Exploring the Strategic Behaviour of FTR Holders with Market Power

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1 Executive summary

This report describes the application of some simple best response and Cournot equilibrium models to explore the possible effects on market outcomes of allocating financial transmission rights (FTRs) to generators with market power. The models are calibrated to a number of wet and dry periods historically observed in the New Zealand market, during 2008. For each period, we study the optimal best response of a selection of generators with market power. We also study a Nash-Cournot model in which two strategic generators with market power interact. We find that:

- When a strategic generator is downstream of the FTR that it holds there can be significant incentive to withhold production and cause increased prices.
- In some periods the effect of withholding is an unbounded rise in prices, i.e. prices can rise without limit in absence of an artificial cap.
- When a strategic generator is upstream of the FTR it holds, the generator may have an incentive to cause network congestion and price differences through increased production. This may cause inefficiency in dispatch.
- The incentive for a generator equipped with an FTR is a function of the volume of the FTR it holds. As this volume increases, the firm is more likely to change its behaviour in an optimal best response. Furthermore, the optimal actions of a generator equipped with an FTR, and the prices resulting from this action, are sensitive to small changes in the level of the FTR held by the generator.
- In the Cournot models, if two firms hold FTRs in the same direction, then network congestion and price differences can be caused with smaller combined FTR volumes than if only one was equipped with an FTR.
- The price rises are less pronounced in a Cournot model, where there are two strategic players, than the best response models, where there is only a single strategic player.

2 Introduction

A financial transmission right (FTR), otherwise known as a transmission congestion contract, is a financial instrument designed to manage risk associated to locational marginal price volatility. In the New Zealand electricity market, as well as many other jurisdictions world-wide, an optimization problem is solved in every period that minimizes the total cost of generation of electricity while complying with physical network constraints[1]. The solution provides optimal dispatch of electricity and prices for each node of the transmission network (these prices are referred to as the locational marginal prices). An FTR pays the holder an income stream based on the nodal prices observed in each period, over the course of the contract.

In the simplest form of FTR, the holder specifies a volume in MW and two nodes, an upstream and a downstream node, in a transmission network. The price at the downstream node minus that at the upstream node is multiplied by the FTR volume (specified in MW) and is paid to the holder as a coupon payment, for each period when the FTR is valid. These FTRs are referred to as *balanced FTRs.* If the payment for an FTR can be exercised as an option, that is, it is only exercised if the downstream price exceeds the upstream price, then we have a so called *option FTR.* In absence of this requirement, the holder must pay the system operator any (negative) price difference between the downstream and upstream nodes multiplied by the FTR volume and this is termed an *obligation FTR.* An FTR can be specified more generally by a vector of nodal loads and injections, specified in MW, where the loads are taken to be positive. The coupon payment for any period is the inner product of this vector with the vector of nodal prices. In this study we focus attention on balanced, obligation, FTRs. In section 3.3 we demonstrate that FTRs over two nodes are equivalent to two contracts for differences held at each of the downstream and upstream nodes.

FTRs were first introduced by Hogan [1] and are used in several jurisdictions in the US including the PJM and New York markets. FTRs have been addressed in several research papers including the seminal works of [2] and [3] as well as [4] and [5]. Although FTRs can function well in markets that are heavily regulated where there are no market power issues (such as PJM), there is concern about their performance in unregulated markets. Joskow and Tirole explore negative interactions of FTRs in presence of market power through simple high level examples in [3]. In this study we have focused on the New Zealand market in particular. We draw on the database of historical offers made available through the Centralized Data Set [6]. We have examined ten historical periods from each of the summer and winter of 2008 and explored models where various generators are assumed to hold an FTR. In each period we start by constructing a counterfactual that ensures our simple models are

[1]In New Zealand, this optimization problem is the Scheduling, Pricing and Dispatch problem that is solved by the transmission owner and operator, Transpower.

reflective of recent history. We then examine two different types of models, a best response and a Nash-Cournot model, each of which is designed to explore the strategic behaviour of a generator equipped with an FTR.

In order to make our models tractable, we have made some simplifying assumptions. The assumptions are laid out in section 3 where we introduce our models. In particular, two generators, Meridian and Mighty River Power are left out of our strategic behaviour analysis. This is done for a purely technical reason, namely to ensure that there is a sufficient competitive fringe to enable calculations in our Cournot paradigm. In section 4 we provide the results of our best response models. This is followed by the results of our Nash-Cournot model in section 5. Additional information is included in the appendix.

3 Model description

This section describes our simplified model of the New Zealand Electricity Market (NZEM). We start by laying out the model data including our simplified network and describing the types of periods that we will examine. We then describe our best response and equilibrium approaches for modelling the strategic behaviour of generators equipped with FTRs, in turn.

3.1 Data

We consider a three node network simplification of the New Zealand transmission network as depicted in Figure 1. The nodes we consider are Otahuhu (OTA), Haywards (HAY) and Benmore (BEN). The line connecting HAY and BEN represents the HVDC link while the line connecting OTA and HAY nodes is a simplified representation of the upper North Island network connecting OTA and HAY.

Figure 1: Three-node Network.

For the purposes of this study, we have sampled periods from the winter and summer of 2008. In New Zealand, electricity prices fluctuate seasonally primarily due to the amount of hydro storage available. Figure 2 shows electricity prices at the 9am time period for Otahuhu, Haywards and Benmore over 2008. We will focus on two types of periods for the purposes of our case studies. The summer periods in

November 2008 are the periods when water is plentiful and the steady state flow of electricity is from South to North. By contrast, in June 2008 we have found the lake levels to be low and the steady state flow of electricity to be from the North to the South. Our price data, as well as the information on the lake levels is obtained from the Centralized Data Set (CDS) released by the Electricity Commission [6].

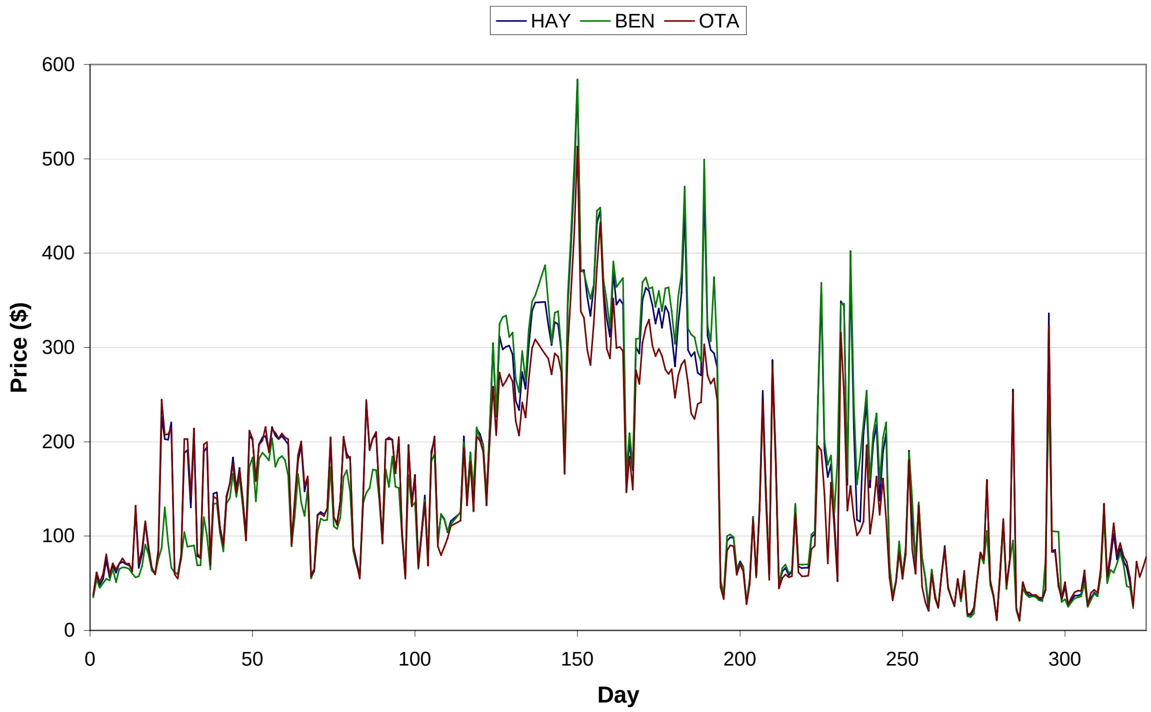

Figure 2: Actual 2008 prices.

We have set the capacity of the HVDC line represented by the link between HAY and BEN to 700 MW for the periods in this studies. This study does not include any modelling of reserve. The effective capacity of the The capacity of the OTA–HAY line is set to 940 MW in the winter months and 785 MW in the summer months[2]. In this simplified representation of the New Zealand network, we have located each generator at one of the three nodes. Table 1, below, shows the location of the generators in our model, for each firm.

We extract the generator offers and demand levels from the Electricity Commission's CDS [6]. We assume that total demand is inelastic in the short term. To account for transmission losses that occur in the real network, we estimate an effective demand from the offer stacks and the actual prices; this inflates the demand

[2]The capacities are arrived at by examining at the proportion of flows from an additional 1MW at Huntly down the SFD-BPE (SFD-BRK) vs TKU-BPE and RPO-BPE lines. Private communications with Mr. Paul Coster, Mighty River Power.

Firm	Plant	Node
Genesis	Huntly	OTA
	E3P	OTA
	P40	OTA
	Tokaanu	OTA
	Rangipo	OTA
Contact	Otahuhu B	OTA
	Stratford	HAY
	Clyde	BEN
	Roxburgh	BEN
Meridian	Tekapo	BEN
	Ohau	BEN
	Benmore	BEN
	Aviemore	BEN
	Waitaki	BEN
	Manapouri	BEN
Mighty River	Waikato Hydro	OTA
	Southdown	OTA

Table 1: Ownership and location of generation plants.

over the country by approximately 9% in 2008. Demand, similar to generation offers, has been aggregated and allocated to one of our three nodes. All the South Island demand is allocated to the BEN node, while all demand located north of Whakamaru is assigned to the OTA node, and all demand south of Bunnythorpe is aggregated at HAY. Of the remaining demand centres, New Plymouth and Whirinaki are assigned to HAY, and Tokaanu is assigned to OTA.

3.2 FTRs

A financial transmission right (FTR) is a financial risk instrument that hedges against price volatility due to transmission congestion. The FTRs that we consider in our model represent a volume (in MWs) between two points in our simplified network. These FTRs are held in either the North to South or South to North direction. We assume that the FTRs are either between the HAY and BEN nodes (representing congestion over the HVDC line), or between OTA and HAY nodes (representing congestion in the upper North Island)[3]. The owner of the FTR receives a payment if the congestion in the network occurs in the direction of the FTR. This payment

[3]There are two exceptions to this description that are pointed out in the results tables.

is the price difference between the nodal prices multiplied by the FTR volume. We will observe in the next section that an FTR can be thought of as a contract for differences.

We assume further that the FTRs are obligation FTRs. This indicates that if the congestion occurs in the opposite direction to that of the FTR, the holder of the FTR will have to now pay the price difference times the volume. Such FTRs are known in the literature as point-to-point, balanced, obligation FTRs. In order for FTRs to be revenue adequate, they have to be simultaneously feasible [1]. In our simplified model, this condition amounts to ensuring that the total FTRs held between the HAY and BEN nodes must not exceed 700 MWs (the assumed capacity of the HVDC line,) and the total FTRs held between OTA and HAY must not exceed 785 MWs in the winter and 940 MWs in the summer. Following common FTR terminology, we refer to the end nodes of an FTR as the "upstream" (i.e. the *from*) node and the "downstream" (i.e. the *to*) node.

In what follows we set out to examine the strategic behaviour of generators who hold various FTRs in our simplified network. We consider Meridian, Genesis and Contact in turn. (The body of the report contains the results for Genesis and the results pertaining to Meridian and Contact are available in the appendix.) We model strategic behaviour by both considering the best response of a firm equipped with an FTR and also by constructing Nash-Cournot equilibria.

In order to assess the effect of strategic behaviour, we need to first produce the counterfactual behaviour of the generator in question which is consistent with historical observations. We then compare this to the behaviour of the generator once equipped with an FTR. We assume that the strategic generators are rational, profit-maximizing firms. Therefore each strategic firm aims to maximize their profit $\rho(q)$ as a function of their offer quantity q in each period. For instance, consider a stylized North-South network (with only two nodes: North and South). If our firm is located in the North (with generation and contract/retails all concentrated at that same node,) the profit function ρ for the firm is given by

$$\rho(q) = qP_N(q) - \int_0^q C(x)dx - Q_N^C(P_N(q) - P_N^C). \tag{1}$$

Here

- q denotes the offered quantity,
- $P_N(q)$ and $P_S(q)$ denote the North and South Island prices as a function of q,
- $C(q)$ is the short run marginal cost of production,
- Q_N^C is the contract quantity and P_N^C the contract price, for a contract held in the North Island.

This profit function is composed of the revenue given by $qP_N(q)$, the cost $\int_0^q C(x)dx$ and any contract obligations given by $Q_N^C(P_N(q) - P_N^C)$.

Once equipped with an FTR, the firm's profit function changes. If the firm holds g MW of FTR between BEN and OTA, in the direction from South to North, then the expression for the profit will be given by:

$$\rho_{FTR}(q) = qP_N(q) - \int_0^q C(x)dx - Q_N^C(P_N(q) - P_N^C) + g(P_N(q) - P_S(q)). \quad (2)$$

Note that we have now added in the coupon payment resulting from the FTR, that is $g(P_N(q) - P_S(q))$. If we rearrange the terms in equation (2) we obtain

$$\rho_{FTR}(q) = qP_N(q) - \int_0^q C(x)dx - (Q_N^C - g)(P_N(q) - P_N^C) - (0+g)(P_S(q) - 0) + gP_N^C. \quad (3)$$

3.3 Contract and retail load levels

Equation (3) demonstrates that an FTR can be viewed as holding two contracts for differences, or equivalently as decreasing the firm's contract obligations in the downstream node and increasing it in the upstream node. (Note that in this interpretation we must also account for the constant term gP_N^C in the firm's profit, although the existence of this term will not have any bearing on the optimal strategy of the firm since it is merely a constant.)

In order to find the new offer quantity of a strategic firm, i.e. the maximizer of $\rho_{FTR}(q)$, we need to know the marginal cost of production and the contract quantity Q_C. We estimate the level of retail load and contracting that the strategic generator is facing in the trading period, and construct a best response or a Nash-Cournot equilibrium for this period[4]. The estimation of contract levels in 2008 is based on published information about each company's load obligations [7] and observations on the offer stack of each generator. It is well-known (see e.g. [8]) that in a supply-function equilibrium, a generator with a contract for differences of quantity Q_C will offer generation at a price below marginal cost up to Q_C, and then bid with a positive markup above Q_C. This enables us to use the marginal cost and bidding behaviour seen in historical offer stacks to estimate the contract and retail exposure of each generator in the trading period we are studying. Table 2 contains the contract/retail levels for each of the strategic generators in the summer and winter periods estimated through the procedure described above.

[4]Here we make the assumption that contract and retail quantities are not changed by the purchase of an FTR although our current model can be extended to a more detailed model that would deal with possible changes in contract positions.

	Summer			Winter		
	OTA	HAY	BEN	OTA	HAY	BEN
Genesis	1000 MW	0 MW	0 MW	1100 MW	0 MW	0 MW
Contact	250 MW	200 MW	450 MW	280 MW	220 MW	490 MW
Meridian	0 MW	0 MW	1400 MW	0 MW	0 MW	1500 MW

Table 2: Contract/retail positions.

3.4 Fuel costs and water values

The procedure for estimating contract/retail levels, described in section 2.3, assumes that the marginal cost of generation is known. In the case of a thermal generator such as Genesis, we assume that gas/coal prices scaled by the heat rate are a good indication of short run marginal cost[5]. The cost of generation for hydro generators is indicated through their water value, which is significantly harder to estimate than the cost of thermal fuels. Here we estimate the water value to be approximately the same as cleared prices when water is short. When water is plentiful however, we consider a range of potential water values. We have analyzed the sensitivity of our results to different water value levels and reported the results of our experiments with alternative water values in tables 18 to 25 in the appendix. Tables 3 – 5 give the short-run marginal costs and capacities of the generators in the model.

	Type	**Heatrate**	**SRMC**	**Capacity**
Huntly	Coal	10.5 GJ / MWh	$42.00 / MWh	972 MW
E3P	Gas	7.08 GJ / MWh	$42.48 / MWh	385 MW
P40	Gas	9.5 GJ / MWh	$57.00 / MWh	50 MW
Tokaanu	Hydro	N/A	Water Value	240 MW
Rangipo	Hydro	N/A	Water Value	120 MW

Table 3: Genesis' Plants

3.5 Producing a counterfactual

Before we examine the strategic behaviour of the generators in possession of an FTR, we must ensure that we have a calibrated counterfactual. Our procedure for producing such a counterfactual is as follows. For each of the periods in question, we estimate the contract levels and any costs including water values as described in sections 3.3 and 3.4. To ensure that these figures are reasonable estimates we compute a best

[5]The gas price is taken to be $6 / GJ, and the coal price is $4 / GJ.

	Type	Heatrate	SRMC	Capacity
Otahuhu B	Gas	7.05 GJ / MWh	$42.30 / MWh	404 MW
Stratford	Gas	7.30 GJ / MWh	$43.80 / MWh	377 MW
Clyde	Hydro	N/A	Water Value	464 MW
Roxburgh	Hydro	N/A	Water Value	225 MW

Table 4: Contact's Plants

	Type	Heatrate	SRMC	Capacity
Tekapo	Hydro	N/A	Water Value	185 MW
Ohau	Hydro	N/A	Water Value	688 MW
Benmore	Hydro	N/A	Water Value	540 MW
Aviemore	Hydro	N/A	Water Value	220 MW
Waitaki	Hydro	N/A	Water Value	105 MW
Manapouri	Hydro	N/A	Water Value	726 MW

Table 5: Meridian's Plants

response and a Nash-Cournot equilibrium (without any FTRs) and ensure that the prices closely replicate the prices that were observed historically. The actual historical prices from the periods that we examine are shown in Tables 6 and 7 below. Our counterfactual produces prices in every period for each of our various models. These prices are different from one another and also different from the historical prices reported below. The counterfactual prices are reported in the tables containing the results for each of the models in sections 4 and 5[6]. The counterfactual prices are approximately within 20% of these prices. The reason for these differences can be attributed to factors such as inaccuracy in estimating contract/retail levels as well as some modelling assumptions where we assume that the strategic generator is fully informed about competitor behaviour.

3.6 Modelling strategic behaviour through best response

To model the strategic behaviour of a firm equipped with an FTR, we first extract generator offer stacks for each period. In this case, where we focus on best response, we assume that the strategic generator equipped with an FTR is the only strategic generator in the market. This assumption means that once the generator in question is equipped with an FTR, it is the only firm who may change its level of production

[6]Including the historical prices in the tables in sections 4 and 5 will make the tables sizes too large to fit in a page, therefore the reader is referred to the historical prices contained in Tables 6 and 7 in this section.

	OTA	HAY	BEN
03-Nov-08	$39.96	$34.22	$32.34
04-Nov-08	$43.00	$40.14	$38.89
05-Nov-08	$39.91	$37.27	$36.11
06-Nov-08	$64.67	$60.11	$56.81
07-Nov-08	$134.32	$127.70	$120.70
10-Nov-08	$113.71	$102.38	$61.16
11-Nov-08	$80.55	$75.25	$71.12
12-Nov-08	$92.46	$86.87	$82.11
13-Nov-08	$78.65	$73.77	$69.73
14-Nov-08	$72.72	$66.77	$47.10

Table 6: Summer Prices

	OTA	HAY	BEN
19-May-08	$292.80	$348.21	$387.09
20-May-08	$288.35	$324.16	$347.92
21-May-08	$271.52	$302.44	$304.51
22-May-08	$293.80	$326.87	$336.73
23-May-08	$290.25	$324.66	$338.49
23-Jun-08	$298.45	$341.33	$359.86
24-Jun-08	$291.00	$320.93	$338.35
25-Jun-08	$276.55	$343.91	$362.58
26-Jun-08	$271.90	$336.92	$363.74
27-Jun-08	$277.10	$313.21	$338.14

Table 7: Winter Prices

to maximize profits and that the other firms behave as they had done in absence of any FTRs. Therefore the post FTR market will see the same set of generation offers for all market participants, except for the strategic generator. To see how the strategic generator will change its offer we separate out its (submitted) offer stack from the historical offers. We then aggregate the remaining historical offers in each of the nodes. These aggregated stacks, together with the nodal demands, produce residual demand curves for each node. For ease of computation we approximate the residual demand curves by piecewise linear curves.

For example, consider the case when we examine the strategic behaviour of Genesis Energy equipped with an FTR that would pay them if the North Island price at HAY is more than the South Island price at BEN. Figure 3 below depicts the approximated residual demand curves (as described above) for period 19 on the 13th of November

2008. These residual demand curves indicate the clearing price of electricity at each of the HAY and BEN nodes as a function of production level for Genesis.

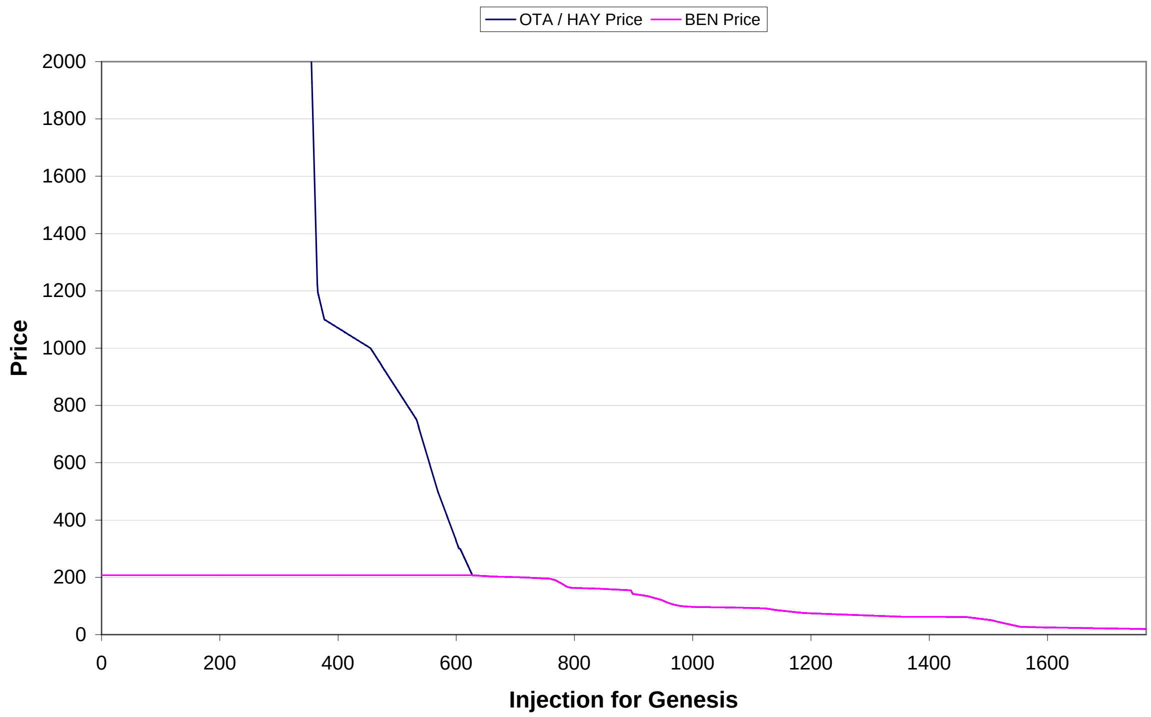

Figure 3: Residual demand curves for Genesis.

From the counterfactual we have the contract/retail obligations of the strategic firm, as well as the demand level and marginal cost figures. For each FTR quantity g, over any 2 nodes, with a specified direction, we can now find the generation quantity that would maximize profits of the strategic FTR holder given by ρ_{FTR} analogous to equation (2) above. Clearly the optimal generation level is a function of the volume of FTR held by the generator.

Figure 4 demonstrates the optimal generation levels for Genesis, in the best response paradigm, when Genesis is equipped with FTR levels of 0 MW, 620 MW, 635 MW or 690 MW over the BEN–HAY line (South to North direction). The plots all pertain to the same period 19 of the 13th of November 2008. Note that while with a 620 MW FTR Genesis has no incentive to withhold production in this period, an increase in the FTR volume to 635 MW changes the optimal generation level for Genesis to approximately 530 MW, which is close to 1000 MWs less than what Genesis was producing in absence of such an FTR. The price at HAY (and OTA) has risen from \$61.85 to \$750.06, whereas at BEN the price has risen from \$61.85 to \$207.14. (Note that when the FTR exceeds 690 MW there is incentive to withhold further, driving prices even higher.)

Tables 8 and 9 in the results section provide threshold FTR levels that cause Genesis, the strategic generator to change their offer behaviour. We compute optimal generation levels and the resulting prices for each period for this threshold FTR level and for the maximum allowable FTR. Analogous tables resulting from applying our best response model to Meridian and Contact over the same periods are provided in the appendix. The qualitative results are very similar for all three generators.

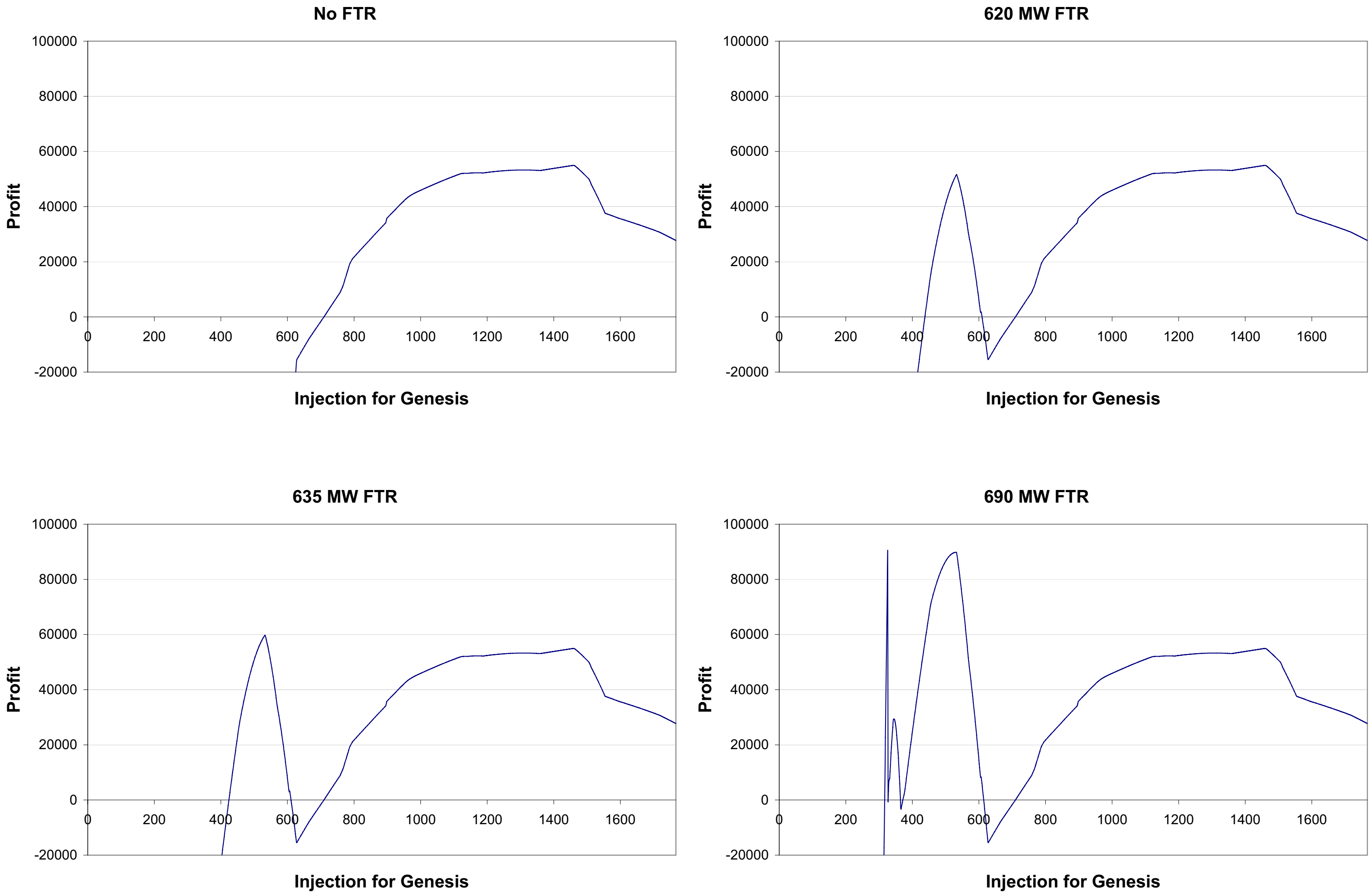

Figure 4: Profit for Genesis with varying FTR levels.

3.7 Modelling strategic behaviour through Nash-Cournot equilibria

For our Nash-Cournot equilibrium models, in contrast to the best response models, we assume that the main thermal generators, Genesis and Contact, are both strategic generators. Here we estimate what level of FTRs each generator is equipped with. Genesis and Contact choose each of their plants' production levels so as to maximize their total profits. We construct our Nash-Cournot equilibrium using fictitious play (see e.g. [9] for further details).

For an equilibrium to be constructed within a Cournot model such as ours, there is a need for so called fringe generation at each node. This is a residual amount of generation that would be called upon to supplement the offers of the strategic players to meet the inelastic demand. The clearing price of electricity is set through this fringe. We use the offers from Meridian in the South Island and Mighty River Power (MRP) in the North Island as these fringes. Our choice of fringe is in part based on the size of generation. Once we use MRP and Meridian as fringe generators, we are limited to Genesis and Contact as the strategic players for our Cournot game. Our equilibrium results are reported in tables 10–11 in the results section. Note that for certain FTR levels we were unable to find an equilibrium. Furthermore, the equilibria that we present are not necessarily the only possible equilibria. Indeed for a situation as captured by this model, there is no theoretical result that guarantees existence or uniqueness of equilibria.

4 Results and observations

4.1 Best response

Tables 8 and 9 in this section provide threshold FTR levels that cause Genesis, the strategic generator to change its offer behaviour. We have presented results for Genesis in the body of this report simply because we want to keep the report brief, and because the qualitative results are the same when we apply this model to either Meridian or Contact. The results of applying our best response model to the other generators are reported in Tables 13 through to 17 in the appendix.

- For each day, we have examined period 19 (9:00–9:30am). In each day we start by presenting the counterfactual, which is our benchmark.
- The counterfactual represents the estimation of historical outcomes by our model. This is only an approximation of what took place historically, but it is the correct benchmark for a hypothetical, post FTR comparison. The counterfactual prices for each period are reported in the rows of the tables that

correspond to an FTR volume of 0 MW. The reader can refer to Tables 6 and 7 for comparison of these counterfactual prices to historical prices for the same period.

- For each day, we report the smallest volume of FTR necessary to induce a change in the offer quantities by the firm in question in our tables.
- The nodes and the direction of the FTRs are specified in the table captions of each table.

Note that some entries in the tables allow for larger FTR values that are permitted (i.e. they violate the physical line capacities). As discussed in equation 3, an FTR can be thought of as a decrease in contract position in the downstream node and an increase in the contract position in the upstream node. Therefore our tables will allow results to be drawn for a contract position different from that which we have specified in the table caption. As an example, in Table 8, for 3 Nov 08, the results of the last row indicate that if Genesis had a contract of 800 MW in the North Island and 200 MW in the South Island, then an FTR of 700 MW (held in the direction South to North,) would cause Genesis to withhold to the extent that prices would reach the artificial cap of $10,000.00.

In addition to the tables, we have produced corresponding graphs to highlight some periods that we present in the subsequent sections.

- Each graph has one horizontal and two vertical axes. The horizontal axis denotes the FTR volume. The left vertical axis denotes energy volumes while the right axis denotes electricity prices. The top half of the left vertical axis indicates the volume of (optimal) generation of electricity for the firm. The bottom half indicates the contract level.
- For each FTR level, we present the firm's generation and contract position as well as the net position in each of the three nodes in our simplified network.
  - In each FTR level, the bar graphs correspond to the two nodes over which the FTR is held. In the case of winter periods the left bar graphs correspond to the OTA node and the right bar graphs correspond to HAY and BEN nodes (note that for these periods there is no congestion between HAY and BEN, therefore they can be considered as a single node). Similarly, for summer periods, the left bar graphs correspond to OTA and HAY nodes and the right bar graphs correspond to the BEN node.
  - The pink bar, extending above the horizontal axis, indicates the optimal generation level for the firm given the FTR level.
  - The blue bar, extending below the horizontal axis indicates the firm's contract level at the node.

- The solid horizontal line indicates the net position of the firm at that node.
- The green bars indicate the interpretation of the FTR as an increase in the contract position in the upstream node and an increase in the generation (or equivalently a decrease in the contract position) in the downstream node.

- For each FTR level, and for each node, we indicate the electricity price on the graph by a cross. Red crosses indicate that the firm has incentive and ability to raise prices without limit, in absence of any artificial price cap.

4.1.1 Genesis

Table 8 contains the strategic best response of Genesis in the sampled periods from November 2008. Here Genesis is downstream of an FTR over the BEN–HAY line. This table demonstrates that Genesis has incentive to congest the BEN–HAY line by reducing production when it holds an FTR. Figure 5 highlights period 19 of 3-Nov-08. Here if Genesis is equipped with an FTR of 550MW, then it will reduce production from 845.7 MW to 503.2 MW. The effect of this reduction in generation is that prices rise at all three of the nodes in our simplified network and a price difference is created between BEN (with price $130.13) and HAY (with price $974.50) which provides a significant coupon payment on the FTR. The next row in Table 8 presents what would have happened if Genesis was equipped with the maximum possible volume of FTR, namely 700 MW, on 3-Nov-08. This case can also presented in Figure 5 below. Here the result of the larger FTR is merely a larger coupon payment and no change in offer behaviour or prices from that of the 550 MW FTR.

Below we have provided Figure 6 corresponding to period 19 of 12-Nov-08. Observe here that holding an FTR entices Genesis, the strategic holder of the FTR, to withhold generation to the point that prices rise without bound. We impose an artificial cap of $10,000.00 that is reached in this period. This is an example of the kind of exacerbation of market power when FTRs are combined with market power as discussed in [3] and [4].

Throughout Tables 8 and 9, there are some periods in which, even when the strategic generator is equipped with the maximum level of FTR there is no incentive to change behaviour. Period 19 4 through 7 November 2008 are such periods for Genesis (downstream of a HAY–OTA FTR,) as outlined in Table 8. Figure 7 is a representative of these periods depicted below.

Table 9 contains sampled periods from June 2008. In contrast to Table 8, here Genesis creates a price difference between OTA and HAY by increasing production. As a result, the prices reduce across all three nodes, although there is a price difference between OTA and HAY which provides the coupon payment. Figure 8 depicts period 19 of 23 June 2008, a representative period from table 9.

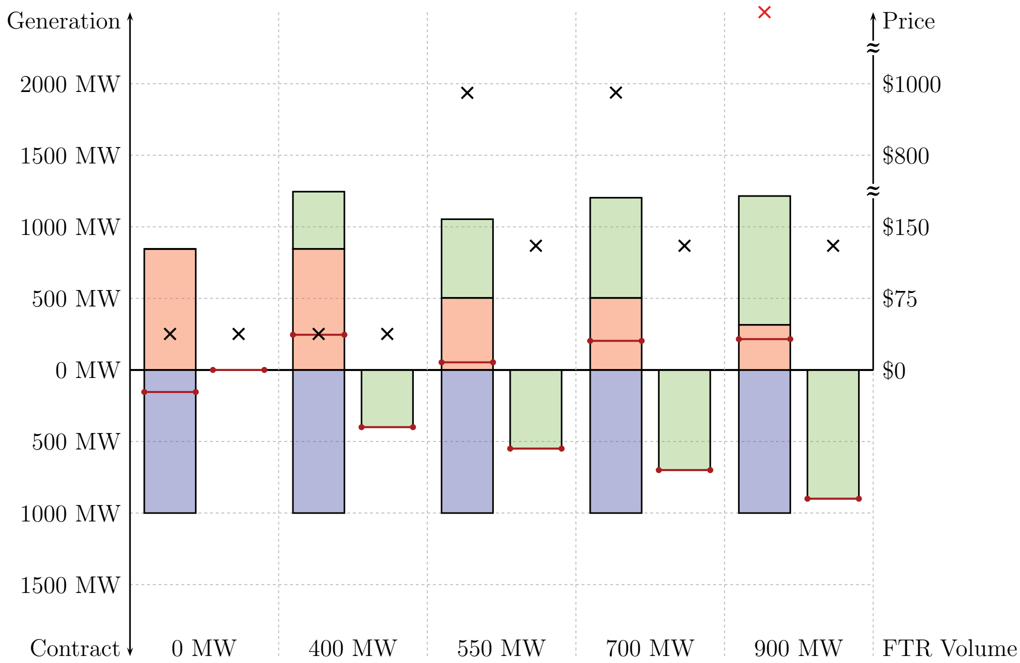

Figure 5: Genesis downstream of an FTR from BEN–HAY; period 19 of 3 Nov 2008.

From Tables 8 and Table 9 it seems that when Genesis is downstream of an FTR, i.e. it holds an FTR from South to North, then it has incentive to create a price difference by withholding. This can increase nodal prices without bound, such as demonstrated in period 19 of 12-Nov-08. On the other hand, when Genesis is upstream of an FTR, i.e. when it holds an FTR from North to South, the result of its strategic best response is to offer more production and decrease prices, although a price difference is also created.

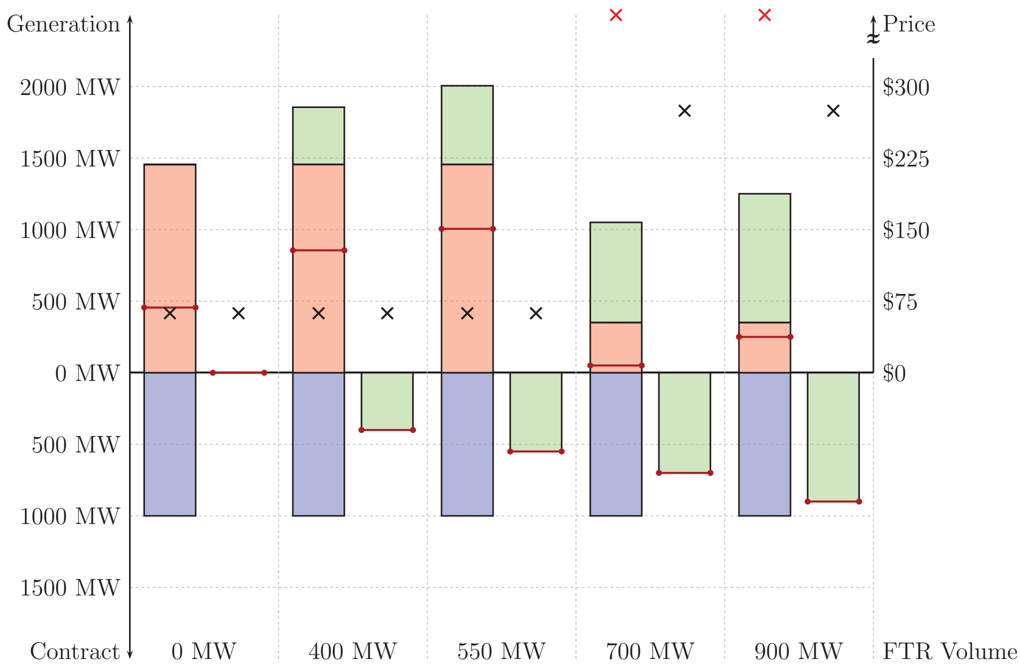

Figure 6: Genesis downstream of an FTR from BEN–HAY; period 19 of 12 Nov 2008.

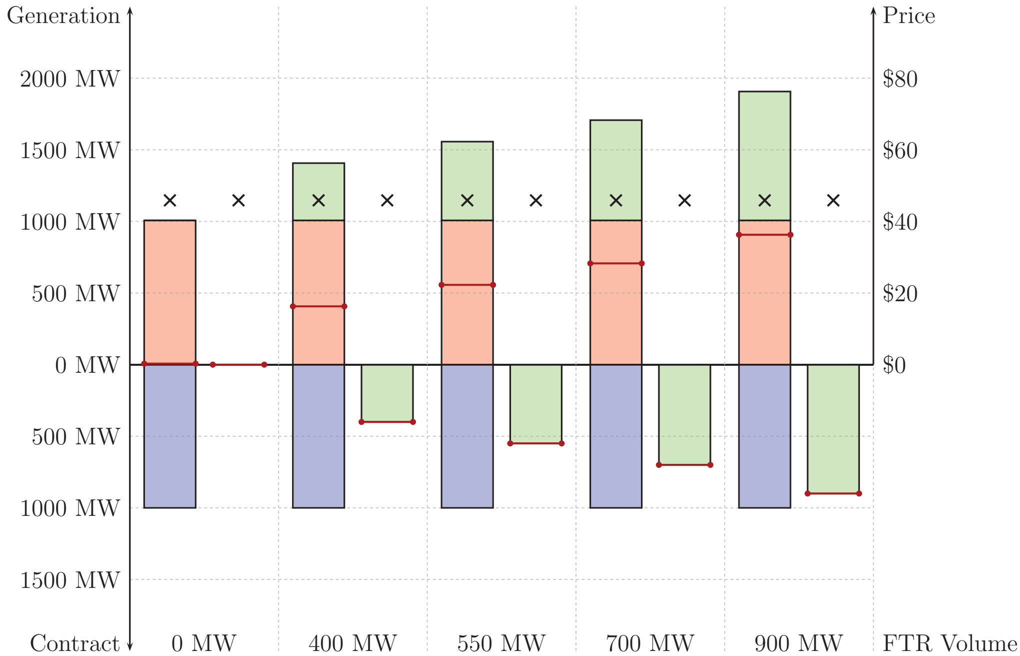

Figure 7: Genesis downstream of an FTR from BEN–HAY; period 19 of 5 Nov 2008.

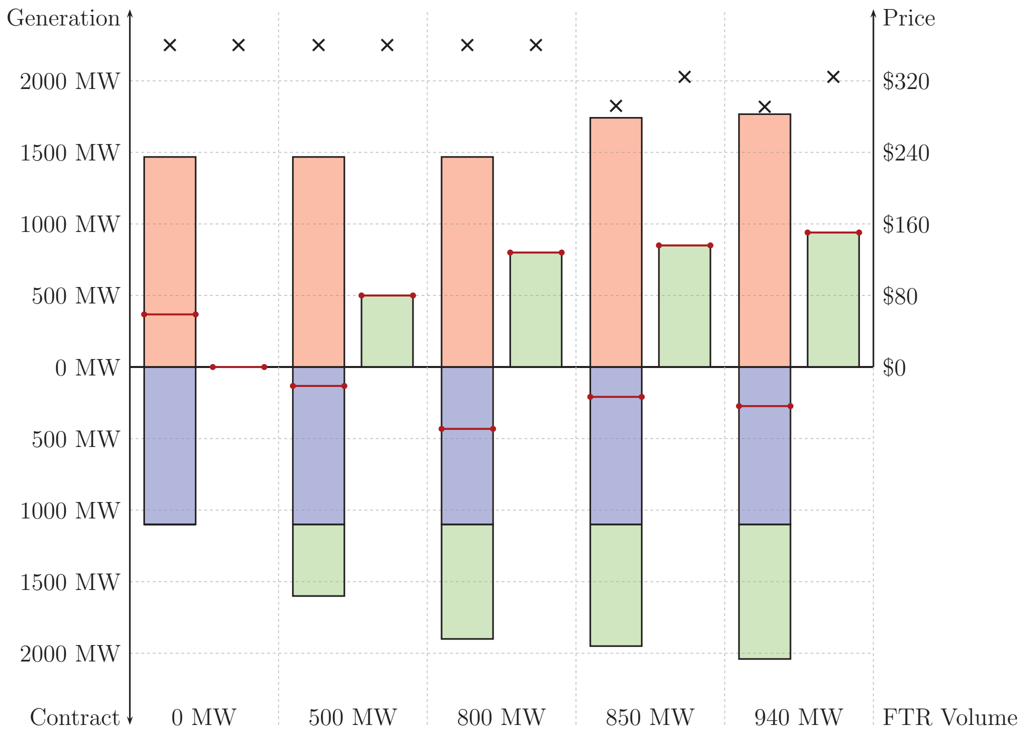

Figure 8: Genesis upstream of an FTR from OTA–HAY; period 19 of 23 June 2008.

		Generation	Prices		
	FTR	OTA	OTA	HAY	BEN
3-Nov-08	0 MW	845.7 MW	$37.70	$37.70	$37.70
	550 MW	503.2 MW	$974.50	$974.50	$130.13
	700 MW	503.2 MW	$974.50	$974.50	$130.13
	900 MW	315.2 MW	$10000.00	$10000.00	$130.13
4-Nov-08	0 MW	1012.9 MW	$42.32	$42.32	$42.32
	700 MW	1012.9 MW	$42.32	$42.32	$42.32
	736 MW	344.2 MW	$974.86	$974.86	$142.79
	900 MW	344.2 MW	$975.11	$975.11	$142.79
5-Nov-08	0 MW	1007 MW	$45.88	$45.88	$45.88
	700 MW	1007 MW	$45.88	$45.88	$45.88
	900 MW	1007 MW	$45.88	$45.88	$45.88
6-Nov-08	0 MW	1169.2 MW	$54.83	$54.83	$54.83
	700 MW	1169.2 MW	$54.83	$54.83	$54.83
	900 MW	1169.2 MW	$54.83	$54.83	$54.83
7-Nov-08	0 MW	1303.2 MW	$110.25	$110.25	$110.25
	700 MW	1303.2 MW	$110.25	$110.25	$110.25
	900 MW	1303.2 MW	$110.25	$110.25	$110.25
10-Nov-08	0 MW	1347.4 MW	$72.80	$72.80	$72.80
	432 MW	656.6 MW	$749.92	$749.92	$161.83
	700 MW	469.6 MW	$10000.00	$10000.00	$161.83
	900 MW	469.6 MW	$10000.00	$10000.00	$161.83
11-Nov-08	0 MW	1340.7 MW	$63.35	$63.35	$63.35
	700 MW	1340.7 MW	$63.35	$63.35	$63.35
	713 MW	461 MW	$975.10	$975.10	$259.37
	900 MW	251.5 MW	$10000.00	$10000.00	$259.37
12-Nov-08	0 MW	1455.6 MW	$62.35	$62.35	$62.35
	666 MW	350.8 MW	$10000.00	$10000.00	$274.62
	700 MW	350.8 MW	$10000.00	$10000.00	$274.62
	900 MW	350.8 MW	$10000.00	$10000.00	$274.62
13-Nov-08	0 MW	1459.6 MW	$61.85	$61.85	$61.85
	627 MW	532.8 MW	$750.06	$750.06	$207.14
	700 MW	325.8 MW	$10000.00	$10000.00	$207.14
	900 MW	325.8 MW	$10000.00	$10000.00	$207.14
14-Nov-08	0 MW	1097.8 MW	$48.44	$48.44	$48.44
	534 MW	519.2 MW	$662.58	$662.58	$102.20
	700 MW	386.2 MW	$10000.00	$10000.00	$102.20
	900 MW	386.2 MW	$10000.00	$10000.00	$102.20

Table 8: Genesis Summer (FTR: South to North, Water Value: $20, Contract: 1000 MW at OTA)

		Generation	Prices		
	FTR	OTA	OTA	HAY	BEN
19-May-08	0 MW	1494.5 MW	$374.58	$374.58	$374.58
	480 MW	1573.8 MW	$299.19	$362.31	$362.31
	940 MW	1688 MW	$289.00	$362.31	$362.31
20-May-08	0 MW	1418 MW	$349.10	$350.07	$350.07
	20 MW	1444.5 MW	$345.10	$350.07	$350.07
	940 MW	1767 MW	$236.46	$350.07	$350.07
	-940 MW	1409 MW	$349.80	$350.07	$350.07
21-May-08	0 MW	1407 MW	$285.94	$308.17	$308.17
	510 MW	1546.4 MW	$254.42	$308.17	$308.17
	940 MW	1709 MW	$1.00	$308.17	$308.17
	-940 MW	1407 MW	$285.94	$308.17	$308.17
22-May-08	0 MW	1407 MW	$297.19	$328.65	$328.65
	340 MW	1412.7 MW	$296.45	$328.65	$328.65
	940 MW	1767 MW	$193.90	$328.65	$328.65
	-940 MW	1303.6 MW	$344.90	$344.90	$344.90
23-May-08	0 MW	1504.7 MW	$345.35	$345.35	$345.35
	624 MW	1672.1 MW	$293.02	$328.84	$328.84
	940 MW	1746.6 MW	$287.03	$328.84	$328.84
23-Jun-08	0 MW	1467.9 MW	$360.00	$360.00	$360.00
	740 MW	1467.9 MW	$360.00	$360.00	$360.00
	839 MW	1741.1 MW	$292.00	$324.44	$324.44
	940 MW	1767 MW	$291.02	$324.44	$324.44
24-Jun-08	0 MW	1624.9 MW	$325.45	$325.45	$325.45
	518 MW	1625.3 MW	$324.09	$325.45	$325.45
	740 MW	1636.3 MW	$288.99	$325.45	$325.45
	940 MW	1767 MW	$281.84	$325.45	$325.45
25-Jun-08	0 MW	1407.8 MW	$339.55	$339.55	$339.55
	247 MW	1407.9 MW	$339.53	$339.55	$339.55
	740 MW	1709.7 MW	$264.20	$339.55	$339.55
	940 MW	1725 MW	$259.99	$339.55	$339.55
26-Jun-08	0 MW	1520.9 MW	$350.57	$350.57	$350.57
	500 MW	1600.3 MW	$300.53	$300.53	$342.57
	700 MW	1699.9 MW	$273.74	$273.74	$342.57
27-Jun-08	0 MW	1543.2 MW	$347.50	$347.50	$347.50
	452 MW	1562.6 MW	$335.09	$335.09	$345.76
	500 MW	1576.8 MW	$288.99	$288.99	$345.76
	700 MW	1627 MW	$284.48	$284.48	$345.76

Table 9: Genesis Winter (FTR: North to South, Water Value: $300, Contract: 1100 MW at OTA)

4.2 Nash-Cournot equilibrium model for strategic behaviour with FTRs

Tables 10 to 12 provide information on the equilibrium prices and production quantities when Genesis and Contact are equipped with various FTR levels and both act strategically. We have also produced some graphs to highlight certain periods. The format of our tables and graphs is much the same as those in the best response section with a couple of minor changes. All data contained in the tables still pertain to the 9:00 am period (that is period 19). The tables now contain FTR levels for each of Genesis and Contact and also present equilibrium generation levels for each firm. Our graphs also contain generation levels for both firms across the same three nodes (OTA, HAY and BEN respectively from left to right). The unshaded bars pertain to Genesis and the shaded bars to Contact.

Let us first discuss the results in Table 10. Here the FTRs are held in the direction South to North (between BEN and HAY). Although in this situation we have two strategic players, we may still come across situations where the post FTR equilibrium is over a congested network. Observe the table entry for 3-Nov-08, where Genesis owns all the available FTRs. Although Contact is able to act strategically, the equilibrium supports a congested regime. Consider Contact faced with a situation where Genesis has withdrawn capacity at OTA (to 375.2 MW). Contact will need to increase production in the North Island to respond to high prices due to its contract obligations. However, Contact's optimum strategy is not to reduce the North Island price much further, rather collect a high price on the residual wholesale generation in the North Island. In the South Island, Contact continues to meet its contract obligations (of 450 MW) but decreases production to 657.7 MW (from 689 MW) which has the effect of increasing the price (though not enough to equate the South and North Island prices). This can be seen in Figure 9 below.

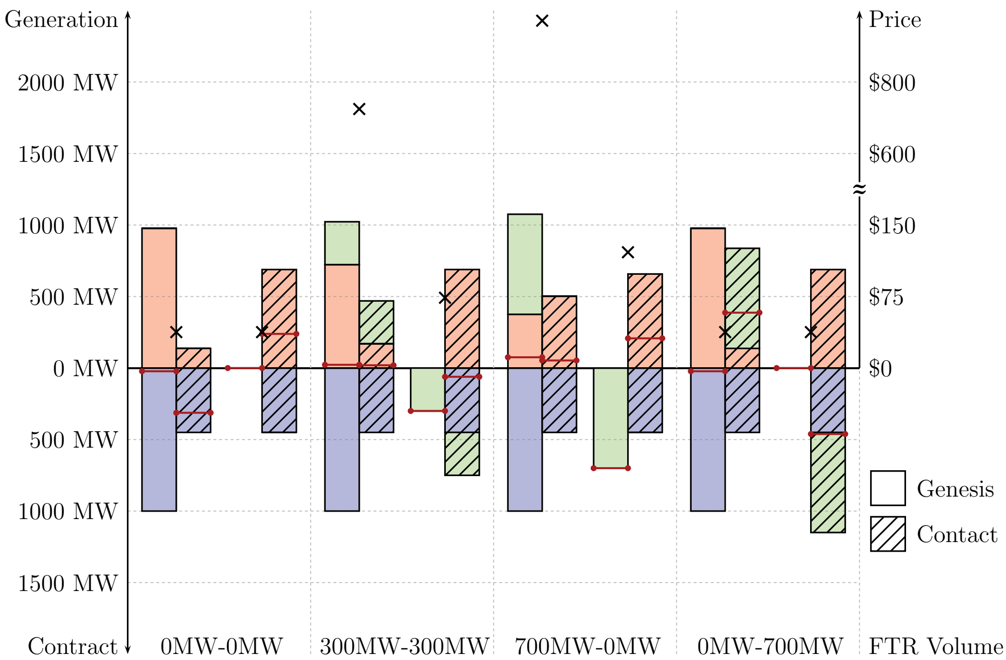

Figure 9: Cournot game with FTRs from BEN–HAY; period 19 of 3 Nov 2008.

Although it may be tempting to conjecture that if both strategic firms are equipped with FTRs, the equilibrium outcome would be more competitive than if only one firm held all the available FTRs, Table 10 provides results to the contrary. In particular, notice that in period 19 of 3-Nov-08, if Contact owns all the FTRs, there will be no congestion in equilibrium. By contrast if both firms held FTRs of 300 MW, the HVDC would be congested in equilibrium.

Note further that in the Nash-Cournot game it is less likely to cause unbounded rises in equilibrium prices, compared to the best response cases; as there is more than one strategic player involved. Nevertheless, there is an occurrence of an unbounded price rise on 10-Nov-08, when Genesis is equipped with an FTR of 720 MW[7]. Figure 10 below depicts this situation.

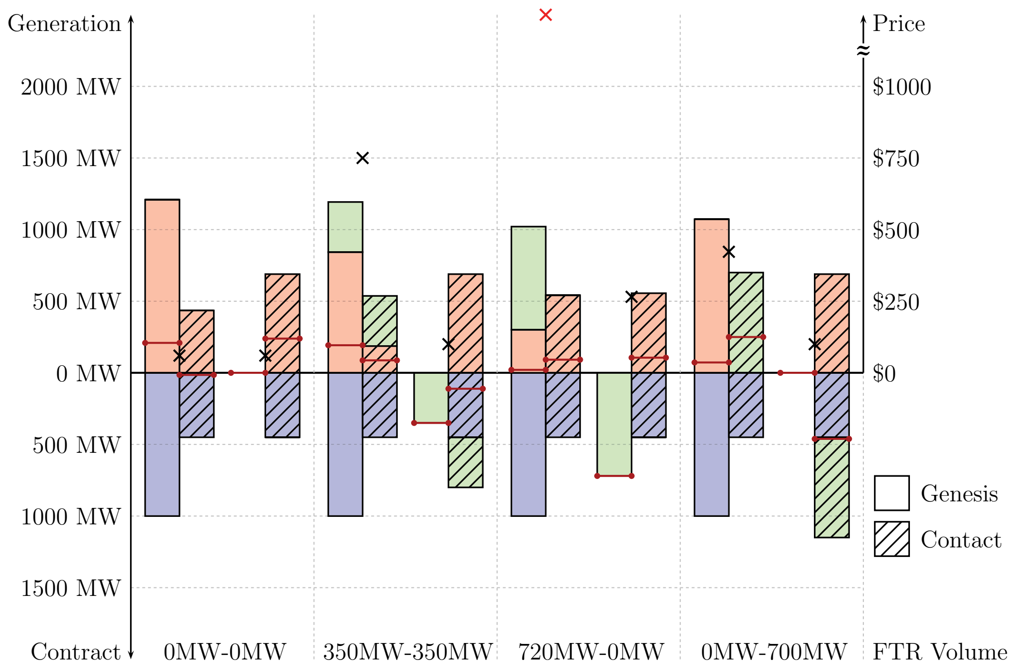

Figure 10: Cournot game with FTRs from BEN–HAY; period 19 of 10 Nov 2008.

[7]Although this FTR volume is technically slightly above the HVDC capacity, we felt it was worth noting the effect. If the HVDC capacity is slightly altered, to 720 MW, instead of 700 MW, our model would predict this very high price level.

	FTR		Genesis	Contact			Price		
	Genesis	Contact	OTA	OTA	HAY	BEN	OTA	HAY	BEN
3-Nov-08	0 MW	0 MW	977.5 MW	137.3 MW	0 MW	689 MW	$37.70	$37.70	$37.70
	700 MW	0 MW	375.2 MW	404 MW	99.1 MW	657.7 MW	$972.70	$972.70	$121.45
	0 MW	700 MW	977.5 MW	137.3 MW	0 MW	689 MW	$37.70	$37.70	$37.70
	300 MW	300 MW	721.7 MW	170.5 MW	0 MW	689 MW	$730.07	$730.07	$73.72
4-Nov-08	0 MW	0 MW	1007.7 MW	199.6 MW	0 MW	689 MW	$42.01	$42.01	$42.01
	700 MW	0 MW	No EQM found						
	350 MW	350 MW	1007.7 MW	199.6 MW	0 MW	689 MW	$42.01	$42.01	$42.01
	0 MW	700 MW	1007.7 MW	199.6 MW	0 MW	689 MW	$42.01	$42.01	$42.01
10-Nov-08	0 MW	0 MW	1209 MW	404 MW	31.4 MW	689 MW	$60.00	$60.00	$60.00
	700 MW	0 MW	No EQM found						
	0 MW	700 MW	1072.3	0 MW	0 MW	689 MW	$422.49	$422.49	$99.95
	350 MW	350 MW	842.6	187.0 MW	0 MW	689 MW	$750.01	$750.01	$99.95
	720 MW	0 MW	300.9 MW	404 MW	137.7 MW	555.9 MW	$10000.00	$10000.00	$265.40
11-Nov-08	0 MW	0 MW	1179.7 MW	339 MW	0 MW	689 MW	$63.35	$63.35	$63.35
	700 MW	0 MW	No EQM found						
	0 MW	700 MW	1179.7 MW	339 MW	0 MW	689 MW	$63.35	$63.35	$63.35
	350 MW	350 MW	698.6 MW	147.9 MW	0 MW	689 MW	$738.17	$738.17	$91.25
12-Nov-08	0 MW	0 MW	1051.1 MW	404 MW	1.5 MW	689 MW	$62.35	$62.35	$62.35
	700 MW	0 MW	389.5 MW	404 MW	135 MW	689 MW	$557.45	$557.45	$103.23
	0 MW	700 MW	1051.1 MW	404 MW	1.5 MW	689 MW	$62.35	$62.35	$62.35
	350 MW	350 MW	739.4 MW	189.2 MW	0 MW	689 MW	$557.19	$557.19	$103.23
13-Nov-08	0 MW	0 MW	1168 MW	351.9 MW	0 MW	689 MW	$61.70	$61.70	$61.70
	700 MW	0 MW	No EQM found						
	0 MW	700 MW	1168 MW	351.9 MW	0 MW	689 MW	$61.70	$61.70	$61.70
	350 MW	350 MW	734.3 MW	184.2 MW	0 MW	689 MW	$626.97	$626.97	$101.47
14-Nov-08	0 MW	0 MW	1092.3 MW	295 MW	0 MW	689 MW	$45.30	$45.30	$45.30
	700 MW	0 MW	370.7 MW	404 MW	112.5 MW	689 MW	$662.57	$662.57	$98.07
	0 MW	700 MW	1092.3 MW	295 MW	0 MW	689 MW	$45.30	$45.30	$45.30
	700 MW	-100 MW	No EQM found						
	350 MW	350 MW	726.3 MW	161 MW	0 MW	689 MW	$662.62	$662.62	$98.07

Table 10: Cournot Summer (FTR: South to North)

Figure 11 below shows the minimum joint FTRs held by Genesis and Contact which lead to congestion at equilibrium. Note that if both firms have FTRs in the same direction, then the total quantity of FTR held does not need to be as large to achieve a congested equilibrium.

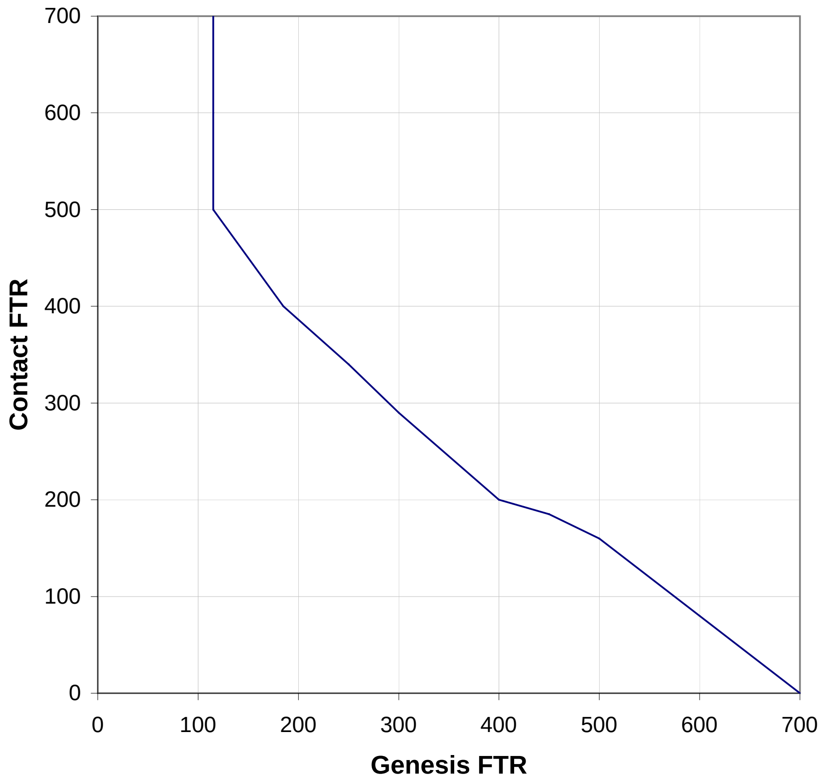

Figure 11: Minimum FTR levels yielding congested equilibria.

In Table 11 both Genesis and Contact act strategically, however these results pertain to the winter when water values are high. Consider 23-Jun-08 when Genesis holds 940 MW FTR in the North to South direction. Note that similar to the best response case, when Genesis is located upstream of the FTR it is holding, in the equilibrium, Genesis produces more electricity and nodal prices have decreased, although there is a price separation now.

In this period, we can compute two equilibria for the counterfactual (i.e. in absence of FTRs). The one reported in Table 11 and depicted in Figure 12 is the equilibrium that produced a price similar to the historically observed price. The second equilibrium is one where Genesis generates 1445.8 MW, and Contact produces 404 MW, 376.8 MW and 334.1 MW for OTA, HAY and BEN respectively. In this second equilibrium, there is no congestion and the prices at all three nodes are $478.40.

Note that multiple equilibria can occur in our model due to the shape of the residual demand curves, where sometimes concave portions occur.

If Contact owns all the FTRs in this period, both Contact and Genesis withhold production and prices rise, although there is no actual payment from the FTR. This is an interesting effect that is triggered by the existence of the FTR, although the FTR itself will not produce a coupon payment in equilibrium. Imagine that we start from the reported counterfactual and equip Contact with a 940 MW FTR. Contact will withhold production at BEN to create a price difference. This creates a steeper residual demand curve that causes Genesis to withhold in order to optimize its profits. The net effect is that prices rise although no congestion occurs.

Once Genesis and Contact are both equipped with equal sized FTRs, Genesis produces more in equilibrium and Contact produces less, which results in a greater price difference than if Genesis alone held all the FTRs. Figure 12 provides a graphical representation for period 19 of 23 June 2008.

Another period of interest is 21-May-08 depicted in Figure 13. Here in the counterfactual there is a price separation between OTA and HAY (note that this actually occurred historically as well). In this period, Genesis is upstream of the FTR and the equilibrium price at the upstream node (namely OTA,) decreases as the FTR volume for Genesis increases. Observe that the production for Genesis at OTA has increased in equilibrium once it has some FTRs. Also, once Contact holds all the available FTRs, it has reduced generation at the downstream node (the aggregated HAY, BEN node,) in the equilibrium. Note that the equilibrium prices (with Contact in possession of all available FTRs,) have increased at the downstream node(s).

Both sets of periods that we have studied indicate that even when more than one firm acts strategically, FTRs can exacerbate market power over oligopolies and result in loss of allocative efficiency by causing prices to rise.

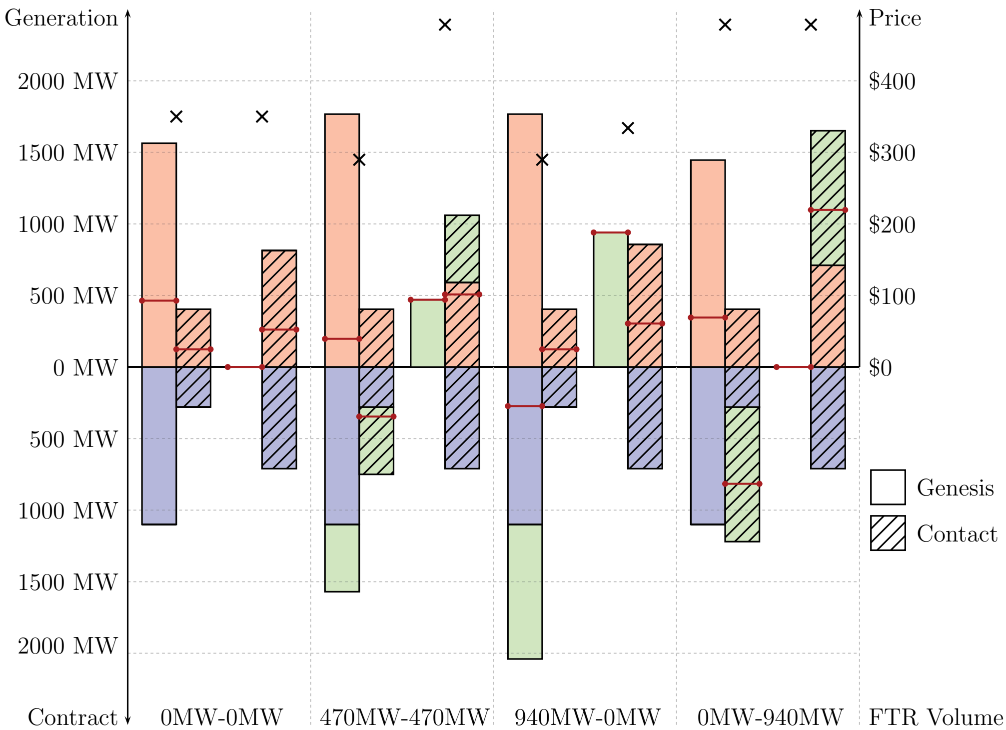

Figure 12: Cournot game with FTRs from HAY–OTA; period 19 of 23 June 2008.

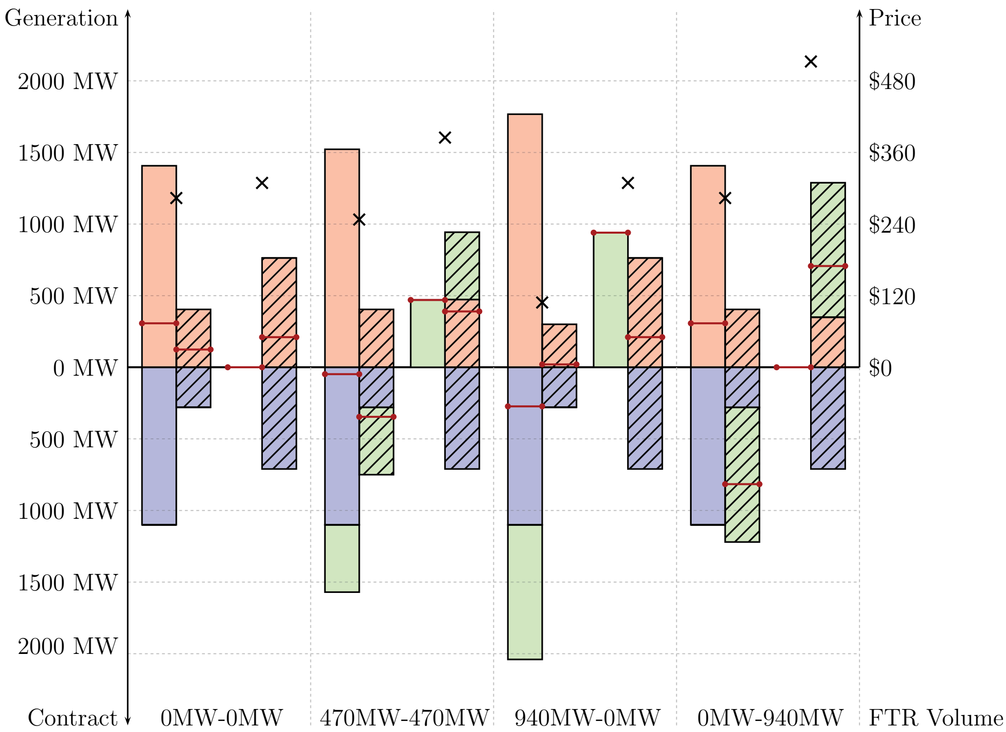

Figure 13: Cournot game with FTRs from HAY–OTA; period 19 of 21 May 2008.

	FTR		Genesis	Contact			Price		
	Genesis	Contact	OTA	OTA	HAY	BEN	OTA	HAY	BEN
19-May-08	0 MW	0 MW	1407.4 MW	404 MW	377 MW	407.7 MW	$370.91	$370.91	$370.91
	940 MW	0 MW	1407.4 MW	404 MW	377 MW	407.7 MW	$370.91	$370.91	$370.91
	0 MW	940 MW	1407.4 MW	404 MW	377 MW	407.7 MW	$370.91	$370.91	$370.91
	470 MW	470 MW	1407.4 MW	404 MW	377 MW	407.7 MW	$370.91	$370.91	$370.91
20-May-08	0 MW	0 MW	1407 MW	404 MW	377 MW	368.4 MW	$329.96	$329.96	$329.96
	940 MW	0 MW	1767 MW	404 MW	377 MW	396.5 MW	$206.47	$317.42	$317.42
	0 MW	940 MW	No EQM						
	0 MW	200 MW	1410.5 MW	404 MW	377 MW	290.3 MW	$345.11	$376.03	$376.03
	470 MW	470 MW	1602.2 MW	404 MW	377 MW	138.4 MW	$282.89	$512.36	$512.36
21-May-08	0 MW	0 MW	1407 MW	404 MW	377 MW	386.6 MW	$283.59	$308.91	$308.91
	940 MW	0 MW	1767 MW	300 MW	377 MW	386.4 MW	$108.55	$308.90	$308.90
	0 MW	940 MW	1407 MW	404 MW	348.5 MW	0 MW	$283.59	$512.38	$512.38
	470 MW	470 MW	1522 MW	404 MW	377 MW	96.2 MW	$247.57	$384.91	$384.91
22-May-08	0 MW	0 MW	1407 MW	404 MW	377 MW	376.1 MW	$294.58	$350.35	$350.35
	940 MW	0 MW	1767 MW	382.5 MW	377 MW	376 MW	$190.22	$350.35	$350.35
	0 MW	940 MW	No EQM						
	470 MW	470 MW	1562.5 MW	404 MW	377 MW	376.1 MW	$277.07	$350.35	$350.35
23-May-08	0 MW	0 MW	1484.7 MW	404 MW	377 MW	382.2 MW	$345.35	$345.35	$345.35
	940 MW	0 MW	1767 MW	404 MW	377 MW	382.2 MW	$283.38	$340.87	$340.87
	0 MW	940 MW	1484.7 MW	404 MW	377 MW	382.2 MW	$345.35	$345.35	$345.35
	470 MW	470 MW	1725.6 MW	404 MW	377 MW	30.6 MW	$286.90	$512.27	$512.27

Table 11: Cournot Winter (FTR: North to South)

	FTR		Genesis	Contact			Price		
	Genesis	Contact	OTA	OTA	HAY	BEN	OTA	HAY	BEN
23-Jun-08	0 MW	0 MW	1481.8 MW	404 MW	377 MW	473.4 MW	$359.95	$359.95	$359.95
	940 MW	0 MW	1767 MW	404 MW	377 MW	480.4 MW	$289.70	$333.93	$333.93
	0 MW	940 MW	1433.9 MW	404 MW	377 MW	345.8 MW	$478.40	$478.40	$478.40
	470 MW	470 MW	1767 MW	404 MW	377 MW	213.6 MW	$289.71	$478.41	$478.41
24-Jun-08	0 MW	0 MW	1557.1 MW	404 MW	377 MW	562.8 MW	$325.45	$325.45	$325.45
	940 MW	0 MW	1767 MW	404 MW	377 MW	524.2 MW	$275.32	$325.45	$325.45
	0 MW	940 MW	1431.4 MW	404 MW	377 MW	688.7 MW	$325.45	$325.45	$325.45
	470 MW	470 MW	1438.1 MW	404 MW	377 MW	681.9 MW	$325.45	$325.45	$325.45
25-Jun-08	0 MW	0 MW	1390.8 MW	404 MW	377 MW	528.2 MW	$339.55	$339.55	$339.55
	940 MW	0 MW	1767 MW	404 MW	377 MW	527.9 MW	$241.06	$339.56	$339.56
	0 MW	940 MW	No EQM						
	470 MW	470 MW	1489.2 MW	404 MW	377 MW	426.9 MW	$289.11	$348.21	$348.21
26-Jun-08	0 MW	0 MW	1482.3 MW	404 MW	377 MW	591.1 MW	$345.97	$345.97	$345.97
	940 MW	0 MW	1718 MW	404 MW	351.8 MW	563.2 MW	$268.00	$340.06	$340.06
	0 MW	940 MW	1482.3 MW	404 MW	377 MW	591.1 MW	$345.97	$345.97	$345.97
	470 MW	470 MW	1583.3 MW	404 MW	351.8 MW	161.8 MW	$343.60	$478.35	$478.35
27-Jun-08	0 MW	0 MW	1517.7 MW	404 MW	377 MW	627.4 MW	$344.83	$344.83	$344.83
	940 MW	0 MW	1767 MW	404 MW	339.6 MW	645.3 MW	$259.28	$342.86	$342.86
	0 MW	940 MW	No EQM						
	470 MW	470 MW	1569.4 MW	404 MW	339.6 MW	243.9 MW	$297.45	$478.41	$478.41

Table 12: Cournot Winter (FTR: North to South)

5 Discussion and extension

Appendix

5.1 Additional best response results

The results in this section demonstrate the outcomes of applying our best response model to Meridian and Contact. The qualitative results are similar to those already presented in the Genesis best response section.

5.1.1 Meridian

Tables 13 and 14 demonstrate Meridian's strategic best response when that firm is equipped with an FTR. Table 13 demonstrates that Meridian does not have much incentive to congest the HVDC and collect an FTR payment if it were equipped with an FTR for the 9:00 am periods of the sampled days in November of 2008, with the exception of the 10th of November. Figure 14 below depicts this effect on period 19 of 5 Nov.

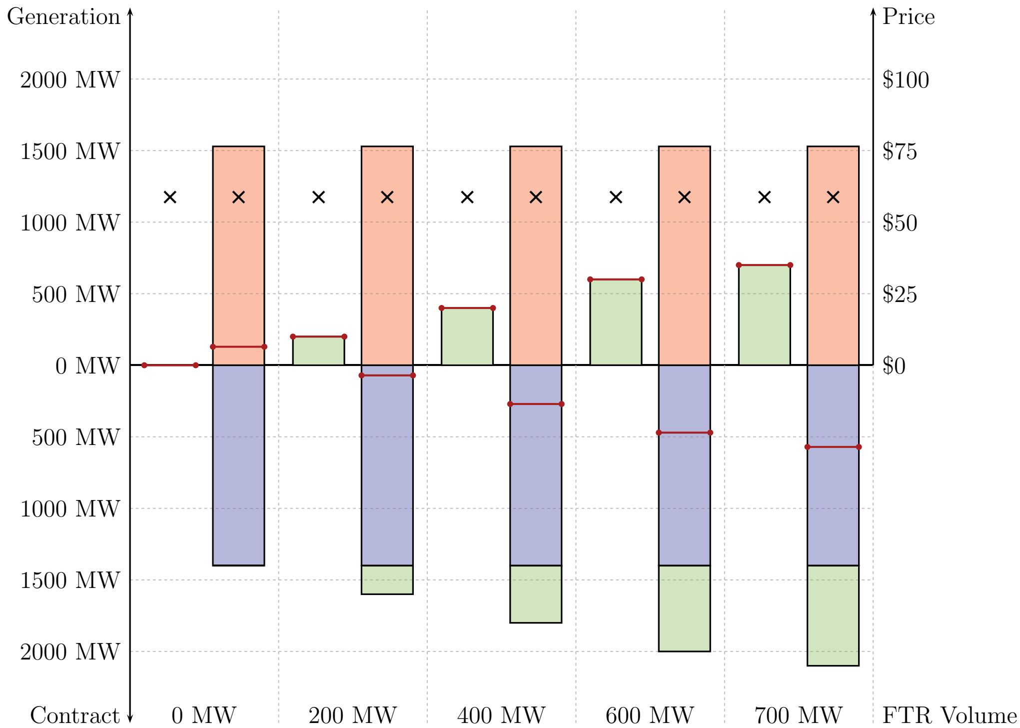

Figure 14: Meridian upstream of an FTR from BEN–HAY; period 19 of 5 Nov 2008.

On the 10th, Meridian collects a coupon payment on the FTR by causing congestion through increasing their offers. Note that Meridian is upstream of the BEN–HAY FTR and that prices are lowered in all three nodes. Figure 15 demonstrates the results for 10 Nov 2008. Note here that when the FTR volume is sufficiently large, Meridian has incentive (and ability) to cause congestion by increasing production. Note also that BEN prices, resulting from FTRs of 615 MW and 700 MW, are below the assumed water values. This could indicate that Meridian has incentive to cause an inefficient dispatch when equipped with a large enough FTR volume.

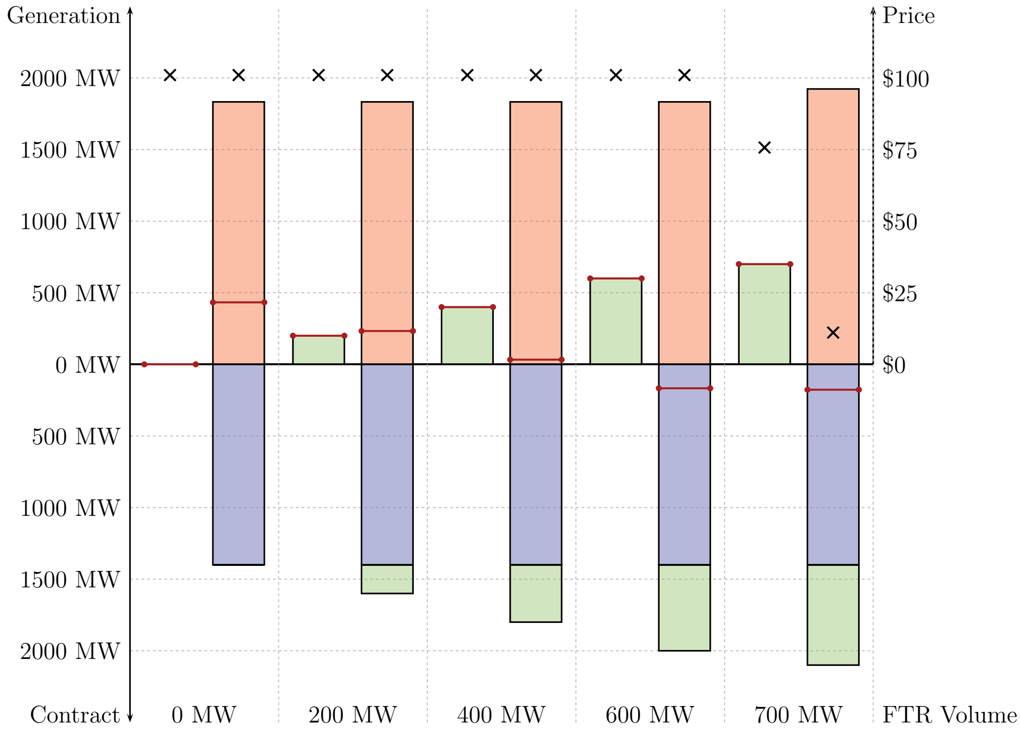

Figure 15: Meridian upstream of an FTR from BEN–HAY; period 19 of 10 Nov 2008.

In the periods presented in Table 14, by contrast, we assume that Meridian is downstream of a BEN–HAY FTR. Note that in every period there is a permissible FTR volume that induces Meridian to withhold generation and the effect is that prices increase, and a price difference is created. In reality, in these periods there was congestion (in absence of any FTRs) however our model is too simple to accurately replicate this in the counterfactual. The fact that the historical periods demonstrated congestion implies that even lower threshold volumes of FTR are necessary to cause withholding of production and price separation. We have selected 23 June as a representative here and depicted the effects in Figure 16 below.

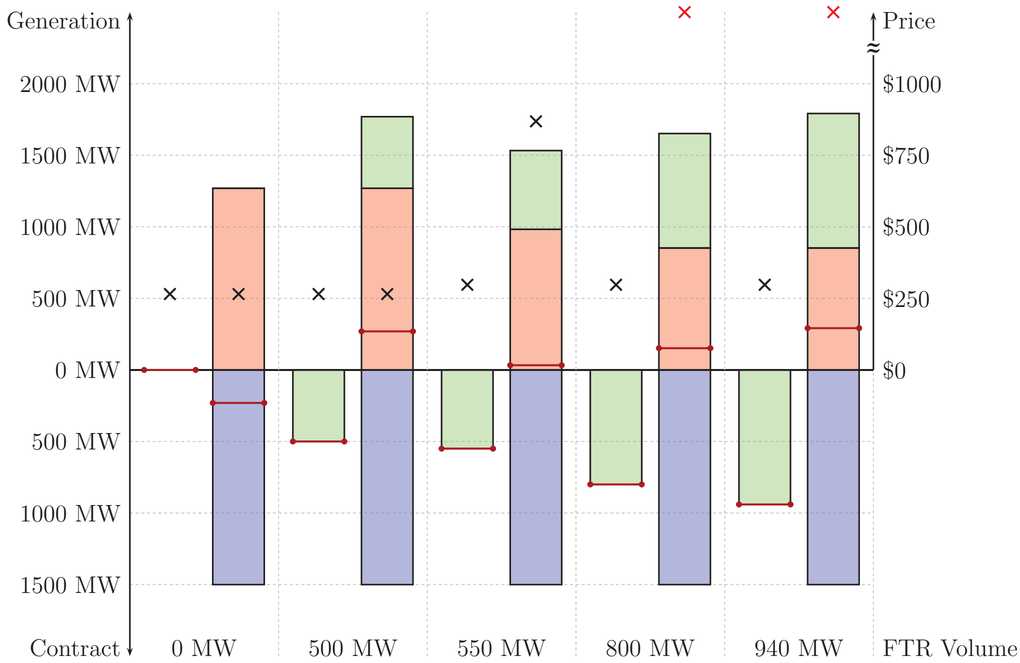

Figure 16: Meridian downstream of an FTR from BEN–HAY; period 19 of 23 June 2008.

Tables 13 and 14 together reinforce the same qualitative conclusions as Tables 8 and 9. That is, if a strategic generator with market power is positioned downstream of an FTR, then the best response of this firm is to withhold production which can cause an unbounded rise in nodal prices.

	FTR	Generation	Prices		
		BEN	OTA	HAY	BEN
3-Nov-08	0 MW	1573.2 MW	$30.00	$30.00	$30.00
	400 MW	1573.2 MW	$30.00	$30.00	$30.00
	700 MW	1573.2 MW	$30.00	$30.00	$30.00
4-Nov-08	0 MW	1516.9 MW	$45.03	$45.03	$45.03
	400 MW	1516.9 MW	$45.03	$45.03	$45.03
	700 MW	1516.9 MW	$45.03	$45.03	$45.03
5-Nov-08	0 MW	1529.2 MW	$58.75	$58.75	$58.75
	400 MW	1529.2 MW	$58.75	$58.75	$58.75
	700 MW	1529.2 MW	$58.75	$58.75	$58.75
10-Nov-08	0 MW	1832.8 MW	$101.00	$101.00	$101.00
	400 MW	1832.8 MW	$101.00	$101.00	$101.00
	615 MW	1920.5 MW	$75.71	$75.71	$11.25
	700 MW	1923 MW	$75.71	$75.71	$11.10
11-Nov-08	0 MW	1657.6 MW	$64.87	$64.87	$64.87
	400 MW	1657.6 MW	$64.87	$64.87	$64.87
	700 MW	1657.6 MW	$64.87	$64.87	$64.87
12-Nov-08	0 MW	1742.3 MW	$71.00	$71.00	$71.00
	400 MW	1742.3 MW	$71.00	$71.00	$71.00
	700 MW	1742.3 MW	$71.00	$71.00	$71.00
13-Nov-08	0 MW	1678.5 MW	$63.50	$63.50	$63.50
	400 MW	1678.5 MW	$63.50	$63.50	$63.50
	700 MW	1678.5 MW	$63.50	$63.50	$63.50
14-Nov-08	0 MW	1590.9 MW	$61.50	$61.50	$61.50
	400 MW	1590.9 MW	$61.50	$61.50	$61.50
	700 MW	1590.9 MW	$61.50	$61.50	$61.50

Table 13: Meridian Summer (FTR: South to North, Water Value: $20, Contract: 1400 MW at BEN)

	FTR	Generation BEN	Prices OTA	HAY	BEN
19-May-08	0 MW	1362.8 MW	$290.71	$290.71	$290.71
	215 MW	1294.7 MW	$294.50	$313.64	$313.64
	940 MW	953.6 MW	$294.50	$10000.00	$10000.00
20-May-08	0 MW	1445.6 MW	$287.00	$287.00	$287.00
	50 MW	1443.4 MW	$287.00	$290.88	$290.88
	940 MW	1183.3 MW	$287.00	$10000.00	$10000.00
21-May-08	0 MW	1407.5 MW	$269.63	$269.63	$269.63
	60 MW	1403.8 MW	$270.05	$271.91	$271.91
	940 MW	1239.2 MW	$270.05	$10000.00	$10000.00
22-May-08	0 MW	1410.4 MW	$293.87	$293.87	$293.87
	100 MW	1399.4 MW	$294.50	$298.51	$298.51
	940 MW	1234.3 MW	$294.50	$10000.00	$10000.00
23-May-08	0 MW	1450.7 MW	$293.73	$293.73	$293.73
	120 MW	1389.6 MW	$299.50	$330.25	$330.25
	940 MW	1246.6 MW	$299.50	$10000.00	$10000.00
23-Jun-08	0 MW	1269.4 MW	$265.10	$265.10	$265.10
	530 MW	982.8 MW	$297.55	$868.62	$868.62
	940 MW	851.8 MW	$297.55	$10000.00	$10000.00
24-Jun-08	0 MW	1148.3 MW	$263.05	$263.05	$263.05
	670 MW	852.4 MW	$299.50	$868.59	$868.59
	940 MW	751.4 MW	$299.50	$10000.00	$10000.00
25-Jun-08	0 MW	1039.5 MW	$265.00	$265.00	$265.00
	561 MW	941.5 MW	$273.50	$868.54	$868.54
	940 MW	840.5 MW	$273.50	$10000.00	$10000.00
26-Jun-08	0 MW	930.2 MW	$268.00	$268.00	$268.00
	628 MW	874.8 MW	$273.19	$273.19	$863.31
	700 MW	874.8 MW	$273.19	$273.19	$868.60
	1000 MW	752.8 MW	$273.19	$273.19	$10000.00
27-Jun-08	0 MW	1040 MW	$265.10	$265.10	$265.10
	588 MW	918.8 MW	$278.32	$278.32	$868.90
	700 MW	872.8 MW	$278.32	$278.32	$10000.00
	1000 MW	872.8 MW	$278.32	$278.32	$10000.00

Table 14: Meridian Winter (FTR: North to South, Water Value: $300, Contract: 1500 MW at BEN)

5.1.2 Contact

Tables 15 and 17 pertain to Contact's incentives to alter its electricity production when this firm holds FTRs. Contact presents a more complex situation as the firm's generation plants are located across all three nodes of the network (see Table 1) and the firm has a mix of thermal and hydro generation. In the periods summarized in Table 15 water is plentiful and water values are low. Therefore Contact prefers to run its hydro stations in preference to the thermal units. This generation cost structure together with Contact's generation capacity at each node implies that it has little ability to cause congestion and collect an FTR payment. Figure 17 below demonstrates this situation for period 19 of 5 November 2008.

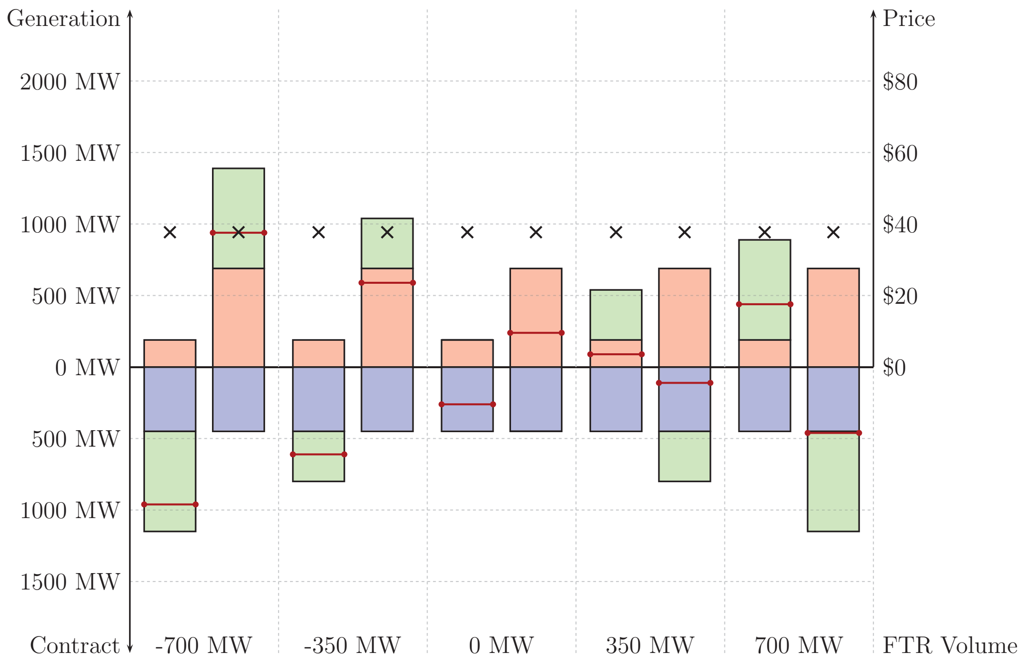

Figure 17: Contact holding an FTR from BEN–HAY; period 19 of 5 Nov 2008.

In period 19 of the 10th of November 2008, Contact does have incentive to cause price differences between BEN and HAY and this is done by reducing generation at OTA, which is consistent with Contact's preference to use hydro over thermal resources. This observation is depicted in Figure 18 below.

The sampled winter periods that are presented in Table 17 have an associated water value that is significantly higher than those of the summer periods. Here if Contact holds a North to South FTR, the natural direction for periods of high water value, then it would have an incentive to reduce production from hydro resources,

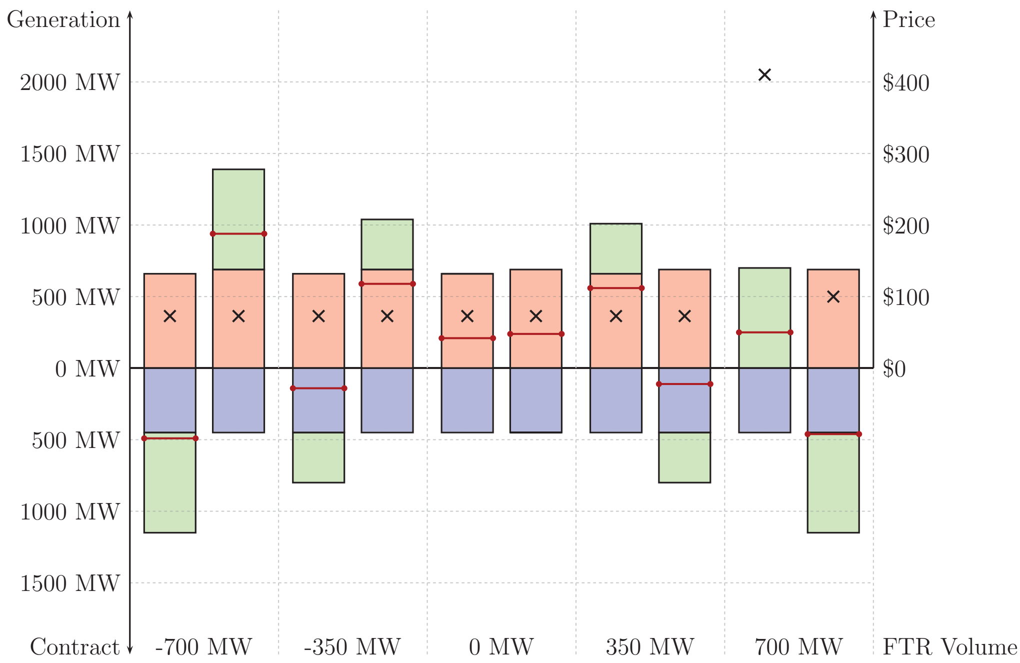

Figure 18: Contact holding an FTR from BEN–HAY; period 19 of 10 Nov 2008.

located at BEN, and it would collect an FTR payment. Note that the prices would increase in HAY and BEN as a result and this increase can be very large when the size of the FTR is large. Figure 19 is a representative winter period for Contact's best response with FTRs. If Contact held FTRs in the opposite direction (South to North) instead, it would have to pay as these FTRs are obligation FTRs. Here the best response for Contact is to generate more at BEN, despite the high water values, to avoid the payments arising from the FTRs.

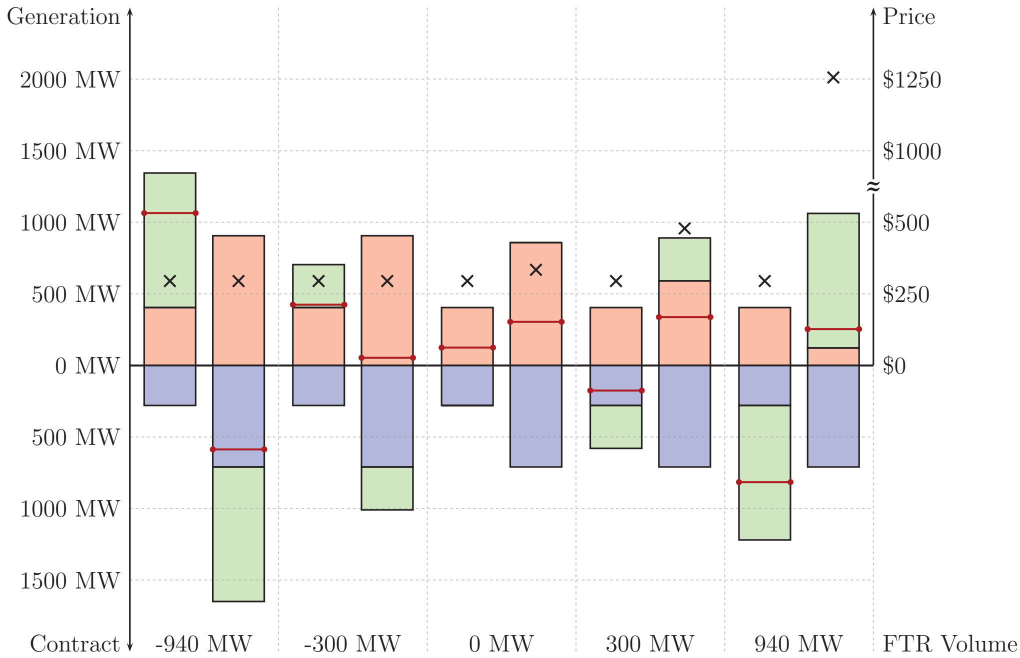

Figure 19: Contact holding an FTR from OTA–HAY; period 19 of 23 June 2008.

		Generation			Prices		
	FTR	OTA	HAY	BEN	OTA	HAY	BEN
3-Nov-08	0 MW	64.6 MW	0 MW	689 MW	$37.70	$37.70	$37.70
4-Nov-08	0 MW	199.3 MW	0 MW	689 MW	$40.16	$40.16	$40.16
5-Nov-08	0 MW	189.1 MW	0 MW	689 MW	$37.70	$37.70	$37.70
6-Nov-08	0 MW	362.8 MW	0 MW	689 MW	$53.14	$53.14	$53.14
7-Nov-08	0 MW	404 MW	196.4 MW	689 MW	$79.45	$79.45	$79.45
10-Nov-08	0 MW	404 MW	255.4 MW	689 MW	$72.80	$72.80	$72.80
	533 MW	0 MW	0 MW	689 MW	$410.08	$410.08	$99.95
	700 MW	0 MW	0 MW	689 MW	$410.08	$410.08	$99.95
11-Nov-08	0 MW	404 MW	103 MW	689 MW	$63.35	$63.35	$63.35
12-Nov-08	0 MW	384.3 MW	0 MW	689 MW	$62.35	$62.35	$62.35
13-Nov-08	0 MW	381.9 MW	0 MW	689 MW	$61.85	$61.85	$61.85
14-Nov-08	0 MW	311.5 MW	0 MW	689 MW	$48.98	$48.98	$48.98

Table 15: Contact Summer (FTR: South to North, Water Value: $20, Contract: 250 MW at OTA, 200 MW at HAY, 450 MW at BEN)

		Generation			Prices		
	FTR	OTA	HAY	BEN	OTA	HAY	BEN
19-May-08	0 MW	404 MW	377 MW	341.5 MW	$293.09	$311.28	$311.28
	-40 MW	404 MW	377 MW	352.9 MW	$293.08	$293.08	$293.08
	-940 MW	404 MW	377 MW	352.6 MW	$293.09	$293.09	$293.09
	10 MW	404 MW	377 MW	331.7 MW	$293.09	$333.97	$333.97
	940 MW	404 MW	342.4 MW	0 MW	$293.09	$510.40	$510.40
20-May-08	0 MW	404 MW	377 MW	396.6 MW	$282.45	$317.42	$317.42
	-10 MW	404 MW	377 MW	401.7 MW	$282.45	$316.04	$316.04
	-940 MW	404 MW	377 MW	428.3 MW	$282.44	$282.44	$282.44
	10 MW	404 MW	377 MW	391.6 MW	$282.45	$318.80	$318.80
	940 MW	404 MW	377 MW	138.3 MW	$282.45	$512.38	$512.38
21-May-08	0 MW	404 MW	377 MW	386.6 MW	$260.05	$308.91	$308.91
	-10 MW	404 MW	377 MW	387.6 MW	$260.05	$308.74	$308.74
	-940 MW	404 MW	377 MW	424.2 MW	$260.05	$260.05	$260.05
	10 MW	404 MW	377 MW	381.5 MW	$260.05	$309.75	$309.75
	940 MW	404 MW	348.6 MW	0 MW	$260.05	$512.36	$512.36
22-May-08	0 MW	404 MW	377 MW	376.1 MW	$292.81	$350.35	$350.35
	-10 MW	404 MW	377 MW	376.5 MW	$292.81	$349.86	$349.86
	-940 MW	404 MW	377 MW	404.4 MW	$292.79	$292.79	$292.79
	525 MW	404 MW	356.9 MW	0 MW	$292.81	$499.84	$499.84
	940 MW	404 MW	351.6 MW	0 MW	$292.81	$512.35	$512.35
23-May-08	0 MW	404 MW	377 MW	382.2 MW	$296.27	$340.87	$340.87
	-30 MW	404 MW	377 MW	382.5 MW	$296.27	$340.30	$340.30
	-940 MW	404 MW	377 MW	402.7 MW	$296.26	$296.26	$296.26
	10 MW	404 MW	377 MW	377.1 MW	$296.27	$345.06	$345.06
	940 MW	404 MW	377 MW	30.6 MW	$296.27	$512.39	$512.39

Table 16: Contact Winter (FTR: North to South, Water Value: $300, Contract: 280 MW at OTA, 220 MW at HAY, 490 MW at BEN)

	FTR	Generation			Prices		
		OTA	HAY	BEN	OTA	HAY	BEN
23-Jun-08	0 MW	404 MW	377 MW	480.4 MW	$294.67	$333.93	$333.93
	-10 MW	404 MW	377 MW	485.5 MW	$294.67	$332.77	$332.77
	-940 MW	404 MW	377 MW	528.9 MW	$294.65	$294.65	$294.65
	10 MW	404 MW	377 MW	475.4 MW	$294.67	$335.10	$335.10
	940 MW	404 MW	121.7 MW	0 MW	$294.67	$1255.94	$1255.94
24-Jun-08	0 MW	404 MW	377 MW	524.2 MW	$295.60	$325.45	$325.45
	-190 MW	404 MW	377 MW	524.5 MW	$295.60	$321.04	$321.04
	-940 MW	404 MW	377 MW	533.2 MW	$295.60	$295.60	$295.60
	338 MW	404 MW	377 MW	523.5 MW	$295.60	$325.48	$325.48
	940 MW	404 MW	296.4 MW	0 MW	$295.60	$478.46	$478.46
25-Jun-08	0 MW	404 MW	377 MW	528.2 MW	$271.13	$339.53	$339.53
	-189 MW	404 MW	377 MW	528.9 MW	$271.13	$335.87	$335.87
	-940 MW	404 MW	377 MW	560.5 MW	$271.13	$271.13	$271.13
	59 MW	404 MW	377 MW	527.9 MW	$271.13	$339.58	$339.58
	940 MW	404 MW	32.4 MW	0 MW	$271.13	$1050.35	$1050.35
26-Jun-08	0 MW	404 MW	351.8 MW	563.2 MW	$272.20	$340.06	$340.06
	-161 MW	404 MW	377 MW	597.5 MW	$267.67	$267.67	$267.67
	-940 MW	404 MW	377 MW	597.5 MW	$267.67	$267.67	$267.67
	119 MW	404 MW	351.8 MW	561.8 MW	$272.20	$340.22	$340.22
	940 MW	404 MW	113.2 MW	0 MW	$272.20	$1226.86	$1226.86
27-Jun-08	0 MW	404 MW	339.6 MW	645.3 MW	$277.66	$342.86	$342.86
	-182 MW	404 MW	377 MW	667.8 MW	$273.21	$273.21	$292.72
	-700 MW	404 MW	377 MW	678.9 MW	$273.17	$273.17	$273.17
	81 MW	404 MW	377 MW	645.3 MW	$273.21	$273.21	$342.85
	940 MW	404 MW	148.2 MW	0 MW	$277.66	$1347.63	$1347.63

Table 17: Contact Winter (FTR: North to South, Water Value: $300, Contract: 280 MW at OTA, 220 MW at HAY, 490 MW at BEN)

5.2 Water Value Sensitivity

5.2.1 Genesis

In summer the results are unchanged for water values between $10 and $40. In winter, for water values of $250 and $350, the results are shown in tables 18 and 19 below.

		Generation	Prices		
	FTR	OTA	OTA	HAY	BEN
23-Jun-08	0 MW	1533.5 MW	$345.79	$345.79	$345.79
	425 MW	1767 MW	$291.00	$324.44	$324.44
	940 MW	1767 MW	$291.00	$324.44	$324.44
24-Jun-08	0 MW	1624.9 MW	$325.45	$325.45	$325.45
	416 MW	1756.5 MW	$284.20	$325.45	$325.45
	940 MW	1767 MW	$281.84	$325.45	$325.45
25-Jun-08	0 MW	1407.8 MW	$339.55	$339.55	$339.55
	182 MW	1635 MW	$282.00	$339.55	$339.55
	940 MW	1767 MW	$254.06	$339.55	$339.55
26-Jun-08	0 MW	1587.4 MW	$342.57	$342.57	$342.57
	446 MW	1681.8 MW	$278.50	$278.50	$342.57
	700 MW	1767 MW	$265.71	$265.71	$342.57
27-Jun-08	0 MW	1559.4 MW	$345.76	$345.76	$345.76
	407 MW	1732.1 MW	$272.29	$272.29	$345.76
	700 MW	1767 MW	$262.70	$262.70	$345.76

Table 18: Genesis Winter (FTR: North to South, Water Value: $250, Contract: 1100 MW at OTA)

5.2.2 Meridian

In summer, for water values of $10 and $40, the results are shown in Tables 20 and 21 below.

In winter, for water values of $250 and $350, the results are shown in Tables 22 and 23 below.

5.2.3 Contact

In summer the results are unchanged for water values between $10 and $40. In winter, for water values of $250 and $350, the results are shown in Tables 24 and 25 below.

	FTR	Generation	Prices		
		OTA	OTA	HAY	BEN
23-Jun-08	0 MW	1407 MW	$365.98	$365.98	$365.98
	940 MW	1407 MW	$365.98	$365.98	$365.98
	1298 MW	1741 MW	$292.00	$324.44	$324.44
24-Jun-08	0 MW	1407 MW	$335.79	$335.79	$335.79
	778 MW	1636 MW	$289.00	$325.45	$325.45
	940 MW	1636 MW	$289.00	$325.45	$325.45
25-Jun-08	0 MW	1407 MW	$339.62	$339.62	$339.62
	322 MW	1412.2 MW	$331.04	$339.55	$339.55
	940 MW	1507 MW	$289.00	$339.55	$339.55
26-Jun-08	0 MW	1407 MW	$364.26	$364.26	$364.26
	656 MW	1603.8 MW	$288.99	$288.99	$342.57
	700 MW	1603.8 MW	$288.99	$288.99	$342.57
27-Jun-08	0 MW	1407 MW	$362.09	$362.09	$362.09
	578 MW	1576.7 MW	$289.00	$289.00	$345.76
	700 MW	1576.7 MW	$289.00	$289.00	$345.76

Table 19: Genesis Winter (FTR: North to South, Water Value: $350, Contract: 1100 MW at OTA)

	FTR	Generation	Prices		
		BEN	OTA	HAY	BEN
3-Nov-08	0 MW	1573.2 MW	$29.99	$29.99	$29.99
4-Nov-08	0 MW	1649.8 MW	$29.80	$29.80	$29.80
5-Nov-08	0 MW	1575.8 MW	$47.56	$47.56	$47.56
10-Nov-08	0 MW	1832.8 MW	$101.00	$101.00	$101.00
	600 MW	1993.6 MW	$75.71	$75.71	$9.83
	700 MW	2053.7 MW	$75.71	$75.71	$2.50

Table 20: Meridian Summer (FTR: South to North, Water Value: $10, Contract: 1400 MW at BEN)

	FTR	Generation BEN	Prices OTA	HAY	BEN
3-Nov-08	0 MW	1437.7 MW	$45.94	$45.94	$45.94
4-Nov-08	0 MW	1435.2 MW	$71.91	$71.91	$71.91
5-Nov-08	0 MW	1487.7 MW	$74.64	$74.64	$74.64
10-Nov-08	0 MW	1832.8 MW	$101.00	$101.00	$101.00
	642 MW	1919 MW	$75.71	$75.71	$11.40
	700 MW	1919 MW	$75.71	$75.71	$11.40

Table 21: Meridian Summer (FTR: South to North, Water Value: $40, Contract: 1400 MW at BEN)

	FTR	Generation BEN	Prices OTA	HAY	BEN
23-Jun-08	0 MW	1508.1 MW	$254.53	$254.53	$254.53
	561 MW	982.8 MW	$297.55	$868.62	$868.62
	940 MW	851.8 MW	$297.55	$10000.00	$10000.00
24-Jun-08	0 MW	1464.8 MW	$242.92	$242.92	$242.92
	705 MW	852.4 MW	$299.50	$868.59	$868.59
	940 MW	751.4 MW	$299.50	$10000.00	$10000.00
25-Jun-08	0 MW	1408.9 MW	$134.48	$134.48	$134.48
	599 MW	941.5 MW	$273.50	$868.54	$868.54
	940 MW	840.5 MW	$273.50	$10000.00	$10000.00
26-Jun-08	0 MW	1423.8 MW	$170.05	$170.05	$170.05
	660 MW	874.8 MW	$273.19	$273.19	$868.60
	700 MW	874.8 MW	$273.19	$273.19	$868.60
27-Jun-08	0 MW	1432.9 MW	$246.54	$246.54	$246.54
	610 MW	918.8 MW	$278.32	$278.32	$868.90
	700 MW	872.8 MW	$278.32	$278.32	$10000.00

Table 22: Meridian Winter (FTR: North to South, Water Value: $250, Contract: 1500 MW at BEN)

	FTR	Generation	Prices		
		BEN	OTA	HAY	BEN
23-Jun-08	0 MW	998 MW	$297.54	$297.54	$297.54
	485 MW	997.9 MW	$297.55	$297.61	$297.61
	940 MW	851.8 MW	$297.55	$10000.00	$10000.00
24-Jun-08	0 MW	944.2 MW	$289.00	$289.00	$289.00
	650 MW	852.4 MW	$299.50	$868.59	$868.59
	940 MW	751.4 MW	$299.50	$10000.00	$10000.00
25-Jun-08	0 MW	974.3 MW	$273.50	$273.50	$273.50
	457 MW	974.2 MW	$273.50	$273.51	$273.51
	940 MW	840.5 MW	$273.50	$10000.00	$10000.00
26-Jun-08	0 MW	930.2 MW	$268.00	$268.00	$268.00
	600 MW	880.8 MW	$273.19	$273.19	$315.09
	700 MW	874.6 MW	$273.19	$273.19	$870.17
27-Jun-08	0 MW	951.3 MW	$278.31	$278.31	$278.31
	506 MW	951.2 MW	$278.32	$278.32	$278.45
	700 MW	872.8 MW	$278.32	$278.32	$10000.00

Table 23: Meridian Winter (FTR: North to South, Water Value: $350, Contract: 1500 MW at BEN)

	FTR	Generation			Prices		
		OTA	HAY	BEN	OTA	HAY	BEN
23-Jun-08	0 MW	404 MW	377 MW	521.1 MW	$294.67	$324.45	$324.45
	-61 MW	404 MW	377 MW	663.8 MW	$288.99	$288.99	$288.99
	-940 MW	404 MW	377 MW	663.8 MW	$288.99	$288.99	$288.99
	129 MW	404 MW	377 MW	520.8 MW	$294.67	$324.53	$324.53
	940 MW	404 MW	121.7 MW	0 MW	$294.67	$1255.94	$1255.94
24-Jun-08	0 MW	404 MW	377 MW	524.2 MW	$295.60	$325.45	$325.45
	-105 MW	404 MW	377 MW	689 MW	$285.37	$285.37	$285.37
	-940 MW	404 MW	377 MW	689 MW	$285.37	$285.37	$285.37
	594 MW	404 MW	377 MW	84.1 MW	$295.60	$366.70	$366.70
	940 MW	404 MW	296.4 MW	0 MW	$295.60	$478.46	$478.46

Table 24: Contact Winter (FTR: North to South, Water Value: $250, Contract: 280 MW at OTA, 220 MW at HAY, 490 MW at BEN)

	FTR	Generation			Prices		
		OTA	HAY	BEN	OTA	HAY	BEN
23-Jun-08	0 MW	404 MW	377 MW	463.9 MW	$294.67	$337.74	$337.74
	-140 MW	404 MW	377 MW	464.3 MW	$294.67	$337.66	$337.66
	-940 MW	404 MW	377 MW	528.9 MW	$294.65	$294.65	$294.65
	34 MW	404 MW	377 MW	463.3 MW	$294.67	$337.89	$337.89
	940 MW	404 MW	121.7 MW	0 MW	$294.67	$1255.94	$1255.94
24-Jun-08	0 MW	404 MW	377 MW	463.9 MW	$295.60	$328.35	$328.35
	-247 MW	404 MW	377 MW	533.2 MW	$295.60	$295.91	$295.91
	-940 MW	404 MW	377 MW	533.2 MW	$295.60	$295.60	$295.60
	459 MW	404 MW	376.8 MW	463.3 MW	$295.60	$328.39	$328.39
	940 MW	404 MW	296.4 MW	0 MW	$295.60	$478.46	$478.46

Table 25: Contact Winter (FTR: North to South, Water Value: $350, Contract: 280 MW at OTA, 220 MW at HAY, 490 MW at BEN)

5.3 Cournot Game

In summer the equilibrium results are largely unchanged for water values between $10 and $40. In the winter periods the equilibrium results for water values of $250 and $350 are shown in Tables 26 and 27 below.

	FTR		Genesis	Contact			Price		
	Genesis	Contact	OTA	OTA	HAY	BEN	OTA	HAY	BEN
23-Jun-08	0 MW	0 MW	1481.6 MW	404 MW	377 MW	590.8 MW	$334.38	$334.38	$334.38
	940 MW	0 MW	1767 MW	404 MW	377 MW	521.1 MW	$289.69	$324.45	$324.45
	470 MW	470 MW	1767 MW	404 MW	377 MW	213.3 MW	$289.70	$478.44	$478.44
	0 MW	940 MW	1481.6 MW	404 MW	377 MW	590.8 MW	$334.38	$334.38	$334.38
24-Jun-08	0 MW	0 MW	1557.2 MW	404 MW	377 MW	562.8 MW	$325.45	$325.45	$325.45
	940 MW	0 MW	1767 MW	404 MW	377 MW	524.2 MW	$275.32	$325.45	$325.45
	0 MW	940 MW	1557.2 MW	404 MW	377 MW	562.8 MW	$325.45	$325.45	$325.45
	470 MW	470 MW	1727.5 MW	404 MW	377 MW	524.2 MW	$284.19	$325.45	$325.45
25-Jun-08	0 MW	0 MW	1390.8 MW	404 MW	377 MW	528.2 MW	$339.55	$339.55	$339.55
	940 MW	0 MW	1767 MW	404 MW	377 MW	527.9 MW	$241.06	$339.56	$339.56
	0 MW	940 MW	No EQM						
	470 MW	470 MW	1666.7 MW	404 MW	377 MW	527.9 MW	$271.29	$339.58	$339.58
26-Jun-08	0 MW	0 MW	1556.7 MW	404 MW	377 MW	565.9 MW	$340.05	$340.05	$340.05
	940 MW	0 MW	1767 MW	404 MW	351.8 MW	563.2 MW	$265.10	$340.06	$340.06
	0 MW	940 MW	1433.9 MW	404 MW	377 MW	688.7 MW	$340.05	$340.05	$340.05
	470 MW	470 MW	1757.9 MW	404 MW	351.8 MW	161.8 MW	$266.55	$478.35	$478.35
27-Jun-08	0 MW	0 MW	1514.1 MW	404 MW	377 MW	649.6 MW	$342.85	$342.85	$342.85
	940 MW	0 MW	1767 MW	404 MW	339.6 MW	645.3 MW	$259.28	$342.86	$342.86
	0 MW	940 MW	No EQM						
	470 MW	470 MW	1750 MW	404 MW	339.6 MW	243.9 MW	$270.05	$478.41	$478.41

Table 26: Cournot Winter – Water Value: $250 (FTR: North to South)

	FTR		Genesis	Contact			Price		
	Genesis	Contact	OTA	OTA	HAY	BEN	OTA	HAY	BEN
23-Jun-08	0 MW	0 MW	1428.7 MW	404 MW	377 MW	351.2 MW	$478.40	$478.40	$478.40
	940 MW	0 MW	1428.7 MW	404 MW	377 MW	351.2 MW	$478.40	$478.40	$478.40
	0 MW	940 MW	1428.7 MW	404 MW	377 MW	351.2 MW	$478.40	$478.40	$478.40
	470 MW	470 MW	1580.4 MW	404 MW	377 MW	213.6 MW	$404.41	$478.41	$478.41
24-Jun-08	0 MW	0 MW	1407 MW	404 MW	377 MW	280.6 MW	$363.01	$363.01	$363.01
	940 MW	0 MW	No EQM						
	0 MW	940 MW	1407 MW	404 MW	377 MW	280.6 MW	$363.01	$363.01	$363.01
	470 MW	470 MW	1407 MW	404 MW	377 MW	280.6 MW	$363.01	$363.01	$363.01
25-Jun-08	0 MW	0 MW	1387.7 MW	403.8 MW	377 MW	308 MW	$358.36	$358.36	$358.36
	940 MW	0 MW	1490 MW	404 MW	377 MW	369.7 MW	$289.00	$353.10	$353.10
	0 MW	940 MW	No EQM						
	470 MW	470 MW	1412 MW	404 MW	377 MW	95.9 MW	$299.55	$387.74	$387.74
26-Jun-08	0 MW	0 MW	1406.8 MW	404 MW	376.8 MW	272.2 MW	$478.40	$478.40	$478.40
	940 MW	0 MW	No EQM						
	0 MW	940 MW	1406.8 MW	404 MW	377 MW	272.2 MW	$478.40	$478.40	$478.40
	470 MW	470 MW	1563.2 MW	404 MW	377 MW	161.8 MW	$327.67	$327.67	$478.17
27-Jun-08	0 MW	0 MW	1407.1 MW	404 MW	377 MW	313.9 MW	$478.40	$478.40	$478.40
	940 MW	0 MW	No EQM						
	0 MW	940 MW	1407.1 MW	404 MW	377 MW	313.9 MW	$478.40	$478.40	$478.40
	470 MW	470 MW	1561.7 MW	404 MW	339.6 MW	243.9 MW	$322.89	$478.41	$478.41

Table 27: Cournot Winter – Water Value: $350 (FTR: North to South)

	FTR		Genesis	Contact			Price		
	Genesis	Contact	OTA	OTA	HAY	BEN	OTA	HAY	BEN
3-Nov-08	900 MW	0 MW	282.3 MW	404 MW	191.9 MW	657.7 MW	$975.11	$975.11	$121.45
	200 MW	700 MW	878.2 MW	0 MW	0 MW	689 MW	$975.10	$975.10	$73.72
4-Nov-08	900 MW	0 MW	198.5 MW	404 MW	107.9 MW	670 MW	$972.15	$972.15	$129.36
	200 MW	700 MW	1007.7 MW	199.6 MW	0 MW	688.8 MW	$42.01	$42.01	$42.01
10-Nov-08	900 MW	0 MW	220.2 MW	404 MW	218.4 MW	555.9 MW	$10000.00	$10000.00	$265.40
11-Nov-08	900 MW	0 MW	142.9 MW	404 MW	73.6 MW	599.7 MW	$10000.00	$10000.00	$255.17
	200 MW	700 MW	1130.3 MW	388.4 MW	0 MW	689 MW	$63.35	$63.35	$63.35
	550 MW	350 MW	664.4 MW	165.6 MW	0 MW	689 MW	$975.08	$975.08	$91.25
12-Nov-08	900 MW	0 MW	138.7 MW	578.1 MW	0 MW	689 MW	$10000.00	$10000.00	$103.23
	200 MW	700 MW	908.9 MW	0 MW	0 MW	689 MW	$670.60	$670.60	$103.23
13-Nov-08	900 MW	0 MW	185.6 MW	508.2 MW	0 MW	636.1 MW	$10000.00	$10000.00	$154.65
	200 MW	700 MW	1136.3 MW	383.4 MW	0 MW	689 MW	$61.72	$61.72	$61.72
	550 MW	350 MW	616.9 MW	283.9 MW	0 MW	689 MW	$750.03	$750.03	$101.47
14-Nov-08	900 MW	0 MW	220.6 MW	404 MW	129.7 MW	689 MW	$10000.00	$10000.00	$98.07
	200 MW	700 MW	1092.3 MW	295 MW	0 MW	689 MW	$45.30	$45.30	$45.30
	550 MW	350 MW	459.3 MW	295 MW	0 MW	689 MW	$10000.00	$10000.00	$98.07

Table 28: Cournot Summer (Additional Entries) (FTR: South to North)

	FTR		Genesis	Contact			Price		
	Genesis	Contact	OTA	OTA	HAY	BEN	OTA	HAY	BEN
23-Jun-08	740 MW	0 MW	1767 MW	404 MW	377 MW	480.4 MW	$289.70	$333.93	$333.93
	-200 MW	940 MW	1406.9 MW	404 MW	377 MW	372.8 MW	$478.40	$478.40	$478.40
	270 MW	470 MW	1563.7 MW	404 MW	377 MW	438 MW	$350.00	$350.00	$350.00
24-Jun-08	740 MW	0 MW	1557.2 MW	404 MW	377 MW	562.8 MW	$325.45	$325.45	$325.45
	-200 MW	940 MW	1557.2 MW	404 MW	377 MW	562.8 MW	$325.45	$325.45	$325.45
	270 MW	470 MW	1557.2 MW	404 MW	377 MW	562.8 MW	$325.45	$325.45	$325.45
25-Jun-08	740 MW	0 MW	1767 MW	404 MW	377 MW	527.9 MW	$241.06	$339.56	$339.56
	-200 MW	940 MW	No EQM						
	270 MW	470 MW	1618 MW	404 MW	377 MW	426.9 MW	$282.00	$348.21	$348.21
26-Jun-08	740 MW	0 MW	1767 MW	404 MW	351.8 MW	563.2 MW	$265.12	$340.06	$340.06
	-200 MW	940 MW	No EQM						
	270 MW	470 MW	No EQM						
27-Jun-08	740 MW	0 MW	1767 MW	404 MW	339.6 MW	645.3 MW	$259.28	$342.86	$342.86
	-200 MW	940 MW	No EQM						
	270 MW	470 MW	No EQM						

Table 29: Cournot Winter (Additional Entries) (FTR: North to South)

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