

System Security Review: Credible Event Management

Identification & Analysis of Credible Events

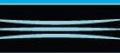
November 2009

TRANSPower



Policy Statement: Security Policy: Risk Management

Security Policy	
	Risk Management
	Security Management
	Emergency Planning
Dispatch Policy	
	Dispatch Policy and Process Statement
Compliance Policy	
Conflict of Interest Policy	



Security Policy: Rule Requirement

13. The **system operator** will:
 - 13.1 In addition to the annual review of the **policy statement** in accordance with rules 10 and 11 of section II of part C, review the identification, assessment and assignment of potential credible events in clause 12 during the 2008 calendar year and not less than once in each period of five years thereafter.
 - 13.2 **Advise**, prior to the commencement of each review, its intended methodology for identifying and assessing the risks to which the risk management policies are directed.
 - 13.3 Invite comments from **registered participants** as to its process and the content of the review.
 - 13.4 **Publish** an explanation and summary of conclusions for each review completed under clause 13.1.



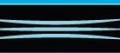
Current Approach

- Identify potential credible events
- Assess risks
- Assign event category
 - Contingent events
 - Extended contingent events
 - Stability events
 - Other events
- Determine mitigating measures



Existing Credible Events

- *single generating unit*
- *multiple generating units*
- *HVDC link valve group / single pole*
- *single transmission circuit*
- *both transmission circuits of a double circuit*
- *multiple transmission circuits*
- *HVDC link bipole*
- *Busbar*
- *interconnecting transformers*
- *large load(s)*
- *reactive injections*



Existing Event Categories & Assignments

Event Class	Defined Credible Events
<i>Contingent Events</i>	Loss of a transmission circuit Loss of a single generating unit Loss of an HVDC pole Loss of both transmission circuits of a double circuit (where a high likelihood of event occurrence is determined based on historical information or where the SO is advised of a change to environmental or system conditions)
<i>Extended Contingent Events</i>	Loss of the HVDC bipole
<i>Stability Events</i>	<i>A Contingent Event</i> <i>An Extended Contingent Event</i> Loss of a busbar section Loss of an interconnecting transformer
<i>Other Events</i>	All other credible events



Scope

- Literature Reviews:
 - New Zealand Planning and Operational Standards
 - International Standards
- Identify & Analyse Credible Events
 - Identify events & likelihood of event
 - Existing means of management
 - Identify events for review
 - Existing/Alternative management measures
 - Event consequence / outcome
 - Event cost
- Determine Optimal Means of Credible Event Management



Methodology

- Literature Reviews:
 - New Zealand Planning and Operational Standards
 - International Standards
- Identify & Analyse Credible Events
 - Likelihood of event
 - Existing means of management
 - Identify events for review
- Determine Optimal Means of Credible Event Management
 - Alternative means of management
 - Consequence / Event Outcome
 - Event Cost



Literature Review

- Planning and Operational Standards:
 - Part C, Schedule C4
 - Part F, Grid Reliability Standard
- International Standards:
 - AEMC, AUS
 - EMA Singapore
 - NORDEL
 - BALTREL
 - Eskom, SA
 - Transpower
 - EIRGRID Ireland
 - National Grid, UK
 - UCTE
 - E.ON Germany
 - NERC, USA
 - WECC



International Standards

Summary of Credible Events

TSO/Country	Trans ^m Circuit	Gen unit	Reactive Plant	Transf'r (Tx)	Bus Section	HVDC Pole	1+ gen units	Double Trans ^m circuit	Busbar (1+ bus section)	Large Load (s)	HVDC Bipole	Protection	N-G-1	N-1-1
NER, AEMC, Australia	✓ CCE	✓ CCE	✓ CCE	✓ CCE	✓ CCE	-	NCCE	NCCE as requir'd	-	✓ CCE	-	-	✓ as requir'd	✓ as requir'd
BALTREL Baltic Ring Elec. Council	✓ CCE	✓ CCE	✓ CCE	✓ CCE	✓ CCE	-	✓ as requir'd	✓ as requir'd	✓ as requir'd		-		-	✓ as requir'd
EIRGrid, Ireland	✓ PCE	✓ PCE	✓ PCE	✓ PCE	✓ LPCE	-	-	✓ LPCE	✓ LPCE	-	-	✓ LPCE	✓ PCE	✓ PCE
EMA, Singapore	✓ SC&O	✓ SC&O	✓ SC&O	✓ SC&O	✓ LPCE	-	✓ LPCE	✓ LPCE	✓ EE	✓ SC&O	-	-	✓ SC&O	✓ SC&O
E.ON, Germany	✓ SF	✓ SF	✓ SF	✓ SF	✓ SF	-	✓ SF	✓ CM	-	-	-	-	-	✓ as requir'd
ESKOM, South Africa	✓ CCE	✓ CCE	✓ CCE	✓ CCE	✓ CCE	✓ CCE	✓ LPCE	✓ CCE	✓ LPCE	-	-	✓ LPCE	✓ as requir'd	✓ as requir'd
National Grid, UK (MITS)	✓ SEF	✓ SEF	✓ SEF	✓ SEF	✓ SEF	✓ SEF	✓ SEF	✓ SEF	-	✓ SEF	✓ SEF			✓ Trans ^m cct Fault
NERC *	✓ Cat B	✓ Cat B	✓ Cat B	✓ Cat B	✓ Cat C	✓ Cat B	✓ Cat C Cat D	✓ Cat C	✓ Cat C Cat D	✓ Cat C Cat D	✓ Cat C	✓ Cat C	✓ Cat C	✓ Cat C
Nordel, Planning Code	✓ FG2/3	✓ FG1	✓ FG1	✓ FG2	✓ FG2	✓ FG1/2	✓ FG4	✓ FG4	✓ FG3/4	✓ FG1	✓ FG4	✓ FG4	✓ as requir'd	✓ as requir'd
Transpower (GRS) NZ	✓ Core Grid CE	✓ Core Grid CE	✓ Core Grid CE	✓ Core Grid CE	✓ Core Grid CE	-	-	-		-	-		-	
Transpower (SOs) NZ	✓ CE	✓ CE	✓ OTH	✓ SE	✓ SE	✓ CE	✓ OTH	✓ CE as requir'd	✓ OTH	✓ OTH	✓ ECE	-	✓ as requir'd	✓ as requir'd
UCTE	✓ PCE	✓ PCE	✓ PCE	✓ PCE	✓ PCE	-	✓ as requir'd	✓ as requir'd	✓ as requir'd	✓ PCE	-	-	-	-



Identification of Credible Events

- Single Elements
 - Transmission circuit
 - Generator unit
 - HVDC Pole
 - Interconnecting Transformer
 - Busbar Section
 - Reactive device
 - Large Load
- Multiple Elements
 - HVDC bipole
 - 1+ Transmission circuits
 - Same corridor
 - Same tower
 - 1+ Busbar sections
 - substation
 - 1+ Generator units
 - Power Station



Historical Data

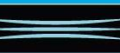
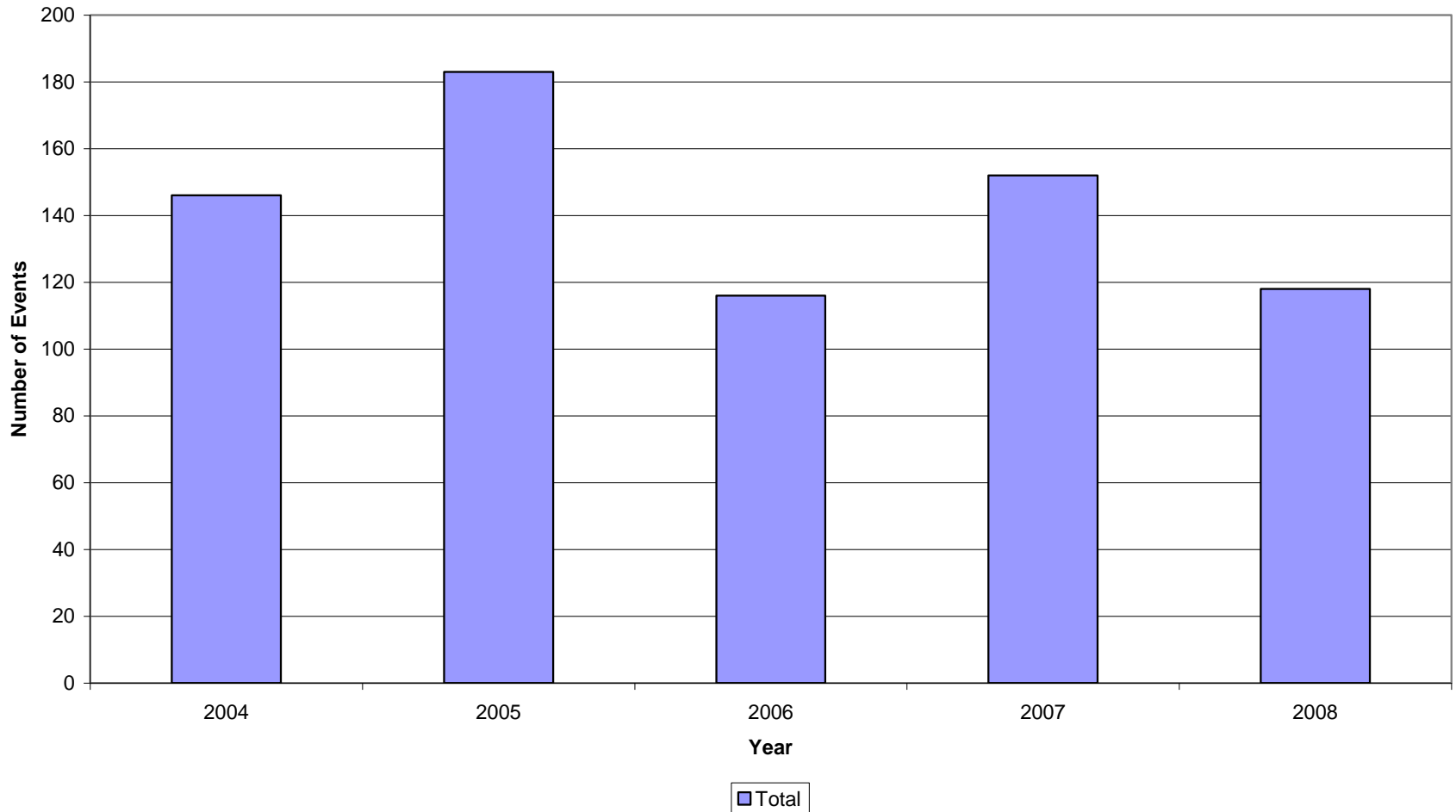
Event Types

- Generator
- HVDC
- Transmission Lines/Circuit
- Busbar Section
- Interconnecting Transformer
- Reactive Device



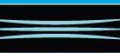
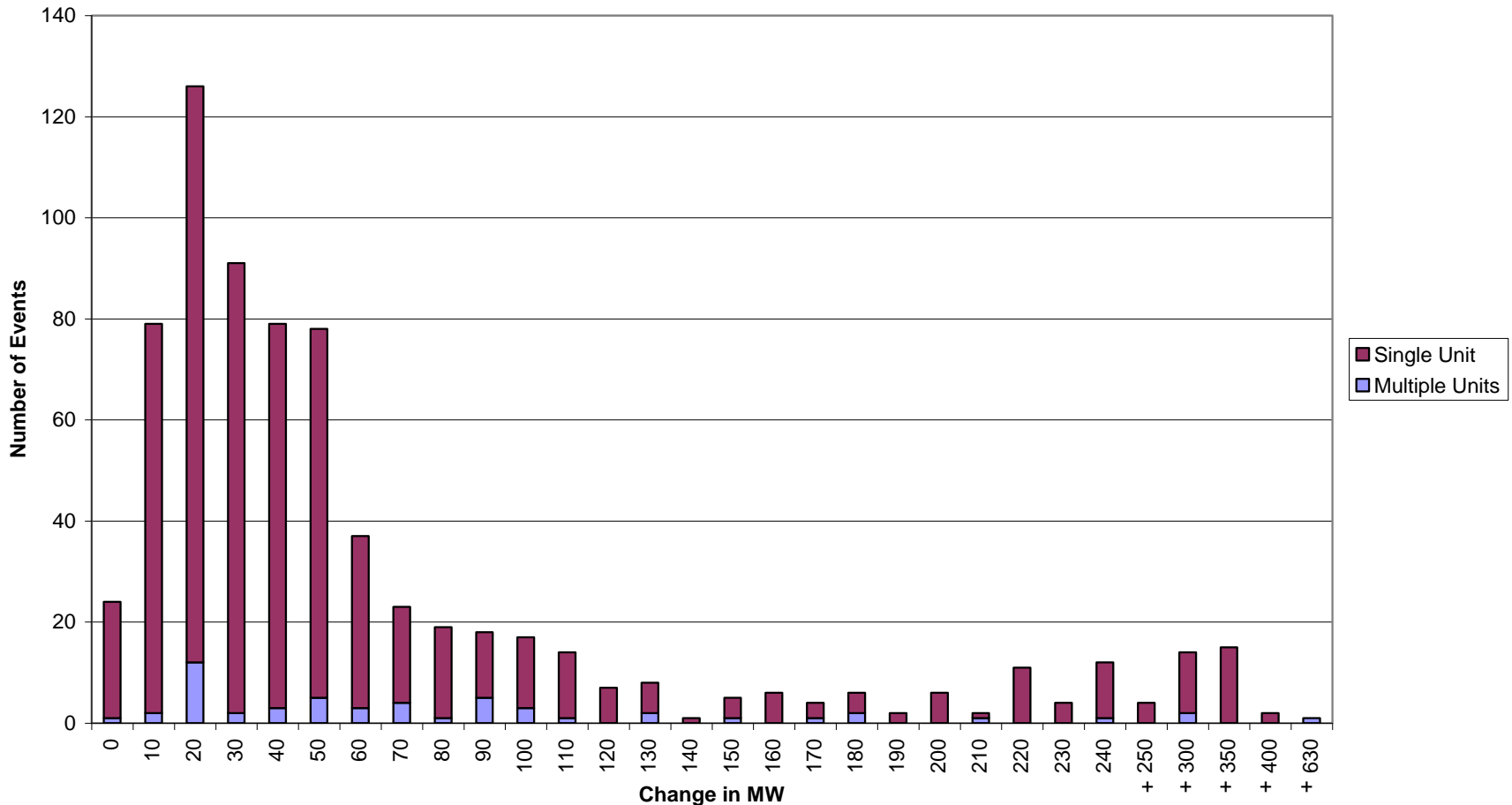
Generator Events

Generator Events - Number of Events [2004-2008]



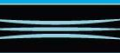
Generator Events

Generator Events - MW Change [2004-2008]



Generator Events

- Average MW Loss ... 70 MW
- 20% of events result in loss of >100MW
- 10% of events result in loss of >200MW
- 30% of events loss of hydro generation units
- 11 events/yrmultiple unit loss
 - of which 3 events result in loss of >100MW
- 17 events/yr frequency outside normal band



Generator Events & Frequency

Number of Occasions System Frequency moved outside normal frequency band following the loss of a generator unit
2004 – 2008 [rule 2.2.3 and 3.2.2 Part C Section II]

Frequency Band (Hz)	Annual Number of Frequency Excursions					Maximum rate of occurrence [rule 2.2.3 & 3.2.2].
	2004	2005	2006	2007	2008	
55 > x ≥ 53.75 **						1 (5 year period)
53.75 > x ≥ 52 **						2 (1 year period)
52 > x ≥ 51.2						7 (1 year period)
51.25 > x ≥ 50.5			2			50 (1 year period)
Normal Frequency Band						
49.5 ≥ x > 48.75	10	17	16	22	13	60 (1 year period)
48.75 ≥ x > 48		1		2		6 (1 year period)
48 ≥ x > 47						1 (5 year period)
47 ≥ x > 45 **						1 (5 year period)

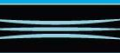
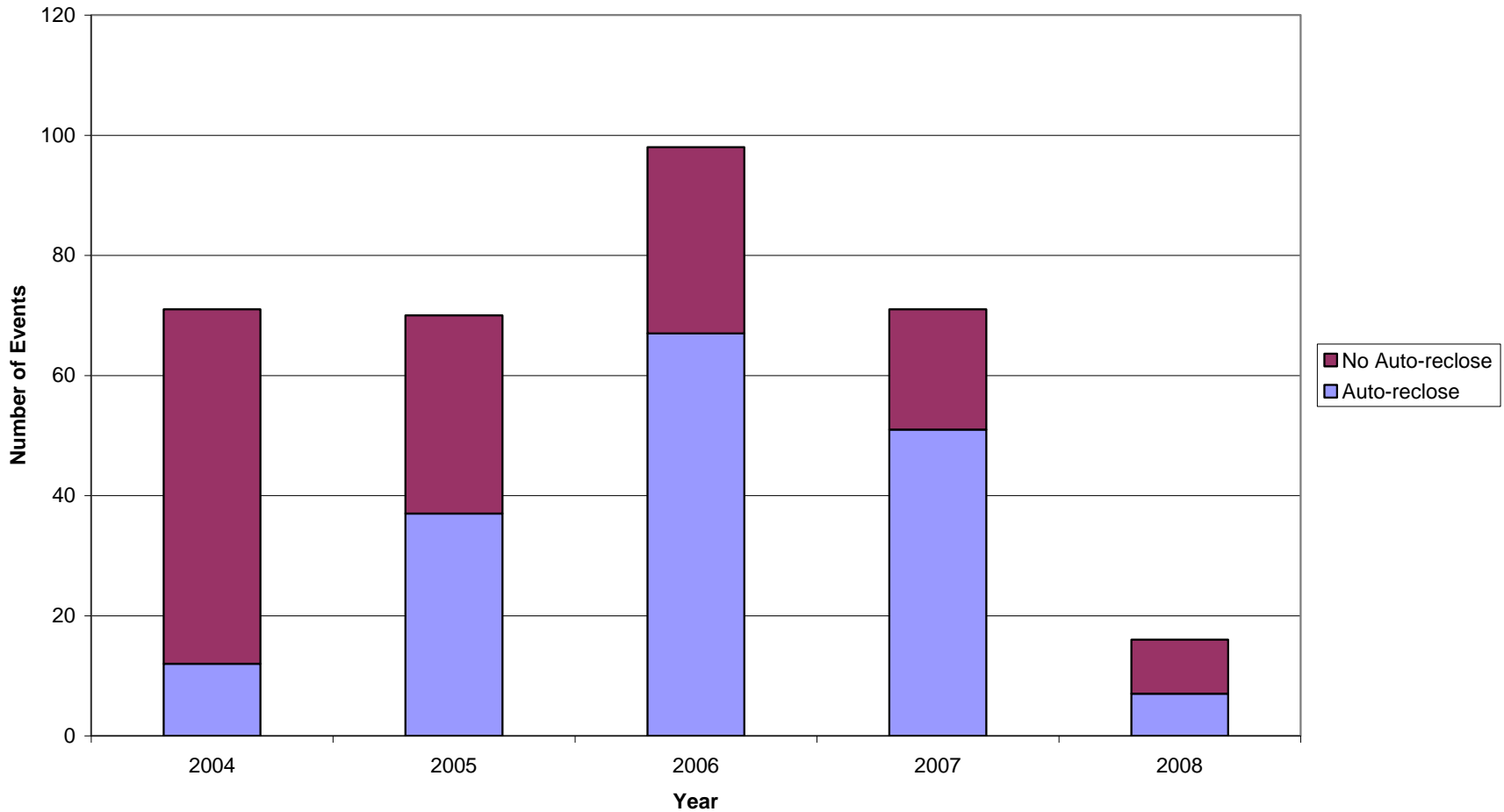
** Additional South Island frequency bands highlighted in blue

17 events/yr frequency outside normal band



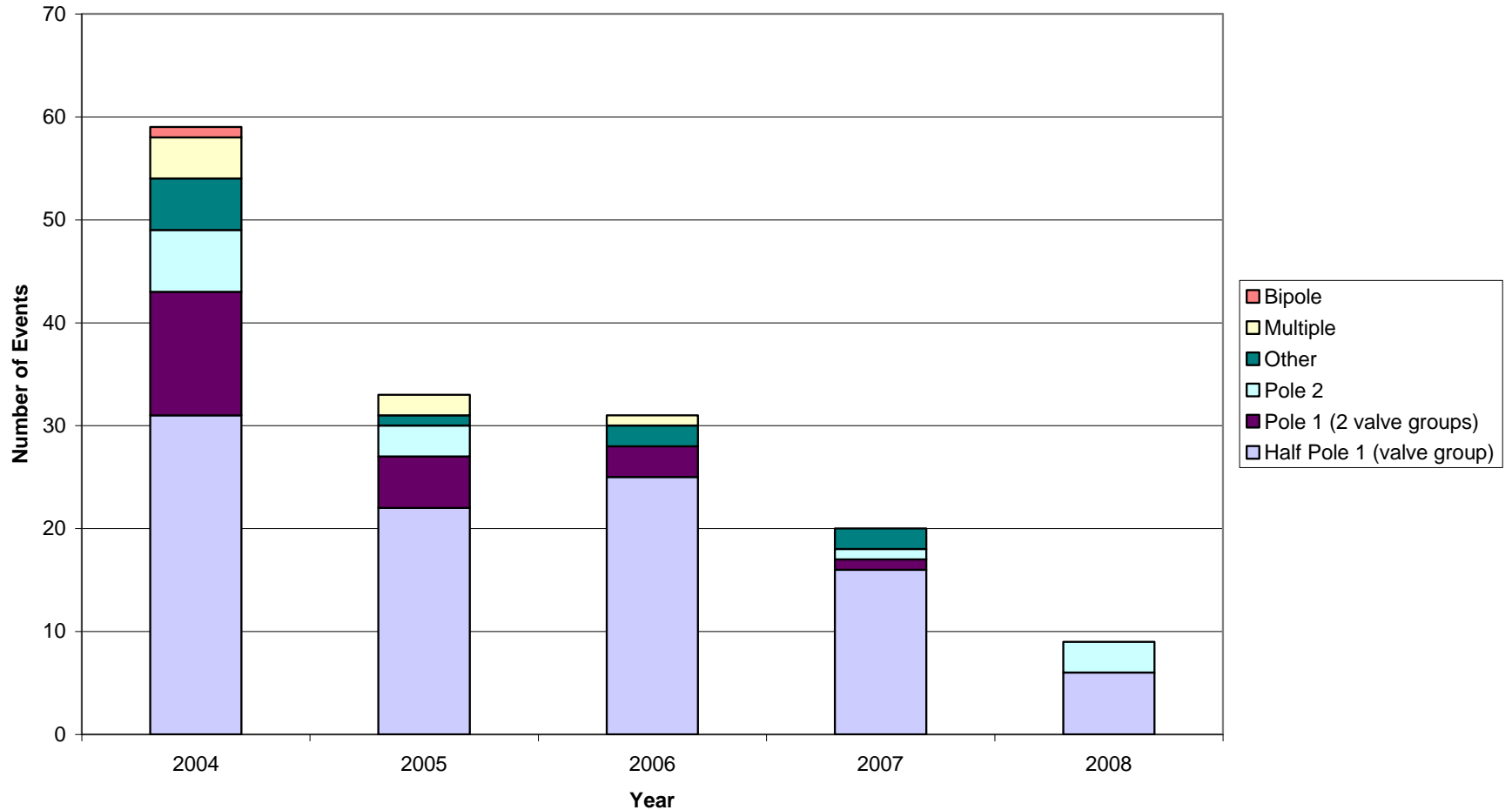
HVDC Events

HVDC Events [2004-2008]



HVDC Events

HVDC Events with No Auto-Reclose [2004-2008]



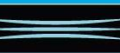
HVDC Events & Frequency

Number of Occasions System Frequency moved outside normal frequency band following the loss of HVDC pole(s) 2004 – 2008 [rule 2.2.3 and 3.2.2 Part C Section II]

Frequency Band (Hz)	Annual Number of Frequency Excursions					Maximum rate of occurrence [rule 2.2.3 & 3.2.2].
	2004	2005	2006	2007	2008	
55>x≥53.75 **						1 (5 year period)
53.75>x≥52 **						2 (1 year period)
52>x≥51.2	2	3			1	7 (1 year period)
51.25>x≥50.5	2	3	1		2	50 (1 year period)
Normal Frequency Band						
49.5≥x>48.75	3	3	1	2	2	60 (1 year period)
48.75≥x>48		1		2		6 (1 year period)
48≥x>47		1				1 (5 year period)
47≥x>45 **						1 (5 year period)

*** Additional South Island frequency bands highlighted in blue

5 events/yr frequency outside normal band



HVDC Events

- HVDC interruption30 events/yr
- 29 events/yr result in loss of single pole
- <1 events/yr result in loss of bipole
- 5 events/yr frequency outside normal band

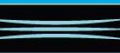


Transmission Circuit Events

Frequency of Transmission circuit interruptions 2004 – 2008

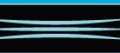
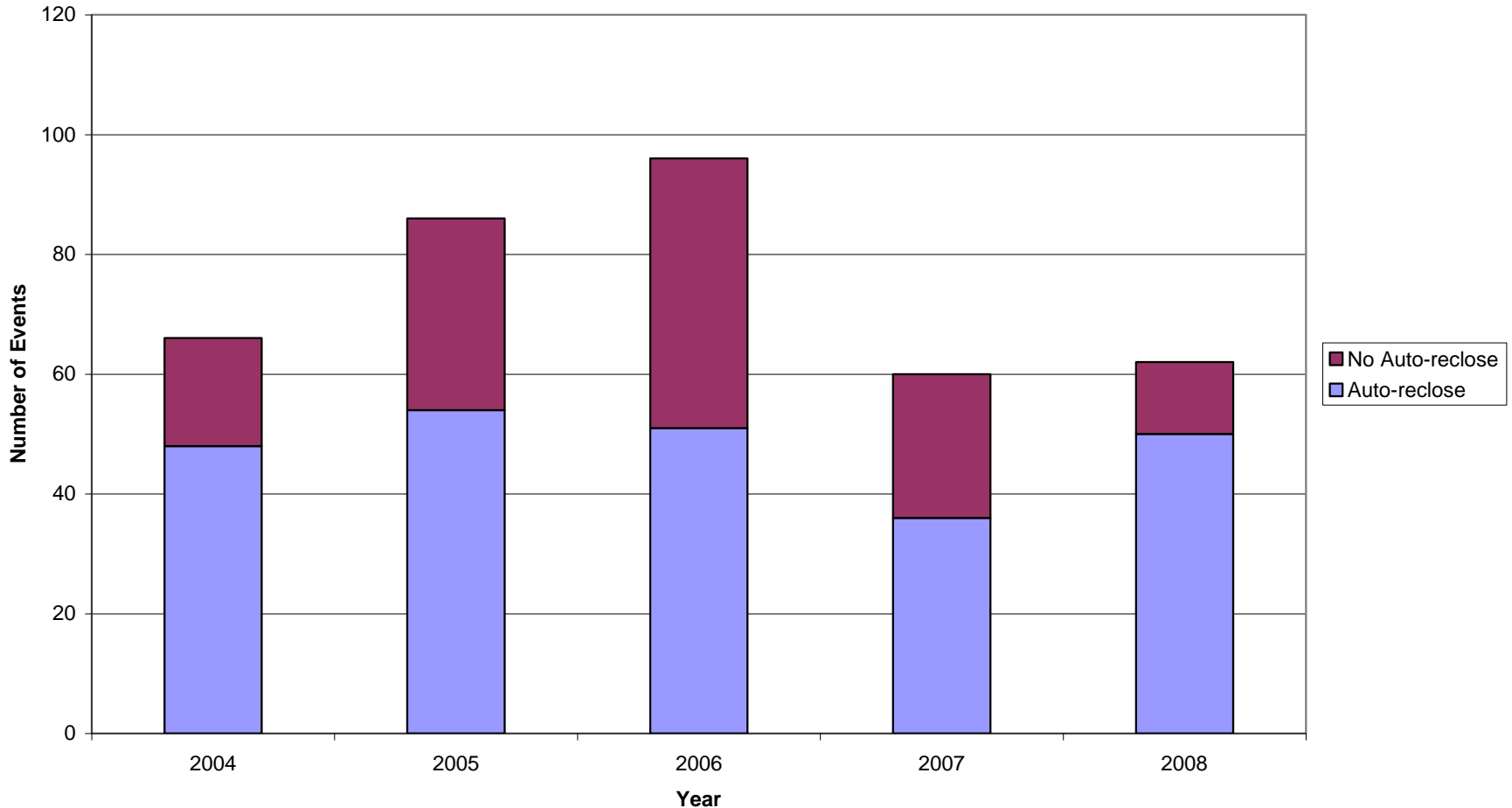
Year	Summary of annual transmission circuit interruptions				TOTAL
	Single Circuit	Double Circuit	Multiple – 3 Circuits	Multiple – 4 Circuits	
2004	215	15	1	0	231
2005	233	17	2	2	254
2006	240	26	3	1	270
2007	214	21	1	1	237
2008	299	16	3	0	318
Average	240.2	19.0	2.0	0.8	262

90% of all interruptions are single circuit outages



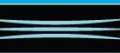
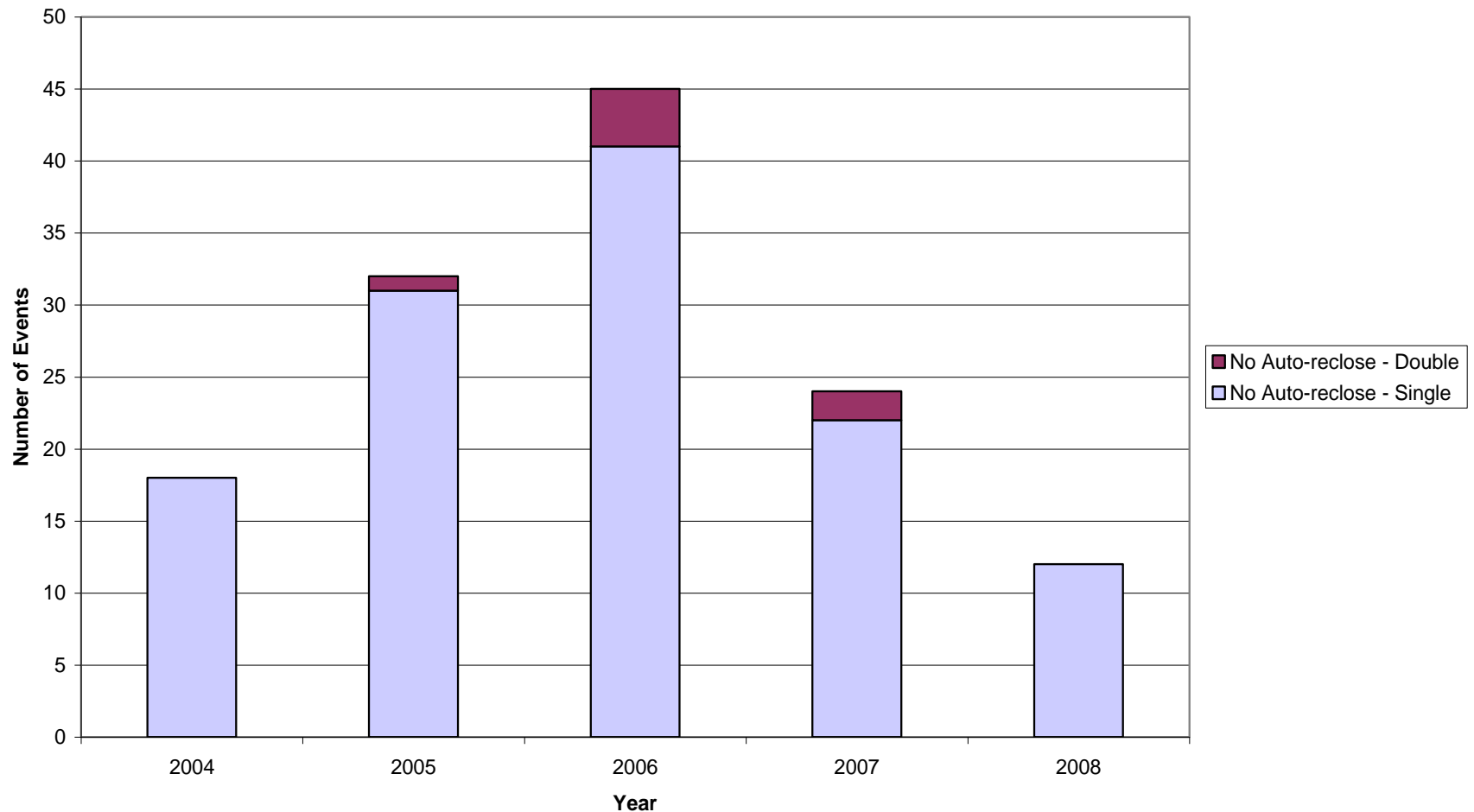
220kV Transmission Events

220kV Transmission Events - with and without Auto-Reclose [2004-2008]



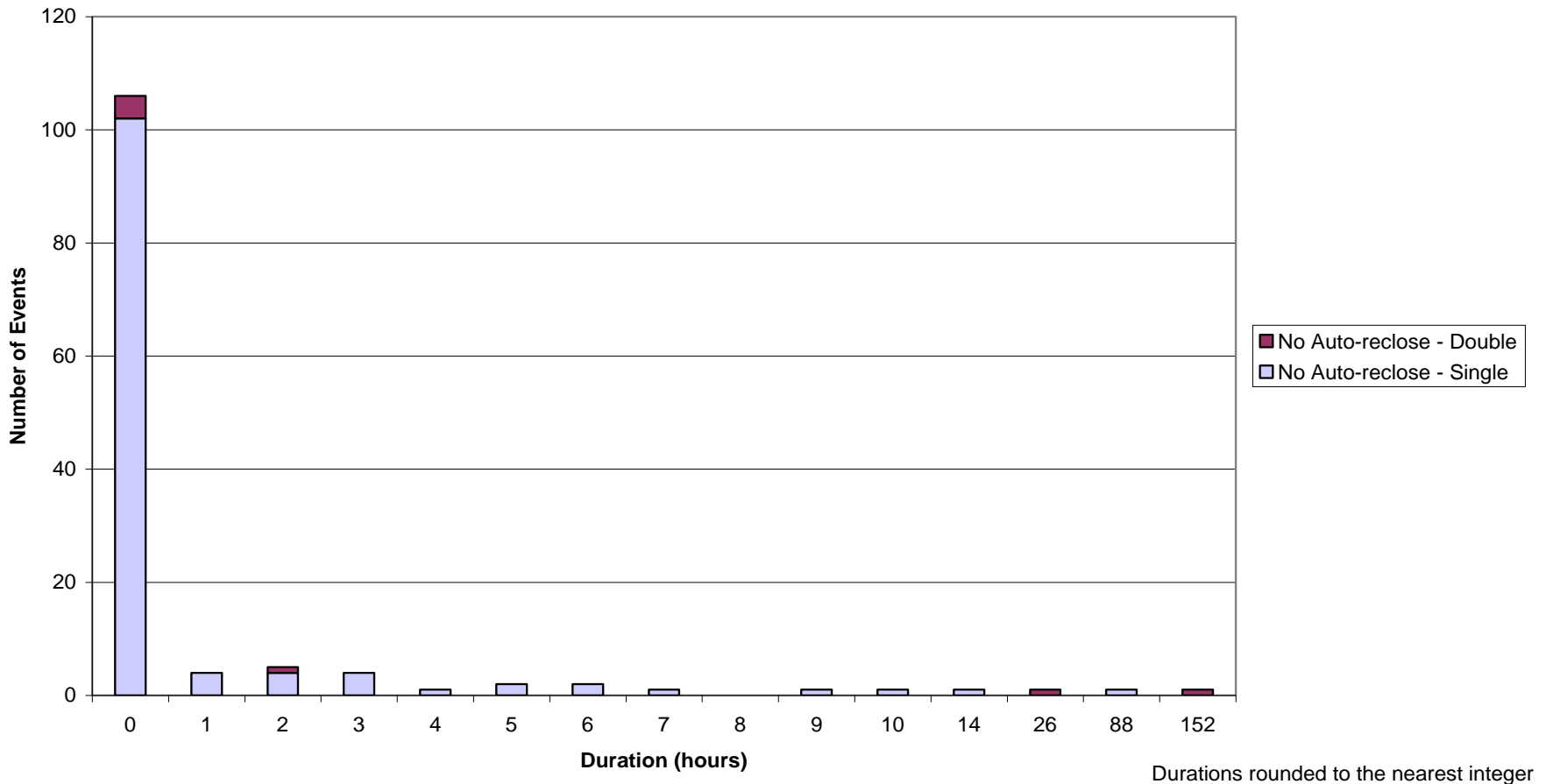
220kV Transmission Events

220kV Transmission Events - without Auto-Reclose - Single & Double Circuit Outages [2004-2008]

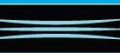


220kV Transmission Event Durations

220kV Transmission Events - without Auto-Reclose, Single & Double Circuit Outage Durations [2004-2008]

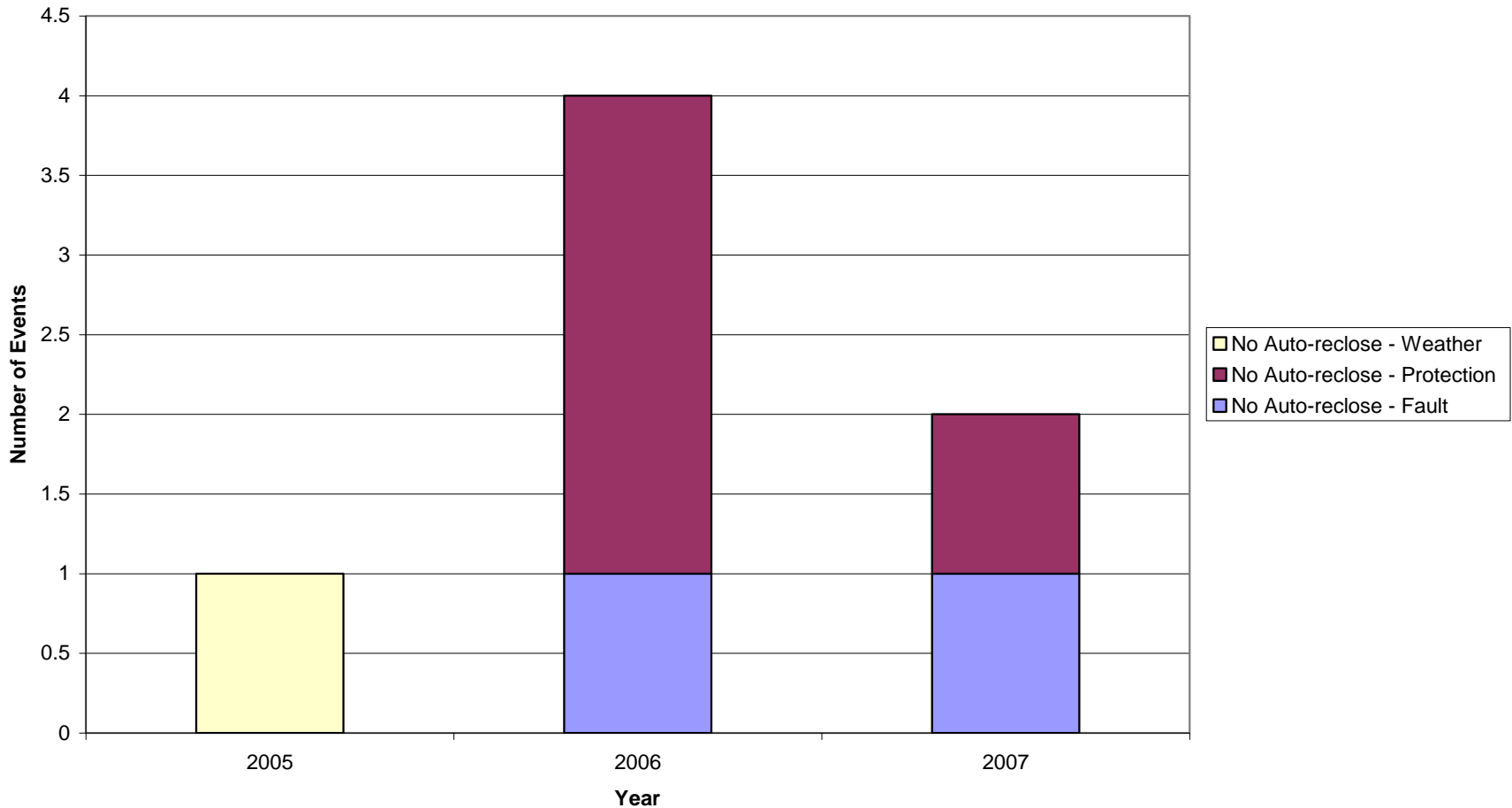


Durations rounded to the nearest integer



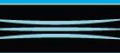
220kV Transmission Events

220kV Transmission Events - without Auto-Reclose - Double Circuit Events [2004-2008]



Transmission Events

- 90% of all interruptions are single circuit outages
- 60% of all 220kV interruptions result in auto-reclose
- 26 events/yr result in unsuccessful re-closure
 - 1-2 events affecting more than 1 circuit



Busbar Event Data

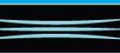
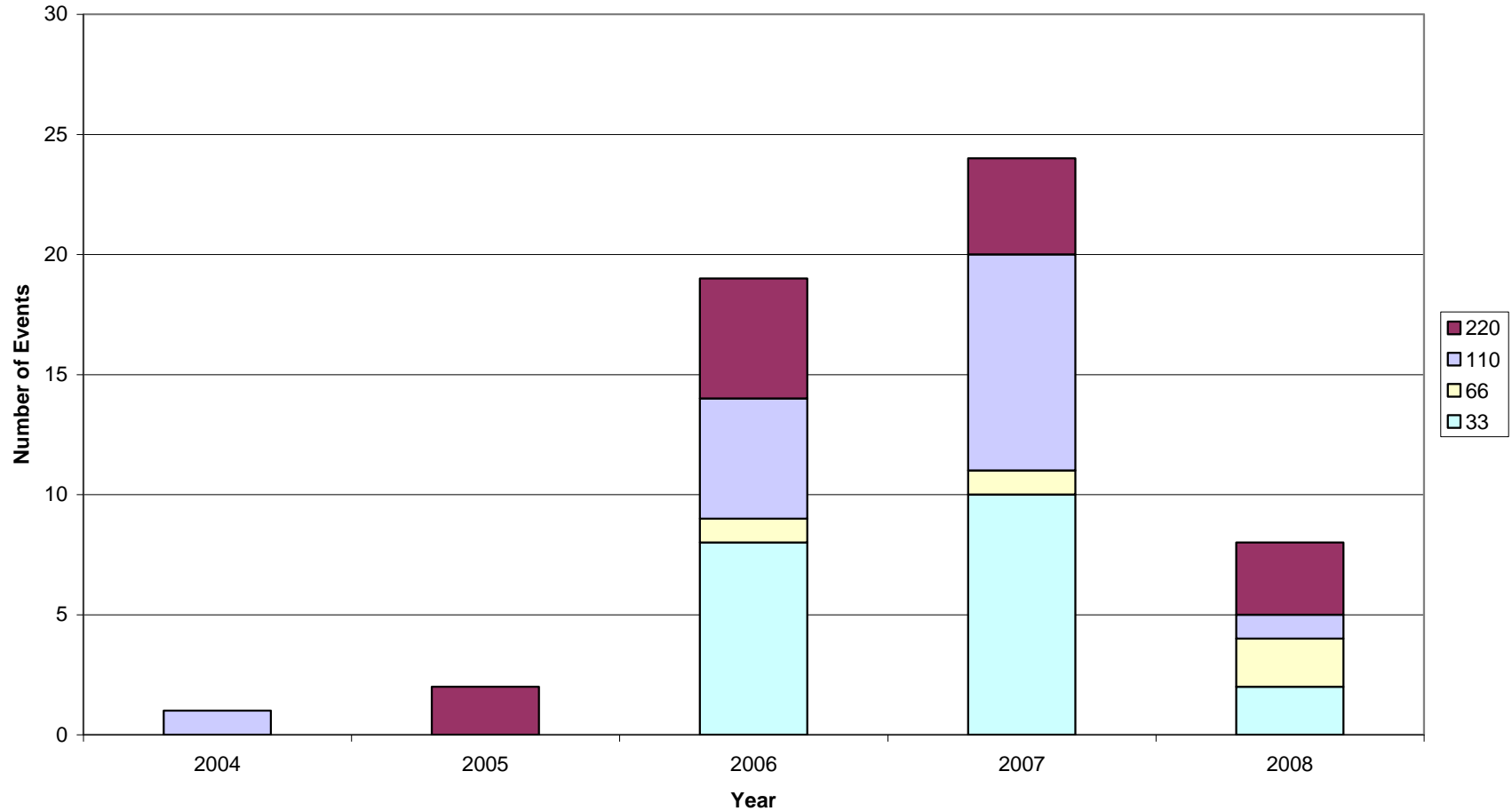
Frequency of busbar interruptions 2004 – 2008

	Summary of busbar section interruptions				
Voltage (kV)	220	110	66&50	33	TOTAL
<i>No. of elements in set</i>	138	144	36	115	433
Year					
2004	0	1	0	0	1
2005	2	0	0	0	2
2006	5	5	1	8	19
2007	4	9	1	10	24
2008	3	1	2	2	8
Average. [2004-08]	2.8	3.2	0.8	4.0	10.8
Average. [1990-99]	-	-	-	-	10
Normalised =10.8x No. of elements in set/433	3.4	3.6	0.9	2.9	10.8



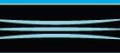
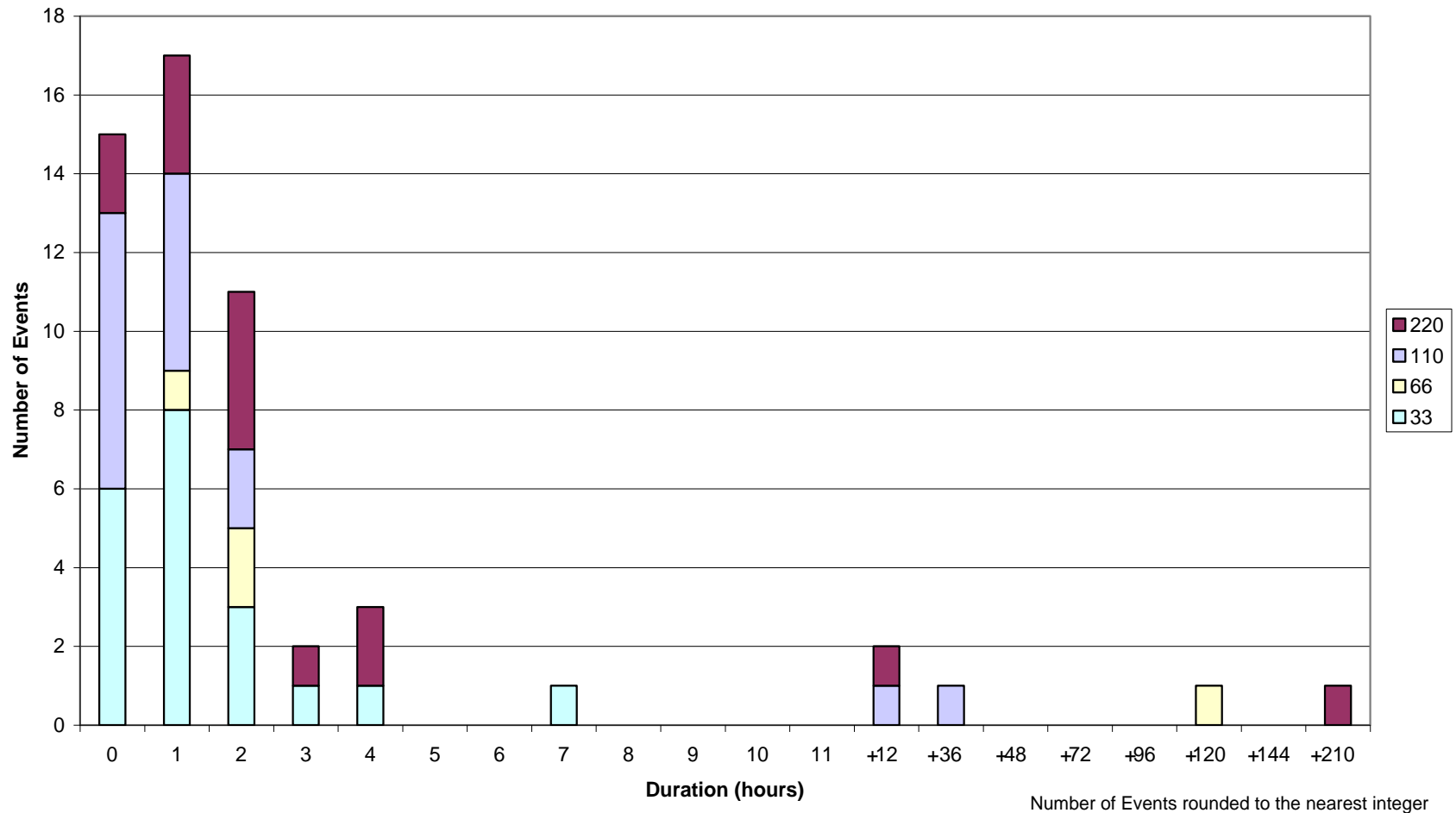
Busbar Events

Busbar Events - 220kV, 100kV, 66kV, 50kV & 33kV [2004-2008]



Busbar Event Durations

Busbar Event Durations, 220kV, 110kV, 66kV, 50kV & 33kV [2004-2008]



Busbar Event Durations

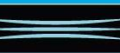
Average Busbar Event Durations [2004 – 2008]

	Average duration of busbar section interruptions				
Voltage (kV)	220	110	66&50	33	All voltages
Av. duration (hours)	17.8	4.4	35.6	1.4	9.1
	10.6		7.1		
Av. duration (hours) capping event duration at 120 hrs	11.2	4.4	31.1	1.4	7.0
	7.5		6.3		



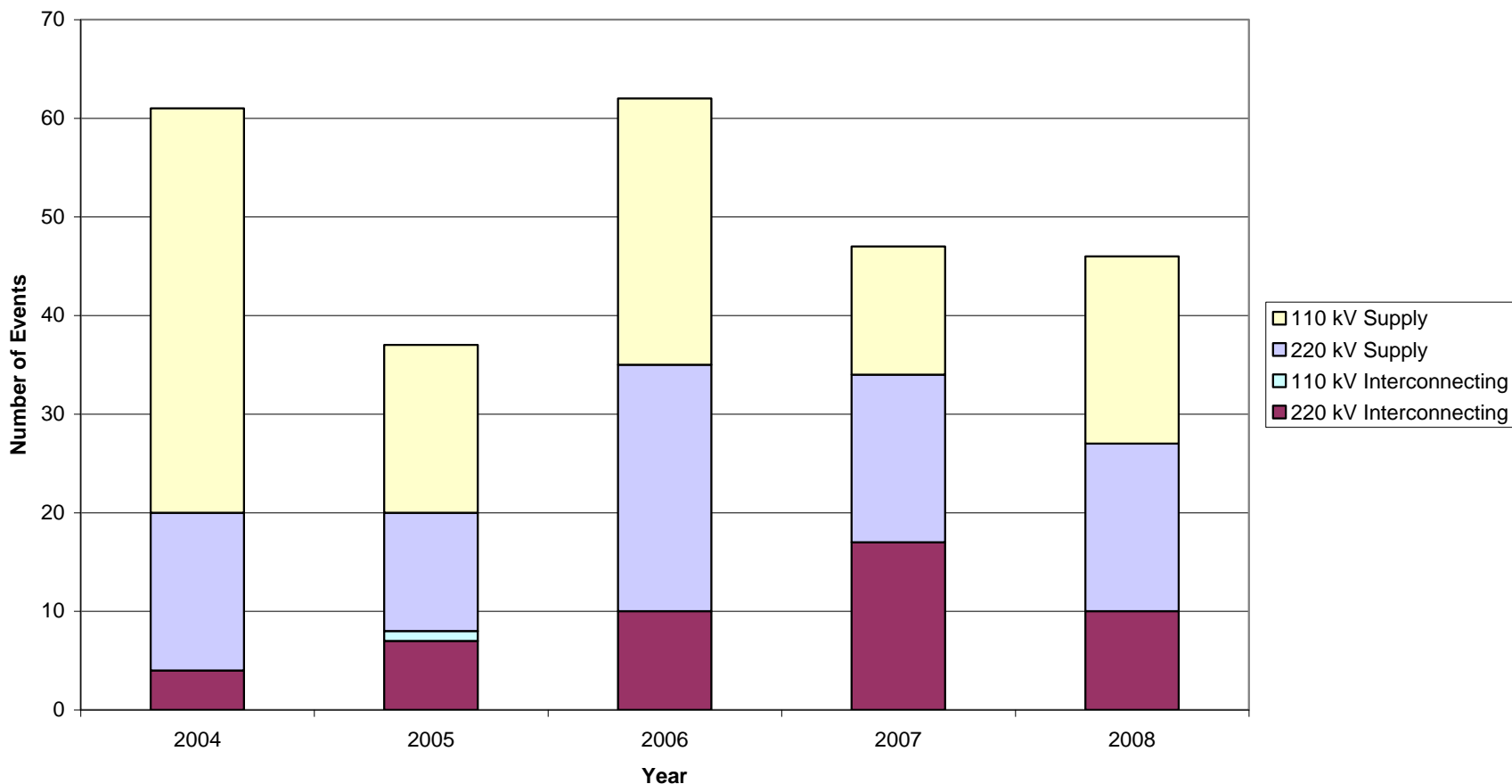
Busbar Events

- 220kV & 110kV
 - 6 events/yr
 - 7.5hr duration
- 66kV, 50kV & 33kV
 - 5 events/yr
 - 6.3hr duration



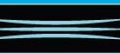
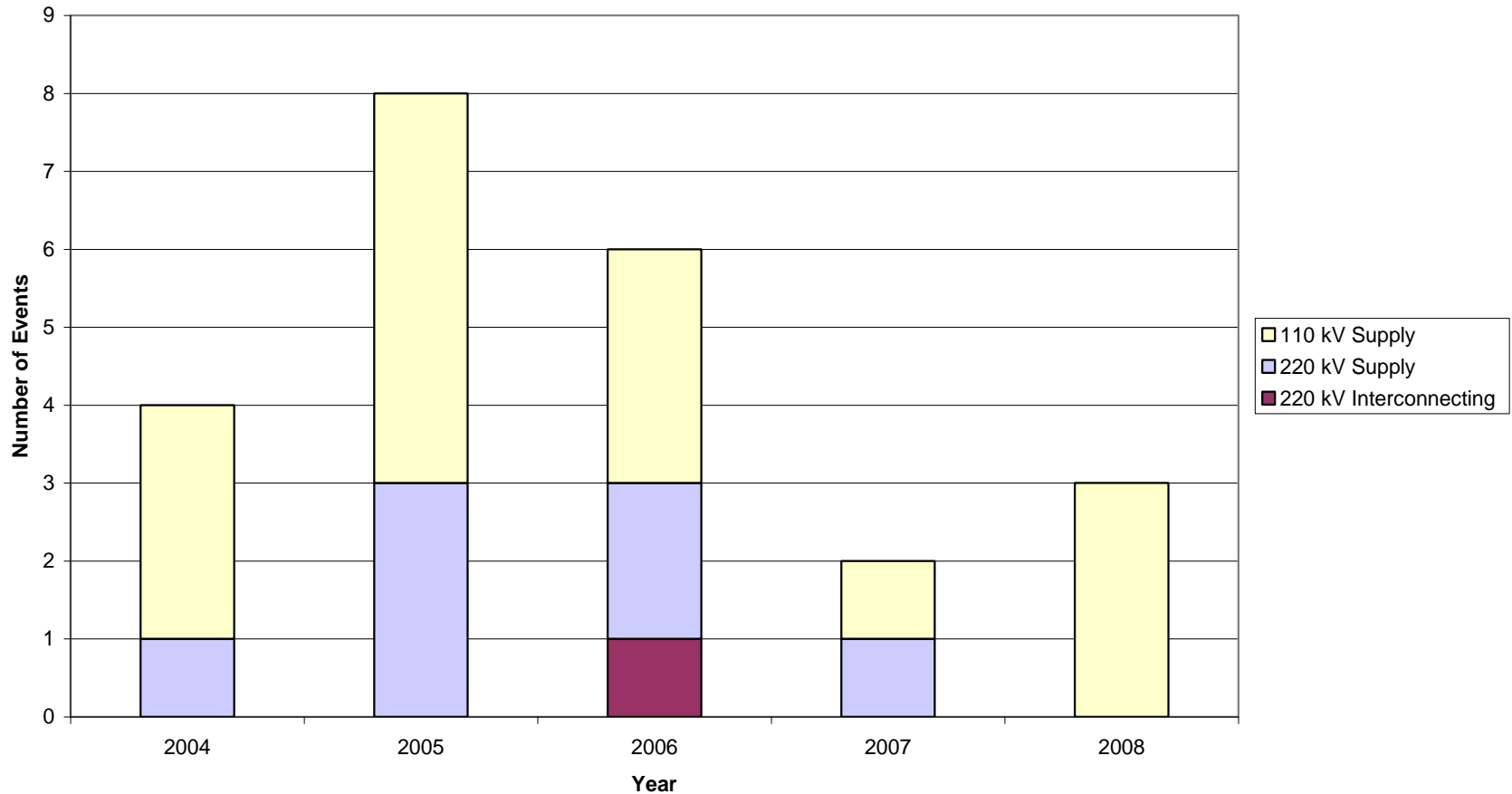
Transformer Events

Single Transformer Events - 220kV & 110kV Interconnecting & Supply Transformer Events [2004-2008]



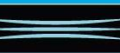
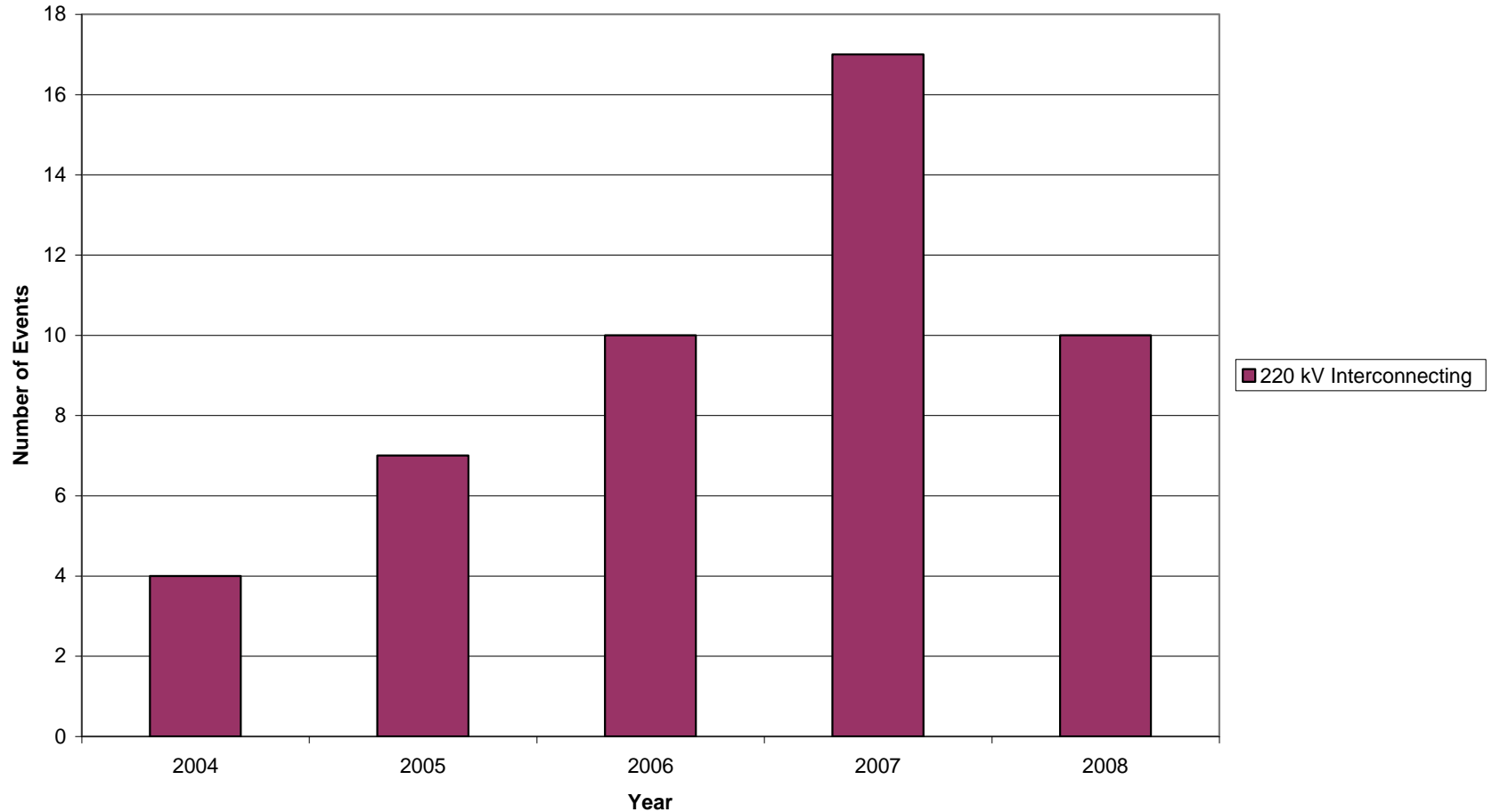
Multiple Transformer Events

Multiple Transformer Events - 220kV & 100kV Interconnecting and Supply Transformer Events [2004-2008]



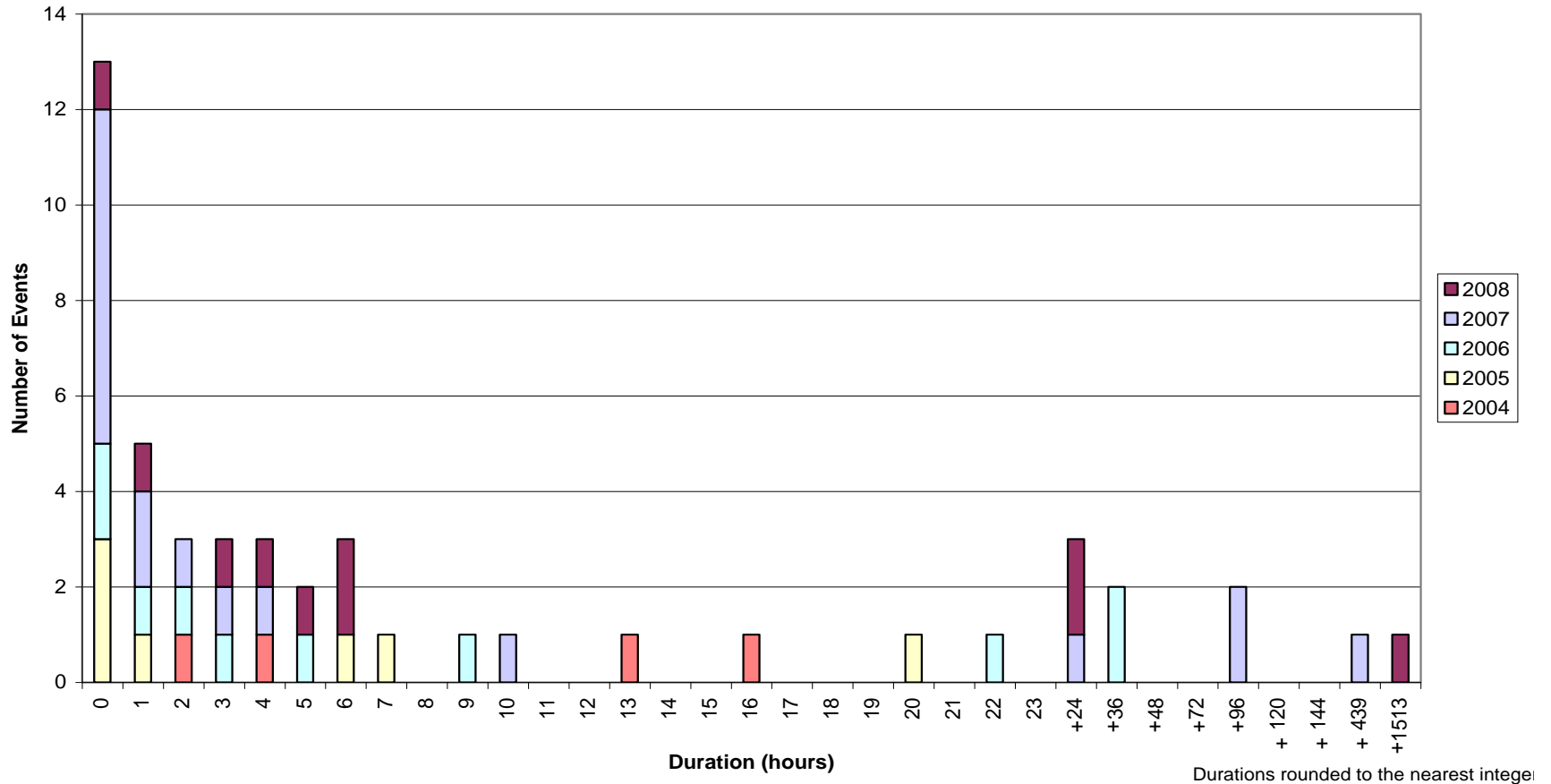
220 kV Interconnecting Tx Event

Single Transformer Events - 220kV Interconnecting Transformer Events [2004-2008]

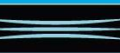


220 kV Interconnecting Tx Event Duration

Single Transformer Event Duration - 220kV Interconnecting Transformers [2004-2008]



Durations rounded to the nearest integer



Transformer Event Durations

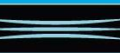
Duration of single 220kV and 110kV interconnecting and supply transformer interruptions 2004 – 2008

	Summary of single transformer interruptions				
<i>Set Name</i>	<i>220kV intercon</i>	<i>110kV intercon</i>	<i>220kV supply & traction</i>	<i>110kV supply</i>	<i>TOTAL</i>
Av. duration (hrs)	52.3	11.6	61.1	37.6	48.4
	51.5		47.7		
Av. duration (hrs) with 120hr duration cap	16.7	11.6	17.8	10.6	14.2
	16.6		13.7		



Transformer Events

- 220kV Interconnecting Transformer
 - 10 events/yr
 - 16.7hr duration

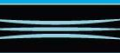


Reactive Plant Events

Frequency of Reactive Plant interruptions 2004 – 2008

Year	Condensers		Capacitor Banks	SVC	Filter Banks		Multiple	Total
	-	HVDC other			-	HVDC other		
2004	5	2	23	0	1	3	3	37
2005	4	1	31	11	1		3	51
2006	11	1	31	2	1	1	1	48
2007	20		31	0	4		1	56
2008	18		15	11	7		3	54
Total	62		131	24	18		11	246
Average	12.4		26.2	4.8	3.6		2.2	49.2

49 reactive device interruptions / year



Summary of Events

Risk Factor Ranking of Credible Events – likelihood of occurrence

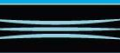
Credible Event Loss of ...	No in Set	No. of Events per year	Event Risk Factor *
a HVDC Half Pole	2	20	10
a HVDC Pole	2	7	3.5
a single generating unit reactive plant	<234	132	0.56
	<134	49	0.37
HVDC bipole	1	<0.5	<0.5
a single 220kV transmission circuit (no A/R)	142	25	0.18
a 220kV interconnecting transformer	105	10	0.095
multiple generating units	<117	11	0.094
110kV interconnecting transformer	10	<0.5	0.05
a 66kV, 50kV or 33kV busbar section	151	5	0.033
a 220kV or 110kV busbar section	282	6	0.021
a double 220kV transmission circuit (no A/R)	<71	1	0.014
multiple 220 or 110kV interconnecting transformers	<53	<0.5	0.009
multiple 220kV transmission circuits	<71	<0.5	0.007

* Likelihood of Occurrence or Event Risk Factor (No. of events/No. of elements in risk set)



Event Classification & Management

- No change to Contingent Event classification of:
 - Transmission Circuit
 - Generator
 - HVDC pole
- Classify the following as Contingent Events:
 - Large load / load block
 - Reactive devices
- No change to Extended Contingent Event classification of:
 - HVDC bipole
- Classify the following as Other Events:
 - Multiple Elements
- Review classification and management of:
 - Interconnecting Transformer
 - Busbar Section
- Consideration of management measures during commissioning and maintenance outages



Questions ?

