Comparison of Costs and Benefits of Connecting a 500 kW Wind Turbine into Major New Zealand Electricity Networks

May 2002

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Summary

The continued geographical diversification of population combined with decreasing government ownership and legislation over the electricity industry has produced much interest in distributed generation (DG). There are two main drivers for this interest. The first and foremost being the reduction on transmission charges imposed by Transpower and the second is the deferment of capital expenditure for upgrading or maintaining uneconomical sections of network.

This research was conducted to determine what commercial rewards, if any, were being offered by 6 large distribution companies towards DG, with a focus on DG from renewable sources. As a result it was determined that Orion NZ provided the best incentive with an annual potential revenue component of $27,748.91 for the DG model chosen.

Results are indicative only as some companies do not have firm policies in place and the values used were estimated.

Introduction

New Zealand has had a substantial "shake up" of its electricity market in recent years. This has most recently resulted in the "Inquiry into the Electricity Industry, June 2000", which has made many recommendations, including encouragement to the development of DG when economically viable.

A large cost to distribution companies is the Transpower charging system where each grid exit point (GXP) has a cost of approximately $50/kW/year. The kW value is determined as the average of the 12 highest demands at that GXP at any time for the last year. This value is updated and the distribution company invoiced on a monthly basis.

Another potential cost is due to the regulation at present which states that any lines that were operational on 1 April 1993 are the responsibility of the lines company or successors of that lines company that owned the lines at that time. This legislation is in force until 2013. This is of concern to distribution companies as some of these lines are no longer economically viable for upgrade or maintenance.

One solution to reduce both of these expenses is to supplement the load on these lines using DG. Under current regulations however, a distribution company cannot own more than 5MW of generation. Thus it may be in the best interests of the distribution company to have incentives for DG so that line upgrade can be delayed until economically viable, or no longer legally required and so that Transpower transmission prices can be reduced.

This report examines the pricing structure in place for the following distribution companies:

- Orion NZ
- Vector

- Powerco
- Northpower
- Dunedin Electricity
- United Networks

These companies were chosen because of their large electricity network customer base.

The aim of this research is to evaluate and compare each company's charges and/or rewards towards distributed generation. To do this a model scenario was developed. The DG source was selected as a 500 kW wind turbine generator located in a rural area, with reactive power export capability. The point of common coupling (PCC) was at the low voltage (415 V) side of a dedicated transformer (750 kVA), which is directly connected to the generator. The power company has no expenditure with respect to line alterations/additions and metering related to the operation of the turbine, but will own and thus maintain all equipment on their side of the PCC.

To simplify the model, when an average value of generation is needed, the kW value generated at a rated wind speed of 10 m/s (ie., 200 kW) and maximum available VAr's at this power (550 kVAr), if needed, will be used. The output power of the generator is mechanically governed to 500 kW and thus cannot be exceeded. When load values are needed, these too will be fixed at a predicted average of 10 kVA.

The findings of the research for each company are represented in this report. Calculations of incentives and costs along with pricing explanations are included. The results for each company are compared and discussed, resulting in a ranking of which companies are more preferable to DG.

Orion NZ Ltd

Company Profile

The Orion network spans the greater Christchurch urban area and a large surrounding rural area. Orion has 165,000 customers and 11,500 km of network.

Pricing Mechanisms

Charges to DG

Table 1, represents the charges to the distributed generator model imposed by Orion. These values are current for April 1 2002 to March 31 2003 and can be found at http://www.oriongroup.co.nz/Energy/Electricity/pricing.htm.

Charge	Line	Trans	Unit	Capacity	Total $/yr
Connection	500.05		$/Conn/yr	1	500.05
Control Demand Period	60.00	21.92	$/kVA/yr	10	819.20
Assessed Capacity	24.40	22.00	$/kVA/yr	10	464.00
Total					**$1,783.25**

Table 1: Line charges for DG from Orion.

The assessed capacity can be based on a number of factors. Generally it is determined by the average of the12 highest half-hourly kVA demands that have occurred between 7.30am and 8.30pm weekdays for the previous year. The assessed capacity for a new connection is to be determined by arrangement between Orion and the customer. In this case it has been assumed that a value for assessed capacity has been measured over the last year and corresponds to the average load of 10 kVA.

Control demand period (CDP) capacity is determined by the average kVA demand during the periods used for Transpower transmission pricing.

Rewards for DG

Orion offers to pay for power generated during a CDP. Table 2, represents the payment for both real and reactive power generated. A reward of 95% of the CDP charge for real power and 31% of the CDP charge for reactive power during CDP events is offered. In this case the capacity is determined as for CDP charges but the average kW's and kVAr's are determined by those generated during the CDP.

Component	Value	Price	Unit	Capacity	Total
Real Power	95%	81.92	$/kW/yr	200	15,564.80
Reactive Power	31%	81.92	$/kVAr/yr	550	13,967.36
Total					**$29,532.16**

Table 2: Rewards for DG from Orion.

For the case of the model, the capacity is 200 kW and 550 kVAr. These are used as real power is governed by the wind where an average of 200 kW (40% capacity factor) is typical. 550 kVAr is the average over the range of wind speeds of the maximum reactive power that can be generated whilst maintaining the rating of the generator. A high kVAr value can be guaranteed as it is able to be set on demand, which is signalled via a ripple control relay.

Therefore, for the model used Orion has the following characteristics:

	$/year	c/kWh
Rewards	$29,532.16	1.69
Charges	-$1,783.25	-0.10
Value	**$27,748.91**	**1.58**

Other

Orion offer no official incentives specific to renewable energy. They are currently considering a reward based on the ancillary charges applied by Transpower and are also deciding whether a load of 10kW is worth billing.

Benefits from the CDP's can be realised immediately for a new connection, as Orion will estimate a capacity value and will adjust (if applicable) and then pay monthly on this value. Any discrepancy will be accounted for annually.

Dunedin Electricity

Company Profile

Dunedin Electricity is located in the South Island and supplies the urban area of Dunedin as well as the fast growing Central Otago area. Dunedin Electricity had 71,600 customer connections as of 31 December 2001 making it 5th largest of the NZ distribution companies.

Pricing Mechanisms

Charges for Loads

The general pricing strategy and methodology placed upon loads are determined by the customer pricing schedule and can be found at: http://www.electricity.co.nz/download/PricMeth.doc.

A charge, which for this case has been called transformer lease is used. This charge is a function of the optimal deprival value (ODV) of the assets installed and include a maintenance component. The offtake charge is related to the load on the network drawn by the turbines ancillary equipment.

Charge	Type	Transformer Lease	Capacity	Total $/yr
Distribution	Injection	3900.00	750 kVA	3,900.00
Distribution	Offtake (Approx)		10 kW	500.00
Total				**$4,400.00**

Table 3: Line charges for DG from Dunedin Electricity.

Rewards for DG

Dunedin Electricity have an embedded generation buy pack scheme during times of high load. The value for this generation is based on $/kW. The dollar value is determined on a case by case basis and depends on the distance from the grid exit point to the generator and from the generator to the load, ie. the distribution losses.

A location was selected that had been identified as a potential wind turbine site. The reward value for this site was estimated at $43/kW based upon the current Transpower pricing of approximately $50 per kW less Transpower's 10% EVA discount. The kW value used is calculated from TOU meters where the time is determined by the Transpower peak use charges. Dunedin Electricity use ripple receiver relays and can thus warn a DG that a control period is on.

Table 4, represents the rewards towards DG. There are none specific to renewables.

Component	Price	Unit	Capacity	Total $/yr
Transpower Transmission	43.00	kW/yr	200	8,600.00
Total				**$8,600.00**

Table 4: Rewards for DG from Dunedin Electricity.

Whilst a simplistic model was evaluated in this instance, Dunedin Electricity advised that each application for embedded generation charges and rewards would be treated on a case by case basis and other rewards may be applicable depending on the value that the embedded generation provides at the point of connection.

Dunedin Electricity has the following pricing properties:

	$/yr	c/kWh
Rewards	$8,600.00	0.49
Charges	-$4,400.00	-0.25
Value	**$4,200.00**	**0.24**

Vector

Company Profile
Vector is a distribution company in Auckland, who mainly supply the areas of Auckland, Manukau and Papakura, which equates to over 260,000 customers.

Pricing Mechanisms
Charges to DG
A 500 kW generator falls under the large customer connection pricing plan found at http://www.vector-business.co.nz/prices2.cfm.

Customer charges are separated into three: connection, demand and distribution. For demand and distribution charges, where metered values of generation are used, the value must be the net generation, ie. generated output less consumed load.

The connection charge is in c/kVA/day and is applied at a fixed value depending on the type of connection to the distribution network. For the model, the type of connection is "transformer" and is thus 3.38 c/kVA/day. The kVA value is determined by the rating of the transformer and it is irrelevant who paid for the equipment.

The demand charge is a variable charge which reflects the generator's proportional use of the network assets. It is charged at a c/kVA/day basis, where the kVA demand is the average net generation for the highest 10 half hourly periods for each month occurring between the hours of 8 am and 8 pm on weekdays. For DG this charge may be reviewable with the value being location and time dependent. The demand charge value for DG in the past has been determined by the distance to the load, which varies depending on the time of day. To account for this variation, a charge proportional to time and distance was calculated.

Distribution charges vary depending on the time of day and year, ie., winter-day/night, summer-day/night. These charges reflect electricity consumption and include the Transpower charges. This charge is based on c/kWh. These charges are not included as the generator effectively reduces these costs.

Table 5, reflects the charges imposed by Vector.

Charge	Type	Value	Unit	Capacity	Total $/yr
Connection	Transformer	3.38	c/kVA/day	750	9,252.75
Demand	First 1000kVA	23.57	c/kVA/day	490	40,422.55
Total					**$49,675.30**

Table 5: Line charges for DG from Vector.

When questioned about the high demand charge, Vector responded that it was their policy to charge for the assets used in obtaining the generator's revenue.

Rewards for DG
Vector will consider each generator on a case by case basis, where location is of main importance. Generators are broken down into two types: constant generation and generation on demand. Constant generation is rewarded as a relationship to the

charges from Transpower where generation on demand has an operating cost subsidy portion also.

When generating during a period of high demand the buy back for the generator is typically 80% of the charge from Transpower which is currently $50.18/kW/year. The kW value is determined as the average net (generator less load) contribution of the distributed generator during the 12 highest peaks at the Transpower point of supply for the last year.

There is also a frequency keeping incentive. As a generator can decrease this demand, Vector will pay back most of this value to the generator. This value has a fixed (0.02 c/kWh) and variable component and on recommendation from Transpower, a typical value of 0.1 c/kWh is used.

These rewards are summarised in Table 6.

Component	Rebate	Price	Unit	Capacity	Total $/yr
Transmission	80%	50.18	$/kW/yr	190	7,627.36
Frequency	100%	0.10	c/kWh	190	1,664.40
Total					**$9,291.76**

Table 6: Rewards for DG from Vector.

There are no incentives for VAR generation as Vector has enough VAR support. But they would pay for VAR's if the right conditions were met. There is also no added incentive for renewable generation.

Vector would also look at further rewards for any generation that may delay capital expenditure on an uneconomical upgrade. This is very location and time dependent. Location in that the generation would need to feed a part of the network that is at high capacity and in need of upgrade and time dependent as it would depend on how long the generation could defer the capital payment. Thus the value of the deferment would be determined by the period between installation and line upgrade and the capital utilisation benefit. This value would be split between Vector and the DG.

As a result the model used for Vector has the following characteristics:

	$/year	c/kWh
Rewards	$9,291.76	0.53
Charges	-$49,675.30	-2.84
Value	**-$40,383.54**	**-2.30**

Vector have two distributed generators on their network who have more desirable financial characteristics than those for this model. This is primarily due to the negotiation process, and that they generate on demand and can guarantee maximum generation during Transpower demand periods and hence gain maximum benefit.

Powerco

Company Profile

Powerco Ltd is a distribution company for both electricity and gas. They operate throughout: Taranaki, Wanganui, Manawatu and the Wairarapa. Their electricity customer base is 155,000 and they have the 2nd longest system length in NZ.

Pricing Mechanisms

Charges to DG

Powerco has two charges: network assets charge and demand charge. Particulars of these charges can be found at: http://www.powerco.co.nz/disclosures/pricing.htm. Charges and reward pricing for DG is considered on a case by case basis, in this case, the following is an estimate that best fits the model. The network assets charge is fixed for customers above 300 kVA capacity at $1.50/kVA/month. Where the kVA value is determined by the rating of the dedicated transformer.

The demand charge varies with GXP. A GXP that closely followed the model was chosen for evaluation purposes (area H, Wairarapa). Charging is determined by $/kVA/month where the pricing plan is based upon the kVA rating of the transformer (E300). The kVA value is usually dependent on the generation during the 12 highest half hourly demand periods. It should also be noted, that the demand charge could be subject to change depending on the total generation for that network area.

The charges are summarised in Table 7.

Charge	Type	Value	Unit	Capacity	Total $/yr
Asset	Transformer	1.50	$/kVA/mnth	750	13500.00
Demand		8.56	$/kVA/mnth	500	51360.00
Total					**$64,860.00**

Table 7: Line charges for DG from Powerco.

Rewards for DG

It is reasonable to assume that 90% of Transpower transmission costs will be paid back on a kW basis. The kW value will be determined by the average generation during the peak Transpower12 half hourly periods. Ancillary cost reductions will be rewarded and the value used below should be considered indicative only.

Table 8, summarises the rewards.

Component	Rebate	Price	Unit	Capacity	Total
Transpower Transmission	90%	50.18	$/kW/year	200	9032.40
Transpower Ancillary		0.15	c/kWh	1752000	2628.00
Total					**$11,660.40**

Table 8: Rewards for DG from Powerco.

There are no additional incentives for renewable energy.

Therefore, for the model used Powerco has the following characteristics:

	$/year	c/kWh
Rewards	$11,660.40	0.67
Charges	-$64,860.00	-3.70
Value	**-$53,199.60**	**-3.04**

Powerco realise that this an unfavourable value for DG and if it would significantly endanger the viability of a project, it could be reviewed.

Northpower

Company Profile

Northpower is located in the North Island and services the areas of Whangarei and the Kaipara District. It has 40,000 customers and covers an area of 5,700sqkm.

Pricing Mechanisms

Charges to DG

Northpower has no fixed policy for DG and as a result the information given is an estimate of what would happen for a dedicated DG case. The charges to the DG are determined from the line charges document found at, http://www.northpower.co.nz/frame-disclosure.htm. The pricing arrangement is broken into two parts, the supply charge (code A) and a non-domestic charge (code 33). The capacity for these charges are based on the generator's 10 kVA load. Table 9, shows how these charges are determined.

Charge	Value	Unit	Capacity	Total $/yr
Supply	25.76	c/day	365	94.02
Non-domestic	7.60	c/kWh	87600	6657.60
Total				**$6,751.62**

Table 9: Line charges for DG from Northpower.

Rewards for DG

Under the model proposed, Northpower have predicted that any charges that have been reduced as a result of the DG will be refunded to the DG. These charges are primarily: a penalty reactive power, frequency regulating and Transpower interconnection charge.

The penalty reactive power charge is determined by kVAr/month where the capacity is the average of the top six kVAr demands with a maximum of one per day. Frequency regulating charge is determined by kWh. The Transpower interconnection charge is determined by the average of the 12 highest half hourly demands over the last year where the capacity is determined by the generation provided during these times.

Component	Price	Unit	Capacity	Total $/yr
Transmission	50.18	$/kW/year	190	9534.20
Var Penalty	0.37	$/kVAr/mnth	550	2442.00
Frequency	0.10	c/kWh	1752000	1752.00
Total				**$13,728.20**

Table 10: Rewards for DG from Northpower.

Therefore, for the model used Northpower has the following characteristics:

	$/year	c/kWh
Rewards	$13,728.20	0.78
Charges	-$6,751.62	-0.39
Value	**$6,976.58**	**0.40**

Northpower offer no specific incentive towards renewable energy.

United Networks

Company Profile

United Networks is an electricity and gas distribution company and offers fibre optic connections in the Auckland and Wellington business area. The electricity networks are in three areas of the North Island labelled: Northern, Eastern, Central. They have 501,254 electricity consumers, which translates to 24,500 km of lines. This makes United Networks New Zealand's largest distribution company.

Pricing Mechanisms

Charges to DG

United Networks has a generation policy which is currently in draft stage and will soon be available in a completed version. United Networks will impose a capacity charge to the generator with the justification that the generator must still use the network to get the generated power to the load. This charge is based upon the maximum average capacity during the highest 12 half-hourly periods for the year.

Charge	Value	Unit	Capacity	Total $/yr
Capacity	3.40	$/kW/mnth	500	20400.00
Total				**$20,400.00**

Table 11: Line charges for DG from United Networks.

Rewards for DG

The reward offered by United Networks is a direct pay back for any Transpower transmission costs reduced due to the generator. The capacity is the maximum average kW's generated during the 30 annually rolling highest half hourly on-peak periods determined by United Networks for that GXP. There is no incentive for VAr generation as United Networks need VAr's in only densely populated regions, which are not conducive to wind turbines. There is also no frequency keeping benefit as this is not considered substantial. Capital deferment would be rewarded if appropriate and related to any revenue as a result of deferment.

Component	Price	Unit	Capacity	Total $/yr
Transmission	4.18	$/kW/mnth	200	10032.00
Total				**$10,032.00**

Table 12: Rewards for DG from United Networks.

United Networks had the following results when used in the model:

	$/year	c/kWh
Rewards	$10,032.00	0.57
Charges	-$20,400.00	-1.16
Value	**-$10,368.00**	**-0.59**

There are no rewards offered specifically to renewable energy.

Discussion

Determining values to use in a comparison between companies has proven difficult. This is mainly due to most of the distribution companies questioned not having any pricing plans/methodologies that can be used on a general basis for this kind of example. Therefore, the results published are indications only and are often best estimates of the people questioned and are not policies of the companies surveyed.

The research was made even more difficult when it was put forth that the DG type was a dedicated generator where the net power flow was generation. This caused confusion as to how to charge for the load drawn by the ancillary equipment as this is a load to the network and should be compensated for. As a result this load was often considered as being separately metered and charged on either the pricing methodology determined by the size of the plant (eg., major customer pricing) or by the size of the load (eg., non-domestic pricing).

All companies who were willing to give numerical examples had significant reward components. This is reasonably sensible as the generator is reducing Transpower transmission and ancillary charges. However, it is more difficult to quantify what incentives would be given to generation that may save capital expenditure on line upgrade. This is largely location dependent and was not thoroughly covered in this research, but the general feeling was that this is an issue that may deserve reward and would have to be looked at independently. A comparison between the companies is shown in Table 13.

Ranking	Company	Effect to DG Revenue			
		Charges $/yr	Rewards $/yr	Value $/yr	Total c/kWh
1	Orion	-1,783.25	29532.16	27,748.91	1.58
2	Northpower	-6,751.62	13728.20	6,976.58	0.40
3	Dunedin Electricity	-4,400.00	8600.00	4,200.00	0.24
4	United Networks	-20400.00	10032.00	-10,368.00	-0.59
5	Vector	-49,675.30	9291.76	-40,383.54	-2.30
6	PowerCo	-64,860.00	11660.40	-53,199.60	-3.04

Table 13: Charges and rewards comparison for DG by distribution company.

The results are reasonably dependent on the model selected. Wind power inherently has a variable output. The assumption of 200 kW average generation has simplified the process and also made it applicable to most other types of generation. The most significant thing to consider when comparing this model to other forms of generation is the capacity value when peak times are used for either charging or rewards.

Orion have the most pleasing values for DG and this is largely related to the model and more specifically to the buy back value of VAr's and the signalling of the control periods. Signalling allows the generator to set itself up to output maximum kVA and thus maximum benefit. Interestingly, if the VAr component of the reward scheme is neglected Orion still outperform the other companies with a value of $13,781.55.

Conclusion

Taken at face value, Orion NZ have shown to have the best reward scheme for the model proposed. It has proven difficult however to accurately compare each pricing plan for every company due to pricing methodology differences. Therefore the value of the final results should be appropriately weighted.

Generally, it was accepted that rewards should be paid to the generator for any reduction in Transpower charges due directly to the generator. The value of this reward varied with some companies believing there are costs to be incurred as a result of the rewards system and others believing that full compensation is appropriate. Large discrepancies were primarily due to capacity selection with respect to both charge and reward calculation.

DG is an issue of growing importance in the NZ electricity industry. This was proven by the interest shown by all of the distribution companies and by their awareness towards DG and efforts to develop DG pricing methodologies.

Acknowledgments

The following distribution companies and the people questioned as their representatives should be acknowledged for their time, thoroughness and willingness:

- Orion NZ – Roger Sutton
- Vector – Pieter Richards
- Northpower – Michael Petrove
- Powerco – Brent Thomas
- Dunedin Electricity – Lindsay McLennan
- United Networks – Ron Smale