Audit of Murraylink Service Standards Performance Reporting

PERFORMANCE RESULTS FOR 2005

- Final Report
- 24 March 2006

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1. Executive Summary

Sinclair Knight Merz (SKM) was engaged by the Australian Energy Regulator (AER) to conduct an audit of the performance report of Murraylink for 2005 under the AER Performance Incentive (PI) Scheme.

The audit reviewed the performance results submitted by Murraylink, in particular:

- the adequacy and accuracy of the recording system used to measure performance;
- the accuracy of the calculations of the final performance; and
- the force majeure and other exclusions to accord with the service standards guidelines.

SKM met with Murraylink staff in Brisbane on Tuesday 21 February 2006, to review their data systems and procedures for gathering and processing outage information. The integrity of the system established by Murraylink for retrieving data from the Events Database for reporting under both internally and the AER PI Scheme was audited. As a result of audit activities undertaken, Sinclair Knight Merz has formed an opinion that:

- the performance reporting by Murraylink was free from material errors and was in accordance with the requirements of the AER service standards guidelines;
- Murraylink correctly determined coefficients to calculate the performance incentive amount using the equations contained in the revenue cap decision for all measures in the performance calculation spreadsheet provided by the AER;
- the Murraylink submission covering letter correctly listed all of the S-factors for Planned Availability (measure 1a) and Peaked Forced Availability (measure 1b) but the value shown for Off-Peak Forced Availability (measure 1c) without exclusions was incorrect; and
- the recording system used by Murraylink to capture outage data is accurate and reliable.

SKM recommends:

- the proposed exclusions for the scheduled outages due to the actions/requests from neighbouring transmission companies are in accordance with the standard definitions for circuit availability and should be accepted;
- the proposed exclusions for the forced outages related to run-back schemes and lightning strikes are considered to be third party inter-trips and should be accepted as satisfying the exclusions defined for circuit availability;

- the extended outage for the failure of IGBTs, which represented an extreme interruption to the operation of Murraylink, satisfied the provisions for exclusion under Force Majeure and therefore should be excluded; and
- the penalty for Murraylink under the AER PI Scheme for 2005 is **(0.154423%) of the agreed Annual Revenue for 2005**.

2. Recording System

Murraylink is an electricity transmission asset operated by the Murraylink Transmission Company (MTC). It includes the 180km underground power cable and connects the Victorian and South Australian regions of the National Electricity Market (NEM), transferring power between the Red Cliffs substation in Victoria and the Monash substation in South Australia. Murraylink's current rated capacity is 220MW.

The main control centre for Murraylink is located in the Brisbane CBD[1], with some control facilities and historical data logging available on site.

The recording of outages is done via manual entry into an Outage Register. Planned outages are taken following discussions within the Brisbane office. For unplanned outages, operators detail the reason at the time of the outage, and these comments are reviewed on a monthly basis.

The primary cause for outages on Murraylink is failures in the Insulated Gate Bipolar Transistor[2] (IGBT) devices. Murraylink can operate with up to 6 faulty IGBTs before the line trips, although planning for replacement begins when 4 IGBTs have failed. There is an annual outage for shutdown maintenance for 2 days in October.

2.1 Categorisation and Exclusions

All outages are categorised as planned/scheduled or unplanned/forced. For unplanned outages, duration is recorded for peak period (0700 to 2200 hours) and off peak (2200 to 0700 hours). In 2005, weekends and public holidays in South Australia were considered off peak in the categorisation of outages.

2.2 Processing of Outage Data

Murraylink compile the Outage Register into Excel spreadsheets which record the basic details of both included and excluded events, and totals the peak and off-peak components. The cause for each outage is categorised as occurring at either MLRC (Red Cliffs) and MLBI (Berri) converter stations, or both where the entire interconnector is affected.

[1] It is understood that the Control Centre may be relocated to the ElectraNet Control Room, Adelaide in the near future.

[2] A solid-state device capable of high speed switching and high current carrying capability

2.3 Calculation of Performance Measure Results

The performance measures are calculated using the S-factor equations defined in Tables 9.4, 9.5 and 9.6[3] of the MTC Application for Conversion and Maximum Allowed Revenue of 1 October 2003.

2.4 System Audit Findings

During a previous audit, SKM conducted a sample testing of a number of randomly chosen outage records from the operator log to ensure that these were correctly recorded in the Excel file for processing. In each instance, the events, reasons and switching times were found to have been correctly transferred to the Excel file, and correctly processed for peak / off-peak hours. No such audit was conducted in this audit as there had been no change in the recording process.

SKM reviewed the categorisation of each outage event and accepted that it was in accordance with the accepted definitions of planned and unplanned.

SKM is satisfied that the recording and data processing systems that have been put in place by MTC appear to accurately log and calculate performance.

[3] pp 179

3. Performance Measures

As part of the AER decision[4] on the application for Murraylink to become a regulated asset, PB Associates was commissioned to develop a performance incentive framework. PB adopted a similar approach to that used by SKM in establishing performance measures and targets.

Due to the unavailability of historical performance data, the measures and targets were developed from a review of technical documents released by the manufacturer (ABB) of much of Murraylink's assets and a CIGRE survey.

3.1 Agreed measures

PB recommended that Measure 1 Circuit Availability be adopted, subdivided into three sub-measures:

- planned availability;
- forced availability during peak periods; and
- forced availability during off-peak periods.

and associated performance targets be set for each category rather than a single overall target.

With consideration of information provided by MTC, the AER adopted the three sub-measures with targets that take account of the Murraylink maintenance and inspection program. The parameters for the sub-measures are shown in Table 1.

Table 1 Performance Targets

No	Measure	Performance for Maximum Penalty	Target Performance	Performance for Maximum Bonus	Weighting Factor
1a	Planned circuit availability	99.04%	99.17%	99.38%	0.40
1b	Forced outage circuit availability in peak periods	98.90%	99.48%	100.00%	0.40
1c	Forced outage circuit availability in off-peak periods	98.84%	99.34%	99.94%	0.20

[4] AER, *Murraylink Transmission Company Application for Conversion and Maximum Allowed Revenue: Decision*, 1 October 2003

These parameters considered advice from MTC regarding its required maintenance program, which includes 3-hour outages for monthly inspections. This allowance reduced Murraylink's planned availability.

4. Exclusions

The AER service standard guidelines noted that the PI Scheme adopted standard definitions for performance measures to ensure that TNSPs have similar incentives, whilst recognising that these definitions needed to be flexible. It was highlighted that the definitions should align with appropriate information that the TNSP has been collecting historically to ensure that performance is measured consistently over time to preserve the incentive to improve.

4.1 Allowable Exclusions

The exclusions allowed under the standard definition for Circuit Availability[5] are:

- Exclude unregulated transmission assets;
- Exclude from 'circuit unavailability' any outages shown to be caused by a fault or other event on a '3rd party system' eg. intertrip signal, generator outage, customer installation; and
- Exclude force majeure events.

In addition, in the decision related to the MTC application for conversion, the AER defined that the replacement of a transformer will be an exclusion *"… from the incentive scheme, if:*

- *Murraylink can demonstrate that the replacement of the transformer was needed;*
- *Murraylink can demonstrate that the time taken was needed; and*
- *The AER is satisfied that the replacement was the best alternative and all reasonable preventative measures had been taken."*[6]

4.2 Audit Findings

The scheduled and forced outages for Murraylink are summarised in Table 2.

There are 7 scheduled outages and 8 forced outages that have been claimed for exclusion by Murraylink.

The proposed excluded scheduled outages have been attributed to third party requests from Victorian Network Switching Centre (VNSC), and the majority of the proposed excluded forced outages have been categorised as third party trips that caused Murraylink to reduce its power transfer to 0.

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[5] AER, *Statement of principles for the regulation of transmission revenue – Service standards guidelines*, 12 November 2003

[6] AER, *Murraylink Transmission Company Application for Conversion and MAR: Decision*, 1 October 2003, pp 176

SKM

■ **Table 2 Outages in 2005**

Type	No of Events	Duration mins	Peak mins	Off-Peak mins	Total mins
Scheduled maintenance					
Equipment repair	6	2,781	-	-	2,781
Annual maintenance	3	2,636	-	-	2,636
Control system modifications	4	1,915	-	-	1,915
IGBT checks & modifications	2	1,737	-	-	1,737
VCU communications	3	329	-	-	329
Vic Very Fast Runback test	1	63	-	-	63
Subtotal	*19*	*9,461*	-	-	*9,461*
Forced outages					
Equipment failure	2	-	1,095	455	1,550
Communications	3	-	599	493	1,092
IGBT failure	1	-	182	484	666
NSW Runback comm trip	2	-	25	-	25
Subtotal	*8*	-	*1,901*	*1,432*	*3,333*
Excluded events claimed					
Scheduled third party	7	1,255	-	-	1,255
Forced third party	8	-	4,642	7,117	11,759
Subtotal	*15*	*1,255*	*4,642*	*7,117*	*13,014*
Total	**42**	**10,716**	**6,543**	**8,549**	**25,808**

4.3 Excluded Events

As an interconnector between Victoria and South Australia, Murraylink may occasionally be subject to an outage resulting from the maintenance and capital works programs of SP AusNet (Vic) and ElectraNet (SA), or by forced outages on the neighbouring Victorian, South Australian and New South Wales transmission networks.

Such outages may fall within the purview of an exclusion due to " ... *a fault or other event on a 3rd party system*" (refer section 4.1). SKM has reviewed each event claimed for exclusion where it is directly related to activity on the connecting transmission networks to ensure that SP AusNet and ElectraNet have included the same outage in their respective performance result calculations.

4.3.1 Scheduled Outages

Table 3 shows the outages requested for exclusion by Murraylink as scheduled or planned outages due to work on the Victorian and South Australian networks, and the related records from SP AusNet and ElectraNet.

Table 3 Requested Scheduled Outages for Interstate Work

Start Date	Duration (mins)	Murraylink record	Interstate TNSP	Interstate TNSP record	Note
13.04.05	4	VNSC[7] required Red Cliffs circuit breaker opened	SP AusNet	Work at RCTS[8] for erection of 220kV capacitor bank disconnector as part of Victorian Run-Back scheme	a
30.07.05	2	VNSC required Red Cliffs circuit breaker opened	SP AusNet	Planned SPA maintenance work at RCTS between 28 July and 4 August on 66kV reactors and bus	b
31.07.05	10	VNSC required Red Cliffs circuit breaker opened	SP AusNet		
03.12.05	580	VNSC requested outage for work at Red Cliffs	SP AusNet	SPA maintenance at RCTS	c
04.12.05	634	VNSC requested outage for work at Red Cliffs	SP AusNet	SPA maintenance at RCTS	
10.12.05	15	VNSC required Red Cliffs circuit breaker opened	SP AusNet	De-energise 220kV bus for commissioning of capacitor bank for Victorian Run-Back scheme	d
12.12.05	10	VNSC required Red Cliffs circuit breaker opened	SP AusNet	De-energise 220kV bus for commissioning of capacitor bank for Victorian Run-Back scheme	

Notes:

a) There is a discrepancy between the TNSPs in the time of the event. The SP AusNet work is recorded as occurring between 0706 and 1348 on 13 April 2005, whilst the Murraylink outage was shown as between 1711 and 1715.

b) The two outages shown by Murraylink are not reflected directly on the SP AusNet outage record. Alstom performed work for both SP AusNet and a distribution company in Red Cliffs Terminal Station between 28 July and 4 August 2005. During this time, it is considered highly likely that some switching would have been required at Murraylink to allow work to continue.

c) These outages at Red Cliffs were included by SP AusNet as maintenance work at Red Cliffs. There are minor discrepancies in the start times for each outage between the Murraylink and SP AusNet records.

d) These commissioning activities have been recorded by SP AusNet.

[7] Victorian Network Switching Centre

[8] Red Cliffs Terminal Station

4.3.2 Forced Outages

Table 3 shows the outages requested for exclusion by Murraylink as forced outages caused by a "third party". These faults are typically due to trips on the neighbouring transmission networks.

Table 4 Requested Forced Outages from Third Party

Start Date	Duration (mins)	Murraylink record	Note
08.01.05	95	Berri converter station isolated due to over frequency trip[9]	a
03.03.05	45	Berri converter station isolated due to over frequency trip	
02.06.05	114	Run-back[10] due to interruption to 11kV supply from Monash	b
16.08.05	76	Run-back due to failure of SA Run-back scheme (between 1:14pm and 2:30pm)	c
16.08.05	21	Run-back due to failure of SA Run-back scheme (between 5:03pm and 5:24pm)	
06.11.05	50	Run-back due to lightning strikes on ElectraNet transmission network	d
06.11.05	46	Berri converter station isolated due to over frequency trip following lightning strike	

Notes:

a) No similar incident recorded by ElectraNet.

b) Interruption caused by a car hitting a power pole.

c) ElectraNet has advised that there were issues with the run-back scheme during 16 August 2005. It is thought that this may have been the result of planned work on the SA network .

d) The ElectraNet outage reports list disruptions on 6 November 2005 due to lightning strikes in the Baroota / Kadina East areas, together with interruptions on Bungama - Brinkworth, Hummocks - Bungama and Para - Davenport lines. These outages were included in the ElectraNet performance calculations. A weather report[11] for 6 November 2005 described widespread thunderstorms across South Australia, with several areas suffering blackouts due to lightning strikes.

[9] In order for the power grid to remain stable, the frequency must be within certain limits. An excursion in frequency above the upper threshold is an "over-frequency" event, and load is typically shed to protect against damage.

[10] An extract from a CIGRE paper B4-103 presented to the 2004 session describing Murraylink stated that " *... in order to increase Murraylink power transfer capability without requiring major physical AC network augmentations, MTC elected to ... implement power transfer run-back controls. The run-back schemes monitor the status of remote network elements (circuit breakers, lines and transformers) and in the event of a remote trip will reduce Murraylink power transfer... run-back speeds can be designed to accommodate specific outages of critical plant and also future load growth in the surrounding AC networks.*"

[11] Australian Weather News, 6 November 2005

4.4 Recommendations

SKM is satisfied that the scheduled outages claimed for exclusion are events that the neighbouring TNSP, SP AusNet, has recorded as its outage, and therefore these 7 scheduled outages should be excluded from the performance results. Whilst there was not a direct correlation in the case of the outages for 30 and 31 July with SP AusNet works orders records, there was sufficient circumstantial evidence to support the claim that these outages were related to maintenance work at Red Cliffs Terminal Station during the period 28 July to 4 August 2005. The discrepancies found in the recorded times between SP AusNet and Murraylink for some events is worthy of note.

The forced outages due to over-frequency at Berri converter station coincided with alarms from Monash substation where three circuit breakers opened and isolated the Berri converter station from the South Australia network. Without a connection to the frequency controlled SA transmission network, the Berri converter lost its reference frequency and drifted until the frequency passed the protection limits. These outages are considered to be due to a third party inter-trip, and should be excluded from the performance results.

Lightning strikes are events that a TNSP can be reasonably expected to take measures to mitigate against the risk, and SKM noted that ElectraNet had included the effects of the lightning strikes on 6 November in their performance reporting. SKM is of the view that the problems incurred by Murraylink as a direct result of these lightning strikes on the neighbouring transmission network are events on a third party system. SKM considers this event should be excluded from the performance measures.

The run-back schemes used by Murraylink are a protection against potential network overloads in the event of incidents on the neighbouring transmission networks, and are designed to control the power throughput on Murraylink from its operating level to lower preset values in a very short timeframe. This includes reducing the throughput to 0MW. The ability of these run-back schemes to respond to an external problem and reduce the power throughput is carefully controlled as Murraylink could potentially respond faster than the connected AC networks and cause instability. However, it is of interest that the events that have caused the run-back incidents on 16 August were not recorded by ElectraNet as an outage.

SKM considers that these outages represent an inter-trip on a third party system, and recommends that these events should be excluded.

5. Force Majeure

In the Service Standards Guidelines published by the AER[12], there are four (4) considerations listed for determining what force majeure events should be "excluded force majeure events". These are:

- Was the event unforeseeable and its impact extraordinary, uncontrollable and not manageable;
- Does the event occur frequently – if so, how did the impact of the particular event differ;
- Could the TNSP, in practice, have prevented the impact (not necessarily the event itself); and
- Could the TNSP have effectively reduced the impact of the event by adopting better practices?

5.1 Definition

The definition used by Murraylink in the determination of performance under the AER PI Scheme reflects the definition outlined in the AER service standards guidelines.

The details are outlined in Appendix B.

5.2 IGBT Explosion

On Sunday 16 October 2005 at 00:20am, Murraylink suffered the loss of 6 IGBTs, resulting in a trip of the Berri converter station. The reported explosion caused the fire system to discharge, and Murraylink was not returned to service until Sunday 23 October at 8:52pm, an outage of approximately 188½ hours.

Murraylink described the event as follows:

"*An arc developed between the voltage divider of one IGBT and a corona ring. The pressure wave resulting from the rapid temperature rise of the air around the arc ejected molten metal and carbonised plastic out of the IGBT stack and onto the surrounding equipment. The high air temperature also damaged the optic fibres that trigger the switching of nearby IGBTs. The arc itself occurred at approximately 00:19:20 and IGBTs failed sequentially until six had failed and the converter tripped shortly before 00:20:04 ... there is insufficient evidence to prove any cause for the explosion ... this incident is not a normal IGBT failure. The IGBT connected to the voltage divider where the arc started did not itself fail. This IGBT was replaced on the 11th of October 2005 and had operated without fault for almost 40 hours prior to the explosion.*"

[12] Schedule 2, Statement of principles for the regulation of transmission revenues – Service standards guidelines, ACCC, 12 November 2003

In assessing this incident, SKM considers that, as a DC interconnector, Murraylink is an atypical type of interconnector in the Australian transmission network. It utilises leading edge IGBT technology that requires specialised technical support, and as such should accept a level of risk for equipment failure. However, SKM is not in a position to speculate on the cause of the original arcing, which appears to have lead to the explosion and resulting in the sequential failure of IGBTs.

A comparison with the four considerations listed by the AER in the Service Standard Guidelines suggests that:

- The event was unforeseeable and its impact was extraordinary. The failure of the six (6) IGBTs occurred within 44 seconds of the original arc, and was uncontrollable and not manageable;
- This was a rare event, and was without precedent in any other DC interconnector in service in Australia or other countries; and
- There was no way for Murraylink to have prevented or reduced the impact of the event.

SKM is of the view that, in the absence of a proven cause for the event, the outage satisfies the considerations for an extreme event and the failure of the IGBTs appeared to have been as a consequence of an explosion, which is within the definition of Force Majeure.

Therefore, SKM accepts that this exclusion as a Force Majeure event.

6. Assessment of S-factors

Table 5 shows the results of S-factor calculation proposed by Murraylink and recommended by SKM following its audit of Murraylink service performance report.

SKM confirmed that the Murraylink has used the S-factor equations contained in the revenue cap decision and correctly applied the formulas and coefficients to calculate the S-factors for all measures in the performance calculation spreadsheet provided by the AER. However, the covering letter to the Murraylink submission dated 31 January 2006 incorrectly showed the S-factor for Off-Peak Forced Availability (measure 1c) without exclusions as (0.177703%). The calculated Measure 1c availability performance without exclusions result was 98.35%, and with the threshold value for the collar value is less than 98.84%, the correct value without exclusions should have been (0.200000%).

Given that SKM does not recommend the exclusion claimed as a Force Majeure event be accepted, the recommended S-factor results are shown in Table 5.

- **Table 5 Performance Results**

No	Performance Measure	Target	Murraylink without exclusions	Murraylink with all proposed exclusions	SKM without exclusions	SKM assessment
1a	Circuit Availability (planned)	99.17%	97.94%	98.18%	97.94%	98.18%
1b	Circuit Availability (forced) (peak)	99.48%	98.74%	99.63%	98.74%	98.76%
1c	Circuit Availability (forced)(off-peak)	99.34%	98.35%	99.72%	98.35%	98.41%

- **Table 6 Calculated S-factors**

No	Performance Measure	Murraylink without exclusions	Murraylink with proposed exclusions	SKM without exclusions	SKM assessment
1a	Circuit Availability (planned)	(0.400000%)	(0.400000%)	(0.400000%)	(0.400000%)
1b	Circuit Availability (forced) (peak)	(0.400000%)	0.117652%	(0.400000%)	0.117652%
1c	Circuit Availability (forced)(off-peak)	(0.177703%)	0.127925%	(0.200000%)	0.127925%
	TOTAL	**(0.977703%)**	**(0.154423%)**	**(1.000000%)**	**(0.154423%)**

The profiles for each of the applicable measures are shown in Appendix A to illustrate the performance in graphical terms.

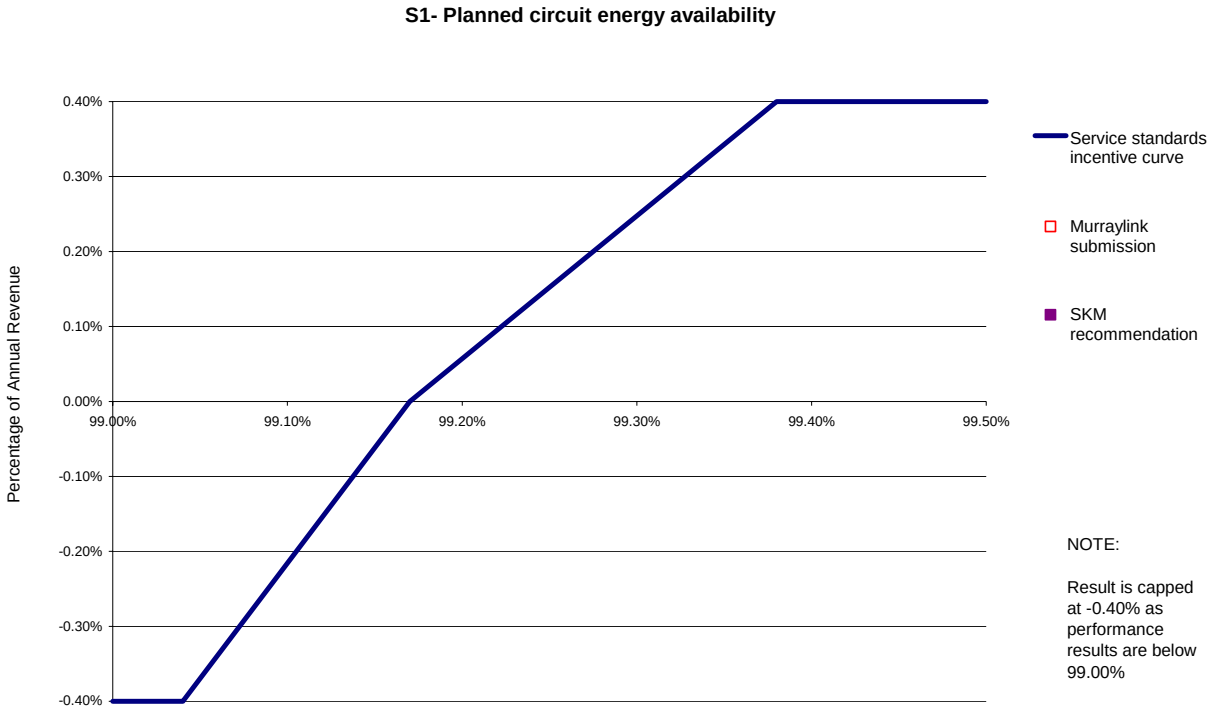
Based on these results, SKM recommends the penalty for Murraylink should be **(0.154423%) of the agreed Annual Revenue for 2005**.

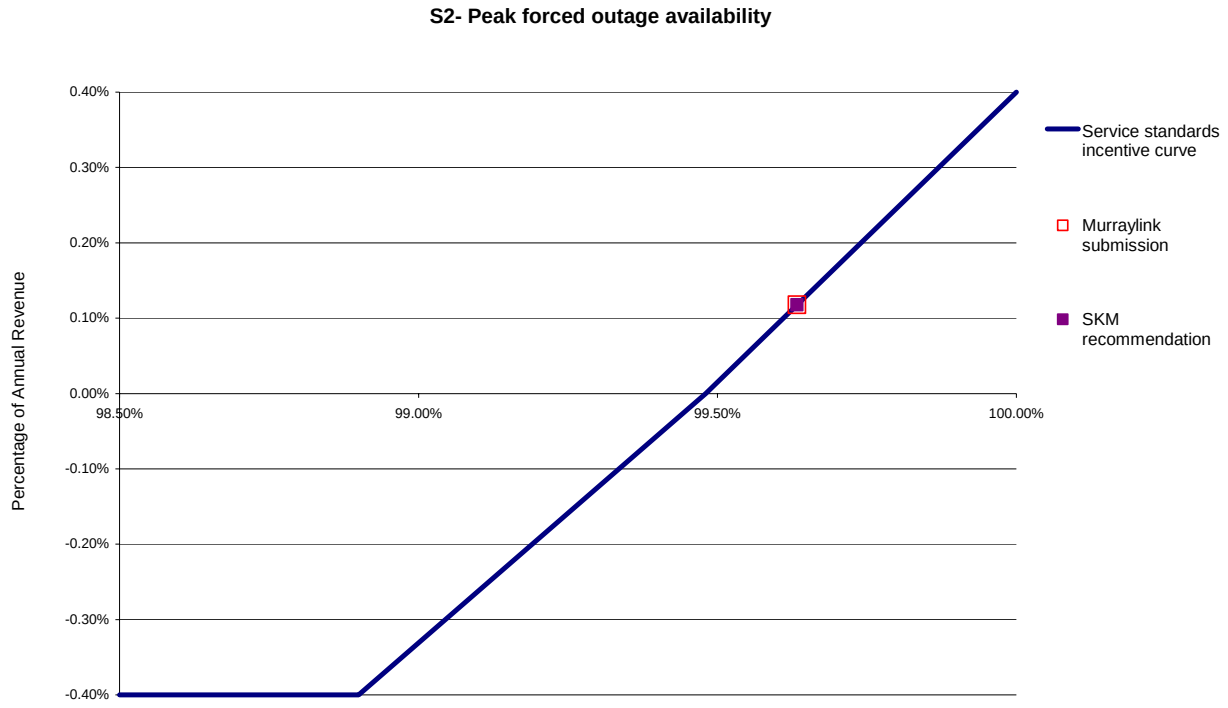
Appendix A 2005 Performance Measure Profiles

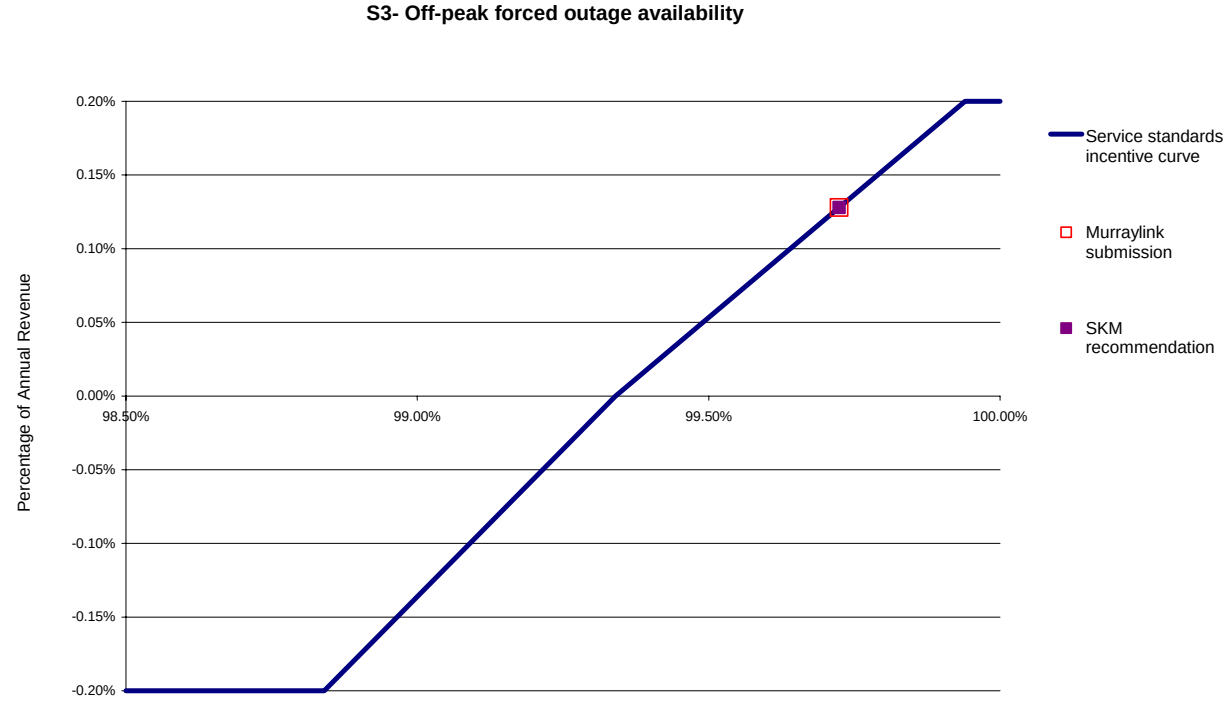
The Performance Measure profiles graphically illustrate the 2005 performance against the targets for Circuit Availability sub-measures.

The profiles shown are:

- Measure 1a Circuit Availability (planned)
- Measure 1b Circuit Availability (forced)(peak)
- Measure 1c Circuit Availability (forced)(off-peak)




S2- Peak forced outage availability
Percentage of Annual Revenue
0.40%
0.30%
0.20%
0.10%
0.00%
-0.10%
-0.20%
-0.30%
-0.40%
98.50%
99.00%
99.50%
100.00%
Service standards incentive curve
Murraylink submission
SKM recommendation


S3- Off-peak forced outage availability
Percentage of Annual Revenue
0.20%
0.15%
0.10%
0.05%
0.00%
-0.05%
-0.10%
-0.15%
-0.20%
98.50%
99.00%
99.50%
100.00%
Service standards incentive curve
Murraylink submission
SKM recommendation

Appendix B Definition of Force Majeure

The following is an extract from Appendix H to the AER decision on the MTC application for conversion and MAR[13]:

"In its past revenue cap decisions and draft service standards guidelines the AER has excluded force majeure events from the performance-incentive scheme. Below is the definition of force majeure, which Murraylink should report on to the AER on an annual basis. The AER will review, amongst other things, performance results and excluded events to ensure compliance with the revenue cap decision.

The following definition is to provide guidance of what may be considered a force majeure event, rather than specifically prescribe every event that may possibly occur.

For the purpose of applying the service standards performance-incentive scheme, 'force majeure events' are any events, acts or circumstances or combination of events, acts and circumstances which (despite the observance of good electricity industry practice) are beyond the reasonable control of the party affected by any such event, which may include, without limitation, the following:

- fire, lightning, explosion, flood, earthquake, storm, cyclone, action of the elements, riots, civil commotion, malicious damage, natural disaster, sabotage, act of a public enemy, act of God, war (declared or undeclared), blockage, revolution, radioactive contamination, toxic or dangerous chemical contamination or force of nature;
- action or inaction by a court, government agency (including denial, refusal or failure to grant any authorisation, despite timely best endeavour to obtain same) strikes, lockouts, industrial and/or labour disputes and/or difficulties, work bans, blockades or picketing; and
- acts or omissions (other than a failure to pay money) of a party other than the TNSP which party either is connected to or uses the high voltage grid or is directly connected to or uses a system for the supply of electricity which in turn is connected to the high voltage grid.

where those acts or omissions affect the ability of the TNSP to perform its obligations under the service standard by virtue of that direct or indirect connection to or use of the high voltage grid."

[13] pp 176