PRICEWATERHOUSECOOPERS

Transpower New Zealand Limited

High Level Assessment of Transpower's Operational Performance during the Auckland System Incident on 12 June 2006

23 June 2006

High Level Assessment

Independent assessment of Transpower's operational performance during the Auckland system incident on 12 June

We have prepared this report to provide management with our independent assessment of Transpower's operational performance in managing the events leading up to, during and following the Auckland incident of 12 June. This work was undertaken at the request of Ralph Craven, Chief Executive Officer.

The events of 12 June should be recognised as being exceptional, rare and extreme by world standards. We understand that multiple, almost simultaneous contingencies, occurred within extremely adverse weather conditions and during a period of high stress to the high voltage transmission system (national grid). Contingency events, caused by the extremely adverse weather in both the North and South Islands, challenged the overall system reliability.

Our high level assessment of Transpower's operational performance was performed by Ian Grubb during 19 to 22 June. Our assessment commenced on Monday 19 June with discussions with Transpower Grid and System Operator managers, and involved the collection of all available relevant data and internal reports for subsequent review and discussion over the following 3 days.

The time constraints imposed by the need for an independent assessment over four days has necessitated that this report focus on the key issues. Our reported findings are high level and highlight areas that warrant further detailed examination.

Our assessment was of necessity limited to an investigation and analysis of Transpower supplied data and records, and is based on the information current at the time of our assessment. We have not assessed any design issues associated with this incident.

We have also not interviewed other market system stakeholders to asses their views. A follow up review involving other Electricity Industry stakeholders may prove valuable in capturing the industry's reflections on the event.

Scope of assessment

Our assessment activities focussed on the following key areas:

- Initial:
  - system conditions and weather forecasts
  - conditions of data systems, information systems and system analysis tools
  - resources and staffing arrangements.

- Operational performance during the fault, including:
  - fault identification, performance of alarms systems, analysis tools and the SCADA/EMS system
  - communications performance.

- Operational performance during the recovery, including:
  - the decision making process
  - performance of decision support tools
  - performance/response of various Transpower operational groups
  - performance of operational communication systems
  - reporting, compliance, business process adequacy and safety issues
  - market impacts
  - restoration delays, possible causes and lessons learnt.

Our experience to conduct an assessment of Transpower's operational performance

Ian Grubb has over 45 years of extensive international operational experience in all facets of the Electricity Industry. Ian has held a number of senior management positions in System Operations, Transmission and Generation organisations in Australia, and served on many committees responsible for developments in the Australian Electricity Industry.

For the past 11 years, Ian has advised clients as a consultant in New Zealand (Transpower), Australia (Southern Hydro, Power Net and Singapore Power as the new national Australian market was established), the USA (California market establishment), New England ISO (as VP Operations and later as consultant to CEO on market issues), Thailand (market design, market rules and onsite project management), China (market design and contracts), Pakistan (market design), Philippines (market design) and Korea (market operations).

PwC has strong global Electicity Industry experience, where we have demonstrated an understanding of our clients business, the quality of our people and our ability to achieve results.

Executive Summary

Our view

Based on our high level assessment of Transpower's operational performance in managing the events leading up to, during and following the Auckland incident of 12 June, we consider the operational response by Transpower to be appropriate and commendable considering the severe weather conditions and stress that the national grid and its operatives were under at the time.

Management's investment in resources and skills training of staff over the past 12 months has contributed positively to Transpower's operational response.

It should be acknowledged that this particular type of fault exceeded usual n-1 (single contingency survival) system design parameters.

Our assessment has highlighted a number of lessons to be learnt from major incidents such as 12 June. Some of the issues that occurred during the incident need further studies and action. Transpower management is already addressing some of these matters. The most pressing being the need to:

- quickly assess likely outage times
- ensure all key operating bodies are informed in a timely fashion
- ensure appropriate arrangements are in place to manage the media.

Our reported findings represent our independent consideration and assessment of the information presented to us to date by Transpower.

As our high level assessment was limited to 4 days, our report should be considered an Interim report pending further dialogue with other industry stakeholders.

We suggest an industry wide operational forum to review all stakeholders' actions and experiences with a view to updating standing plans, communications plans and links, and media management.

Key findings

We understand that 12 June presented Transpower with extremely adverse weather conditions in both Islands. Multiple contingencies requiring complex operational requirements began occurring early in the day in the South Island. To its credit, Transpower implemented operational management arrangements early in the day that strengthened its ability to handle the unfolding events.

When the Auckland event occurred, Transpower was able to quickly identify the cause, assemble the necessary resources, action a recovery plan and safely implement repairs. Recovery time was largely constrained by the extremely adverse weather conditions at the site of the fault.

We are not aware of any Transpower primary or auxiliary plant abnormalities occurring during the recovery period that inhibited Transpower's operational response and recovery efforts. Following the event, Transpower initiated internal reviews of operational performance.

Taking into account the system conditions of the day and the difficulties encountered, Transpower operational and field staff have generally performed well. Based on the operational information supplied and reviewed at the date of our report, in our view the recovery time for the Transpower plant involved was not unreasonable.

Key areas for further consideration during Transpower's internal review:

- Decision making regarding recovery options. A further internal review of the decision making routines currently in use would be of value. Existing arrangements may be satisfactory for simple outages but more complex events, such as 12 June, highlight some challenges.

- Some of the systems supplying decision support tools suffered a capacity overload. A review of the policies to manage such capacity overloads during tight system events is needed. The solution should not place undue work loads on the System Operator staff to manage this problem.

- Some of Transpower's communication systems became heavily loaded with unnecessary non-operational users during 12 June. A review of the communication systems used, including filtering mechanisms to deflect unwanted traffic, should be performed.

Key observations that became evident during our assessment that should be recognised:

- Generally, operational staff displayed the benefits of increased training received over the last 12 months.
- Management was prepared and able to deploy appropriate additional staffing arrangements to provide adequate skilled support to the system operatives during 12 June.
- Management and staff were able to overcome some technical analytical tool problems and continue to perform Transpower's role in operating the Market.
- Some delays in restoring customers were outside Transpower's control.
- Further consultation with stakeholders to review the industry's response and experience during this event would be valuable. It is understood that the organisational forums to facilitate this already exist.

Detailed findings

Our detailed findings arising from our assessment are provided in the following section of this report and address:

- initial positions
- operational performance during the fault
- operational performance during the recovery
- lessons learnt and positives gained.

Limitations of our work

Our high level assessment was performed during 19 to 22 June and we have relied on the information provided by Transpower as being complete and accurate at the time it was given.

Our high level assessment was limited to the documentation provided by Transpower, and consisted primarily of reading the documents made available, applying limited verification and analytical review procedures, and enquiries. During our high level assessment, we obtained all the information and explanations that we considered necessary.

Our high level assessment of the documentation provided did not involve any testing of the operational assumptions and judgmental decisions made by management. We also did not test the detail information supporting management decisions.

Our high level assessment does not constitute an audit performed in accordance with New Zealand Auditing Standards and, accordingly, we do not express an audit opinion.

Use of our report

Our report has been prepared solely for the use of Transpower New Zealand Limited. It is not intended for general circulation or publication, and no one other than Transpower should rely on this report for any purpose. We do not accept responsibility for losses caused to any person as a result of the circulation, reproduction or use of our report, or part thereof, contrary to this paragraph.

We understand that our report may be provided to other parties (referred to collectively as the Third Parties or individually as a Third Party). If copies of our report are made available to the Third Parties we accept no liability or responsibility to them.

We would be pleased to discuss with Transpower any further actions which may be required as a result of this report. Please do not hesitate to contact me directly by telephone (09 355 8045) or email (chris.perree@nz.pwc.com).

PricewaterhouseCoopers

Date: 23 June 2006

Chris Perree
Partner
PricewaterhouseCoopers

Initial Position as Events Unfolded

Initial system conditions

We understand that severe weather conditions had existed in the South Island for the preceding 24 hours. This contributed to a considerable increase in operational activity being managed by both the National Co-ordination Centres (NCC's) and the respective Regional Operational Centres (ROC's). A combination of forced circuit outages and pre-existing circuit constraints placed security of the north of the South Island and the west coast at risk. The Industry had been placed on alert by the System Operator for possible load management measures over the evening peak. As it eventuated, Transpower was able to repair and return to service plant in time to avoid shedding.

Weather forecasts indicated that severe weather conditions were expected to move North and affect the North Island Grid over the following 24 hour period. This raised concerns for security of supply to the lower North Island. Forced circuit outages as a result of wind damage was threatening reliability of supply to Wellington. A grid emergency was declared by the System Operator between 0221 to 0700 on 12 June.

A review of impending planned outages in the North Island resulted in a decision to reschedule and defer an outage that would have affected Auckland. Consequently, the section of the grid supplying Auckland was in a system normal state.

There were no protection scheme works planned and the grid protection systems were in a system normal state.

The SCADA/EMS systems supplying information and control data to the NCC's and ROC's were operating normally, with no planned work likely to impact on their performance.

Operational communications systems were operating normally.

By 3am on 12 June an increase in line tripping due to heavy snow loads was causing concern. Arrangements were made to strengthen staffing and a support arrangement in the NCC's to cope with what was appearing to be an increasingly busy day ahead.

By early morning a Maui Gas contingency was declared, adding to the evolving day's events. By late afternoon this had not been resolved and operation plans were being prepared to manage the evening peak with a short fall of thermal energy. Whilst this event was resolved during the afternoon in time to avoid an affect on supply, it created additional abnormal work load requirements at the time the NCC was managing the energy and voltage support issues created by the Auckland event.

Operational Performance during the Fault

The fault

Our assessment of Transpower's operational performance during the fault focussed on the following key areas.

At Otahuhu substation at approximately 0832, a failure of two earth wires (wires strung on top of tower lines to provide lightning protection to HV conductors slung beneath them) resulted in the wires dropping onto three 110kv buses and one 220kv line below them. This resulted in a major bus fault developing, which contributed to a considerable disruption to a major portion of the electricity supply to the City of Auckland.

The resulting fault was cleared by the appropriate protection within design parameters, but approximately 740MW of customer load was lost and approximately 427 MW of generation capacity was lost.

North Island system load at the time of the fault was approximately 3,939MW and fell to approximately 3000MW. Some 200MW of the reduction was assumed to be as a result of voltage depression and/or frequency effects during the fault.

Observed frequency swings indicate a maximum deviation of 50.8 HZ occurred during the fault and the fault clearance.

SCADA/EMS systems captured the detail of the event and provided visible evidence to both the NCC's and local ROC.

Alarm systems provided all the appropriate information regarding the events, although the usual problem of "swamping" appears to have occurred. We elaborate on this problem in later sections of our report.

Time stamped data logs recorded the events. Subsequent evaluation of these logs indicates some minor timing differences from other logs (Voice) but the differences are not significant in the evaluation of the event.

Staffing at the NCC's was further strengthened by additional personnel and control arrangements altered to provide a dedicated focal point for managing North Island security. Another security co-coordinator was assigned South Island responsibility in-lieu of the normal one security coordinator for both Islands.

The Crisis Centre at Wellington NCC was activated and additional technical support staff arranged to provide offline analysis tool support to the online controllers.

Within Transpower's Grid organisation, regular meetings were held between Grid Operations and Maintenance staff to co-ordinate restoration. At the Northern ROC, online and offline support staff were also strengthened.

Staff at the Transfield depot near the Otahuhu substation observed the fault (reported as 4 distinct flashes) and dispatched staff within 3 minutes to ascertain what had occurred. Lines maintenance contractor staff arrived onsite within 30 minutes and commenced planning recovery actions to remove the earth wires from the various affected plant.

Up until this point, our assessment identified no communication problems. Refer Appendix 1 for the NCC management supplied timeline report covering the incident.

Operational Performance during the Recovery

Our assessment of Transpower's operational performance during the recovery focussed on the following key areas.

Operational records and logs

From the documents supplied by the NCC and ROC relating to the recovery process, there are some discrepancies in timing regarding the identification of what had actually transpired at Otahuhu. The records from the ROC indicate they advised the NCC at 0834 of the fault and by 0834 the ROC had assessed the nature of the fault.

It is acknowledged that records and logs derive their time stamps from various sources and some minor timing discrepancies can occur during major events such as this. The ROC records also indicate that at 0846 the Transpower Stations Manager advised the Transpower Communications Manager that the repairs and restoration would take approximately 3 hours. There is no evidence that the contents of this call reached the NCC operational staff. We are informed that a check of voice recording tapes is underway.

The NCC logs indicate that the NCC initiated a call to the ROC at 0850 seeking advice as to what had happened. Upon receiving the advice, the NCC inquired as to whether a Change to Offer (CTO) would be made and were advised a further assessment was in the process of being made.

At this point (0850), the NCC verbally declared a grid emergency.

Logs indicate that by 0903 switching had commenced according to the prepared Contingency Plan.

At 0955 the NCC logs indicate that the ROC was again reminded of the need for a CTO for Auckland area. We could find no record of when the CTO for the affected plant was made. It is acknowledged that although a formal CTO offer was not made, dialogue between the NCC and ROC over progress of assessment and repairs was occurring.

Other entries in the ROC log indicate that preliminary advice had been made to the appropriate stakeholders and customers by 0856.

It would appear from the ROC records that procedures were followed to notify the appropriate external stakeholders. Grid management concede that the ROC may not have informed the System Operator immediately after the event. It is noted that both the ROC and NCC share common SCADA information.

Recovery planning

Consultation between the NCC and ROC, regarding their assessment of options available based on information current at the time, resulted in a decision to utilise existing contingency plans modified as necessary to suit the circumstances. This involved focusing on preparing alternate circuits through another substations utilising a 220kV connection back to Otahuhu. This was based on the presumption of the 220kV ties becoming available in a shorter time span than the 110kv buses at Otahuhu. This assumption later proved to be incorrect as the magnitude of the repairs unfolded.

It would appear from the NCC logs that accurate assessments of the situation concerning the 220kv option was proving difficult due to the inability to obtain a clear estimate of repair times. The initial strategy was to clear the earth wire from the 220kV circuits but it was established that because of the various safety permits required it would be quicker to remove the earth wire from the 110kV busses.

At approximately 10am, the ROC field staff had completed an updated assessment of the situation and agreed to focus on clearing the 110kV buses as the best and quickest option.

We understand that the weather conditions onsite were not conducive to safe working conditions and the efforts made in the field involved conditions that would not normally be worked in. This was probably a significant factor in determining accurate return times.

Tools and systems performance

Log entries indicate that the NCC started having problems with some of their support tools at approximately 0900.

The SCADA/EMS systems started to run slow and though no control functions were interrupted, some of the EMS applications became so slow as to be of little value. The NCC requested Transpower IT to help to improve the performance of the systems.

During the recovery period some of the market system applications also failed to operate.

Preliminary advice from IT indicated that they were experiencing an excessive number of users logging into the various systems and creating congestion above the original design specifications of the various systems. The response suggested was to disable unnecessary users, most of which would probably be within the System Operator.

We understand that IT have no other mechanism to achieve the rapid disabling of other Transpower and contractor system users. This issue needs further attention both from an equipment and policy basis.

Regarding performance of the alarms systems, both the NCC and ROC reported that apparently the alarm systems functioned to deliver a vast volume of alarms associated with the disturbance. The risk of "swamping" the operatives with too many alarms is always present in situations such as this. The operatives in the various control centres did not report any alarm system overload situations.

We recommend that a post event review of the alarm systems be performed to examine the appropriateness and classifications of alarms generated during this incident. Particularly as Transpower is in the process of implementing new and upgraded systems.

Despite the preceding short comings, we understand no Rule breaches were incurred by Transpower.

Communications performance

As would be expected, both the NCC and ROC reported increased communications traffic. Whilst no communications issues arose between the control centres, field operatives reported difficulties communicating using their mobile phones. Congestion on the mobile network made calls into the ROC from the field difficult and the existing landline links were subjected to a large number of general public calls vying for priority with operational calls.

Communications between field staff and the ROC were also possible using trunk mobile radio and using Transpower's speech network phones at substations. The ROC reports flag the need for a better filtering system to screen incoming calls and divert non-operational calls to an appropriate call management centre.

A disturbing event was the apparent breaching of confidentiality of the NCC call numbers, with some non-operational calls and media calls getting through to what were thought to be confidential NCC numbers.

The impact of congestion on the Distribution company's communications links is unknown at this stage and is recommended as an issue to be reviewed in the future.

Vector has a Transpower speech network phone in the control room which assisted in direct operational communications.

Plant Performance during the outage

No problems were reported with plant auxiliaries during the outage (ie. batteries, CB closing mechanisms). A short delay occurred closing some bus ties during the restoration process due to some protection targets being overlooked, but the delay was minimal.

Reporting, compliance, business process adequacy and safety

The initial internal review of the reporting performed by Transpower indicates that it complied with its obligations under the Electricity Regulations for the Grid emergency situation it found itself in.

During recovery some unusual voltage swings may have occurred on some grid assets and some distribution assets but the known excursions were viewed as acceptable during an emergency such as this event.

There is no evidence at this point of time of any reportable breaches incurred by Transpower during the recovery.

During the recovery, safety of the work force in the extreme weather conditions was of prime concern. No injuries or further plant damage during the restoration process indicates that the repairs were carried out efficiently and safely using proven procedures.

We understand some Generators may have felt deprived of some of the forward market information they are use to and may have been concerned by some of the information they were receiving (eg. unusual infeasible prices due to forward load forecast errors). However, generally there has been no negative feedback at this point of time.

No business process inadequacy issues have arisen to date.

Training programs, which have been strengthened in the past 12 months and involve considerable simulator training for such events, have proved invaluable.

Staffing levels, which were increased during the past 12 months to facilitate increased training, enabled Transpower to be well placed resource wise to manage this type of emergency.

Market impacts

Other than the failures due to capacity saturation with some of the market data base users mentioned previously within this report, we understand the market operation continued during the emergency period. We are not, at the date of our report, aware of any significant financial impacts due Transpower's performance during this event.

Further work is required to protect any of the market based (and EMS) systems in the period leading up to their replacement or upgrading. It should be noted that Transpower continued to operate the market throughout the incident without the need to provide any notification of suspending the market.

Transpower should ensure that the new market systems under development have sufficient capacity to cope with events such as 12 June incident.

Restoration issues

We understand that the initial field response for the 12 June incident was extremely short. Transpower substation maintenance staff were onsite within 3 minutes due to the fortunate fact the faulted substation is physically located alongside the Transfield depot and the fault occurred during normal work hours. By 0850 Transpower line maintenance contractors were onsite.

The fact that the fault occurred during working hours was also fortunate for the Transpower support staff that were also able to respond quickly to provide valued support to the online control centres.

Whilst it is understood that standby arrangements are in place to cover the out of hour's emergency situation, the short comings of use of mobile phones in black outs for key communications needs careful consideration. It is understood Fleet link (a radio based system) is available for field mobile communications. Transpower also has its own speech network with phones at key stations. Transpower also has use of a pager system.

Restoration issues

Radio use priorities for situations such as this event should be reviewed.

It is noted that field resources (both personnel and equipment) were onsite extremely quickly and did not contribute to any identifiable delays.

It should also be noted that whilst in this incident, field response was extremely quick; decision making over the appropriate methods to be used and the likely timeframes involved became drawn out. This is because it took a while to determine the most appropriate safe method to remove the earth wires in the prevailing conditions. We acknowledge that prevailing weather conditions made accurate estimating difficult.

It is suggested that Transpower examines in more detail the decision making interactions that occurred on the day with a view to streamlining the processes where possible.

When recovery commenced and supply options became available, Distribution companies, for reasons unknown at this stage, took longer than was expected to restore load. The uncertainty of progress of the Distribution company's load restoration program made prediction of available generation capacity difficult and may have slowed down the rate of recovery.

It should be noted that Transpower progressively made transmission capacity available as soon as it was cleared for service.

Refer Appendix 2 for a diagram displaying a timescale of when Transpower made capacity available to the distribution companies versus take up of that capacity.

The measure of Transpower's response to this outage should be determined by reference to this diagram and the accompanying table in Appendix 3.

Transpower gave permission to restore the last load block at 1620.

At 1630 the grid emergency notice was lifted by the NCC.

Lessons Learnt/Positives Gained

System Operator self assessment

System Operator management were asked to provide a self assessment of what lessons were gained from this incident. Their response largely covered 3 areas:

- Logistics: The value of having two control rooms and the ability to expand the number of operating positions to meet the increased work load by having sufficient numbers of trained personnel to man them. A further positive gained from this exercise was a successful test of the new flexible staffing arrangements.

- Communications: Communication issues and the sometimes slowness of provision of appropriate operational information to the relevant party was seen as a concern that will need further attention. Managing information flows to stakeholders without impacting on operational abilities needs further consideration.

- Plans and planning: Appropriate contingency plans existed and were of considerable value in forming the basis of decisions on restoration plans. However, they have largely been developed in isolation from the Distribution companies. This matter needs consideration as the Distribution companies may well bring added value to these plans.

The System Operator observations above align with our findings and are supported.

Regional Operational Centres self assessment

The ROC management were also requested to supply a similar self assessment of what lessons were gained from this incident. Their response is as follows:

- There was a continuous period of activities involving multiple parties for fault clearance, preparatory work and restoration.

- The Otahuhu outage was a major system incident. Despite that, the normal process of planning and restoration were adhered to before restoration of supply.

- Local knowledge and rapport with Vector proved conducive to the restoration process.

- The ROC communications lines were occupied by the 0800 THE GRID calls such that the field switching staff were hampered at times in speaking to the ROC operators. Many calls via the 0800 THE GRID were a result of the power companies referring callers back to Transpower. This is not considered to have had a material impact on the supply restoration times.

- Although the Contingency Plan worked well, a preset action plan with Vector may help to co-ordinate collective input efforts to ensure restoration priorities are identified.

The ROC management observations above align with our findings.

Appendix 1

Time Log Report on Loss of Supply to Auckland 12th June 2006 - time line and key points [excludes maintenance and ground crew activities]

(i) The Event
(times from HDR, actual may vary by up to 5 seconds)

08:31:58 OTA PEN 5 (220kV) tripped, autoreclosed at OTA then tripped again
OTC tripped
SWN steam turbine tripped, station load from 124MW to ~80MW initially, then slowly down to 52 before settling at 62MW

08:32:00 OTA 110kV Bus B2 (57 – 178) tripped, opening the following at OTA:
OTA PEN 2
OTA PAK 1
OTA Tie Line 1
OTA T2 LVCB
OTA PEN 7 remained closed at OTA, however note this circuit is only ever energised from OTA, and has no connection at PEN

08:32:10 OTA PEN 6 and OTA Tie Line 3 (220kV) tripped
OTA 110kV Bus A2 (47 – 188) tripped, opening the following at OTA:
OTA ROS 1
OTA ROS 2
OTA T3 LVCB
OTA 110kV Bus A1 (188-313) except for 212 (OTA T5 LVCB) tripped, opening the following at OTA:
MNG OTA 1
MNG OTA 2
OTA Tie Line 2
OTA C11 (may have tripped through overvoltage)
OTA C12 (may have tripped through overvoltage)

08:32:15 ARI PAK 1 tripped (voltage or system instability related?)

08:32:25 OTA T5 (both HV & LV) tripped

Total loss of supply of 739MW occurred at the following grid exit points:
PEN (349MW from the 110, 33 & 22kV buses)
MNG (78MW from the 33kV bus, Pacific Steel was off due to a fault within the site the previous day)
ROS (209MW from the 110 & 22kV buses)
PAK (103MW from the 33kV bus) giving a total of 739MW.

NIPS dropped from 3939MW to ~3000MW, indicating partial load loss of a further 200MW occurred at other grid exit points in the North Island.

Loss of 427MW of generation occurred on the following plant:
OTC (367MW)
SWN (from 124 to ~60MW)

Remaining in service on the OTA 110 kV was Bus B1. Remaining connected to Bus B1 was OTA T4, BOB OTA 1 and BOB OTA 2.

(ii) Situation Pre-event

There were no planned outages in the Auckland region at the time of the event. However, a planned outage on ATI WKM, due to commence at 07:30 and extending through till 18:00 on the following day, had been delayed for one hour by the System Operator. Concerns with putting the Bay of Plenty on n security when severe weather was forecast was raised with senior management in Field Services. Their advice, received at 08:17, was to cancel the outage.

Numerous trippings due to snow in the South Island had been occurring from about 03:00 of the same day. At various times from then, losses of supply from the grid occurred at ABY, TKA, TMK, STU, OAM, BPT, WTK, COL, APS and CLH. Numerous trippings of circuits in the area bounded by Christchurch - Otira - Waitaki Valley, some transient, some permanent, were occurring and continued to occur during the day.

A grid emergency had been declared from 02:21 to 07:00 due to the need for the system operator to reconfigure the grid (remove WGN WVY 1) to manage an unplanned outage of BPE BRK 2. The 220kV circuit had been damaged by wind.

A tripping of OPI KPI SFD 2 on permanent fault occurred at 07:11. A broken insulator was reported on the KPI tee at 08:22, resulting in a CTO being made, extending the end time from 11:30 to 18:00

A Phase 1 Maui gas contingency had been declared at 08:29 due to problems being experienced at the on-shore processing station.

(iii) Initial Response

Overview
At the time of the OTA event, the duty Security Co-ordinator was receiving advice of a tripping of COL OTI 1 & 2. The support Co-ordinator then managed this event.

At an early stage, NCC Operations Management at NCCW instructed a second Security Co-ordinator, working on the MSP project in Wellington, to go to NCCW to assist. At 08:48, she confirmed with the NCCN duty and support Security Co-ordinators that she would manage South Island events and leave the NCCN based Security Co-ordinators to manage North Island events. Regional Centre South was informed to direct calls to a Wellington number.

At an early stage, NCC Operations Management at NCCW made a call for the MDN condenser to be connected.

At an early stage, NCC Operations Management at NCCN worked with duty Security on the restoration steps based on an adapted Auckland contingency plan. This targeted restoration of PEN from the 220kV first as early indications were that the fault involved the 110kV bus only and the 220kV, and the 220kV could be restored first.

At an early stage, a Systems Operations Planning Engineer at NCCN joined the support Security Co-ordinator. Together they worked during the event to manage unrelated CTO's, trippings, MDE entries and doing studies to ensure loading limits (voltage, equipment loading) would not be exceeded when restoring.

Detailed Time Log

08:41	OTC claim a bona fide, believe the cause was a lightning strike as a fire ball was seen. KIN bona fide, mill on half load
08:43	OTA GT's confirm no tie line voltage, GT5 is available
08:46	MRP advise that the MDN condenser will be available in about 1 hour
08:47	Energy Co-ordinator commenced making calls to determine whether any IL providers had lost IL. None were identified, Norske Skog advised of a reduction in mill load but not IL.
08:50	Security called RCN. Confirmed event and large loss of load. Declared a grid emergency (verbal). Received advice of an earth wire down on OTA 110 bus, still one end of the bus in service.

09:03 RCN called Security. 2 RO's will manage the restoration, one doing PEN the other "the rest of Auckland". Not making anything available at present, but working to prepare the PEN bus for livening. Confirmed Auckland contingency plan versions, noting the need to extract the appropriate bits out of it for the scenario they were in.
PTP give to RCN to the clear the PEN 220kV bus ready for livening.

09:19 RCN called Security. He'd had an inquiry from OTC if they could connect, RCN's advice to OTC was that no as they had to take out Tie Line 3 to remove an earth wire. It was confirmed by Security they could not connect. RCN advised nothing could yet be made available. Earth wire(s) were being removed from the 110kV using live line techniques. Two earth wires were down affecting 3 x 110kV buses and were close to the 4th bus.

09:24 Security called RCN. RCN confirmed that the PEN 220kV bus was prepared as per the contingency plan, and that Vector has been instructed to clear all their breakers off the supply bus, leaving no load conencted.
RCN advised only able to offer supply from OTA PEN 6. As soon as OTA PEN 6 is available, when the earth wire is cleared from Tie Line 3.
PTP give to clear the PEN 11kV bus.

09:41 MRP advise MDN SC2 on.

09:46 RCN called Security. Confirmed moving on to clear PAK bus and the other operator is clearing MNG and ROS buses as per the contingency plan. RCN inquired if there was any chance of backfeeding PAK from ARI, Security advised prefer not to as "its way down the track, until we get the 220kV in we can't do any more".
RCN advises he's put a "release" in SCADA on OTA PEN 5, and that Vector will be opening all their breakers off the supply buses at all affected sites, leaving no load conencted when we liven up.

09:50 Security to RCN. RCN requested to check where the work effort is focussed. Need is for it to be on the 220kV circuits between OTA and PEN so that it can be made available asap.

09:51 ARI BOB 1 tripped.

09:55 RCN advised a CTO for ARI BOB 1. Reminded also that there had been no CTO's for the Auckland area, they are needed on circuits which have tripped. Security also informed RCN that he was looking at getting some supply to PAK.

10:01 Security to RCN. RCN was asked if it would help if all the OTA 11 bus was made dead, to speed things up.

10:04 Security to RCN. RCN was asked for advice on how long clearing the earth wire on the 220 will take, that it may be advantageous to close the HEP splits and get some supply down that way. Advice was that it was not imminent, more than 1 hour.

10:10 Inquiry put to Operations Planning Wellington on HEP ROS loading limitations, and whether thermal limits would be reached before any stability limits.

10:11 Security to RCN. RCN advised our focus now changed from PEN to ROS and MNG. RCN to confirm Vector are ready to take supply at MNG and ROS, also to advise Vector a limited supply only will be possible.
PTP given to close HEP splits, and to limit ROS supply to 30MW

(iv) Restoration of Supply

10:16 RCN to Security. Inquired as to the implications of taking out OTA 110 bus B1, as removing the earth wire from the 110kV was a "5 minute job" if the bus was made dead. Security to get back to RCN.

10:22 DVK 11kV bus coupler tripped, partial loss of supply.

10:25 Security to RCN. RCN advised that NCCN was unable to do the study, but need would be to reduce WIR (57MW) and BOB (48MW) loads by 50% each. RCN to advise.

10:31 Confirmed HEP ROS splits closed and ROS load 30MW.
ROS load to be increased to 60MW.

10:37 Security to RCN. Determined that an outage of OTA bus B1 is to proceed, PTP issued to reduce WIR and BOB loads to 25MW each.

10:43 RCN to Security. Vector wish to get supply onto ROS 110 rather than the 22kV, as this supplies hospitals. Confirmed there would be no tie back to PEN.
PTP give the restore Liverpool St 1 at ROS, ROS load limit still 60.

	RCN requested also to call Security as soon as time permits to restore supply to PAK.
10:47	Security to RCN. RCN asked why Vector was not picking up the additional 30MW allocated at ROS. Vector apparently having problems in their network.
10:48	Tripping of OKI T31.
10:51	RCN to Security. Ready to restore supply to PAK. Confirmed Vector ready to take supply and PAK bus prepared. Vector to limit load at PAK to 20MW, then PTP to restore ARI PAK 1.
10:57	Security to RCN. Concern with lack of progress with requested load reduction at WIR.
11:02	Security to RCN. Confirmed 15MW on at PAK. Increase PAK to 30MW. RCN also advise that Vector wish to get supply on at MNG. Confirmed Vector ready to take supply and the MNG bus is prepared. Vector to limit conencted MNG load to 40MW, then PTP to restore MNG ROS 1 & 2.
11:10	Operations Planning Wellington feedback on HEP ROS circuit capability. Good for 200MVA at n security, then review depending on power factor.
11:14	Security to RCN. RCN confirms MNG 110 bus is alive, waiting on Vector before restoring supply. Increase PAK to 50MW. Increase MNG/ROS total to 150MW.
11:20	Security to RCN. Concern with delay in getting the requested load reduction at WIR. Security asked whether they were aware this is holding up restoration of 220 into PEN.
11:25	RCN to Security. WIR and BOB loads now as requested. PTP to off load BOB OTA 1 & 2 at OTA, then open T4 LVCB
11:31	Operations Planning Wellington advised of a temporary rerating of the disconnectors at HEP, circuits now 800 amps, good for 250MVA
11:40	Security to RCN. WIR load can increase 5MW (from 23 to 28).
11:49	OTA T4, BOB OTA 1 & 2 CTO. Earth wire completely removed. PTP to restore T4, BOB OTA 1 & 2, then remove load restrictions on BOB and WIR.
11:55	Energy advised OTC that connection may be possible in 30 – 45 minutes.
12:03	RCN to Security. OTA Buses A2, B2, A1 AFS. T3, T2, T5 AFS. PTP given to restore.
12:19	Security to RCN. Inquiry as to whether the 220kV OTA PEN can be made available. RCN advise that the earth wire is still delaying return of OTA PEN 5 and Tie Line 3, and that it's only the 110 that is clear.
12:28	RCN to Security. Advised of plan to restore OTA ROS 1 & 2 and MNG OTA 1 & 2 from OTA, also Tie Lines 1 & 2. PTP given.
12:43	Energy confirmed voltage on Tie Lines 1 & 2 with OTC and instructed connection of GT5 and GT6.
12:51	Security to RCN. Security requested an update on the 220kV, advice was there is none.
12:53	Security to RCN. PTP to restore OTA PAK 1, open HEP ROS splits and restore all load at MNG< ROS and PAK.
13:05	Security to RCN. Security requested an update on the 220kV.
13:12	RCN to Security. OTA Tie Line 3 in approx 35 minutes. RCN informed by Security that the next step is to restore OTA PEN 2. Vector to confirm they are ready to take some supply from PEN 110, load to be limited to 50MW. PTP to restore OTA PEN 2.
13:21	Security to RCN. RCN advises Vector will be progressively loading Liverpool St 1 & 2 up to 50MW, currently only 2. RCN informed by Security that the plan now is to backliven T10 to liven PEN 220. PTP to restore PEN T10, with extended delay after livening to allow inrush current to settle.
13:32	RCN to Security. Vector request they load up Quay St feeders rather than Liverpool St. Determined that we can connect Quay St as well as Liverpool St. PTP to restore Quay St feeders 1 & 2, total load still 50MW. PTP to restore PAK PEN 1.
13:46	Security to RCN. Tie Line 3 update requested.
13:54	Energy Co-ordinator requests an update on load still to come on. Advice was about 200MW.
13:55	Security to RCN. Tie Line 3 update requested.

	Security advise plan is to restore 33kV load at PEN. Currently only taking 39MW. Vector to confirm they are ready to take supply from the PEN 33, and to limit off-take to 50MW.
14:00	RCN to Security. Ready to go at PEN PTP to remove T21 and T22 HVCB (extra to the contingency plan). PTP to restore PEN T9, T8 and T11.
14:05	Security to RCN. Request again for information on Tie Line 3 and OTA PEN 5.
14:18	Security to RCN. Request for information again requested. Advice was 1.5 hours for Tie Line 3, circuit 5 will be out longer.
14:29	Advice sought from Vector on Maui gas contingency. Still Phase 1, not expecting to go to Phase 2, not looking to end Phase 1.
14:35	Discussion with Contact on ability to generate from OTC given gas contingency even when Tie Line 3 is restored. Intent was to run OTC on at least minimum load when able to.
14:41	Security to RCN. Increase PEN load to 100MW, distributed as they wish (currently 78). Confirm Vector ready to take supply from PEN 22, then PTP to restore PEN T23, T22 and T21.
14:47	Security to RCN. Increase PEN load to 130MW.
15:23	RT Support Wellington advises that for evening peak with 220kV OTA PEN still out, PEN load of 215MW will give unmanageables.
15:36	Genesis to Security. Inquiry about whether we'll be declaring a grid emergency due to infeasibilities over evening peak. Advice give was that it was currently being looked at.
15:39	RCN to Security. OTA PEN 6 and OTA Tie Line 3 AFS. PTP given to restore.
15:44	RCN to Security. OTA PEN 5 AFS. PTP given to restore.
15:47	Energy to OTC. OTA PEN 6 and Tie Line 3 are in. they can connect.
15:48	RCN to Security. OTA PEN 5 now in. Increase PEN load to 200MW.
15:44	RT Support has altered load forecast for this evening, was forecasting NI load of 4700.
15:59	RCN to Security. Requesting additional load for PEN Increase PEN to 250MW.
16:11	Security to RCN. Able to give more load to Vector at PEN, currently at 226, limit is 250. Need is to know how much more load is left to come on. RCN confirms Vector is still having some trouble in there network.
16:13	Maui gas contingency ended.
16:20	RCN to Security. Vector believe total PEN load would be about 270MW. Instruction given to restore all PEN load. RCN to also check that all load has been restore to Vector.
16:29	RCN confirm Vector has only about 10MW to go and all load will be restored. RCN to also check that all Counties load has been restored.

(v) Other

The following gives snapshots of actual loads and compares with the applicable load limit applying at that time.

Details extracted from SCADA displays using HDR

	Actual Loading (MW)	Security Co-ord limit instruction issued
08:31	PEN 349	no limit
	ROS 209	no limit
	MNG 78	no limit
	PAK 103	no limit
10:29	ROS 11	30
10:33	ROS 30	from 10:31, 60
11:02	PAK 16	20
11:10	PAK 30	from 11:02, 30
11:20	MNG/ROS 50	from 11:14, 150

11:30	PAK 50	from 11:14, 50
12:15	MNG/ROS 80	
12:30	MNG/ROS 145	
12:45	HEP ROS Split re-instated	
13:18	MNG/ROS 240	from 12:53, restore all load
	PAK 40	from 12:53, restore all load
13:26	MNG/ROS 291	
	PAK 46	
13:32	MNG/ROS 330	
	PAK 48	
13:35	PEN 35	50
	PAK 106	
13:55	PEN 39	
14:23	PEN 66	
	MNG/ROS 350	
14:26	PEN 75	
14:56	PEN 104	from 14:41 100, from 14:47 130
15:10	PEN 127	
15:16	PEN 155	

15:48 OTA PEN 5 & 6 in — from 15:48, PEN 200

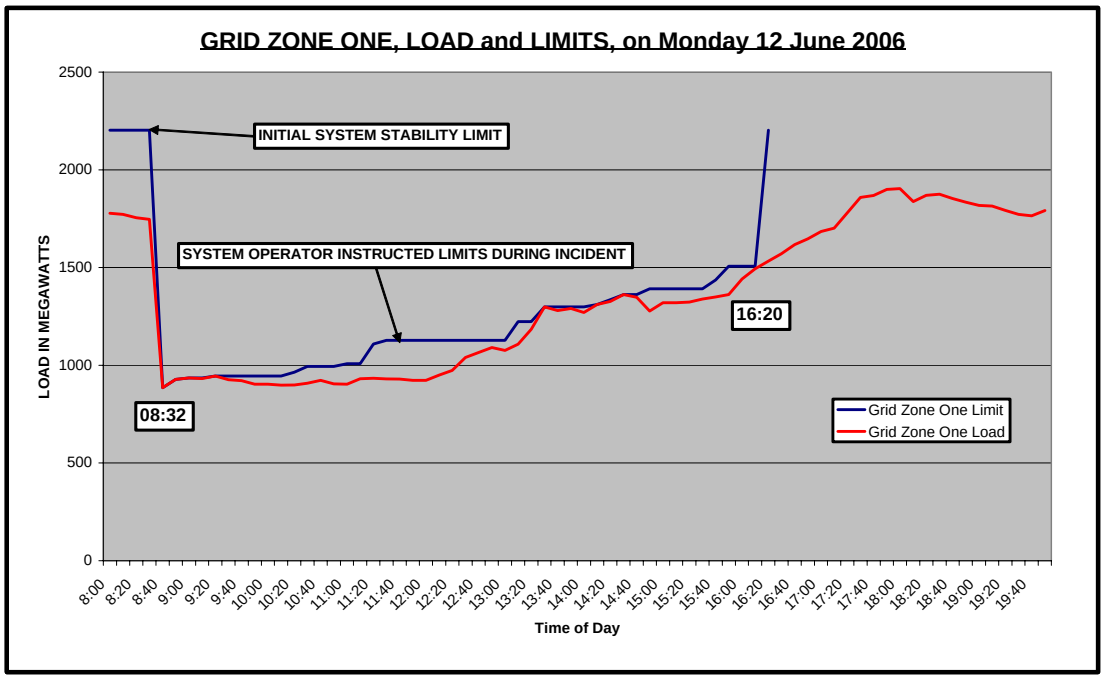
15:56	PEN 180	
16:02	PEN 200	from 15:59, 250
16:08	PEN 230	
16:17	PEN 240	
16:23	PEN 260	from 16:20, restore all load at PEN
16:28	PEN 280	
16:45	PEN 300	

WIR & BOB load reduction for total OTA 110kV Bus outage

Actual Loading		Security Co-ord limit instruction issued
10:30	WIR 57	no limit
	BOB 48	no limit
		from 10:39, 25 each gxp
10:50	WIR 54	
	BOB 41	
11:00	WIR 54	
	BOB 32	
11:10	WIR 55	
	BOB 34	
11:20	WIR 46	
	BOB 33	
11:25	WIR 27	
	BOB 32	

11:30	BOB OTA 1 & 2 AT OTA, OTA T4 LVCB opened, OTA 110kV B1 bus de-energised (true for all the 110kV)
11:52	BOB OTA 1 & 2 AT OTA, OTA T4 LVCB closed, OTA 110kV B1 bus energised
11:58	BOB and WIR load restoration commenced

Appendix 2


GRID ZONE ONE, LOAD and LIMITS, on Monday 12 June 2006
LOAD IN MEGAWATTS
2500
2000
1500
1000
500
0
INITIAL SYSTEM STABILITY LIMIT
SYSTEM OPERATOR INSTRUCTED LIMITS DURING INCIDENT
08:32
16:20
Grid Zone One Limit
Grid Zone One Load
8:00
8:20
8:40
9:00
9:20
9:40
10:00
10:20
10:40
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19:20
19:40
Time of Day

Appendix 3

Table showing times when buses were cleared, load restoration instructions given, load actually restored. Note: instruction times capture the instruction as issued by the System Operator to the Regional Operator.

MNG/ROS

Bus Prepared for Livening (voice recorder)	Instruction to Restore (voice recorder)	Load Restored (samples from HDR)
110, 33 & 22kV commenced at 09:46. Confirmed done when giving PTP to restore first block of load at 10:11.	30MW at 10:11 60MW at 10:31 100MW at 11:02 150MW at 11:14 restore all load at 12:53	30MW at 10:33 50MW at 11:20 80MW at 12:15 145MW at 12:30 240MW at 13:18 330MW at 13:32

PAK

Bus Prepared for Livening (voice recorder)	Instruction to Restore (voice recorder)	Load Restored (samples from HDR)
110 & 33kV commenced at 09:46. Confirmed done when giving PTP to restore first block of load at 10:51.	20MW at 10:51 30MW at 11:02 50MW at 11:14 (50MW was the limit while being single cct fed) restore all load at 12:53	16MW at 11:02 30MW at 11:10 50MW at 11:30 106MW at 13:35

PEN

Bus Prepared for Livening (voice recorder)	Instruction to Restore (voice recorder)	Load Restored (samples from HDR)
220kV commenced at 09:03 completed at 09:24. 110, 33 & 22 kV commenced at 09:24. Confirmed done at 13:12.	50MW at 13:12 100MW at 14:00 130MW at 14:47 (200MW was the expected limit while fed by a single 110kV circuit) 200MWat 15:48 250MW at 15:59 restore all load at 16:20	35MW at 13:35 75MW at 14:26 104MW at 14:56 127MW at 15:10 155MW at 15:16 200MW at 16:02 240MW at 16:17 280MW at 16:28