

# System Security Forecast 2010

## Part C Security Analysis

### HVDC



*Keeping the lights on  
24 hours a day, 7 days a week*

SYSTEM OPERATOR

*Keeping the energy flowing*

TRANSPOWER



# I M P O R T A N T

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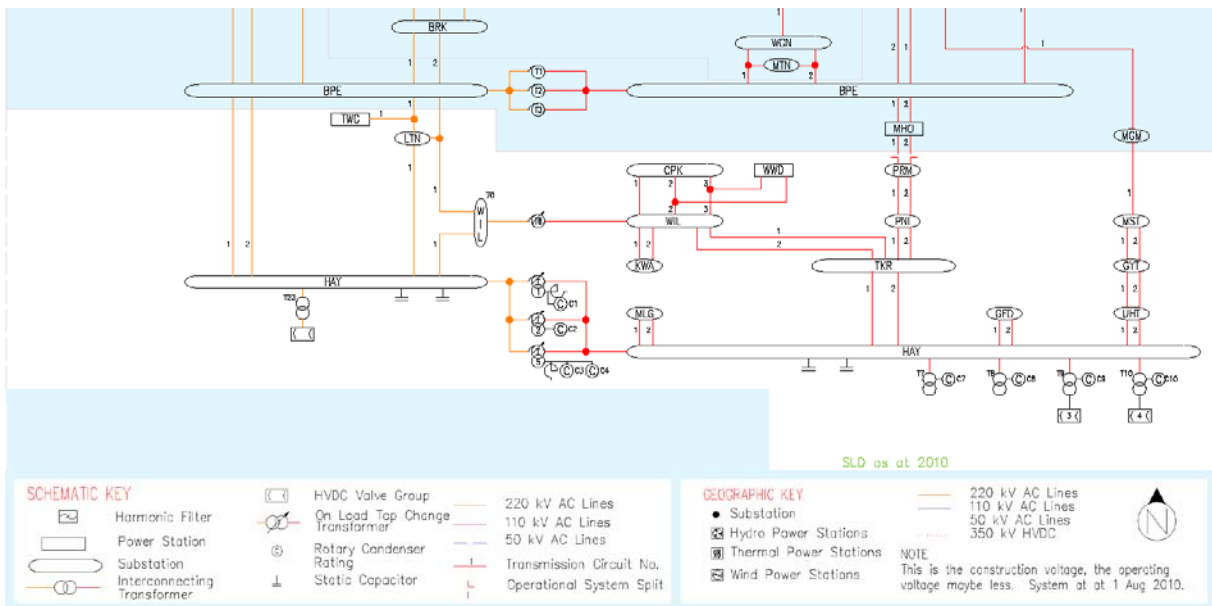
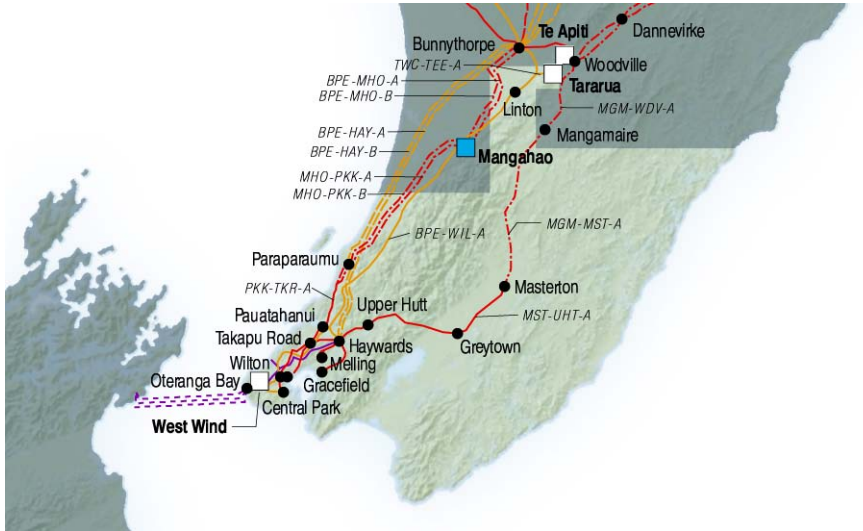
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# 1 LIMIT GROUP ANALYSIS

Power system limits on the amount of HVDC transfer are required under certain power system conditions. Limitations on HVDC North and South transfer arise from the need to avoid voltage instability and assets exceeding stated capability under steady state and contingent events.



## 1.1 ASSUMPTIONS:

For study purposes the assumed HVDC transfer levels are listed below.

HVDC Transfer (MW)	2011		2012		2013	
	summer	winter	summer	winter	summer	winter
<i>North Transfer</i>	600	600	500	500-1000	1000	1000
<i>South Transfer</i>	300	300	300	300-400	400-500	400-500

The following assumptions are made:

- Normal system configuration – all reactive plants in the Wellington region are available and in service;
- HVDC power factor is 0.92;
- Wind generation is the combined output from Tararua Wind Farms (158 MW), Te Rere Hau Stage 1-4 (49 MW), West Wind (142 MW) and Te Apiti (90 MW);
- No-Wind condition (0 MW); Maximum-Wind condition (439 MW);
- Synchronous Condenser Refurbishment Schedule:

	2011		2012		2013	
	summer	winter	summer	winter	summer	winter
<i>Haywards Condenser Refurbishment Schedule</i>	C7	C2; C8	C9	C3	C4	--

## 1.2 KEY POWER SYSTEM CAPABILITY LIMITS ON LIMIT GROUP

### 1.2.1 POWER SYSTEM ISSUES

Power system capability limits that apply to the region are shown in the following table. Detailed analysis for each issue can be found in the Appendix (section 2). You can navigate to the relevant issue by clicking on the section number in the right hand column of the following table.

Limit Group	Power System Issue	Causing Factor	Indicative Limit	Operational Measures	Detailed Analysis Section
<i>HVDC/Wellington</i>	Voltage instability issues under HVDC South transfer	Loss of the Haywards-Linton-1 220 kV circuit	Under No-Wind conditions, transfer limit on the combined Wellington regional load and HVDC South transfer is 824 MW (2011 Winter).  Under Maximum-Wind conditions, transfer limit on the combined Wellington regional load and HVDC South transfer is 1001 MW (2011 Winter).	Security constraints, Short term ratings, Grid reconfiguration, Load management	2.1.1

Limit Group	Power System Issue	Causing Factor	Indicative Limit	Operational Measures	Detailed Analysis Section
	Bunnythorpe-Haywards 220 kV circuits may exceed stated capability		Under No-Wind conditions, transfer limit on the combined Wellington regional load and HVDC South transfer is 857 MW (2011 summer).  Under Maximum-Wind conditions, transfer limit on the combined Wellington regional load and HVDC South transfer is 1048 MW (2011 summer).		
<p><i>The following power system capability limits apply during outages of certain plant. Where possible, outages will be scheduled at times when demand is less than the power system capability limit so that no operational measures are required. Where this not possible, the listed operational measures can be used during the outage.</i></p>					
<i>HVDC</i>	Reduce HVDC power transfer	Outage of one of the Haywards Interconnecting Transformers	Various HVDC operational runback power transfer levels	Runback levels on the HVDC	2.2.1
<i>North/South Island</i>	Reduce HVDC power transfer	Outage of various HVDC related plant	Various HVDC operational runback power levels	HVDC manual runback	--

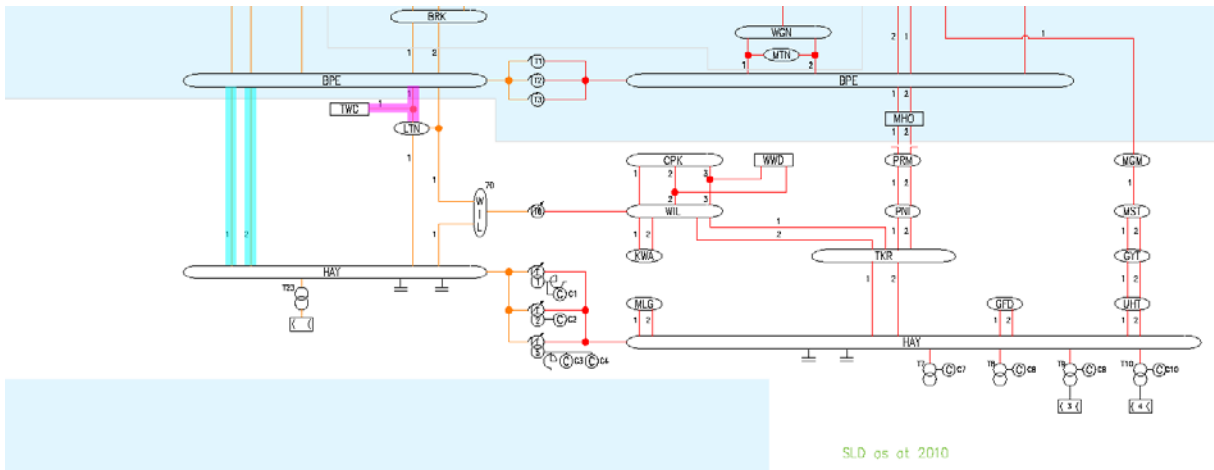
*Regional Power System Capability Limits*

## 2. APPENDIX

### 2.1 REGIONAL ISSUES DURING NORMAL OPERATION

#### 2.1.1 LOSS OF THE HAYWARDS-LINTON-1 220 kV CIRCUIT

Grid Group	Power System Issue	Causing Factor	Indicative Limit	Operational Measures
HVDC/Wellington	Voltage instability issues under HVDC South transfer	Loss of the Haywards-Linton-1 220 kV circuit	No voltage instability issues under HVDC North transfer with all Haywards reactive support in service  Under No-Wind conditions, transfer limit on the combined Wellington regional load and HVDC South transfer is 824 MW (2011 Winter).  Under Maximum-Wind conditions, transfer limit on the combined Wellington regional load and HVDC South transfer is 1001 MW (2011 Winter).	Security constraints, Short term ratings, Grid reconfiguration, Load management
	Bunnynthorpe-Haywards 220 kV circuits may exceed stated capability		Under No-Wind conditions, transfer limit on the combined Wellington regional load and HVDC South transfer is 857 MW (2011 summer).  Under Maximum-Wind conditions, transfer limit on the combined Wellington regional load and HVDC South transfer is 1048 MW (summer).	



#### HVDC North Transfer

After the replacement of Wilton T8 interconnecting transformer and the conductor of the Masterton-Mangamaire-Woodville 110 kV circuits, there are no foreseeable issues under HVDC North transfer conditions within the study period.

#### HVDC South Transfer

Under HVDC South transfer, there are a number of power system issues:

- Under normal system conditions with all assets in service, the first issue that may arise is the Bunnynthorpe-Woodville-1 and 2 110 kV circuits exceeding stated capability. A power system capability limit is required to manage the loading on these circuits. Alternatively, the

overloading issue may be resolved by the grid owner reconfiguring the 110 kV systems by opening the system split at Mangamaire.

- Voltage instability during HVDC South transfer in winter and Maximum-Wind conditions in summer.
- Bunnythorpe-Haywards-1 and 2 220 kV circuits may exceed stated capability under No-Wind conditions in summer, when the system split at Mangamaire is open.
- The next binding constraint is the limit to avoid voltage instability after the loss of any one of the Bunnythorpe-Haywards 220 kV circuits, with Haywards-Linton-1 220 kV circuit being the critical contingency.

### ***Power System Analysis to avoid assets exceeding stated capability***

#### ***HVDC South Transfer***

Power system capability limits on the combined Wellington regional load and HVDC South transfer is 857 MW (2011 summer). This limit is to prevent the Bunnythorpe-Haywards-1 and 2 220 kV circuits exceeding stated capacity following the loss of the Bunnythorpe-Tararua-Linton-1 220 kV circuit under No-Wind conditions in summer. Note that Wellington regional load power factor has a secondary effect on circuit loading. In winter and Maximum-Wind conditions in summer, the issue is voltage instability.

### ***Power System Analysis due to Voltage Instability***

#### ***HVDC South Transfer***

Power system capability limits are required on the combined Wellington regional load and HVDC South transfer to avoid voltage instability following the loss of the Haywards-Linton-1 220 kV circuit.

The following has been determined:

- The power system capability limit while maintaining the HVDC power factor at 0.92 and Wellington load power factor of 0.96 is 824 MW in winter under No-Wind conditions, and 1048/1001 MW (2011 summer/winter) under Maximum-Wind conditions.
- If the Wellington load power factor is increased by 0.02, then the transfer limit increases by approximately 30 MW.

### ***Sensitivity to Haywards Condensers***

The sensitivity of the Haywards condensers to the power system limits has also been determined. While maintaining the HVDC power factor at 0.92 and under the same system conditions, the unavailability of one of the smaller condenser units at Haywards, C3 or C4, will reduce the power system limits by approximately 7 MW. And for the unavailability of one of the larger units at Haywards, C1 or C2, the power system limits will reduce by approximately 40 MW.



### Operational Measures

The following operational measures may apply:

- Application of security constraints
- Short term ratings
- Grid reconfiguration
- Load management

### Summary of Power System Capability Limits

A summary of indicative limits are shown below.

Generation scenario	Wellington Load Power Factor 0.96		
	2011 (summer/winter)	2012 (summer/winter)	2013 (summer/winter)
<b>HVDC South transfer + Wellington load</b>			
<i>No-Wind</i>	857/*824 MW	853/820MW	856/*855 MW
<i>Maximum-Wind (including West Wind)</i>	1048/*1001 MW	1050/*1055 MW	1059/*1049 MW

\*Safety margin of 5% taken for voltage instability

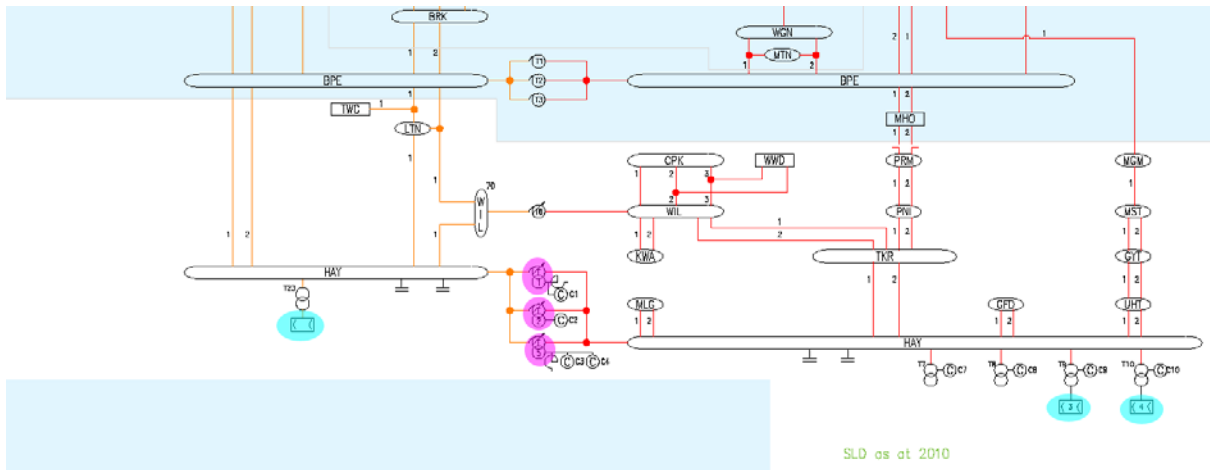
Generation scenario	Haywards Condenser Availability				
	All in service	HAY C3 or C4 out of service	HAY C2 out of service	HAY C2, C7, C3 out of service	HAY C7 or C8 or C9 or C10 out of service
<b>HVDC South transfer + Wellington load</b>					
<i>No-Wind</i>	849 MW	*846 MW	*845 MW	*789 MW	*843 MW
<i>Maximum-Wind (including West Wind)</i>	*1064 MW	*1048 MW	*1028 MW	*966 MW	1026 MW

\*Safety margin of 5% has been taken for voltage instability

## 2.2 REGIONAL ISSUES DURING OUTAGES

### 2.2.1 OUTAGE OF ONE OF THE HAYWARDS INTERCONNECTING TRANSFORMERS

Grid Exit Point	Power System Issues	Causing Factor	Indicative Limit	Operational Measures
<i>HVDC</i>	Reduce HVDC power transfer	Outage of one of the Haywards Interconnecting Transformers	Various HVDC operational runback power transfer levels	Runback levels on the HVDC



Following the limited operation of Pole 1, Wellington loads are supplied from three Haywards interconnecting transformers (T1, T2 and T5), Wilton interconnecting transformer (T8) and from Bunnythorpe 110 kV via the Mangamaire-Woodville-1 110 kV circuit. A power system capability limit is required during an outage of one of the Haywards interconnecting transformers (T1, T2 or T5) to avoid voltage instability.

There are no issues under HVDC North transfer. High HVDC South transfer is only possible during low Wellington loads as this is governed by the Bunnythorpe-Haywards circuits' stated capability limit and voltage stability limit. For high Wellington loads, HVDC South transfer has to be constrained back to avoid voltage stability limits. The system split at Mangamaire is assumed to be opened under No-Wind conditions in summer to avoid the overloading of the Bunnythorpe-Woodville 110 kV circuits.

The outage of one of the Haywards interconnecting transformer, T1 or T2 or T5, will remove the tertiary connected synchronous condensers, C1 or C2 or C3 and C4, which reduces the HVDC South transfer limit.