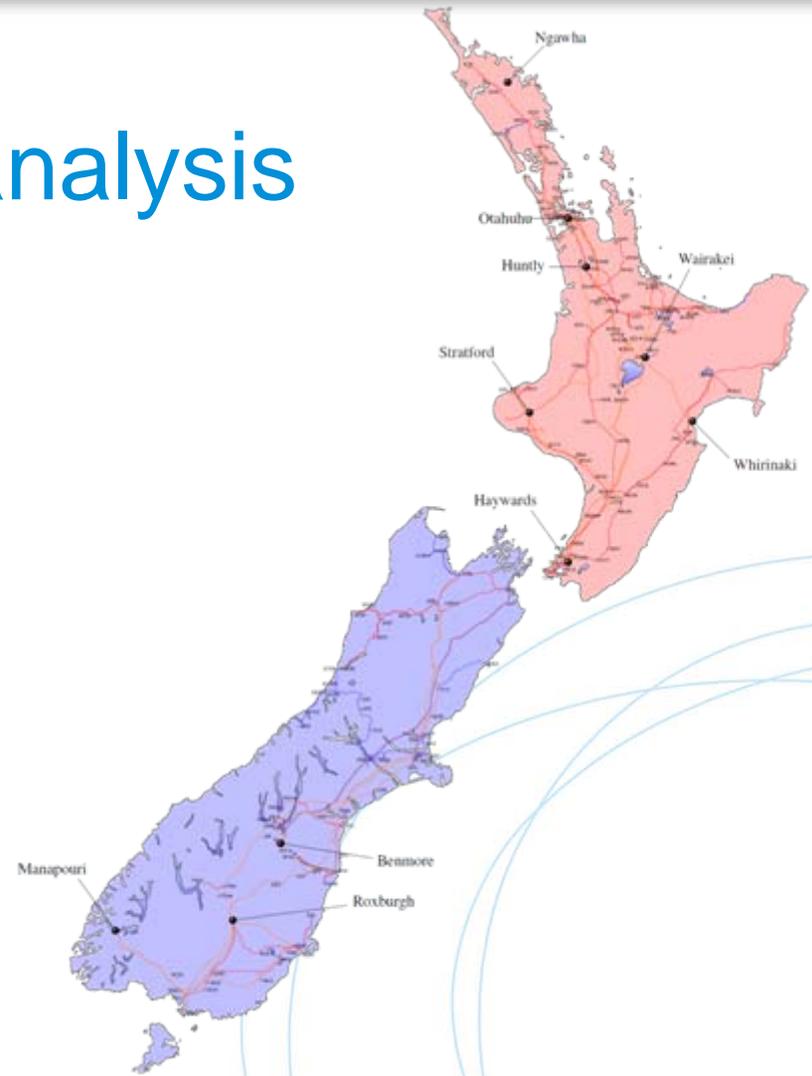


Power Flow network analysis (Tracing)

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Introduction

- Commission is investigating tools to assist decision making with regard to the current MDP, this includes Transmission Pricing (and LRAs);
- Power Flow Tracing can;
 - Determine who uses which assets;
 - I.e., the proportion of power flow attributable to each asset caused by the users of the power system (both generation and demand);
 - Was first introduced in 1993 as part of Trans Powers TPM;
 - Discontinued due to issues with pricing variation;
 - Some participants not keen, based on past experience...

Trans Powers 1993 TPM

- Based on a Power Flow trace around a single ‘pseudo’ operating point;
- ‘Pseudo’ operating point determined using ‘cluster analysis’;
- Resulted in inconsistent pricing, year-on-year with ‘tide mark’ effects, eg, Tangiwai (Winstone) issues, among others;
- Has resulted in a ‘negative view’ by some to any type of Power Flow pricing mechanism.

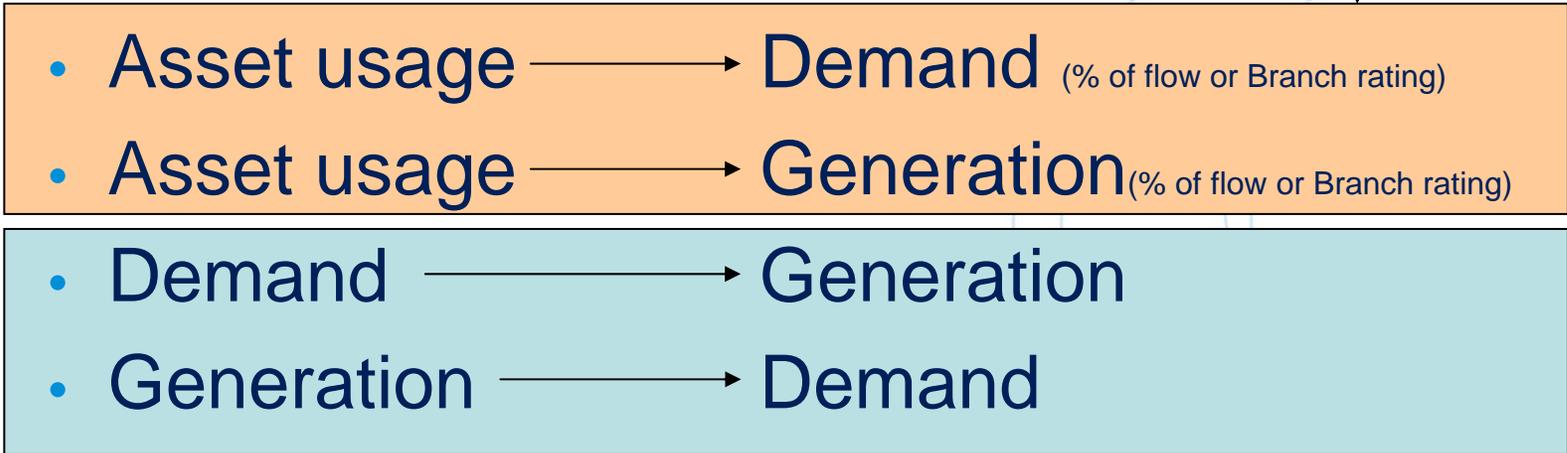
Since 1993...

- Formally documented by J. Bialek in 1996
(with reference to Transpowers 1993 TPM)
- Computational power has increased significantly;
- Market data since 1996/1997 now available;
- Data consistency since 1999 (so far);
 - Although some data/topology issues still to resolve...
- Able to perform ex-post tracing run for all half-hours between 1999 and 2008;
- Possibility of performing 'ex-ante' tracing runs for future peak periods (based on SOO 2010) (to do?)

Types of Trace

Useful for TPM

Four different types of trace available;



Possibly useful
for LRA

Why Trace for TPM?

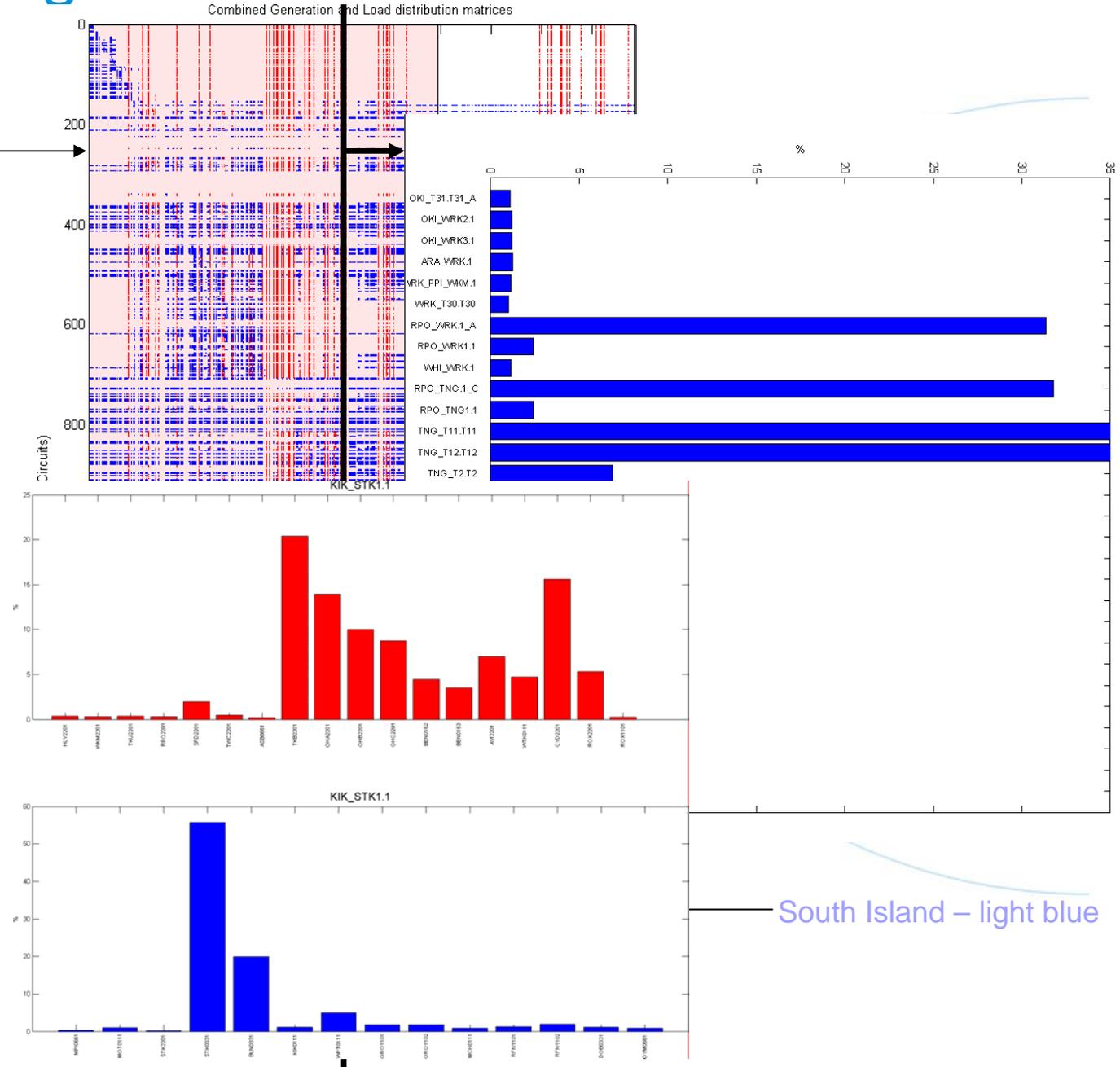
- Participants 'actual' usage of the network can be determined;
- No specific connection/interconnection definition required;
- Based on actual power system behaviour/usage rather than the marginal nodal spot market;
- Can be used in conjunction with Location Rental Allocations (LRAs);
- However, could be regarded as complex and reliant on **good data** (branch flows, load and generation data as well as historic network topology);

Is a power flow trace the correct tool for Transmission Pricing?

- Market characteristics
 - Market based around marginal pricing with generators being the main participants;
 - Load/Demand generally do not participate in the marginal market;
- Tracing based around actual physical power flows;
- Suggests tracing more suited to Demand/Load participants, rather than generation participants?

Topological Distribution Matrices

- **Date: 1/1/2007**
- HVDC – northward flow;
- North Island – pink
- South Island – light blue
- Red – Generators usage
- Blue – Load usage



South Island – light blue

What about year-on-year variation?

- Likely to still be an issue;
 - Due to the vast variation of NZ operating points (e.g., wet/dry year variation);
- Rolling averages could be used ('Ex-post');
 - Help dampen year-on-year variation by averaging over a number of years;
- 'Peak period' trace could be used for 'Ex-ante' pricing;
 - Could be achieved using forecast 'peak period' traces based around SOO 2010 demand forecasts;
- Combined use of LRAs could also dampen variation;
 - I.e., higher than average use of transmission assets would result in more rentals received;
- Alternatively, trace could be applied up to a point, i.e., some usage 'limit' that redefines connection assets?

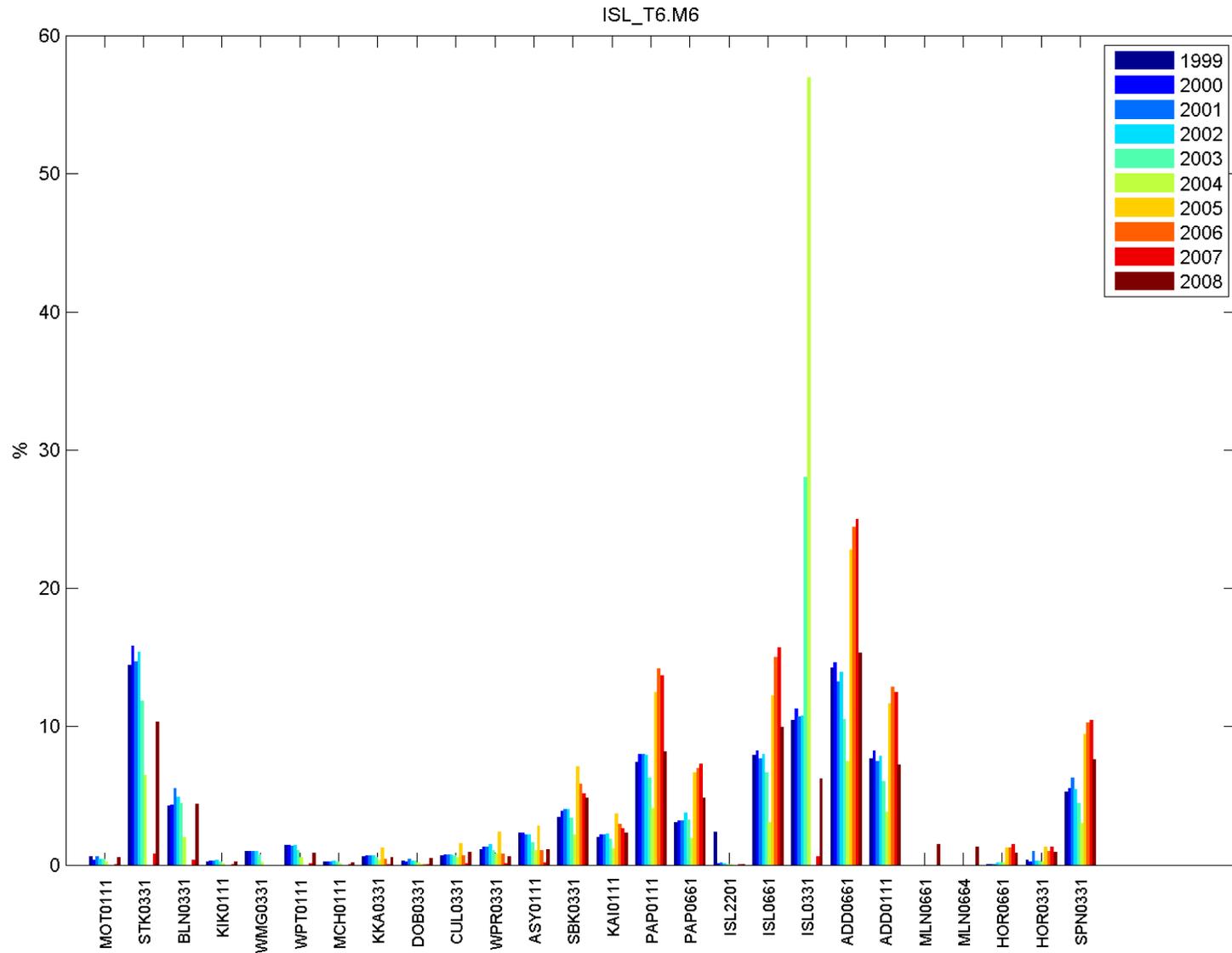
Example 1: Connection/Interconnection issues

- Chch requires 220-66kV interconnector upgrade;
- Transpower would prefer Bromley (higher net benefits);
- Bromley 100% charged as connection asset to Orion;
- Islington would incur only 10% of the charge to Orion (under current TPM);

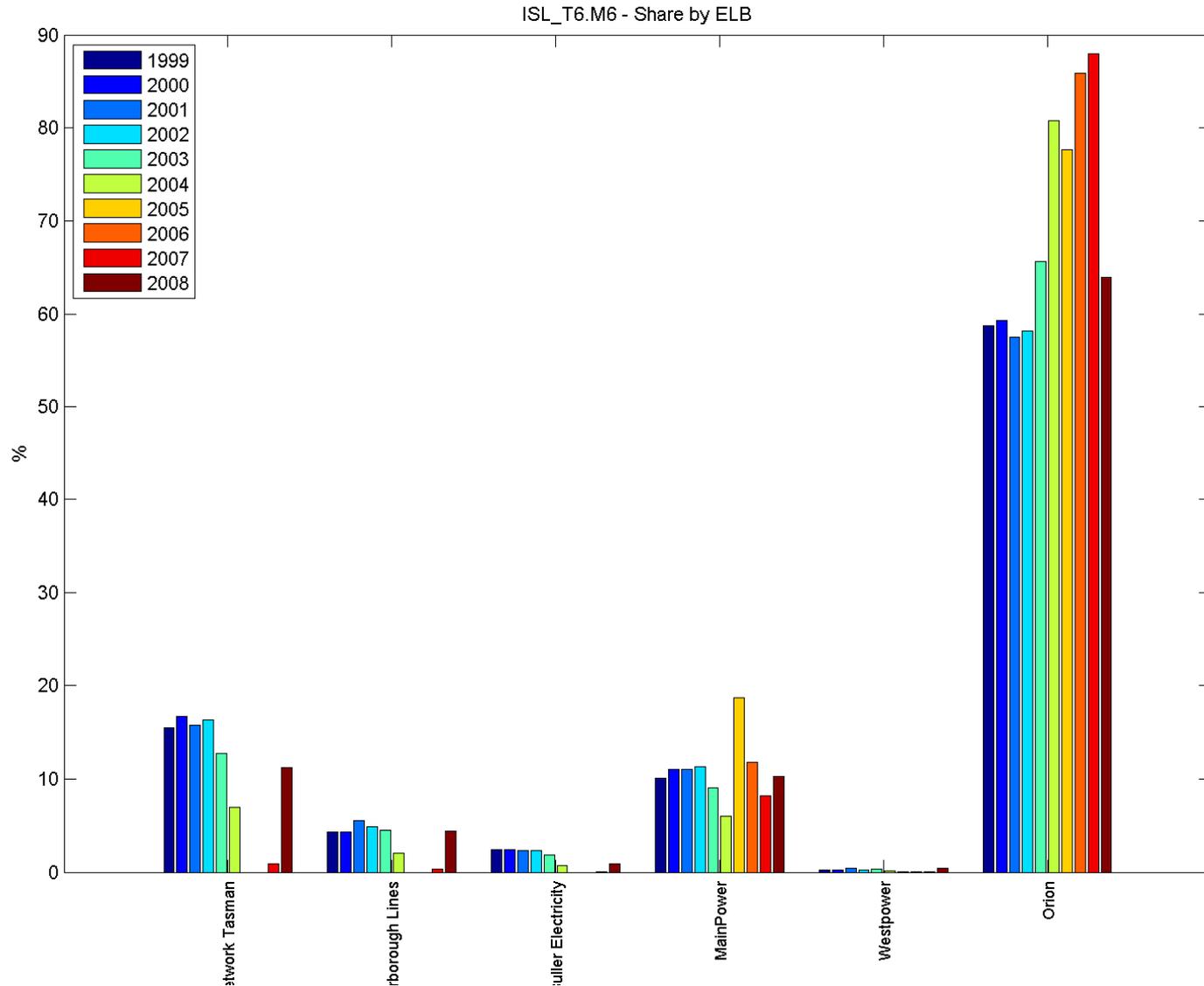
With trace, assets charged to those who use them

- An Islington interconnector would be charged to both Orion, ~80 to 90% and also to Mainpower ~10 to 20%;
- A Bromley interconnector would still be charged 100% to Orion.

Example 1: Yearly variation of users of Islington Interconnector (by GXP)

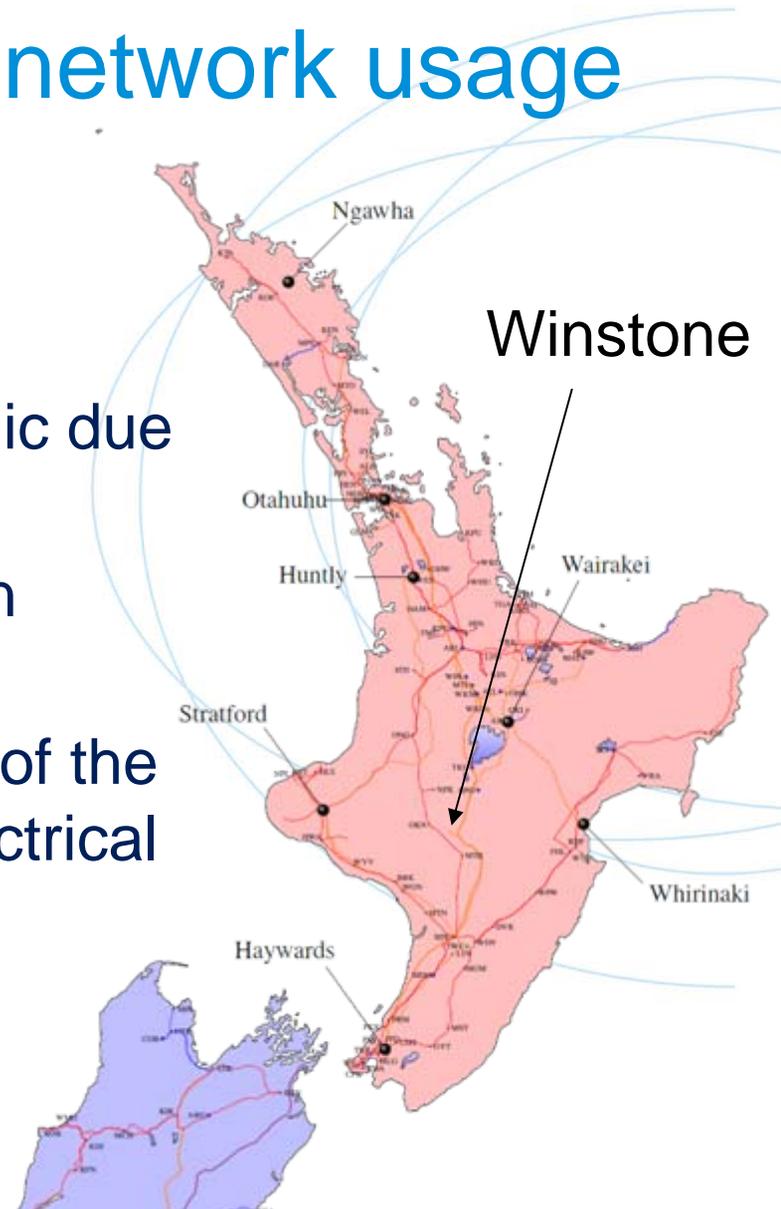


Example 1: Yearly variation of users of Islington Interconnector (by ELB)



Example 2: Winstone network usage

- Located in central North Island;
- Averages ~30MW
- Usage of network assets dynamic due to north-south flow issues;
- Still likely to have some variation year-on-year;
- What matters is the percentage of the cost of variation over the total electrical energy costs of Winstone (to do).



To do...

- Still in development phase (error checking etc)
- There are some data/historic topology issues;
- Currently working on allocating Transmission Line replacement costs on a per circuit allocation;
 - Will enable simulated trace TPM for all customers with \$ values and \$ variation over the previous 10 years.
- Some questions over substation allocation costs;
 - Various methods;
 - Based on power flow into and out of each substation?;
 - Pro-rata share based on number of branches?;
- 'Peak period' trace could be used for 'Ex-ante' pricing using SOO 2010 MDS scenarios?

Aside: Tracing for LRA

- Tracing is able to allocate Transmission Rentals;
 - And in real time... (this could be an SPD add-on module);
- Achieved by tracing from Generation to Demand for each trading period;
- A New Demand/GXP Nodal price becomes a weighted average of all generators, volume x nodal price, that physically supply each demand;

- Market model → Dual nodal pricing regime (GIP/GXP prices);
 - Generation Nodal Price (as per current SPD model);
 - New Demand/Load Nodal price → weighted average
 - Could be considered a 'perfect LRA' as there are no longer any transmission rentals;

Aside (cont.): Tracing for LRA

Pros:

- In conjunction with a Trace TPM, would help dampen any year-on-year variation incurred in participants transmission charge;
The more transmission used, the more rentals received
- Perfect LRA? Eliminates all rentals in real time;
- Transmission constraints still apply and effect nodal prices;
- Demand/Load Nodal price becomes a 'damped' version of the generation nodal price;
- Losses kept intact, generators still participate in the marginal market, Demand/Load Nodal price still includes the effect of marginal loss
(plus the 'actual' loss between generators and each demand/load);
- Dampens nodal price volatility at Demand/Load GXPs;
(Increased likelihood of retail competition);
- Even if not implemented, further investigation may aid decision making process/options for the various MDP work streams;
- Well documented (J. Bialek).

Cons:

1. Could be considered overly complex/technical?
2. Really only applicable to demand customers;
3. Further work is required.