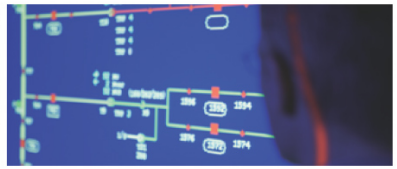
Summary of South Transfer Limits

Updated for 2008

Slide 23 revised for 48.0 Hz South Island RMT
CE limit in the South Island from 18 April

TRANSPOWER



SYSTEM OPERATOR

Background

- Update of 2006 presentation of power system limits for high southwards transfer – “dry year” scenario
  - Changes made reflect stand down of HVDC Pole 1 and decommissioning of New Plymouth.
  - No further changes in power system limits since upgrades completed in mid 2006.
  - Additional background from previous years at end of slides.

- High south transfer through the North Island and across HVDC
  - Effectively operating power system in reverse.
  - Different transmission constraints and issues.
  - Results in an increase in South Island reserve requirements.

South transfer power system limits

- Four distinct power system pinch points

  1. Export south out of the Taranaki

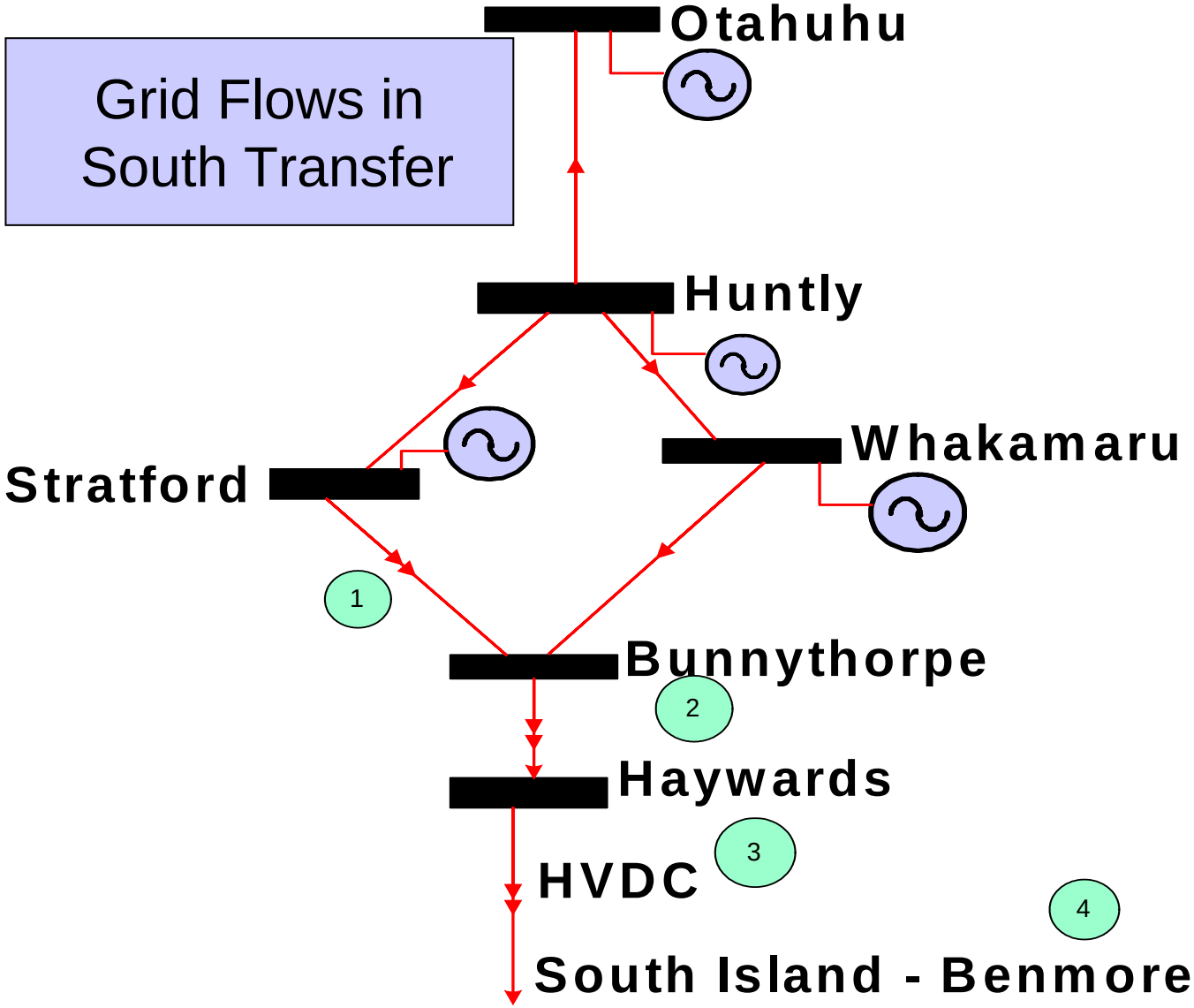
  2. Transfer from Bunnythorpe to Haywards

  3. Transfer over HVDC & Impact of Wellington load

  4. South Island instantaneous reserves to cover HVDC south transfer configuration

  These are shown graphically on the next slide

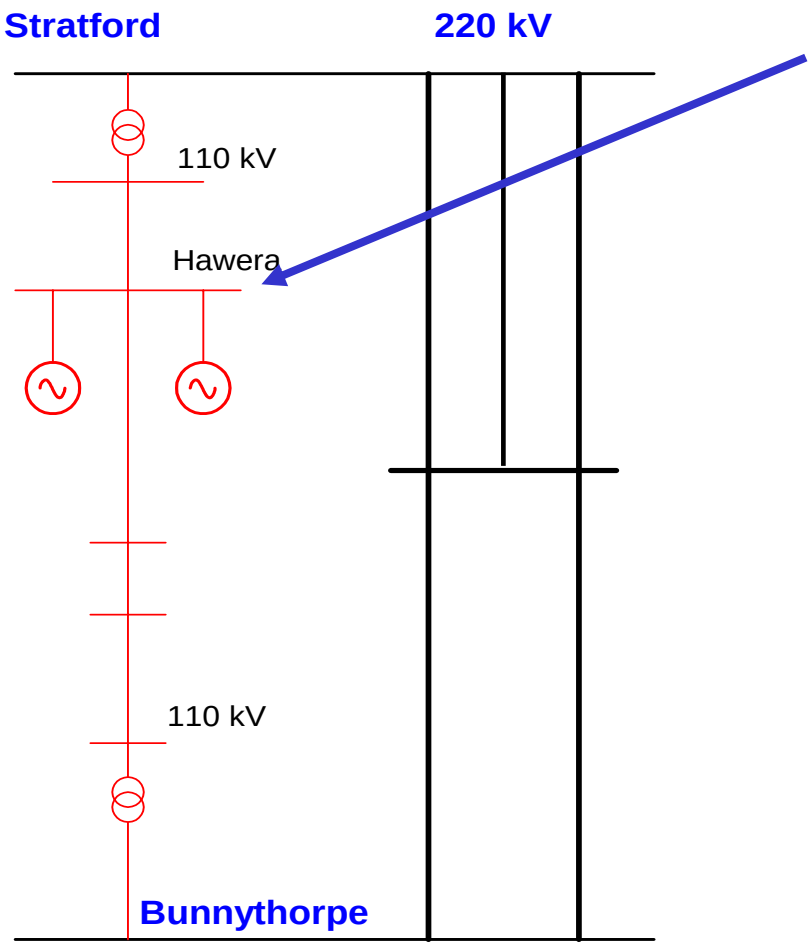
Grid Flows in South Transfer



Export south out of the Taranaki region (Constraint 1).

- Constraint
  - Due to 110 kV parallel link that limits 220 kV transfer south to Bunnythorpe from Stratford.
  - Can constrain generation from within the Taranaki region and at Huntly.
  - Constraint unlikely with decommissioning of New Plymouth power station.

- Mitigation measures
  - Reactor and automatic post fault splitting scheme for 110 kV link from Stratford to Bunnythorpe at Hawera.
    - Initiative enabled in stages as constraints appear.
    - Maintains n-1 connection security pre-event for local consumer demand.



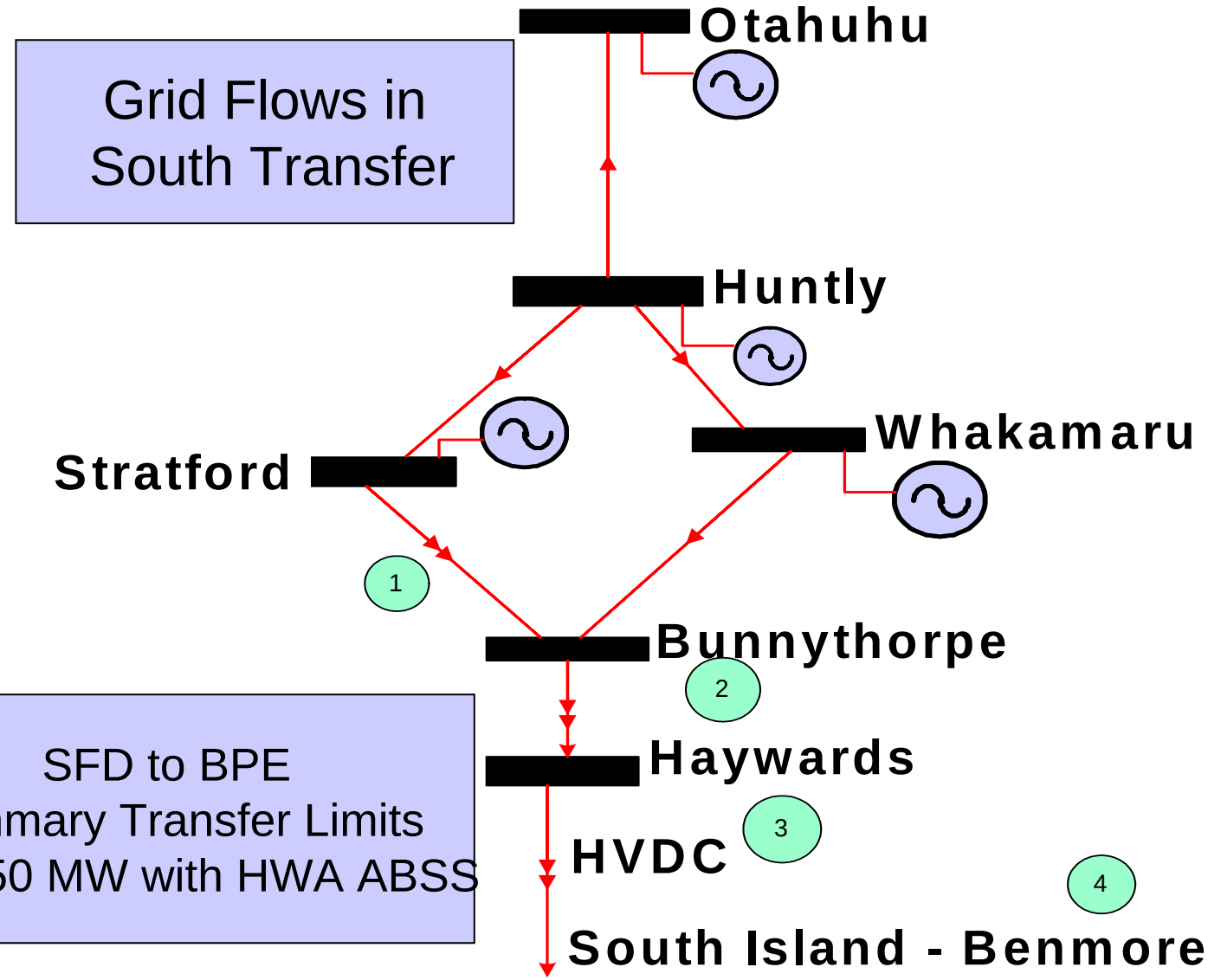
Mitigations at Hawera

- reactor put into service (1st option)
- auto post fault splitting scheme enabled

Export south out of the Taranaki region. (Constraint 1)

- Impact of mitigation measure
  - Increase export limit south out of Taranaki from ~480 up to 690 MW (winter) and 550 MW (summer).
  - Full Taranaki and full Huntly generation should be possible post decommissioning of New Plymouth.

Grid Flows in South Transfer



SFD to BPE
Summary Transfer Limits
690/550 MW with HWA ABSS

Transfer from Bunnythorpe to Haywards (Constraint 2)

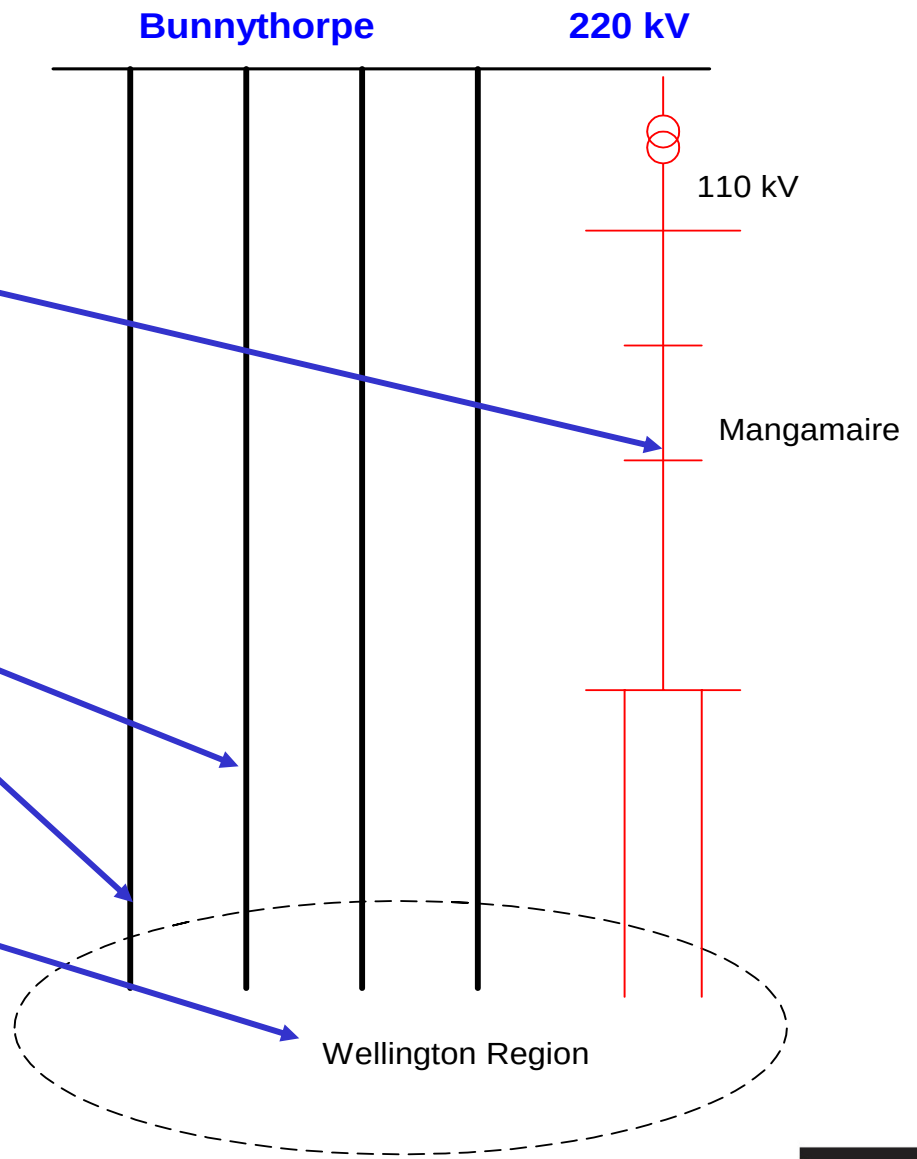
- Constraint
  - Due to the 110 kV link through the Wairarapa limiting transfer on the four 220 kV circuits south to Haywards from Bunnythorpe.
  - This constraint is the critical limitation on south transfer.

- Mitigation measures
  - Automatic post fault splitting scheme for 110 kV enabled as constraints appear allowing n-1 connection security to be retained pre-event as an initial response.
  - Operational split for Wairarapa reducing connection security to “n”. A special Transpower protocol sets out how and when this step is initiated in a dry year situation.

Mitigations at Mangamaire
- auto post fault splitting (1st option)
- operational split (if protocol met)

Upgraded of 220 kV circuits in 2006

Mitigations in Wellington
- Wilton interconnector (WIL T8) switched out when required



Transfer from Bunnythorpe to Haywards (Constraint 2)

- Impact of mitigation measures:
  - With the automatic post fault splitting scheme enabled in the Wairarapa 110 kV link transfer south to Haywards of up to 845 MW (winter) or 655 MW (summer) is possible.
  - Putting in place the operational split in the Wairarapa 110 kV link, at Mangamaire, increases transfer limit to 868 MW for both winter and summer transmission ratings.
  - The operational split at Mangamaire is only implemented when in a dry year situation where the conditions of the Transpower protocol are met.

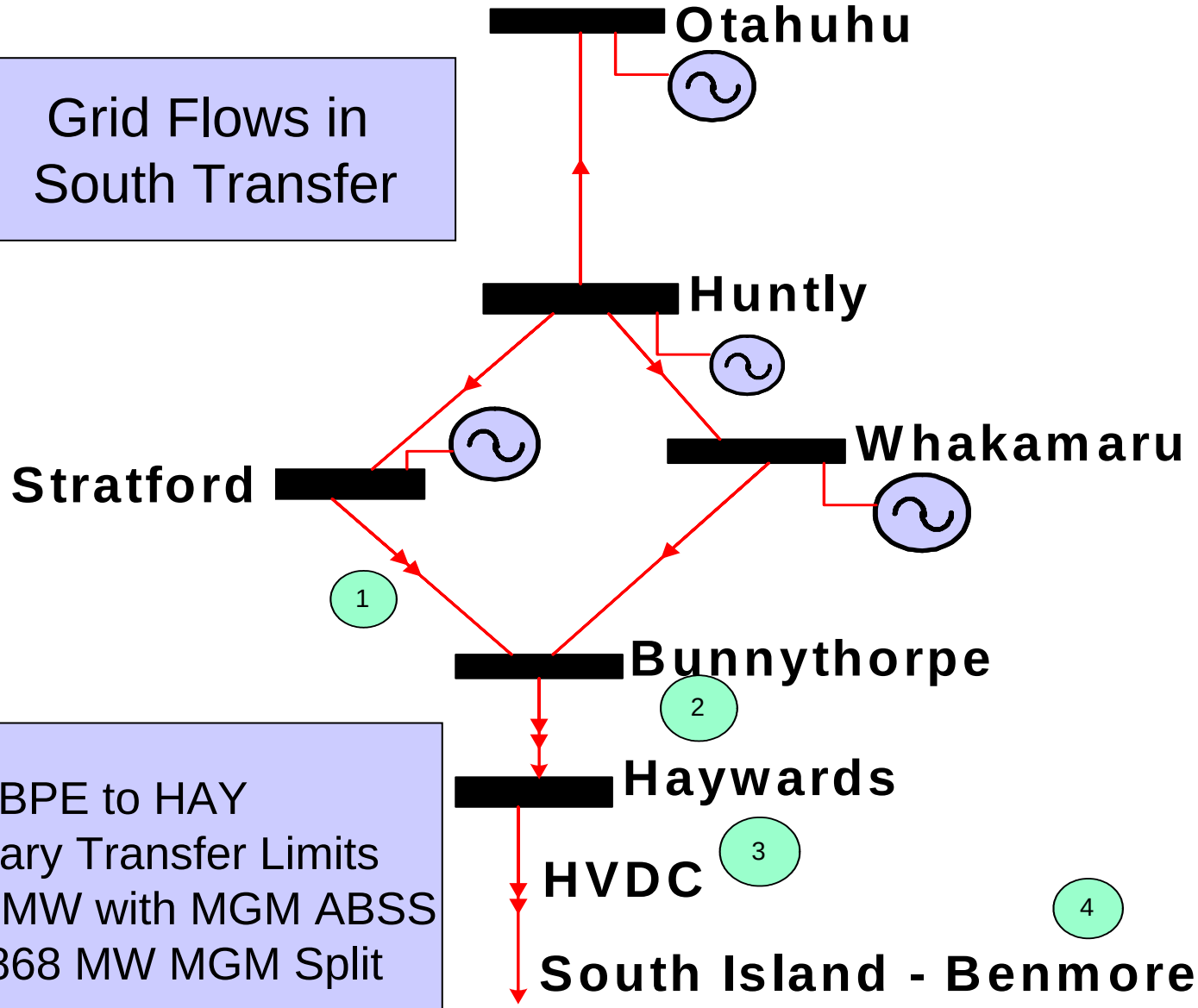
Transfer from Bunnythorpe to Haywards (Constraint 2)

- Transpower Protocol for reducing connection security at Mangamaire
  - First response is to enable automatic post fault splitting scheme when constraint is within 90% of binding for 5% of time.
  - In dry year situation use of 110 kV operational split is also considered. This puts the GXP on N security with a momentary interruption if a fault occurs.
  - Transpower does not make the decision to activate this split unilaterally when required. Agreement for this initiative is requested from Powerco.

Transfer from Bunnythorpe to Haywards (Constraint 2)

- Limits are indicative:
  - Limits with automatic post fault splitting scheme activated are due to the capacity of Wairarapa 110 kV route. These vary due to Wellington load and HVDC transfer sharing across 110 kV and 220 kV circuits.
  - When the operational split is in place the limit is due to voltage stability. It will vary up to 868 MW with actual HVDC south transfer and the associated reactive plant in service at Haywards.
  - Limits will be reviewed with future system changes (eg new wind generation connections in Wellington region).

Grid Flows in South Transfer

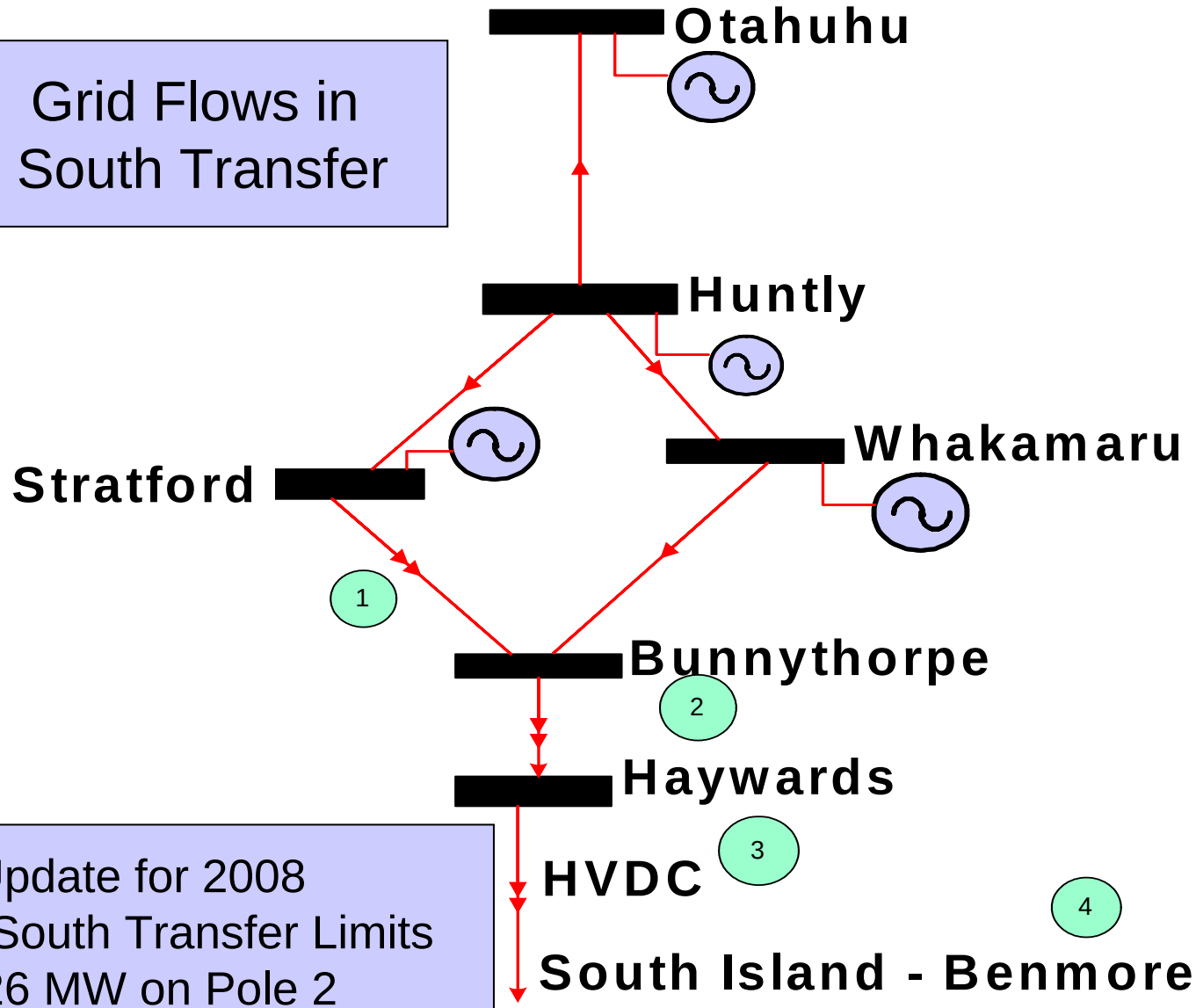


BPE to HAY
Summary Transfer Limits
845/655 MW with MGM ABSS
Up to 868 MW MGM Split

HVDC South transfer limits Pole 2 only (Constraint 3)

- HVDC south transfer now on Pole 2 only:
  - Pole 1 available for north transfer only – under emergency conditions.
  - Two undersea cables on Pole 2 with a limit of 626 MW sent from Haywards to Benmore.
  - The 626 MW limit is to ensure stability of the North Island power system if Pole 2 trips.

Grid Flows in South Transfer



Update for 2008
HVDC South Transfer Limits
626 MW on Pole 2

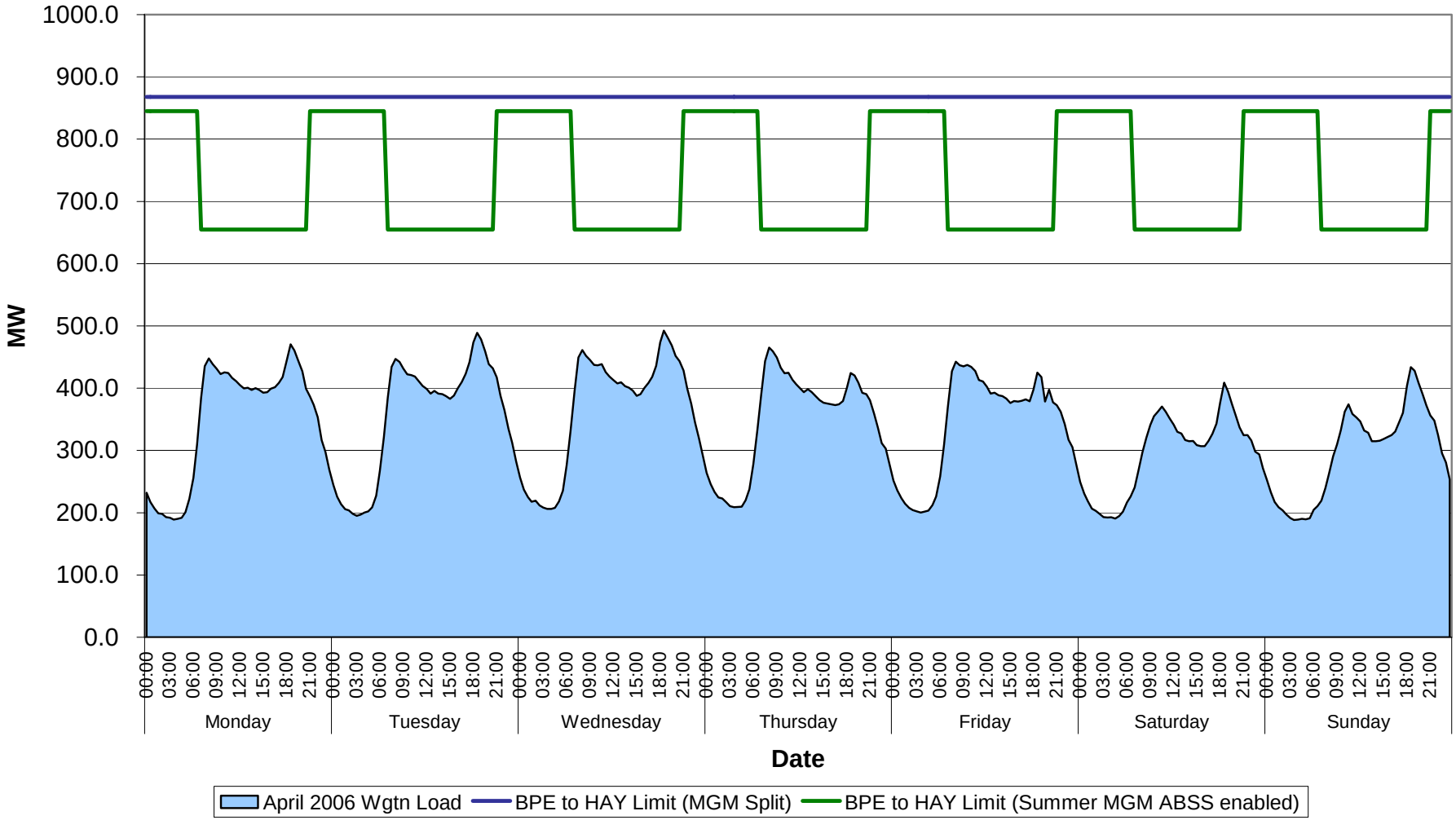
Impact of combined HVDC & Wellington load

- HVDC transfer south limited to the Bunnythorpe to Haywards transmission capacity less the Wellington load.
- Mitigation
  - Switching out “Wilton Interconnector” at peak times.
- Impact of mitigation
  - Wilton Interconnector (T8) is switched out when required to maximise Bunnythorpe to Haywards transfer.

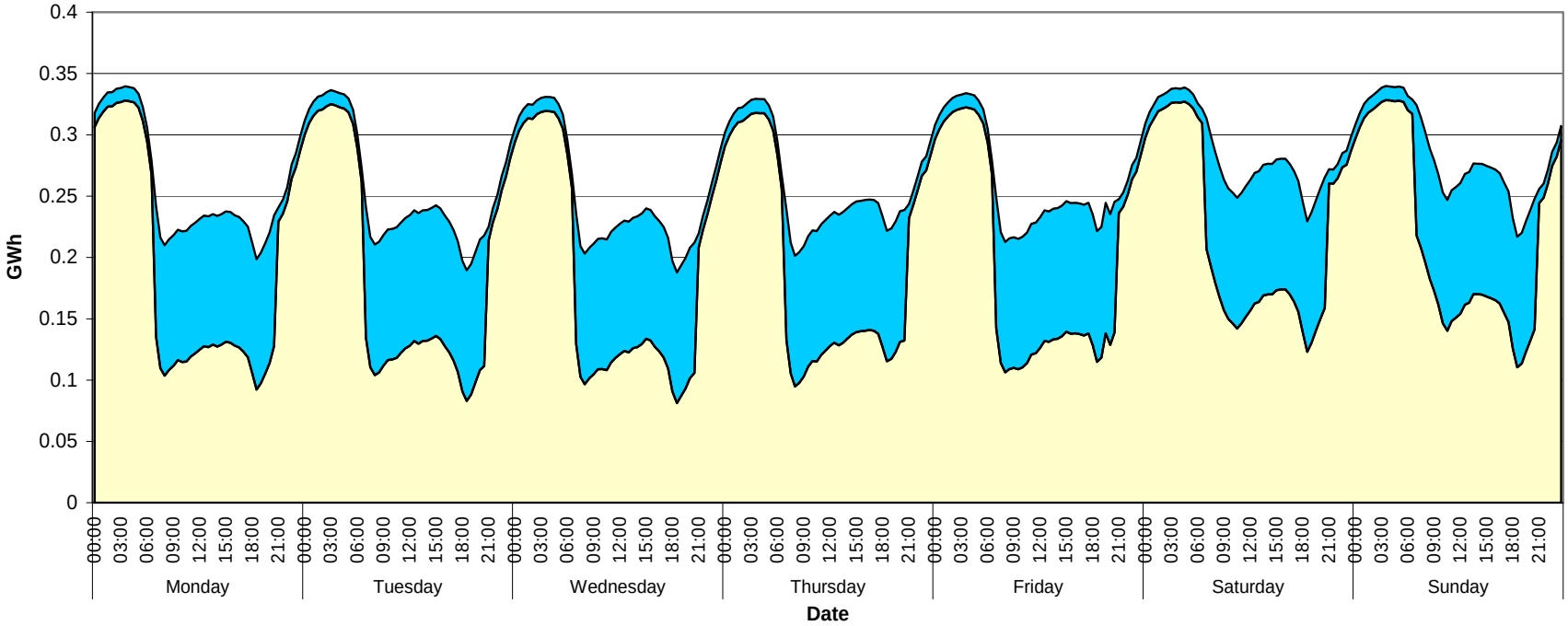
Impact of combined HVDC & Wellington load

- Capacity on Bunnythorpe to Haywards
  - First chart shows Wellington load data from April 2006 and Bunnythorpe-Haywards limits with both:
    - Post fault splitting scheme enabled when summer ratings apply.
    - The Mangamaire operational split in place.
  - Second chart shows additional daily energy transfer possible in each case above.
  - Similar charts will be posted each day on the System Operator website with actual flows with significant south transfer.

Impact of combined HVDC & Wellington load



Impact of combined HVDC & Wellington load – Possible energy transfer on HVDC



3.212 GWh	3.212 GWh	3.212 GWh	3.212 GWh	3.212 GWh	3.212 GWh	3.212 GWh

Daily Energy Totals MGM Split

Weekly Total 22.484 GWh

9.273 GWh	9.120 GWh	8.890 GWh	9.301 GWh	9.430 GWh	10.562 GWh	10.510 GWh

Daily Energy Totals MGM ABSS in Service (Summer)

Weekly Total 67.086 GWh

Energy Transfer (Summer MGM ABSS enabled) Additional Energy Transfer (MGM Split)

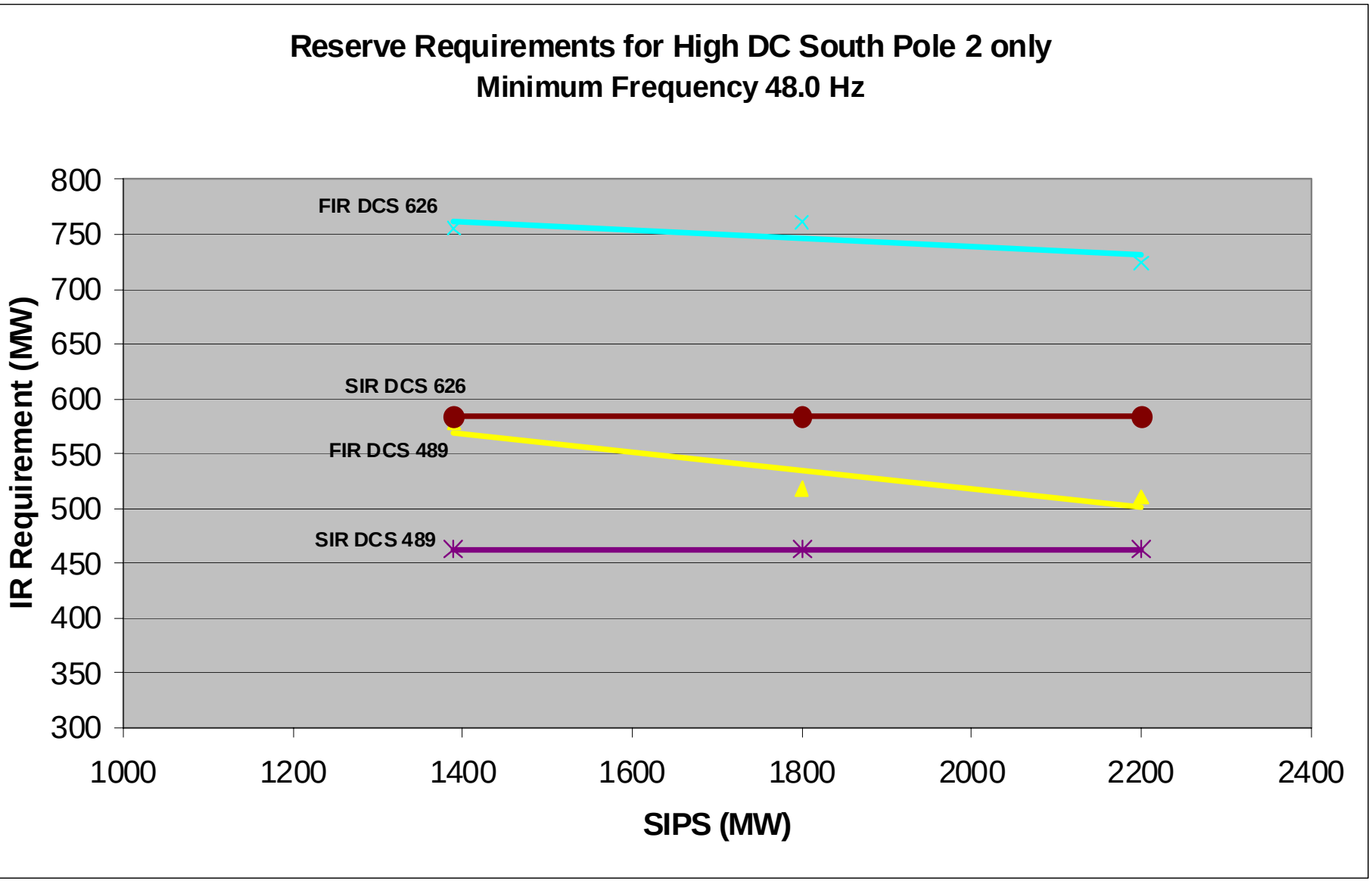
Impact of South Island Instantaneous Reserve Availability

- Constraint on HVDC South transfer.
  - South Island reserve requirements for HVDC south transfer.
  - Stability limit on HVDC south transfer.

- SI Reserves with HVDC south transfer
  - Reserve risk in South Island usually largest generating (Manapouri at 121 MW).
  - South transfer requires additional reserves to cover loss of HVDC when transfer on Pole 2 greater than 121 MW.
  - With Pole 2 only loss of HVDC is contingent event. Reserves required to cover up to 626 MW south transfer.

Impact of South Island Instantaneous Reserve Availability

- Charts of reserve requirements
  - Next chart shows the indicative fast and sustained reserve requirements for 500 MW and 626 MW HVDC transfer sent from Haywards with varying South Island demand for the loss of Pole 2 as a contingent event.

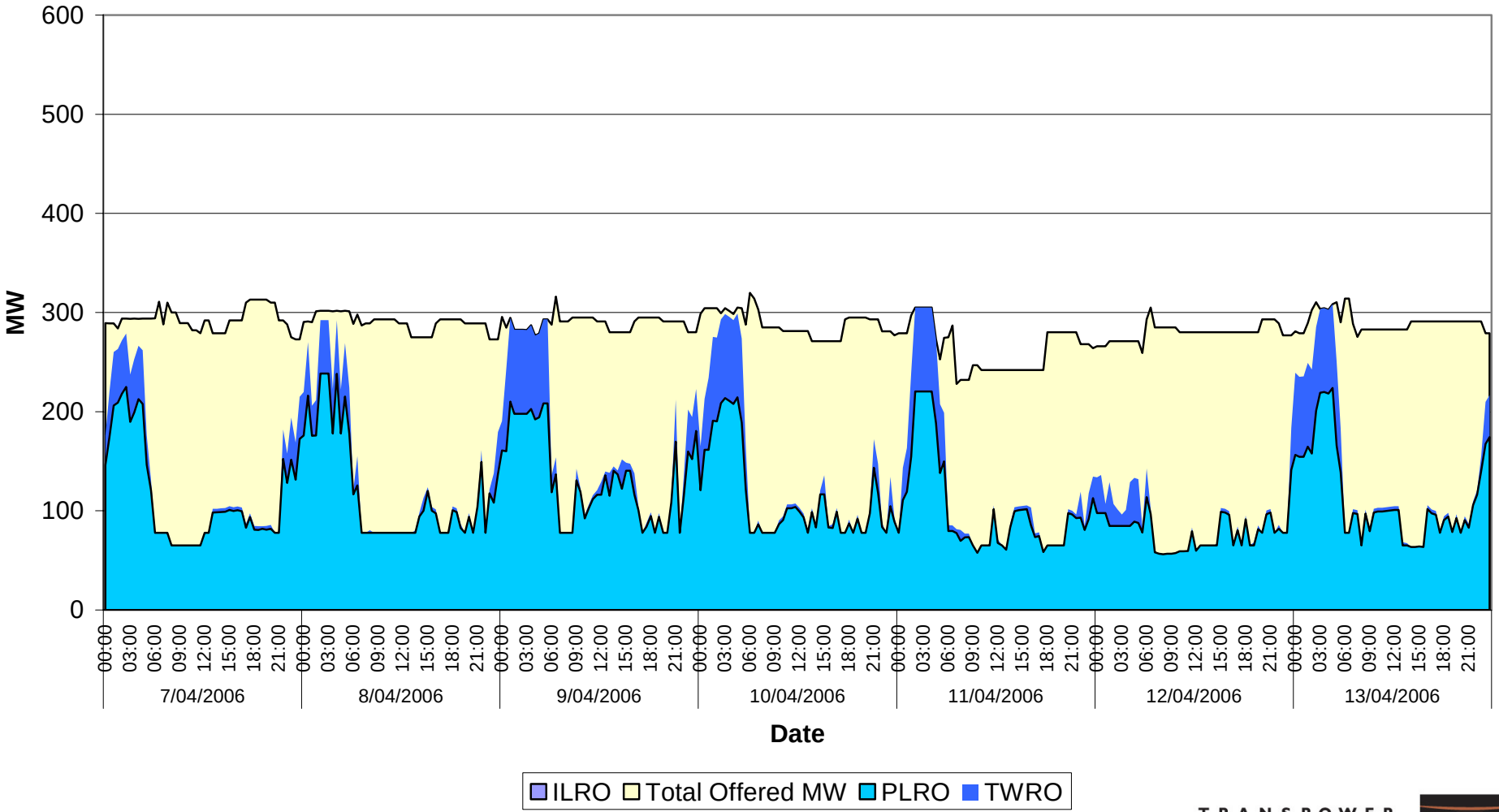

Reserve Requirements for High DC South Pole 2 only
Minimum Frequency 48.0 Hz
FIR DCS 626
SIR DCS 626
FIR DCS 489
SIR DCS 489
IR Requirement (MW)
800
750
700
650
600
550
500
450
400
350
300
1000
1200
1400
1600
1800
2000
2200
2400
SIPS (MW)

Impact of South Island Instantaneous Reserve Availability

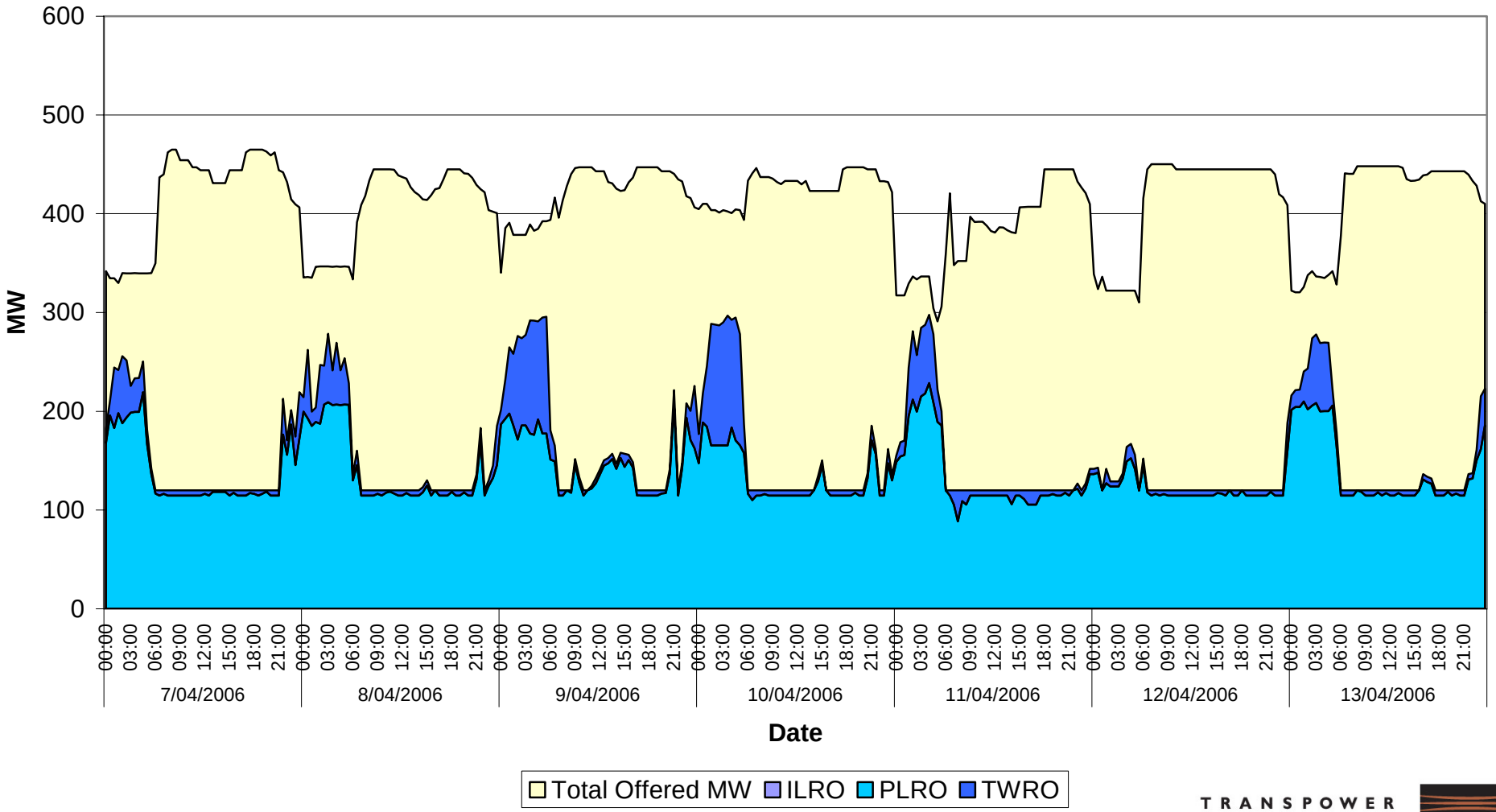
- Charts of reserve requirements
  - Next two charts are the actual South Island fast and sustained reserve available during high HVDC south transfer in April 2006 (yellow) with the reserves cleared (dark/light blue).
  - Full HVDC bipole configuration in 2006 resulted in lower reserve requirements than will be the case for Pole 2 only in 2008. Refer previous slide.
  - Fast Instantaneous Reserves (FIR) availability in the South Island can potentially limit south transfer on the HVDC.

Graph of SI reserves fast (FIR)

South Island FIR



Graph of SI reserves sustained (SIR)



Additional Background Information 1

- Mitigations that have enabled additional south transfer:
  - Range of measures introduced following 2001 dry year event:
    - Hawera ABSS, Mangamaire split, South Island AUFLS.
  - Additional measures added in 2003:
    - Hawera reactor, Mangamaire ABSS, HVDC runback.
  - Upgrade to Bunnythorpe-Haywards transmission route in 2006.
  - Upgrade to regional Wellington 110 kV in 2007.

Additional Background Information 2

- Bunnythorpe to Haywards mitigations (Constraint 2)
  - As stated in slides 9 and 12, the first step is to enable automatic post fault splitting scheme at Mangamaire when constraints start to appear (transfer is within 90% of binding for 5% of time).
  - If the automatic post fault splitting scheme is not in service the transfer limits from Bunnythorpe to Haywards are approx 640 MW (winter) and 500 MW (summer).
  - Thermal upgrade of two of the four 220 kV transmission circuits between Bunnythorpe and Haywards was completed in 2006.
  - “HVDC Runback” developed for 2003 dry year - now superseded by the 220 kV line upgrade in 2006.

Additional Background Information 3

- Switching out “Wilton Interconnector”
  - Switched out when required to enhance Bunnythorpe to Haywards transfer at peak load.
  - Winter 2006 increased peak load in the Wellington 110 kV network required Wilton interconnector to be kept in service.
  - Result southwards transfer to be reduced at peak times to avoid overloading equipment.
  - This restriction removed with thermal upgrade of 110 kV circuits that supply Wellington city in 2007.

Additional Background Information 4

- Impact of decommissioning of HVDC Pole 1
  - Half pole of HVDC Pole 1 available for up to North transfer up to 200 MW on in a grid emergency. Two synchronous condensers at Haywards are not available when half pole in service.
  - Proposed emergency use of Pole 1 half pole for north transfer at times of winter peak load will reduce Bunnythorpe to Haywards limit by ~70 MW when Pole 1 half pole in service.
  - This reduction has no operational impact as transfer from Bunnythorpe to Haywards can not exceed 450 MW with HVDC Pole 1 operating at 200 MW north transfer at winter peak load.

Additional Background Information 5

- South transfer on Pole 2 only
  - Change to two cables on Pole 2 has increased Pole 2 only south transfer limit from 489 MW to 626 MW, the same limit as with full HVDC Bipole.
  - SI AUFLS reduces the reserve requirement for loss of the HVDC Bipole (both Pole 1 and Pole 2) together. However with transfer on Pole 2 only reserve requirement is for a contingent event and full reserve cover of the Pole 2 transfer.

SPD constraints for South Transfer – with no planned outages

- The following constraints relate to south transfer:
  - Mangamaire automatic post fault splitting scheme *disabled*
  - Mangamaire automatic post fault splitting scheme *enabled*
  - Mangamaire operational split in place
  - Maximum HVDC South Transfer Limit.

- Constraint details on the following slides.

SPD constraints for South Transfer – with no planned outages

- Mangamaire automatic post fault splitting scheme *disabled*
  - MGM_WDV_1_MGM_OTAS_DISABLED_W _P_1B_z = 49
  - MGM_WDV_1_MGM_OTAS_DISABLED_S_P_1B_z = 40
  - The effect of this constraint is to manage flows through Mangamaire-Woodville 1 circuit for a contingency of Haywards-Linton during DC south conditions and the Mangamaire Overload Trip & Auto Changeover Scheme is disabled.

  - Equations are:
    - Winter -1.03 * MGM_WDV1.1 + -0.06 * HAY_LTN1.1
    - Summer -1.03 * MGM_WDV1.1 + -0.05 * HAY_LTN1.1

SPD constraints for South Transfer – with no planned outages

- Mangamaire automatic post fault splitting scheme *enabled*
  - MGM_WDV_1_MGM_OTAS_ENABLED_W_P_z = 46
  - MGM_WDV_1_MGM_OTAS_ENABLED_S_P_z = 38.5
  - The effect of this constraint is to manage flows from Woodville to Mangamaire in steady state to prevent an inadvertent operation of the Mangamaire OTAS scheme when enabled.
  - The Equation for Summer and Winter is:
    - -1 * MGM_WDV1.1

SPD constraints for South Transfer – with no planned outages

- Mangamaire operational split in place
  - MGM_MST_1_or_MGM_WDV_1_ WELLINGTON_STABILITY_O_1_z = 868
  - The effect of this constraint is to manage flows through Bunnythorpe_Haywards 1 and 2, Haywards_Linton 1 and Bunnythorpe_Wilton 1 circuits for a contingency of Haywards_Linton 1 during high HVDC south transfer for stability reasons when Mangamaire_Masterton or Mangamaire_Woodville is out of service. This voltage stability constraint covers all grid exit points south of and including Masterton and Paraparaumu on the 110 kV system, and all grid exit points south of and excluding Linton on the 220 kV system.
  - Equation is:
    - 1 * BPE_HAY1.1 + 1 * BPE_HAY2.1 + -1 * HAY_LTN1.1 + 1 * BPE_WIL1.2

SPD constraints for South Transfer – with no planned outages

- Maximum HVDC South Transfer Limit
  - HAY_BEN_P = 626
  - The effect of this constraint is to limit pre-contingency flows from Haywards to Benmore to set the maximum HVDC stability limit at Benmore during south transfer for a fault at Benmore or a tripping of Pole 2, causing post contingent North Island dynamic instability.
  - Equation is:
    - 1 * HAY_BEN1.1 + 1 * HAY_BEN2.1