# A Critique of Wolak's Evaluation of the NZ Electricity Market:

## *The Incentive to Exercise Market Power with Vertical Integration and Transmission Loss**

Seamus Hogan[1] and Peter Jackson[2]

[1] Corresponding Author
Department of Economics
University of Canterbury
seamus.hogan@canterbury.ac.nz
(03) 364-2524

[2]Department of Management
University of Canterbury
sonofjack1@mac.com

**Abstract:**

This paper provides a critique of the 2009 report by Frank Wolak into the New Zealand electricity market that concluded that there had been a cumulative total of $4.3b (NZD) of overcharging over a period of seven years. We find that his conclusion that the market structure has given generators an incentive to exercise substantial market power is highly sensitive to some (unrealistic) assumptions made about the elasticity of demand and the extent of transmission loss, and that the observed correlations between estimates of that incentive and market price are also consistent with perfect competition.

Key Words: Wolak Report; electricity markets; market power.

JEL Codes: L41, L13

* This paper is part of a symposium of papers by the authors together with Graeme Guthrie and Lew Evans of Victoria University of Wellington that together provide a critique of the 2009 Wolak report into the wholesale electricity market in New Zealand. This paper, prepared for the NZAE 2010 conference focuses on the measurement of market power in the Wolak report

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## 1. Introduction.

In 2009, the Commerce Commission of New Zealand released a commissioned report by Professor Frank Wolak: An Assessment of the Performance of the New Zealand Wholesale Electricity Market (Wolak, 2009). This report was an analysis of the extent to which electricity generators in New Zealand have exercised unilateral market power to achieve wholesale electricity prices in excess of the levels that would result from perfect competition. The report concluded that there was evidence that generators have had an incentive to exercise unilateral market power, and evidence that they have exercised that market power. It also estimated a counterfactual benchmark of what prices would have been in the absence of market power and used this counterfactual to conclude that there had been a cumulative total of $4.3b (NZD) of overcharging over a period of seven years.

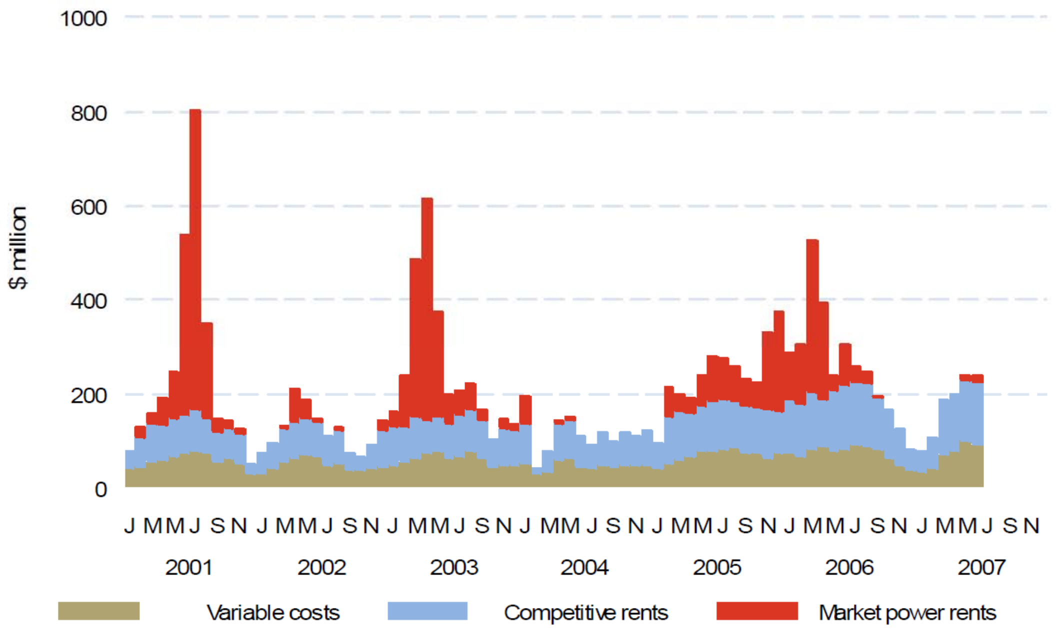
The Wolak report contains three broad strands of empirical evidence that generators have exercised unilateral market power in New Zealand. The first strand calculates empirically from the observed offers, the extent to which firms have had the ability and the incentive to exercise unilateral market power using standard oligopoly theory. The second strand uses regression analysis to estimate the extent to which those measures of market power can explain the observed price movements in the New Zealand wholesale market. Finally, the report uses direct estimates of firms' short-run marginal cost curves to calculate the extent to which market prices have exceeded marginal cost.

The estimate of $4.3b of overcharging is derived from this third strand of empirical analysis, and not surprisingly, this is the part of the report that has received most attention and criticism.[1] Figure 5.1 in the Wolak report, reproduced below, shows the calculation of the $4.3b. The bars in red are the total payments made to generators in excess of the estimated

[1] See, for example, Electricity Technical Advisory Group (2009), NZIER (2009), and University of Auckland (2009),

short-run marginal cost. The bulk of the $4.3b was obtained in during the three dry-year periods of high wholesale prices, in 2001, 2003, and 2006.

**Figure 5.12:** Decomposition of Wholesale Market Revenues, Counterfactual 2




**Source:** Calculations as described in text using offer data from Centralised Data Set and EMS, dispatch data from M-Co, and fuel price and usage data from Contact Energy, Genesis Energy and MED.

The consensus in the critiques of the report seems to be that the method used has likely led to an overstatement of the relevant marginal cost of production and hence an overstatement of the amount of market-power rents. These critiques, however, do not provide an alternative estimate of the rents, and so the other two strands of empirical evidence in the report acquire greater significance and are worth of analysis. This paper and the parallel paper, Evans and Guthrie (2010), seek to do this. Evans and Guthrie consider the regression evidence in relating market power to prices. In this paper we discuss the estimates of market power themselves.

In the following section, we briefly outline the basis of the various criticisms of the direct-estimation of market rents in the Wolak report. In Section 3, we describe the report's estimates of the ability and incentive for firms to exercise market power. In Section 4 we suggest some reasons why these estimates are likely to be overstated.

## 2. The Direct Estimate of Market Rents.

In order to estimate the extent to which firms have been exercising market power in dry years, it is necessary to establish a counterfactual for how much prices would have risen in those years due to the normal interaction of supply and demand in a competitive market. The Wolak Report's method for estimating this perfectly competitive benchmark has been subject to four main criticisms: that the short-run marginal cost is the wrong benchmark for identifying the perfect-competition counterfactual; that measures of excess capacity ignored the importance of ancillary services; that the report incorrectly measured the opportunity cost of fuel in thermal stations and water in hydro stations; and that the report's assumption of zero elasticity of demand is inappropriate.

We will briefly address each one of these in turn.

### *2.1 Short-Run Marginal Cost.*

When the New Zealand Electricity Market was formed in 1996, the philosophy of the market design was to balance the sometimes conflicting goals of short run and long run efficiency, while providing security of supply resembling a 1 in X dry year standard. After much deliberation it was decided to implement an energy-only, or single-payment, market. In such a market investors must not only variable costs, but fixed costs also, from a single payment for energy. An energy-only payment equal to short-run marginal cost can never provide a market return on the marginal capital cost of plant. This is particularly so in an industry like electricity with seasonal fluctuations in both supply and demand in which the marginal unit of capacity is likely only to be needed in high-demand periods in dry years. High prices during these periods will be a necessity to pay for that marginal capacity and provide an incentive for investment in new capacity.

This logic implies that the perfectly competitive benchmark prices will be at the point at which demand intersects a vertical supply curve at the point of full capacity. The argument for using short-run marginal cost in the Wolak report was that, at all times in the period of the data being considered, total output from all power stations was considerably less than the implied capacity derived by considering the sum of the maximum output of each individual station over the period in question. This conclusion of permanent excess capacity ignores two additional factors.

*2.2 Ancillary Services.*

The New Zealand wholesale market combines a market for power, and a market for "ancillary reserves", which is a planned excess capacity kept available for generation at short notice in case of a fault in the transmission network. Ancillary reserves are not so important in countries with two-dimensional networks and a larger number of power stations, but they are are particularly important in New Zealand because of the one-dimensional high-voltage direct current (HVDC) link connecting the North and South Islands. In the event of a failure of the HVDC, it is important that there be enough ancillary reserves in the island to which power if flowing in order to prevent cascading failure. Since power sometimes flows north and, less frequently, south, the amount of capacity kept in reserve for ancillary services will fluctuate over time between North Island and South Island stations.

*2.3 Opportunity Cost of Fuel and Water.*

The Wolak Report's perfectly-competitive benchmark assumed that the opportunity cost of fuel used in thermal power stations is simply the replacement cost of that fuel, and that the opportunity cost of water in a hydro station is the highest value in a season of the thermal-station, short-run marginal cost calculated using the fuel replacement cost. Both assumptions can be questioned. New Zealand is not situated close to ready sources of fuel. Because of "take or pay" contracts, thermal stations are not able to access significantly more or less fuel according to the particular hydrological outcome of the year, and so need to husband their fuel reservoirs with an associated opportunity cost of use that exceeds simple replacement cost. Similarly, hydro stations need to take account of the option value of a limited reservoir of water in a dry year, taking into account uncertainty about hydrological inflows and demand patterns. The *ex post* realised market prices throughout the winter is not a reliable measure of the true opportunity cost of water at any point in time given the information available at that time. For a fuller discussion of this point, see Evans and Guthrie (2009).

*2.4 Elasticity of Demand.*

Even if it were the case that short-run marginal cost could be estimated from the replacement cost of thermal station fuel, and that there was permanent excess capacity in the New Zealand market, short-run marginal cost would still not be the appropriate benchmark if demand were to exceed capacity in a dry year at that price. The Wolak report assumed away this possibility by assuming that demand is perfectly inelastic. This is a reasonable assumption for the describing the performance of the market in the very short term. The market operates by sellers submitting supply offers every half-hour, buyers simply drawing as much power as they wish, and the market price being realised ex post to equate demand to aggregate supply. By definition, this demand is insensitive to price. Over a period of several weeks or months in a dry year, however, demand can and does respond to increases in the wholesale price. This arises through three mechanisms: First, there is a small percentage of the final demand that buys directly from the wholesale market and so has an incentive to reduce demand when prices rise; second, retail companies offer financial incentives to customers to reduce demand; and third, the threat of supply shortages associated with the high prices lead to government-sponsored conservation campaigns.

The non-zero medium term elasticity of demand with respect to wholesale prices is also an important factor in indirect measures of market power considered in the sections below.

*2.5 Summary.*

The four critiques above overwhelmingly point in the direction that the estimate of market power in the Wolak report is too high, but they don't provide an alternative measure. There still remains the other strands of empirical evidence in the report that are also consistent with the high prices in dry years being the result of market power.

This leads the authors of the NZIER discussion document prepared for the *Major Electricity User's Group* (NZIER, 2009), to comment:

> *Wolak's analysis has drawn a lot of criticism, not all of it valid. Most criticisms have been directed at the way in which he constructs competitive benchmark prices and thereby estimates market power rents. Criticism of this additional step in his analysis does not detract from the earlier steps in his methodology of examining the slopes of residual demand curves to determine ability and incentive to influence market clearing prices. This basic methodology is well-established and widely recognised and applied worldwide to assess competition in short-term wholesale markets.*

In the remainder of this paper, we turn our attention to these measures of the ability and incentive to exercise unilateral market power.

## 3. Measures of the Ability and Incentive to Exercise Unilateral Market Power.

In this section, we present the theory for how one can infer from market data on firms' offer curves, each firm's ability and incentive to inflate wholesale prices by overstating the prices at which they would be willing to supply given quantities.

Consider first, a simple Cournot model with no transmission loss and no vertical integration. Let $S_j(p)$ be the offer curve (supply) submitted by generator *j*, and let the demand curve be *D*(*p*). The residual demand curve, $R_i(p)$, facing firm *i* gives the quantity that firm *i* would need to supply into the market to produce a market price of *p*, taking the demand curve and the offer curves of the remaining generators as given. That is

$$R_i(p) = D(p) - \sum_{j \neq i} S_j(p).$$

Let $c_i(q_i)$ be firm *i*'s cost of supplying $q_i$ units of output. Firm *i*'s profit maximisation problem then is

$$\underset{p}{Max} \quad pR_i(p) - c_i(R_i(p)),$$

for which the first-order condition is

$$(p - c_i')R_i'(p) + R_i(p) = 0.$$

This equation can be re-written as

$$p = c_i' + 100\eta_i, \tag{1}$$

where

$$\eta_i = -\frac{R_i(p)}{100R_i'(p)}. \tag{2}$$

The term, $\eta_i$, is what the Wolak report terms an "inverse semi-elasticity". It measures the amount by which a generator could increase price by withholding 1% of its supply from the market and so is a measure of the market-power of a single firm. In the case where firms have no fixed-price forward contracts, as shown by Equation (1), it is also a measure of the incentive of a firm to withhold supply in order to push price higher than marginal cost.

If firms do have a commitment to sell a certain amount of power at a fixed price determined prior to submitting supply offers into the market, then, while $\eta_i$ still reflects a firm's *ability* to exercise market power, the incentive to do so is mitigated by the extent to which it needs to be a buyer in the wholesale market in order to meet its fixed-price obligations. To show this, let generator *i*, have fixed-price forward contracts to sell a quantity, $Q_i$, of power at an average price of $\overline{p}$.[2] In this case, the firm's optimisation problem becomes

$$\underset{p}{Max} \quad pR_i(p) - c_i(R_i(p)) + (\overline{p} - p)Q_i, \tag{3}$$

and the associated first-order conditions and semi-elasticity mark-up rule become

$$(p - c_i')R_i'(p) + (R_i(p) - Q_i) = 0, \text{ and}$$

$$p = c_i' + 100\eta_i \cdot \delta_i, \tag{4}$$

where

$$\delta_i = \frac{R_i(p) - Q_i}{R_i(p)}.$$

The mitigation term, $\delta_i$, gives the extent to which fixed-price forward obligations reduce the incentive to exercise market power. In the special case where the generator will supply exactly the same quantity of power as its forward obligation, the mitigation is 100% and the optimal quantity will be such that price equals marginal cost. If its forward obligations are greater than its quantity supplied, the incentive is to expand output to force price below marginal cost.

## 4. Potential Modifications to the Measures.

The theory laid out in the previous section replicates, with slight notation changes, that presented in the Wolak report. Of course, the theory describes the incentives facing firms in a very simple model that abstracts away from many features of the actual New Zealand electricity market. Given the complicated nature of that market, simplification is necessary to get a tractable model, but there are two aspects of reality in particular that, if not considered, will lead to a biasing up of the estimates of $\eta_i$ and $\delta_i$ and consequently of the estimates of the incentive to exercise market power. The first concerns the impact of the elasticity of demand for wholesale-market electricity on the calculation of $\eta_i$, and the second concerns the impact of transmission loss on the formula $\delta_i$.

[2] Since $\overline{p}$ has no effect on the firm's offer strategy, it doesn't matter whether all its fixed-price obligations are at the same price, or contract-specific prices.

*4.1 The impact of demand elasticity on market power*.

As noted in Section 2, the Wolak report assumes that demand is perfectly inelastic. This is a perfectly sensible assumption for the short-run elasticity, and so might accurately represent the market power that could result from, say, a failure in the transmission network. When prices are consistently high over a period of weeks or months, however, the market does contain mechanisms by which load can respond to price incentives. That is, generators looking to exploit market power over longer periods, may well face perfectly inelastic demand curves in the very short-run of a single 30-minute pricing period, but they must also take into account the impact that persistent high prices will have on that inelastic short-run demand curve over time.

This is particularly pertinent in assessing measures of market power. Although a small amount of demand elasticity will not have much impact on the semi-elasticity most of the time, it can have a very large impact when the semi-elasticity is very high. To see this, imagine that we have an estimate of the market-power elasticity, $\hat{\eta}_i$, made under the assumption that demand elasticity is zero when the absolute elasticity is in fact positive. Note that

$$-R_i'(p) = \sum_{j \neq i} S_j'(p) - D'(p).$$

We therefore have

$$\eta_i = \frac{R_i(p)}{100(\sum_{j \neq i} S_j'(p) - D'(p))} \tag{5}$$

while

$$\hat{\eta}_i = \frac{R_i(p)}{100 \sum_{j \neq i} S_j'(p)}. \tag{6}$$

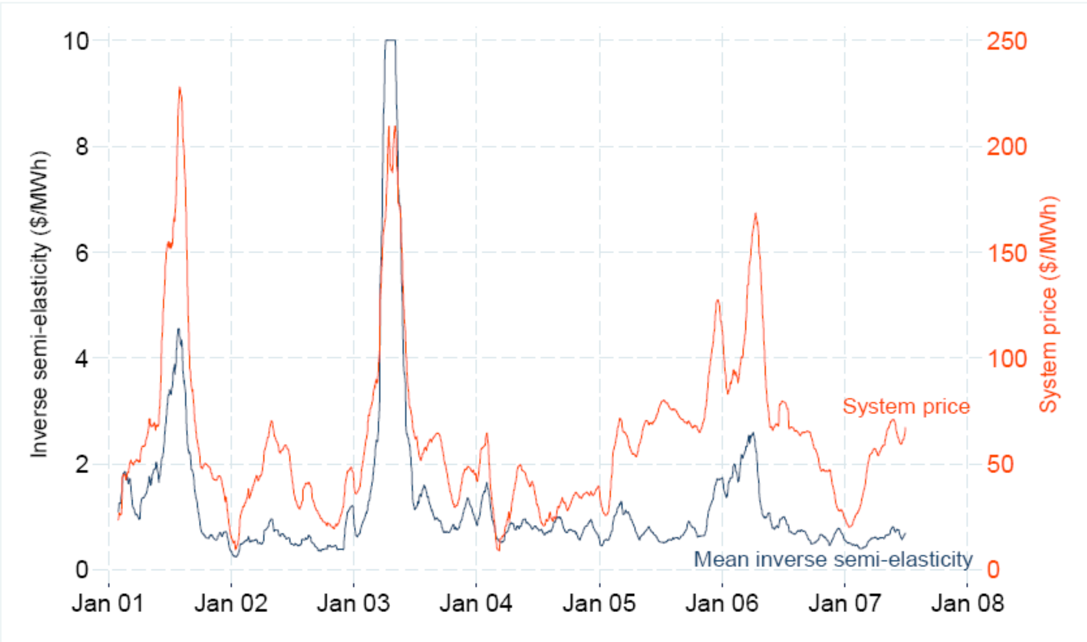
Putting Equation (6) into (5) gives

$$\eta_i = \frac{1}{\frac{1}{\hat{\eta}_i} + \frac{\varepsilon 100 \theta_i}{p}},$$

where $\varepsilon = -pD'(p)/D(p)$ is the absolute elasticity of demand and $\theta_i = D(p)/R_i(p)$ is the inverse of firm *i*'s market share.

Now consider Figure 4.5 from the Wolak report, reproduced below. The highest average (across all generators) value for the estimated inverse semi-elasticity, $\hat{\eta}_i$, is 10, which occurred at the peak of the dry-year price-spike of 2003. That corresponded to a market wholesale price of 200. If we generously assume an inverse market share of $\theta_i = 4$, then a demand elasticity as low as $\varepsilon = 0.05$ would be enough to lower the true inverse semi-elasticity from 10 to 5.

**Figure 4.5:** Mean inverse semi-elasticities and system price, 30-day rolling average




*4.2. The Impact of Transmission Loss on the Incentive to Inflate.*

The model presented in Section 2 describes a network with no transmission loss. In reality, firms supply power to "injection points" on the national grid, and demanders in the wholesale market purchase power from "exit points". The offers of generators are offers to supply a quantity of electricity at the injection point at the specified prices, whereas the prices paid by buyers refer to the quantity taken at the exit points. With transmission loss along the grid, the total quantity supplied at injection points will exceed that demanded at exit points, with a corresponding differential in the prices.

To see how this can affect the empirical estimates of the incentive to inflate, consider a slight modification to the model of Section 2, by considering a two-node system in which all generators supply at one node, and demanders purchase at the other. Further, assume that a fraction, $\lambda$, of the energy supplied is lost in transmission.

Let $S(p^s)$ be the total energy supplied at the injection node as a function of the price received by sellers, and let $D(p^d)$ be the total energy demanded at the exit node, as a function of the price paid by buyers. Equilibrium in this market requires that the energy supplied is enough to meet demand taking into account the transmission loss,

$$D(p^d) = (1-\lambda)S(p^s), \tag{7}$$

and that the prices are such that total payments equal total receipts,

$$p^d D(p^d) = p^s S(p^s). \tag{8}$$

Equation (7) into (8)gives

$$p^d = \frac{p^s}{1-\lambda},$$

and the modification to Equation (3) to account for transmission loss is

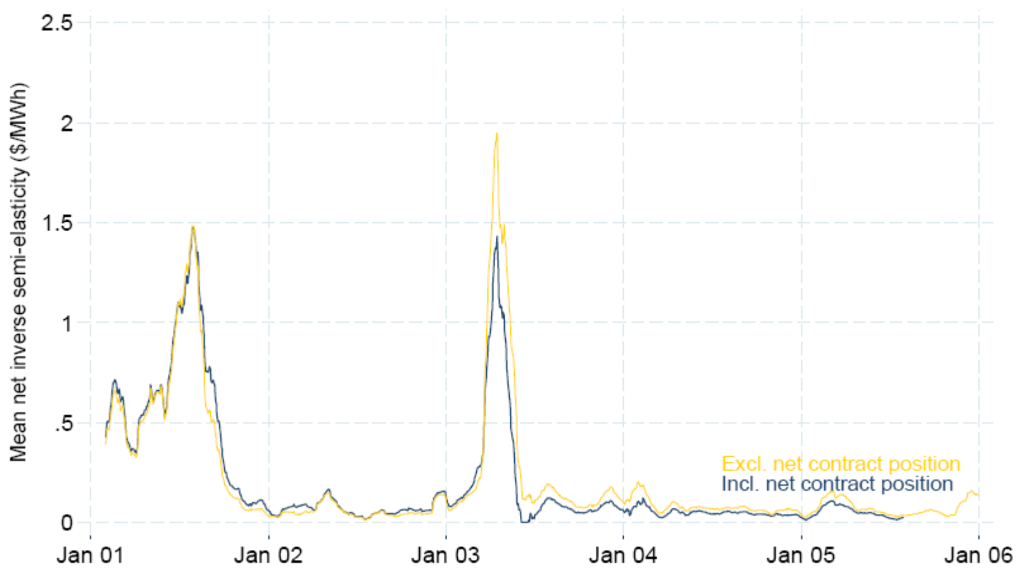
$$\underset{p^s}{Max} \quad p^s R_i(p^s) - c_i(R_i(p^s)) + (\overline{p} - p^s/(1-\lambda))Q_i,$$

for which the first-order condition is

$$\begin{aligned} p &= c_i' + \frac{R_i(p)}{R_i'(p)} \cdot \frac{R_i(p) - Q_i/(1-\lambda)}{R_i(p)} \\ &= c_i' + 100\eta_i \cdot \frac{\delta_i - \lambda}{(1-\lambda)}. \end{aligned} \tag{9}$$

To get a sense of how important transmission loss might be, consider Figure 4.8 below, again reproduced from the Wolak report. Again, we focus on the dry-year price spike in 2003. The mean net inverse semi-elasticity at the peak, taking into account both vertical integration and generators' fixed-price forward contracts, is approximately 1.5. Recall from the previous graph that the mean inverse semi-elasticity was 10. That is, we have mean values of $\overline{\eta} = 10$ and $\overline{\eta}\overline{\delta} = 1.5$, and so can infer a mean value of $\delta_i$ of approximately 0.15.

**Figure 4.8: Mean net inverse semi-elasticities with and without forward contracts**




**Source:** Calculations based on offer and generation data from Centralised Data Set and EMS, firm-level settlement data from EMS, dispatch data from M-Co, and contract data from individual firms.

Transmission loss is estimated to average approximately 6.5% to 7.5%. Although some of this loss will come in the lines connections between generators and the grid, and between the grid and final users, it is also the case that transmission loss is greatest when load is high, particularly when the flow on the HVDC is high, which are also the times which put the most demand pressure on price. In other words, the extent to which estimates of the incentive to exercise market power that do not take into account transmission loss are likely to be most overstated are the periods when prices will have a tendency to spike even in the absence of market power.

*4.3. Implications for Estimates of Overcharging.*

The Wolak report's estimate of $4.3b of market rents earned from the exercise of unilateral market power came mostly from the three high-price periods, in 2001, 2003, and 2006, respectively. The estimation method assumed that true marginal cost was not significantly higher in those periods, and so all of the price increases could be attributable to market power.

This is consistent with the estimates of the market-power incentive shown in the Report's Figure 4.8. For instance, in the 2003 price spike, a net inverse semi-elasticity of 1.5 implies that profit-maximising generators would have been setting prices approximately

$150/MWh above marginal cost. As can be seen in Figure 4.7, this is roughly the same amount that prices at the peak were above the mode.

The adjustments suggested in this section, however, could imply a very different interpretation of the high prices. It is beyond the scope of this paper empirically estimate the appropriate demand elasticity and relevant transmission loss, but the theoretical analysis does suggest the degree to which the estimates are sensitive to assumptions.

For instance, a transmission loss of 10% and an elasticity of demand of 0.1 would generate a net inverse semielasticity of only 0.2 a figure that would be consistent with only $20/MWh of the price spike being the result of the exercise of market power.

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