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PRICING THE OUTPUTS OF THE NEW ZEALAND ELECTRICITY INDUSTRY

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Abstract

The work discussed in this paper was undertaken as part of the redevelopment of our Producer Price Indexes in 1996 and 1997.

The New Zealand Producer Price Indexes are a suite of base weighted Laspeyres indexes which are published quarterly. Input indexes are produced for all industries in the economy and output indexes are produced for all market industries. All transactions have a weight in the indexes. That is, the indexes are produced on a gross basis - transactions between enterprises in the same industry are not netted out. For example, the electricity outputs index includes sales of bulk electricity by generators to power companies as well as sales by power companies to final consumers.

Introduction

This paper outlines the methods used to price the outputs of enterprises belonging to the electricity industry in New Zealand. The International Standard Industrial Classification (ISIC) classifies to the electricity industry those enterprises involved in the "production, collection and distribution of electricity." The work discussed in this paper was undertaken as part of the redevelopment of our Producer Price Indexes in 1996 and 1997.

The New Zealand Producer Price Indexes are a suite of base weighted Laspeyres indexes which are published quarterly. Input indexes are produced for all industries in the economy and output indexes are produced for all market industries[1]. All transactions have a weight in the indexes. That is, the indexes are produced on a gross basis - transactions between enterprises in the same industry are not netted out. For example, the electricity outputs index includes sales of bulk electricity by generators to power companies as well as sales by power companies to final consumers[2].

2 The structure of the New Zealand electricity industry

The base period of the electricity indexes is the December 1996 quarter. In this section of the paper I describe the structure of the electricity industry as it was at that time. I will refer to changes that have occurred in the interim if they impact on the methodology I have used. The major influence on industry structure over the last decade has been government policy.

The electricity industry in New Zealand has never been vertically integrated. For most of this century central government operated the power stations and the high voltage transmission network (also known as the national grid) while local government operated the low voltage local networks that supply electricity to businesses and households.

At the present time the majority of power stations in New Zealand are still owned by the state and the national grid is operated by a state owned company called Trans Power. There are 30 power companies supplying final consumers. While all these companies are limited liability enterprises ownership structure varies. Some are 100 percent owned by local government, others are owned by consumer trusts while the remainder are at least partly owned by private and institutional investors who can trade their shares on the New Zealand stock exchange. American and Canadian investors have sizeable share holdings in some of the listed power companies.

A wholesale electricity market has been operating since 1996. Most of the electricity consumed in New Zealand is purchased by power companies through the wholesale market.

2.1 Generators

Two companies owned by the government generate 90 percent of New Zealand's electricity[3]. Hydro power stations produce 70 percent of our electricity, gas 20 percent, geothermal 5 percent while the remaining 5 percent is generated using other energy

[1] "Input" refers to any transaction that is classified as intermediate consumption. "Output" refers to any transaction that is classified as gross output.

[2] See section 0 for the electricity industry outputs regimen.

[3] The Electricity Corporation of New Zealand (ECNZ) generates 70 percent of New Zealand's electricity while Contact Energy generates 20 percent.

sources[4]. The output of the hydro power stations varies from year to year according to water levels in the dams. Hydro power stations are utilised whenever possible because the marginal cost of generation is less but during times of drought it is necessary to increase gas generation significantly.

The government wants to reduce its involvement in the construction of power stations and one of the aims of its reforms is to encourage investment in new generation by the private sector. This was an important reason for the formation of the wholesale market (see section 0). The proposed split of the Electricity Corporation of New Zealand (announced in April 1998) into three "baby" generators is meant to encourage investment in generation by ensuring that no single company is able to behave in an anti-competitive manner.

2.2 Trans Power

Trans Power is the state owned company that operates the national grid; it is responsible for the successful functioning of the national electricity system. Trans Power tells generators when it wants them to provide spinning reserve or reactive support and it tells power companies when it wants them to reduce demand by cutting off interruptible load[5].

While the government wants a reasonable rate of return on its assets it is equally important that as a natural monopoly Trans Power be equitable and efficient in its dealings with generators and power companies. Trans Power obtains its revenue by charging power companies and generators for transmission services using complicated formulae (see section 0).

2.3 Power companies

Power companies supply electricity to final consumers via low voltage local networks. They purchase electricity from the wholesale market and on sell it to final consumers. They pay Trans Power for transmission services. Most power companies have hedge contracts with generators to protect themselves from fluctuations in the spot price on the wholesale market. Many companies have forward cover for more than 80 percent of their expected electricity purchases. There are currently 30 power companies in New Zealand; the five largest between them sell more than 60 percent of our electricity.

In April 1998 the government announced a radical programme of reform which will see all power companies split into two separate businesses by 31 December 2003. The network operation activity (which is a natural monopoly) and the electricity retailing

[4] Coal generation accounts for about 3 percent of the total with biogas, industrial waste, wood and wind generation accounting for the rest.

[5] These terms refer to processes that are essential for maintaining the stability of the system.

Spinning reserve refers to generating capacity that is not needed but is able to be accessed by Trans Power within milliseconds if demand for electricity rises.

Reactive support is required from generators when there is sufficient current available but insufficient voltage differential to drive the current.

Calling on interruptible load is a technique used to manage demand. If demand threatens to exceed supply Trans Power will ask a power company to reduce its load in return for a discount on transmission fees. The power company will shut off supply to customers who have agreed in advance that this may be done in return for cheaper electricity.

activity[6] (which is competitive) must be under separate ownership. The government wants consumers to be able to choose between competing electricity retailers. The light-handed regulatory regime implemented in 1994 has not been successful because power companies have used anti-competitive pricing practices to prevent competitors from selling electricity in their network.

2.4 The wholesale electricity market

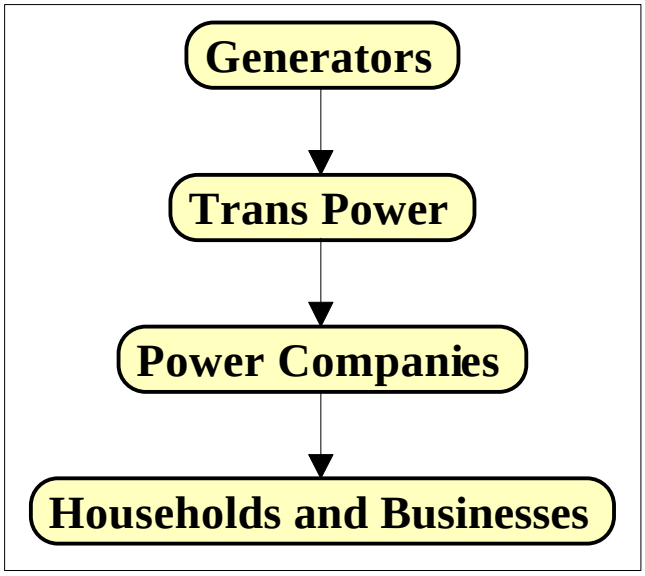
The wholesale electricity market has been operating since 1996. Power companies purchase most of their electricity on the wholesale market; some small generators have fixed price contracts with a power company rather than allowing the price to be set by the wholesale market.

The price of electricity varies according to the time of day, the time of year and the day of the week. For the purposes of the wholesale market electricity is regarded as a different commodity in each half hour period of the day. Each day generators provide the market with a supply curve for each of the 48 half hour periods in the day and similarly power companies provide a demand curve. The supply and demand curves received from each participant are aggregated and a single ex ante price is determined for each period. However, the final spot price is not determined until after the completion of the period. If power companies have underestimated their demand the ex post price is higher than the ex ante price.

In the first few months of operation of the wholesale market there were several price spikes caused by power companies underestimating their demand. If the generators have steep supply curves a small increase in quantity demanded can result in a large increase in price.

The spot price fluctuates but as noted in section 0 most power companies hedge their wholesale market purchases to a significant degree. The generators and power companies settle hedge contracts at the end of each month.

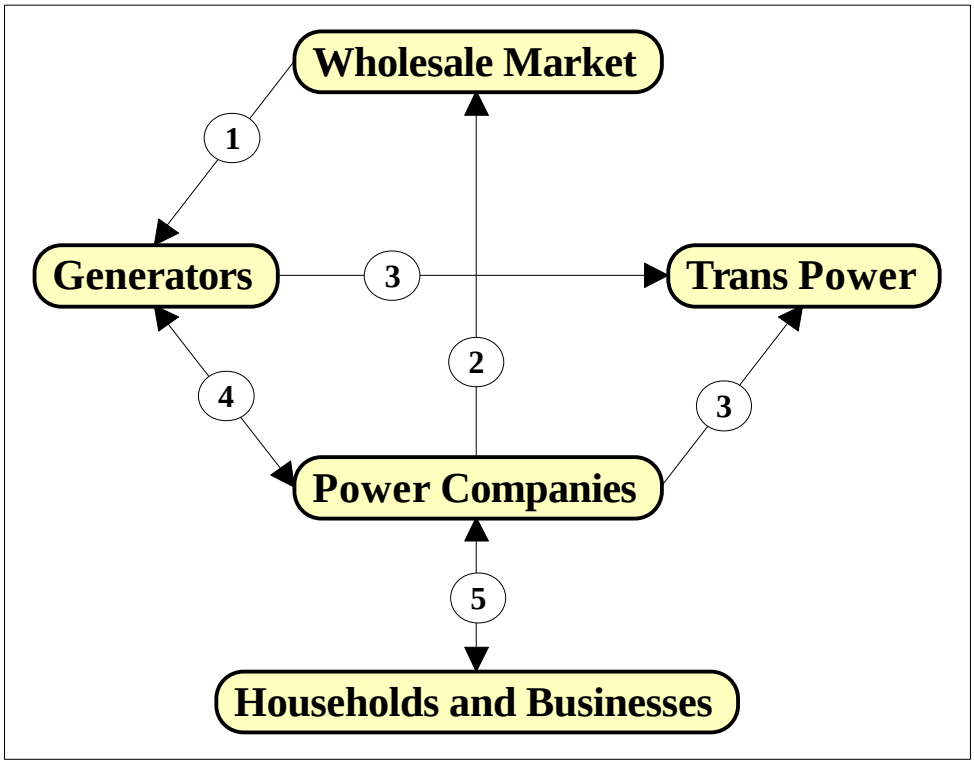
2.5 The flow of electricity



[6] Power companies are involved in two main activities. Network operation means managing the assets and operating and maintaining them. Electricity retailing means buying and selling electricity, invoicing, marketing etc.

2.6

The flow of money



(1) EMCO (the company that runs the wholesale market) pays the generators each month. The payment is equal to:

$$\sum_{i=1}^{1440} \text{Price}_i * \text{Volume}_i$$

a) Price_i is the spot price paid in period i, expressed in c/kWh.

b) Volume_i is the volume of electricity sold in period i, expressed in kWh.

c) Each day is divided into 48 half hour pricing periods. In a 30 day month there are 1440 pricing periods.

(2) Power companies pay EMCO each month for the electricity they purchase.

(3) The generators and power companies pay Trans Power for the transmission of electricity.

(4) The generators have hedge contracts with power companies. At the end of each month these hedge contracts are settled. If the average spot price for the month was greater than the forward price then the generator will refund the difference to the power company. If the average spot price was less than the forward price the power company will refund the difference to the generator.

(5) Households and businesses pay power companies for their electricity. Many power companies are owned by electricity consumers. These consumers receive dividends from the power company. The dividend can be in the form of a rebate or by way of interim and final dividends.

3

The pricing methodologies

3.1 Generators

ECNZ and Contact Energy generate 90 percent of New Zealand's electricity. Most of the remaining 10 percent is produced by power companies who own small power stations. A small amount is produced by businesses with cogeneration plants. I did not attempt to price electricity generated by power companies as most of it is sold directly to final consumers i.e.there is a small degree of vertical integration in the New Zealand electricity industry.

ECNZ and Contact Energy sell their electricity through the wholesale market. However, as the level of hedging is so high (about 80 percent) I decided that the best way to price sales of bulk electricity was to ask ECNZ and Contact Energy for the average quarterly price received per kW/h after settlement of hedge contracts. Obtaining an average of wholesale market spot prices could be misleading given the high level of hedging by most power companies.

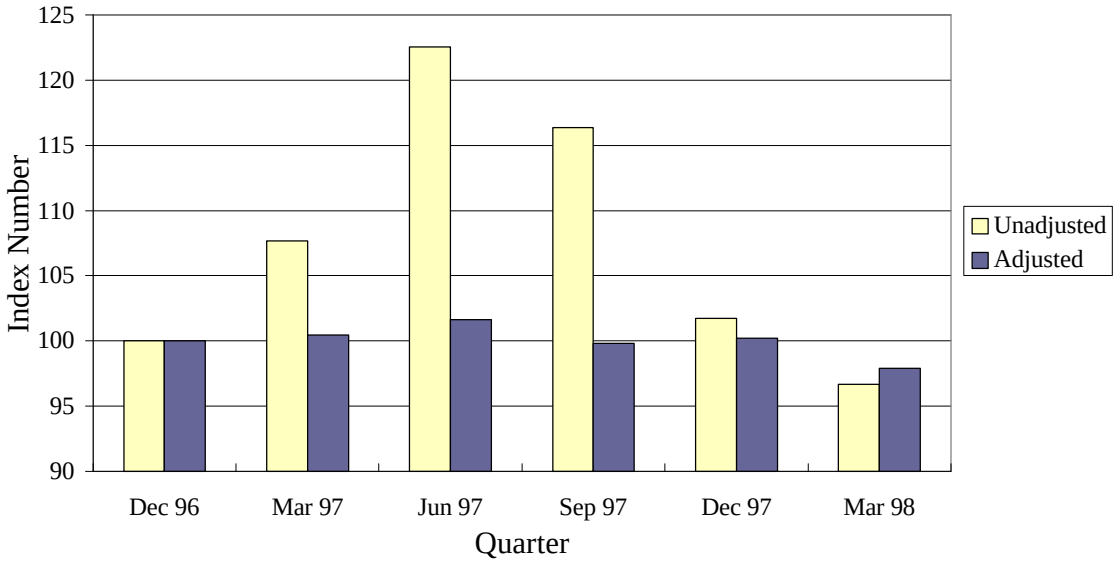
The prices collected each quarter from ECNZ and Contact Energy do not feed directly into the PPI. While the PPI is not seasonally adjusted using a package such as X-12-Arima certain commodities are adjusted on an ad hoc basis. Bulk electricity prices are adjusted by calculating a four quarter moving average. Quarterly weights were obtained by averaging sales for each quarter in the three years to December 1996.

Sales by Generators

Quarter	NZ$million	percent
March	316	22
June	388	27
September	416	29
December	316	22
	1,436	100

The high sales in the winter quarters (June and September) result from both price and volume increases. The seasonality in price can be seen in the graph on the following page. Demand for electricity increases in winter as households and businesses use more electricity for heating. Price increases in the winter months mainly because more electricity has to be generated using the more expensive gas power stations. The increase in demand in winter coincides with low lake levels in the South Island hydro dams. Hydro generation is greatest in spring and early summer as the snow melts in the Southern Alps.

The Output of Generators



3.2 Trans Power

As a government owned monopoly Trans Power's brief is not merely to maximise profits. Behind many of the reforms of the last decade has been a desire by government to foster competition in the potentially competitive areas of generation and electricity retailing. As all power companies and most generators are connected to the national grid Trans Power's modus operandi is critical to the successful functioning of the electricity system. It must treat all its customers fairly and use its assets efficiently rather than just charging what it can get away with.

Trans Power manages valuable assets and through its pricing it wants to ensure that these assets are used efficiently. Trans Power uses pricing signals to force power companies to manage demand so that existing assets are fully utilised before new transmission lines and substations are built.

Trans Power offers power companies a choice of two contracts.

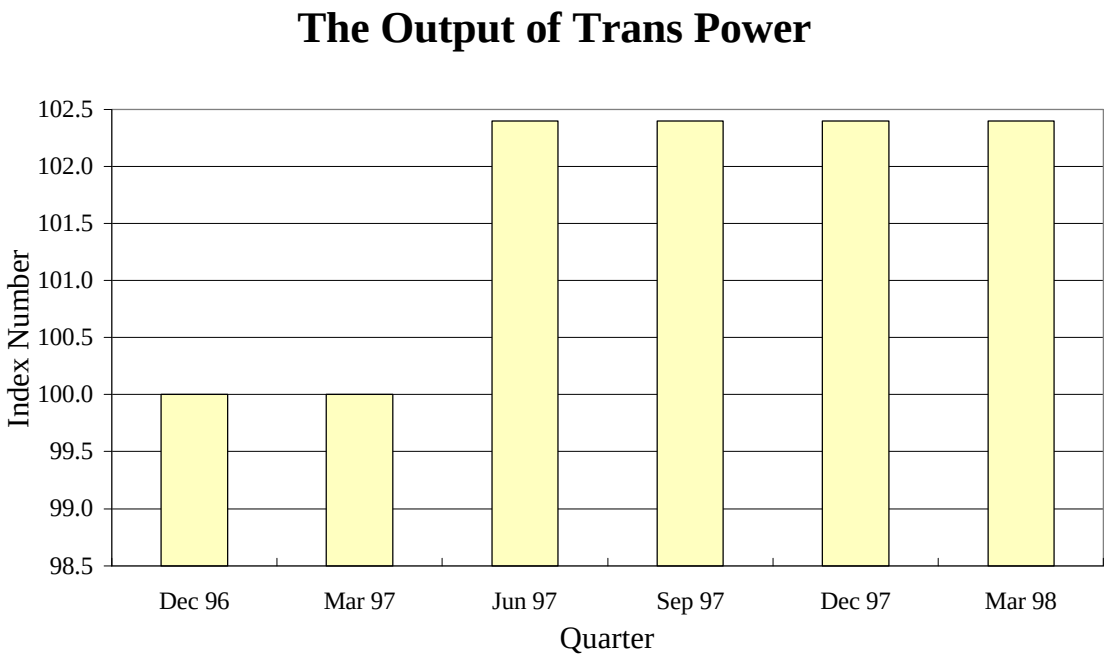
1) A power company choosing the first option nominates a demand level (in MW) that it may not exceed in any half hour period. The lower the nominated level the lower the contract price. However, if this level is exceeded in any half hour period the power company must pay for transmission services at the new rate for the next 12 months.

2) A power company choosing the second option nominates a demand level that it may exceed at any time on payment of a penalty.

The first option suits power companies that are good at managing their load. The second option suits power companies that are unable to accurately predict their network loads for all half hour periods. Option one is significantly cheaper than option two. However, a single lapse in demand management will mean higher transmission costs for the next year. The optimal strategy for companies choosing option two is to exceed their nominated load in about 400 half hour periods each year

This pricing system was set up while I was constructing the index. I had neither the time nor the expertise to develop a technically sophisticated pricing method for transmission services. However, I found that the contracts were adjusted on 1 April each year according to movements in an underlying inflation index produced by the Reserve Bank.

Therefore, I chose this index to represent movements in the price of transmission services, as illustrated in the graph below.



3.3 Power companies

New Zealand power companies sell 54 percent (by value) of their electricity to businesses and 46 percent to households. The CPI prices sales to households so my task was to price sales to businesses. Electricity prices can be tracked over time by calculating an average price in c/kWh (the method I used for pricing bulk electricity) or by using model customers. In order to price a model customer the following must be specified:

- Electricity used (kWh) by time of day and by day of week
- Monthly half hour peak load (kVA)
- Capacity requirement (kVA)
- Whether any of the load is interruptible
- Location of the load (if the price charged depends on the location of the customer)

To price sales of electricity to businesses I chose the model customer approach. The following cases illustrate my reasons for adopting this method.

Case 1: Assume a new factory opens in Christchurch. This factory operates 24 hours a day but organises its workflow so that electricity intensive production processes occur in the early hours of the morning. From 12am to 6am Southpower adds its normal margin to energy and transmission charges but only bills the factory a fraction of the day rate for the use of its network. Southpower does this because it has spare capacity from 12am to 6am and wants to encourage a more balanced use of its network.

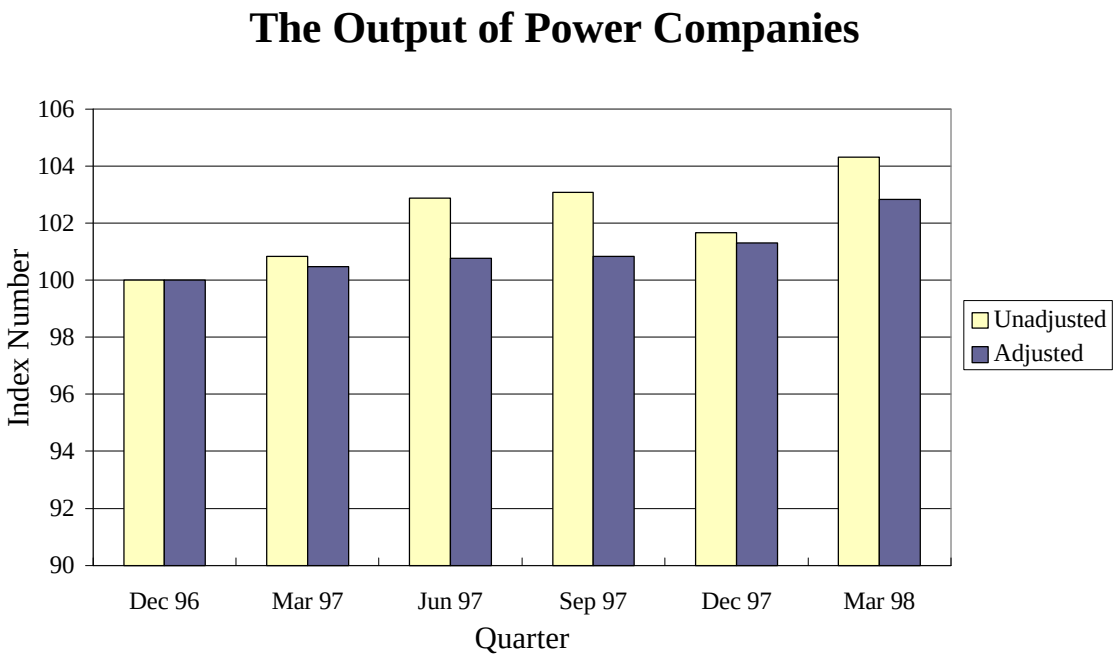
Case 2: Assume a similar increase in electricity consumption to Case 1 but this time caused by population growth and a related increase in the number of shops and offices in Christchurch. In this case demand for electricity during peak times will increase as the new businesses and residents will simply add to existing consumption patterns. In order to satisfy the increase in demand at peak times Southpower must invest in more substations, transformers and power cables even though the extra capacity may only be required on especially cold winter afternoons and evenings. To pay for this investment Southpower raises power prices.

Conclusion: The average price of electricity is very dependent on the prices paid by large electricity users but may not bear any relationship to the prices being paid by the majority of businesses. For example, if an aluminium smelter began operating in Christchurch the average price would fall dramatically even if no other business had a reduction in its electricity bill. The use of model customers allows the tracking of the electricity prices faced by certain types of consumers.

In consultation with several power companies I developed three model customers to represent electricity use by businesses. For the specifications of these models see section 0. While there is no such thing as a typical consumer these models are meant to represent the electricity demand characteristics of at least some business types. Model 1 could represent a retailer or some other small business, model 2 could represent a warehouse or a factory while model 3 could represent an office building, a supermarket or a factory.

The models measure the cost of 30 days supply of electricity using the tariff in existence on the middle day of the quarter. Separate indexes are calculated for each model for the North and South Islands because electricity is cheaper in the South Island. A significant amount of the electricity consumed in the lower North Island is generated by the hydro power stations located in the lower South Island.

The graph below shows adjusted and unadjusted indexes for the large model priced at a sample of North Island power companies. The adjusted series is a rolling weighted average of summer and winter prices. In section 0 I look at possible problems with this index caused by incorrect reporting of prices by respondents.



4

Maintenance of the indexes

4.1 Generation

At the moment prices for bulk electricity can be obtained by sending questionnaires to only two companies. When ECNZ is split into three separate state owned enterprises and as privately owned power stations become more important it might be preferable to collect prices directly from the wholesale market. However, if hedging levels remain high then the average spot price won't necessarily reflect the average final price paid by power companies for bulk electricity.

4.2 Trans Power

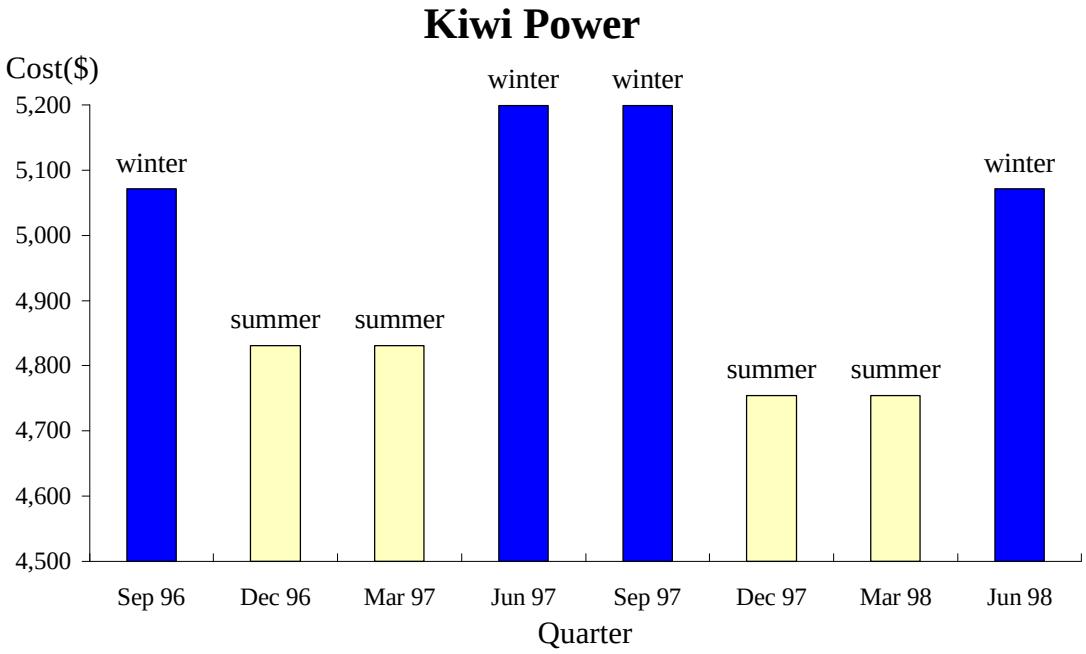
The current index is not satisfactory because we do not price a defined service. There are two problems with using the underlying inflation rate to proxy movements in the price of transmission services. The first arises because we assume that all increases in revenue are due to price change whereas in fact revenue may increase in order to recover the cost of constructing more transmission lines or substations i.e. the volume of the service has changed rather than the price. The second is that the price setting mechanism is changed without our knowledge i.e. the price is no longer varied on 1 April each year by the previous year's inflation rate.

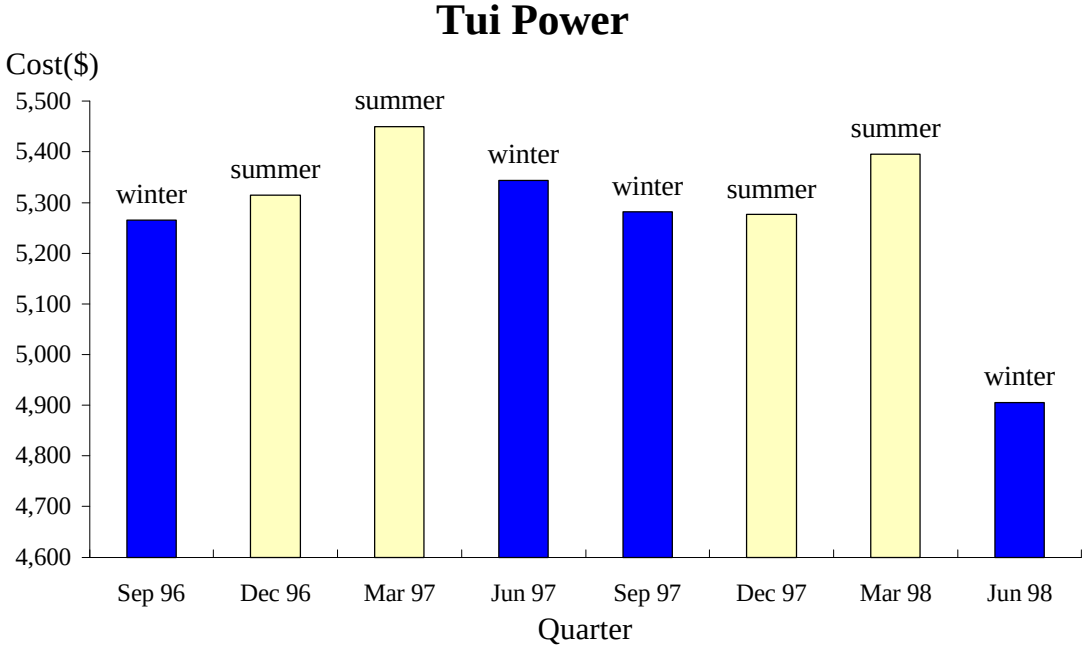
4.3 Power Companies

The main problem with the model customer approach is that respondents often give incorrect prices. While this is generally unintentional some respondents may be tempted to use the latitude offered by the specifications to deliberately understate prices. Until we are sure that the power companies are responding accurately we can't rely on the price indexes.

On the following page are graphs showing the prices returned for the large model by two power companies[7]. Most power companies have tariffs for large customers that set higher prices in winter. This reflects both the higher cost of bulk electricity in winter (see section 0) and the fact that power companies increase the peak rate price in winter in order to relieve the strain on their networks. Therefore, the prices returned by Kiwi Power are what one would expect. However, the price series for Tui Power shows no discernible pattern and is almost certainly incorrect as it is highly unlikely that summer prices are higher than winter prices.

[7] The names have been changed to protect the identity of the respondents.





5 Conclusion

Pricing the outputs of the electricity industry was a tough assignment. The recent introduction of sophisticated metering technology has led to complex tariffs as power companies use pricing signals to manage demand. Improved demand management means better utilisation of assets which should lead to cheaper electricity for businesses and households.

Power companies are planning to introduce time-of-use tariffs for domestic customers. This will give households the ability to reduce their electricity bill if they are able to

change the time of day at which they consume electricity. When this happens the CPI may need to develop model customers similar to those used by the PPI.

Electricity is often thought of as a good. However, as I have demonstrated in this paper the techniques used to price electricity are similar to those used to price many services.

6

Appendices

6.1 Regimen - sales by the electricity industry

Below is the regimen for the PPI electricity indexes. The New Zealand PPI is constructed on a gross flow basis so every transaction is priced and has a weight in the regimen. Only 54.2 percent of the transactions priced in the electricity indexes are sales to final consumers. The remaining transactions are sales of electricity by generators to power companies and sales of transmission services by Trans Power to power companies and generators.

Sales by the Electricity Industry

	percent		NZ$million	
Generators	**34.2**		**1,436**	
Trans Power	**11.6**		**487**	
Power companies - sales to households	**25.1**		**1,054**	
Power companies - sales to businesses	**29.1**		**1,222**	
North Island				
0 -100,000 kWh/annum		7.9		332
100,000 - 500,000 kWh/annum		4.2		176
500,000+ kWh/annum		10.0		420
South Island				
0 -100,000 kWh/annum		2.8		118
100,000 - 500,000 kWh/annum		2.0		84
500,000+ kWh/annum		2.2		92
	100.0		**4,200**	

6.2 Model customer specifications

On the following page is a copy of the pricing sheet sent to power companies each quarter. They are asked how much it would cost to supply each of the three model customers with electricity for 30 days using the tariff in existence on the middle day of the quarter.

Instructions for pricing the models

1. The purpose of pricing these models is to track the cost of the monthly power bill for each of the three model customers. This cost should be expressed in $, not in c/kWh.
2. If a published tariff can't be used to price a model then treat the model as you would a contract customer with the same specifications.
3. Prices are to be exclusive of GST.
4. To price the models:
   a) Look at the attached Commodity Price Survey questionnaire to see the date on which the models should be priced.
   b) Use the tariffs in force on this date.
   c) Calculate the power bill for each model for the month in which the models should be priced.
   d) So comparisons can be made between months use a billing period of 30 days rather than using the actual number of days in the particular month.
   e) Enter the totals on the Commodity Price Survey questionnaire.
5. All charges relating to the supply of electricity are to be included. For example, if the appropriate tariff includes a charge for meter hireage then this should be included as part of the monthly price.
6. All prices are to be after the deduction of discounts for prompt payment.
7. Where a rebate is paid (eg if the power company is owned by a consumer trust), the amount of the rebate should not be deducted from the price provided to us.
8. If any of the models are not specified clearly enough for you to calculate a price, alter the specifications and price accordingly. Please make a note of any change in specifications so that we can update the model on our spreadsheet.

Model 1 (Small)

Energy used per annum (kWh)	48,000
Energy used per month (kWh)	4,000

Day	78.0%
Night	22.0%

Weekday	76.0%
Weekend	24.0%

	Weekday	Weekend
Day	59.3%	18.7%
Night	16.7%	5.3%

kWh	Weekday	Weekend
Day	2,371	749
Night	669	211

Capacity requirement	30kVA	Three phase	
Monthly half hour peak load	20kVA	No controlled load or interruptible load	
Day is defined to be:	0800-2400	Zone:	Mapiu

Model 2 (Medium)

Energy used per annum (kWh)	192,000
Energy used per month (kWh)	16,000

Day	85.0%
Night	15.0%

Weekday	85.0%
Weekend	15.0%

	Weekday	Weekend
Day	72.3%	12.8%
Night	12.8%	2.3%

kWh	Weekday	Weekend
Day	11,560	2,040
Night	2,040	360

Capacity requirement	110kVA	Three phase	
Monthly half hour peak load	80kVA	No controlled load or interruptible load	
Day is defined to be:	0800-2400	Zone:	Mapiu

Model 3 (Large)

Energy used per annum (kWh)	600,000
Energy used per month (kWh)	50,000

000-0700	20.0%
0700-0800	5.0%
0800-2300	72.0%
2300-2400	3.0%

Weekday	80.0%
Weekend	20.0%

	Weekday	Weekend
000-0700	16.0%	4.0%
0700-0800	4.0%	1.0%
0800-2300	57.6%	14.4%
2300-2400	2.4%	0.6%

kWh	Weekday	Weekend
000-0700	8,000	2,000
0700-0800	2,000	500
0800-2300	28,800	7,200
2300-2400	1,200	300

Capacity requirement	300kVA	Transformer supply	
Monthly half hour peak load	230kVA	No controlled load or interruptible load	
Zone:	Mapiu		

6.3 Who uses the indexes?

The electricity output indexes are not used for estimating the value added by the electricity industry at constant prices. Price deflation is not required on the output side because data on volumes of electricity generated and supplied is available. The annual and quarterly methodologies for constant price production (GDP(P)) are given in the table below. This table comes from a Statistics New Zealand publication called Quarterly Gross Domestic Product - Sources and Methods.

Annual Method	Quarterly Method
Electricity generation Double deflation. Output is extrapolated by an output volume index using sales of electricity. Intermediate consumption is deflated by sub-indexes of the Producers Price Index except for fuel inputs which are extrapolated by a volume index. The index uses quantity revaluation of natural gas used and price deflation for other fuels.	**Electricity generation** Double deflation. Output is extrapolated by a quarterly volume indicator using total electricity generated. Intermediate consumption is extrapolated by a quarterly volume indicator using the volume of electricity from thermal generation for fuel inputs, and total electricity generated for the remainder.
Electricity supply Double deflation. Output is extrapolated by an output volume index using sales of electricity by supply authorities. Intermediate consumption is extrapolated by a volume index using purchases of electricity by the supply authorities.	**Electricity supply** Extrapolation by an output volume indicator. The indicator uses the total volume of electricity generated.

The electricity indexes are used in contract escalation clauses. This use of the indexes is becoming more common now that the government is leaving the operation of new power stations to private enterprise. Where a power company has a long term contract for the purchase of electricity from a small generator the electricity is not generally traded on the wholesale market so some price setting mechanism is required. One way of adjusting for price changes is to use an electricity price index.