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A Guide to the Application of Diesel and Gas Engine Generation in New Zealand

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1 Outline

Background

CAE believes a key issue for advancing electricity efficiency in New Zealand is the development of a better working knowledge within the management and operating structures of our distribution network companies with regard to how DG might deliver local economic benefit and commercial advantage.

Currently, understanding of the range of practical options for DG is limited due to the historic lack of technical expertise within network companies and the communication of that knowledge through to the strategic planning function of senior management.

Also, until recently the low cost of energy supply and ample grid network capacity has not created a perceived need for DG. Higher and more volatile energy pricing, combined with other risk management issues, such as security, is bringing more focus on the enhancement of service delivery and improvement of the cost effectiveness of the existing energy supply.

DG has been widely perceived to constitute a threat to the conventional participants in the electricity industry. In reality, it presents a local opportunity to better allocate supply and price risk in an increasingly volatile energy market. DG is not a replacement for electricity supplied through the wholesale market. Rather DG is a different market, complementary to the wholesale market, with each providing different cost structures and benefits.

The aim of this project is to demonstrate to network companies and eventually large users, real world benefits of DG for their particular power supply situations.

This paper is intended as a guideline for the integration of diesel and gas engine generators into energy supply solutions. It also outlines the basis on which such investments may be financially justified.

Specifically, the guidelines provide the following content:

1. A list and description of the generic electricity generation applications that diesel and gas engines have been successfully applied to in New Zealand.
2. A methodology for assessing the scope and magnitude of opportunity for the investor.
3. Details of user specific issues that may need consideration during specification.
4. A suggested means quantifying benefits and costs associated with each application.

This is supported by a case study for embedding diesel generation into a lines company power distribution network.

for further information or direct advice on application of these guidelines, contact:

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2 Applications of Engine Driven Generation

Reciprocating engine technology fills an energy supply niche where firm, dependable, instantaneous supply is required and peak demand exists for relatively short durations. While primary fuel costs are high, it competes on the basis that the capital investment required is low, application is flexible, and projects are quick to implement.

Its application targets the enhancement of service delivery and improvement of the cost effectiveness of the existing energy supply, rather than being intended as a complete substitution.

In general diesel engines have higher fuel cost than gas engines, but being manufactured in substantially larger numbers and being of smaller physical size, have a lower capital cost. They are target niches at the top of the load profile while gas engines can economically target lower longer duration demand peaks. Gas engines are also usually confined to a permanent installation as they need to connect to a gas supply and tend to be physically larger (a function of the energy to volume ratio of the fuel). They are therefore less suitable for mobile applications in comparison with diesel generators.

The breadth of value creating applications to which this form of distributed generation can be applied is evident in the following list of opportunity statements:

2.1 Avoidance of Transpower Interconnection Charges

In accordance with Transpower's Pricing Methodology, Interconnection Charges are charged to each off-take customer at each Grid Exit Point, GXP, per a kW demand charge based on a rolling 12 month average of the top 12 half hour demand peaks presented at that GXP to the grid.

Demand charges are therefore driven by a peak load which only needs to exist for durations of less than 1% of the year to incur a heavy cost penalty. This penalty is easy to incur but slow to reset.

Depending on the magnitude and duration of load peak relatively expensive generation such as diesel plant can by-pass grid supply at lower cost than Transpower's Interconnection Charges. The lower cost of gas allows the lower longer duration sections of the demand profile to be targeted.

Whereas a diesel generator might be run for 2 hours a day to serve demand peak, a gas engine might be viable for 6 hours.

2.2 Deferral of Transmission New Investment

When the capacity of a Transpower GXP becomes constrained the cost of upgrading the grid connection assets is charged to the users of those assets via the terms and conditions of a Transpower New Investment Agreement. If the demand presented to grid can be constrained to within the capacity of the GXP then upgrade can be deferred.

Capacity upgrade typically involves a significant step increase in the capacity and size or quantity of the assets involved. Load may be growing in relatively small increments which presents issues of capital efficiency when large investment is required but the capacity increment can only be utilized over a long period.

Distributed generation can contribute in several ways:

- It can improve peak management and therefore allow load to be managed within the constraint.
- Capacity can be delivered in increments that match load growth.

- Capital expenditure can be minimized.
- GXP upgrade can be deferred until there is a significant gap between supply and demand such that the utilization of new assets is sufficient to deliver an adequate return on investment i.e. generation can be used as a "stop gap" measure.

2.3 Avoidance of Transpower Connection Charges

Another form of transmission by-pass that may be realizable is to reduce peak demand to a level at where connection assets can be optimized down to lower capacities or voltages per Transpower's ODV based pricing of connection assets.

Similarly, if demand is reduced to a level where an "n-1" security standard cannot be justified, and the alternative security provided by generation is considered adequate, then the quantity of connection assets paid for can be literally halved.

In this scenario it should be remembered that the probability of transmission outage is typically very low. The risk of running generation for an extended time is very low and the decision to terminate, ration, or reduce the service remains the choice of the lines company rather than an inflexible Transpower standard.

The bulk of the contingent generation capacity can be provided by other forms generation that may be connected to the GXP (for example, utilizing some hydro storage). The diesel generator only needs to contribute firming capacity.

2.4 Deferral of Distribution New Investment

Capacity constraints within a distribution network tend to be more localized than a transmission network and the reduced load diversity often results in a more peaky load profile. The capital cost of upgrades can greatly exceed the prospects for revenue growth. This is a common issue for long lines remote from sub-transmission support.

Constraints may be related to short seasonal loads such as holiday loads. Volt drop problems may only be present for a few hours per day or a few weeks per year.

In these scenarios distributed generation, along with other solutions such as capacitors, voltage regulators, etc., can provide temporary relief until the constraint condition exists for sufficient duration to justify a permanent line upgrade.

2.5 Deferral of Consumer New Investment

Consumer installations also face capacity related connection charges and pay for connection asset upgrades on a use basis. For large consumers, needing a dedicated HV cable connection for example, upgrade costs can exceed the cost of a generator and achieving a capital efficient capacity increment can also be challenging for companies with short risk horizons.

Adding distributed generation to a consumer's installation increases the diversity of their load and provides more capability to manage demand. In a permanent installation scenario, consumers may have scope to utilize the waste heat from the engine. This greatly improves the operating cost efficiency.

2.6 Alternative to Transmission Security Upgrades

Expenditure on security provisions can be very difficult to justify because the duration of contingent events are short and probabilities of outages very low. The traditional full redundancy approach to providing security at transmission level tends to be prohibitive for small loads. Consumers are therefore served with inconsistent levels of security dependent on where they are connected to the grid and in terms of the transmission charges they pay.

Distributed generation can deliver greater resolution in the security standards able to be provided.

Security constraints are generally reached before capacity constraint becomes an issue. Distributed generation can be applied to cover the security constraint until upgrade of normal capacity is warranted. Similarly a security constraint can be covered until the duration of the constraint justifies greater expenditure.

Transpower applies much higher security standards (particularly in the core grid) than line companies tend to apply/deliver on their distribution networks. Coordination of these different standards in light of what is actually delivered to the consumer may present opportunity for rationalization and alternatives such as generation.

Assessment of security requirements on a probabilistic basis, instead of Transpower's deterministic approach, is likely to provide a more cost effective niche for generation. Transmission asset is extremely reliable. On a probabilistic basis only small investments in security provision can be justified. Lower cost generation solutions with other value creating applications may be viable where currently service is constrained by cost.

2.7 Alternative to Distribution Security Provisions

Distribution networks face the same security cost/service issues as transmission networks. However their loads are smaller, more spread out, and more likely to be spur connected. Security provision, via interconnection and redundancy, consistently to all consumers is likely to be beyond affordability.

Whereas the upgrade or dual installation of a line or transformer addresses the security of one asset at one location, the security provided by a generator can impact deeper into a network and, if mobile, can be used at several locations.

Its security provision will also impact up into the transmission system. In general, security is most effectively delivered at the lowest voltage possible.

An alternative to redundancy in major installations (e.g. dual transformers), maintaining a high level of contingent capacity in supporting assets, or carrying strategic spares, might be to use mobile generators.

2.8 Alternative to Consumer Installation Security Provisions

Individual consumer security requirements may be beyond the standard provisions that a network might offer on a global basis. Installation of a standby generator, that can be shared by a number of applications, may provide an affordable solution.

Generation may also be incorporated into a more optimal design for an industrial plant. For example, instead of a plant having dual boilers to provide for security of steam supply and sufficient boiler turndown capability, it might be possible to use one boiler, with a steam accumulator, and a generator recovering waste heat energy, and providing an electrical boost.

Industrial plants often use diesel engines to provide direct contingency provisions such as the operation of critical pumps, fire fighting, etc. Substitution with diesel electric plant would allow this asset to be utilized by a broader number of applications.

Similarly consumer installations often have their own standby generation. The installation of synchronization and control equipment can allow more benefits to be captured.

2.9 Managing Planned Outages

Supply outages, for the purposes of maintenance and network upgrade, interrupt economic activity. Intuitively it would be reasonable to invest in security until the risk of economic loss balanced the cost of security. Line companies are under regulatory pressure to improve outage performance but formal obligation to deliver prescribed standards is not legislated.

Where outage duration is sufficient to justify the cost of providing a generator and the impact on overall outage performance is sufficient to increase risk of regulatory controls, then the application of a generator can be used to manage outage performance.

Supply can be maintained to key connections allowing greater flexibility in work planning.

2.10 Enhancing Load Control Systems

New Zealand line companies operate load systems to provide energy retailers with tariff switching services, consumers with control services, manage constraints on their networks, and minimize Transpower charges.

Failure of load control plant exposes line companies to breaching contractual obligations, being held responsible for appliance damage, and high transmission charges. Typically there are limited or no contingency provisions for load control equipment.

The amount of controllable load present on a network limits the load management capability of the control system. Controllable load is not firm. When load control is being driven hard it ultimately reaches a point where the controller runs out of options for maintaining targets and meeting the required levels of service. A runaway peak may then result.

With load control typically constraining 10 to 25% of system peak demand a single runaway event or load controller failure can result in a very severe transmission charge penalty.

In just 2 hours one third of demand peaks determining demand charges can occur. It is a curious feature of New Zealand's transmission pricing that demand charges can be so harsh when the transmission assets involved may not have any real physical constraint or the transmission system may be completely insensitive to the impact of an event.

When automated and controlled by the Load Management System, diesel/gas engine generation can enhance load control via the following mechanisms:

- It provides contingency during faults.
- It increases the effective amount of controllable load able to be used by the Load Management System. This allows lower targets to be set.
- It is firm load and therefore increases the quality of controllable load. This allows tighter tolerances on control.

2.11 Firming Other Generation

In much the same way as diversity in the loads of consumers can be managed to limit the peak demand needing to be supplied from the system, diversity in a generation portfolio can be used to increase or match the supply to the demand profile.

For example, where a hydro scheme is sensitive to inflows, and must manage water storage conservatively to meet supply obligations, adding diesel generation into the management equation allows storage to be managed on the basis of energy price rather than network cost avoidance.

A wind farm has more value when it forms part of a diverse portfolio of generation than it does as a stand alone project.

There are very few GXP's where there is insufficient opportunity to manage peak demand presented to the grid, via load control, distributed generation, and demand side management, to reduce peak by an estimated 30% and to do so in a more economically efficient manner than line solutions.

Firm peaking plant can contribute in order of 15% of this capability.

2.12 Wholesale Energy Value

Some recovery of operating costs can be realized by contracting the sale of the energy output to a retailer. This is only a cost "claw back" mechanism because at most times the wholesale market value of the energy will be below the cost of generation.

However, the following issues can be used to deliver a premium on the value of that output:

- The energy is delivered closer to the user. Therefore the transmission location factor recognizing transmission losses is not applicable. Lower distribution network loss factors are also warranted.
- The spot price has a correlation with demand peak when the generation is likely to be operating. An energy premium over average spot could therefore be expected.
- The energy is firm and therefore may attract a hedge premium.

The use of the generation by retailers on demand during periods of high spot price can also be pre-negotiated at a higher contracted price.

Over the last 5 years the Benmore spot price has exceeded the 19c/kWh operating cost of diesel generation for an average of 11days/year. If the generation is using a cheaper fuel, such as gas, and/or recovering heat energy then base loading during weekday, day time, peak season starts to become viable.

The Hayward's spot price tends to have a slightly higher value than Benmore's. Some transmission nodes associated with constraints can become decoupled from the spot market with very high localized spot prices during transmission maintenance outages. Having access to generation behind a constraint provides a cost advantage in these circumstances.

2.13 Consumer Management of Spot Market Risks

Large energy users exposed to spot prices via the energy contracts have expressed concern over the availability of hedge contracts. Installing a generator provides them with a physical hedge.

Further they can use this "fuel switching" to offer interruptible load in the market, manage their demand, etc.

2.14 Capture of Retail Energy Margin

When a consumer utilizes generation to displace energy they would have otherwise purchased from a retailer then they realize the delivered retail value of that energy. However this is limited to variable component of the retail tariff and if the generation is not totally consumed within the installation a retailer will only purchase the export energy at a lower rate.

For the average domestic consumer variable retail energy tariffs are currently in the order of 13c/kWh. High volume commercial consumers might have lower variable tariffs, say 9c/kWh.

Where heat energy can be recovered gas engines are a viable alternative supply and diesel generation becomes viable if other benefits are considered. Consider, for example, a domestic installation with a 7.5kW diesel generator. Running this generator for approximately 4 hours per day would be sufficient to achieve a net nil energy position with regard to grid supply. Recovering the 5kW of heat it produces would compensate for the fixed retail charges.

2.15 Additional Benefits for Gas Engines

While there is a differential between the price paid for gas and electricity and/or differences in "time of use" or demand charges, there is opportunity to achieve a lower total energy cost.

Any consumer that has excess capacity in their contracted gas supply can utilize that capacity to generate electricity. Gas is often used by industrial process to manage the quality of heating fuels, such as wood waste, and for fuel switching, where alternative energy sources are subject to pricing fluctuation (waste wood for example has a value on the wood chip spot market).

Similarly if a gas transmission network has excess capacity in an area where there is an electricity network constraint, then gas engines used in a peaking role can deliver more efficient asset utilization for both network owners.

Managing waste on-site is an increasing resource management issue for industry. Turning waste into a value adding biogas by-product running gas engines is a proven application. There are now engine variants available that can manage the fuel quality of biogas by blending gas and diesel.

Industrial plant with coal fired boilers that face issues of boiler turn down or need multiple units to secure steam supply may find that a generator with heat recovery allows a smaller boiler to used by targeting base load. Employing a generator and steam accumulator may be sufficient to secure steam supply.

Gas engines tend to be physically larger than diesel equivalents. This is a function of the energy to volume ratio of the fuel. Gas engines are therefore have a higher capital cost but a lower operating cost.

3 Assessing Opportunity

The following methodology is recommended to determine the applications, requirements and size of opportunity for generators.

3.1 Derive the Load Duration Curve and Load Profile

Many of the above benefits are centred around ability to manage peak demand whether at GXP level, distribution feeder level or installation level. Analysis of the load characteristics is therefore necessary.

The Load Duration Curve is the demand in kW for each half hour of the year plotted in order of highest demand to lowest demand. In particular the first section of this curve is of interest; its steepness and at what duration it rolls out to a flatter gradient.

In theory, on the load duration curve for a GXP, the first 12 data points of the 17,520 point annual dataset form the basis of Transpower's Interconnection Connection Charge.

The Load Profile is the same data plotted in time sequential order. It is used to identify seasonal, weekly, and daily peak patterns.

The impacts of load control on profiles can be assessed or added, if known. Fully developed load control systems are able to reduce controlled peak demand by up to 25%. This level of control can only be realised where there is sufficient user diversity and quantity of controllable load and/or storage in the system.

Maximum capture of controllable load is achieved primarily through tariff innovation i.e. offering different controlled products to suit specific loads and appliances. The effectiveness of load control systems has been in decline since the energy/line company split in the industry reforms. Line companies are the prime benefactor of load control while retailers, who create the retail tariffs, do not realize sufficient benefit.

The generation profile of any existing distributed generation can be accounted for in the system profile. This exercise should include a check that the existing generation operating regime is optimum.

3.2 Identify the Relevant Applications

Once the characteristics of the system in which the generator is to be integrated are understood, the application check list provided by Section 2 of this paper can be used to identify which applications are strongest and which ones will be targeted by a given project.

Independent developers may benefit from confirming this assessment with a suitable business partner in the industry able to provide technical support.

Where load management applications deliver the greatest scope the project will naturally fit into the line company domain. This generation primarily suited to peaking, firming, and security applications which have a high correlation with Line Function Services.

Line company co-operation is an enabler of such projects. They are likely to be involved in the management function and control the pass through of benefits, like transmission savings, to other parties such as the investor.

However line companies also have dependence on others to realize opportunities. They face limitation on the ownership of certain quantities of non-renewable generation and are not permitted to participate directly in the energy markets. Existing load and industrial processes are needed to host this type of generation.

Distributed generation competes with the centralized generation owned by retailers and by-passes the transmission system owned by Transpower. It is a local solution for the local economy and faces inherent resistance to changing the status quo from the industries structure and rules.

The industry operates under a contractual structure which involves cascaded and interposed contractual relationships between:

- Transpower and grid connected Generators/Retailers
- Transpower and Line Companies
- Transpower and Major Direct Connected Consumers
- Lines Companies and Transpower
- Lines Company and Retailer/Generators
- Lines Companies and Consumers
- Lines Companies and Independent Network Connected Generators
- Retailers and Consumers
- Retailers and Independent Network Connected Generators

If a project involves the export of generation onto the distribution network the generator owner will need to negotiate energy purchase terms with an energy retailer. An initial assessment of the generating capacity and operating regime of the project will be needed to initiate discussion. The final project dimensions may be dependent on the deal negotiated with the retailer.

3.3 Determine Optimum Generator Size

Just considering the value of avoided transmission interconnection charges at $50/kW and an operating cost of a diesel generator of 20c/kWh the breakeven point occurs at 250 hours operation. This is sufficient for up to 4 hours operating per weekday for a 3 month peak load season.

On this basis a gas engine might be expected be viable if operating up to 8 hours per day or 500 hours per year.

A margin needs to be considered for capital cost recovery and it depends on the strength of other benefits that can be captured.

The number of kW represented by the difference between the highest peak and the demand at the 250 or 500 hour point gives the target capacity. This type of plant has difficulty regulating output at loads less than 50% full load. Accordingly at least two machines each sized to half the target capacity would be recommended.

Where the load profile is particularly peaky finer resolution i.e. more but smaller machines may be beneficial. For example, if the 250 hour peak target was 4MW but the top 1MW had a duration of only 20 hours, four 1MW machines might give the optimum operating regime. Only one machine would be operating for the full 250 hours and the others would operate closer to their full load.

Multiple machines contribute toward reduced unavailability risks, provide more flexibility with regard to being shared for other applications, can be distributed across multiple sites, are moved more easily, etc.

3.4 Diversity Between Different Sites

If there is sufficient diversity between timing of peaks, across the width of their duration, at different locations then one generator may be able to service both peaks. For example, one GXP may have summer peak driven by holiday makers while another has a winter peak. So long as the peak periods do not overlap then arrangements can be put in place to move the generator between GXP's.

Generators located diversely in a distribution network to manage specific distribution issues can also be utilized where they are to manage that GXP's demand.

Plotting the demand data points order number, from highest to lowest demand, against date/time will give a visual indication of whether any overlap exists between different locations.

3.5 Determine Operating Regime

Operating costs are driven by the number hours in the operating regime. Applications tend to niche into areas where a large fixed cost can be avoided by a relatively small amount of generation. The trade-off between operating requirement, costs and project viability require the operating regime to be determined as part of the cost assessment process.

Having determined to size and a number of generators to be applied to peak avoidance the hours of operation for each generator can be calculated. Whenever a higher order generator is operating the lower order generator will also need to operate. As a guide the ratio of operating cost to savings will need to be below 20% to be making a meaningful contribution to project viability. This keeps the return high and the risk low.

4 Plant Specification Issues

The integration of generation into power system involves a significant overhead in terms of connection assets, control, fuel supply, mobility, etc. This section is intended to highlight the issues that impact the quality of a solution and therefore a project's viability.

4.1 Housing

Modern plant does not require housing in purpose built installation facilities. It can be located outdoors and is generally assembled as independent modularized units on a skid-mounted base frame.

The main options for security and providing sound control are:

- A manufacturers provided nacelle, or
- Fitting into a shipping container.

Purchasing the manufacturer's "off the shelf" solution presents issues of where to house connections assets such as the injection transformer, auxiliary fuel tanks, and additional automation and protection equipment. This would generally be the most economic solution for smaller units up to about 750kVA.

Shipping containers provide more space and can accommodate units up to 1500kVA before space and weight become an issue. There is also a choice of using 20 or 40 foot containers and housing auxiliary plant in a second container.

Consenting issues are likely to require noise control in the order of 75dBA at 7m (or property boundary). In addition to acoustic lining, attenuation of the air intake and exhausts will be required to meeting this specification.

The use of double skinned fuel tanks will provide secondary containment. Fuel couplings should ideally allow refueling without the need for the generator to be shutdown. Where external auxiliary or separate fuel tanks are installed couplings can be protected from vandalism, leakage, and theft via special shutoff valves.

4.2 Mobility

Optimum design for mobile application requires consideration of issues with regard to ease and speed of relocation. Planning and securing "on-demand" access to external lifting and transportation equipment is a major contributor to the success of any solution selected.

When designing a containerized installation consideration of weight distribution can reduce lifting issues and the need for heavy load permits.

Larger units will exceed the capability of truck mounted hydraulic cranes. Operators will therefore be constrained by the availability of local lifting equipment e.g. container swing lifts, mobile cranes, lifting jacks.

- Swing lifts may place limits on the length of container that is lifted. Forty foot lifts are not likely to be in plentiful supply outside major freight centres. Attenuation equipment at the container ends may require removal for transportation. These issues limit the speed of response.
- Unbalanced loads may require two cranes to achieve sufficient lifting capacity and reach. Availability of cranes "on demand" may be an issue.
- A set of hydraulic jacks that clip onto a container may be a worthwhile consideration particularly if there are more one generator sets to be moved. The jacks are operated from a valve bank that a house moving company might use.

Separate fuel tank (or de-fueling tanks) and injection transformers are considerations if lifting capacities are an issue. Auxiliary fuel tanks and injection transformers can be fitted into a separate container i.e. instead of all plant being installed in a 40 foot it can be split between two 20 foot containers.

Permanent installations are ideally designed to recover the waste heat. The energy involved can match the electrical output and so efficiency is greatly enhanced. The most straight forward method is to use the heat to pre-heat water for a local hot water system need, if one can be identified.

4.3 Injection Site

For smaller genset sizes the distribution transformers in most urban networks will be of sufficient capacity to act as injection sites for temporary or security related applications. In rural networks an injection transformer will generally need to be supplied as large transformers are not often sited at the remote end of long rural feeders.

If the generator is to provide rural backup power supply its capacity will generally be small to match the load. Such applications place very minimal requirements on site selection. A wide load reserve and a set of high voltage links or an air break switch is sufficient. If the plant is to be remotely controlled or left in on hot stand-by, then a local power supply may be necessary.

In voltage support applications the optimal location along the feeder is dependent on the line voltage gradient, location of voltage regulators, etc. This is determined by load flow analysis.

Whenever a generator is to be connected to existing equipment it will be necessary to check that the earthing provisions are adequate.

General site requirements are:

- Level, firm site, with sufficient compacted gravel, to bear the weight of the plant, truck, and crane.
- Flood zones and proximity to water ways should be avoided.
- Concrete pads are preferable if lifting jacks are to be used.
- Concrete mounting plinths can be used to create an air gap underneath the unit to reduce corrosion.
- If the unit is mounted on concrete pads then anti-vibration packers are recommended between metal bears and concrete contact points.
- Locating pins are recommended to keep the unit in position.
- Adjacent to the power line but with sufficient clearance to allow lifting.
- Adjacent to a roadway to minimize fueling tanker access tracks. Road reserve is ideal if consents can be achieved.
- Locate at least 300m from neighbouring occupied buildings where noise may be an issue. Ideally 10m back from the property boundary to reduce noise control requirements.
- If using the road reserve traffic management issues during lifting, fueling, etc. need to be considered and accident prone corners, interference with viewing lines, etc. should be avoided.
- The site should allow optimum orientation of air induction and expulsion and exhausts for minimum flow restriction and noise envelopes. Note that in a two container configuration the containers will need to be mounted side by side rather than end to end.
- The site should ideally be free of vegetation to prevent inductions of leaf debris and restriction of air flow. Note that hot air and engine exhausts will burn off grass and vegetation. Air scoops are an option for directing exhausts.
- Visibility is a matter of individual company preferences with regard to public profile, security considerations, etc.
- The use of double skinned fuel tanks and shut-off valves is recommended instead of site bunding.

- Security fencing is a matter of individual preference/necessity. However refueling facilities need to be considered.
- Permanent quick connect facilities for 11kV cables, control equipment (e.g. radio aerial) and local power supply are recommended for larger units. This can be achieved via the use of a ground mounted 11kV switch with suitable cable terminations.
- Earthing design will require a more substantial earth mat than a standard distribution system earth provides.

It should be noted that most of the above issues will have been addressed at power company zone substation sites and therefore there are many advantages to co-locating at these sites if space permits.

In peak load management applications, co-siting at a network company zone substation is recommended because of the potential to share connection, protection, and automation assets.

Local planning regulations will have noise standards to be complied with. These are typically 75dBA at 7m. Also note that the quantity of fuel stored on-site may require a resource consent and Dangerous Goods Licence.

4.4 Controls and Automation

The generator controller provides motor governor, setpoint, synchronization, and protection functions. Choice of controller will depend on the following requirements:

- Is synchronization with the grid supply required? Generators can operated in islanded mode but this requires interruption to the power supply when switching between grid connection and generator supply.
- Will more than one generator be ganged together?
- Is remote control and indication needed? For example, the ability to alter setpoint and monitor fuel level. This may use an existing system such as a power company's SCADA and radio communication network. Additional interfacing equipment such as a PLC may be needed. Equipment suppliers will be able offer other remote control systems if a standalone arrangement is necessary.
- Will operation be automated by another control system such as a Load Management System? Special programming of these systems will be required to integrate the generator operating optimally with other load management control actions. The capability of existing systems may place restrictions on what can be achieved or require enhanced controllers.
- Standardisation with other generators and existing technology. Availability of support and spares.

The need for enhanced protection systems is also a matter of individual circumstance. In network connected applications protection design will need to consider the following:

- Where the load connected to the generator is larger than the capacity of the generator then an outage in grid supply will overload the generator. The generator needs adequate protection equipment to ensure it trips off-line quickly enough. An under-frequency relay usually provides this function.
- An inter-tripping and lockout arrangement is needed with feeder protection to prevent the generator being able to liven into a fault.
- For larger more permanently installed generators located beyond a zone substations 11kV protection, the use of a star – star wound 400V/11kV injection transformer is recommended. Within a zone substation using a generator star point may present difficulties.
- Existing network protection systems will need their settings checked to confirm grading is maintained and to adjust for altered fault levels. The impact of by-directional power flows will also need to be considered.

The grading of generator protection and feeder high-set protection at zone substations should be checked to ensure the sudden change in loading when the generator is turned on and off doesn't cause an unwarranted protection tripping.

5 Quantification of Benefits

This section describes the methodologies by which each of the applications given in Section 2 can be quantified in monetary value for the purpose of cost benefit analysis.

5.1 Avoidance of Transpower Interconnection Charges

Transpower publishes its Interconnection Charge annually and these charges will remain as long as Transpower adheres to its current Pricing Methodology. It is assumed that Transpower are more likely to adjust the charge than change their Pricing Methodology radically to remove the Interconnection Charge. It has been a relatively stable figure for the last five years with only minor inflation and valuation type adjustments.

Future investment in the core grid is forecast to be significant. This will place upwards pricing pressure on the Interconnection Charge over the next 20 years. It would not be overly optimistic to project a 2% increasing trend in addition to inflation for the purpose of Discounted Cash Flows.

This charge is currently in the order of $50/kW and is applied to the rolling 12 month average of the highest 12 half hour demand peaks at each GXP. There is no allowance for diversity between GXP's or with grid constraints. The amount that the average peak demand can be reduced at each GXP, where generation is applied, determines the annual saving in Interconnection Charges.

Interconnection Charges are paid by the line companies. They carry the risk of peak management not realizing the savings assumed. If they are to pass through the full benefit of generation applied to peak management then they are also likely to want to pass through all the risk.

Optimal peak management is only likely to be achieved if generation is coordinated with the other load management activity of network operators. Consequently this application will require the cooperation of line companies who will most likely want to have high degree of operational control over the generation equipment.

From a contractual point of view distributed generation can be considered as an alternative to transmission services. Line companies can meet their transmission requirements by purchasing services from Transpower or DG owners. The Transpower Pricing sets the cost benchmark for total transmission services that line companies use to determine the transmission cost recovery they need to charge consumers.

Generally line companies make no profit margin on transmission and so have very little incentive to manage load and minimise transmission charges, especially if this involves more complex operations and risk taking, other than for benefit of local consumers.

Achieving this benefit therefore relies on the goodwill of line companies rather than them being motivated by their own commercial advantage. Line companies are therefore the natural owner of this investment when applied in this way.

5.2 Deferral of Transmission New Investment

When a line company requests an increase in transmission service, such as a capacity increase or security enhancement, that requires Transpower to install more assets at a GXP, then those assets are paid for via a New Investment Contract.

This contract annualizes the capital cost of the upgrade (including design, installation, project management, and commercial return) over a fixed term (typically 10 -20 years) which is charged in addition to the Transpower Connection Charges. If a line company can achieve the benefit via a lower cost alternative than the Transpower New Investment then a by-pass opportunity exists.

Firm distributed generation can often deliver more cost efficient solutions because:

- It can more closely match capacity increment to load growth.
- The asset can be shared with other applications.

The value of deferred transmission investment is calculated by taking the annualized charge and applying it for the number of years that the alternative investment can cover the load growth. If this benefit continues after expiry of the full term of the New Investment Contract then assets continue to be charged for via Connection Charges.

Note that one generator may be able to be applied to more than one GXP.

If Transpower has not been asked to present a New Investment proposal then the likely cost of such a contract can be determined by applying Transpower's standard ODV building block values to the asset components necessary to achieve the upgrade.

A less tangible benefit is that the Transpower New Investment Agreement locks the annual charge in for a fixed term. If service requirements are likely to change over that term, such as the loss of a large consumer, then meeting demand with an asset that can be re-deployed has some benefit in terms of risk management.

5.3 Avoidance of Transpower Connection Charges

Transpower's Connection Charges are based on the value of the optimum asset capacity and configuration needed to deliver the required service.

If distributed generation allows peak demand to be reduced, or supplies alternative capacity, then it may be technically viable to meet demand at a lower voltage standard. Transpower can be requested to optimize down to lower asset values which reduces their Connection Charges. Note that no physical asset changes are required by Transpower.

Similarly, if firm generation can act as an alternative security provision a Transpower "n-1" security standard may be acceptably reduced to an 'n" standard. This has the potential to nearly halve the Connection Charges.

The 100% redundancy required to deliver an "n-1" security standard is far less asset efficient than a generator that can be matched to the required security shortfall and applied to multiple uses.

Also of note is that the level of security purchased by a lines company at a given GXP may be dominated by the needs of a single large consumer. Securing the demand of one consumer by securing the entire GXP demand is inefficient. If a generator can provide that consumer's security needs then the remaining load at the GXP may be serviced by a lower standard and assets can be optimized down.

Formal acknowledgement of the reduced service requirement will be required by Transpower and if Transpower removes assets there will be reinstatement costs if they are required later. Transpower are legally obligated to optimize; they will advise what changes they will accept and the associated reduction in Connection Charges.

5.4 Deferral of Distribution New Investment

Line company pass-through of new investment does not follow a consistent Pricing Methodology and is less transparent than Transpower's asset value based approach i.e. line charges are not so directly charged on a use of optimized assets basis.

Awareness of investment opportunity is also less publicly notified as a matter of disclosure or regulated with an investment efficiency test. However a line company may be prepared to contract for alternative provisions to a network upgrade or undertake the alternative investment itself when faced with a upgrade issue struggling to meet commercial viability.

The line company should therefore be approached to determine what the cost differential between a lines solution and generation alternative is worth to them. The same advantages apply as for transmission upgrade in terms of more flexible incremental solutions.

5.5 Deferral of Consumer New Investment

Electricity assets beyond the network connection are owned and paid for by the consumer. Where network assets are dedicated to a single consumer they are often charged for on a "user pays" basis.

Where increased Line Function Services demanded by a consumer requires extensive network asset upgrades a lines company may charge a variety of capital contributions, connection fees, or new investment charges. Increased capacity is also likely to incur a higher standard line charge.

Installation of distributed generation in a consumer's installation can defer upgrades by either allowing better load management within the installation, avoiding the need to upgrade, or delivering a lower cost alternative to the line upgrade. Lower costs again will be related to more efficient match of asset to need and the opportunity for multiple applications of that asset.

Where line companies can access use of the plant to manage load and costs on their wider network they may be prepared to acknowledge this additional benefit via their line charges.

The differential between the line company's line solution and a generation solution, after normalizing service delivery and time periods, determines the cost benefit. Working on an annual cost basis assists Discounted Cash Flow analysis. Any increase in normal line charges also needs to be included.

Note that line company pricing methodologies can often distort the preferred engineering physical solution in favour of maximizing financial position. It is economically inefficient to make a physical change in order to overcome a financial pricing model. There is also a risk that a line company may change its pricing methodology leaving the investment stranded.

Any such issues should be discussed with the lines company to ensure a rational outcome results.

5.6 Alternative to Transmission Security Upgrades

The cost of transmission security upgrades can be calculated as given in section 5.2 above.

Here, it is reiterated that installing generation in the distribution network can not only address a distribution network security issue but also reduces the need for transmission security provisions. When combined with a shift to probabilistic standards and coordination of standards as outlined in Section 2.6 not only can upgrades be avoided but existing Connection Charges may be able to be reduced.

As Transpower charges are paid by line companies access to these savings is controlled by the line companies. Line companies also decide what security standards will be delivered to consumers as service levels are not prescribed by legislation.

As with all benefits derived from transmission or distribution system optimization, the investment opportunity is strongest for the network operator and requires their cooperation, willingness to share risk, etc. for independent investors to achieve a gain.

5.7 Alternative to Distribution Security Provisions

As outlined in Section 2.7 the magnitude of loads at distribution level often fails to justify security provisions or the cost of providing traditional line solutions may prove prohibitive. The application of a generator can greatly lower these hurdles. This results in savings in investment cost and/or increased service level.

Due to the cost of the assets involved, improvements at sub-transmission system level are likely to provide the greatest opportunity. Instead of an "n-1" zone substation, configured with dual sub-transmission feeders and transformers, a single line and transformer backed up by a standby generator can deliver an acceptable alternative at much lower cost.

The longer the sub-transmission circuit the greater the cost advantage. A generator can be sized to only secure part of the load and can be moved to cover more than one site. Consequently there is more flexibility in level of service that can be delivered.

As described in section 5.3 it may be possible to rationalize substation assets i.e. by-pass distribution assets. Unless the line company has a desire to redeploy the by-passed assets there is no commercial advantage to them in shifting towards a more efficient solution. They lose asset value (earning potential) and while this does improve the returns on their remaining assets they are exposed to pricing controls.

Regulation and industry structure is counter-productive to distributed generation and system modernization in general. This does not preclude line companies acting in the interests of their consumers. However as lines companies are contracted to energy retailers the mechanisms are weak for delivering pricing benefits down to consumer level.

Assessment of the size of opportunity, quantification of its value, and allocation of benefits is the line company's prerogative.

5.8 Alternative to Consumer Installation Security Provisions

This application is a sub-set of the investment described in Section 5.5. Calculation of benefits follows the same process.

5.9 Managing Planned Outages

Where a generator is mobile and of suitable size, with suitable controls, it can be used during maintenance work to reduce the number of consumers disrupted by an outage.

Line companies are required to disclose outage statistics annually as a measure of their performance. Their pricing control assessment by the Commerce Commission also considers these statistics. Generators can be used to manage their outage statistics through reducing the level of planned outage.

While this is a risk management tool and delivers benefit to consumers, the commercial value to the company is subjective. However the loss of company value, customer compensation payments, etc., suffered by Mercury Energy during the Auckland CBD crisis in 1998, suggests that this is a tangible benefit. Only the line company concerned can determine the level of recognition they are prepared to count.

The following methodology is suggested as means of quantifying the benefit:

- Calculate the number of kWh of unserved energy that the generator would have to cover in order to deliver the overall improvement in SAIDI (System Average Interruption Duration Index).
- This will need to be reconciled with the number of consumers interrupted during each planned outage, the duration of each outage, and the number of outages required to achieve the target. If a large improvement is needed and opportunity in the work program limited then not all of the improvement may be realizable.
- It is recommended that the economic cost of unserved load, or alternatively the value of security, be assessed in accordance with the EEA Guidelines on Security Standards which form the default industry standard.
- This guide applies a $/kWh Value of Lost Load, VoLL, figure to quantity of unserved energy. The value of investing in security is then determined by the risk or probability of an event occurring.
- In this case we are dealing with planned outages have a high level of certainty so the risk factor is

excluded as the level benefit is certain.

- In the absence of a line company having their own figures in their Security Standard, CAE has recently determined the following VoLL's for the Electricity Commission: Residential $5.41/kWh, Agriculture $1.77/kWh, Commercial $8.19/kWh, Industrial $1.80/kWh.

Individual consumers can use the same methodology to determine the value of providing their own security/risk management measures.

5.10 Enhancing Load Control Systems

The value of securing a load control system can be determined by assessing the magnitude of the uncontrolled peak and applying the Transpower Interconnection Charge. If the load is being depended on to manage transmission or distribution constraints then these issues can also be accounted for. Other consequences, such as loss of tariff switching function for retailers, may also need consideration especial where service penalties are applicable.

Responsibilities of various service providers and mechanisms for the allocation of benefits derived from load control are currently weak in the industry.

Once a total value has been assessed then it is reduced by the probability of plant failure and probability that failure is coincident with a system peak. In general low risks will deliver a low level benefit. Typically this is unable to justify this provision on a stand-alone basis and hence the lack of back-up load control systems.

The probability of plant failure or control problem will depend on the weakest link in the system, its age, and its duty. This is expected to be in the order of 0.001.

If the Load Controller is operating, it is doing so to constrain the peak, so loss of this function will almost certainly result in running a peak. It is unlikely that repairs will be effected within the remaining duration of the current peak period so it would be reasonable to assume that perhaps 4 half hour system peaks will be run during a single fault.

5.11 Firming Other Generation

Applying firm generation as a backup to unfirm generation, such as hydro and wind, can deliver a higher value for their output. The gains are dependent on the consistency of the particular water and wind flows of each generation facility and the diversity between them.

Higher value can be realized via the following mechanisms:

- Hedge premium on the energy sale value.
- Avoided transmission charges achieved via reducing demand on grid assets.

It should be noted that these two applications may compete with each other for priority over the use of the standby generator for support. The transmission pricing signal is likely to be the stronger of the two and more sensitive.

The generator owner is dependent on negotiating the energy hedge value with an energy retailer or direct connected consumer. As this generation is in competition with any generation the retailer may own the negotiation position is weak.

The quantity of firming capability added by a standby generator requires analysis of the overall capability to manage demand at the GXP through the coordinated application of load control, existing distributed generation, and the new standby generator. This in turn will be dependent on how well any unfirm generation matches normal load profile and how consistent its primary energy supply is.

It is advisable to consider the statistical deviation from long term averages, load growth patterns across different consumer groups, etc.

Only a lines company is able to manage the load and generation dispatch at distribution network level. This is an underlying reason for why most distributed generation installed to date and owned by retailers generates primarily to compete in energy markets. Peaking plant applications are strongest as competiton to providing additional line assets.

Conversely if an energy retailer owns unfirm distributed generation then they may wish to negotiate access to a standby generator to firm their generation if there are pricing signals that reward them for the effort.

Note that line companies who own generation are still legally prevented from selling hedge contracts and energy directly to consumers because this is seen as competing in the energy markets. Legislation has not been drafted from the perspective that distributed generation has wider application than energy production. Generation that operates for such short periods is hardly offering any significant competition in the energy market and this forms a basis on which dispensation may be able to be obtained from the Commerce Commission.

Innovation with regard to asset ownership demarcations and operating contracts can overcome these legislative hurdles.

5.12 Wholesale Energy Value

Section 2.12 outlines the means for achieving various premiums on the energy value of generation output. An energy retailer will be able provide an assessment of what they consider the energy is worth to them. Energy consultants can provide an independent assessment.

If the GXP load profile peaks align closely with the electricity spot market peaks then higher premiums might be expected with average energy values in the order of 5 to 7c/kWh.

Energy retailers will also be prepared to offer a much higher energy price when they can call on generation to generate during periods of high spot price. This provides them with a hedge on spot price. The higher the margin on operating cost, the lower the probability that the generation trigger will be reached.

Analysis of historical spot prices (provided on the energy market web site) will give an indication of how many hours per year spot price can be expected to exceed a certain hurdle.

Transpower maintenance shutdowns can also create localized high spot prices in areas when there is limited generation behind the constraint. Retailers are very susceptible to gaming by any competitors who might own that generation. Accordingly the price offered by different retailers may be quite varied.

These opportunities are likely to exist where a generation grid node is interposed between the core grid and a spur connected off-take node.

5.13 Consumer Management of Spot Market Risks

The recent high electricity pricing events have resulted in a trend, at the time of energy contract renewal, for large consumers being given more exposure to spot price. A consumer that has a dependency for secure energy supply and stable pricing can manage this risk via hedge contracts.

Hedge contracts, in a time of generation capacity constraint, are proving difficult and costly to obtain. Spot price only reaches such high peaks because demand does not have capability to respond over the short term. Installing standby generation increases demand side response capability and acts to cap spot price.

Locally applied generation is more competitive than the Electricity Commission provided peaking plant intended to limit spot prices. An improvement for New Zealand's energy supply would be the creation of a market to capture the distributed generation resource for emergency supply.

Consumer owned generation can deliver the following benefits:

- Lower cost alternative to a hedging contract.
- Increases the amount of interruptible load that can be bid into the market.
- Captures fuel switching incentives where offered by line companies and retailers.
- Increases consumer load management capability where demand based tariffs provide a reward for doing so.

With regard to fuel switching, gas prices are competitive with peak electricity pricing, particularly when heat energy is recovered from the engine. Many commercial facilities have a high heating demand able to host such an application.

5.14 Capture of Retail Energy Margin

Embedding generation within a consumer's installation has the advantage that the energy it produces displaces the energy that would have otherwise been supplied across the connection point and therefore realizes the value of the retailers variable energy tariff.

The margins able to be captured are typically in the 10 to 20% of the consumers total electricity account. This depends on the particular retailer and the structure of their tariff for a given customer.

Fixed charges and demand charges may also be able to be reduced if it can be demonstrated that lower capacity is needed.

Standard retail tariffs are approaching levels where gas engines in particular are able to compete on an energy price basis. Heat recovery adds to the viability of this opportunity where the consumers load has a suitable heating requirement.

Energy produced in surplus to the installations requirements would need to be sold to a retailer, who will only offer what they consider a reasonable wholesale price. Retailers will also place restrictions on how much energy they are prepared to net meter. If generation capacity is restricted to the installation's base load then the need to export energy will not arise.

The local line company may be prepared to allow a consumer to wheel their energy over the distribution network to allow multiple sites and connections to be consolidated from an energy tariff perspective. This opportunity may be able to be traded for line company access to the generation plant for their purposes.

Domestic consumers are now permitted to connect up 10kW of net metered generation. This is sufficient to achieve a nil net energy off-take over a 24 hour period for most domestic households with 2 to 3 hours operation. They would also then qualify for the "Low User" low fixed charge retail tariff option. Compared to the standard retail fixed charge an annual saving in order of $365 is available.

More than double the heat required for existing hot water load would be available and can be accessed on a demand basis.

5.15 Additional Benefits for Gas Engines

The task of analyzing the optimum use of various energy fuels is similar to optimizing a portfolio of generation facilities against load profile. Where electricity charges have a "time of use" and/or demand component, gas engines may prove to be a competitive alternative to external electricity supply at certain times.

A host load with a large heating requirement is needed for this application, as is a connection to a gas supply of suitable capacity. Economics will be driven by the terms of the gas contract and some long term pricing guarantees will also be necessary. In particular gas contracts, based on a maximum demand entitlement and a minimum volume guarantee, may offer a financial optimization opportunity.

Electricity retailers who deal in gas supply may have some advantages as business partners. However if they are the existing electricity supplier this plant will be in competition with their existing business.

Like electricity networks gas pipe networks can have significant excess capacity. These assets deliver their owners optimum returns when capacity is 100% utilized. A gas company may therefore be prepared to offer low cost transmission tariffs in order to achieve better capacity utilization, load factor, and higher volumes.

6 Project Justification

CAE recommends the following process is applied to substantiating the business case for a distributed generation project.

1 Determine the number of applications to which a specific proposal can be applied.

2 Identify and seek early input from the business partners that will be key to the success of the project.

3 Assess probable size, location, and operating regime. In particular, the hours of operation per annum and the number of kWh's generated.

4 Determine capital cost via manufacturers tender.

5 Determine operating cost which is driven by the number of kWh's generated. Variabilising all costs on an annual and/or per kWh base may be helpful.

6 Once costs are known negotiate the contracted relationships between the various parties that may be involved.

7 Determine the value of the benefits that can be derived.

8 Enter costs and benefits into a Discounted Cash Flow model to calculate the Net Present Value of a project. If the NPV is positive then the project meets the cost of capital and adds value to the company.

9 Assess viability in terms of company investment criteria regarding investment hurdle rates, payback periods, sensitivities, etc. If necessary and permitted by financial policy add in the non-cash benefits and highlight any intangible benefit.

A further justification for investment in distributed generation is that it increases the diversity of business activity. For example, a lines company can create a new revenue stream that is not subject to such stringent regulatory control. Consequently it can raise the overall capital inefficiency of its asset investment.

Other strategic benefits include:

- The ability to manage and counter the pass-through of risks. In particular pricing and security of contracted positions.
- Opportunity to form new business partnerships.
- Development of local resources and simulation of economic activity that provides in turn organic business growth to infrastructure companies.
- Overcoming the current trend of escalating energy prices, with their issues of sustainability and negative impact on the economy.

Delivering consistent levels of service across all consumers and meeting servicing obligations.

Annex 1

A Case Study on the Application of Diesel Generation by New Zealand Lines Companies

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January 2005

Contents

1 Terms of Reference

This case study provides a worked example of the business case for embedding diesel generation in a lines company power distribution network primarily for the purpose of managing peak demand and thereby minimizing transmission cost.

It follows the methodology described in the CAE paper "A Guide to the Application of Diesel and Gas Engine Generation in New Zealand" and should be read in conjunction with that paper.

The paper is presented in a "Sanction for Expenditure" format as might be submitted to company management for financial approval.

A real example has been used however the identity of the lines company and its specific corporate policies have been kept confidential.

Description of Scenario

In the example being considered by this Case Study the lines company is connected to three Transpower Grid Exit Points, GXP's.

1 GXP A supplies a peak demand approximately 29MW and 90% of the lines company's load. The GXP complies with an "n-1" security standard and has no immediate capacity constraint issues.

2 GXP B supplies a peak demand approximately 5MW and 10% of the lines company's load. The GXP only complies with an "n" security standard and has a capacity constraint of 5MW resulting from the size of Transpower's transformer and the length of the lines company's own 33kV sub-transmission network. There is no interconnection with the network supplied from GXP A.

3 GXP C provides a grid interconnection at the remote end of the 33kV sub-transmission line fed by GXP B. Normally it has zero demand and is only during contingent events or when maintenance requires an outage at GXP B. The GXP requires the installation some automation and load control equipment before it can be used as a permanent GXP in order to deliver ICP metering tariff switching functionality. In the event of demand exceeding capacity at GXP B any load shifted to GXP C for longer than 6 hours incurs Transpower's Interconnection for 12 months.

The line company has the following objectives in its application of diesel generation:

1 To reduce transmission charges at all GXP's.

2 To delay the need for GXP B capacity upgrade.

3 To delay the need to establish GXP C as a permanent point of supply.

4 To improve security.

5 To improve service in terms of planned outage performance across the network.

At a strategic level the intent is to improve company capital efficiency, gain some independence from grid connection, and decouple its charges from the upwards pricing path of the electricity market.

2 Detailed Investigation

GXP Profiles and Genset Sizing

To determine the size of the opportunity for peak load management and to correctly size the generators the load duration curves for each GXP have been analysed.

The load duration curve plots the number of hours demand is at or above certain levels. Plots for GXP A and the combined profiles of GXP's B and C are provided in Appendix A.

Diesel generation is expensive to operate and therefore it is only applied to the very top end of the load duration where peaks exist for a very short duration (typically in the order of less than 100 hours per year). If the load profile is very peaky then the cost benefit ratio of avoiding that peak is improved.

Compared to GXP A, the GXP B/C services a smaller load, with greater variance due to holiday makers and irrigation load, and has less capability with regard to load control. Consequently we would expect it to present greater opportunity for peak limiting via generation.

The following observations are made with respect to the GXP B/C load duration curve.

- The centre section of the curve has a relatively steep gradient as a result of its smaller load base, with less diversity, and less control opportunity.
- Two distinct gradients are observable in the centre section which reflects the different load characteristics between the summer and winter seasons.
- The 40 hour duration peak has a magnitude of approximately 500kW. This represents approximately 10% of GXP peak demand. Typically the 100 hour duration peak would be expected to be in the order of 5%. Therefore the load profile is peaky and the opportunity for managing the peak strong.
- The next 500kW of peak duration extends through the knee of the load duration curve. Duration increases significantly to approximately 400 hours which takes its management to the upper limit normally able to be cost effectively manageable by diesel generation. However, because the load is shared between two points of supply (B and C) and transmission charges are applied to both GXP's on a non-diversified basis, the avoided transmission benefit is twice as strong in comparison to a normal GXP.
- Diesel generation niches on the peak portion of the load duration curve where the lines company's load management capability via its load control system is weak. In simple terms the more tools that can be applied the better management options are available. The GXP B does not have enough controllable load to manage the summer peak. Turning on generation is as effective as switching off controlled load and therefore generation increases control options eliminating uncontrollable peak runaway.
- In addition, the GXP B is capacity constrained requiring load shifting to the GXP C during summer peaks. GXP C has no load control capability exasperating the peaking issue and creating new problems for meter switching. Generation adds capacity and mitigates this issue.
- With the top 500kW of the peak present for 40 hours while the second 500kW block is present for 400 hours it is desirable to have sufficient resolution in terms generator set point to allow generation to operate as much as possible at its maximum efficiency. Efficiency falls off rapidly at set points below 75% full load and turn down is limit to approximately 50% full load. In this case multiple gensets with full load outputs of 500kW deliver the most operational flexibility.

It is therefore concluded that the correct sizing for GXP B is 500kW of generation. A further marginal 500kW opportunity exists which becomes viable with the support of other benefit streams.

With regard to the GXP A load duration curve the following observations are made:

- The curve has a very flat profile with load being managed between 28 and 29MW for all but 4% of the top 100 hours. This is the result of the load control system being worked very hard, to its full capacity, for the majority of the year.

- There are 8 half hour peaks where the load controller has been unable to manage the load to a 29MW target. During this time load can runaway to peaks in the order of 3.5MW above 29MW. Transpower's charges are based on the 12 highest half hour peaks so this lines company's costs are sensitive to these very large magnitude, very short duration peaks.
- Total failure of the Load Control System for just a 6 hour period during peak conditions would cost lines company in the order of $300,000 in increased Transmission charges for a year. With the load controller operating on an increasingly continual basis, the risk of this occurring is increasing.
- Consequently the lines company has a high dependency on its load control equipment which has very little backup or security provision. Without the extra control capability provided by generation the only way of addressing the shortfall in control capacity is to manually intervene by cutting load in violation of normal service standards.

It is concluded that if the same 500kW capacity block resolution is used as for GXP B/C then the GXP A has in order of 6 load blocks that could be targeted economically by diesel generation.

In the absence of other considerations such as standardization, mobility logistics, other applications, etc. the optimum unit size for peak management at the GXP A would be approximately 1MW gensets.

If 3 or 4 mobile 500kW gensets are decided upon there remains sufficient opportunity to apply a 1MW permanently installed genset at a location like the local freezing works. This may allow capture of other benefits such as cost effective improvement in an individual customer's security and recovery of waste heat.

Generator Specifications

With a target unit size of 500kW it has been determined that opting for an "off the shelf" design package of generator set, sound proofing nacelle, integral fuel tanks, and integrated controls, best serves the lines company's requirements for ease of transport.

Appendix B contains the manufactures specifications for a 600kVA (480kW) genset marketed by PowerHire which are used as the basis of this investigation.

To interface the gensets to lines company's network (at locations other than zone substations) dedicated star-star wound injection transformers are required. In larger containerized arrangements these transformers are able to permanently housed within the container.

In this lines company's case they will be transported as a separate item. No special transportation and lifting equipment is needed for generators of this size and in this configuration.

Special protection, interfacing to lines company's Abbey Systems SCADA, and site development have been considered and provided for.

A standalone auxiliary fuel tank has also been provisioned to reduce refueling requirements when gensets are being operated in remote locations for long durations.

Costs

Costs applied in this analysis are based on the quotes from PowerHire provided in Appendix B.

Appendix C schedules capital cost for 3 and 4 genset scenarios. The per unit costs show there are some economies of scale.

Total capital cost for a 3 genset proposal is $843,160 and $1,086,360 for a 4 genset proposal.

Also provided in Appendix C is an estimate of the fixed and variable running costs associated with the operating of the gensets. These are based on manufactures specifications and an enhanced servicing regime to that recommended. This is used to determine the cost/kWh of generation applied in the remainder of the analysis.

The generation costs less than 17c/kWh provided the generators are operating above 75% full load. At 50% full load the costs increase to $18.25 as a result of lower engine efficiency. Finer resolution provided by the 500kW generator size selection improves ability to match generation to optimum loading conditions.

These costs are off-set by the fact that generation is sold for approximately 6c/kWh. The derivation of energy benefits is provided later in this document.

The cost of diesel fuel is the main driver of operating costs. This analysis assumes an average of 67c/litre GST excluded which equates to the bulk delivered price quoted at the time of investigation. Low annual operating hours desensitises project viability to fuel cost.

Operating Regime

To determine the likely operating regime the half hour demand at each GXP was converted into kWh and summated for each 480kW capacity block of peak load able to be serviced by a generator over a year. This was then used to determine how long each generator would need to operate for each year and how many units of electricity it would produce during that time.

This analysis is provided in Appendix D.

With each successive lower peak block of capacity the operating time of gensets increases. This creates a diminishing return on the benefit of peak avoidance. Various scenarios of up to three 480kW blocks of avoidance at GXP B/C and up to five 480kW load blocks at GXP A were investigated.

Two scenarios were tested in the Cost Benefit Model. A three genset option able to avoid two load blocks at each of the B/C and A GXP's and a four genset option able to avoid two load blocks at B/C GXP and three at the A GXP.

Appendix D therefore shows the full calculation of costs for each of these two scenarios including other costs created by application to different uses such as energy markets, network maintenance, etc. The three genset scenario delivers the greatest rate of return and is accordingly recommended as the preferred option. This is discussed in more detail later.

By graphing the periods each generator would be required to operate in, it has been determined that one of the gensets can be shared for peak avoidance at two GXP's. The graph provided in Appendix E shows that the peak at GXP B/C occurs at New Year while the peak at GXP A occurs in March. There is sufficient diversity to rely on shifting one genset between the two GXP's to service both peaks.

This approach can't be applied to lower priority load blocks because their peaks are spread over longer durations that clash. It is therefore recommended that one generator will be confined to servicing each GXP while the third is used to as a roving set to service both GXP's, network maintenance, etc.

Benefits

This Sanction for Expenditure only considers the strongest benefits likely to be delivered via investment in diesel gensets. The Cost Benefit Analysis is therefore considered conservative and understated in the interests of good accounting principles.

Benefits not included in the analysis worthy of note are:

- Backup of the load control system.
- Improvement of security against unplanned outages such as a transformer fault at specific zone

substations.

- A more optimistic assessment of the windfall profit that can be extracted during power crisis's. The average spot price experienced during the last two crisis's were sufficiently high and sustained to have paid for the gensets outright.

There are two main tangible benefits: transmission cost savings and deferral of GXP/network upgrades. The third area considered relates to energy sale. This is considered as a cost recovery benefit improving the overall cost effectiveness of the solution.

Improvement of outage performance during planned network maintenance can provide a large tangible benefit depending on company policy with regard to Security Standards and how that particular company quantifies the economic benefit of security enhancement.

CAE recommends a risk assessment approach applied to security standards based on EEA Guidelines (as the default industry standard) with quantification of economic benefit determined by applying "Value of Lost Load" standards.

In this analysis the value assessed this way is significant. However this benefit is excluded from the Discounted Cash Flow Analysis per company policy as the benefit is a non cash item. The value is recognized as an "add-on" of additional value to determination of the project NPV.

Unless company policy presents very high investment hurdles a viable project generally does not need to support of this benefit.

Avoided Transmission Cost, ATC

This benefit relates to a potential reduction in Transpower's interconnection charge by reducing the demand on the core grid. The Interconnection Charge is based on a $50/kW demand charge applied to the average of the 12 highest half hourly demands on a rolling 12 month basis.

This pricing methodology does not recognize any diversity between GXP's and so is applied to each GXP individually. Being able to utilize the same generator to cover the peaks at two GXP's exploits a physical reality that Transpower's pricing methodology does not acknowledge. For at least one genset the lines company can capture twice the ATC.

Similarly because the lines company has to shift load between GXP's B and C to meet capacity constraint issues, the same load is creating two sets of peaks and incurring twice the transmission charges. Applying generation at GXP B prevents the need to shift load to C during the peak and therefore delivers a high ATC benefit.

This is the underlying reason why diesel generation is able to cost effectively target such a high percentage of the peak demand in this lines company's case.

Should the opportunity for gaining a double ATC benefit at GXP's B/C change then avoidance of a third load block at A is the next most attractive viable redeployment of this asset. This contingent consideration drives the recommendation for a three genset proposal in preference to the four genset option.

With paybacks in the order of 4 to 5 years the risk of Transpower's pricing methodology being changed is considered low. It is likely that with transmission investment in the core grid the interconnection charge will have an increasing trend strengthening this justification.

For projects to meet basic viability they need to have a Net Present Value greater than zero. This implies they are not only meeting their cost of capital but add value to the company and therefore improve the efficiency of its capital structure.

The value of the ATC for each genset is derived on the spreadsheets contained in Appendix D. The ratio of cost to ATC benefit for each genset ranges from 4 to 32% with an average 21%. The returns therefore diminish fairly rapidly once the knee of the load duration curve is passed.

In theory it is viable to continue pursuing successive load blocks until marginal cost equals marginal benefit. In this case it has been decided to limit aggressiveness so as to ensure returns are kept well above the lines company's investment hurdle rate i.e. this is a low risk lazy gain stance.

Deferral of New Investment

Without the ability to manage peak demand within the existing supply capacity the lines company has two options for investment in traditional lines solutions:

1 Upgrade the existing transformer at GXP B and reconductor its 33kV line as load grows. This option is expensive if load develops at the remote end of the 33kV line. It will incur a Transpower New Investment charge.

2 Upgrade GXP C with load control plant and enhanced automation. Existing GXP assets have sufficient capacity but the lines company will incur an increase the Connection Charges it currently pays Transpower. Non diversified Interconnection Charges will also be applicable in this arrangement; an initial load of 960kW is assumed in this analysis.

Option 2 has the lowest risk and most durability as a long term least cost solution. This option will incur approximately $128,000 of additional Transpower charges; approximately $80,000 in extra Connection Charges and $48,000 in extra Interconnection Charges (2x 480kWx$50/kW). It will also require approximately $360,000 of capital investment by the lines company which is annualized to $39,600 by assuming a commercial return requirement of 11%.

As the generation is limited to 960kW of extra capacity deferral of this annual cost will only last until load growth has consumed the extra capacity. At this time the lines company is experiencing an annual average load growth of approximately 3% and applies the rate to its long term planning. Accordingly the deferral of the total annualised costs of $167,600 have been limited to a life expectancy of 6 years in the Cost Benefit Analysis.

This figure is entered into CBA model as an additional 6 years of $128,000 ATC and 39,600 annualised line company capital expenditure. After six years the generators continue to deliver an ATC benefit at GXP B only i.e. the double avoidance effect stops.

Energy Sale Revenue

The value of the energy generated and able to be sold to retailers on a deliver price basis is calculated on the spreadsheet contained in Appendix F. A conservative value of 5.95c/kWh has been determined. It is expected that long term contracts will be able to extract a hedge premium not included in this calculation.

The 5 year average spot price at Benmore of $5.03c/kWh has been applied as the base value. This value is substantially higher if a 3 year average is used because of the recent electricity crisis's.

This figure has been inflated by the transmission location factor because no transmission loss is applicable and a daily peaking premium to reflect the fact that generation scheduling to avoid load peaks coincides with energy market pricing peaks. Analysis of pricing suggests a 16% premium.

It should be noted that there can be significant differences in market prices between different grid locations and during different seasons.

The net benefit of this energy sale is that it effectively reduces the operating cost to 11c/kWh. When the retail cost of electricity is considered, it can be seen that for operators, such as lines companies, who are not reliant on energy price margin for core revenues, diesel generation is relatively attractive. Permanent installations where there is a demand for the waste heat are clearly viable.

For the purposes of the Cost Benefit Analysis all kWh's produced during any application of the generators have been assumed as revenue creating. Retailers have the public relations issue of the generation turning the retail metering on which they charge. Therefore they have an obligation to refund the over recovery at a fair rate.

Spot Market Gains

Further analysis of the energy market demonstrates that the spot price has exceeded 19c/kWh for a 3% duration over the past 5 years. This gives an average of 11 days per year.

During such events retailers will contract for a higher price so long as it remains below the spot price. 19c/kWh has been used because it is the minimum margin on costs needed to overcome the investment hurdle rate. Increasing this strike rate reduces the number hours likely to trigger it.

If contracts can be negotiated such that when the generation is applied and paid for on a (spot price – X) basis then much larger margins are able to be captured by the generator. This would contribute to capital cost rather than the marginal pricing approach currently assumed. A much stronger contribution from this source is probable.

Improved Security

Some analysis is provided in Appendix G on the security benefit able to be derived from using a generator during planned outages. Network Maintenance has the advantage over faults in that the outage can be planned for and is therefore an easy target for managed improvement via the application of generators.

In this case the lines company's current performance with regard to average duration of its planned outages is 200 minutes (3 hours 20 minutes). The national average is closer to 120 minutes (2 hours). The difference is the result of a few long duration outages affecting a wide area/number of consumers.

Operating a genset for approximately 90 hours per year would overcome this service issue. It has been assumed that the lines company wishes to at least deliver average performance, subject to an economically acceptable solution, rather than continue with the status quo of underperformance.

lines company's Security Standard provides a methodology for valuing the economic cost to consumers when deprived of a supply. If an upgrade proposal can deliver a gain with certainty for less cost than the value of that gain then it passes the lines company's upgrade test.

A conservatively low value of benefit ($3.20/kWh) has been assumed. This is a specific figure determined by the lines company for its own purposes based on its local knowledge of consumer requirements connected to this particular location in its network.

In this case it reflects a high portion of rural and domestic connections relative to industrial connections and the fact that the outage is planned. This value is approximately six times lower than that which CAE has recently recommended be applied to grid investment.

Diesel generators applied to planned outages have a very high level of certainty with regard to success. Approximately 38% of the annual benefits attributed to this project are derived from outage performance improvement. This will cost lines company only $7,380.00 in operating costs to realize and is therefore considered a very worthwhile proposition.

The inclusion of this benefit should be viewed as improving the value delivered by the project. Its exclusion does not impact basic viability and extends payback by only 3 years.

Cost Benefit Analysis

Full Discounted Cash Flows analysis and calculation of Net Present Value is documented in Appendix H.

These are provided for three and four genset proposals.

The following assumptions have been applied:

- CPI 2%
- Tax Rate 33%
- Depreciation Rate 9% DV
- WACC 7.5%

The following table summarises results:

	3 Gensets	4 Gensets
Investment	$843,160	$1,086,360
NPV 20 Years	$480,393	$429,068
Internal Rate of Return	9.1%	6.1%
Simple Payback	4 years	5 years

Both proposals have a positive NPV and therefore are viable on the basis that they deliver returns in excess of the cost of capital, adding value to the company, and improving its capital efficiency.

Most lines companies will find 4 to 5 year pay backs well within their normal risk horizon. Accordingly this investment opportunity is likely to have a higher priority ranking than alternative uses of capital.

The 3 Genset option has an IRR that exceeds WACC by a healthy margin unlikely to attract regulatory attention. It is therefore likely to meet lines company policy with regard to investment hurdle rates.

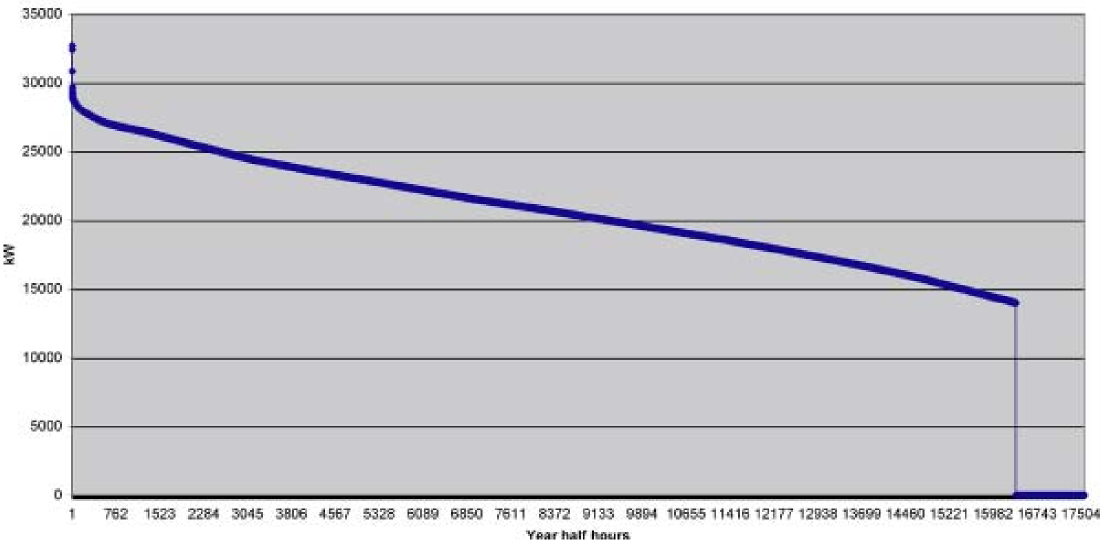
It should also be noted that the above figures do not include the non cash benefit of security improvement. This was determined to have an economic value of $139,264 p.a. for a cost of $7,380 p.a. This equates to an increase in benefits by approximately 40%.

The three genset option is preferred on the basis that it is lower risk (less investment, shorter payback) and delivers a higher NPV i.e. creates more value and therefore improves capital structure efficiency by a greater amount.

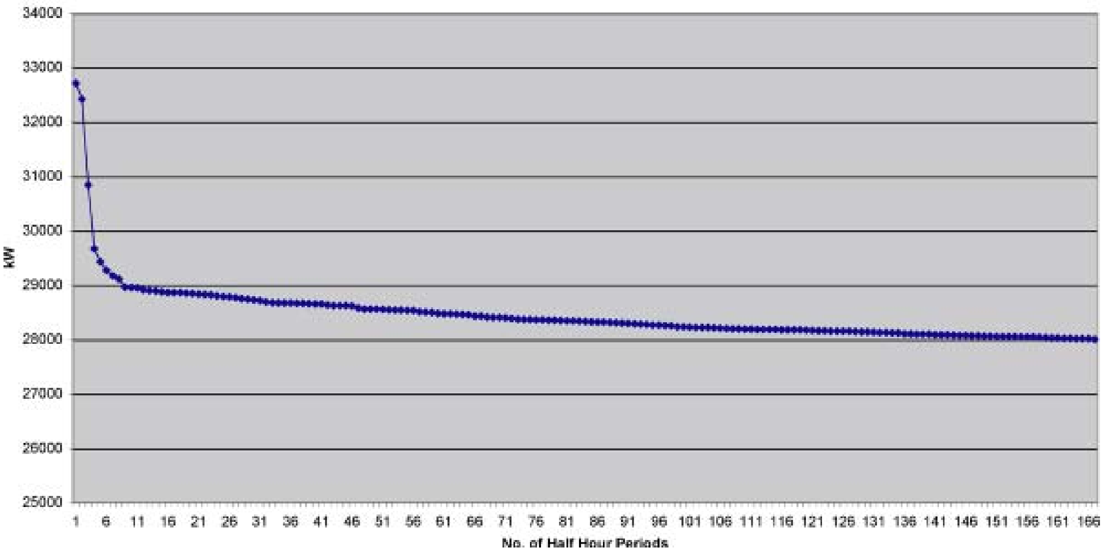
Appendices

Appendix A	Load Duration Curves
Appendix B	Manufacturers Specifications PowerHire Budgetary Quotes
Appendix C	Capital Cost Running Costs
Appendix D	Operating Statistics
Appendix E	Genset Usage Pattern
Appendix F	Energy Benefit
Appendix G	Security Benefit
Appendix H	Cost Benefit Analysis

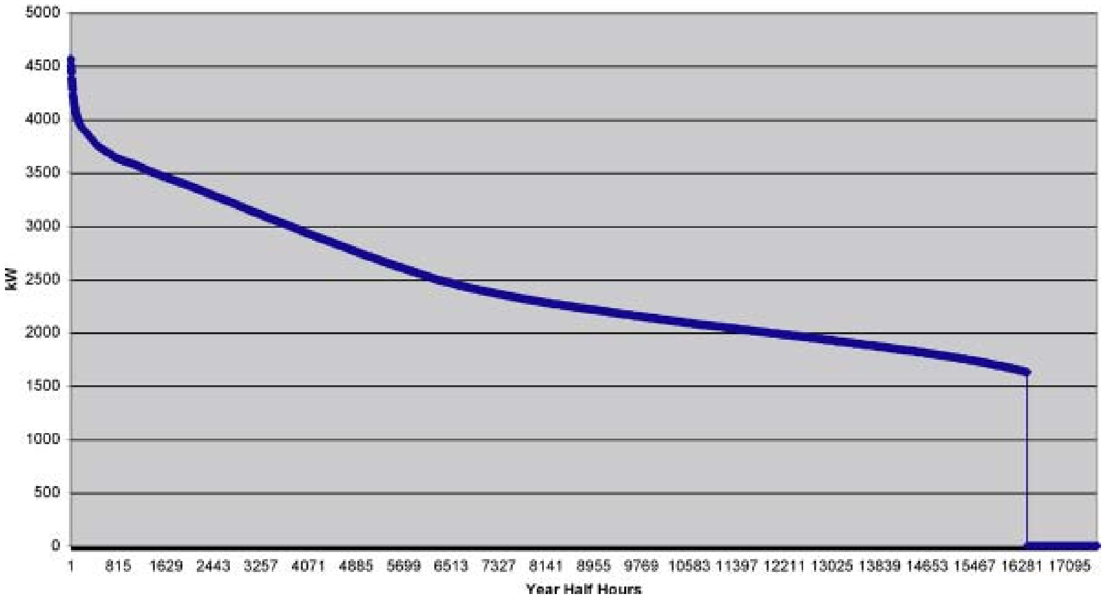
Appendix A : Load Duration Curves



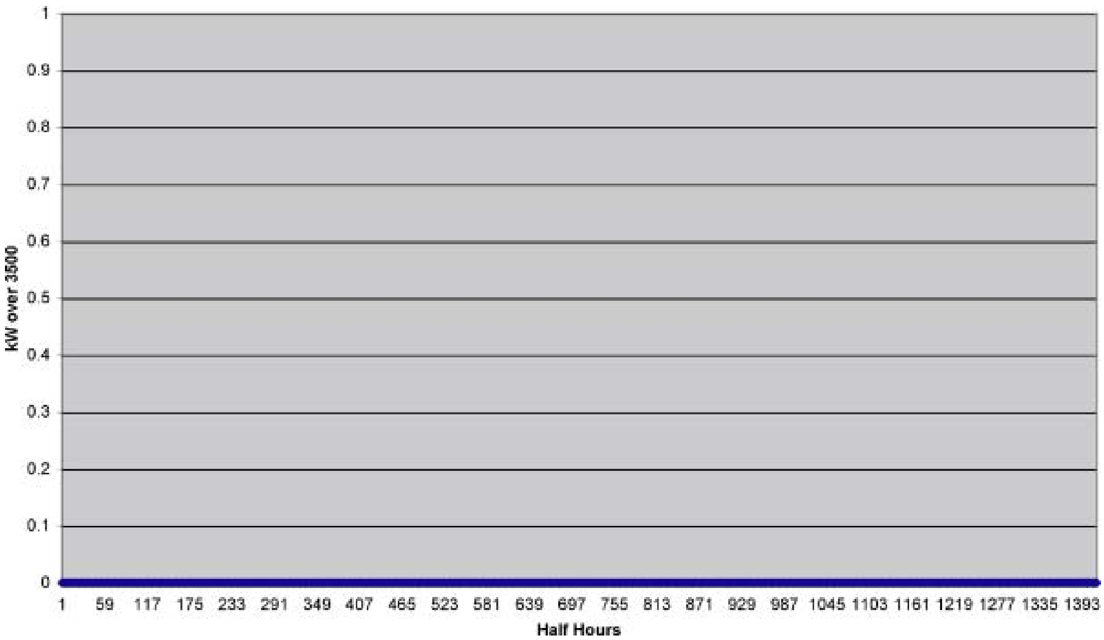
Load duration curve GXP A



Load duration curve GXP A



Load duration curve GXP B/C



Load duration curve GXP B/C

Appendix B : Manufacturer's Specifications & PowerHire Budgetary Quotes

POWERHIRE

GENERATOR SETS • SALES • HIRE • INSTALLATION • 24HRS

8 Fox Street, Hillside, Dunedin N.Z. - Tel: 03 455 1599, Fax: 03 455 1022, Mobile: 0274 356 222
Email Address :- donb@powerhire.co.nz Additional depots in Wellington, Christchurch & Auckland

FAX TRANSMISSION

TO	**:- Mr. Ken Mitchell**	**DATE**	**:- 24th August 2004**
COMPANY	**:- Whitston Holdings Ltd.**	**OUR REF.**	**:- D903**
FAX No.	**:- kenmitchell@ihug.co.nz**	**No. OF PAGES**	**:- Five**
FROM	**:- Don Biss**		

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Dear Ken,

Further to your recent E-mail we are pleased to detail on the attached specification sheets our offer to supply two Perkins/Leroy Somer 500 kVa or 600 kVa diesel generators, as requested. This offer is for budgetary purposes only.

Conditions

- Payment terms will be 90% of order value upon delivery with the balance upon successful commissioning.
- Delivery of the Generators is 20 weeks from order placement, subject to prior sale.
- This offer is valid for 30 days from the 24th August 2004.
- The generator and associated equipment is subject to 12 months warranty on all parts and labour from date of commissioning.

Pricing

To supply 2 No. Perkins/ Leroy Somer 500 kVa diesel generator complete with options detailed on the attached specification sheets will be:- $ 144,000.00 + G.S.T. ex Christchurch each

To supply 2 No. Perkins/ Leroy Somer 600 kVa diesel generator complete with options detailed on the attached specification sheets will be:- $ 188,000.00 + G.S.T. ex Christchurch each

Notes

- The fuel tank capacity on Option one is 880 litres and Option two is 1350 litres. Fuel consumption at full load is 107.9 and 116.3 litres per hour respectively.
- Assuming one annual oil and filter change per year, we would allow $750.00 per service per unit plus travel to site. This would include oil and filter change, coolant conditioner and our standard service checklist.
- Fuel tank connections would be of the QRC type (Quick release coupling type) unless other wise requested. We still await fuel tank prices and will forward these to you as soon as they are available.

- The controllers would be of the Woodward type either EGCP 1 as per the attached brochure, sold as FG Wilson 6400 panel or Woodward EGCP2.
- Option one being the 500 kVa units we would expect the kW setpoint to be in the 380 – 400 kW range. Option two being the 600 kVa units we would expect the kW set point to be in the 460 - 480 kW range.
- Regarding the interface with the Abbey Systems Powerlink SCADA system please see the attached spreadsheet to view our scope of supply

We trust that this information meets with your requirements, if you have any questions or require other options that you feel would be better suited to this project please do not hesitate to contact myself at our Dunedin depot.

Yours sincerely,

Don Biss
POWER HIRE LTD.
DUNEDIN

POWERHIRE

GENERATOR SETS • SALES • HIRE • INSTALLATION • 24HRS

8 Fox Street, Hillside, Dunedin N.Z. - Tel: 03 455 1599, Fax: 03 455 1022, Mobile: 0274 356 222
Email Address :- donb@powerhire.co.nz Additional depots in Wellington, Christchurch & Auckland

FAX TRANSMISSION

TO	**:- Mr. Ken Mitchell**	**DATE**	**:- 30 August 2004**
COMPANY	**:- Whitston Holdings Ltd.**	**OUR REF.**	**:- D903**
FAX No.	**:- kenmitchell@ihug.co.nz**	**No. OF PAGES**	**:- One**
FROM	**:- Don Biss**		

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Dear Ken,

Further to our generator offer of last week, please see below budget pricing and specification for fuel tanks, as requested.

To supply 2 No. 5000 litre double skinned tanks complete with anti siphon valve, vent, lockable cap and top cabinet and lifting lugs will be:-$16,280 each + GST & Freight

We trust that this information meets with your requirements, if you have any questions please do not hesitate to contact myself at our Dunedin depot.

Yours sincerely,

Don Biss
POWER HIRE LTD.
DUNEDIN

Diesel Generator Specification

500 kVa Perkins/ Leroy Somer Diesel Generator

We are pleased to detail below our offer for the supply of one F.G.Wilson model P500P1 diesel generating set. Rated at 500 kVa, 400 kW at 0.8 pf.

Voltage 415 V, Phase 3, Frequency 50 Hz. Engine operating speed of 1500 RPM will produce 730 amps. per phase.

Diesel Engine:	Perkins		
Model:	2806C-E16TAG2		
Cylinders:	6		
Governor:	Electronic	Type: A1	Class: BS5514

600 kVa Perkins/ Leroy Somer Diesel Generator

We are pleased to detail below our offer for the supply of one F.G.Wilson model P600P1 diesel generating set. Rated at 600 kVa, 480 kW at 0.8 pf.

Voltage 415 V, Phase 3, Frequency 50 Hz. Engine operating speed of 1500 RPM will produce 876 amps. per phase.

Diesel Engine:	Perkins		
Model:	2806C-E18TAG2		
Cylinders:	6		
Governor:	Electronic	Type: A1	Class: BS5514

From this point on the specification is common to all options unless otherwise stated

ENGINE:
6 cylinder, 4 stroke, direct injection, compression ignition, continuously rated, watercooled industrial diesel engine. Arranged for electric start and stop. Built to comply with BS5514 and capable of sustaining a 10% overload for one hour in a 12 hour running period. Complete with cooling fan drive, lubricating oil filters, air cleaners, start motor, battery charging alternator or dynamo and regulator, multi cylinder, fuel injection pump, fuel control solenoid, fuel lift pump, engine speed adjustment. The engine will be fitted with a heavy dynamically balanced flywheel suitable for constant speed generator duty. An efficient approved engine speed governor is fitted to maintain engine speed at all conditions of load in line with the requirements of BS5514:

COOLING SYSTEM:
The engine will be complete with tropical capacity radiator for cooling the machine in tropical ambient temperatures with engine driven blower type heavy duty cooling fan. Radiator core and fin design will take into account compensation for possible ingress of dirt which would normally clog the fins.

A thermostatically controlled "stand still" heater will be fitted to aid cold starting. The heater will require a single phase AC supply and provision should be made for this in the generator room distribution board.

FILTRATION SYSTEM:
The engine will be fitted with dry type air filters with replaceable elements. The engine will be complete with fuel and lubricating oil filters with replaceable elements.

STARTING SYSTEM:

The engine will be electric start complete with starter motor, heavy duty lead acid batteries, battery racks and interconnecting cables.

BATTERY CHARGING SYSTEM:
The engine will be complete with battery charging alternator unit complete with voltage regulator.

STATIC BATTERY CHARGING SYSTEM:
The generating set will be complete with a constant voltage current limiting type static battery trickle charger. The design of this charger will be fully automatic which continuously monitors the battery voltage and automatically switches the charger via solid state switching device. At the same time the current is fully controlled and overcharging of the battery is therefore impossible. The charger will require a single phase AC supply and provision should be made for this in the generator room distribution board.

EXHAUST SILENCER SYSTEM:
The engine will be complete with residential capacity exhaust silencer of the reactive type to meet an overall noise level of 75 dba.

ALTERNATOR:
The alternator will be as manufactured by Leroy Somer. The alternator will be of brushless, self-exciting, self-regulating design.
The alternator will be directly coupled to the engine and will include excitation system, automatic voltage regulator, voltage adjusting potentiometer and underspeed protection.
The excitation system will provide an exceptionally rapid response to load change and all alternators are designed for high motors starting capability.
The alternator will be tropically insulated and windings will be impregnated with thermosetting insulated varnish for use in tropical climates.
The rotor system is dynamically balanced to minimise vibration.
Ample ventilation is provided by a shaft mounting centrifugal fan.
A screen protected enclosure is standard and the automatic voltage regulator is readily accessible at the non-drive end.

COUPLING ARRANGEMENT:
The engine and alternator will be directly coupled by means of an SAE flange so that there is no possibility of misalignment being found after prolonged use. A flexible coupling is used in all cases and the coupling is completely guarded for safety purposes.

MOUNTING ARRANGEMENT:
The engine and alternator will be mounted as a whole on a heavy duty fabricated steel baseframe constructed from folded channel sections. Crane lifting arrangement is included.

MOUNTING ARRANGEMENT (FUEL TANK):
The above mentioned baseframe will incorporate an 8 hour capacity fuel tank which will be complete with contents indicator, venting arrangement, drain plug, filler cap, fuel strainer, fuel feed and return lines to engine.

ANTI-VIBRATION MOUNTING PADS:
The above mentioned baseframe will be complete with anti-vibration mounting pads for affixing between the engine/alternator feet and the baseframe itself thus ensuring complete vibration isolation of the rotating assemblies and enabling the machine to be placed on an uneven surface without any detrimental effects.

FUEL TANK:
To be advised

CONTROL PANEL:
Please see the attached brochure

CIRCUIT BREAKER:
Set mounted sheet steel box containing suitably rated 3 pole motorised circuit breaker.

ACCESSORIES:
1 set operation and maintenance instructions
1 circuit wiring diagram

FINISH:
The generator is thoroughly cleaned and primed with two coats of industrial primer and finished in two coats industrial high gloss paint.

WORKS TEST:
The generator will be load tested in our test bay before despatch. All systems will be thoroughly checked for correct operation. All fluid seals will be proved. Where possible, faults, control functions and site load conditions will be simulated and the generator and its systems will be checked, proved and then passed for despatch.

COMMISSIONING:
Our engineers will fully test and commission the generator and associated control systems and accessories after completion of installation. The costs for this service are detailed in the price schedule. We have not included for fuel or load banks.

SOUND ATTENUATED ENCLOSURE:
The generator will be offered fitted within a close fitting acoustic canopy giving a noise reduction to 80 dBa @ 1 metre @ 100% load. This canopy is manufactured from a galvanised steel body with all sheet metal components pre-treated with zinc phosphate prior to polyester powder coating. Full length doors on either side allow easy access for maintenance. All external fittings, locks and hinges are made from stainless steel.

P600P1/P660E1

FG WILSON

Output Ratings		
Generating Set Model	P600P1 Prime*	P660E1 Standby*
380-415V, 50 Hz	600 kVA 480 kW	660 kVA 528 kW

* Refer to ratings definitions on page 4.
Ratings at 0.8 pf

Technical Data	
Engine Make & Model	Perkins 2806C-E18TAG2
Alternator Model	LL6114K
Base Frame Type	Heavy Duty Fabricated Steel
Circuit Breaker Type/Rating	3 Pole ACB/MCCB
Frequency	50 Hz
Engine Speed	1500
Fuel Tank Capacity: Litres (US Gal)	1350 (357)
Fuel Consump, P600P1: L/hr (US Gal/hr)	116 (30.7)
Fuel Consump, P660E1: L/hr (US Gal/hr)	130 (34.3)

FG Wilson (Engineering) Ltd
Old Glenarm Road, Larne, County Antrim BT40 1EJ
Northern Ireland, United Kingdom
Tel: 44 (0) 28 2826 1000 Fax: 44 (0) 28 2826 1111
www.FGWilson.com

Engine Technical Data

Physical Data	
Manufacturer:	Perkins
Model:	2806C-E18TAG2
No. of Cylinders/Alignment:	6 in-line
Cycle:	4 Stroke
Induction:	TurboCharged
Cooling Method:	Water
Governing Type:	Electronic
Class:	ISO8528 G2
Compression Ratio:	14.5:1
Displacement: L (cu.in):	18.1 (1106)
Bore/Stroke: mm (in)	145 (5.7) / 183 (7.2)
Moment of Inertia: kg m² (lb/in²)	7.44 (25424)
Engine Electrical System:	
-Voltage/Ground	24/Negative
-Battery Charger Amps	70
Weight: kg (lbs) -Dry	1832 (4039)
-Wet	1900 (4189)

Performance	50 Hz
Engine Speed: rpm	1500
Gross Engine Power: kW (hp)	
-Standby:	607 (814)
-Prime:	550 (738)
BMEP: kPa (psi)	
-Standby:	2678 (388)
-Prime:	2427 (352)
Regenerative Power: kW	20.0

Fuel System	
Fuel Filter Type:	Eco Replaceable Element
Recommended Fuel:	Class A2 Diesel

Fuel Consumption: L/hr (US Gal/hr)

	110% Load	100% Load	75% Load	50% Load
P600P1				
50 Hz	130.0 (34.3)	116.3 (30.7)	86.0 (22.7)	60.3 (15.9)
P660E1				
50 Hz	N/A	129.9 (34.3)	94.5 (25.0)	65.0 (17.2)

(based on diesel fuel with a specific gravity of 0.85 and conforming to BS2869, class A2)

Air System	50 Hz
Air Filter Type:	Replaceable Element
Combustion Air Flow:	
m³/min (cfm) - Standby:	42.8 (1511)
- Prime:	41.8 (1476)
Max. Combustion Air Intake Restriction: kPa (in H_2O)	6.25 (25.1)
Radiator Cooling Airflow: m³/min (cfm)	660 (23308)
External Restriction to Cooling Airflow: Pa (in Wg)	125 (0.5)

Cooling System	50 Hz
Cooling System Capacity: L (US Gal)	61 (16.1)
Water Pump Type:	Centrifugal
Heat Rejected to Water & Lube Oil: kW (Btu/min)	
- Standby:	TBA
- Prime:	TBA
Heat Radiation to Room:	
kW (Btu/min) - Standby:	TBA
- Prime:	TBA
Radiator Fan Load: kW (hp)	8.0 (10.7)

Lubrication System	
Oil Filter Type:	Eco, Full Flow
Total Oil Capacity L (US Gal):	55.3 (14.6)
Oil Pan L (US Gal):	53.5 (14.1)
Oil Type:	API CG4 15W-40
Cooling Method:	Water

Exhaust System	50 Hz
Silencer Type:	Level 1
Silencer Model & Qty:	SD200 (1)
Pressure Drop Across Silencer System: kPa (in Hg)	0.20 (0.1)
Silencer Noise Reduction Level: dBA	11.0
Max. Allowable Back Pressure: kPa (in Hg)	6.7 (2.0)
Exhaust Gas Flow: m³/min (cfm)	
- Standby:	109 (3849)
- Prime:	109 (3849)
Exhaust Gas Temperature:	
°C (°F) - Standby:	541 (1006)
- Prime:	541 (1006)

2

Alternator Performance Data

Data Item	50 Hz		
	380/220	400/230	415/240
Motor Starting Capability* kVA	1301	1427	1525
Short Circuit Capacity**%	300	300	300
Reactances: Per Unit			
Xd	3.60	3.25	3.02
X'd	0.18	0.16	0.15
X"d	0.13	0.12	0.11

Reactances shown are applicable to prime ratings

* Based on 30% voltage dip. Improved motor starting capability is available with optional Permanent Magnet generator or AREP excitation

** With optional Permanent Magnet generator or AREP excitation.

Alternator Technical Data

Physical Data		Operating Data	
Manufacturer:	FG Wilson	**Overspeed:** RPM	2250
Model:	LL6114K	**Voltage Regulation (steady state)**	±0.5%
No. of Bearings:	Single	**Wave Form NEMA = TIF**	<50
Insulation Class:	H	**Wave Form IEC = THF**	<2%
Winding Pitch (Code):	2/3 (No. 6S)	**Total Harmonic Content LL/LN**	<2%
Wires:	6	**Radio Interference**	Suppression is in line with British Standard BSEN61000-6
Ingress Protection Rating:	IP23	**Radiant Heat:** kW (Btu/min)	
Excitation System:	Shunt	-50 Hz:	31.3 (1780)
AVR Model:	R448		

Technical Data

3 Phase Ratings and Performance at 50 Hz, 1500 RPM

Voltage	Model: P600P1 Prime		Model: P660E1 Standby	
	kVA	kW	kVA	kW
415/240	600	480	660	528
400/230	600	480	660	528
380/220	600	480	660	528

Definitions

Standby Rating

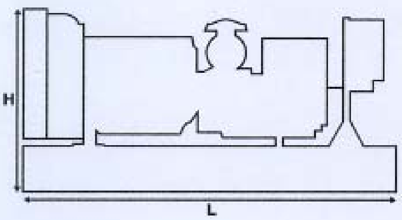
These ratings are applicable for supplying continuous electrical power (at variable load) in the event of a utility power failure. No overload is permitted on these ratings. The alternator on this model is peak continuous rated (as defined in ISO8528-3).

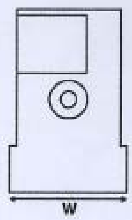
Prime Rating

These ratings are applicable for supplying continuous electrical power (at variable load) in lieu of commercially purchased power. There is no limitation to the annual hours of operation and this model can supply 10% overload power for 1 hour in 12 hours.

Standard Reference Conditions

Note: Standard reference conditions 27°C (80°F) Air Inlet Temp, 152.4m (500ft) A.S.L. 60% relative humidity. All engine performance data based on the above mentioned maximum continuous ratings. Fuel consumption data at full load with diesel fuel with specific gravity of 0.85 and conforming to BS2869: 1998, Class A2.





Weights & Dimensions

Weights: kg (lbs)		Dimensions: mm (in)	
Net (+ lube oil)	4727 (10423)	Length	4111 (162)
Wet (+ lube oil & coolant)	4797 (10577)	Width	1536 (60.5)
Fuel, lube oil & coolant	5942 (13102)	Height	2098 (83.0)

General Data

Documents

A full set of operation and maintenance manuals, circuit wiring diagrams, and commissioning/fault finding instruction leaflets.

Generating Set Standards

The equipment meets the following standards: BS5000, ISO 8528, ISO 3406, IEC 60034, VDE 0530, NEMA MG-1.22.

FG Wilson is a fully accredited ISO9001 company.

Warranty

All equipment carries full manufacturer's warranty. Extended warranty terms available. For details on warranty cover please contact your local dealer, or visit our website, www.FGWilson.com

950-394

P600P1-P660E1/TECHDATA/FGW/0504

450 - 688 kVA Generating Set Range

Modular Acoustic Enclosure

The FG Wilson sound attenuated enclosures for the range of Perkins powered P450P1 to P688E1 generating sets are a result of continuing research and development by our specialist acoustic engineers.These enclosures reduce sound levels to comply with the new European Community regulations 2000/14/EC which became effective on 1 January 2002.

The fully weatherproof enclosures incorporate internally mounted exhaust silencers and are of extremely rugged construction in order to withstand the rough handling common on many construction sites. They are designed on modular principles with many interchangeable components permitting on-site repair.

Robust/Highly Corrosion Resistant Construction

- Black finish stainless steel locks and hinges
- Zinc plated or stainless steel fasteners
- Body made from steel components treated with polyester powder coating

Excellent Access for Maintenance

- Two large doors on each side
- Radiator fill access plate
- Lube oil and cooling water drains piped to exterior of the enclosure

Security and Safety

- Control panel viewing window in a lockable access door
- Emergency stop push button (red) mounted on enclosure exterior
- Cooling fan and battery charging alternator fully guarded
- Fuel fill and battery can only be reached via lockable access doors
- Exhaust silencing system totally enclosed for operator safety

Transportability

- Tested and certified single point lifting facility
- Lifting points on baseframe

Optional Features

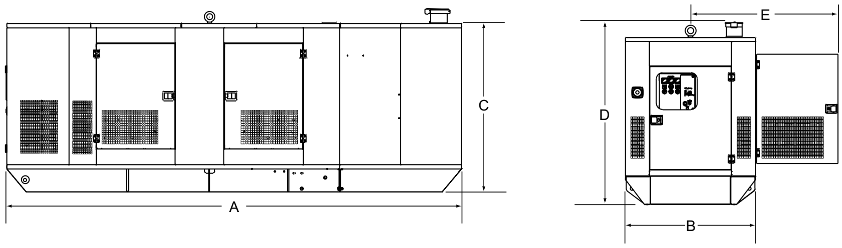
- Oil field type skid with dragging points and fork lift truck pockets

Sound Pressure Levels (dBA)

		50 Hz					
		15 m (50 ft)		7 m (23 ft)		1 m (3 ft)	
Generating Set Model	LWA	75% Load	100% Load	75% Load	100% Load	75% Load	100% Load
P450P1	99	64.5	65.6	70.5	71.6	79.4	80.2
P500E1	99	64.5	65.6	70.5	71.6	79.4	80.2
P500P1	99	64.5	65.6	70.5	71.6	79.4	80.2
P550E1	99	64.5	66.5	70.5	72.5	79.4	80.7

		60 Hz					
		15 m (50 ft)		7 m (23 ft)		1 m (3 ft)	
Generating Set Model	LWA	75% Load	100% Load	75% Load	100% Load	75% Load	100% Load
P563P1	tba	66.5	68.5	72.5	74.5	83.5	84.7
P625E1	tba	66.5	68.5	72.5	74.5	83.5	84.7
P625P1	tba	66.5	68.5	72.5	74.5	83.5	84.7
P688E1	tba	66.5	69.7	72.5	75.7	83.5	85.2

Levels in accordance with European Noise Directive (2000/14/EC)



Dimensions and Weights

Generating Set Model	A: mm (in)	B: mm (in)	C: mm (in)	D: mm (in)	E:* mm (in)	Weight: kgs (lb)	Fuel Capacity L (US Gal)
P450P1	5820 (229.1)	1600 (63.0)	2150 (84.6)	2346 (92.4)	1810 (71.3)	5490 (12103)	880 (232)
P500E1	5820 (229.1)	1600 (63.0)	2150 (84.6)	2346 (92.4)	1810 (71.3)	5490 (12103)	880 (232)
P500P1	5820 (229.1)	1600 (63.0)	2150 (84.6)	2346 (92.4)	1810 (71.3)	5500 (12125)	880 (232)
P550E1	5820 (229.1)	1600 (63.0)	2150 (84.6)	2346 (92.4)	1810 (71.3)	5500 (12125)	880 (232)
P563P1	5820 (229.1)	1600 (63.0)	2150 (84.6)	2346 (92.4)	1810 (71.3)	5500 (12125)	880 (232)
P625E1	5820 (229.1)	1600 (63.0)	2150 (84.6)	2346 (92.4)	1810 (71.3)	5500 (12125)	880 (232)
P625P1	5820 (229.1)	1600 (63.0)	2150 (84.6)	2346 (92.4)	1810 (71.3)	5500 (12125)	880 (232)
P688E1	5820 (229.1)	1600 (63.0)	2150 (84.6)	2346 (92.4)	1810 (71.3)	5500 (12125)	880 (232)

Weight with lube oil, no coolant, no fuel.; * Clearance required on both sides

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The FG Wilson sound attenuated enclosures for the range of Perkins powered P550P1 to P750E1 generating sets are a result of continuing research and development by our specialist acoustic engineers.

These enclosures are fully weatherproof and incorporate internally mounted exhaust silencers. They are of extremely rugged construction in order to withstand rough handling conditions and are designed on modular principles with many interchangeable components permitting on-site repair.

550 - 750 kVA Generating Set Range

Robust/Highly Corrosion Resistant Construction

- Black finish stainless steel locks and hinges
- Zinc plated or stainless steel fasteners
- Body made from steel components treated with polyester powder coating

Excellent Access for Maintenance

- Two large doors on each side
- Radiator fill access cover
- Lube oil and cooling water drains piped to exterior of the enclosure

Security and Safety

- Control panel viewing window in a lockable access door
- Recessed emergency stop push button (red) mounted on enclosure exterior
- Cooling fan and battery charging alternator fully guarded
- Fuel fill and battery can only be reached via lockable access doors
- Exhaust silencing system totally enclosed for operator safety

Transportability

- Lifting points on baseframe

Optional Features

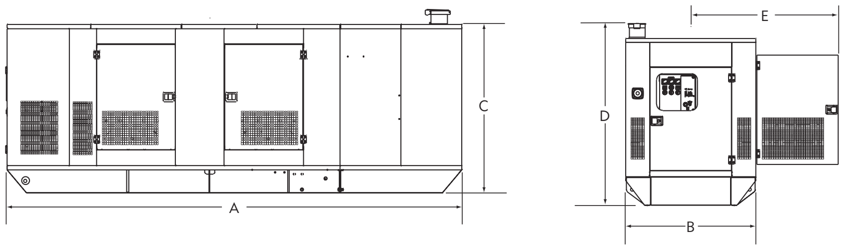
- Oil field type skid with dragging points

Modular Acoustic Enclosure

Sound Pressure Levels (dBA)

Generating Set Model	LWA	50 Hz 15 m (50 ft) 75% Load	50 Hz 15 m (50 ft) 100% Load	50 Hz 7 m (23 ft) 75% Load	50 Hz 7 m (23 ft) 100% Load	50 Hz 1 m (3 ft) 75% Load	50 Hz 1 m (3 ft) 100% Load	60 Hz 15 m (50 ft) 75% Load	60 Hz 15 m (50 ft) 100% Load	60 Hz 7 m (23 ft) 75% Load	60 Hz 7 m (23 ft) 100% Load	60 Hz 1 m (3 ft) 75% Load	60 Hz 1 m (3 ft) 100% Load
P550P1	103	68.0	69.5	74.0	75.5	84.0	85.3	n/a	n/a	n/a	n/a	n/a	n/a
P605E1	103	68.4	70.1	74.4	76.1	84.4	85.8	n/a	n/a	n/a	n/a	n/a	n/a
P635E1	103	68.7	70.4	74.7	76.4	84.6	86.1	n/a	n/a	n/a	n/a	n/a	n/a
P600P1	103	68.4	70.0	74.4	76.0	84.4	85.8	n/a	n/a	n/a	n/a	n/a	n/a
P660E1	103	68.9	70.6	74.9	76.6	84.8	86.3	n/a	n/a	n/a	n/a	n/a	n/a
P635P1	103	68.7	70.4	74.7	76.4	84.6	86.1	n/a	n/a	n/a	n/a	n/a	n/a
P700E1	103	69.2	71.1	75.2	77.1	85.1	86.7	n/a	n/a	n/a	n/a	n/a	n/a
P675P1	TBA	n/a	n/a	n/a	n/a	n/a	n/a	70.7	72.4	76.7	78.4	86.6	88.1
P750E1	TBA	n/a	n/a	n/a	n/a	n/a	n/a	71.2	73.1	77.2	79.1	87.1	88.7

Levels in accordance with European Noise Directive (2000/14/EC)



Dimensions and Weights

Generating Set Model	**A:** mm (in)	**B:** mm (in)	**C:** mm (in)	**D:** mm (in)	**E:** mm (in)*	**Weight:** kgs (lb)	**Fuel Tank Capacity** Litres (US Gal)
P550P1	5880 (231)	1930 (76.0)	2200 (87.4)	2400 (94.5)	1008 (39.7)	6266 (13814)	1350 (357)
P605E1	5880 (231)	1930 (76.0)	2200 (87.4)	2400 (94.5)	1008 (39.7)	6266 (13814)	1350 (357)
P635E1	5880 (231)	1930 (76.0)	2200 (87.4)	2400 (94.5)	1008 (39.7)	6330 (13955)	1350 (357)
P600P1	5880 (231)	1930 (76.0)	2200 (87.4)	2400 (94.5)	1008 (39.7)	6330 (13955)	1350 (357)
P660E1	5880 (231)	1930 (76.0)	2200 (87.4)	2400 (94.5)	1008 (39.7)	6330 (13955)	1350 (357)
P635P1	5880 (231)	1930 (76.0)	2200 (87.4)	2400 (94.5)	1008 (39.7)	6430 (14176)	1350 (357)
P700E1	5880 (231)	1930 (76.0)	2200 (87.4)	2400 (94.5)	1008 (39.7)	6430 (14176)	1350 (357)
P675P1	5880 (231)	1930 (76.0)	2200 (87.4)	2400 (94.5)	1008 (39.7)	6535 (14176)	1350 (357)
P750E1	5880 (231)	1930 (76.0)	2200 (87.4)	2400 (94.5)	1008 (39.7)	6535 (14176)	1350 (357)

Weight with lube oil, no coolant, no fuel.
* Clearance required on both sides

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Auto synchronizing one generating set with the mains (including AMF function). When the 6000 Series panel is configured as a 6400 Control system, the controller can autosynchronize up to 8 generating sets with the mains (including Automatic Mains Failure function). Two types of operation are available:

- **Baseload operation**

The operator manually starts the generating set. Each set will automatically synchronize to the mains supply. The amount of active (kW) and reactive (kVAr) power supplied by the generating set is increased at a predetermined rate until the preset quota is met. Power will be exported to the mains if the generating set output is greater than the local load.

- **Peak lopping**

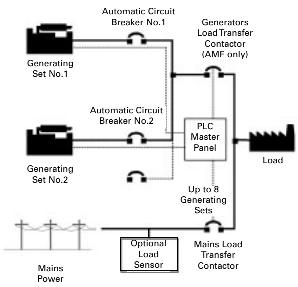
With the addition of an optional load sensor on the mains supply, the controller will ensure that only local load is supplied and no power is exported to the grid. This operating mode must be specified when ordering.

When operating independently from the mains, the generating sets will run to supply the required load demand automatically.

Note:
The above modes also allow for AMF operation with soft load re-transfer.

The optional facility of the industry standard Modbus protocol communication interface ensures compatibility with most building management or SCADA/HMI systems.

Note:
Consult your local utility to ensure that the control and protection equipment incorporated in the 6000 Series control panel meets their specific regulations. Consult the factory if the utility requires additional protection relays. Due to the specialized nature of generating set systems synchronizing with the mains, consult the factory before specifying a 6400 control system.



FG WILSON

6400 Series

Control panel

Standard features

Generating set parameter displays (2 X 4 line LCD display)

AC voltage phase to phase and phase to neutral (on 3 phases)
AC current (on each of 3 phases)
Frequency
CosΦ (power factor) average
kW - total + per phase
kVAr - total + per phase
kWh - total
% Voltage difference between bus and generator
Phase shift
Frequency slip
Hours run
Coolant temperature
Lube oil pressure
DC voltage

Bus parameter displays

AC voltage (on a single phase)
AC voltage/frequency within limits indicator

Operator controls

Off/auto/test/run control switch
Emergency stop pushbutton (lockdown)
Membrane keypad with tactile feedback
AC voltage adjust - manual and automatic
Engine speed adjust - manual and automatic

System controls

3 attempt start counter
Cool down delay
Pre-glow delay
Remote start capability
Check synch relay
Reverse power relay
Manual synchronizing
Automatic synchronizing
Automatic load sharing control
Automatic loading and unloading ramp controller
Automatic mains failure controller
Load sequencing control
Static battery charger (5amp) 220/240 Volt AC
Quadrature droop kit

Shutdowns and alarms

High coolant temperature shutdown
Low oil pressure shutdown
Overspeed shutdown
Fail to start shutdown
Emergency stop operated
Reverse power shutdown
Overvoltage shutdown
Undervoltage shutdown or alarm
Overfrequency shutdown
Underfrequency shutdown or alarm
Alternator loss of excitation alarm
Fail to synchronize alarm
Battery overvoltage shutdown or alarm
Battery undervoltage alarm
Bus overvoltage alarm
Bus undervoltage alarm
Bus underfrequency alarm
Bus overfrequency alarm
Bus load surge
Spare fault channels, up to 3:
– Low coolant temperature alarm
– Low fuel level shutdown or alarm
– Low coolant level shutdown

Status indicators

Load switch status indicator
General switch status indicator
Fault log memory
Password security
Interface to remote monitoring package

Optional features

System controls

Volt free contacts for generating set running
R448 regulator (required)
Electronic governor (required)
Droop engine control module

Shutdowns and alarms

Earth fault shutdown
High fuel level alarm

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Appendix C : Running Costs & Capital Cost

Running Costs

600kVA GENERATOR SET - OPERATING COSTS

VARIABLE OPERATING COSTS

Description	Load (kW)	Quantity	Unit	Cost	Running Cost	Cost /kWh
Fuel (litres) F.	480	116.3	litre	$0.6700	$77.92 /hr	$0.1696
75% F.L.	360	86.0		$0.6700	$57.62 /hr	$0.1697
50% F.L.	240	60.3		$0.6700	$40.40 /hr	$0.1828

FIXED OPERATING COSTS - 500h INTERVAL

Description	Quantity	Unit	Cost	Running Cost
Oil filter	1	ea	$30.90	$30.90
Fuel filter	1	ea	$46.20	$46.20
Lube Oil	55	litre	$5.50	$302.50
Air Cleaner	1	ea	$467.00	$467.00
Breather Gasket	1	ea	$38.78	$38.78
Rocker Cover Joint	1	ea	$3.19	$3.19
Oil Tests	1	ea	$42.50	$42.50
Sundries	1	ea	$20.00	$20.00
Labour	10	hr	$40.00	$400.00
Lube Oil Comsumption when	10	litre	$5.30	$53.00
Costs from 2500 hr service	.2		$1,647.82	$329.56
			Total	$1,733.63
Service Interval	**500**	**hr**	**Total / h**	**$3.47**

FIXED OPERATING COSTS - 2500 h INTERVAL

Description		Quantity	Unit	Cost	Running Cost
Injector Service		6	ea	$150.00	$900.00
Injector O Ring		6	ea	$4.07	$24.42
Injector O Ring		6	ea	$3.02	$18.12
Injector O Ring		6	ea	$3.39	$20.34
Injector Washer		6	ea	$5.49	$32.94
Sundries		1	ea	$50.00	$50.00
Internal Inspecti	Labour	12	hrs	$40.00	$480.00
Cooling System		61	litre	$2.00	$122.00
Service Interval		**2500**		**Total**	**$1,647.82**

Generator Costs - 4 Generator Scenario

GENERATOR SET

Description		**Unit Cost**	**Total Cost**
Generator set:	4	$188,000	$752,000
Generator Trans	4	$30,000	$120,000
Generator Trans	4	$3,500	$14,000
Generator - trans	4	$8,000	$32,000
Scada installation (provisioned in		$0	$0
NWL Controls ar	4	$3,200	$12,800
Export power Me	4	$5,500	$22,000
Supplementary F	2	$16,280	$32,560
Plinths	4	$5,000	$20,000
Contingency	1	$12,000	$12,000
Consultant	1	$5,000	$5,000
Total		**$276,480**	**$1,022,360**

SITE INSTALLATION

Description		**Costings**	**Costings**
Site works	2	$10,000	$20,000
Earthing	2	$2,500	$5,000
11kV cables	2	$4,500	$9,000
ABS and DDO ir	2	$5,000	$10,000
11kV line extens	2	$3,500	$7,000
Site acquisition a	2	$5,000	$10,000
Contingency	1	$3,000	$3,000
Total		**$33,500**	**$64,000**
TOTAL		**$271,590**	**$1,086,360**

Generator Costs - 3 Generator Scenario

GENERATOR SET

Description		**Unit Cost**	**Total Cost**
Generator set:	3	$188,000	$564,000
Generator Trans	3	$30,000	$90,000
Generator Trans	3	$3,500	$10,500
Generator - trans	3	$8,000	$24,000
Scada installation (provisioned in		$0	$0
NWL Controls ar	3	$3,200	$9,600
Export power Me	3	$5,500	$16,500
Supplementary F	2	$16,280	$32,560
Plinths	3	$5,000	$15,000
Contingency	1	$12,000	$12,000
Consultant	1	$5,000	$5,000
Total		**$276,480**	**$779,160**

SITE INSTALLATION

Description		**Costings**	**Costings**
Site works	2	$10,000	$20,000
Earthing	2	$2,500	$5,000
11kV cables	2	$4,500	$9,000
ABS and DDO ir	2	$5,000	$10,000
11kV line extens	2	$3,500	$7,000
Site acquisition a	2	$5,000	$10,000
Contingency	1	$3,000	$3,000
Total		**$33,500**	**$64,000**
TOTAL		**$281,053**	**$843,160**

Appendix D : Operating Statistics

3 Generator Scenario

		HH Periods	Hours	kWh	Cost	ATC	Cost/ATC
Genset 1					$0.17	$50.62	
	Operating to Avoid GXP B/C Peak Block 1	76	38	6,737	$1,142.32	$24,297.60	4.70%
	Operating to Avoid GXP A Peak Block 1	51	25.5	5,860	$993.62	$24,297.60	4.09%
	Genset 1 Cost Total	**127**	**63.5**	**12,597**	**$2,135.93**	**$48,595.20**	**4.40%**
Genset 2							
	Operating to Avoid GXP A Peak Block 1	51	25.5	12,240	$2,075.40		
	Operating to Avoid GXP A Peak Block 2	107	53.5	11,073	$1,877.53		
	Genset 2 Cost Total	**158**	**79**	**23,313**	**$3,952.93**		
	GXP A Peak Block 1-2 Total				**$4,946.54**	**$48,595.20**	**10.18%**
Genset 3							
	Operating to Avoid GXP B/C Peak Block 1	76	38	18,240	$3,092.75		
	Operating to Avoid GXP B/C Peak Block 2	830	415	67,129	$11,382.32		
	Genset 4 Cost Total	**906**	**453**	**85,369**	**$14,475.07**		
	GXP B/C Peak Block 1-2 Total				**$15,617.39**	**$48,595.20**	**32.14%**
	Overall Totals		**595.5**	**121,279**	**$20,563.93**	**$97,190.40**	**21.16%**

Other Variable Costs

		Hours	kWh	Cost
Genset 1	Operating Costs for Network Maintenance	91	43,520	$7,379.20
All	Energy Market	264	380,160	$64,459.51

Maintenance Costs

		Hours	Cost/h	Total Cost
Genset 1	Peak Limiting	63.50	3.47	$220.17
	Network Maintenance	90.67	3.47	$314.37
Genset 2	Peak Limiting	79.00	3.47	$273.91
Genset 3	Peak Limiting	453.00	3.47	$1,570.67
All	Energy Market	792.00	3.47	$2,746.08
		1478.17		**$5,125.20**

Other Fixed Costs

Transportation	Units	Cost	
Relocate between GXP's for shared peaking duty	2	750	$1,500.00
Assume 12 site relocations for maintenance	12	750	$9,000.00

Total Operating Costs	**$108,027.84**
Total Operating Costs - peak limiting only	$24,128.69

4 Generator Scenario

		HH Periods	Hours	kWh	Cost	ATC	Cost/ATC
Genset 1					$0.17	$50.62	
	Operating to Avoid GXP B/C Peak Block 1	76	38	6,737	$1,142.32	$24,297.60	4.70%
	Operating to Avoid GXP A Peak Block 1	51	25.5	5,860	$993.62	$24,297.60	4.09%
	Genset 1 Cost Total	**127**	**63.5**	**12,597**	**$2,135.93**	**$48,595.20**	**4.40%**
Genset 2							
	Operating to Avoid GXP A Peak Block 1	51	25.5	12,240	$2,075.40		
	Operating to Avoid GXP A Peak Block 2	107	53.5	11,073	$1,877.53		
	Genset 2 Cost Total	**158**	**79**	**23,313**	**$3,952.93**		
	GXP A Peak Block 1-2 Total				**$4,946.54**	**$48,595.20**	**10.18%**
Genset 3							
	Operating to Avoid GXP A Peak Block 1	51	25.5	12,240	$2,075.40		
	Operating to Avoid GXP A Peak Block 2	107	53.5	25,680	$4,354.27		
	Operating to Avoid GXP A Peak Block 3	184	92	20,412	$3,461.04		
	Genset 3 Cost Total	**342**	**171**	**58,332**	**$9,890.71**		
	GXP A Peak Block 1-3 Total				**$15,830.87**	**$72,892.80**	**21.72%**
Genset 4							
	Operating to Avoid GXP B/C Peak Block 1	76	38	18,240	$3,092.75		
	Operating to Avoid GXP B/C Peak Block 2	830	415	67,129	$11,382.32		
	Genset 4 Cost Total	**906**	**453**	**85,369**	**$14,475.07**		
	GXP B/C Peak Block 1-2 Total				**$15,617.39**	**$48,595.20**	**32.14%**
	Overall Totals		**766.5**	**179,611**	**$30,454.64**	**$121,488.00**	**25.07%**

Other Variable Costs

		Hours	kWh	Cost
Genset 1	Operating Costs for Network Maintenance	91	43,520	$7,379.20
All	Energy Market	264	506,880	$85,946.01

Maintenance Costs

		Hours	Cost/h	Total Cost
Genset 1	Peak Limiting	63.50	3.47	$220.17
	Network Maintenance	90.67	3.47	$314.37
Genset 2	Peak Limiting	79.00	3.47	$273.91
Genset 3	Peak Limiting	171.00	3.47	$592.90
Genset 4	Peak Limiting	453.00	3.47	$1,570.67
All	Energy Market	1056.00	3.47	$3,661.44
		1913.17		**$6,633.46**

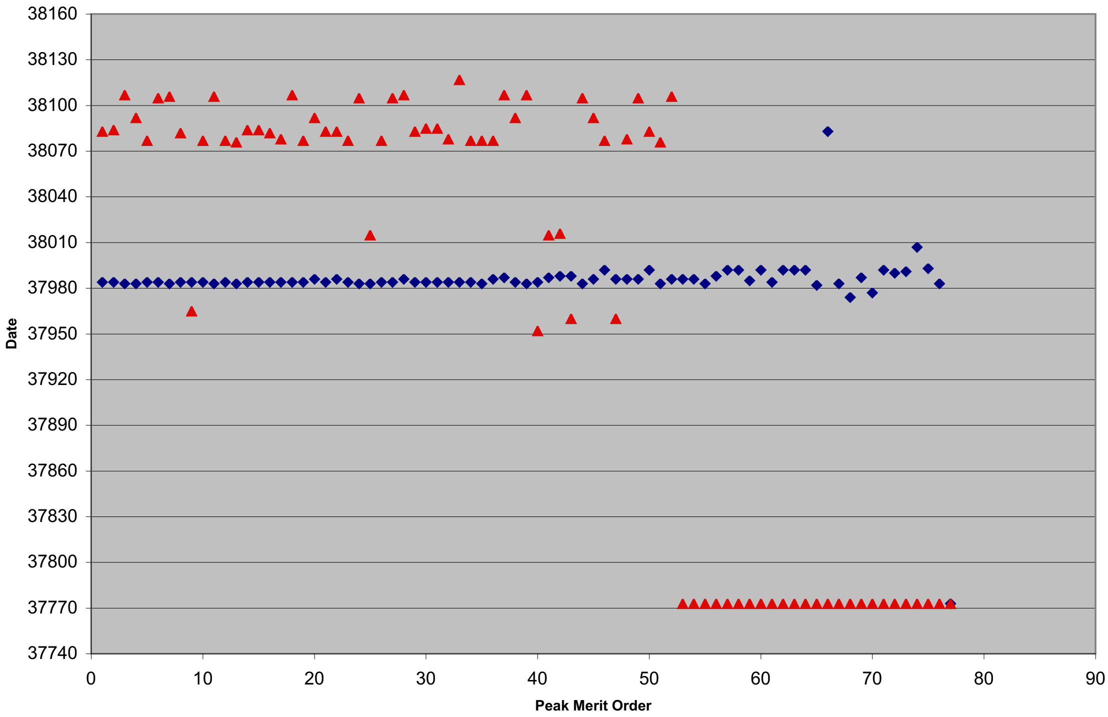
Other Fixed Costs

Transportation	Units	Cost	
Relocate between GXP's for shared peaking duty	2	750	$1,500.00
Assume 12 site relocations for maintenance	12	750	$9,000.00

Total Operating Costs **$140,913.32**

Total Operating Costs - peak limiting only $34,612.30

Appendix E : Genset Usage Pattern



Appendix F : Energy Sales Revenue

Assumed Energy Contract Price

5 yr Average Benmore Node Price	5.03	c/kWh
Transmission Loss Factor	1.02	
Average Daily Peaking Factor (periods 36 to 41)	1.16	
Forecast Contract Price	**5.95**	**c/kWh**

Energy Revenues

	kWh	**Revenue**
Genset 1	56,117	$ 3,339.80
Genset 2	23,313	$ 1,387.47
Genset 3	58,332	$ 3,471.63
Genset 4	85,369	$ 5,080.73
Revenue - 4 Gensets		**$ 13,279.63**
Revenue - 3 Gensets		**$ 9,808.01**

Energy Market Benefits

Spot price over the past 5 years has exceeded 19c/kWh for 3% of all half hour periods

Average days per annum spot > 19c/kWh	11	
4 Gensets operating at F.L.	506880	kWh
Revenue - 4 Gensets	**$ 96,307.20**	
Revenue - 3 Gensets	**$ 72,230.40**	

Appendix G : Security Benefit

SAIDI Class B Interruptions 2003	30	
SAIFI Class B Interruptions 2003	0.15	
CAIDI Class B Interruptions 2003	200	
No. of Interuptions	68	
No. of Consumers	1687	

Average Planned Outage	**Current**	**Target**
Duration	200	120
Customers Affected	253	100
Total Hours	**227**	**91**

Conclusion
One Genset operating for 91 hours is sufficient to achieve targeted improvement.
Note: One genset or 500kVA equates to 100 consumers with ADMD of 5kVA

Assumed Average Value of Lost Load	3.20	$/kWh

Note: assumes 60% domestic 40% non-domestic applying VoLL figures from Security Standard

Annual Load to be Secured by Gensets	43,520	kWh
Variable Operating Cost	$ 7,379.20	
Total VoLL	$ 139,264.00	

Appendix H1 : DCF for Purchase of 3 x 600kVA Diesel Generators

Assumptions	
CPI	2%
Corporate Tax Rate	33%
Depreciation (DV)	9%
Weighted Cost of Capital	7.5%

Pay Back	4 Years
20 Year NPV	$ 480,393
IRR	9.1%

	2002	2003	2004	2005	2006	2007	2008	2009
Period	0	1	2	3	4	5	6	7
Reducing Transmission Cost		$ 225,190	$ 229,694	$ 234,288	$ 238,974	$ 243,753	$ 248,628	$ 125,601
Deferred New Investment		$ 39,600	$ 40,392	$ 41,200	$ 42,024	$ 42,864	$ 43,722	
Sale of Generation		$ 9,808	$ 10,004	$ 10,204	$ 10,408	$ 10,617	$ 10,829	$ 11,045
Energy Market Earnings	$ -	$ 72,230	$ 73,675	$ 75,149	$ 76,651	$ 78,185	$ 79,748	$ 81,343
Security Benefit		$ -	$ -	$ -	$ -	$ -	$ -	$ -
			$ -	$ -	$ -	$ -	$ -	$ -
	$ -		$ -	$ -	$ -	$ -	$ -	$ -
Total New Earnings (EBIT)	**$ -**	**$ 346,829**	**$ 353,765**	**$ 360,841**	**$ 368,058**	**$ 375,419**	**$ 382,927**	**$ 217,990**
Annual operating costs		$ 108,028	$ 110,188	$ 112,392	$ 114,640	$ 116,933	$ 119,271	$ 121,657
Depreciation	$ 75,884	$ 69,055	$ 62,840	$ 57,184	$ 52,038	$ 47,354	$ 43,092	$ 39,214
Earnings before tax	-$ 75,884	$ 169,746	$ 180,737	$ 191,264	$ 201,380	$ 211,132	$ 220,563	$ 57,119
Tax	-$ 25,042	$ 56,016	$ 59,643	$ 63,117	$ 66,455	$ 69,673	$ 72,786	$ 18,849
Net Operating Income	$ -50,843	$ 113,730	$ 121,094	$ 128,147	$ 134,924	$ 141,458	$ 147,777	$ 38,269
Add back Depreciation	$ 75,884	$ 69,055	$ 62,840	$ 57,184	$ 52,038	$ 47,354	$ 43,092	$ 39,214
Net Operating Cashflow	**$ 25,042**	**$ 182,785**	**$ 183,934**	**$ 185,331**	**$ 186,962**	**$ 188,812**	**$ 190,870**	**$ 77,484**
Investment	$ -843,160							
Net Cashflows after taxes	$ -818,118	$ 182,785	$ 183,934	$ 185,331	$ 186,962	$ 188,812	$ 190,870	$ 77,484
Cumulative Cashflows after Tax	$ -818,118	$ -635,333	$ -451,400	$ -266,068	$ -79,106	$ 109,706	$ 300,576	$ 378,059
PVof this Periods Cashflow	**$ -818,118**	**$ 170,111**	**$ 159,312**	**$ 149,393**	**$ 140,258**	**$ 131,825**	**$ 124,022**	**$ 46,856**
Planned Expenditure								
Generators Capital Purchase	$ -843,160	$ -	$ -					
Cummulative Capital Expenditure	$ -843,160	$ -843,160	$ -843,160	$ -843,160	$ -843,160	$ -843,160	$ -843,160	$ -843,160
Open Book Value		$ -767,276	$ -698,221	$ -635,381	$ -578,197	$ -526,159	$ -478,805	$ -435,712
Total BV & Additions	$ -843,160	$ -767,276	$ -698,221	$ -635,381	$ -578,197	$ -526,159	$ -478,805	$ -435,712
Depreciation	$ -75,884	$ -69,055	$ -62,840	$ -57,184	$ -52,038	$ -47,354	$ -43,092	$ -39,214
Closing Book Value	$ -767,276	$ -698,221	$ -635,381	$ -578,197	$ -526,159	$ -478,805	$ -435,712	$ -396,498

2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
8	9	10	11	12	13	14	15	16	17	18	19
$ 128,113	$ 130,675	$ 133,289	$ 135,955	$ 138,674	$ 141,447	$ 144,276	$ 147,162	$ 150,105	$ 153,107	$ 156,169	$ 159,292
$ 11,266	$ 11,492	$ 11,721	$ 11,956	$ 12,195	$ 12,439	$ 12,688	$ 12,941	$ 13,200	$ 13,464	$ 13,734	$ 14,008
$ 82,970	$ 84,629	$ 86,322	$ 88,048	$ 89,809	$ 91,606	$ 93,438	$ 95,306	$ 97,213	$ 99,157	$ 101,140	$ 103,163
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ 222,349	**$ 226,796**	**$ 231,332**	**$ 235,959**	**$ 240,678**	**$ 245,492**	**$ 250,401**	**$ 255,409**	**$ 260,518**	**$ 265,728**	**$ 271,043**	**$ 276,463**
$ 124,090	$ 126,572	$ 129,103	$ 131,685	$ 134,319	$ 137,005	$ 139,746	$ 142,540	$ 145,391	$ 148,299	$ 151,265	$ 154,290
$ 35,685	$ 32,473	$ 29,551	$ 26,891	$ 24,471	$ 22,268	$ 20,264	$ 18,441	$ 16,781	$ 15,271	$ 13,896	$ 12,646
$ 62,574	$ 67,751	$ 72,678	$ 77,382	$ 81,888	$ 86,218	$ 90,392	$ 94,429	$ 98,346	$ 102,158	$ 105,881	$ 109,527
$ 20,650	$ 22,358	$ 23,984	$ 25,536	$ 27,023	$ 28,452	$ 29,829	$ 31,161	$ 32,454	$ 33,712	$ 34,941	$ 36,144
$ 41,925	$ 45,393	$ 48,694	$ 51,846	$ 54,865	$ 57,766	$ 60,562	$ 63,267	$ 65,892	$ 68,446	$ 70,940	$ 73,383
$ 35,685	$ 32,473	$ 29,551	$ 26,891	$ 24,471	$ 22,268	$ 20,264	$ 18,441	$ 16,781	$ 15,271	$ 13,896	$ 12,646
$ 77,610	**$ 77,867**	**$ 78,245**	**$ 78,737**	**$ 79,336**	**$ 80,034**	**$ 80,827**	**$ 81,708**	**$ 82,672**	**$ 83,717**	**$ 84,837**	**$ 86,029**
$ 77,610	$ 77,867	$ 78,245	$ 78,737	$ 79,336	$ 80,034	$ 80,827	$ 81,708	$ 82,672	$ 83,717	$ 84,837	$ 86,029
$ 455,669	$ 533,536	$ 611,781	$ 690,518	$ 769,854	$ 849,888	$ 930,715	$ 1,012,423	$ 1,095,095	$ 1,178,812	$ 1,263,649	$ 1,349,678
$ 43,678	**$ 40,784**	**$ 38,141**	**$ 35,720**	**$ 33,496**	**$ 31,448**	**$ 29,557**	**$ 27,808**	**$ 26,185**	**$ 24,678**	**$ 23,274**	**$ 21,965**
$ -843,160	$ -843,160	$ -843,160	$ -843,160	$ -843,160	$ -843,160	$ -843,160	$ -843,160	$ -843,160	$ -843,160	$ -843,160	$ -843,160
$ -396,498	$ -360,813	$ -328,340	$ -298,789	$ -271,898	$ -247,428	$ -225,159	$ -204,895	$ -186,454	$ -169,673	$ -154,403	$ -140,507
$ -396,498	$ -360,813	$ -328,340	$ -298,789	$ -271,898	$ -247,428	$ -225,159	$ -204,895	$ -186,454	$ -169,673	$ -154,403	$ -140,507
$ -35,685	$ -32,473	$ -29,551	$ -26,891	$ -24,471	$ -22,268	$ -20,264	$ -18,441	$ -16,781	$ -15,271	$ -13,896	$ -12,646
$ -360,813	$ -328,340	$ -298,789	$ -271,898	$ -247,428	$ -225,159	$ -204,895	$ -186,454	$ -169,673	$ -154,403	$ -140,507	$ -127,861

Appendix H2 : DCF for Purchase of 4 x 600kVA Diesel Generators

Assumptions												
CPI	2%											
Corporate Tax Rate	33%						**PayBack**	**5 Years**				
Depreciation (DV)	9%						**20 Year NPV $**	**429,068**				
Weighted Cost of Capital	7.5%						**IRR**	**6.1%**				
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Period	0	1	2	3	4	5	6	7	8	9	10	11
Reducing Transmission Cost		$ 249,488	$ 254,478	$ 259,567	$ 264,759	$ 270,054	$ 275,455	$ 152,964	$ 156,023	$ 159,144	$ 162,327	$ 165,573
		$ 39,600	$ 40,392	$ 41,200	$ 42,024	$ 42,864	$ 43,722					
Sale of Generation		$ 13,280	$ 13,545	$ 13,816	$ 14,092	$ 14,374	$ 14,662	$ 14,955	$ 15,254	$ 15,559	$ 15,870	$ 16,188
Energy Market Earnings	$ -	$ 96,307	$ 98,233	$ 100,198	$ 102,202	$ 104,246	$ 106,331	$ 108,458	$ 110,627	$ 112,839	$ 115,096	$ 117,398
Security Benefit		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	$ -		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total New Earnings (EBIT)	**$ -**	**$ 398,675**	**$ 406,648**	**$ 414,781**	**$ 423,077**	**$ 431,538**	**$ 440,169**	**$ 276,377**	**$ 281,904**	**$ 287,542**	**$ 293,293**	**$ 299,159**
Annual operating costs		$ 140,913	$ 143,732	$ 146,606	$ 149,538	$ 152,529	$ 155,580	$ 158,691	$ 161,865	$ 165,102	$ 168,404	$ 171,773
Depreciation	$ 97,772	$ 88,973	$ 80,965	$ 73,678	$ 67,047	$ 61,013	$ 55,522	$ 50,525	$ 45,978	$ 41,840	$ 38,074	$ 34,647
Earnings before tax	-$ 97,772	$ 168,789	$ 181,951	$ 194,497	$ 206,491	$ 217,996	$ 229,068	$ 67,160	$ 74,061	$ 80,600	$ 86,814	$ 92,739
Tax	-$ 32,265	$ 55,700	$ 60,044	$ 64,184	$ 68,142	$ 71,939	$ 75,592	$ 22,163	$ 24,440	$ 26,598	$ 28,649	$ 30,604
Net Operating Income	$ -65,508	$ 113,088	$ 121,907	$ 130,313	$ 138,349	$ 146,057	$ 153,475	$ 44,997	$ 49,621	$ 54,002	$ 58,166	$ 62,135
Add back Depreciation	$ 97,772	$ 88,973	$ 80,965	$ 73,678	$ 67,047	$ 61,013	$ 55,522	$ 50,525	$ 45,978	$ 41,840	$ 38,074	$ 34,647
Net Operating Cashflow	**$ 32,265**	**$ 202,061**	**$ 202,873**	**$ 203,991**	**$ 205,396**	**$ 207,071**	**$ 208,997**	**$ 95,522**	**$ 95,599**	**$ 95,842**	**$ 96,240**	**$ 96,783**
Investment	$ -1,086,360											
Net Cashflows after taxes	$ -1,054,095	$ 202,061	$ 202,873	$ 203,991	$ 205,396	$ 207,071	$ 208,997	$ 95,522	$ 95,599	$ 95,842	$ 96,240	$ 96,783
Cumulative Cashflows after Tax	$ -1,054,095	$ -852,034	$ -649,161	$ -445,170	$ -239,773	$ -32,703	$ 176,294	$ 271,817	$ 367,416	$ 463,257	$ 559,497	$ 656,280
PVof this Periods Cashflow	**$ -1,054,095**	**$ 188,051**	**$ 175,716**	**$ 164,434**	**$ 154,087**	**$ 144,573**	**$ 135,801**	**$ 57,764**	**$ 53,802**	**$ 50,199**	**$ 46,913**	**$ 43,906**
Planned Expenditure												
Generators Capital Purchase	$ -1,086,360	$ -	$ -									
Cummulative Capital Expenditure	$ -1,086,360	$ -1,086,360	$ -1,086,360	$ -1,086,360	$ -1,086,360	$ -1,086,360	$ -1,086,360	$ -1,086,360	$ -1,086,360	$ -1,086,360	$ -1,086,360	$ -1,086,360
Open Book Value		$ -988,588	$ -899,615	$ -818,649	$ -744,971	$ -677,924	$ -616,910	$ -561,389	$ -510,864	$ -464,886	$ -423,046	$ -384,972
Total BV & Additions	$ -1,086,360	$ -988,588	$ -899,615	$ -818,649	$ -744,971	$ -677,924	$ -616,910	$ -561,389	$ -510,864	$ -464,886	$ -423,046	$ -384,972
Depreciation	$ -97,772	$ -88,973	$ -80,965	$ -73,678	$ -67,047	$ -61,013	$ -55,522	$ -50,525	$ -45,978	$ -41,840	$ -38,074	$ -34,647
Closing Book Value	$ -988,588	$ -899,615	$ -818,649	$ -744,971	$ -677,924	$ -616,910	$ -561,389	$ -510,864	$ -464,886	$ -423,046	$ -384,972	$ -350,324

	2014	2015	2016	2017	2018	2019	2020	2021
Assumptions								
CPI								
Corporate Tax Rate								
Depreciation (DV)								
Weighted Cost of Capital								
Period	12	13	14	15	16	17	18	19
Reducing Transmission Cost	$ 168,885	$ 172,262	$ 175,708	$ 179,222	$ 182,806	$ 186,462	$ 190,192	$ 193,995
Sale of Generation	$ 16,512	$ 16,842	$ 17,179	$ 17,522	$ 17,873	$ 18,230	$ 18,595	$ 18,967
Energy Market Earnings	$ 119,746	$ 122,141	$ 124,584	$ 127,075	$ 129,617	$ 132,209	$ 134,853	$ 137,550
Security Benefit	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total New Earnings (EBIT)	**$ 305,142**	**$ 311,245**	**$ 317,470**	**$ 323,819**	**$ 330,296**	**$ 336,902**	**$ 343,640**	**$ 350,512**
Annual operating costs	$ 175,208	$ 178,712	$ 182,286	$ 185,932	$ 189,651	$ 193,444	$ 197,313	$ 201,259
Depreciation	$ 31,529	$ 28,692	$ 26,109	$ 23,759	$ 21,621	$ 19,675	$ 17,904	$ 16,293
Earnings before tax	$ 98,405	$ 103,841	$ 109,074	$ 114,128	$ 119,024	$ 123,782	$ 128,422	$ 132,960
Tax	$ 32,474	$ 34,268	$ 35,994	$ 37,662	$ 39,278	$ 40,848	$ 42,379	$ 43,877
Net Operating Income	$ 65,931	$ 69,574	$ 73,080	$ 76,465	$ 79,746	$ 82,934	$ 86,043	$ 89,083
Add back Depreciation	$ 31,529	$ 28,692	$ 26,109	$ 23,759	$ 21,621	$ 19,675	$ 17,904	$ 16,293
Net Operating Cashflow	**$ 97,460**	**$ 98,265**	**$ 99,189**	**$ 100,225**	**$ 101,367**	**$ 102,610**	**$ 103,947**	**$ 105,376**
Investment								
Net Cashflows after taxes	$ 97,460	$ 98,265	$ 99,189	$ 100,225	$ 101,367	$ 102,610	$ 103,947	$ 105,376
Cumulative Cashflows after Tax	$ 753,740	$ 852,005	$ 951,194	$ 1,051,419	$ 1,152,786	$ 1,255,396	$ 1,359,343	$ 1,464,720
PVof this Periods Cashflow	**$ 41,148**	**$ 38,611**	**$ 36,272**	**$ 34,110**	**$ 32,107**	**$ 30,247**	**$ 28,517**	**$ 26,904**
Planned Expenditure								
Generators Capital Purchase								
Cummulative Capital Expenditure	$ -1,086,360	$ -1,086,360	$ -1,086,360	$ -1,086,360	$ -1,086,360	$ -1,086,360	$ -1,086,360	$ -1,086,360
Open Book Value	$ -350,324	$ -318,795	$ -290,104	$ -263,994	$ -240,235	$ -218,614	$ -198,938	$ -181,034
Total BV & Additions	$ -350,324	$ -318,795	$ -290,104	$ -263,994	$ -240,235	$ -218,614	$ -198,938	$ -181,034
Depreciation	$ -31,529	$ -28,692	$ -26,109	$ -23,759	$ -21,621	$ -19,675	$ -17,904	$ -16,293
Closing Book Value	$ -318,795	$ -290,104	$ -263,994	$ -240,235	$ -218,614	$ -198,938	$ -181,034	$ -164,741