

Security Policy Review: Credible Event Management

Appendix 7 - Transformer Event Costs

December 2009



SYSTEM OPERATOR

Keeping the energy flowing

TRANSPower



NOTICE

COPYRIGHT © 2009 TRANSPOWER New Zealand LIMITED

ALL RIGHTS RESERVED

The information contained in the report is protected by copyright vested in Transpower New Zealand Limited ("Transpower"). The report is supplied in confidence to you solely for your information. No part of the report may be reproduced or transmitted in any form by any means including, without limitation, electronic, photocopying, recording, or otherwise, without the prior written permission of Transpower. No information embodied in the report which is not already in the public domain shall be communicated in any manner whatsoever to any third party without the prior written consent of Transpower.

Any breach of the above obligations may be restrained by legal proceedings seeking remedies including injunctions, damages and costs.

LIMITATION OF LIABILITY/DISCLAIMER OF WARRANTY

Transpower makes no representation or warranties with respect to the accuracy or completeness of the information contained in the report. Unless it is not lawfully permitted to do so, Transpower specifically disclaims any implied warranties of merchantability or fitness for any particular purpose and shall in no event be liable for, any loss of profit or any other commercial damage, including but not limited to special, incidental, consequential or other damages.

Version	Date	Change
1	October 2009	Draft
2	December 2009	Final

TABLE OF CONTENTS

APPENDIX 7 – TRANSFORMER EVENT COSTS	4
<i>North Island N-1.....</i>	<i>4</i>
<i>South Island N-1</i>	<i>7</i>
<i>North Island N-1-1.....</i>	<i>9</i>
<i>South Island N-1-1</i>	<i>10</i>

Appendix 7 – Transformer Event Costs

North Island N-1

Transformer	Stability Event (\$m)	Contingent Event (\$m)	Extended Contingent Event (\$m)			Link
			\$10k	\$5k	\$2k	
220/110/x	\$20k	\$10k	\$10k	\$5k	\$2k	
Northland						
ALB T4	-	-	-	-	-	No issues
HEN T1	-	-	-	-	-	No issues
HEN T5	0.3684	29.784	0.0054	0.0027	0.0011	HEN T5
MDN T1	-	-	-	-	-	No issues
MDN T2						out of service
MDN T3	-	-	-	-	-	No issues
Auckland						
OTA T2	-	-	-	-	-	No issues
OTA T3	-	-	-	-	-	No issues
OTA T4	0.155	9.64	0.002	0.0009	0.0003	OTA T4
OTA T5	-	-	-	-	-	No issues
PEN T10	-	-	-	-	-	No issues
Hamilton						
HAM T6	-	-	-	-	-	No issues
HAM T9	-	-	-	-	-	No issues
Bay of Plenty						
EDG T4						out of service
EDG T5						out of service
KAW T12	-	-	-	-	-	No issues
KAW T13	-	-	-	-	-	No issues
TRK T1	0.1656	31.536	0.00571	0.0029	0.0011	TRK T1

Transformer	Stability Event (\$m)	Contingent Event (\$m)	Extended Contingent Event (\$m)			Link
	220/110/x	\$20k	\$10k	\$10k	\$5k	
TRK T2	0.1656	31.536	0.00571	0.0029	0.0011	TRK T2
Hawkes Bay						
RDF T3	0.8631	280.32	0.051	0.0254	0.0102	RDF T3
RDF T4	0.8631	280.32	0.051	0.0254	0.0102	RDF T4
Taranaki						
NPL T8	-	-	-	-	-	No issues
SFD T10	--		-	-	-	No issues
Bunnythorpe						
BPE T1 HVDC North	0.172	21.9	0.004	0.002	0.001	BPE T1
BPE T1 HVDC South	--		--		-	No issues
BPE T2 HVDC North	0.172	21.9	0.004	0.002	0.001	BPE T2
BPE T2 HVDC South	--		--		-	No issues
BPE T3 HVDC North	0.172	21.9	0.004	0.002	0.001	BPE T3
BPE T3 HVDC South	--		--		-	No issues
Wellington						
HAY T1 HVDC North	2.17	740.22	0.134	0.067	0.027	HAY T1 HVDC North
HAY T1 HVDC South	0.905	183.96	0.034	0.0175	0.0076	HAY T1 HVDC South
HAY T2 HVDC North	2.17	740.22	0.134	0.067	0.027	HAY T2 HVDC North
HAY T2 HVDC South	0.905	183.96	0.034	0.0175	0.0076	HAY T2 HVDC South

Transformer	Stability Event (\$m)	Contingent Event (\$m)	Extended Contingent Event (\$m)			Link
	\$20k	\$10k	\$10k	\$5k	\$2k	
220/110/x						
HAY T5 HVDC North	2.17	740.22	0.134	0.067	0.027	HAY T5 HVDC North
HAY T5 HVDC South	0.905	183.96	0.034	0.0175	0.0076	HAY T5 HVDC South
WIL T8 HVDC North	--		--		-	No issues
WIL T8 HVDC South	--		--		-	No issues

South Island N-1

Rows in grey ink result in loss of supply and no alternative measures.

Transformer	Stability Event (\$m)	Contingent Event (\$m)	Extended Contingent Event (\$m)			Link
	\$20k	\$10k	\$10k	\$5k	\$2k	
Nelson						
KIK T1 200/110/11	0.0539					KIK T1
KIK T2 220/110/11	0.9480	39.42	0.0071	0.0036	0.0014	KIK T2
STK T7 220/110/11	2.4898	78.84	0.0143	0.0071	0.0029	STK T7
WPR T12 220/66	-	-	-	-	-	No issues
WPR T13 220/66	-	-	-	-	-	No issues
Christchurch						
ISL T3 220/66/11	1.0397	5.26	0.0010	0.0005	0.0002	ISL T3
ISL T6 220/66/11	2.0164	50.81	0.0092	0.0046	0.0018	ISL T6
ISL T7 220/66/11	1.0397	5.26	0.0010	0.0005	0.0002	ISL T7
Canterbury						
ASB T8* 220/66	0.6346					ASB T8
BRY T5 220/66/11	0.4163	98.11	0.0178	0.0089	0.0036	BRY T5
BRY T6 220/66/11	0.4163	98.11	0.0178	0.0089	0.0036	BRY T6
TIM T5 220/110	0.0378	7.88	0.0014	0.0007	0.0003	TIM T5
TIM T8 220/110	0.0749	17.52	0.0032	0.0016	0.0006	TIM T8

Transformer	Stability Event (\$m)	Contingent Event (\$m)	Extended Contingent Event (\$m)			Link
	\$20k	\$10k	\$10k	\$5k	\$2k	
West Coast						
None						
Otago						
CML T5 220/110/33	--		--		-	No issues
CML T8 220/110/33	--		--		-	No issues
WTK T23 220/110/11	0.2665					WTK T23
WTK T24 220/110/11	0.2253					WTK T24
Southland						
HWB T4 220/110	2.51 1676.66		0.303	0.1515	0.0606	HWB T4
INV T1 220/110	0.051 14.89		0.003 0.0015		0.0006	INV T1
ROX T4 220/110	--		--		-	No issues

* Note – Considered a 220 kV supply transformer.

North Island N-1-1

Values in grey ink are not included in the summary of Total Annual Costs.

Transformer	Stability Event (\$m)	Contingent Event (\$m)	Extended Contingent Event (\$m)			Link
	\$20k	\$10k	\$10k	\$5k	\$2k	
Auckland						
OTA T4 & PEN T10 220/110/11	2.01	1555	0.282	0.141	0.056	OTA T4 & PEN T10
Bunnythorpe						
BPE T1 & T2 220/110/11 HVDC North	2.79	1167.27	0.211	0.106	0.042	BPE T1 & T2
BPE T1 & T2 220/110/11 HVDC South	-	-	-	-	-	No issues
BPE T1 & T3 220/110/11 HVDC North	2.79	1167.27	0.211	0.106	0.042	BPE T1 & T3
BPE T1 & T3 220/110/11 HVDC South	-	-	-	-	-	No issues
BPE T2 & T3 220/110/11 HVDC North	2.79	1167.27	0.211	0.106	0.042	BPE T2 & T3
BPE T2 & T3 220/110/11 HVDC South	-	-	-	-	-	No issues
Wellington						
HAY T1 & T2 220/110/11 HVDC North	2.99	1544.39	0.28	0.14	0.056	HAY T1 & T2 HVDC North
HAY T1 & T2 220/110/11 HVDC South	1.976	-	0.115	0.077	0.023	HAY T1 & T2 HVDC South
HAY T1 & T5 220/110/11 HVDC North	2.99	1544.39	0.29	0.14	0.056	HAY T1 & T5 HVDC North

Transformer	Stability Event (\$m)	Contingent Event (\$m)	Extended Contingent Event (\$m)			Link
	\$20k	\$10k	\$10k	\$5k	\$2k	
HAY T1 & T5 220/110/11 HVDC South	1.976	-	0.115	0.077	0.023	HAY T1 & T5 HVDC South
HAY T2 & T5 220/110/11 HVDC North	2.99	1544.39	0.29	0.14	0.056	HAY T2 & T5 HVDC North
HAY T2 & T5 220/110/11 HVDC South	1.976	-	0.115	0.077	0.023	HAY T2 & T5 HVDC South

South Island N-1-1

Transformer	Stability Event	Contingent Event	Extended Contingent Event			Link
	\$20k	\$10k	\$10k	\$5k	\$2k	
Christchurch						
ISL T3 & T6 220/66/11	15.8866	1330.64	0.2410	0.1205	0.0482	ISL T3 & T6
ISL T6 & T7 220/66/11	16.1424	1379.70	0.2499	0.1249	0.0500	ISL T6 & T7
ISL T3 & T7 220/66/11	10.5808	488.81	0.0885	0.0443	0.0177	ISL T3 & T7

Event: Loss of Bunnythorpe transformer T1 or T2 or T3 **Region:** Bunnythorpe

Planned Outage: Bunnythorpe transformer T1 or T2 or T3

Event Risk Factor: 0.0475

Average Duration: 16.7h

SE Approach: Post-event unplanned load shedding

Assumptions:

HVDC North transfer on Pole 2 – 660MW

HVDC

Pole 1 – 200MW

Local generation at Te Apiti and Mangahao set to zero.

Post event:

Loss of a Bunnythorpe transformer while one is out on planned maintenance.

Consequence:

The remaining Bunnythorpe 220/110 kV transformer overloads to 102MVA.

Summer 24 hour post contingency rating of the transformers is 58MVA.

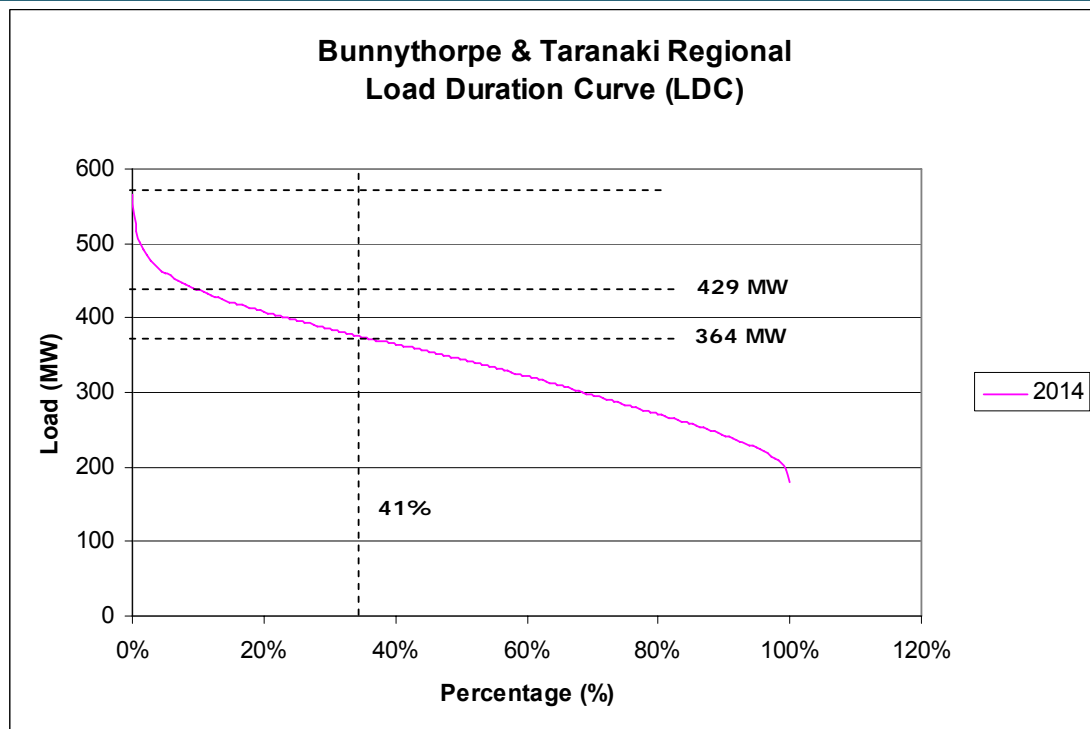
The transformer will trip resulting in loss of supply to the Bunnythorpe and Taranaki regions.

Constraint:

Load constraint limit in the Bunnythorpe and Taranaki regions 364MW.

For 2014, the constraint is exceeded for 41% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	429	16.7	20,000	143.29	0.0475	0.41	2.79



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 65MW load constraint in the Bunnythorpe and Taranaki regions.

Install a SP S at Hanga tiki which will open the Arapuni 110kV circuit breakers during this event

Post event: The remaining load in the Bunnythorpe and Taranaki regions is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	65	4380	10,000	n/a	n/a	0.41	1167.27

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 65MW post event load shedding in the Bunnythorpe and Taranaki regions.

Install a SP S at Hanga tiki which will open the Arapuni 110kV circuit breakers during this event

Post event: The remaining load in the Bunnythorpe and Taranaki regions is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	65	16.7	10,000	10.86	0.0475	0.41	0.211

Event: Loss of Otahuhu transformer T4

Region: Auckland

Event Risk Factor: 0.095

Average Duration: 16.7 hours

SE Approach: *Post-event unplanned load shedding*

Assumptions: The Mount Roskill-Hepburn split considered closed

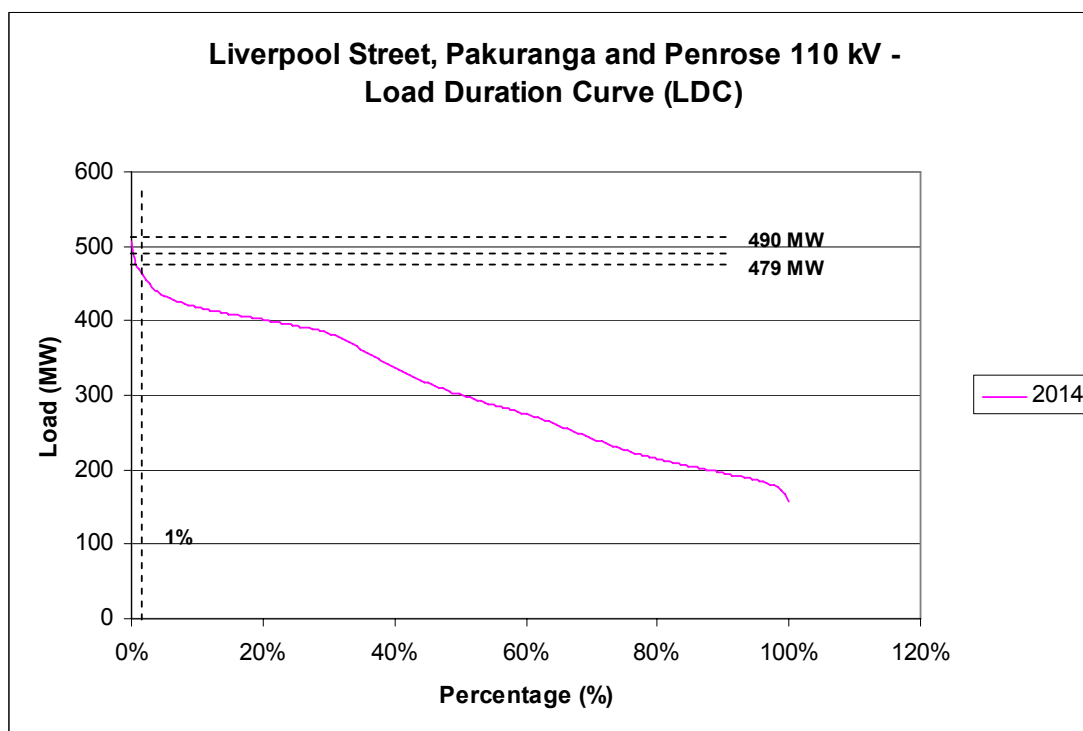
Post event: None

Consequence: The Otahuhu 220/110/11kV transformer T2 overloads to 174MVA. Winter 24 hour post contingency rating of the transformer is 170MVA. Hence it will trip the loads connected to the Otahuhu 110kV busbar B resulting in loss of supply to the Liverpool Street, Pakuranga and Penrose 110kV loads.

Constraint: Load constraint limit at Liverpool Street, Pakuranga and the Penrose 110kV load is 479MW.

For 2014, the constraint is exceeded for 1% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	490	16.7	20,000	163.66	0.095	0.01	0.156



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 11MW of combined load constraint at Liverpool street, Pakuranga and Penrose.

Post event: The remaining Liverpool street, Pakuranga and Penrose load is secured

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	11	8760	10,000	n/a	n/a	0.01	9.64

ECE Approach: Pre-arranged post event load shedding

Pre-event measures: Arrange 11MW of combined post event load shedding at Liverpool street, Pakuranga and Penrose.

Post event: The remaining Liverpool street, Pakuranga and Penrose load is secured

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	11	16.7	10,000	1.84	0.095	0.01	0.002

Event: Loss of Tarukenga transformer T1

Region: Bay of Plenty

Event Risk Factor: 0.095

Average Duration: 16.7 hours

SE Approach: *Post-event unplanned load shedding*

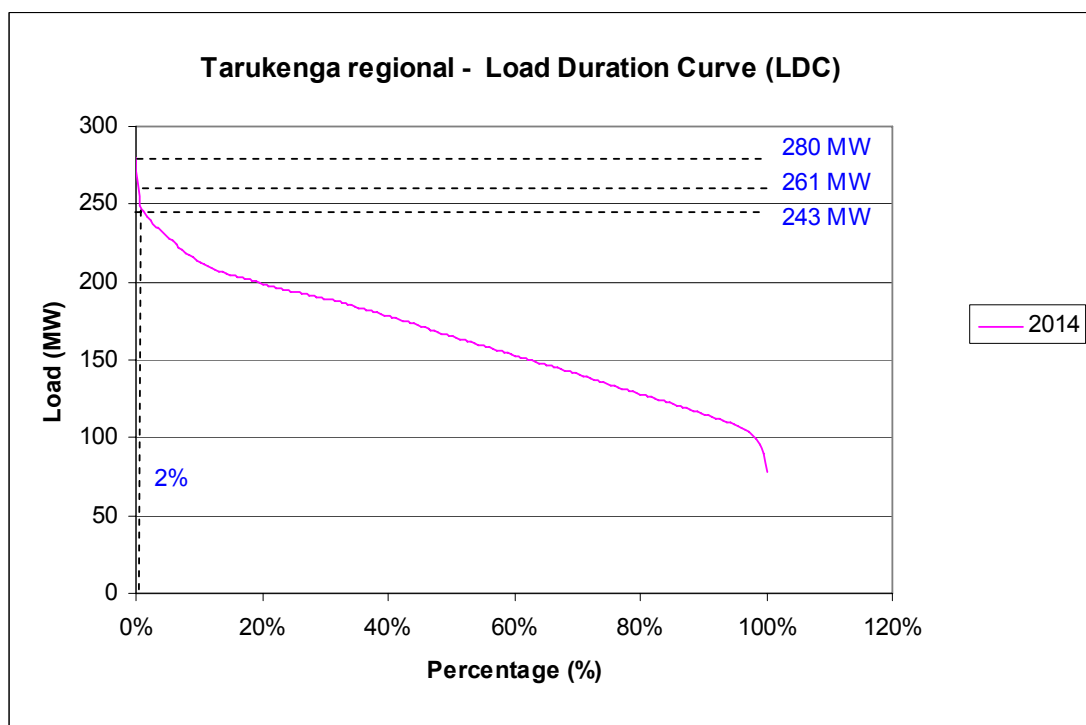
Assumptions: Local Generation at Aniwhenua set to 10MW, Matahina at 10MW, Kawerau at 50MW and Wheo at 5MW. No generation at Otahuhu C.

Post event: None

Consequence: The remaining Tarukenga 220/110/11kV transformer T2 overloads to 283MVA. Winter 24 h our post contingency rating of the transformer is 273MVA. Hence it will trip resulting in the loss of supply to the Tarukenga region.

Constraint: Load constraint limit in the Tarukenga region is 243MW. For 2014, the constraint is exceeded for 2% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	261	16.7	20,000	87.17	0.095	0.02	0.1656



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 18MW load constraint in the Tarukenga region.

Post event: The remaining load in the Tarukenga region will be secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	18	8760	10,000	n/a	n/a	0.02	31.54

ECE Approach: Pre-arranged post event load shedding

Pre-event measures: Arrange 18MW post event load shedding in the Tarukenga region.

Post event: The remaining load in the Tarukenga region will be secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	18	16.7	10,000	3.00	0.095	0.02	0.0057

Event: Loss of Tarukenga transformer T2

Region: Bay of Plenty

Event Risk Factor: 0.095

Average Duration: 16.7 hours

SE Approach: *Post-event unplanned load shedding*

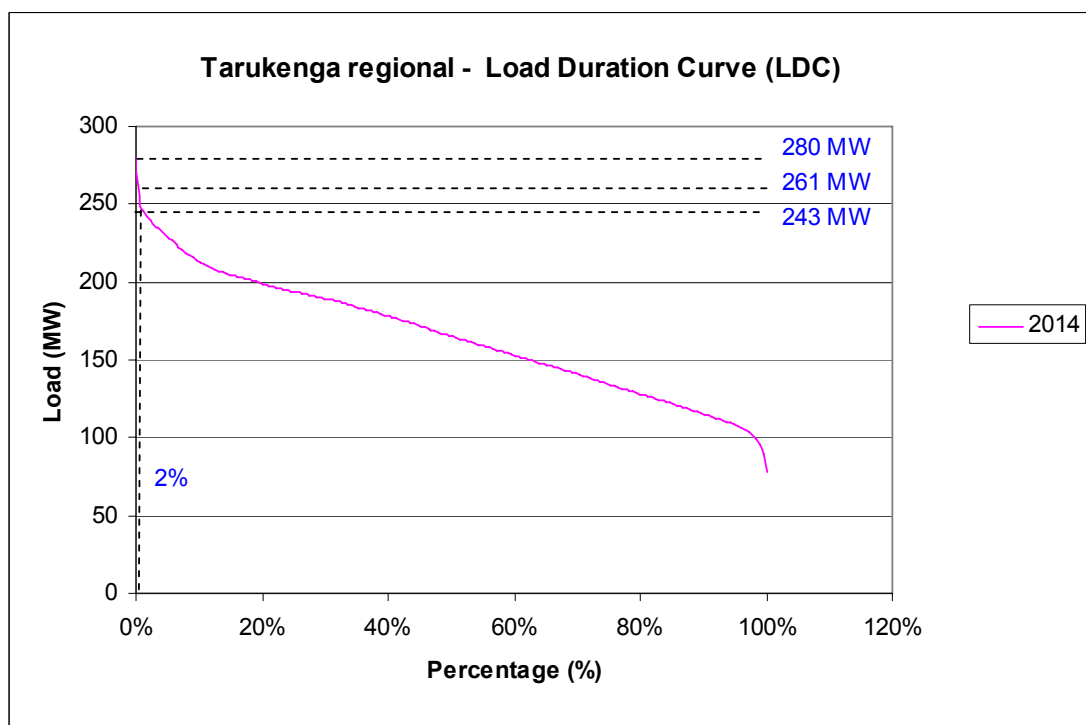
Assumptions: Local Generation at Aniwhenua set to 10MW, Matahina at 10MW, Kawerau at 50MW and Wheo at 5MW. No generation at Otahuhu C.

Post event: None

Consequence: The remaining Tarukenga 220/110/11kV transformer T1 overloads to 275MVA. Winter 24 h our post contingency rating of the transformer is 264MVA. Hence it will trip resulting in the loss of supply to the Bay of Plenty region.

Constraint: Load constraint limit in the Tarukenga region is 243MW. For 2014, the constraint is exceeded for 2% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	261	16.7	20,000	87.17	0.095	0.02	0.1656



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 18MW load constraint in the Tarukenga region.

Post event: The remaining load in the Tarukenga region will be secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	18	8760	10,000	n/a	n/a	0.02	31.54

ECE Approach: Pre-arranged post event load shedding

Pre-event measures: Arrange 18MW post event load shedding in the Tarukenga region.

Post event: The remaining load in the Tarukenga region will be secured.

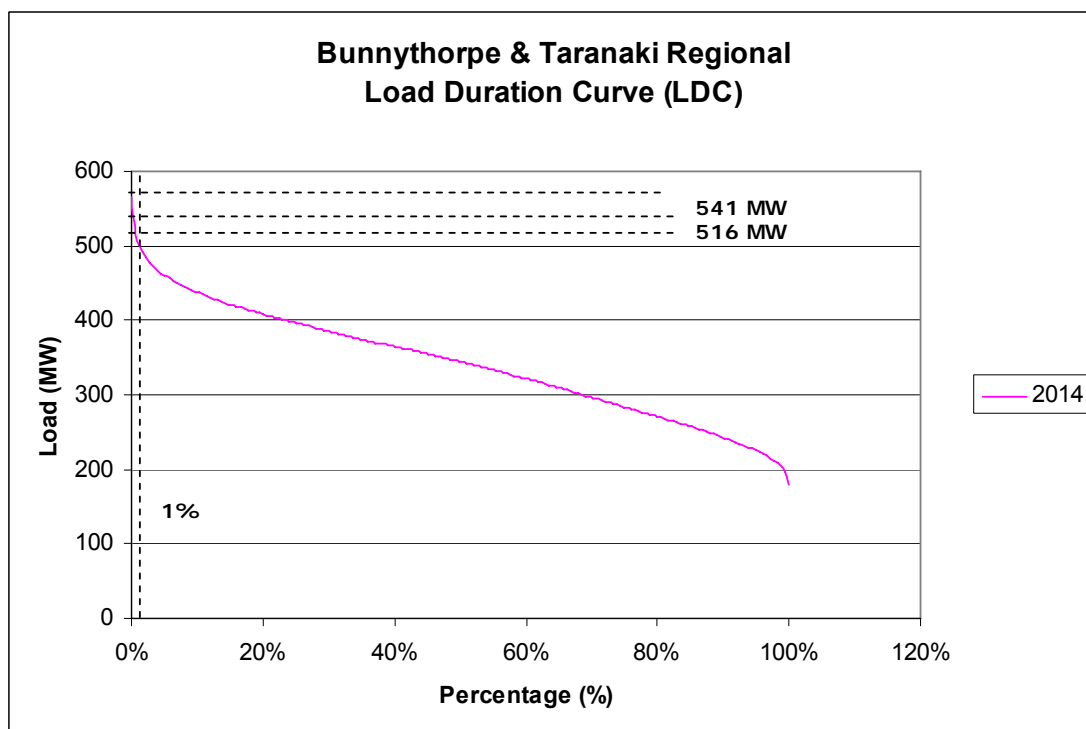
Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	18	16.7	10,000	3.00	0.095	0.02	0.0057

Event: Loss of Bunnythorpe transformer T1 or T2 or T3 **Region:** Bunnythorpe
Event Risk Factor: 0.095 **Average Duration:** 16.7 h

SE Approach: *Post-event unplanned load shedding*

Assumptions: Local generation at Te Apiti and Mangahao set to zero
Post event: Loss of Bunnythorpe transformer T1 or T2 or T3
Consequence: The remaining Bunnythorpe 220/110/11 kV transformers overloads to 70MVA each.
 Winter 24 hour post contingency rating of the transformers is 62MVA.
 These transformers will trip resulting in the loss of supply to the Bunnythorpe and Taranaki regions.
Constraint: Load constraint limit in the Bunnythorpe and Taranaki regions 516MW.
 For 2014, the constraint is exceeded for 1% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	541	16.7	20,000	180.69	0.095	0.01	0.172



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 25MW load constraint in the Bunnythorpe and Taranaki regions.

Post event: The remaining load in the Bunnythorpe and Taranaki regions is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	25	8760	10,000	n/a	n/a	0.01	21.9

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 25MW post event load shedding in the Bunnythorpe and Taranaki regions.

Post event: The remaining load in the Bunnythorpe and Taranaki regions is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	25	16.7	10,000	4.18	0.095	0.01	0.004

Event: Loss of Ashburton transformer T1

Region: Canterbury

Event Risk Factor: 0.095

Average Duration: 16.7 h

SE Approach: *Post-event unplanned load shedding*

Assumptions: No local generation at Tekapo A, Highbank and Opuha

Post event: Loss of Ashburton transformer T1

Consequence: The remaining Ashburton on 220/33kV transformer T3 overloads to 56MVA.

Winter 24 hour post contingency rating of the transformer is 54MVA.

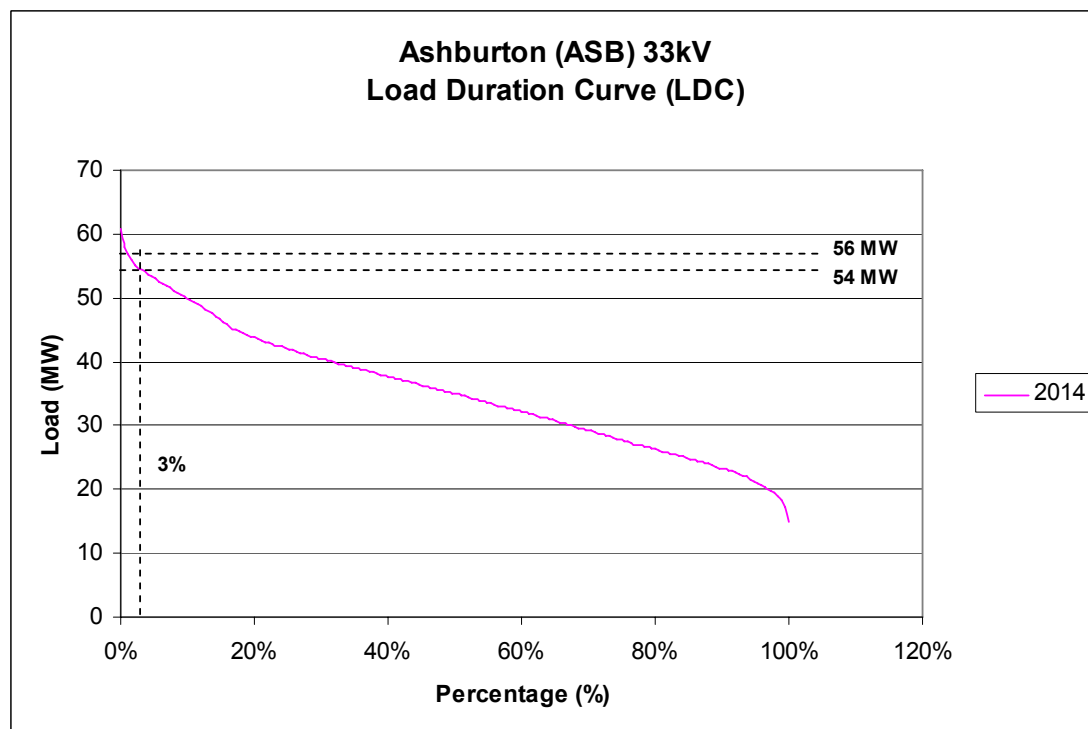
Loss of supply to Ashburton 33kV load.

Constraint:

Load constraint limit at Ashburton 33kV is 54MW.

For 2014, the constraint is exceeded for 3% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	56	16.7	20,000	18.704	0.095	0.03	0.0533



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 2MW load constraint for the Ashburton 33kV load.

Post event: The remaining load at Ashburton 33kV is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	2	8760	10,000	n/a	n/a	0.03	5.26

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 2MW post event load shedding at Ashburton 33kV load.

Post event: The remaining load at Ashburton 33kV is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	2	16.7	10,000	0.334	0.095	0.03	0.001

Event: Loss of Ashburton transformer T3

Region: Canterbury

Event Risk Factor: 0.095

Average Duration: 16.7 h

SE Approach: *Post-event unplanned load shedding*

Assumptions: No local generation at Tekapo A, Highbank and Opuha

Post event: Loss of Ashburton transformer T3

Consequence: The remaining Ashburton on 220/33kV transformer T1 overloads to 56MVA.

Winter 24 hour post contingency rating of the transformer is 54MVA.

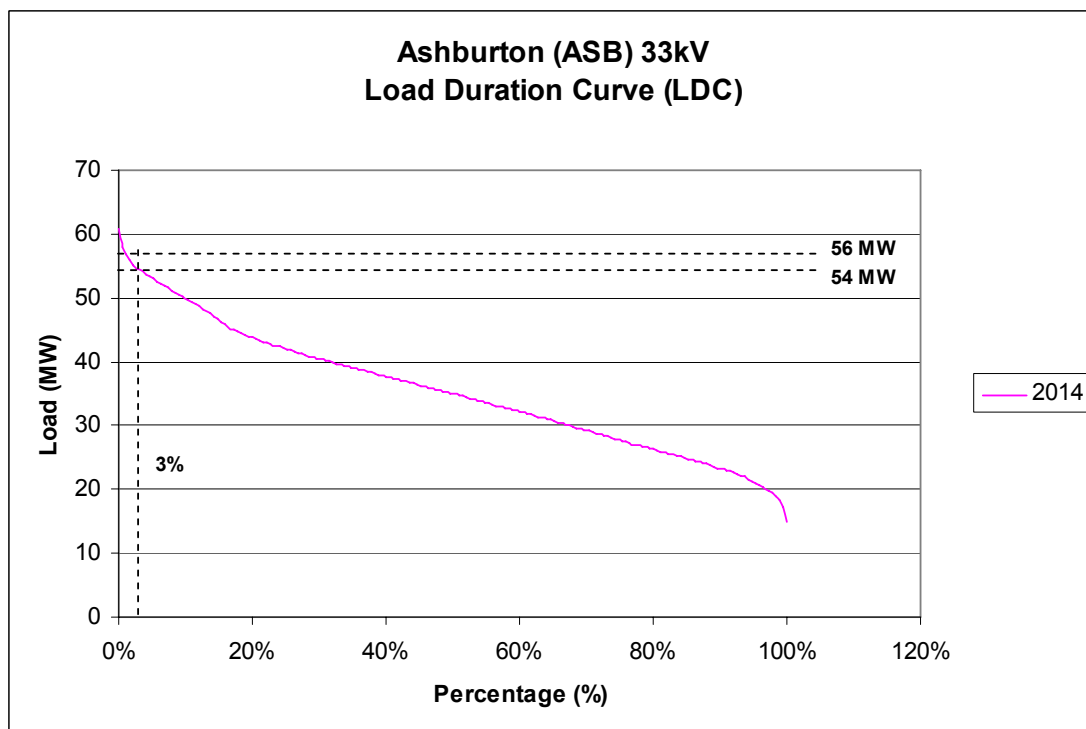
Loss of supply to Ashburton 33kV load.

Constraint:

Load constraint limit at Ashburton 33kV is 54MW.

For 2014, the constraint is exceeded for 3% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	56	16.7	20,000	18.704	0.095	0.03	0.0533



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 2MW load constraint for the Ashburton 33kV load.

Post event: The remaining load at Ashburton 33kV is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	2	8760	10,000	n/a	n/a	0.03	5.26

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 2MW post event load shedding at Ashburton 33kV load.

Post event: The remaining load at Ashburton 33kV is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	2	16.7	10,000	0.334	0.095	0.03	0.001

Event: Loss of Ashburton transformer T8

Region: Canterbury

Event Risk Factor: 0.095

Average Duration: 16.7 h

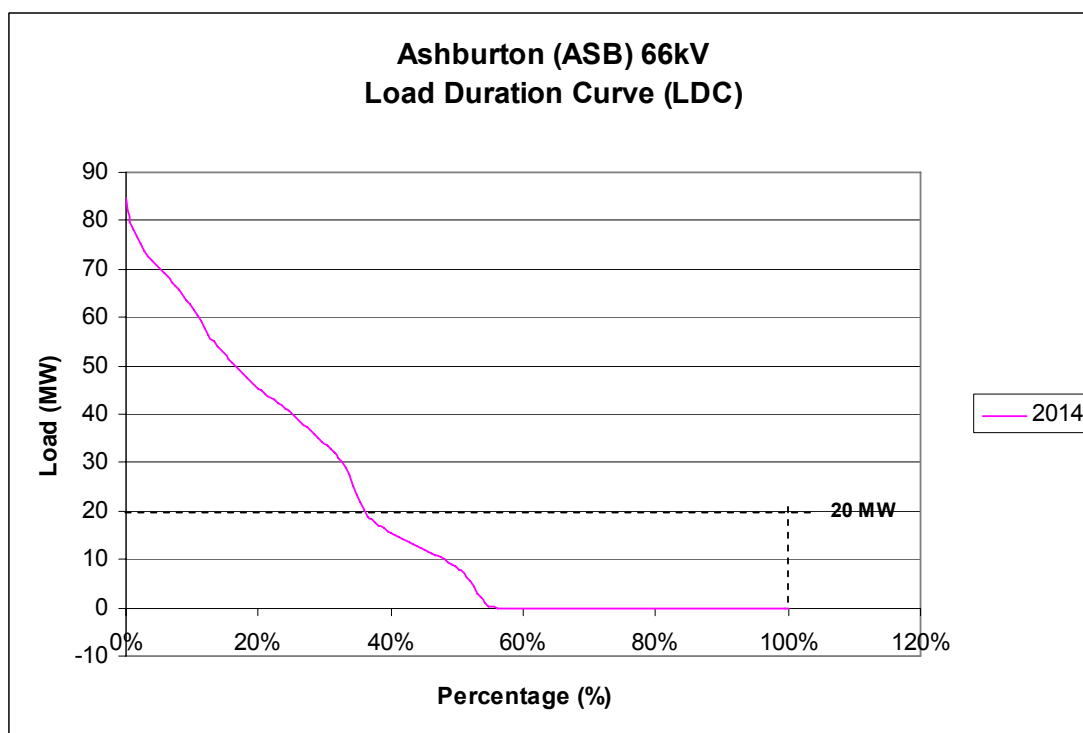
SE Approach: *Post-event unplanned load shedding*

Assumptions: None

Post event: Loss of Ashburton transformer T8

Consequence: Loss of Ashburton 66kV load

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	20	16.7	20,000	6.68	0.095	1	0.6346



CE Approach: *Alternate measures unavailable*

Direct loss of supply unavoidable, managed as described above

ECE Approach: *Alternate measures unavailable*

Direct loss of supply unavoidable, managed as described above

Event: Loss of Bromley transformer T5

Region: Canterbury

Event Risk Factor: 0.095

Average Duration: 16.7 h

SE Approach: *Post-event unplanned load shedding*

Assumptions: No local generation at Tekapo A, Highbank and Opuha
 Bromley capacitors C5A and C6A are out of service

Post event: Loss of Bromley transformer T5

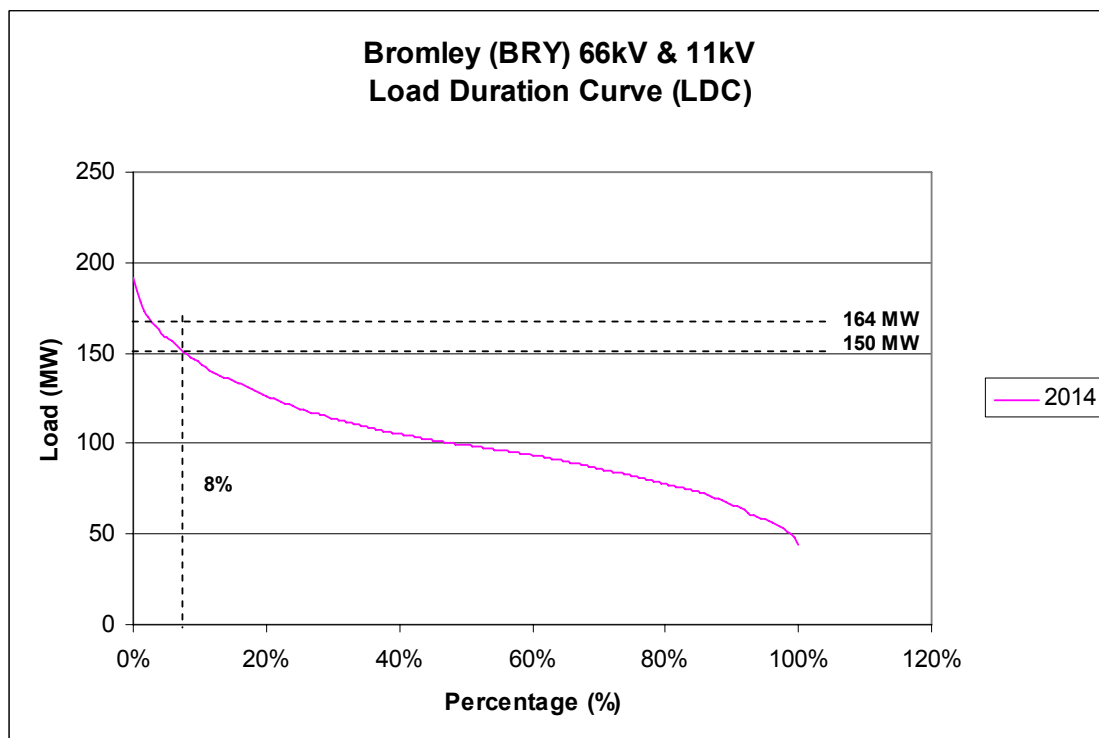
Consequence: Bromley transformer 6 will be overloaded to 196MVA.
 Winter 24 hour post contingency rating of Bromley T6 is 156MVA.

Loss of supply to Bromley 66kV and 11kV loads.

Constraint: Load constraint limit at Bromley 66kV and 11kV is 150MW.

For 2014, the constraint is exceeded for 8% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	164	16.7	20,000	54.776	0.095	0.08	0.4163



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 14MW load constraint at Bromley 6 6kV and 11kV.

Post event: The remaining Bromley 66kV and 11kV load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	14	8760	10,000	n/a	n/a	0.08	98.112

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 14MW post-event load shedding at Bromley 66kV and 11kV.

Post event: The remaining Bromley 66kV and 11kV load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	14	16.7	10,000	2.338	0.095	0.08	0.0178

Event: Loss of Bromley transformer T6

Region: Canterbury

Event Risk Factor: 0.095

Average Duration: 16.7 h

SE Approach: *Post-event unplanned load shedding*

Assumptions: No local generation at Tekapo A, Highbank and Opuha
 Bromley capacitors C5A and C6A are out of service

Post event: Loss of Bromley transformer T6

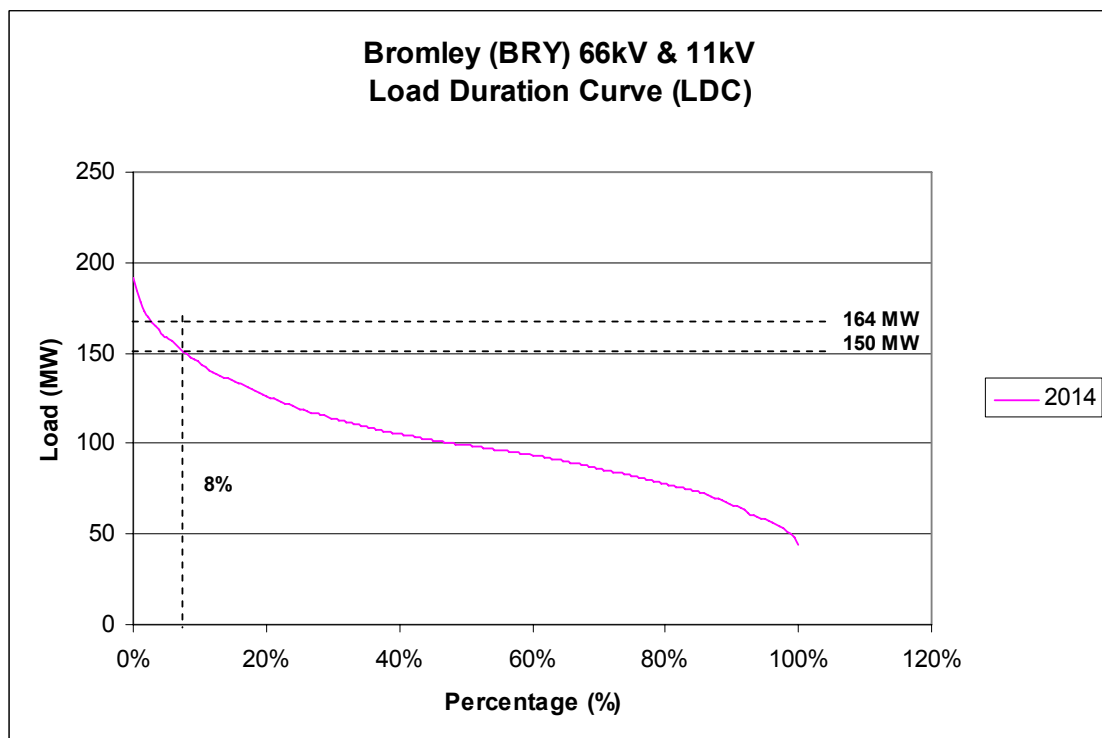
Consequence: Bromley transformers T5 overloads to 197MVA.
 Winter 24 hour post contingency rating of Bromley T5 is 156MVA.

Loss of supply to Bromley 66kV and 11kV loads.

Constraint: Load constraint limit at Bromley 66 kV and 11kV load is 150MW.

For 2014, the constraint is exceeded for 8% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	164	16.7	20,000	54.776	0.095	0.08	0.4163



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 14MW load constraint at Bromley 6 6kV and 11kV.

Post event: The remaining Bromley 66kV and 11kV load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	14	8760	10,000	n/a	n/a	0.08	98.112

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 14MW post-event load shedding at Bromley 66kV and 11kV.

Post event: The remaining Bromley 66kV and 11kV load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	14	16.7	10,000	2.338	0.095	0.08	0.0178

Event: Loss of Timaru transformer T5

Region: Canterbury

Event Risk Factor: 0.095

Average Duration: 16.7 h

SE Approach: *Post-event unplanned load shedding*

Assumptions: No local generation at Tekapo A, Highbank and Opuha

Post event: Loss of Timaru transformer T5

Consequence: The remaining Timaru 220/110 kV transformer T8 overloads to 150MVA.

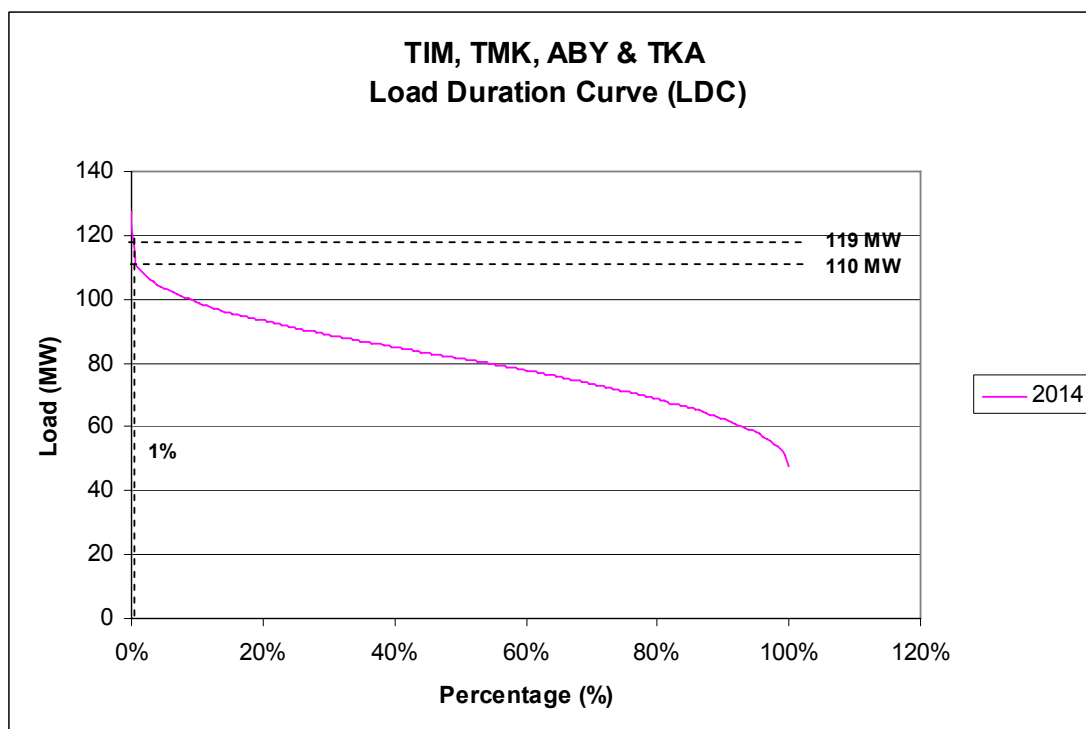
Winter 24 hour post contingency rating of the transformer is 129MVA.

Loss of supply to Timaru, Temuka, Tekapo A and Albury loads.

Constraint: Load constraint limit at Timaru, Temuka, Tekapo A and Albury is 110MW.

For 2014, the constraint is exceeded for 1% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	119	16.7	20,000	39.75	0.095	0.01	0.0378



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 9MW load constraint for Timaru, Temuka, Tekapo A and Albury.

Post event: The remaining load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	9	8760	10,000	n/a	n/a	0.01	7.884

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 9MW post event load shedding at Timaru, Temuka, Tekapo A and Albury.

Post event: The remaining load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	9	16.7	10,000	1.503	0.095	0.01	0.0014

Event: Loss of Timaru transformer T8

Region: Canterbury

Event Risk Factor: 0.095

Average Duration: 16.7 h

SE Approach: *Post-event unplanned load shedding*

Assumptions: No local generation at Tekapo A, Highbank and Opuha

Post event: Loss of Timaru transformer T8

Consequence: The remaining Timaru 220/110 kV transformer T5 overloads to 150MVA.

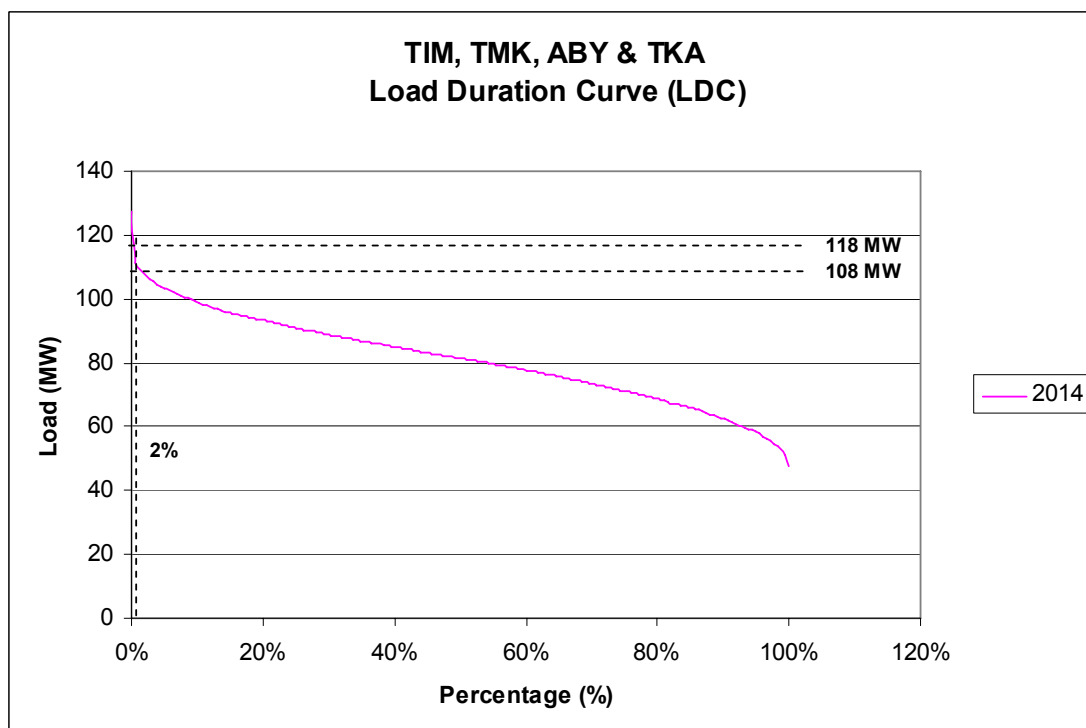
Winter 24 hour post contingency rating of the transformer is 125MVA.

Loss of supply to Timaru, Temuka, Tekapo A and Albury loads.

Constraint: Load constraint limit at Timaru, Temuka, Tekapo A and Albury is 108MW.

For 2014, the constraint is exceeded for 2% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	118	16.7	20,000	39.41	0.095	0.02	0.0749



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 10MW load constraint for the Timaru, Temuka, Tekapo A and Albury.

Post event: The remaining load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	10	8760	10,000	n/a	n/a	0.02	17.52

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 10MW post event load shedding for Timaru, Temuka, Tekapo A and Albury.

Post event: The remaining load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	10	16.7	10,000	1.67	0.095	0.02	0.0032

Event: Loss of Islington transformer T3

Region: Christchurch

Event Risk Factor: 0.095

Average Duration: 16.7 h

SE Approach: *Post-event unplanned load shedding*

Assumptions: None

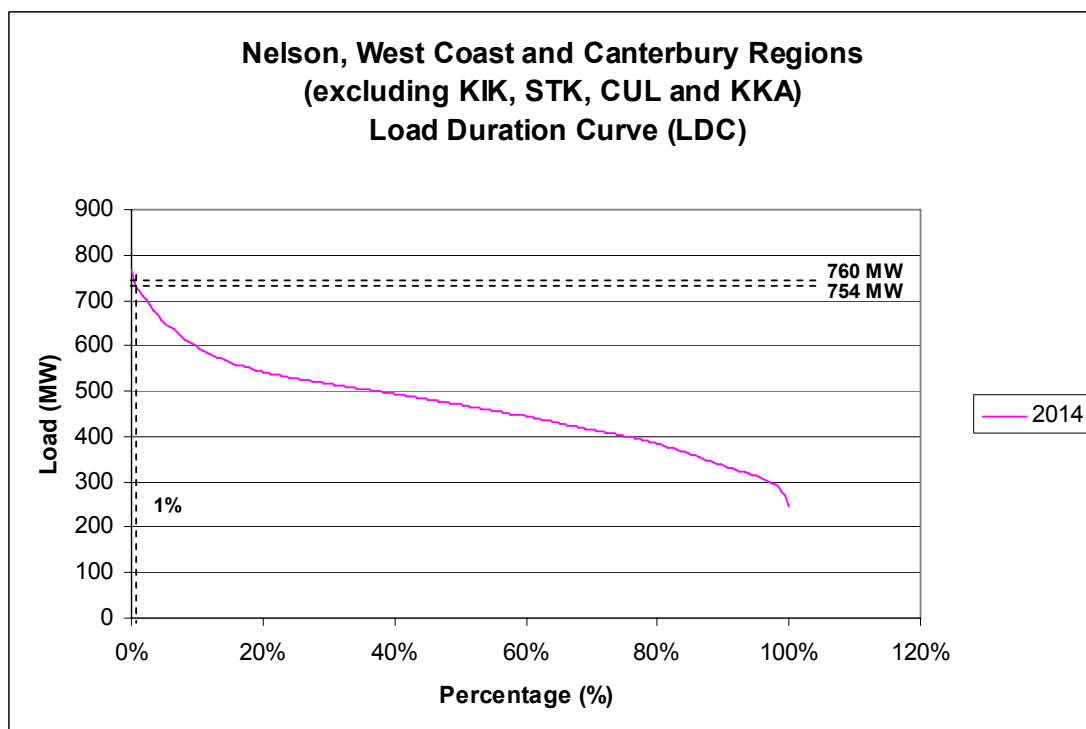
Post event: Loss of Islington transformer T3

Consequence: Voltage collapse in the West Coast, Christchurch and Nelson regions.

Constraint: Load constraint limit in West Coast, Christchurch and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura) 754MW.

For 2014, the constraint is exceeded for 1% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	760	72	20,000	1094.4	0.095	0.01	1.0397



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 6MW load constraint in West Coast, Christchurch and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura).

Post event: The remaining load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	6	8760	10,000	n/a	n/a	0.01	5.256

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 6MW post event load shedding in West Coast, Christchurch and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura).

Post event: The remaining load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	6	16.7	10,000	1.002	0.095	0.01	0.0010

Event: Loss of Islington transformer T6

Region: Christchurch

Event Risk Factor: 0.095

Average Duration: 16.7 h

SE Approach: *Post-event unplanned load shedding*

Assumptions: None

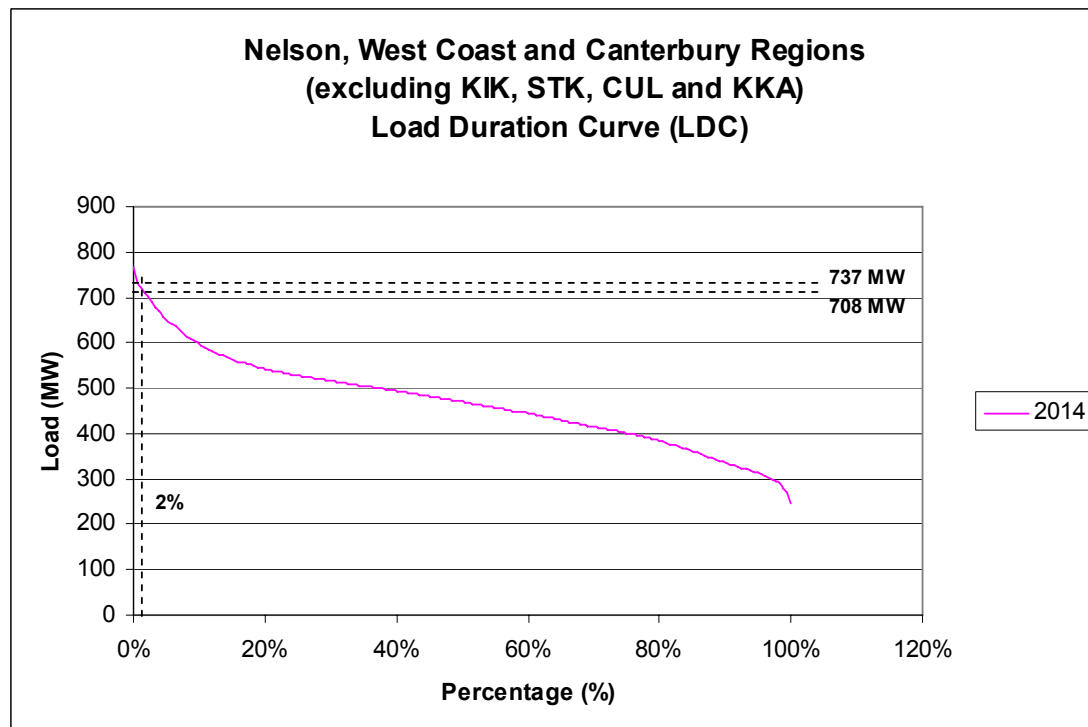
Post event: Loss of Islington transformer T6

Consequence: Voltage collapse in the West Coast, Christchurch and Nelson regions.

Constraint: Load constraint limit in West Coast, Christchurch and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura) 708MW.

For 2014, the constraint is exceeded for 2% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	737	72	20,000	1061.3	0.095	0.02	2.0164



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 29MW load constraint in West Coast, Christchurch and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura).

Post event: The remaining load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	29	8760	10,000	n/a	n/a	0.02	50.81

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 29MW post event load shedding in West Coast, Christchurch and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura).

Post event: The remaining load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	29	16.7	10,000	4.843	0.095	0.02	0.0092

Event: Loss of Islington transformer T7

Region: Christchurch

Event Risk Factor: 0.095

Average Duration: 16.7 h

SE Approach: *Post-event unplanned load shedding*

Assumptions: None

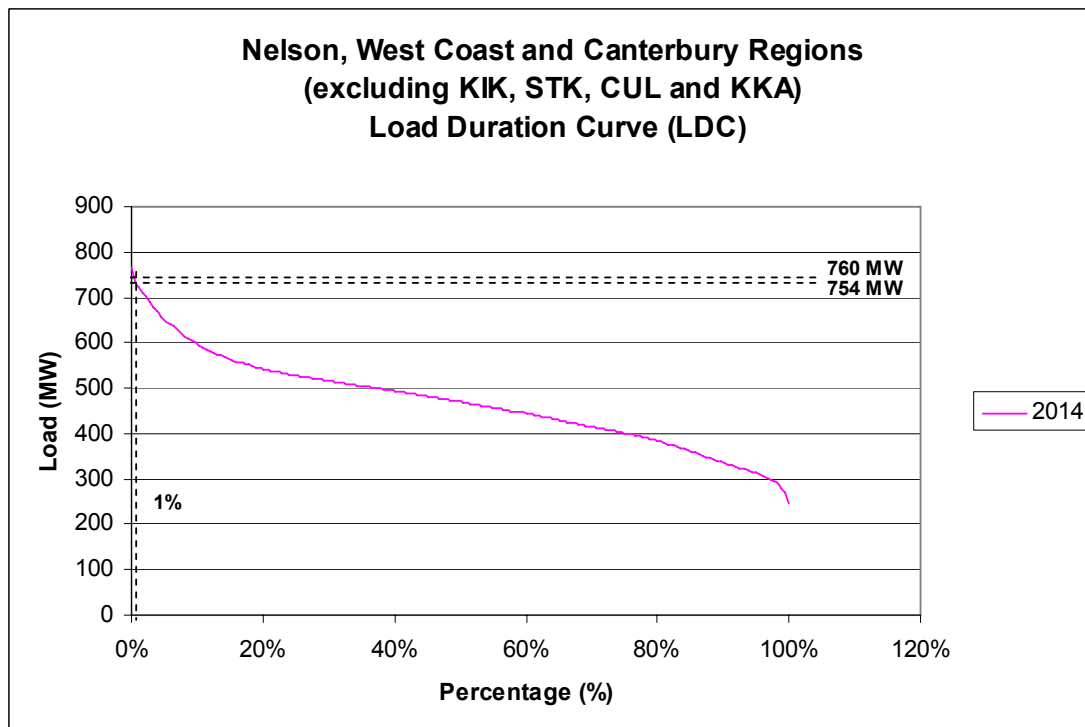
Post event: Loss of Islington transformer T7

Consequence: Voltage collapse in the West Coast, Christchurch and Nelson regions.

Constraint: Load constraint limit load in West Coast, Christchurch and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura) 754MW.

For 2014, the constraint is exceeded for 1% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	760	72	20,000	1094.4	0.095	0.01	1.0397



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 6MW load constraint in West Coast, Christchurch and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura).

Post event: The remaining load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	6	8760	10,000	n/a	n/a	0.01	5.256

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 6MW post event load shedding in West Coast, Christchurch and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura).

Post event: The remaining load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	6	16.7	10,000	1.002	0.095	0.01	0.0010

Event: Loss of Redclyffe transformer T3

Region: Hawke's Bay

Event Risk Factor: 0.095

Average Duration: 16.7 hours

SE Approach: *Post-event unplanned load shedding*

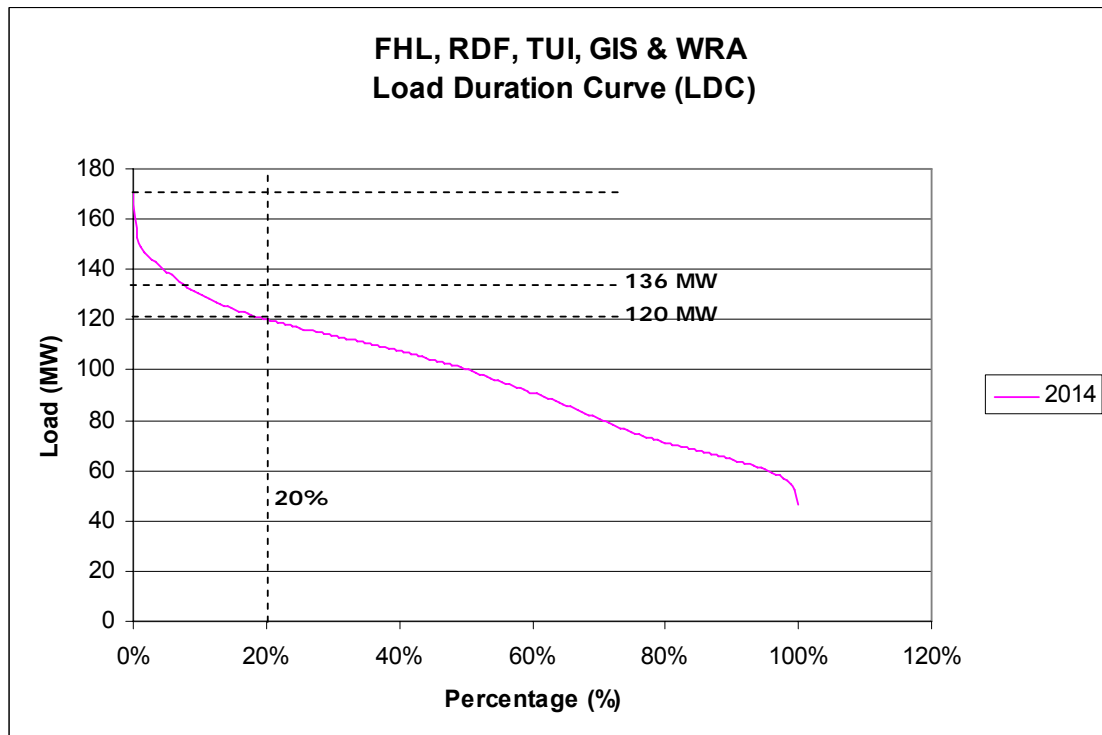
Assumptions: No generation at Tuai (including Kaitawa and Piripaua)

Post event: None

Consequence: The Redclyffe 220/110 transformer T4 overloads to 181MVA. Winter 24 hour post contingency rating of the transformer is 120MVA. Hence it will trip resulting in loss of supply to Redclyffe, Tuai, Gisborne, Wairoa and Fernhill load.

Constraint: Load constraint limit in the Hawkes Bay region is 120MVA.
 For 2014, the constraint is exceeded for 20% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	136	16.7	20,000	45.42	0.095	0.2	0.863



CE Approach : Pre-event security constraints

Pre-event measures: Arrange 16MW load constraint in the Hawkes Bay region.

Post event: The remaining load in the Hawkes Bay region will be secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	16	8760	10,000	n/a	n/a	0.2	280.32

ECE Approach : Pre-arranged post event load shedding

Pre-event measures: Arrange 16MW post event load shedding in the Hawkes Bay region.

Post event: The remaining load in the Hawkes Bay region will be secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	16	16.7	10,000	2.672	0.095	0.2	0.051

Event: Loss of Redclyffe transformer T4

Region: Hawke's Bay

Event Risk Factor: 0.095

Average Duration: 16.7 hours

SE Approach: *Post-event unplanned load shedding*

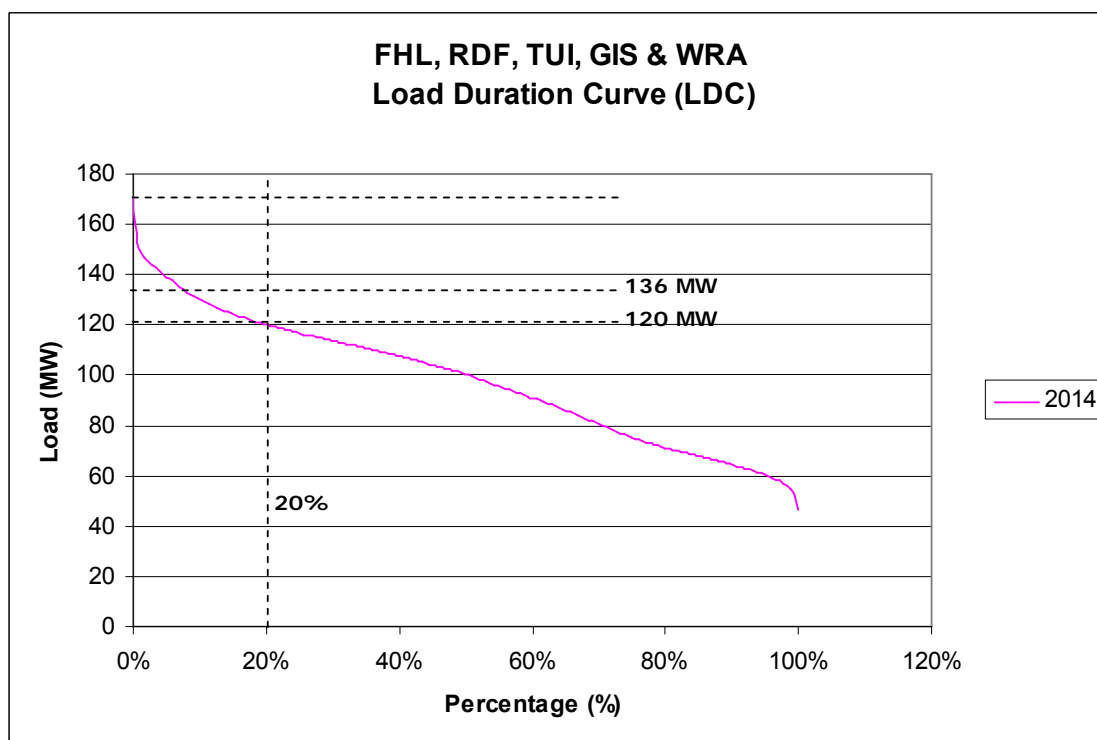
Assumptions: No generation at Tuai (including Kaitawa and Piripaua)

Post event: None

Consequence: The Redclyffe 220/110 transformer T3 overloads to 181MVA. Winter 24 hour post contingency rating of the transformer is 120MVA. Hence it will trip resulting in loss of supply to Redclyffe, Tuai, Gisborne, Wairoa and Fernhill load.

Constraint: Load constraint limit in the Hawkes Bay region is 120MVA.
 For 2014, the constraint is exceeded for 20% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	136	16.7	20,000	45.42	0.095	0.2	0.863



CE Approach : Pre-event security constraints

Pre-event measures: Arrange 16MW load constraint in the Hawkes Bay region.

Post event: The remaining load in the Hawkes Bay region will be secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	16	8760	10,000	n/a	n/a	0.2	280.32

ECE Approach : Pre-arranged post event load shedding

Pre-event measures: Arrange 16MW post event load shedding in the Hawkes Bay region.

Post event: The remaining load in the Hawkes Bay region will be secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	16	16.7	10,000	2.672	0.095	0.2	0.051

Event: Loss of Kikiwa transformer T1

Region: Nelson

Event Risk Factor: 0.095

Average Duration: 16.7 h

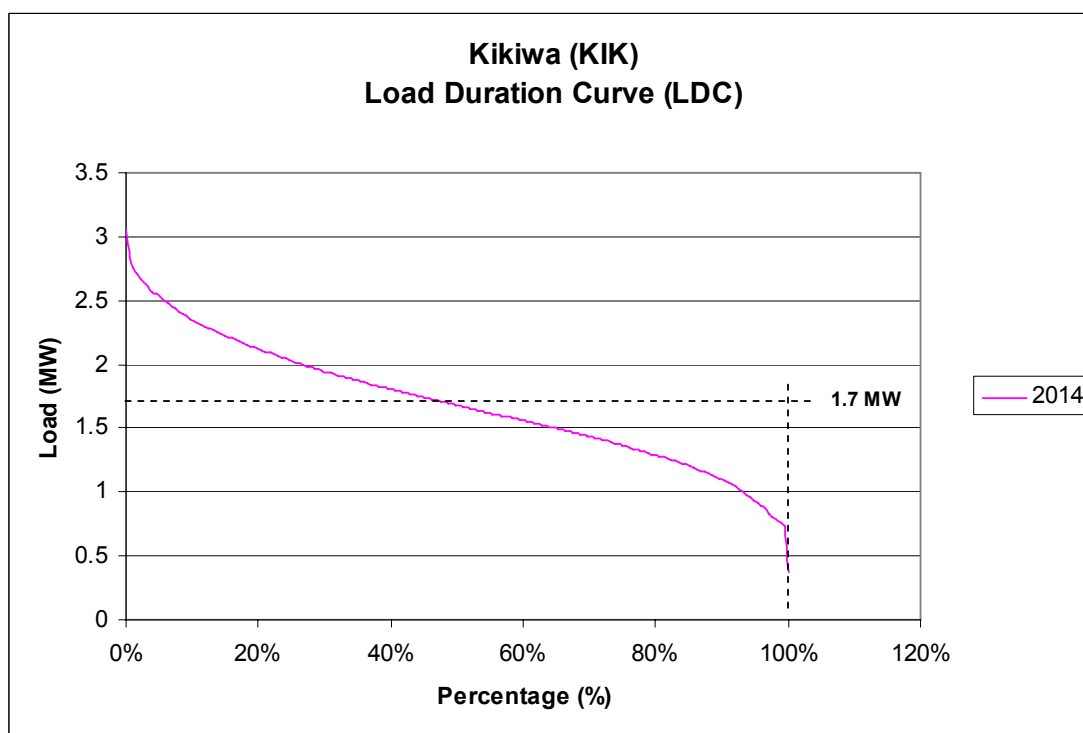
SE Approach: *Post-event unplanned load shedding*

Assumptions: None

Post event: Loss of Kikiwa transformer T1

Consequence: Loss of Kikiwa load

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	1.7	16.7	20,000	0.5678	0.095	1	0.0539



CE Approach: *Alternate measures unavailable*

Direct loss of supply unavoidable, managed as described above

ECE Approach: *Alternate measures unavailable*

Direct loss of supply unavoidable, managed as described above

Event: Loss of Kikiwa transformer T2

Region: Nelson

Event Risk Factor: 0.095

Average Duration: 16.7 h

SE Approach: *Post-event unplanned load shedding*

Assumptions: No local generation at Cobb and Argyle

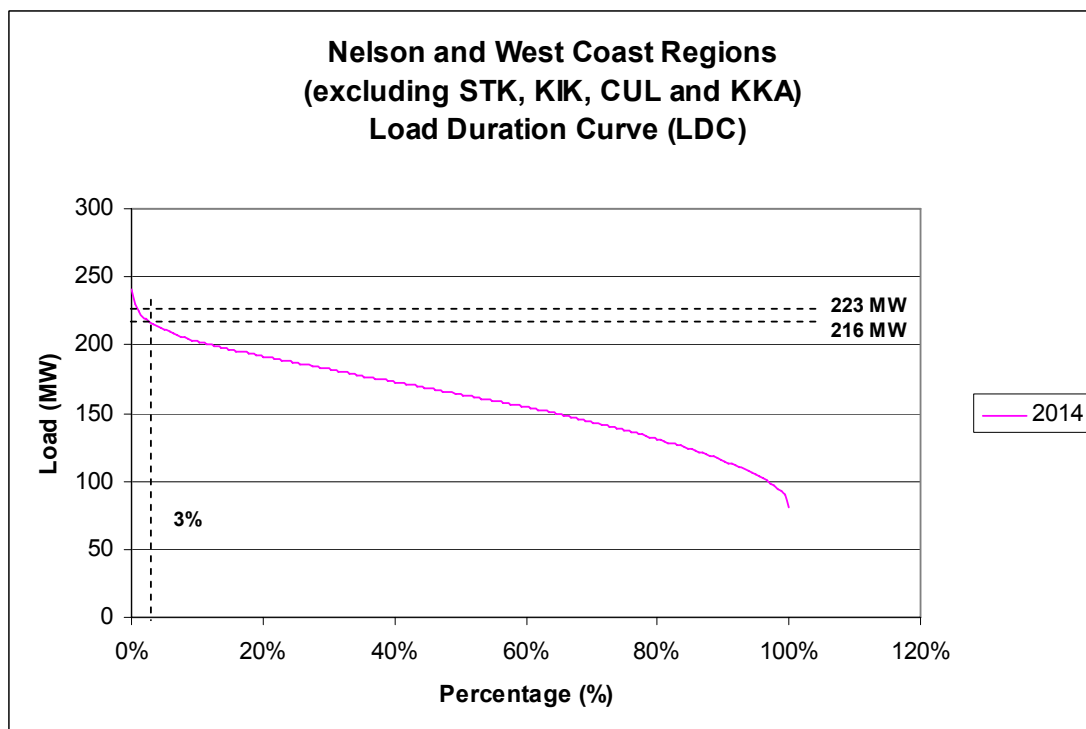
Post event: Loss of Kikiwa transformer T2

Consequence: Voltage collapse in the West Coast and Nelson regions.

Constraint: Load constraint limit in West Coast and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura) 216MW.

For 2014, the constraint is exceeded for 3% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	231	72	20,000	332.64	0.095	0.03	0.948



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 15MW load constraint in West Coast and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura).

Post event: The remaining load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	15	8760	10,000	n/a	n/a	0.03	39.42

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 15MW post event load shedding in West Coast and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura).

Post event: The remaining load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	15	16.7	10,000	2.505	0.095	0.03	0.0071

Event: Loss of Stoke Transformer T10

Region: Nelson

Event Risk Factor: 0.095

Average Duration: 16.7 h

SE Approach: *Post-event unplanned load shedding*

Assumptions: No local generation at Cobb and Argyle

Post event: Loss of Stoke transformer T10

Consequence: Stoke transformers T8 and T9 overload to 67 MVA and 68MVA respectively.

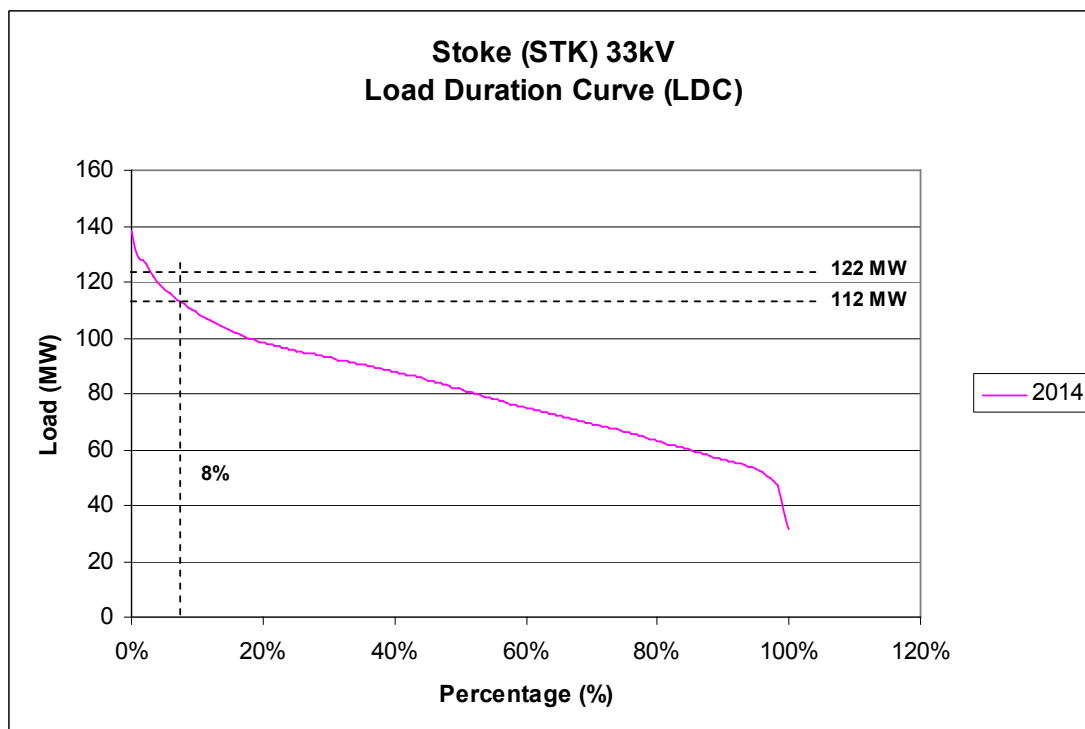
Winter 24 hour post contingency rating for Stoke T8 and T9 are 57.1MVA and 57.1MVA respectively.

Loss of supply to Stoke 33kV load.

Constraint: Load constraint limit at Stoke 33kV is 112MW.

For 2014, the constraint is exceeded for 8% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	122	16.7	20,000	40.748	0.095	0.08	0.3097



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 10MW load constraint for the Stoke 33kV load.

Post event: The remaining load at Stoke 33kV is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	10	8760	10,000	n/a	n/a	0.08	70.08

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 10MW post event load shedding at Stoke 33kV load.

Post event: The remaining load at Stoke 33kV is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	10	16.7	10,000	1.67	0.095	0.08	0.0127

Event: Loss of Stoke transformer T3

Region: Nelson

Event Risk Factor: 0.095

Average Duration: 16.7 h

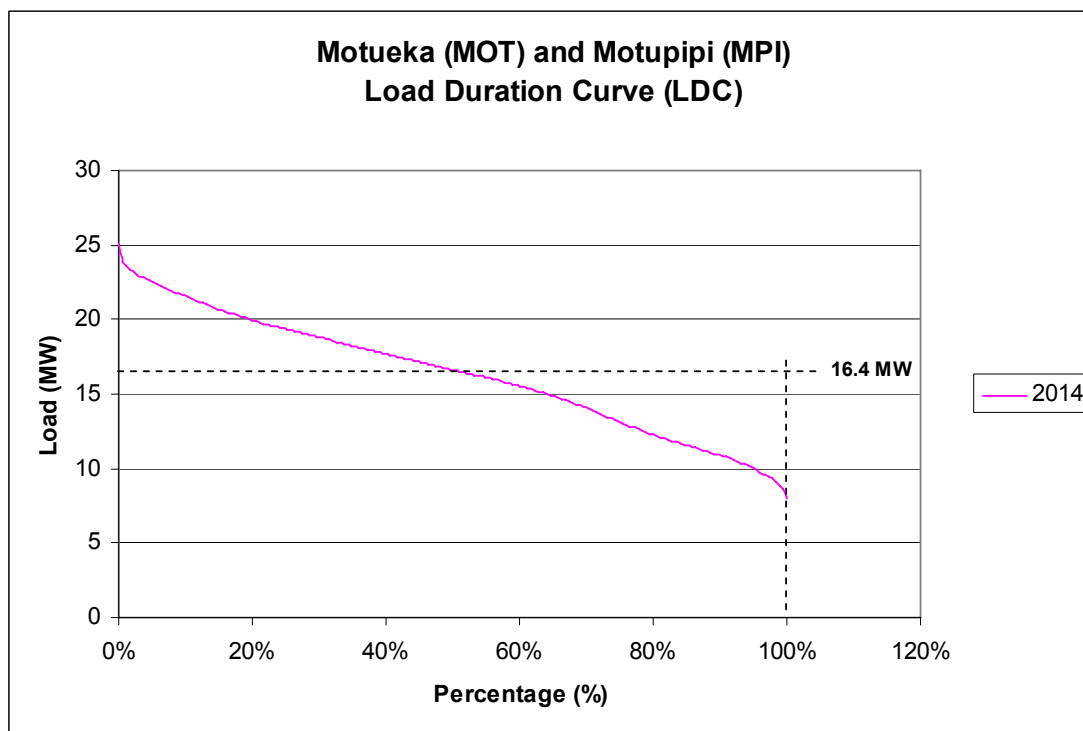
SE Approach: *Post-event unplanned load shedding*

Assumptions: None

Post event: Loss of Stoke transformer T3

Consequence: Loss of Motueka and Motupipi loads
 Loss of Cobb generation

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	16.4	16.7	20,000	5.478	0.095	1	0.5204



CE Approach: *Alternate measures unavailable*

Direct loss of supply unavoidable, managed as described above

ECE Approach: *Alternate measures unavailable*

Direct loss of supply unavoidable, managed as described above

Event: Loss of Stoke transformer T7

Region: Nelson

Event Risk Factor: 0.095

Average Duration: 16.7 h

SE Approach: *Post-event unplanned load shedding*

Assumptions: No local generation at Cobb and Argyle

Post event: Loss of Stoke transformer T7

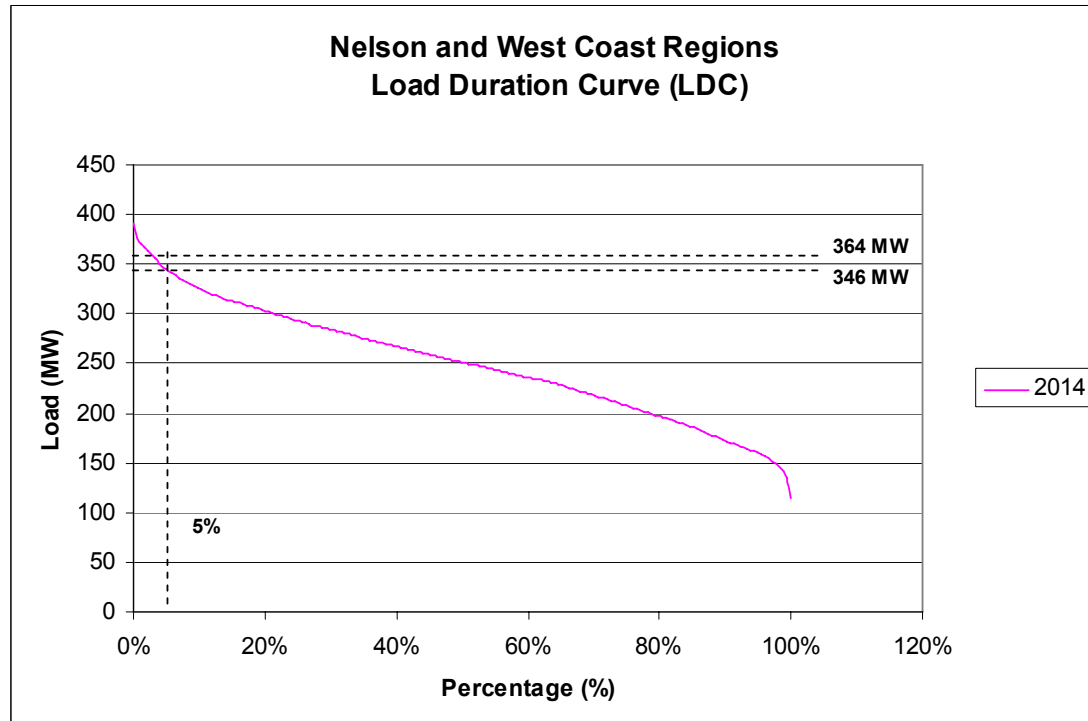
Consequence: Low voltages across the Nelson and West Coast regions.

Voltage collapse across the Nelson and West Coast regions.

Constraint: Load constraint limit in Nelson and West Coast regions 346MW.

For 2014, the constraint is exceeded for 5% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	364	72	20,000	524.16	0.095	0.05	2.4898



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 18MW load constraint across the Nelson and West Coast regions.

Post event: The remaining Nelson and West Coast load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	18	8760	10,000	n/a	n/a	0.05	78.84

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 18 MW post event load shedding across the Nelson and West Coast regions.

Post event: The remaining Nelson and West Coast load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	18	16.7	10,000	3.006	0.095	0.05	0.0143

Event: Loss of Stoke transformer T8

Region: Nelson

Event Risk Factor: 0.095

Average Duration: 16.7 h

SE Approach: *Post-event unplanned load shedding*

Assumptions: No local generation at Cobb and Argyle

Post event: Loss of Stoke transformer T8

Consequence: Stoke transformers T9 and T10 overload to 68MVA and 67MVA respectively.

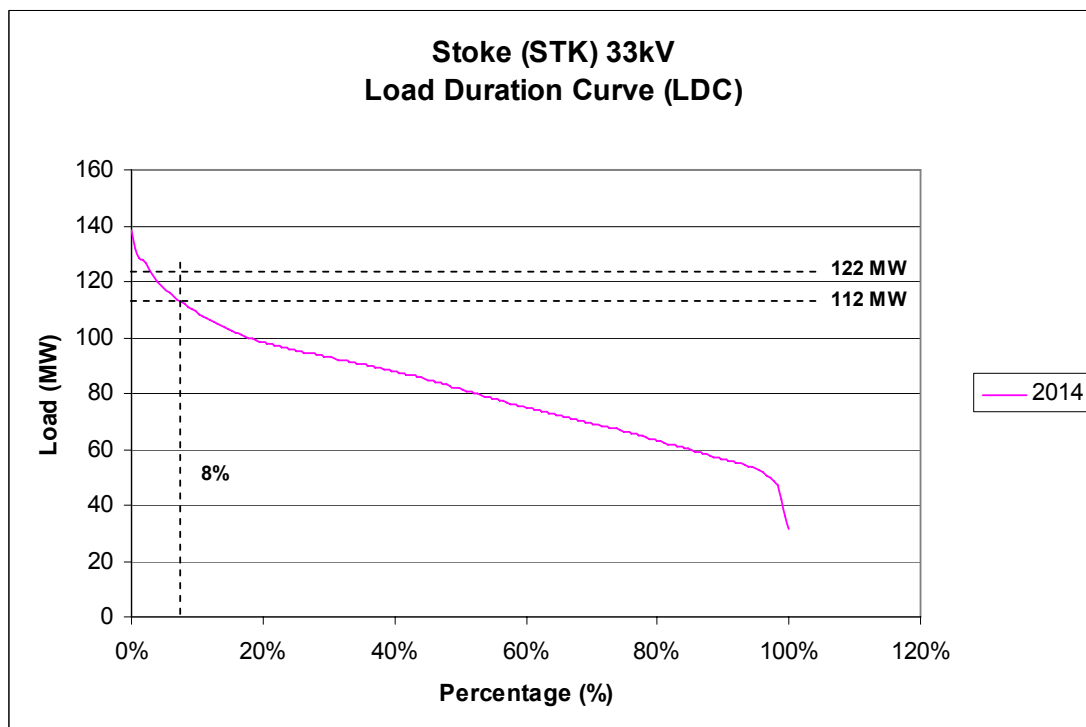
Winter 24 h our post co ntingency rating for tra nsformer T9 and T10 is 57.1MVA and 59.6MVA respectively.

Loss of supply to Stoke 33kV load.

Constraint: Load constraint limit at Stoke 33kV is 112MW.

For 2014, the constraint is exceeded for 8% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	122	16.7	20,000	40.748	0.095	0.08	0.3097



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 10MW load constraint for Stoke 33kV load.

Post event: The remaining load at Stoke is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	10	8760	10,000	n/a	n/a	0.08	70.08

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 10MW post event load shedding at Stoke 33kV load.

Post event: The remaining load at Stoke 33kV is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	10	16.7	10,000	1.67	0.095	0.08	0.0127

Event: Loss of Stoke transformer T9

Region: Nelson

Event Risk Factor: 0.095

Average Duration: 16.7 h

SE Approach: *Post-event unplanned load shedding*

Assumptions: No local generation at Cobb and Argyle

Post event: Loss of Stoke transformer T9

Consequence: Stoke transformers T8 and T10 overload to 68MVA and 68MVA respectively.

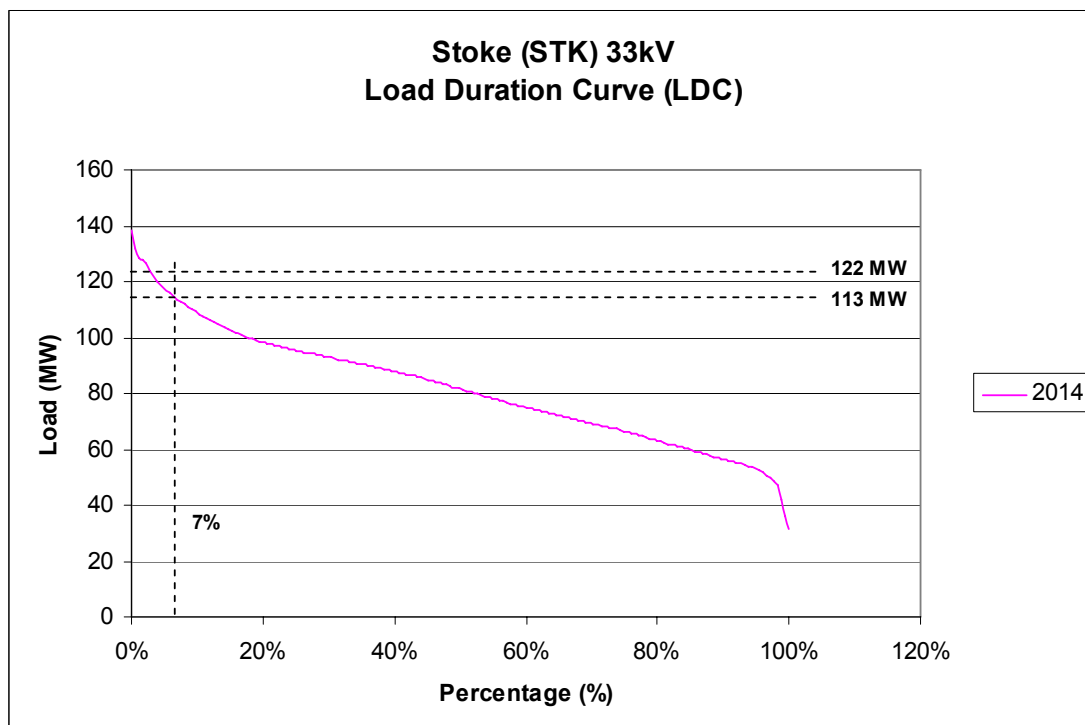
Winter 24 hour post contingency rating for Stoke T8 and T10 is 57.1MVA and 59.6MVA respectively.

Loss of supply to Stoke 33kV load.

Constraint: Constrain Stoke 33kV load to 113MW.

For 2014, the constraint is exceeded for 7% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	122	16.7	20,000	40.748	0.095	0.07	0.271



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 9MW load constraint for the Stoke 33kV load.

Post event: The remaining load at Stoke 33kV is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	9	8760	10,000	n/a	n/a	0.07	55.19

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 9MW post event load shedding at Stoke 33kV load.

Post event: The remaining load at Stoke 33kV is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	9	16.7	10,000	1.503	0.095	0.07	0.01

Event: Loss of Henderson Transformer T5

Region: Northland

Event Risk Factor: 0.095

Average duration: 16.7 h

SE Approach: *Post-event unplanned load shedding*

Pre-event measures: None

Assumptions: Ngawha generation set to 0 MW, total Northland load is 940MW and Mount Roskill load is 198MW.

Post event: Loss of Henderson 220/110kV transformer T5.

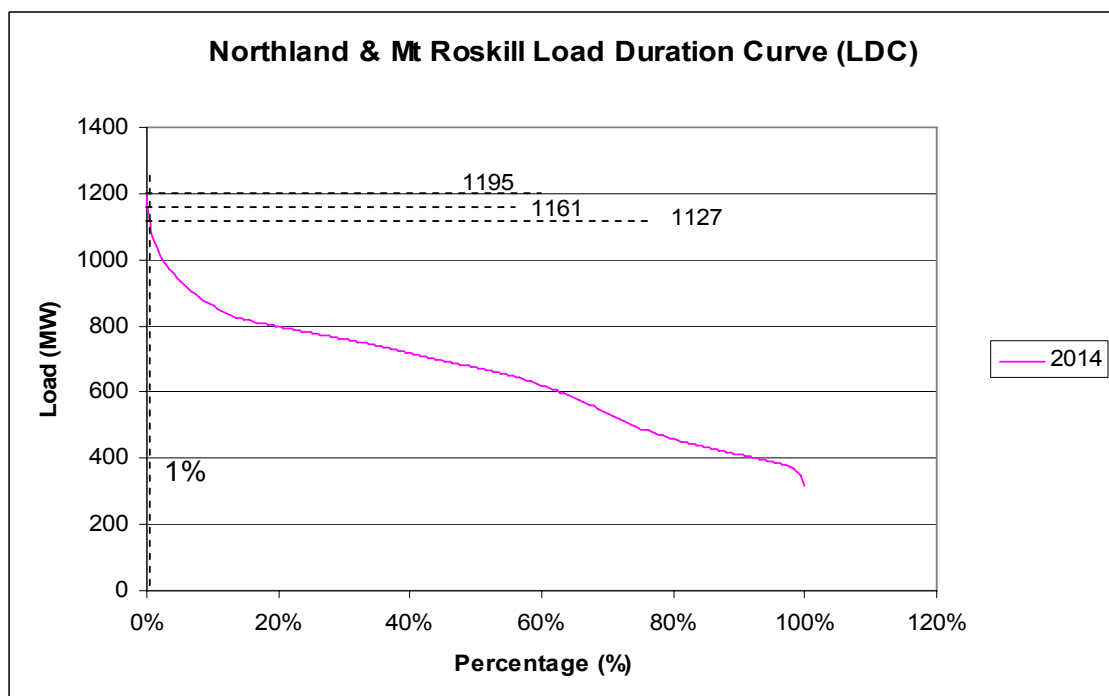
Consequence: Henderson 220/110kV transformer T1 will be overloaded to 273MVA. Winter 24 hr post contingency rating of Henderson 220/110kV T1 is 270MVA.

Should Henderson 220 /110kV transformer T1 trip on overload then the 110kV Mount Roskill-Mangere-1 and 2 will be overloaded to 109MVA each. Winter rating of 110kV Mount Roskill-Mangere-1 and 2 is 101MVA.

This could result in cascade failure and loss of the entire Northland and Mount Roskill load.

Constraint: Load constraint limit in Northland and Mount Roskill region 1127MW. For 2014 the constraint is exceeded for 1% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	1161	16.7	20,000	387.77	0.095	0.01	0.3684



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 34MW load constraint in the Northland area and Mount Roskill.

Post event: The remaining Northland and Mount Roskill load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	34	8760	10,000	n/a	n/a	0.01	29.784

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 34MW post event load shedding in the Northland area and Mount Roskill.

Post event: The remaining Northland and Mount Roskill load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	34	16.7	10,000	5.68	0.095	0.01	0.0054

Event: Loss of Waitaki transformer T23

Region: Otago

Event Risk Factor: 0.095

Average Duration: 16.7 h

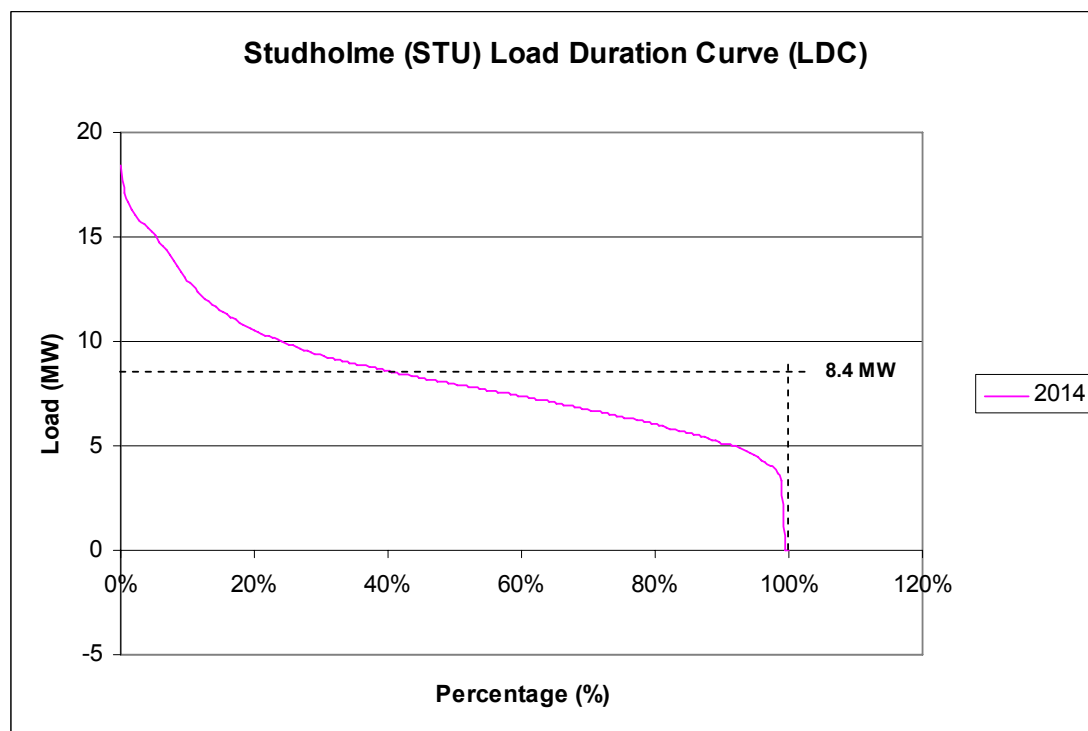
SE Approach: *Post-event unplanned load shedding*

Assumptions: None

Post event: Loss of Waitaki transformer T23

Consequence: Loss of Studholme load

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	8.4	16.7	20,000	2.806	0.095	1	0.2665



CE Approach: *Alternate measures unavailable*

Direct loss of supply unavoidable, managed as described above

ECE Approach: *Alternate measures unavailable*

Direct loss of supply unavoidable, managed as described above

Event: Loss of Waitaki transformer T24

Region: Otago

Event Risk Factor: 0.095

Average Duration: 16.7 h

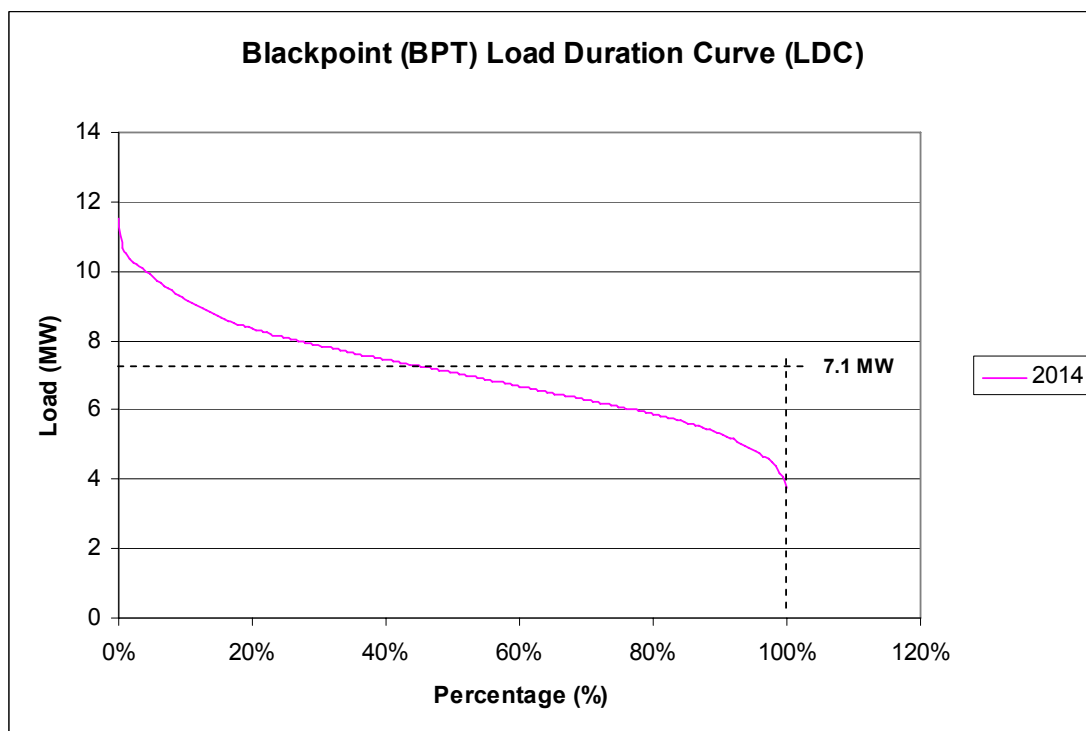
SE Approach: *Post-event unplanned load shedding*

Pre-event measures: None

Post event: Loss of Waitaki transformer T24

Consequence: Loss of Blackpoint load

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	7.1	16.7	20,000	2.3714	0.095	1	0.2253



CE Approach: *Alternate measures unavailable*

Direct loss of supply unavoidable, managed as described above

ECE Approach: *Alternate measures unavailable*

Direct loss of supply unavoidable, managed as described above

Event: Loss of Halfway Bush transformer T4

Region: Southland

Event Risk Factor: 0.095

Average Duration: 16.7h

SE Approach: *Post-event unplanned load shedding*

Assumptions: No 110 kV generation at Waipori and Roxburgh and no wind generation at White Hill

Post event: Loss of the Halfway Bush transformer T4

Consequence: Roxburgh T10 overloads and trips, followed by Invercargill T1 overloading and tripping

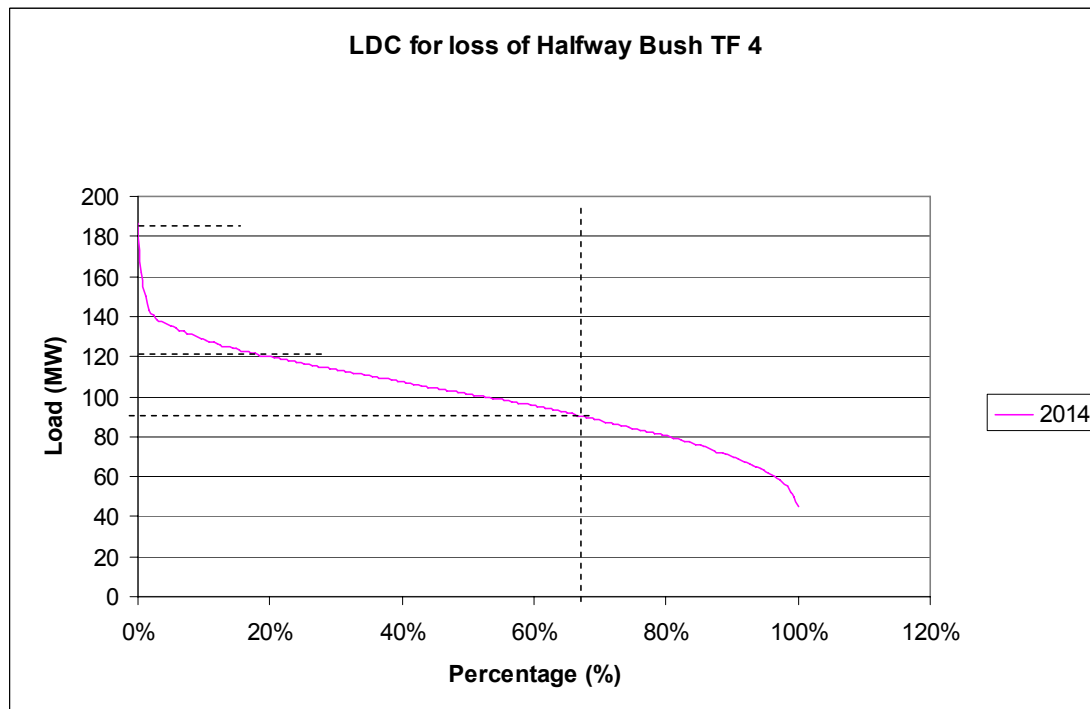
Loss of supply to the 110kV GXPs in region – Edendale, Brydone, Gore, Balclutha, Palmerston Halfway Bush

Low voltages at the 110kV busbars in the region

Constraint: Constrain load at the six GXP to 91MW

For 2014, the constraint is exceeded for 66% of the time. The average value above the constraint is 120MW

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	120	16.7	20,000	40.08	0.095	0.66	2.51



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 29MW of load constraint to avoid loss of load to all 110kV GXPs in the region

Consequence: Load at the 110kV GXPs is secured for this fault

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	29	8760	10,000	N/A	N/A	0.66	1676.66

ECE Approach: Pre-arranged post event load shedding

Pre-event measures: Arrange 29MW of post-event load shedding

Consequence: Load at the 110kV GXPs is secured for this fault

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	29	16.7	10,000	4.84	0.095	0.66	0.303

Event: Loss of Invercargill transformer T1

Region: Southland

Event Risk Factor: 0.095

Average Duration: 16.7h

SE Approach: *Post-event unplanned load shedding*

Assumptions: No 110kV generation at Roxburgh and Waipori and no wind generation at White Hill

Post event: Loss of the interconnecting transformer T1

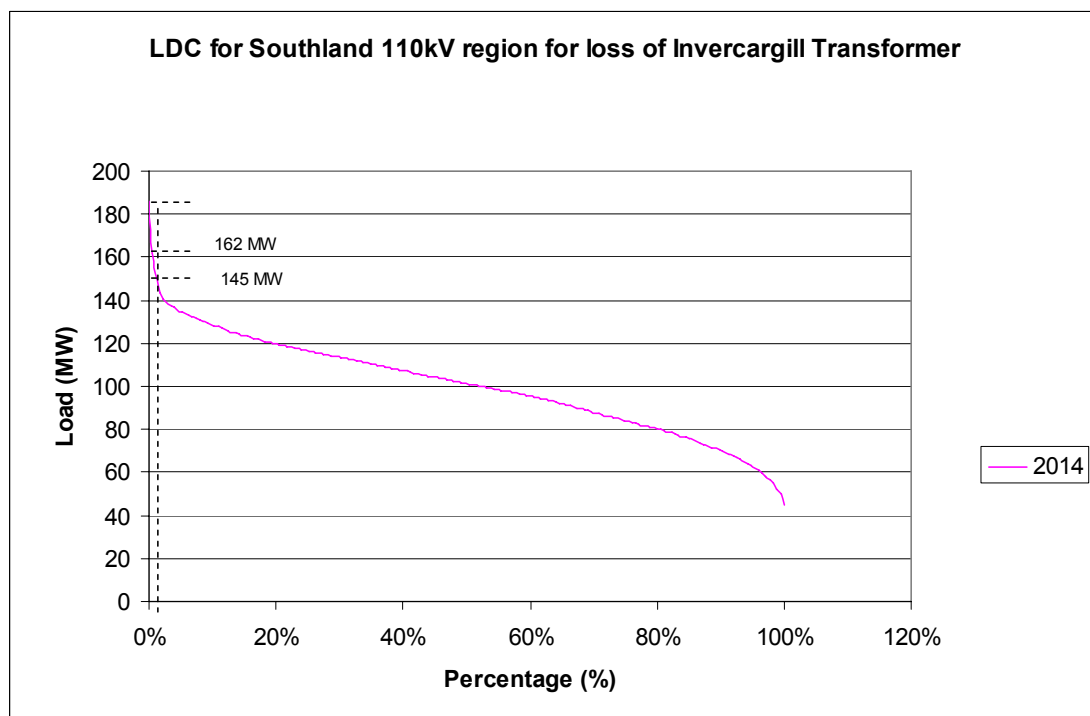
Consequence: Overload and tripping of the Roxburgh transformer T10 and cascading overload and tripping of Halfway Bush T4.

Loss of supply to the Southland 110kV network

Constraint: Constrain load at the six GXPs in the Southland region to 145MW

For 2014, the constraint is exceeded for 1% of the time. The average value above the constraint is 162MW

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	162	16.7	20,000	54.11	0.095	0.01	0.051



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 17 MW of load constraint to avoid cascade tripping of the Roxburgh and Halfway Bush transformers

Consequence: Load in the Southland 110kV region is secured for this fault

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	17	8760	10,000	N/A	N/A	0.01	14.89

ECE Approach: Pre-arranged post event load shedding

Pre-event measures: Arrange 17MW of post-event load shedding

Consequence: Load in the Southland 110kV region is secured for this fault

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	17	16.7	10,000	2.84	0.095	0.01	0.003

Event: Loss of Haywards transformer T1 T2 or T5

Region: Wellington

Event Risk Factor: 0.095

Average Duration: 16.7h

SE Approach: *Post-event unplanned load shedding*

Assumptions: HVDC North Transfer on Pole 2 of 660MW. HVDC Pole 1 out of service, No Wind Generation. Wellington load excluding Linton and Wilton is 648MW. Under these conditions, the Wilton interconnector or T8 is overloading and is switched off.

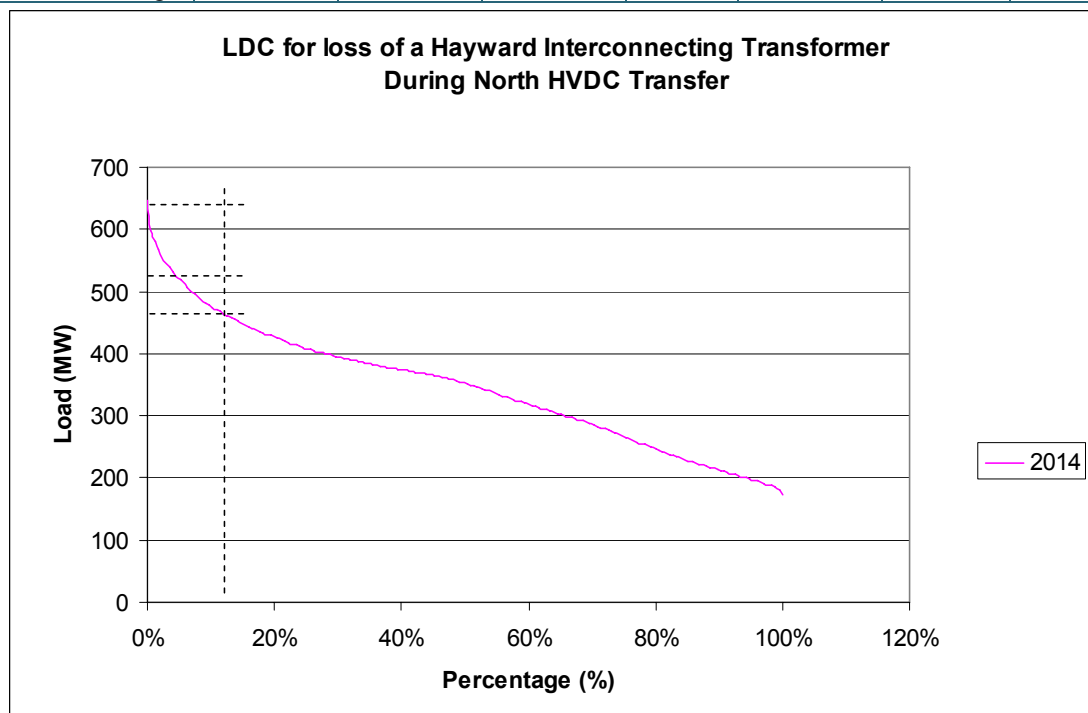
Post event: Loss of one of the three interconnecting transformers. Loss of reactive support

Consequence: Overloading/Tripping of the remaining two interconnecting transformers at Haywards
Loss of the Wellington regional load. Low voltages in the Wellington region

Constraint: Load constraint limit of 460MW for Wellington region to avoid overloading of the remaining two interconnecting transformers above their 24h post-contingency winter rating of 221MVA.

For 2014, the constraint is exceeded for 13% of the time. From the LDC for the Wellington region for 2014, the average value of the load above the constrained limit of 460MW is 525MW.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	525	16.7	20,000	175.35	0.095	0.13	2.17



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 65MW of load constraint to avoid cascading failure of the remaining two interconnecting transformers.

Consequence: Wellington load is secured for this event

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	65	8760	10,000	N/A	N/A	0.13	740.22

ECE Approach: Pre-arranged post event load shedding

Pre-event measures: Arrange 65MW of post-event load shedding

Consequence: Wellington load is secured for this event

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	65	16.7	10,000	10.86	0.095	0.13	0.134

Event: Loss of Haywards transformer T1, T2 or T5

Region: Wellington

Event Risk Factor: 0.095

Average Duration: 16.7h

SE Approach: *Post-event unplanned load shedding*

Assumptions: HVDC South Transfer on Pole 2 of 430MW. HVDC. No Wind Generation. Wellington load excluding Linton and Wilton is 648MW. Under these conditions, the Wilton interconnector T8 overloads and is switched off.

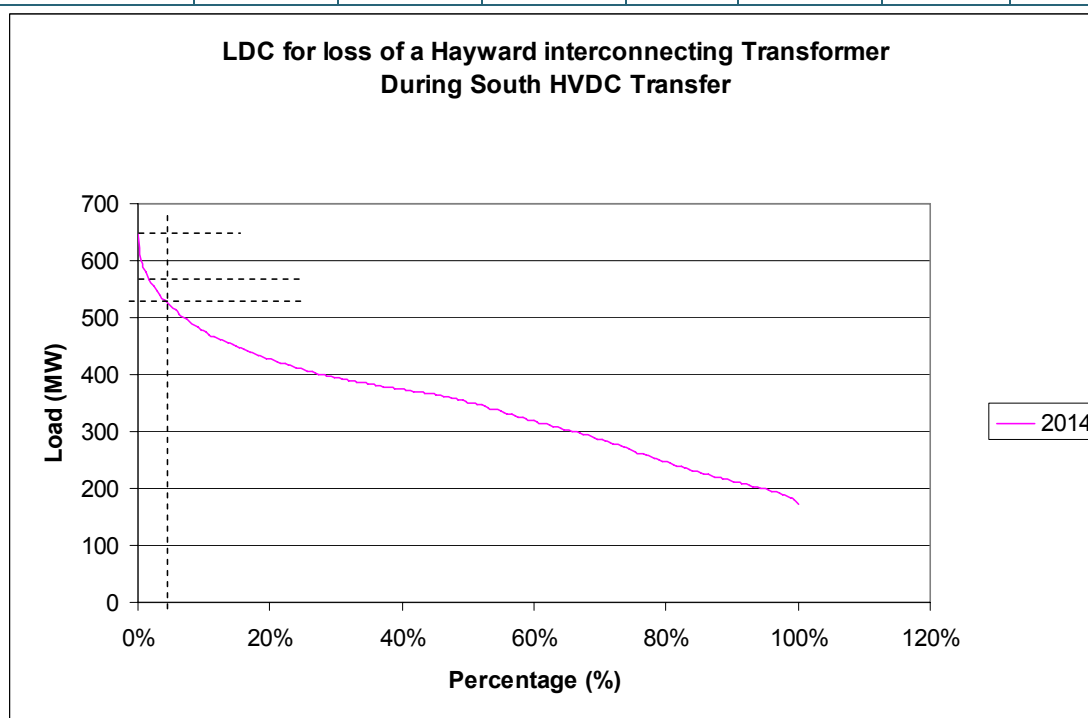
Post event: Loss of one of the three interconnecting transformers. Loss of reactive support

Consequence: Overloading/Tripping of the remaining two interconnecting transformers at Haywards. Loss of the Wellington regional load. Low voltages in the Wellington region. Voltage instability at the 220kV busbar causing the HVDC to trip

Constraint: Load constraint of 525MW for Wellington region to avoid overloading of the remaining two interconnecting transformers above their 24h post-contingency winter rating of 221MVA.

For 2014, the constraint is exceeded for 5% of the time. From the LDC, the average value of the load above the constrained limit of 525MW is 567MW.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	567	16.7	20,000	189.38	0.095	0.05	0.90
HVDC drop	220	N/A	1250.00	0.275	0.095	0.20	0.003
TOTAL							0.90



CE Approach: Pre-event security constraints

The application of a pre-event security constraint on HVDC South transfer as a management measure for treatment as a Contingent event is not considered to be an economical option

Pre-event measures: Arrange 42MW of load constraint to avoid cascading failure of the remaining two interconnecting transformers.

Consequence: Wellington load is secured for this event

ECE Approach: Pre-arranged post event load shedding & constrain back HVDC South transfer (pre-2012)

Pre-2012: Trip the average of 220MW for HVDC South transfer post event

Pre-event measures: Arrange 42MW post-event load shedding

Consequence: Wellington regional load secured for this event

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	42	16.7	10,000	7.01	0.095	0.05	0.03
Pre-2012 HVDC	220		1250.00	0.275	0.095	0.2	0.003
Total:							0.03

ECE Approach: Pre-arranged post event load shedding & constrain back HVDC South transfer (post-2012)

Post-2012: Arrange to constrain 75MW HVDC post event. Average HVDC transfer above the constraint of 280MW is 355MW for 1% of the time

Pre-event measures: Arrange 42MW post-event load shedding

Consequence: Wellington regional load secured for this event

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	42	16.7	10,000	7.01	0.095	0.05	0.03
Post-2012 HVDC	75		1250	0.093	0.095	0.01	0.00008
Total:							0.03

Event: Loss of Otahuhu transformer T4

Planned Outage: Penrose transformer T10

Region: Auckland

Event Risk Factor: 0.0475

Average Duration: 16.7 hours

SE Approach: *Post-event unplanned load shedding*

Pre-event measures: None

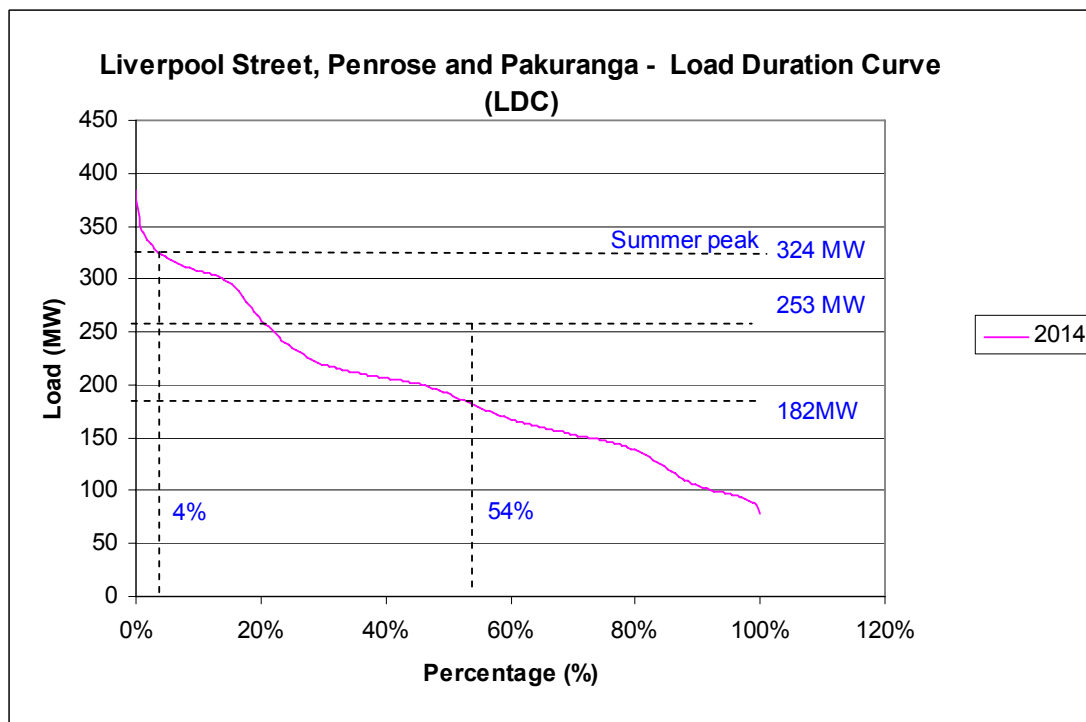
Assumptions: The Mount Roskill-Hepburn split considered closed

Post event: None

Consequence: The Otahuhu 220/110/11kV transformer T2 overloads to 218MVA. Summer 24 hour post contingency rating of the transformer is 158 MVA. Hence it will trip the loads connected to the Otahuhu lower busbar resulting in loss of supply to the Liverpool Street, Pakuranga and Penrose 110kV loads.

Constraint: Load constraint at Liverpool Street, Pakuranga and the Penrose 110kV load is 182MW.
 For 2014, the constraint is exceeded for 50% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	253	16.7	20,000	84.5	0.0475	0.50	2.01



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 71MW of combined load constraint at Liverpool Street, Pakuranga and Penrose.

Post event: The remaining Liverpool Street, Pakuranga and Penrose load is secured

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	71	4380	10,000	n/a	n/a	0.50	1555

ECE Approach: Pre-arranged post event load shedding

Pre-event measures: Arrange 71MW of combined post event load shedding at Liverpool Street, Pakuranga and Penrose.

Post event: The remaining Liverpool Street, Pakuranga and Penrose load is secured

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	71	16.7	10,000	11.87	0.0475	0.50	0.282

Event: Loss of Bunnythorpe transformer T1 or T2 or T3 **Region:** Bunnythorpe

Planned Outage: Bunnythorpe transformer T1 or T2 or T3

Event Risk Factor: 0.0475

Average Duration: 16.7h

SE Approach: Post-event unplanned load shedding

Assumptions:

HVDC North transfer on Pole 2 – 660MW
 HVDC Pole 1 – 200MW

Local generation at Te Apiti and Mangahao set to zero.

Post event:

Loss of a Bunnythorpe transformer while one is out on planned maintenance.

Consequence:

The remaining Bunnythorpe 220/110 kV transformer overloads to 102MVA.

Summer 24 hour post contingency rating of the transformers is 58MVA.

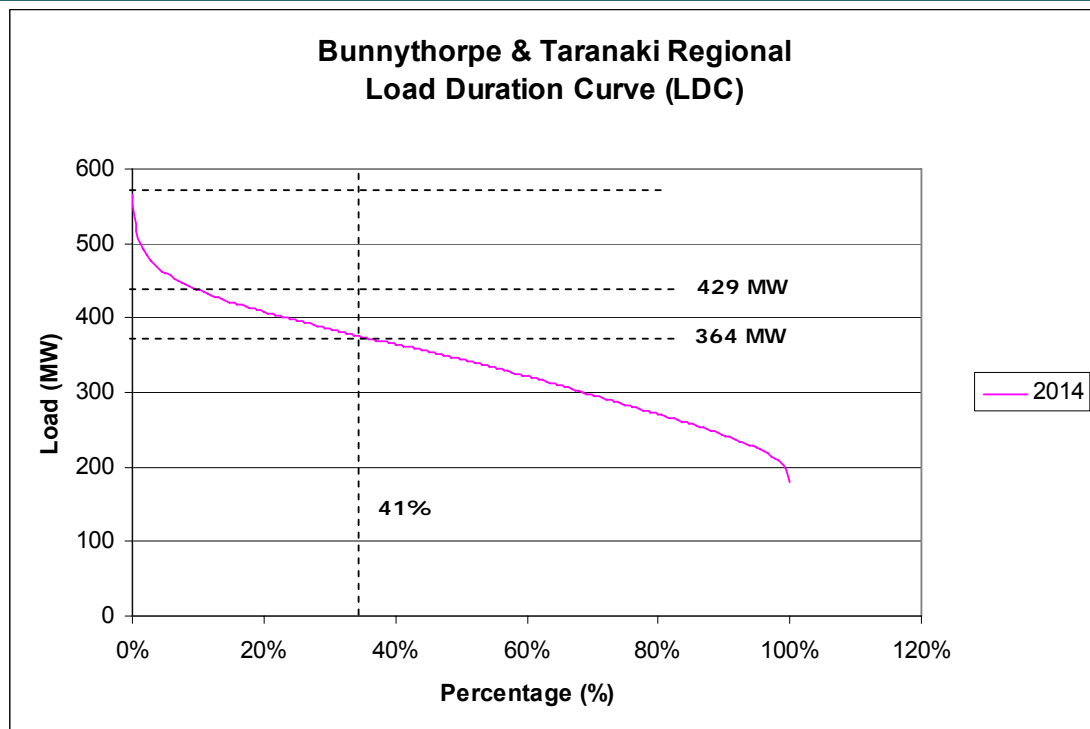
The transformer will trip resulting in loss of supply to the Bunnythorpe and Taranaki regions.

Constraint:

Load constraint limit in the Bunnythorpe and Taranaki regions 364MW.

For 2014, the constraint is exceeded for 41% of the time.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	429	16.7	20,000	143.29	0.0475	0.41	2.79



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 65MW load constraint in the Bunnythorpe and Taranaki regions.

Install a SP S at Hanga tiki which will open the Arapuni 110kV circuit breakers during this event

Post event: The remaining load in the Bunnythorpe and Taranaki regions is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	65	4380	10,000	n/a	n/a	0.41	1167.27

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 65MW post event load shedding in the Bunnythorpe and Taranaki regions.

Install a SP S at Hanga tiki which will open the Arapuni 110kV circuit breakers during this event

Post event: The remaining load in the Bunnythorpe and Taranaki regions is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	65	16.7	10,000	10.86	0.0475	0.41	0.211

Event: Loss of Islington transformer T6

Region: Christchurch

Planned outage: Islington transformer T3

Event Risk Factor: 0.0475

Average Duration: 16.7h

SE Approach: *Post-event unplanned load shedding*

Assumptions: None

Post event: Loss of Islington transformer T6

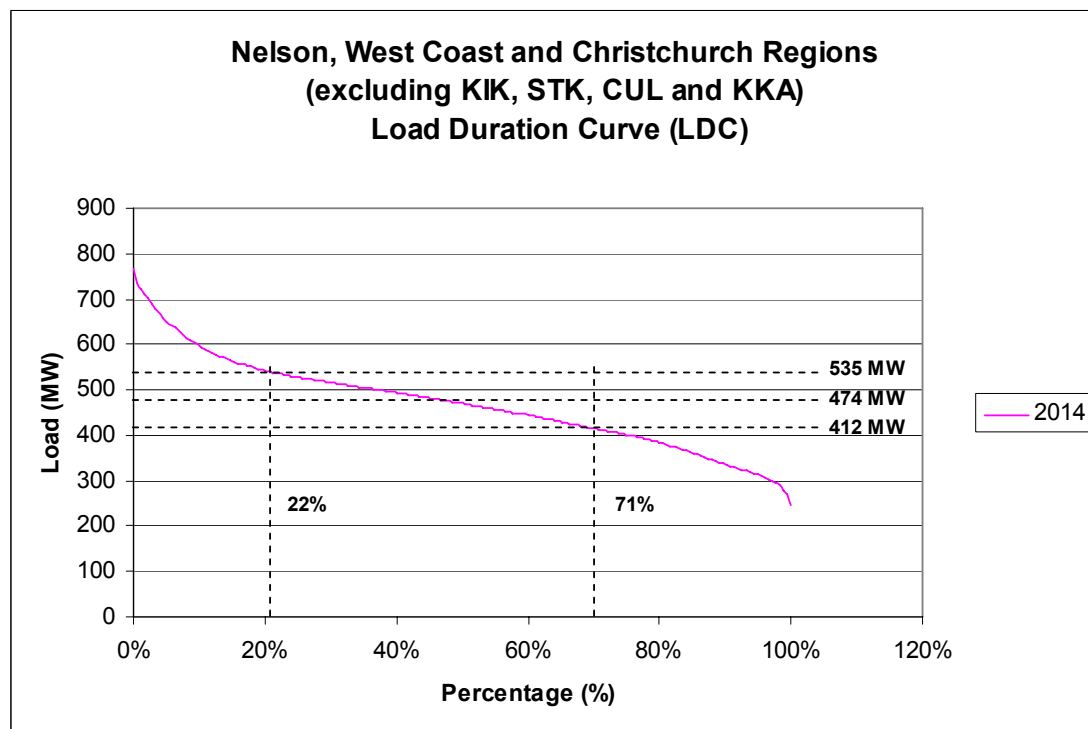
Consequence: Voltage collapse in the West Coast, Christchurch and Nelson regions.

Constraint: Load constraint limit in West Coast, Christchurch and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura) 412MW.

For 2014, the constraint is exceeded for 49% of the time.

Summer peak load constraint is 535MW.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	474	72	20,000	682.56	0.0475	0.49	15.8866



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 62MW load constraint in West Coast, Christchurch and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura).

Post event: The remaining load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	62	4380	10,000	n/a	n/a	0.49	1330.64

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 62MW post event load shedding in West Coast, Christchurch and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura).

Post event: The remaining load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	62	16.7	10,000	10.354	0.0475	0.49	0.2410

Event: Loss of Islington transformer T3

Region: Christchurch

Planned outage: Islington transformer T7

Event Risk Factor: 0.0475

Average Duration: 16.7h

SE Approach: Post-event unplanned load shedding

Assumptions: None

Post event: Loss of Islington transformer T3

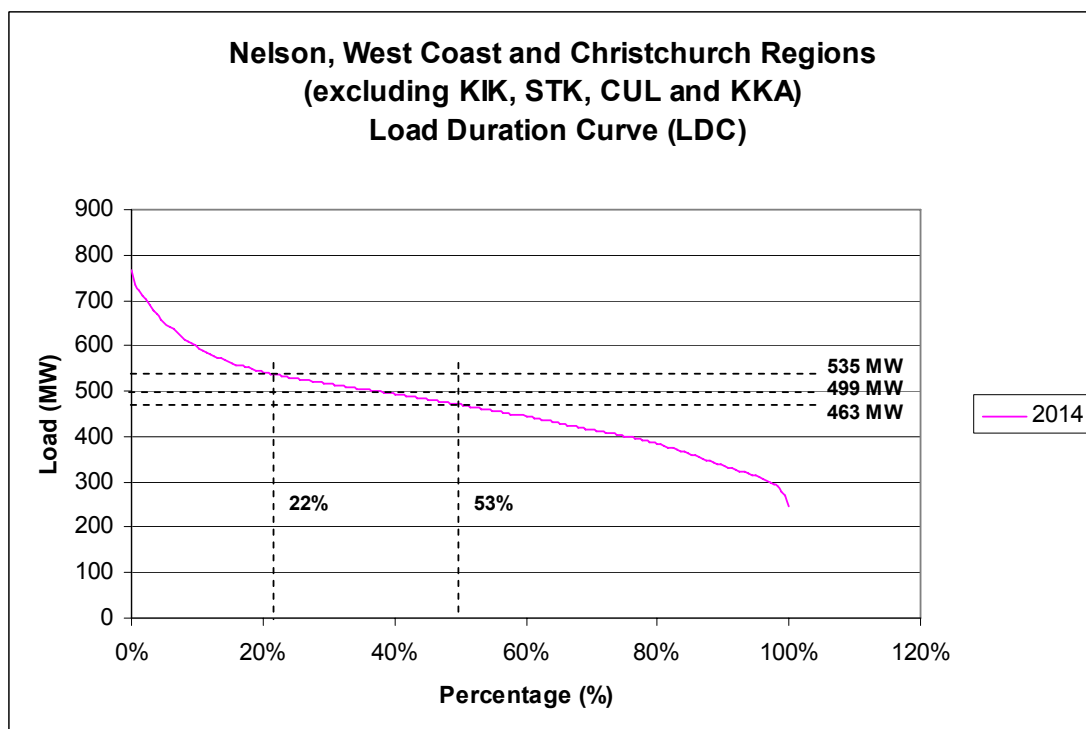
Consequence: Voltage collapse in the West Coast, Christchurch and Nelson regions.

Constraint: Load constraint limit in West Coast, Christchurch and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura) 463MW.

For 2014, the constraint is exceeded for 31% of the time.

Summer peak load constraint is 535MW.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	499	72	20,000	718.56	0.0475	0.31	10.5808



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 36MW load constraint in West Coast, Christchurch and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura).

Post event: The remaining load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	36	4380	10,000	n/a	n/a	0.31	488.808

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 36MW post event load shedding in West Coast, Christchurch and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura).

Post event: The remaining load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	36	16.7	10,000	6.012	0.0475	0.31	0.0885

Event: Loss of Islington transformer T6

Region: Christchurch

Planned outage: Islington transformer T7

Event Risk Factor: 0.0475

Average Duration: 16.7h

SE Approach: Post-event unplanned load shedding

Assumptions: None

Post event: Loss of Islington transformer T6

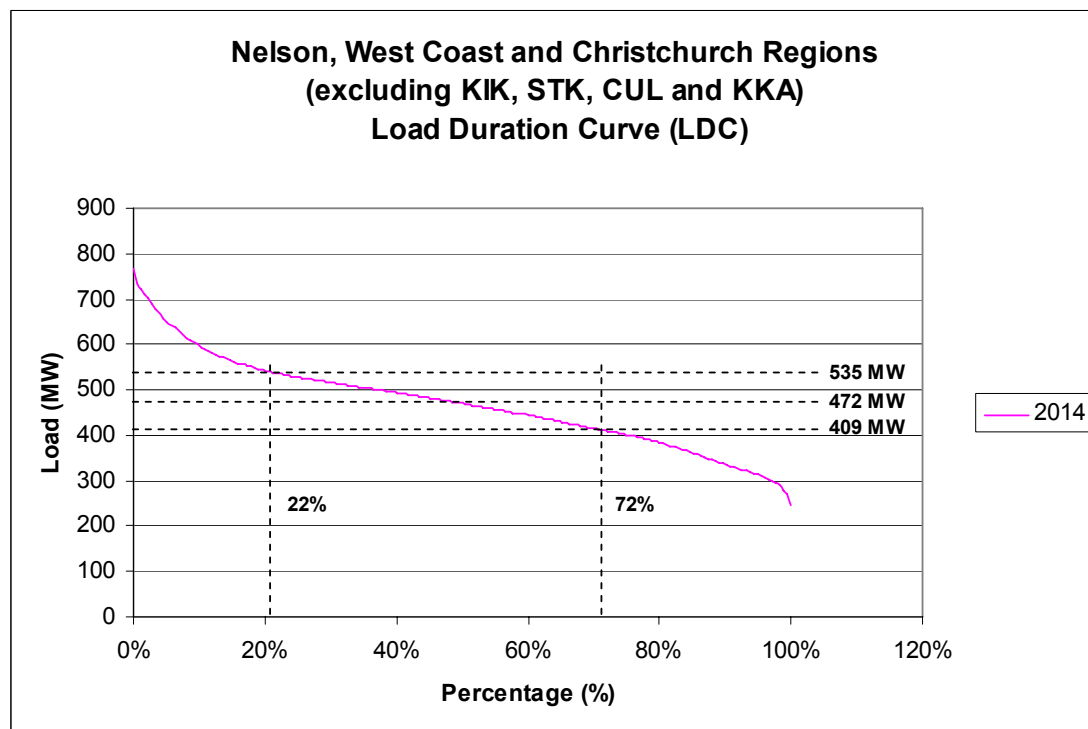
Consequence: Voltage collapse in the West Coast, Christchurch and Nelson regions.

Constraint: Load constraint limit in West Coast, Christchurch and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura) 409MW.

For 2014, the constraint is exceeded for 50% of the time.

Summer peak load constraint is 535MW.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	472	72	20,000	679.68	0.0475	0.5	16.1424



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 63MW load constraint Load constraint limit in West Coast, Christchurch and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura).

Post event: The remaining load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Pre-event load constraint	63	4380	10,000	n/a	n/a	0.5	1379.7

ECE Approach: Pre-arranged post-event planned load shedding

Pre-event measures: Arrange 63MW post event load shedding Load constraint limit in West Coast, Christchurch and Nelson regions (excluding Stoke, Culverden, Kikiwa and Kaikoura).

Post event: The remaining load is secured.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	63	16.7	10,000	10.521	0.0475	0.5	0.2499

Event: Loss of Haywards transformers T1, T2 or T5

Region: Wellington

Planned outage: Haywards Transformer T1, T2 or T5

Event Risk Factor: 0.0475

Average Duration: 16.7h

SE Approach: Post-event unplanned load shedding

Assumptions: HVDC North Transfer on Pole 2 of 660MW. No Wind Generation. Wellington load excluding Linton and Wilton is 522MW.

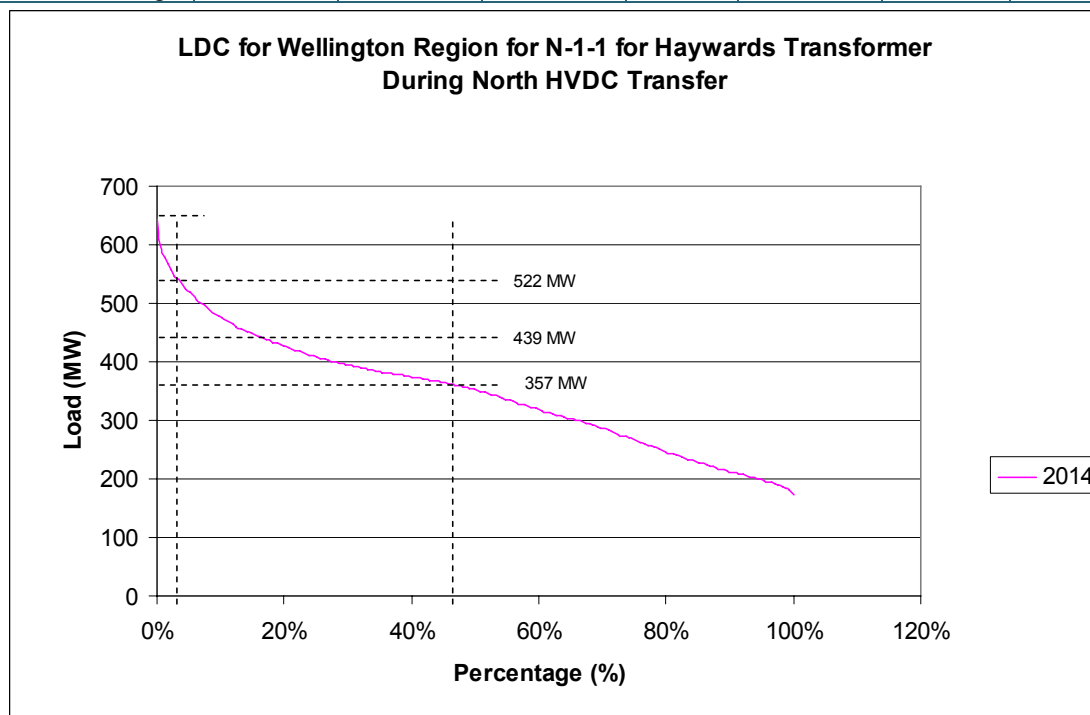
Post event: Loss of two of the three interconnecting transformers at Haywards, Loss of reactive support

Consequence: Overloading/Tripping of the remaining interconnecting transformers at Haywards. Overloading and tripping of the Wilton T8. Loss of the Wellington regional load. Low voltages in the Wellington region.

Constraint: Load constraint limit of 357MW in the Wellington region to avoid overloading the Wilton T8 above its 24h post contingency summer rating of 135MVA and the remaining interconnecting Haywards transformer above its 24h post-contingency summer rating of 221MVA.

For 2014, the constraint is exceeded for 43% of the time. From the LDC for the Wellington region the average value of the load above the constrained limit of 357MW is 439MW.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	439	16.7	20,000	146.63	0.0475	0.43	2.99



CE Approach: Pre-event security constraints

Pre-event measures: Arrange 82MW of load constraint to avoid cascading failure of the remaining two interconnecting transformers.

Consequence: Wellington load is secured for this event

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Constrained load	82	4380	10,000	N/A	N/A	0.43	1544.39

ECE Approach: Pre-arranged post event load shedding

Pre-event measures: Arrange 82MW of post-event load shedding

Consequence: Wellington load is secured for this event

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Load shedding	82	16.7	10,000	13.39	0.0475	0.43	0.28

Event: Loss of Haywards transformer T1, T2 or T5

Region: Wellington

Planned outage: Haywards transformer T1, T2 or T5

Event Risk Factor: 0.0475

Average Duration: 16.7h

SE Approach: Post-event unplanned load shedding

Pre-event measures: Wilton T8 out of service during planned outage. To manage the loss of the 110kV Mangamaire-Woodville circuit, Wellington load is constrained to 418MW

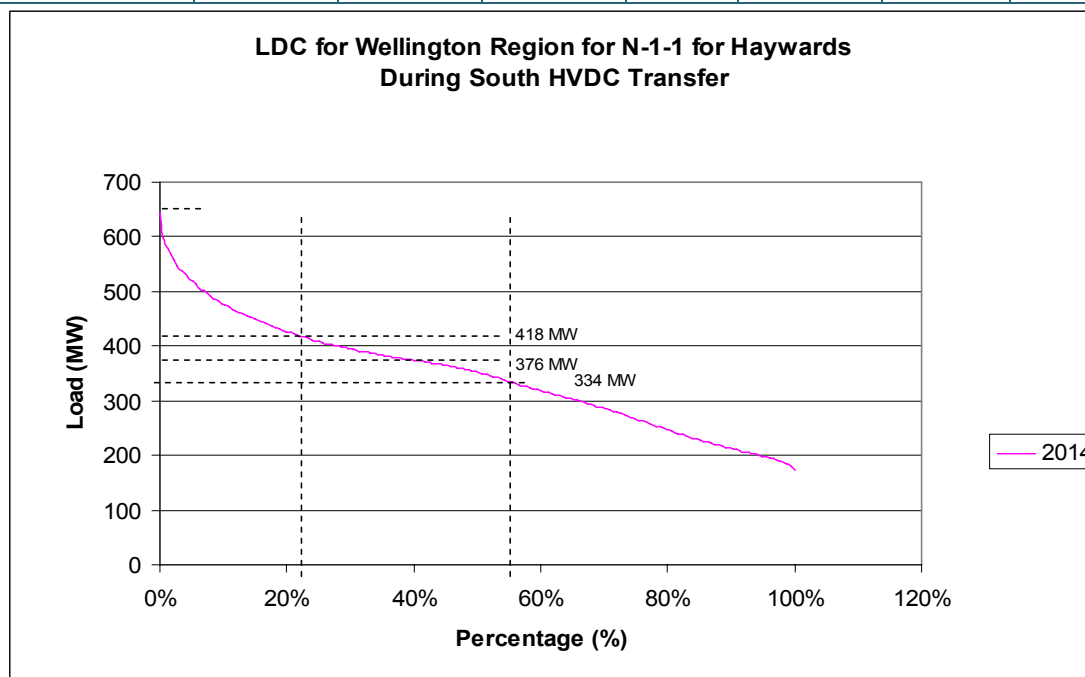
Assumptions: HVDC South Transfer on Pole 2 of 430MW. HVDC Pole 1 out of service. Te Apati Generation 90MW to avoid overloading of Bunnythorpe- Woodville circuits.

Post event: Loss of two of the three interconnecting transformers. Loss of reactive support

Consequence: Overloading/Tripping of the remaining interconnecting transformer at Haywards. Loss of the Wellington regional load.

Constraint: Load constraint limit of 334MW in the Wellington region to avoid overloading the remaining interconnecting Haywards transformer above its 24h post-contingency summer rating of 221MVA. For 2014, the constraint is exceeded for 33% of the time. From the LDC for the Wellington region the average value of the load above the constrained limit of 334MW is 376MW.

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Unplanned load shedding	376	16.7	20,000	125.58	0.0475	0.33	1.97
HVDC trip	220		1250.00	0.275	0.0475	0.20	0.006
Total:							1.976



CE Approach: Pre-event security constraints

The application of a pre-event security constraint on HVDC south transfer as a management measure for treatment as a Contingent Event is not considered to be an economic option.

Pre-event measures: Arrange 42MW of load constraint to avoid cascading failure of the remaining two interconnecting transformers.

Consequence: Wellington load is secured for this event

ECE Approach : Pre-arranged post event load shedding & constrain back HVDC South transfer (pre-2012)

Pre-2012: Trip the average of 220 MW for HVDC South transfer post event

Pre-event measures: Arrange 42MW post-event load shedding

Consequence: Wellington regional load is secured for this event

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	42	16.7	10,000	7.01	0.0475	0.33	0.109
HVDC trip	220		1250.00	0.275	0.0475	0.2	0.006
TOTAL							0.115

ECE Approach: Pre-arranged post event load shedding & constrain back HVDC South transfer (post-2012)

Post-2012: Arrange to constrain 75MW HVDC post event. Average HVDC transfer above the constraint of 280MW is 355MW for 1% of the time

Pre-event measures: Arrange 42MW post-event load shedding

Arrange 5MW of post-event load shedding at Haywards

Consequence: Wellington regional load is secured for this event

Event Measure	Average Load (MW)	Duration (h)	Unit Cost (\$/MWh)	Event Cost (\$m)	Event Risk Factor	Load Risk Factor	Annual Cost (\$m)
Planned load shedding	42	16.7	10,000	7.01	0.0475	0.33	0.109
HVDC constraint	75		1250.00	0.094	0.0475	0.01	0.00004
TOTAL							0.109