest to the System Operator when an asset owner is contracting for new plant and taking such maters into account in such contracts would be helpful for all parties to the commissioning process.

Commissioning and the Rules

When Genesis was carrying out its initial studies and preparing the business case for the new combined cycle plant, reference was made to the regulatory framework and combined industry rulebook which prevailed at that time. Transpower's Common Quality Obligations (CQO's) which applied then and were incorporated into the contract with the supplier of the plant were superseded by the Rules. The situation thus arose that Mitsubishi had to meet contractual obligations for a set of rules which were different from the Rules to which the System Operator was required to refer when the commissioning took place several years later. Of particular importance was the lack of any detail in the Rules as to what obligations relevant to system performance and the market Mitsubishi would have to meet and demonstrate when the plant was ultimately commissioned.

Plant contractors will understandably be inclined to interpret the applicable rules and conduct the commissioning of plant in ways that most easily and expeditiously suit them, whilst minimising their costs and contractual obligations. Unless the applicable Rules and the corresponding (and possibly additional) commissioning requirements of the System

Operator are specifically embodied in the contract, it may be difficult to achieve the respective interests of the owner, the contractor and the System Operator. Given the System Operator has no contractual relationship with the contractor there is considerable reliance by all relevant parties upon the contractual relationship between the owner and the contractor. As it happened, there appeared to be sufficient goodwill amongst all parties to resolve technical issues, negotiate testing requirements and achieve a successful commissioning outcome despite real difficulties arising from the Rules and the needs (under the Rules) advised by the System Operator.

Nevertheless this experience did foreshadow a number of aspects of the present Rules for which further consideration is desirable. Aside from a view that the Rules are generally light on commissioning, there is also the view that it would be helpful if they better covered, directly or indirectly, certain important aspects of commissioning such as: test plan and acceptance requirements, grid outage management, procurement of instantaneous reserves, concurrent plant commissionings[5] and conditions under which commissioning activities should be temporarily held in abeyance.

A greater level of detail in the Rules or in a document mandated by the Rules (probably a System Operator document which provides specific detailed commissioning requirements consistent with the Rules) would be useful for future power plant contracts. However, there is a need to be mindful of the risks of prospective contractors being uninterested in tendering on contracts which, by international standards are relatively small and onerous, and the possibility of cost penalties for risk management compliance if they are prepared to tender. Even so, security of supply still needs to be balanced against these factors.

Commissioning Plan

A Commissioning Plan was developed in conjunction with the System Operator during 2006. This described the expected tests of relevance to the System Operator in greater detail and was intended for the System Operator to gain assurance on managing risk

[5] It was found that stricter rules and greater clarity are required to deal with managing the risks of concurrent testing of power plants. What is meant by concurrent testing, how, and when concurrent testing may occur or must be limited remain to be clarified. What constitutes a secondary system risk should also be defined and agreed in advance since debates of this kind during commissioning can be very distracting and add unnecessary tension.

particularly when the plant is synchronised to the grid. A large proportion of the Commissioning Plan comprised test procedures and a dispatch guide intended for co-ordinating security dispatch and traders. More information was needed by the System Operator to assess risks than was contained in the Commissioning Plan. It would have been helpful if the plan had contained better descriptions of what the tests were for and more information on such things as megawatt profiles, ramp rates and technical details required to assess the potential impact of various tests on the grid and system operations. The information expectations of the System Operator could well be included in the Commissioning Plan template and mandated in the Rules (as noted above).

Nature of tests

To a limited extent, the proposed test plan regime (currently being addressed by the Commission as changes to the Rules) could be expected to provide guidance for plant owners and their contractors to determine what tests should be carried out when commissioning new plant. However, in practice the guidance is likely to be limited. Genesis suggested the proposed test plan should be updated with greater clarity around the System Operator's technical expectations and the plant owner's obligations. It should also contain better definitions on what constitutes passing or failing a test, and be based upon industry agreement on performance requirements such as what plant performance models are required and what the relevant parameters are. It was agreed that a revised test plan should deal with different types of power plant, be that a combined cycle gas turbine, hydroelectric turbine or wind power plant.

In the absence of better guidance in the test plan, detail of tests and desired outcomes relevant to the System Operator should be included in the Commissioning Plan and, ideally, be identified early in the plant contracting arrangements so as to make the contractor's commissioning obligations clear.

Other information identified during the project as being usefully included in a Commissioning Plan is:

- rules of engagement (who talks with whom)
- what items are on the critical path
- key contractual milestones for the System Operator's information
- clear transition points from one phase to another
- criteria and definitions for making transitions from one phase to another (e.g. pass/fail)

- all expectations (including any variations for different types of power plant) clearly documented.

It was agreed that it would be useful if the Commissioning Plan provided some form of mediation or means for resolving administrative and procedural differences at a higher level[6].

There were some difficulties in obtaining more detailed commissioning information to satisfy requests from the System Operator. This was attributable in part to information having to come from the contractor which had no contractual obligation to do so. Sometimes this was because of misunderstandings about precisely what type of information was required. Ultimately, however, notwithstanding the provision of significant amounts of technical and operational information related to the commissioning plant, including in relation to commissionings elsewhere in the world, the System Operator did not develop sufficient comfort regarding the possibility of a secondary tripping during e3p testing to feel comfortable in allowing some tests to proceed in the absence of special reserves provisions to cover the contingency of secondary trip.

The commissioning experience showed that the e3p plant, while it suffered a number of primary trips during the testing period, did not in fact experience a secondary trip during the relevant period. It is noted, however, the lowest frequency experienced on the system during the relevant period was 49.48Hz which occurred during a planned system ride through test. There were several under frequency system events during the commissioning period but in each case e3p was not connected and operating.

The Commissioning Plan was agreed on the 25th January 2007 with initial synchronisation and commissioning commencing on the 2nd of February 2007. If the System Operator's requirements had been known in advance, then stronger contractual arrangements, perhaps by way of Special Conditions to the Contract, could have been put in place. Having the Commissioning Plan with a clear outline of expected system-related tests available prior to the start of commissioning would have reduced the number of queries and been more efficient for all involved.

Resourcing

[6] It is not intended that System Operator decisions in relation to the power system (e.g. its determination of when the risk of trip of a commissioning asset is or is not an event for which specific planning actions should be taken) would be the subject of mediation or other means. Such decisions are managed through the EGRs and the relevant mechanisms thereunder.

The System Operator's involvement ramped up in mid 2005 with the pre-commissioning preparations and various risk management initiatives mentioned previously. As the commissioning progressed it became apparent that considerable resources and a range of specialist expertise within Transpower were required. The project was even more complex than the System Operator had anticipated and may have been very difficult to manage with existing resources had the commissioning not been delayed because of construction delays. Unlike Genesis, which had people and funds specifically allocated to the e3p project and to the commissioning, the System Operator had to fit this extended, complex and critical project into its existing work streams, largely without additional personnel and budgets.

Transpower was also somewhat under-resourced in relevant specialist engineering fields and there were other pressures for resources being exerted by concurrent major upgrades to market and SCADA systems going on within Transpower, the impact of which had not (and could not) have been anticipated when construction of the plant was being contracted. Nor also was the need to amend the System Operator's reserve management tool considered or even thought likely as the preparations for commissioning got underway. Ultimately, some changes to the Reserve Management Tool (RMT) and additional training were needed before commissioning could proceed. These pressures caused small but undesirable delays in approvals for Genesis and complicated the overall commissioning work programme.

Also complicating the commissioning activities were resourcing issues around tests planned for holiday periods, caused by program slippage. The System Operator, under its mandate to facilitate commissioning as quickly as possible, felt that it was effectively being driven by a commissioning schedule being set by Genesis' contractor, a situation that also caused resourcing problems for Genesis.

As things transpired and with the delayed schedule, both Genesis and the System Operator thought that their own level of resourcing for the commissioning was satisfactory even if they didn't quite believe each other's claims.

The System Operator did not (nor could it be expected to) have sufficient in-depth in-house technical expertise on CCGT technology and plant. So, in light of the criticality of the project to both Genesis and system security, the System Operator engaged external technical advisors to assist both with understanding the technical elements of the CCGT plant operation and commissioning relevant to synchronisation, and to consider the

elements of risk the commissioning process introduced. Two contractors[7] engaged for these purposes provided assistance on an as-required basis and assisted with the necessary assessment work whilst also giving an independent review of the System Operator's own work in critical areas.

Communications

Maintaining appropriate communications was a vital and mostly successful element of the project. There was clearly a need to share specialist power systems know-how and CCGT knowledge across Genesis and the System Operator. It was helpful that each party had its own independent specialist engineering advisors with international experience.

A communications protocol was established early. It was included in early drafts of the Commissioning Plan, essentially calling for channelling and coordinating all communications through each party's Commissioning Manager. The System Operator's Commissioning Manager was selected specifically to have the skills and status to ensure cross-functional matters within System Operator were effectively managed.

Commissioning planning meetings were held regularly, at alternating venues. The meetings were generally productive, and progressively worked through matters associated with the test schedule. However there were some issues that were repeatedly canvassed where unanimity of approach was not reached. The revisited discussions emphasised the importance for parties agreeing an effective process for managing issues where a material difference of view became apparent.

Email communications in accordance with the established protocol generally worked well. On a few occasions when the protocol was not observed problems did arise, making the virtue of adherence to protocol very evident. Adopting a sequential numbering protocol for future projects would be helpful in future projects. Delays sometimes occurred when there were misunderstandings concerning what was being said, what was really required and how it was being said – a certain amount of goodwill being necessary in order to be really helpful. The importance of maintaining goodwill under what were often stressful times

[7] It should be noted the two contractors did not have plant-specific knowledge and were not engaged to advise specifically in regard to the technical or commissioning attributes of the Mitsubishi plant.

during commissioning cannot be overstated; on some occasions communications were undermined through email communication.

When written requests had greater implications and took longer to answer than the requester may have thought, it would have been helpful to explain that this alone was the case. Sometimes meetings proved to be more effective. In hindsight it may have been productive to have had an independent person for chairing some meetings, taking and circulating minutes, producing action lists and following up issues through to resolution. This might have assisted the progress of meetings where contentious issues were discussed and, on occasions, not resolved.

It helped to have a System Operator representative on site when key commissioning tests were being carried out. To improve information exchange and knowledge transfer in future projects, Genesis recommend that consideration be given to incorporating a System Operator engineer into the plant owner's internal review and engineering processes leading up to commissioning as well.

Although the commissioning plan was managed by a small number of System Operator personnel, in fact, depending on the specifics of a decision required, relevant aspects of queries and decisions were in fact widely canvassed amongst specialists within System Operations and more widely within Transpower, and outside if necessary. Sometimes the views of the Electricity Commission or the potential implications of decisions on the industry had to be considered as well (specifically, the consequences of reserves requirements)[8]. Greater understanding of how each party processed information and information requests would have assisted the ease with which matters were dealt with, especially when time pressures were evident.

It was agreed it would be useful for future Commissioning Plans to establish guidelines for gaining needed approvals from Transpower, including what to ask and how much time to allow.

Communications with external parties were also required. The System Operator agreed it would release Customer Advice Notices advising industry participants several days before

[8] For instance, the System Operator was keen to ensure the Electricity Commission and the industry were aware of its adopted approach to contingent events and the consequence for the industry regarding the need for reserves at times when certain testing was scheduled. The November 2006 industry briefing was arranged to ensure elements of the commissioning test arrangements were well known.

any planned drop load test and system ride through test was scheduled to occur. Recurring movement in commissioning programmes eventuated in customer advice notices being released the 'day-before' a planned test. High levels of interest from generators and the market created further requests for information, not all of which could be answered when commercial sensitivities for Genesis were involved. The System Operator held an industry briefing meeting in late November 2006. Genesis issued a useful market statement explaining the status of the project.

A single point of contact into Transpower for the duration of the project – not just the commissioning phase, for which the System Operator did have one – would have been helpful for Genesis in working with the Grid Owner, the System Operator and others at the different stages of the project. Plant owners' project plans would benefit from including key milestones in relation to commissioning activities with the System Operator and the Grid owner to expressly cater for better information exchange.

End of Commissioning

In July 2007, once the commissioning was substantially completed, the contractor reduced its presence on site. There continued to be a range of adjustments and fine tuning of the plant.

Genesis questioned how 'completion' of commissioning is defined, particularly since the industry would say that fine tuning and adjustments continue asymptotically for a number of years. An Engineers' Certificate is likely to be issued two years after 'substantial completion'. At completion of commissioning tests and the activities agreed in the Commissioning Plan Genesis submitted all test results for the System Operator to carry out a 'final assessment' as provided for under the EGRs.

It was agreed the System Operator needed to better define when commissioning completion occurs and, in doing so, consult with the industry. It was also agreed that some form of final checklist would be prepared and included in a plan template. It is envisaged the final checklist would contain certain acceptance tests and criteria for achieving functional completion, beyond which point the commissioning plant will be considered a normally operating generator and as such, no longer eligible for further exemptions for commissioning. The practical end point for the System Operator might, for instance, be aligned with a milestone or milestones in the plant construction contract, such as the point at which the contractor hands over the project to the owner. It should take into account that the contractor's staffing levels and expertise peels away towards the end of the project

which can make final checks and requests for information increasingly difficult for the plant owner to provide easily. The goal is to provide a methodology for reference in future contracts and commissioning plans.