Reserve in Electricity Markets

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EPOC

February 13, 2014

INTRODUCTION

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RESERVE CONSTRAINTS
- frame 1

RESULTS
- Frame 1

ABOUT ME

- University of Canterbury, BE(Hons) Chemical and Process Engineering
- University of Auckland, Year Three, Ph.D Eng. Sci and C&M
- Prior work at load aggregators
- HVDC Pole 3 Commissioning (Trading Team)
- Based at Transpower S.O. 2013
- Various Consulting Jobs

ROUGH AGENDA

- Reserve Constraints
- Assessment of Spot Prices
- Equilibrium Models of Reserve Participants
- Visualising Energy and Reserve Offers
- Using Bayesian Probability to assess Constraints
- Theoretical HVDC Transfer Capabilities
- Open Source and Open Data

IT STARTS WITH A PICTURE

Figure : Haywards Nodal Spot Price (x axis) compared with the North Island FIR Price (y axis)

WHY DOES THIS MATTER?

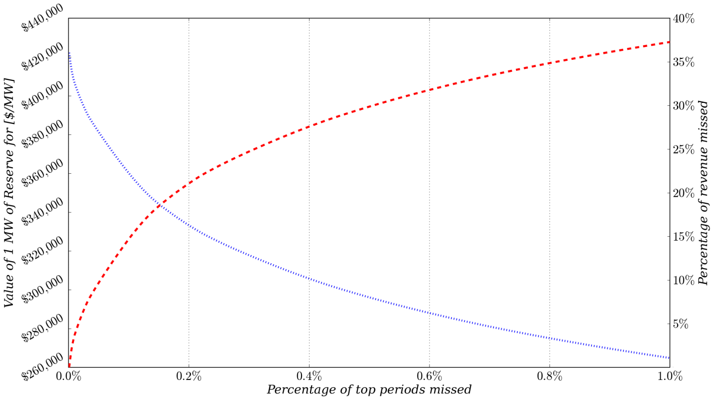

Figure : Revenue "lost" for missing highly priced trading periods

EFFECT ON INDIVIDUAL CONSUMERS

Table : Monthly Revenue "missed" by various IL producers

	NZST	PPAC	SKOG
2009	18-85%	2-92%	30-80%
2010	4-90%	0-90%	5-70%

In November 2010 NZST missed 90% of the monthly IR Revenue, SKOG missed 6%

SOME THEORY

$$
\begin{aligned}
[POPF]\ \min \quad & p_g^T g + p_r^T r & \\
\text{st.} \quad & Mg + Af = d & [\pi] \\
& r + g \le G & [\epsilon] \\
& r - Kg \le 0 & [\kappa] \\
& Er - g \ge 0 & [\lambda^1] \\
& Hr - Bf \ge 0 & [\lambda^2] \\
& r \le R & [\omega] \\
& |f| \le F & [\tau^{\pm}] \\
& Lf = 0 & [\alpha] \\
& r, g \ge 0 &
\end{aligned}
$$

$$
\begin{aligned}
[DOPF]\ \max \quad & d^T + R^T\omega + G^T\epsilon + F^T(\tau^+ + \tau^-) & \\
\text{st.} \quad & M^T\pi + \epsilon - K\kappa + \lambda^1 \le p_g & [g] \\
& \omega + \epsilon + \kappa + E\lambda^1 \le p_r & [r] \\
& A^T\pi + \tau^+ - \tau^- - B^T\lambda^2 + L^T\alpha = 0 & [f] \\
& \omega, \epsilon, \tau^{\pm}, \kappa \le 0 & \\
& \lambda^1, \lambda^2 \ge 0 &
\end{aligned}
$$

CASE STUDIES

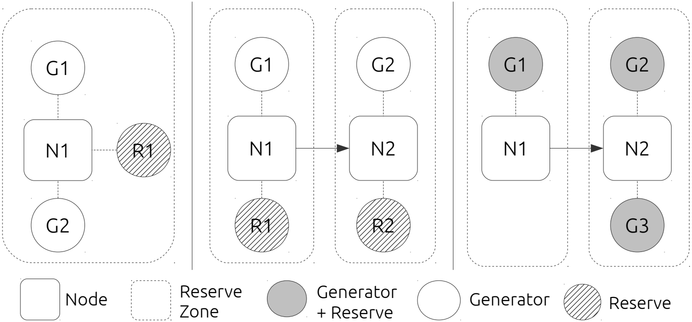

Figure : Some Case Studies to illustrate different mechanisms of binding constraints occurring

Case Study Results

Marginal Risk Setting Generator

$$\pi = p_{g,marginal} - \lambda \quad (1)$$

Risk Constrained Transmission Line

$$\pi_2 = \pi_1 - \lambda_2 \quad (2)$$

Bathtub Constrained Transmission

$$\pi_2 = \frac{1}{1+k_{g,2}} p_{g,2} + \frac{k_{g,2}}{1+k_{g,2}} (\pi_1 + p_{r,2}) \quad (3)$$

TESTING THESE, MARGINAL GENERATOR

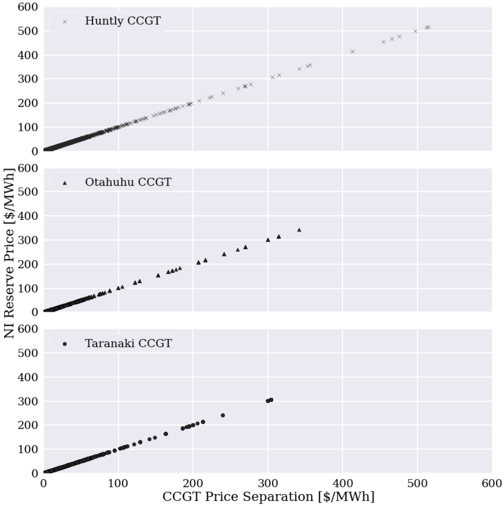

Figure : Reserve Constraints binding upon major CCGT Units

TESTING THESE, MARGINAL TRANSMISSION, NI

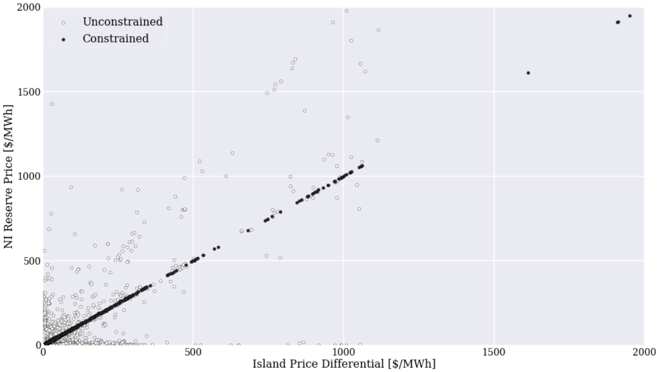

Figure : Reserve Constraints Binding upon Northward HVDC Transmission

Testing These, Marginal Transmission, SI

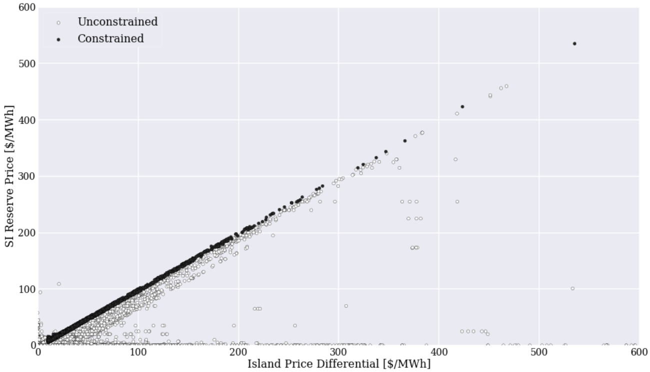

Figure : Reserve Constraints Binding upon Southward HVDC Transmission

Testing These, Bathtub Constraints

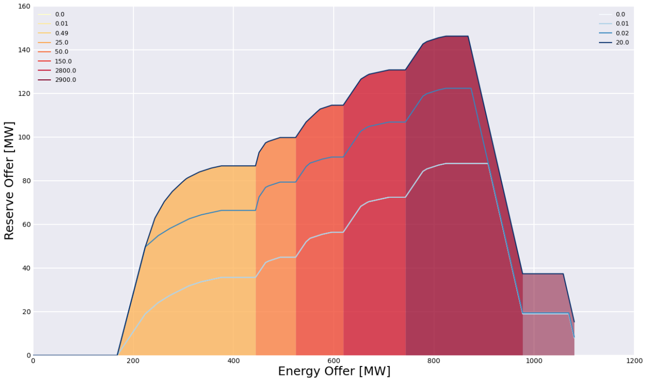

Figure : Mighty River Fan Curve, TP 19, October 3 2013.

Impact on the market

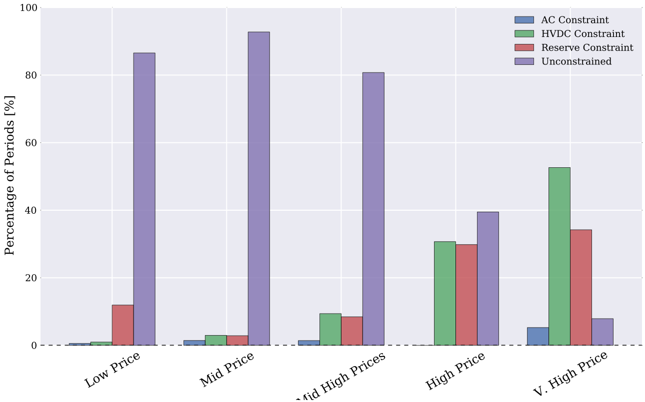

Figure : Aggregate assessment of constraints in the New Zealand Market

FRAME 1

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