Diesel Power Plant Review

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Attachment D

May, 2000

NEWFOUNDLAND POWER
A FORTIS COMPANY

Newfoundland Power Inc.

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Executive Summary

This study was performed in order to develop a strategy to deal with the deteriorating condition of Newfoundland Power operated diesel plants and increased liabilities associated with operating them. Currently, Newfoundland Power operates seven diesel plants consisting of twelve units. The installed capacity of these plants is 10,029 kilowatts. Included in this group is a 1,500 kW diesel generator set which is presently leased from Pennecon Construction Ltd. The average annual electrical generation from the six diesel plants owned by Newfoundland Power, excluding the Pennecon unit, is approximately 167,644 kWh (1990-1999 average). The Pennecon Lease unit produced 142,625 kWh of generation alone in 1999. The average overall utilization, excluding the Pennecon Lease unit, is 20 hours per year with a large portion of this being for test run purposes.

The utilization of these diesel plants has been steadily dropping since 1990 and the capital and operating funds dedicated to maintaining these plants has also seen a marked decrease. The recommended strategy over the next five years with these plants is to decommission those of little utility and to spend funds to modernize those plants we intend to keep for the long term.

The list of plants that should be decommissioned in the year 2000 would include the Portable Diesel #2, the St. John's Diesel Plant, and the Port aux Basques Main Plant (6 units) [See Analysis section of report]. Public Utilities Board (PUB) approval has already been received to decommission the Port aux Basques Main Plant and this would be done in 2000. The decommissioned capacity for the year 2000 would thus be 4,829 kilowatts. The remaining standby diesel capacity would be 5,200 kilowatts. The future cost savings associated with these retirements would be approximately $1.5 Million, in additional estimated capital and operating costs, plus future operating costs based upon historical figures. The associated retirement costs are expected to be about $250,000 for the three diesel plants. The Aguathuna, Gander and Salt Pond Diesel Plant units were decommissioned in the Fall of 1998.

In terms of long-term system planning; refurbished diesel or gas turbine units should be considered for remote locations such as Wesleyville, Trepassey, and Twillingate. The installation of these remote diesels would have the dual effect of replacing the capacity lost from the system due to diesel plant retirements plus the system reliability would be enhanced greatly in these outage prone areas. Natural gas fired plants must also be considered in the long-term for the West Coast due to the known presence of natural gas deposits in the Port au Port Peninsula area.

The Port Union and Portable Diesel #1 diesel units should be reviewed in another five years to determine their utility to the company at that point. These two plants are currently fairly inexpensive and provide capacity in troublesome areas.

The General Motors EMD diesel in Port aux Basques should be overhauled and modernized to ensure its availability and reliability for the next 10-15 years. This will cost an estimated additional $388,000 in operating and capital expenditures, which will need to be placed within the five-year budget. The enclosure replacement project should review the possibility of utilizing the existing powerhouse structure for long-term protection of the diesel unit and repairs to the radiator on this unit should be undertaken at this time in order to save overall costs. Additionally, refurbished General Motors EMD units are available and should be considered for installation at the Port aux

Basques plant to replace lost diesel capacity. A refurbished 2,500 kW stationary diesel unit with powerhouse infrastructure could be installed for a capital cost of approximately $2.4 Million.

Small hydroelectric developments could also be investigated for future capacity and energy requirements in the Port aux Basques / Southwest Coast area as well as from a system reliability perspective. This could enable the Portable Gas Turbine, currently located in Port aux Basques, to be deployed to other areas such as Wesleyville.

Currently, the diesel plants have a combined annual operating cost of approximately $189,000. In order to extend the life of all of these units, an additional $2,041,000 would have to be spent over the next 5-10 years over and above the historical annual operating costs.

Plant	Historical Annual Operating Cost	Projected Add. Maintenance Expenses	Projected Capital Expenses	Extended Life (years)
St. John's Diesel	$45,911	$157,000	$377,000	10
Port Union Diesel	$7,442	$12,000	$66,300	10
Port aux Basques Main Diesel	$62,638	$25,500	$793,000	10
Port aux Basques Unit 10 Diesel	$20,934	$199,500	$188,500	15
Portable Diesel #1	$11,321	$38,500	$31,200	10
Portable Diesel #2	$11,727	$29,000	$96,200	10
Pennecon Lease	$29,178	$44,500	$9,100	20
Totals	**$189,151**	**$506,000**	**$1,535,000**	

Assessments of the different plants have generated numerous issues, which need to be addressed and these maintenance issues can be found in the Condition of Diesel Power Plants section of this report.

Environmental liabilities are increasingly a major concern in the maintenance of the diesel plant facilities. The storage of bulk quantities of No.2 distillate fuel increases Newfoundland Power's exposure to liability arising from future fuel spills or leaks. The future costs to deal with the storage of petroleum products are predicted to increase substantially over the next five years.

Safety concerns are also apparent at a number of our diesel plants in particular the St. John's Diesel plant. This plant contains very old switchgear equipment, which is of an open contact-type design. These are potentially dangerous to operate. This set of switchgear should be replaced in order to continue to operate the St. John's Diesel plant safely into the future. The controls and protective relays in most of the plants are obsolete thereby rendering safety alarm and shutdown devices unreliable.

The table below summarizes the fixed and variable costs of the diesel plants as well as several alternative generation options. The total annual fixed costs include the historical fixed costs as well as those projected additional maintenance and capital costs.

Plant	Total Annual Fixed Cost ($/kW-yr)	Variable Cost ($/kWh)
St. John's Diesel	$52.19	$0.111
Port Union Diesel	$38.83	$0.156
Port aux Basques Main Diesel	$114.14	$0.131
Port aux Basques Unit 10 Diesel	$26.92	$0.096
Portable Diesel #1	$28.57	$0.137
Portable Diesel #2	$43.25	$0.144
Pennecon Lease	$15.36	$0.107
New 25 MW Gas Turbine Station	$135.00	$0.073
Refurbished 2.5 MW Diesel	$118.00	$0.086
Refurbished 2.25 MW Gas Turbine	$111.00	$0.116
New 2 MW Portable Cat Diesel	$97.00	$0.085
New 2 MW Portable Gas Turbine	$202.00	$0.116
		Total Levelized Energy Cost ($/kWh)
Small Hydroelectric Installation		$0.065
New 2.5 MW Wind Turbine		$0.065
NLH Capacity Credit[1]	$14.00	
Holyrood Marginal Energy Cost		$0.046

[1] Based upon Newfoundland & Labrador Hydro 1995 Cost of Service Study.

Even though the projected total annual fixed costs of the existing diesel plants are less than the new hydro, diesel or gas turbine generation alternatives; investing additional funds into a number of these plants is not recommended. The failure of a major component on one of the older units such as the St. John's Diesel, Port aux Basques Main Plant diesels or the Portable Diesels would leave any new additional investment stranded. This is due to the lack of replacement parts availability for these older units. It can be seen from the table shown above that none of the diesel plants are cheap enough to base load them. However, most of these diesel plants are utilized for emergency purposes and are located in areas prone to system outages.

It can also be seen that from a capacity perspective that new installations should be either gas turbine or diesel units. However, if energy production is key then hydroelectric installations provide the best alternative. Wind turbine farms should also be considered, for energy purposes, as the technology for cold weather climates has improved greatly over the past few years and pricing for these units continues to drop. For further information please refer to the Conclusions and Recommendations sections of this report.

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Introduction

This study has been undertaken with the knowledge that the six smaller diesel units contained within the Port aux Basques Diesel Plant have already been approved for decommissioning and require no further study. The Public Utilities Board issued Order No. P.U. 1 (1998-99) on April 7, 1998. This order approved the decommissioning of the diesel plants at Aguathuna, Salt Pond, and Gander immediately, and the diesel plant units at Port aux Basques as soon as practicable after the Rose Blanche Hydroelectric development was in operation. However, data on the Port aux Basques plant is contained within this report in order to serve as a benchmark in the comparison of the condition and costs of the other diesel plants.

This report summarizes the results of a review of the existing condition of seven internal combustion engine diesel plants. The report also reviews the required maintenance, and the current and projected costs associated with the Newfoundland Power owned facilities. A similar diesel plant study was undertaken recently in 1991 and again in 1997. The purpose of this current year 2000 study is to determine to what extent these existing diesel plants should be maintained or retired. This review is required due to the age of the existing deteriorated facilities and the loss of experienced operating and maintenance personnel in these plants over recent years. A listing of current Newfoundland Power owned or leased internal combustion engine diesel plants is shown in Table A below:

Table A

Plant Location	Unit No	Nameplate Capacity (kW)	Date Commissioned	Manufacturer
St. John's Diesel	1	2,500	1953	Nordberg
Port Union Diesel	1	500	1962	Caterpillar
Port aux Basques Main Plant	1	350	1945	Caterpillar
Port aux Basques Main Plant	2	250	1953	Caterpillar
Port aux Basques Main Plant	3	350	1954	Caterpillar
Port aux Basques Main Plant	4	209	1958	Caterpillar
Port aux Basques Main Plant	5	250	1965	Caterpillar
Port aux Basques Main Plant	8	250	1965	Caterpillar
Port aux Basques EMD Diesel	10	2,500	1969	General Motors
Portable Diesels	1	700	1973	Caterpillar
Portable Diesels	2	670	1976	Caterpillar
Pennecon Lease Unit	1	1,500	1990	Detroit Diesel

The gas turbine plants, in service at Newfoundland Power, were excluded from this study due to their size (i.e. greater than 7.0 MW) and utility to the customers in terms of system reliability. The condition and OEM support of the gas turbine plants is much better than the diesel plants.

An inspection of all diesel units, excluding the Pennecon Construction unit, was undertaken by Newfoundland Power personnel in 1996. This inspection was supplemented by an assessment by Acres International and D.G. Champion in 1997. Their report reviewed the mechanical and electrical condition of the units and made recommendations for work required in order to extend the life of the diesel units by an additional ten years. The Acres report also investigated the availability of spare parts. (See Appendix E) The units were once again inspected in 1999 and 2000 to determine to what extent the condition of the units has deteriorated since 1997.

The value of having diesel power plant capacity on the Newfoundland electrical grid system was determined using information from the Newfoundland & Labrador Hydro's 1995 Cost of Service Study. The capacity credit was determined to be $14.00/kW-year in this study. This number was arrived at by taking the total Newfoundland Power company capacity, less an 18% reserve margin, and dividing this into the cost allocations for the years 1997 to 2001. The replacement energy cost for generation from the Holyrood Thermal Generating Station was taken to be $0.046/kWh.

A historical review of the actual operating costs for each diesel plant was performed for the years of 1990 to 1999. This ten-year summary of operating costs found in Appendix C provides a detailed snapshot of the cost structure of operating these diesels. The costs accumulated here were subdivided into net operating (labour, consumables, general maintenance) fuel, insurance, tax, depreciation, and other costs. (leasing agreements) A historical average fixed cost per kilowatt-year was determined.

The fuel efficiency (kWh/L) and cost efficiency ($/kWh), normalized for fuel cost fluctuations, of each diesel plant were calculated by averaging the fuel consumed, the kilowatt-hours produced, and the fuel cost per unit. The variable cost per kilowatt-hour was also calculated. See Appendix C.

Description of Diesel Power Plants

St. John's Diesel Plant Description

The St. John's Diesel Plant is located on the Southside of St. John's Harbour on the Southside Road. The powerhouse contains one 2,500 kW diesel generator set with auxiliaries and was commissioned in 1953. The powerhouse foundations are securely tied to bedrock. A 22,703 litre #2 diesel self-dyked fuel tank is located at the front of the powerhouse. This plant was originally installed in order to Black Start the St. John's Thermal Plant, which has now been decommissioned.

Powerhouse

The powerhouse is approximately 21 m long by 12 m wide by 10 m high and consists of a structural steel substructure on a concrete foundation. The building walls have asbestos cladding. The interior lighting in the powerhouse is substandard. Lube oil and diesel fuel containment are a problem at the St. John's Diesel Plant.

Turbine – Generator

The diesel engine was manufactured by Nordberg and the generator by General Electric. Auxiliaries include controls, lube oil cooler, cooling water cooler, air compressor, air receivers and fuel day tank. The engine air intake is built into the foundation of the building. The switchgear is very old and of an open design in which all parts are open in plain view.

Fuel Tank

The fuel tank is 22,703 litre self-dyked steel tank of welded construction. There is #2 diesel fuel stored in the tank. An automatic solenoid valve shuts off the fuel flow from the tank when the plant is not running.

Substation

The substation steps the generator voltage down from 6900 V to 4160 V for transmission to the grid. There are 3 – 1500 kVA transformers and two station service transformers associated with this plant.

Transmission Line

This plant ties directly to a distribution line and does not have a transmission line associated with it. The distribution line ties into the buss work of the St. John's Main Substation.

Port Union Diesel Plant Description

The Port Union Diesel Plant is located in Port Union on the Bonavista Peninsula. The unit is contained in the Port Union Hydroelectric Development Powerhouse. The machine is comprised of a 500 kW diesel generator set, one 9,100 litre fuel tank, controls and auxiliaries. The unit was commissioned in 1962.

Powerhouse

The powerhouse contains the diesel set and two hydroelectric generating units. The powerhouse measures 7.3m x 18.9m x 4.0m high. The building consists of a concrete substructure, concrete walls, and a wooden roof.

Turbine – Generator

The diesel engine was manufactured by Caterpillar. The generator was manufactured by General Electric and is rated at 625 kVA. Auxiliaries include controls and cooling system. The cooling is performed by a shell and tube type heat exchanger where lube oil is cooled by water.

Fuel Tank

The self-dyked fuel tank has a capacity of 9,100 litres of #2 diesel fuel and is of steel construction. The fuel lines are located aboveground; however they are hidden from view within a wooden covered trench. The fuel lines are of galvanized steel construction.

Substation

The substation equipment is common for the diesel set and the two hydro sets.

Transmission Line

This plant ties directly to a distribution line and does not have a transmission line associated with it.

Port aux Basques Diesel Plant Description

The Port aux Basques Diesel Plant is located in the community of Port aux Basques. The powerhouse contains six diesel generator sets ranging in size from 262 kVA to 438 kVA. A 3,250 kVA packaged diesel generator set is located adjacent to the main building. Auxiliaries include coolers, fuel tanks, day tanks and controls.

Powerhouse

The powerhouse is mainly of concrete construction with a wooden frame extension built on. The building measures approximately 26 m long by 7.5 m wide by 5 m high. The wooden frame extension houses the battery system, control panel and switchgear for the General Motors EMD packaged diesel generator set.

Turbine-Generators

The six diesel generator sets installed in the powerhouse were all manufactured by Caterpillar. The capacities of the sets are 438 kVA, 262 kVA, 312 kVA, 312 kVA, 438 kVA and 282 kVA. These units were installed between 1945 and 1965. Cooling on these units is provided by a shell and tube type heat exchanger where lube oil is cooled by water. The packaged diesel-generator set installed adjacent to the powerhouse was manufactured by General Motors and installed in 1969. This unit is rated at 3,250 kVA. Auxiliaries for this unit include a cooling tower and control room.

Fuel Tanks

All of the diesel generators are supplied with # 2 diesel fuel from one only 22,700 litre steel self-dyked tank located outside the powerhouse.

Substation

The voltage of the six generators in the main powerhouse is stepped up from 2.4 kV to 4.16 kV by the substation. The packaged diesel generates at 4.16 kV and does not require transformation. There is one 600 kVA transformer, one 1 MVA transformer and one station service transformer associated with this Plant. The transformers are located just outside the powerhouse walls.

Transmission Line

This plant ties directly into the Port aux Basques substation and does not have a transmission line associated with it.

Portable Diesel Units

The Portable Diesel units consists of one 700 kW and one 670 kW diesel generator package mounted in self contained high bed road trailers and include all auxiliaries controls, fuel tanks, switchgear and transformers. Unit #l was purchased in 1973 and Unit # 2 in 1976.

Powerhouses

All equipment is contained in the trailers. The trailers are of steel frame structure with sheet metal siding. The trailer chassis' are both double axis units.

Turbine-Generators

The diesel engines were both manufactured by Caterpillar. Unit # 1 generator was made by Tamper-Camron and is rated at 700 kW. Unit # 2 generator was manufactured by Brown-Boveri and is rated at 670 kW.

Fuel Tank

In both units, the fuel tanks are located on the trailers and are relatively small in size. There is currently no secondary containment around either of the fuel tanks.

Substation

The transformers associated with these units are mounted on the trailer.

Transmission Line

There is no transmission line associated with either unit. Currently, both units are tied into the bus-work at the Grand Bay Substation in Port aux Basques, Newfoundland.

Pennecon Lease Diesel Unit

This mobile diesel unit consists of one Marlin / Detroit Diesel 1,500 kW diesel generator package mounted in a self contained high bed road trailer and includes all auxiliaries controls, and switchgear. A padmount transformer has to be setup with the portable diesel unit for voltage boost from 600 Volts to power grid voltage levels. A self-dyked steel fuel tank is utilized for the storage and supply of No.2 diesel fuel for this unit. This unit was leased from Pennecon Construction Ltd. starting in 1999 and is temporarily stationed at the Trepassey substation.

Powerhouses

All equipment is contained in the trailer. The trailer is of steel frame structure with sheet metal siding.

Turbine-Generators

The diesel engine was manufactured in 1990 by Marlin / Detroit Diesel. The generator was manufactured in 1990 by Kato Engineering Ltd. and is rated at 1,500 kW at 347 / 600 Volts. The engine lube oil is cooled using glycol which is cooled with a forced air radiator set.

Fuel Tank

A self-dyked steel fuel tank is typically relocated to the site of the portable 1,500 kW generator set and setup to provide the supply of diesel fuel to the engine.

Substation

The transformer associated with this unit has to be brought in and setup specifically for the unit.

Transmission Line

There is no transmission line associated with this unit.

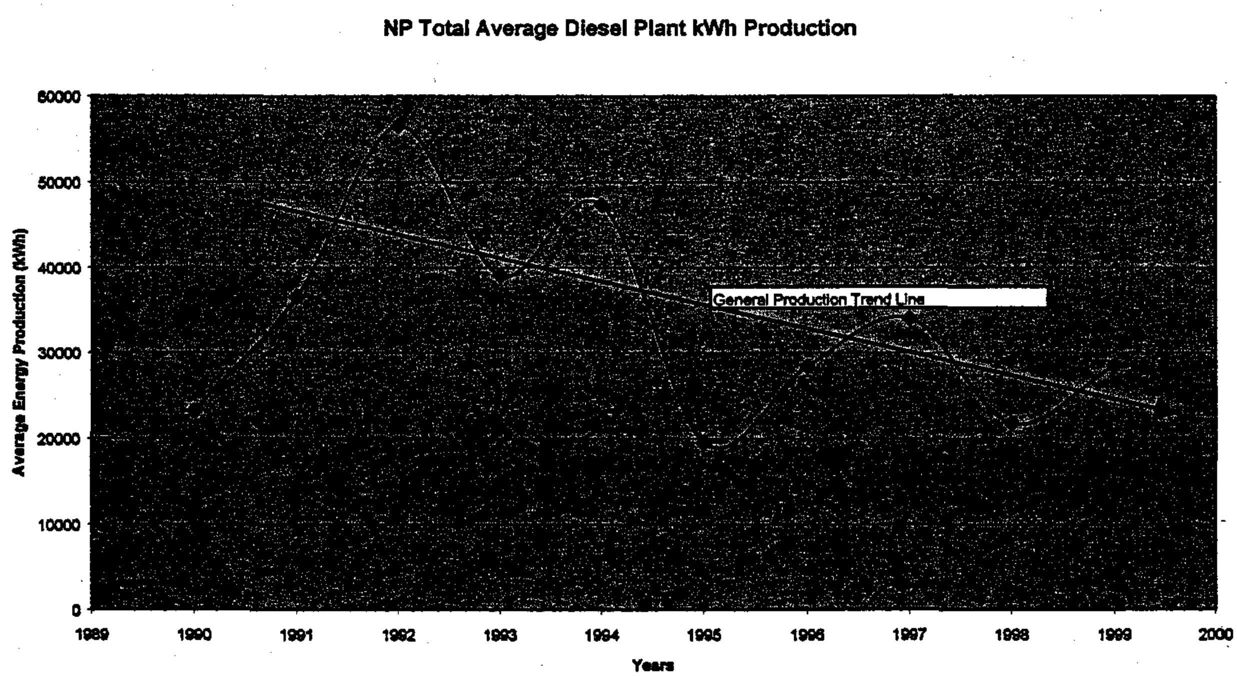
Utilization of Diesel Power Plants

In more recent years the internal combustion engine diesel plants owned by Newfoundland Power have been used mainly for emergency service or as reserve capacity for power generated by Newfoundland & Labrador Hydro and purchased by Newfoundland Power Inc.

Most diesel plants had a slightly more active year in 1999 in preparation for the Year 2000 roll-over. These diesels became part of the contingency plans put in place to cover off any loss of power events as a result of Y2K computer problems. This resulted in increased operating hours and operating expenses for nearly all units in 1999. In general, however, the utilization of these six diesel power plants has decreased in recent years. A graph of average total company diesel energy production over the last ten years, shown below, clearly shows a downward trend in the useage of these plants.

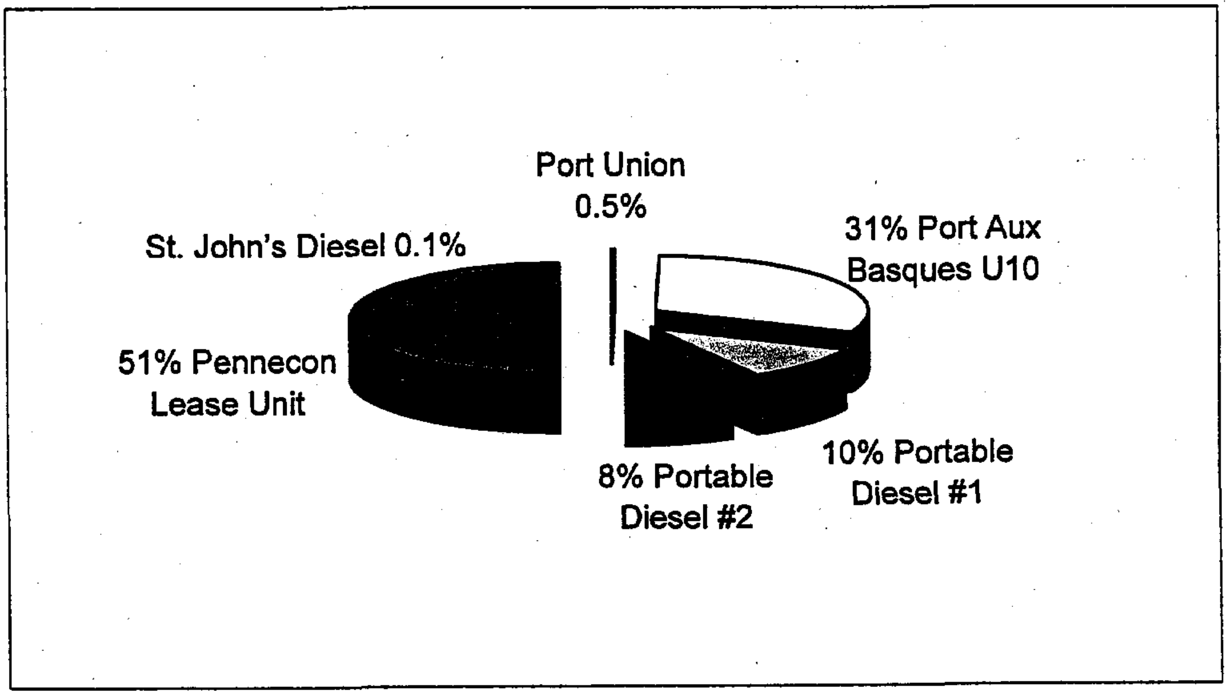
This downward trend may be explained by enhanced electrical grid reliability, and seemingly better weather patterns over the last few years.

Figure 1 Newfoundland Power Total Diesel Electrical Production



Note: The energy generation from the Pennecon Leased Unit was not included so as to not skew the numbers. The Pennecon unit was used mainly to supply power during insulator replacements and not for the provision of emergency generation.

Figure 2 1999 Energy Production Segmentation Chart



It can be easily seen in Figure 2 that the leased Pennecon Unit and the Port aux Basques Diesel Unit 10, produced the majority of diesel produced energy on the Newfoundland Power system in 1999. This generation is mainly due to planned outages with distribution system reconstruction in Lark's Harbour and St. Vincent's in 1999 as well as planned outages with Newfoundland & Labrador Hydro's TL214 and TL215 transmission lines in the Port aux Basques area. The units located in the Port aux Basques area are usually run due to system outages in the area from weather problems.

Table B

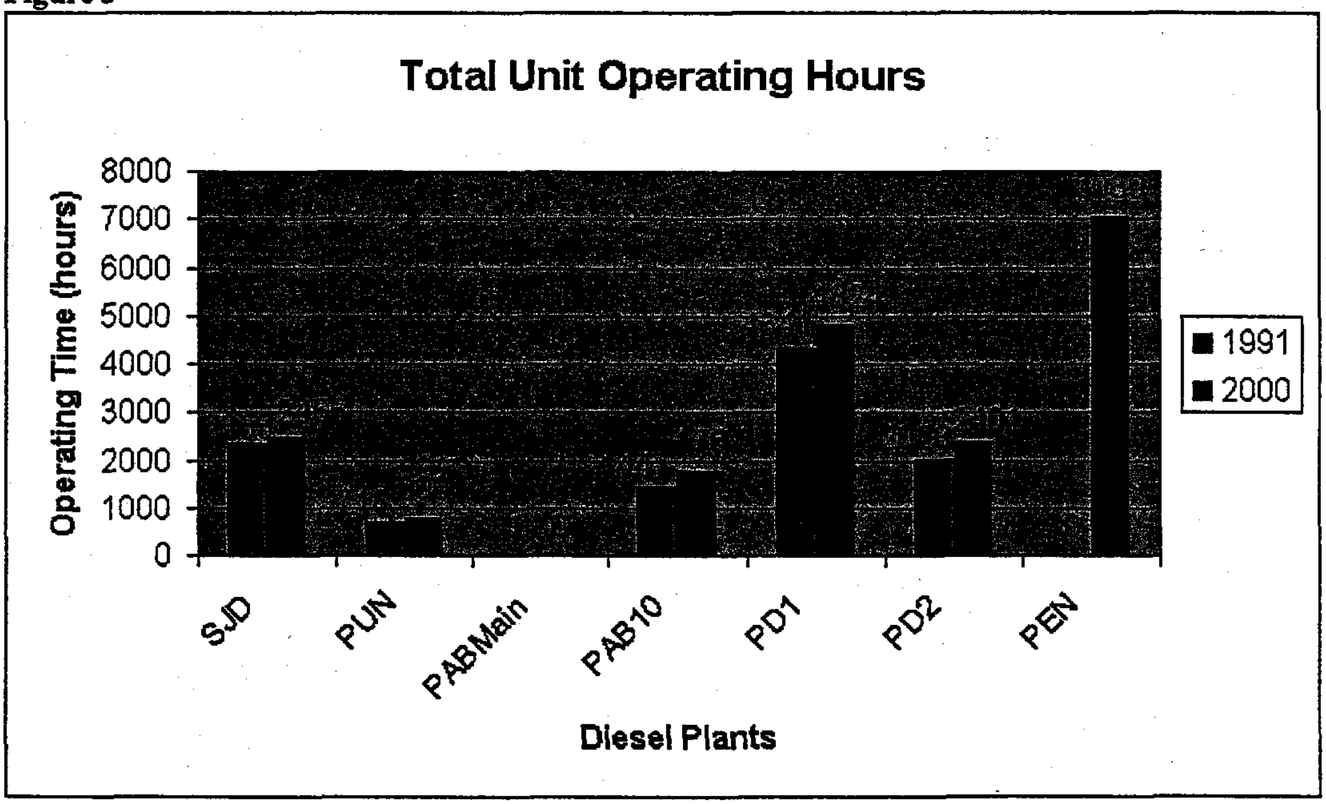
Plant	Available Capacity (kW)	Avg. Annual Generation 1990 – 1999 (kWh)	Annual Avg. NFP Operation 1990-1999(Hrs)
St. John's Diesel	2,500	12,953	11.1
Port Union Diesel	500	4,526	9.1
Port aux Basques Main Plant	1,659	27,006	16.3
Port aux Basques Diesel # 10	2,500	87,250	34.9
Portable Diesel # 1	700	21,645	53.7
Portable Diesel # 2	670	14,228	41.4
Pennecon Lease Unit	1,500	142,625 (1999 only)	95.1 (1999 only)

Table C shows the Operating Hour Meter readings for each of the diesel plants from 1991 and then again in 2000. It can be seen from the table that the average hours of operation between 1991 and 2000 were lower than the lifetime operating averages for each of the diesel units. The PAB Unit10, Portable Diesels, and the leased Pennecon Diesel unit have the highest utilization rates.

Table C

Diesel Plant	**Meter** 1991 (hours)	**Readings** 2000 (hours)	**Hours per Year** (hours/year)	**Plant Age** (years)	**Lifetime Average** (hours/year)
SJD	2355	2455	11.1	48	51.1
PUN	718	800	9.1	39	20.5
PABMain	?	?	?	?	?
PAB10	1447	1761	34.9	32	55.0
PD1	4341	4824	53.7	28	172.3
PD2	2028	2401	41.4	25	96.0
PEN	0	7039	782.1	10	703.9

Figure 3



Operation and Maintenance

Most diesel plants in our system have no direct supervision and the maintenance of a particular unit becomes a secondary duty to the principal duty of most operators, which are hydroelectric facilities. The one exception to this rule in the past had been the Port aux Basques area where a full-time employee was responsible for the diesel and gas turbine units in this area. With the installation of the Rose Blanche hydroelectric unit in the Port aux Basques area; a second individual was added to power plant operations. However, the end result is that the Port aux Basques area no longer has a full-time employee dedicated to diesel plant maintenance and operations only.

The maintenance on the diesel units has received little priority within the last ten years due to the lack of operating hours on these units. A centralized mechanical maintenance staff is responsible for heavy maintenance activities at the diesel, gas turbine and hydroelectric plants. Electrical maintenance is also handled from the same group located in St. John's. Major civil maintenance on the diesel, gas turbine and hydroelectric plants is coordinated from the Facilities Engineering Group. Maintenance activities, on a day-to-day basis, are the responsibility of local Plant Supervisors and their staff. The loss of experienced operating and maintenance personnel in the last number of years has significantly reduced our ability to perform the necessary maintenance on these units. These staffing losses in combination with reduced operating hours have significantly reduced our companies knowledge about these generating units. Port aux Basques is the only area in the province with employees with sufficient experience in the operation and maintenance of these diesel units.

The employees in the Power Plant Maintenance Group have been trained in the operation of the leased Pennecon diesel unit and are available throughout the winter for emergency generation purposes. However, the operation of the leased Pennecon diesel unit during the summer for scheduled transmission line maintenance; requires that staff from Port aux Basques or the Power Plant Maintenance Group are relocated to the site. This causes undue stress on local staffing levels. The Port aux Basques area is affected in that it reduces the amount of attention paid to the Port aux Basques diesel units as well as Rose Blanche. The Power Plant Maintenance Group is historically understaffed in the summer due to vacation time and capital work and the loss of staff to the operation of the diesel makes the situation worse.

Newfoundland Power's current diesel plant operating regime of very few operating hours per year means that rotating machinery is left standing for long periods of time. This can cause damage to bearings upon start-up. The St. John's Diesel is not currently started-up on a regular basis.

Cold starts on units, such as Port Union and the two Portable Diesels, are also prevalent and can be very hard on the diesel engines. These units are located inside heated buildings but the engine internals can at times get fairly cool. Engine block heaters are recommended for operation of these diesels in cold starting situations. The St. John's Diesel is warmed up prior to operation with a propane salamander but this method probably does not do a good job of uniformly heat soaking the engine. The leased Pennecon diesel unit has a block heater and the Port aux Basques GM Diesel has a heated lube oil re-circulation pump.

Condition of Diesel Power Plants

Condition assessments of the various diesel plants has taken many forms in the compilation of this report. Site visits have been made to each of these facilities to visually inspect the condition of the prime mover equipment and auxiliaries such as fuel storage tanks, cooling systems, buildings, compressed air systems, and substations.

Verbal interviews were conducted with the operators and supervisors for each diesel plant site. Information was collected from these interviews on: recent operating patterns, recent maintenance work completed; required maintenance work; spare parts stored on-site; operating problems; environmental problems; and general overall condition of the equipment. The fuel efficiency of the units was also calculated to give an idea as to the overall operating condition of the diesel units.

A 1997 consultant's report from Acres International also provided some information as to the availability of spare parts and to the condition of each unit and the expected remaining service life of these diesel plants. See Appendix E.

The condition of the St. John's Diesel plant is satisfactory to poor overall. The fuel tank has been replaced in recent years with a self-dyked steel unit. However, the switchgear and engine instrumentation are obsolete and require replacement. Access to this diesel plant in icy winter conditions, must be made by climbing a ladder up the side of a cliff off the Southside Road. The plant continues to have poor lighting levels and the powerhouse requires some upgrading work. The exhaust stack requires painting and the powerhouse requires the installation of an oil / water separator in the future.

The Port Union Diesel plant is in satisfactory condition. The fuel tank has been replaced in recent years with a self-dyked steel unit. An overhaul of the unit including repair work to the turbocharger bearing housing seals, compressor impeller, and auxiliary gear train will be required in order to keep this unit operating into the future. Engine instrumentation will also require upgrading to bring this unit to today's standards.

The Port aux Basques Main Diesel plant units are in poor condition. This plant has been approved for decommissioning by the Public Utilities Board in 1998.

The Port aux Basques Unit 10 Diesel is in good condition and should be capable of a number of years of remaining service life. Maintenance required on this unit includes repairs or replacement of the enclosure and repairs to the engine radiator.

Portable Diesel #1 is in satisfactory condition with only minor oil leaks and dirty radiators and fans. The continued use of this unit will require the installation of secondary containment for the fuel tanks onboard, an engine overhaul, and some minor repair work to the trailer chassis.

Portable Diesel #2 is in satisfactory condition with the exception of the trailer chassis. The chassis is in very poor condition and is not roadworthy. Continued use of this unit would require the replacement of the chassis with a new unit as well as an overhaul of the engine.

The leased Pennecon Diesel unit is in good condition and has many years of remaining service life despite the larger number of operating hours on this unit. The unit itself is only ten years old. Required maintenance on this unit include the replacement of some wiring and connectors in the engine control panel due to a small electrical fire in 1999. Work will also be required on the louver system and the reverse power relay.

Spare parts are no longer manufactured for the St. John's Diesel and surplus parts are limited and costly. It is foreseeable that this unit could require significant spares in the future and would thus cost significant dollars to continue operating. The Port Union diesel unit is not manufactured anymore but spare parts are still readily available for this unit. Four of the six Port aux Basques Main Plant Diesels are obsolete and the remaining two are nearing the end of the OEM's 50 year guarantee for parts availability. The Port aux Basques Unit 10 diesel is still manufactured and is supported with service parts. The two portable diesel units are also out of production but some spares are still available. Finally, the leased Pennecon unit is also still manufactured and spare parts are readily available for this unit now and in the short-term future.

Environmental Issues

The main environmental liability at each of the diesel plants in our system is the storage and handling of bulk amounts of diesel fuel. Both portable diesel units have fuel tanks with no secondary containment of the fuel products. Of greater concern is the fact that the fuel tank for the Portable Diesel #2 is located below the undercarriage of the trailer unit. A puncture of this single-walled tank would leak diesel fuel directly onto the ground beneath. The Portable Diesel #1 fuel tank cannot be dipped due to inaccessibility and thus the fuel volumes cannot be reconciled for this tank. Both fuel tanks would have to be replaced should these units be maintained for future service.

The Port aux Basques and St. John's diesel plants have the greatest volume of No.2 marked diesel storage and thus the potential environmental liabilities are higher with these sites. The St. John's Diesel unit is located adjacent to the Southside Road and a major fuel spill could conceivably end up in the St. John's Harbour. The St. John's Diesel powerhouse also has a floor drain system, which flows directly to the Harbour beneath the Southside Road.

Another main area of concern is the fossil fuel emissions resulting from the combustion of No.2 marked diesel fuel in the diesel plants. Emission testing has never been completed for any of our diesel plant facilities. Our diesel units operate so rarely that annual emission levels are not significant. Emission concentration levels during hours of operation, however could be an issue should regulatory maximum limits continue to drop.

Storage of lubricating products and coolant, such as glycol, also represent an environmental liability in the operation of the diesel plants. The St. John's Diesel plant uses a large quantity of lubricating oil which currently has no secondary containment. The potential for a leak of this product to the St. John's Harbour, through the floor drains system, is high. Environmental requirements will become more stringent in these areas and as such costs will increase in the future.

Non-friable asbestos is also a problem at a number of the diesel plant sites. The St. John's Diesel plant has transite wall, ceiling and exterior sheeting panels containing 10-25% chrysotile non-friable asbestos. The Port Union hydroelectric and diesel plant also contains a small amount of non-friable transite ceiling tiles. The Port aux Basques Main Diesel plant building is covered in non-friable asbestos cement shingles. The Portable Diesel #1 contains non-friable asbestos transite wall panels in the engine room. The leased Pennecon diesel and Portable Diesel #2 have no asbestos containing materials.

All friable asbestos products were removed from the diesel plant locations in 1998.

Finally, the decommissioning of the diesel plants themselves can identify major environmental issues, which have to be dealt with in a timely fashion.

The decommissioning of the Salt Pond Diesel plant in 1998 was performed with Phase I and Phase II environmental site assessments having been done. These assessments identified areas of hydrocarbon contamination due to the storage of petroleum products. The costs to clean-up the associated contamination was approximately $168,000 for this site in 1998 and 1999.

The Aguathuna Diesel plant was also assessed in 1998 and hydrocarbon contamination was found on the property. The origin of these hydrocarbon contaminants could not easily be determined due to the historical storage of large amounts of petroleum products on adjoining properties. The approximate cost to clean-up this site in 1999 was approximately $38,000.

The Gander diesel plant also has a few environmental issues and the potential costs to clean-up Newfoundland Power's portion of this site could be significant. Newfoundland Power is currently in negotiations with Transport Canada on the extent of the cleanup.

The costs to clean-up environmental contaminants from diesel plant sites is expected to rise in the coming years and thus it is advisable to address environmental issues as soon as possible.

Remaining Service Life

The service life of a plant is typically determined by the running time until normal replacement is necessary for the major item of the plant. Physical life of a plant is determined by the overall plant life taking into account interim replacement of major components. To determine the physical life of a plant rigorous inspections are required usually involving the original equipment manufacturers. Much of the plant's present condition depends on how the plant was operated over its lifetime. Most fossil fuel plants were originally designed as base load units and were intended to run steadily with as few starts, stops and cycling as possible. As the duty cycle changes, the increased stops, starts and load swings may cause major components to become more susceptible to failure through fatigue or creep. Typically, Newfoundland Power operated diesel units have been operated rather infrequently with long down periods between starts. This can be particularly hard on engine life.

Based on normal operation high speed diesels are not designed for continuous running and have 15 year lives. Low speed diesels are generally expected to last 25 years.

Factors taken into account in determining the remaining service life of each generating unit were as follows:

- total hours run
- expected operating cycle
- availability of spare parts
- operating and maintenance history
- degree of operator site supervision

The expected remaining service life for each generating unit is summarized in Table D below.

Table D

Plant	Nameplate Capacity (kW)	Lifetime Operation To Date (hours)	Remaining Service Life (Years)
St. John's Diesel	2,500	2,455	2
Port Union Diesel	500	800	2
Port aux Basques Main Plant	1,659	> 25,000	2
Port aux Basques Diesel # 10	2,500	1,761	7
Portable Diesel # 1	700	4,824	2
Portable Diesel # 2	670	2,401	2
Pennecon Lease Diesel	1,500	7,039	15

PAB Main Diesel Operating Hours estimated on fact that units ran continuously prior to 1968.

Plant Costs

As mentioned earlier in this report, historical and projected costs were determined for each of the diesel plants listed based upon required maintenance and capital work. A loading of 30% was added to capital projects to account for financing, depreciation, and tax considerations. A detailed listing of the work that comprises the projected capital and large maintenance work required may be found in Appendix C. The historical costs as well as the projected costs to achieve the extended life listed are in Table E below:

Table E

Plant	Historical Annual Operating Cost	Projected Add. Maintenance Expenses	Projected Capital Expenses	Extended Life (years)
St. John's Diesel	$45,911	$157,000	$377,000	10
Port Union Diesel	$7,442	$12,000	$66,300	10
Port aux Basques Main Diesel	$62,638	$25,500	$793,000	10
Port aux Basques Unit 10 Diesel	$20,934	$199,500	$188,500	15
Portable Diesel #1	$11,321	$38,500	$31,200	10
Portable Diesel #2	$11,727	$29,000	$96,200	10
Pennecon Lease	$29,178	$44,500	$9,100	20
Totals	**$189,151**	**$506,000**	**$1,535,000**	

The total of all projected additional operating and capital expenses is approximately $2,041,000 in order to attain the extended unit lives listed in this table.

The next table lists the annual fixed cost basis in $/kW-yr and an average annual variable cost in $/kWh. The average annual fixed cost is the historical cost with the variable costs removed. The capital costs were added to the projected operating expenses and a levelized projected annual cost was calculated. The total annual fixed cost is the sum of the average annual historical and projected levelized annual costs divided by the plant capacity. The average variable cost is based upon plant fuel efficiency, fuel costs and labour required to operate each of the diesel generating plants. The total cost to operate a plant per year would be the product of the capacity and the total fixed costs added to the product of the average annual generation and the variable cost.

Table F Summary of Diesel Plant Fixed and Variable Per Unit Costs

Plant	Installed Capacity (kW)	Average Annual Generation (kWh)	Average Fuel Efficiency (kWh/L)	Historical Annual Fixed Costs ($/kWyr)	Projected Additional Annual Fixed Cost ($/kW-yr)	Total Annual Fixed Cost ($/kW-yr)	Average Annual Variable Cost ($/kWh)
St. John's	2,500	12,953	3.043	$17.90	$34.29	$52.19	$0.111
Port Union	500	4,526	2.873	$13.69	$25.14	$38.83	$0.156
Port aux Basques Main Plant	1,659	27,006	2.860	$34.93	$79.21	$114.14	$0.131
Port aux Basques Unit 10	2,500	87,250	3.333	$6.12	$20.80	$26.92	$0.096
Portable#1	700	21,645	3.037	$12.58	$15.99	$28.57	$0.137
Portable#2	670	14,228	2.864	$13.25	$30.00	$43.25	$0.144
Pennecon	1,500	142,625	3.415	$10.97	$4.39	$15.36	$0.107

Decommissioning Costs

The diesel plant decommissioning costs have been estimated below for each of the sites.

Estimated St. John's Diesel Plant Decommissioning Costs

Asbestos Removal	$50,000
Equipment Removal	$25,000
Building Demolition	$50,000
Fuel Tank Demolition	$ 2,000
Substation Demolition	$ 3,000
Site Work	$ 1,500
Decommissioning Subtotal	**$131,500**
10% Contingency	$13,150
Environmental Testing & Remediation	$40,000
Engineering & Supervision	$ 4,000
Decommissioning Total	**$188,650**

Estimated Port Union Diesel Plant Decommissioning Costs

Note: Environmental remediation costs are not included in this analysis as the building and grounds will remain once the diesel unit has been removed.

Asbestos Removal	$ 1,000
Equipment Removal	$10,000
Fuel Tank Demolition	$ 2,000
Site Work	$ 1,500
Decommissioning Subtotal	**$14,500**
10% Contingency	$ 1,450
Environmental Testing & Remediation	$20,000
Engineering & Supervision	$ 2,000
Decommissioning Total	**$37,950**

Estimated Port aux Basques Main Diesel Plant Decommissioning Costs

Note: Environmental remediation costs are not included in this analysis as the building and grounds will remain once the diesel units have been removed. The fuel tank will also remain onsite.

Equipment Removal	$50,000
Asbestos Removal	$ 1,000
Sitework	$ 5,000
Decommissioning Subtotal	**$56,000**
10% Contingency	$ 5,600
Environmental Testing	$10,000
Engineering & Supervision	$ 2,800
Decommissioning Total	**$74,400**

Estimated Port aux Basques Unit 10 Diesel Plant Decommissioning Costs

Note: Environmental remediation costs are not included in this analysis as the building and grounds will remain once the diesel units have been removed. The fuel tank will also remain onsite.

Equipment Removal	$35,000
Asbestos Removal	$ 1,000
Sitework	$ 5,000
Decommissioning Subtotal	**$41,000**
10% Contingency	$ 4,100
Environmental Testing	$10,000
Engineering & Supervision	$ 2,800
Decommissioning Total	**$57,900**

Portable Diesel #1 Decommissioning Cost Assumptions

As this unit is mobile, it is assumed that the decommissioning costs will be minimal and will equal the salvage value.

Decommissioning Total **$0**

Portable Diesel #2 Decommissioning Cost Assumptions

As this unit is mobile, it is assumed that the decommissioning costs will be minimal and will equal the salvage value.

Decommissioning Total **$0**

Pennecon Diesel Decommissioning Cost Assumptions

Presently, Newfoundland Power Inc. does not own this diesel unit. Newfoundland Power is leasing the diesel unit from Pennecon Construction Ltd.

As this unit is mobile, it is assumed that the decommissioning costs will be minimal and will equal the salvage value.

Decommissioning Total **$0**

New Generation Alternatives

When energy is required, the cheaper alternative is typically hydroelectric plants where resources are available. The installation of the Rose Blanche Hydroelectric Development in 1998 replaces the energy and capacity associated with the decommissioning of the Port aux Basques Diesel Main Plant and one or both of the Portable Diesels in the Grand Bay Substation. Future hydroelectric developments in the Port aux Basques area would firm up the power supply to the Southwest corner of the province. This energy would have a total levelized cost of approximately $0.065/kWh based on an average hydroelectric installation in the area.

The variable costs associated with hydroelectric installations are less variable than thermal sites and thus are much more attractive for energy requirements. Hydroelectric installations utilize no cost water resources whereas thermal sites utilize diesel fuel with highly variable costs. The steep escalation in fuel prices in Newfoundland over the past six months demonstrates the potential volatility in thermal site variable costs.

Wind turbine technology has also been enhanced greatly over the last few years and Hydro Quebec is now producing wind-generated electricity at approximately $0.065/kWh (total levelized cost). In locations where hydroelectric resources are not available; wind turbine sites might be a viable alternative for energy and voltage boosting purposes. However, due to their use of induction-type generators; wind turbine sites are not viable for isolated capacity and emergency generation.

Gas turbine plants are typically the cheapest alternative where capacity and not energy are required. As diesel plants are retired from the system the capacity should be replaced by gas turbines if hydroelectric resources are not available. If natural gas should become available in Newfoundland; this would be the natural selection for fuel type with distillate fuel as primary backup. A new 25 MW peaking gas turbine unit has been estimated to be approximately $132/kW-yr. Fixed operating costs would be similar to Newfoundland Power's Greenhill Gas Turbine, located in Grand Bank NF, which is approximately $3.15/kW-yr. The total cost would be about $135/kW/yr for a new 25 MW gas turbine installation.

The capital cost of a new 2,000 kW diesel generating set mounted in a portable trailer / enclosure unit was estimated at $1.2 Million in response to our Request for Information on Emergency Power Systems in July 1999. The total annual fixed cost per year is $85.00/kW-yr for this 2 MW of portable generation.

The capital cost of a new 2,000 kW portable gas turbine generating set mounted in a portable trailer/enclosure unit was estimated at $2.7 Million in response to our Request for Information on Emergency Power Systems in July 1999. The total annual fixed cost per year is $202.00/kW-yr for this 2 MW of portable generation.

Table G Comparison of Diesel Plant Costs versus New Generation Alternatives

Plant	Total Annual Fixed Cost ($/kW-yr)	Variable Cost ($/kWh)
St. John's Diesel	$52.19	$0.111
Port Union Diesel	$38.83	$0.156
Port aux Basques Main Diesel	$114.14	$0.131
Port aux Basques Unit 10 Diesel	$26.92	$0.096
Portable Diesel #1	$28.57	$0.137
Portable Diesel #2	$43.25	$0.144
Pennecon Lease	$15.36	$0.107
New 25 MW Gas Turbine Station	$135.00	$0.073
Refurbished 2.5 MW Diesel	$118.00	$0.086
Refurbished 2.25 MW Gas Turbine	$111.00	$0.116
New 2 MW Portable Cat Diesel	$97.00	$0.085
New 2 MW Portable Gas Turbine	$202.00	$0.116
		Total Levelized Energy Cost ($/kWh)
Small Hydroelectric Installation		$0.065
New 2.5 MW Wind Turbine		$0.065
NLH Capacity Credit[1]	$14.00	
Holyrood Marginal Energy Cost		$0.046

[1] Based upon Newfoundland & Labrador Hydro 1995 Cost of Service Study.

Analysis

A weighted evaluation matrix was used to rank the diesel plants in terms of their value to Newfoundland Power Inc. Six evaluation parameters were used to compare these plants which are namely: importance to local grid reliability; hours of annual operation; annual kWh generation; plant fuel efficiency; potential environmental liabilities; average annual fixed cost; and variable cost. The parameters for each of the plants were ranked relative to one another where 1 was the best score and 6 the worst. Each of the parameters was given a weighting to make some parameters more important to the overall ranking than others. For instance, the "Importance to Local Area Operations" is three times as important in the rankings as the "Number of Operating Hours per year" for each diesel unit. The matrix is shown on the following page.

The value of generation in terms of a capacity credit on costs assigned to Newfoundland Power by Newfoundland & Labrador Hydro was determined using the 1995 Cost of Service Study. The average capacity credit was $14.00 / kW-yr over the years studied of 1997-2001. Plants which have a total annual fixed cost of less than this amount are of economic benefit to Newfoundland Power while those higher have less benefit to Newfoundland Power. These assets however may be of value to the interconnected Newfoundland customer as they may be less expensive than the cheapest new generation alternative.

The evaluation matrix ranked the Port aux Basques Unit 10 Diesel as being the most useful, and cost effective diesel generating unit in the company today. These numbers make sense as the capacity and age of the unit would be of benefit to its overall efficiency and costs. The leased Pennecon diesel unit was the second highest ranked unit. The higher capacity units have the impact of reducing the $/kWh and $/kW average costs. The Portable Diesel #1 and the Port Union Diesel were ranked third and fourth respectively. The St. John's Diesel and the Portable Diesel #2 were tied for fifth in the overall rankings. The Port aux Basques Main Plant was ranked last of all the diesel plants.

In reviewing the associated costs with the diesel units it becomes obvious that the more expensive plants to operate are the older units, namely: St. John's Diesel; Port Aux Basques Main Diesel units; and the Portable Diesels. If you factor in the age of these units and the potential future costs and environmental liabilities it backs up the rankings of the plants. Thus, it is advisable to decommission the Port aux Basques Main Diesel units, the St. John's Diesel, and the Portable Diesel #2.

Conclusions

1. Newfoundland Power currently operates seven diesel generating plants with a total installed electrical capacity of 10,029 kW. A leased diesel unit from Pennecon Construction Ltd. accounts for 1,500 kW of that capacity.

2. The diesel plants have seen little operation over the past ten years with an average total generation of 167,644 kWh for the six diesel units, excluding the Pennecon unit. The Pennecon Leased unit accounted for 142,625 kWh by itself and the Port aux Basques Unit #10 accounted for a total of 87,250 kWh from the average total figure.

3. The storage of large amounts of lubricating oil at the St. John's Diesel plant site coupled with the lack of secondary containment for this product represents a significant environmental liability for this site. The powerhouse floor drain system will have to be modified if this plant continues to operate. The plant's location adjacent to the St. John's Harbour also represents a high risk for fuel spills.

4. The fuel tank attached to the undercarriage of the Portable Diesel #2, without secondary containment, also represents a significant environmental liability for this unit.

5. The lack of secondary containment for the Portable Diesel #1 fuel tank represents an environmental risk and thus the tank will have to be replaced on this unit.

6. The continued use of the switchgear at the St. John's Diesel plant is not recommended due to the open-contact type design of this equipment. The access to this plant during winter conditions is another safety concern that will have to be addressed if this plant continues to operate.

7. The operating hours in 1999 were abnormally high for our diesel plants due to operations and testing undertaken for the Y2K roll-over. The energy production for the year 2000 should be lower than 1999.

8. Excluding the Pennecon Construction leased unit the average utilization of these diesel plants is approximately 20 hours per year.

9. The energy production and useage of these plants has been dropping steadily since 1990. The funds allocated to the upkeep of these units has also been following the same trend.

10. The projected additional operating and capital costs to extend the life of these diesel units would be approximately $2,041,000 over the next five to ten years. These costs are over and above the existing historical operating costs for these plants.

11. The total historical average annual operating cost for these diesel plants is approximately $189,000 per year.

12. Small scale hydroelectric developments in the Port aux Basques area are estimated to have a total levelized energy cost of approximately $0.064 to $0.066 per kWh.

13. A new 25 MW gas turbine installation would have an annual fixed cost of approximately $135/kW-yr.

14. A reconditioned unit similar to the Port aux Basques GM diesel would have an annual fixed cost of approximately $118/kW-yr.

15. A small refurbished portable gas turbine would have an annual fixed cost of approximately $111/kW-yr.

16. Spare parts and replacement parts for the St. John's Diesel unit as well as the older Port aux Basques units are not readily available anymore. Thus replacement parts cannot be obtained or must be custom fabricated at high costs.

17. The leased Pennecon Diesel and the Port aux Basques Unit10 GM Diesel are the most fuel efficient diesel units at 3.415 and 3.333 kWh / Litre respectively.

18. The seven diesel plants were ranked as to their utility to the company, and are from best to worst: The Port aux Basques Unit #10 Diesel; Pennecon Lease Diesel; Portable Diesel #1; Port Union Diesel; St. John's Diesel; Portable Diesel #2; and the older Port aux Basques diesel units.

19. Based upon the rankings of the diesel units, the degree of machine obsolescence, spare parts availability, and the impact upon customer service; this report concludes that the St. John's Diesel and the Portable Diesel #2 should be decommissioned in addition to the Port aux Basques Main Plant diesel units in the year 2000.

Recommendations

1. Based upon the analysis of the operating costs, utilization, importance to local area grid, and potential environmental liabilities it is recommended that the Port aux Basques Main Plant, Portable Diesel #2, and the St. John's Diesel Plant be decommissioned in the summer of 2000. The building at Port aux Basques should be retained for future diesel unit site and PAB Unit #10 Diesel maintenance.

2. The St. John's Diesel plant site will require a Phase I Environmental Site Assessment following which the property should be cleaned-up and sold.

3. The Port Union diesel unit, although utilized infrequently, provides an important emergency power source in the Port Union area. The costs are low at this plant due to shared resources such as powerhouse and local labour. This diesel unit should be decommissioned if and when the two hydroelectric units at this site are decommissioned.

4. Portable Diesel #1 should be kept on site and funds spent to recondition the unit for future service as per recommended maintenance tasks.

5. The Pennecon Lease Diesel Unit provides Newfoundland Power with transmission line maintenance scheduling flexibility which is important and also provides us with a remote generator in the Trepassey area which has historically been prone to transmission line problems. Considerable funds were spent on this unit in 1999 to maintain its reliability. The lease agreement should be renewed each year for the near future.

6. Hydroelectric developments should be investigated for the Port aux Basques area to shore up the power supply in the area. Alternatively, a refurbished diesel unit of similar size to the PAB Unit #10 should be installed in the Port aux Basques Main Plant building if additional capacity is deemed to be required.

7. Refurbished diesel or gas turbine units should be considered for remote locations such as Wesleyville, Trepassey, and Twillingate. Alternatively, small scale hydroelectric sites in the vicinity of these areas should be considered.

8. Long term planning should investigate the possibility of installing natural gas fired simple cycle gas turbine or combined cycle plants on the West Coast (Port au Port Peninsula).

9. Consideration should be given to moving the General Motors EMD diesel into the adjoining powerhouse building once the smaller diesels have been removed.

10. Capital funds and greater operating resources should be allocated to the General Motors EMD diesel unit located in Port aux Basques. This unit provides a valuable generating asset on the end of the long radial transmission line into the Port aux Basques area.

11. Sites requiring energy production should be serviced with small hydroelectric installations where possible.

12. Major capital and operating expenditures are not warranted on the older units as a major component failure could leave the plant in-operational thus stranding the invested funds.

Appendix A

Condition Assessments of Diesel Plants

ST. JOHN'S DIESEL PLANT

Plant: **St. John's Diesel**

Inspected by: K. Nicholson
Date: 2000-05-24

Location: **St. John's**
Newfoundland

Description: Plant is comprised of one 2,500 kW diesel generator manufactured by Nordberg. The plant contains auxiliaries such as lube oil coolers, overhead crane, pump, day tank, fuel tank, gasoline fueled air compressor, air receivers, switchgear, controls, and transformers. The equipment is housed in a building with asbestos siding.

Specifications: See Technical Data Sheet in Appendix B1.

Date Installed: 1953
Metered Operating Hours: 2,455 hours

Recent Operating Pattern:

Year	Generation (kWh)
1990	18,080
1991	800
1992	27,608
1993	12,160
1994	34,480
1995	0
1996	3,120
1997	7,280
1998	26,000
1999	0
Average	12,953

Operation For
Reliability Check: - No regularly scheduled operation.

General
Plant is in good condition. Engine instrumentation and switchgear are obsolete. Building has asbestos panels. Building is cluttered although much better than the condition prior to 1998.

Recent Maintenance:
<u>1999</u>

- Infrared heater installed directly above lube oil purifier / separator.

1998

- Governor was removed from service to be overhauled, however Diesel Injection Inc. informed Newfoundland Power that the governor could not be overhauled due to its age and type.
- Fuel line piping was modified to allow for manual operation in the event of a solenoid valve failure at the self dyked steel fuel tank.
- Slip Ring brushes were field dressed with stones.
- All friable asbestos were removed from the plant with the engine exhaust manifold insulation having been removed and replaced with non-ACM.

1997

- New batteries and battery charger installed in powerhouse.

1994

- Air valve on #8 cylinder replaced with spare unit.

Required Maintenance:

- Exhaust stack requires painting.
- Governor overhaul.
- Fuel flow meter installation.
- Switchgear requires replacement.
- Instrumentation and protective controls require replacement.

Required Inspections:

- Air receiver and system require annual inspection and certification by Newfoundland and Labrador Department of Labour.
- Building crane requires regular inspection to maintain Department of Labour approval.

Spare Parts:

- Engine is obsolete, some minor spares kept on site.
- Other components are easily repaired or replaced.
- Spares on site include: 1 spare cylinder head, 1 liner, 1 piston, and various other smaller spares.

Environmental Restraints: None

Remaining Service Life: 2 years

Factors Affecting Service Life:

1. Low usage of plant.
2. Engine overhaul required within the next few years if reliable operation is to be expected.
3. Lack of spare parts.

PORT UNION DIESEL PLANT

Plant: **Port Union Diesel** **Inspected by: M. Hunter 1996-04-01**
Diesel Injection Inc. 1998

Location: **Port Union**
Newfoundland

Description: Unit consists of one 500 kW diesel generator set manufactured by Caterpillar. Unit is located in Port Union Hydroelectric Plant and consists of auxiliaries such as lube oil cooler, fuel tank, and switchgear.

Specifications: See Technical Data Sheet in Appendix B2.

Date Installed: 1962
Metered Operating Hours: 800 hours

Recent Operating Pattern:

Year	Generation (kWh)
1990	6,570
1991	4,620
1992	3,560
1993	3,320
1994	7,160
1995	4,070
1996	7,040
1997	6,780
1998	1,000
1999	1,140
Average	4,526

Operation For
Reliability Check: - Unit is started, synchronized and put on load monthly.

General
Equipment is in good condition. New self-dyked fuel tank has been installed. New fuel flow meters have been installed.

Recent Maintenance:
<u>**1999**</u>
- Six only re-manufactured heads and liners were installed on Caterpillar engine by Toromont.

1998

- Engine speed tachometer and gear tooth pick-up installed on diesel unit.
- Diesel Injection Inc. completed a governor overhaul on Port Union Diesel.
- New batteries installed on diesel unit.
- All friable asbestos were removed from the diesel unit with the breaching exhaust insulation having been removed and replaced with non-ACM.

1996

- Cooler and aftercooler cleaned.

1994

- 9,100 litre self-dyked steel fuel storage tank installed.

1991

- Two new batteries installed.

Required Maintenance:

- Turbocharger bearing housing seals are gone and require repair.
- Pistons are cracked and require replacement.
- Approved lighting fixtures required in diesel workshop.
- The turbocharger compressor impeller needs replacement due to loss of bearing clearances.
- Water lines need to be replaced.
- Auxiliary gear train needs to be repaired to reverse excessive wear in this equipment.
- See 1998 Diesel Injection Report.

Required Inspections:

- Below grade fuel lines require annual testing for leaks and corrosion protection.

Spare Parts:

- Toromont Caterpillar still stock spares for the engine.
- Some minor spares are kept on site.
- Other components are easily repaired or replaced.

Environmental Restraints: None

Remaining Service Life: 2 years

Factors Affecting Service Life:

1. Low usage of plant.
2. Regular preventative maintenance.
3. Spare parts availability.

PORT AUX BASQUES DIESEL PLANT

Plant:	**Port aux Basques Diesel**	**Inspected by: K. Nicholson**
Location:	**Port aux Basques**	**Date: 2000-02-07**

Description: Plant comprised of six Caterpillar diesel generator sets ranging in size from 262 kVA to 438 kVA located in the main building and one 3,250 kVA packaged General Motors (EMD) diesel generator set located adjacent to the building. Plant also includes auxiliaries such as controls, switchgear, fuel storage and transformers. Total installed capacity of the plant is 4,159 KW.

Specifications: See Technical Data Sheet in Appendix B3.

Date Installed:

Unit #1: 1949	Unit #5: 1965
Unit #2: 1953	Unit #8: 1965
Unit #3: 1954	Unit#10: 1969
Unit #4: 1958	

Operating Duty: Emergency generation in the event of transmission line or system outage.

Metered Operating Hours: Unit#10: 1,761 hours
The older Caterpillar units ran continuously until 1968. Thus these units must all have a minimum of 25,000 hours of operation. These units do not have operating hour meters.

Recent Operating Pattern:

Year	Total Generation (kWh)
1990	44,498
1991	177,640
1992	252,350
1993	139,669
1994	149,493
1995	65,716
1996	85,347
1997	105,027
1998	58,000
1999	89,300
Average	114,292

Operation for Reliability Check: Cranked Weekly.
Started monthly, synchronized and run on load for 1 hour.

General Condition:
Overall units are in fair to good operating condition. Unit #2 generator is faulted and has yet to be repaired. Some mufflers require rebuild. Generators require cleaning. The switchgear was manufactured in 1937 and is obsolete. The only unit protection is overcurrent on the main breaker. Fuel tank system is in excellent condition.

Recent Maintenance:

Unit #l
1995
- Muffler repaired and painted.
- Engine cleaned and painted.

Unit #2
1995
- Engine cleaned and painted.
- Muffler painted.

Unit #3
1995
- Muffler repaired and painted.
- Engine cleaned and painted.

1993
- Section of exhaust manifold replaced.
- Cooling fan fin repaired (third time).

Unit #4
1995
- Muffler painted.
- Engine cleaned and painted.

1993
- Engine oil changed.

1991

Rebuilt cylinder head installed.

Unit #5
1995
- Muffler painted.
- Engine cleaned and painted.

1994
- Engine oil changed.
- V section stripped and gasket renewed

1991
- Cylinder head repaired.

Unit #8

1995

- Muffler painted.
- Engine cleaned and painted.

1992

- Rectifier board replaced.

Unit#10

1998

- self-dyked fuel tank for diesels was sandblasted, repainted, and hinged doors were welded shut.
- Governor overhauled by Diesel Injection Inc.

1996

- Immersion heater replaced.

1995

- Muffler repaired and painted.
- New exhaust stack liner installed.

1993

- Generator air filters replaced.
- Engine cooling tower air intake louvers and actuator motor replaced.
- Engine oil changed (@ 1533 hrs).
- Cooling system antifreeze changed.
- Governor oil changed.

Other

1995

- Main powerhouse control room extended to include Unit #1 0 controls. Old enclosure retired.
- Main powerhouse shingles replaced/repaired.
- Old main fuel tanks and day tanks removed and replaced by two 22,700 Litre self dyked tanks.

Main Plant Units Required Maintenance:

- Unit #2 generator rewind.
- Main powerhouse generators require stator / rotor cleaning.
- Installation of anti condensation strip heaters on main powerhouse generators.
- Minor water leaks around exhaust pipes.
- Main powerhouse roof leaks.
- Mufflers on Units #2, 4, 5 & 8 require repair.
- Main powerhouse switchgear metering and protection require replacement.
- Fuel flow metering required for main plant.

Unit #10 Required Maintenance:

- Exterior repair and painting.
- Governor overhaul.
- Cooling air louver motor controls.
- Unit #10 requires replacement of piping to radiator.
- Enclosure on Unit #10 requires major overhaul or replacement.
- Louvers on Unit #10 require repairs to ensure proper operation.
- Radiator on Unit #10 requires overhaul and must be re-supported as existing supports are corroded.
- Fuel flow metering required for Unit #10.

Required Inspections:

- Air receiver and system requires annual inspection and certification by Newfoundland and Labrador Department of Labour.

Spare Parts:

- Unit #1 0 engine is still supported by GM through Midwest Power Products, Winnipeg. Caterpillar engines are obsolete and parts are becoming difficult to obtain. Some spares are kept on site.
- Other components are easily repaired or replaced.

Environmental Restraints: None

Remaining Service Life:	Unit #1, 3, 4, 5, 8:	2 years
	Unit #2:	0 years
	Unit#10:	7 years

Factors Affecting Remaining Service Life:

1. Plant usage.
2. Generator stator/rotor cleaning.
3. Availability of spare parts.
4. Implementation of preventative maintenance program.

PORTABLE DIESEL UNITS

Plant: **Portable Diesel Units #l & #2**

Inspected by: K. Nicholson
Date: 2000-02-10

Location: **Grand Bay Substation**
Port aux Basques

Description: The units consist of diesel generator sets each mounted in a self contained high bed road trailer. Each trailer includes all auxiliaries such as fuel tank, switchgear and transformers. Unit #l is rated at 700 KW and Unit #2, 670 KW.

Specifications: See Technical Data Sheet in Appendix B4.

Date Installed: Unit #1: 1973
Unit #2: 1976

Metered Operating Hours: Unit #1: 4,824 hours
Unit #2: 2,401 hours

Recent Operating Pattern:

Year	Generation (kWh)	
	Unit #l	Unit #2
1990	33,830	13,000
1991	0	0
1992	23,080	410
1993	22,610	17,900
1994	26,120	19,660
1995	15,280	12,700
1996	25,410	21,290
1997	27,940	23,230
1998	14,000	10,000
1999	28,180	24,090
Average	21,645	14,228

Operation For Reliability Check:
- Cranked weekly.
- Started monthly, synchronized and run on load for 1 hour.

General Condition:
Both generating units are in good condition. Mufflers are rusty, minor oil leaks on both engines. Radiators and fans are dirty. Trailer chassis on Unit #2 is very deteriorated and is no longer road worthy. Unit #2 is also fairly difficult to start at times and local operators sometimes use Quick Start (Ether) to start the unit.

Recent Maintenance:

1999

- Batteries replaced on both Portable Diesels from old batteries from Port aux Basques Main Plant diesel units.

1998

- All friable asbestos were removed from the diesel unit with the muffler and exhaust system insulation having been removed and replaced with non-ACM.

1995

- Exhaust manifold guards installed.
- Intake louvre doors installed on Unit #2.
- HV transformer bushings and lightening arresters replaced on Unit #2.
- Unit #2 transformer and deck painted.
- Annual tire, brake and light inspection.

1994

- Unit #2 fuel tank refurbished.

1993

- Complete engine oil changes on both engines (Unit #l - 4489 hrs, Unit #2 - 2088 hrs)
- Unit #l batteries replaced.

1992

- Unit #2 batteries replaced.
- Unit #l governor overhauled.
- Unit #l chassis underwent minor repairs and painting.
- Unit #2 chassis underwent temporary structural repairs.

Required Maintenance:

Unit #l

- Engine oil leak repair.
- Reverse power relay repair.
- Annual tire, brake and light inspection
- New battery charger required.
- Chassis minor painting
- Generator, radiator and fan cleaning.
- Oil change required.

Unit #2

- Automatic voltage regulator repair.
- Underfrequency relay not operational.
- Governor overhaul.
- Repairs / Modifications to starting system.
- Chassis replacement.
- Engine minor oil leak.
- Generator, radiator and fan cleaning.
- Unit to fence grounding.
- Oil change required.

Required Inspections:

- Annual fire extinguisher inspection.

Spare Parts:

- Engines are older vintage Caterpillar and some trouble have been experienced obtaining spare parts.
- Other components are easily repaired or replaced.

Environmental Restraints: None

Remaining Service Life:	Unit #1:	2 years
	Unit #2:	2 years

Factors Affecting Service Life:

1. Low usage of plant.
2. High level of maintenance required on components susceptible to corrosion damage. Chassis on Unit #2 major concern.
3. Spare parts availability.
4. Implementation of preventative maintenance program.

PENNECON LEASE DIESEL UNIT

Plant: **Pennecon Lease Unit**

Inspected by: M. Northcott
Date: August 1999

Location: **Trepassey Substation**
Trepassey, Newfoundland

Description: The unit consists of a diesel generator set mounted in a self-contained high bed road trailer. The trailer includes auxiliaries such as switchgear and control panels. The unit is rated at 1,500 KW.

Specifications: See Technical Data Sheet in Appendix B5.

Date Installed:

1990	Unit Produced by Stewart & Stevenson
≈1993	Sold to Hibernia Fabrication Yard, Bull Arm, NF
≈1997	Sold to Pennecon Construction Ltd.
1999	First Use by Newfoundland Power

Metered Operating Hours: 7,039 hours

Recent Operating Pattern:

Year	Generation (kWh)
1999	142,625
Average	142,625

Operation For Reliability Check:
- Unit started monthly by local service personnel in Trepassey.
- Unit sits dormant for long periods of time at which point it is run continuously for system outages, etc.

General Condition:
This unit was built in 1990 by Stewart & Stevenson and then sold to Detroit Diesel in St. John's, Newfoundland. The unit was then sold to the Hibernia Management & Development Company (HMDC) for the Bull Arm Fabrication yard along with three other identical units. Pennecon Construction bought this unit during a Hibernia (HMDC) surplus equipment sale. Newfoundland Power Inc. rented this unit from Pennecon for use during the 1998 Canada Winter Games in Cornerbrook and again in Buchans. Newfoundland Power has been leasing this unit from Pennecon Construction continuously since 1999. The diesel unit is in fairly good condition although there have been some problems encountered due to a dirty radiator and faulty reverse power relay. The wiring in the control panel also is somewhat suspect as a small fire in 1999 may have damaged some of the wiring connections in this panel.

Recent Maintenance:

1999

- Oil, oil filters, and fuel filters were changed in diesel unit and test run.
- Replaced one generator instrumentation PT and checked operation of others.
- Air filter canister elements were replaced.
- Front drive seal was replaced.
- Chassis brakes and trailer lights were serviced.

1998

- A new set of batteries were installed during the 1998 Canada Winter Games (Cornerbrook).

Required Maintenance:

- Oil leak in one of the seals for the Alternator drive on the engine.
- Glycol cooling radiator, engine, and spill pan needs to be cleaned.
- Louvre system needs some attention.
- Reverse Power Relay has been disconnected due to frequent trip problems. Relay needs to be repaired and put back in service.
- An electrical fire in 1999 has caused some damage to electrical wiring and connections inside the engine control panel. This wiring should be inspected and repaired.

Required Inspections:

- Annual fire extinguisher inspection.

Spare Parts:

- There are no spare parts with the existing unit, however spare parts are still available from the Original Equipment Manufacturers (OEM): Marlin / Detroit Diesel and Kato Engineering.

Environmental Restraints: None

Remaining Service Life: 15 years

Factors Affecting Service Life:

1. Low usage of plant.
2. High level of maintenance required on components susceptible to corrosion damage. Chassis on unit will be a concern in years to come.
3. Implementation of preventative maintenance program.

Appendix B

Plant Data Sheets

Appendix B1

St. John's Diesel Plant – Data Sheet

Engine Manufacturer	Nordberg
Engine No.	201200804
Bore x Stroke	21-1/2" x 31"
rpm	225
Governor	Woodward Type 1C 500
BHP	3,580
Generator Manufacturer	General Electric Type AT1
kVA	3,125
kW	2,500
Volts	6,600
Amps	274 Armature
	228 Field
Exciter Model	General Electric 33G743
Type	CD 1126
Speed	1150 rpm
Excitation Volts	125
Amps	240
Phases	3
Cycles (Hz)	60
Temp. Rise	60°C
Power Factor	0.80

Appendix B2

Port Union Diesel Plant – Data Sheet

Engine Manufacturer	Caterpillar
Model	D-398A
Serial No.	66B127, Series A
Rating (HP)	750
rpm	1,200
Cylinders	12 cyl
Bore x Stroke	6-1/4" x 8"
Generator Manufacturer	General Electric
Model	102041-A
Frame	7635
Serial No.	754784
kW	500
rpm	1,200
Volts	2,400
Phases	3
Cycles (Hz)	60
Power Factor	0.80
Exciter Model	General Electric
Type	BF-823
Model	101424A
Serial No.	749761
kW	6

Appendix B3

Port aux Basques Diesel Plant – Data Sheet

Unit 1

Engine Manufacturer	Caterpillar
Model	D-397
Serial No.	41B1388
Rating (HP)	505
Cylinders	12 cyl 5-3 / 4x8
Bore x Stroke	5.75" x 8"
rpm	1,200
Generator Manufacturer	General Electric
Serial No.	850RN60
Frame	?
kVA	438
kW	350
rpm	1,200
Volts	2,400
Amps	105
Phases	3
Cycles (Hz)	60
Power Factor	0.80
Exciter Model	General Electric
Amps	40
Volts	125 VDC

Unit 2

Engine Manufacturer	Caterpillar
Model	D-353
Serial No.	46B
Rating (HP)	?
Cylinders	6 cyl
Bore x Stroke	6.25" x 8"
rpm	1,200

Generator Manufacturer	General Electric
Serial No.	2505N17
Frame	683
kVA	315
kW	250
rpm	1,200
Volts	2,400
Amps	75
Phases	3
Cycles (Hz)	60
Power Factor	0.80

Exciter Model	General Electric
Amps	53
Volts	77 VDC

Unit 3

Engine Manufacturer	Caterpillar
Model	D-397
Serial No.	48B1181
Rating (HP)	505
Cylinders	12 cyl 5-3 / 4x8
Bore x Stroke	5.75" x 8"
rpm	1,200

Generator Manufacturer	General Electric
Serial No.	350RN2
Frame	?
kVA	438
kW	350
rpm	1,200
Volts	2,400
Amps	108
Phases	3
Cycles (Hz)	60
Power Factor	0.80

Exciter Model	General Electric
Amps	40
Volts	125 VDC

Unit 4

Engine Manufacturer	Caterpillar
Model	D-386
Serial No.	15B1
Rating (HP)	344
Cylinders	12 cyl
Bore x Stroke	5.75" x 8"
rpm	1,200

Generator Manufacturer	General Electric
Serial No.	6842237
Frame	966
kVA	262
kW	209
rpm	1,200
Volts	2,400
Amps	71
Phases	3
Cycles (Hz)	60
Power Factor	0.80

Exciter Model	General Electric
Amps	40
Volts	125 VDC

Unit 5

Engine Manufacturer	Caterpillar
Model	D-386
Serial No.	15V54
Rating (HP)	364
Cylinders	12 cyl 5-3 / 4x8
Bore x Stroke	5.75" x 8"
rpm	1,200
Generator Manufacturer	General Electric
Serial No.	6917550
Frame	?
kVA	282
kW	250
rpm	1,200
Volts	2,400
Amps	75.4
Phases	3
Cycles (Hz)	60
Power Factor	0.80
Exciter Model	General Electric
Amps	40
Volts	125 VDC

Unit 8

Engine Manufacturer	Caterpillar
Model	D-353
Serial No.	46B1663
Rating (HP)	?
Cylinders	6 cyl
Bore x Stroke	6.25" x 8"
rpm	1,200

Generator Manufacturer	General Electric
Serial No.	2050N16
Frame	683
kVA	312
kW	250
rpm	1,200
Volts	2,400
Amps	75
Phases	3
Cycles (Hz)	60
Power Factor	0.80

Exciter Model	General Electric
Amps	53
Volts	77 VDC

Unit 10

Engine Manufacturer	General Motors EMD
Model	20-645-E4
Serial No.	64E1 1081
Rating (HP)	3600
Cylinders	20 cyl
Bore x Stroke	9-1/16" x 10"
rpm	900

Generator Manufacturer	General Electric
Serial No.	69-E1-1199 (1081)
Frame	?
kVA	3125
kW	2500
rpm	900
Volts	4,160
Amps	?
Phases	3
Cycles (Hz)	60
Power Factor	0.80

Exciter Model	General Electric
Amps	?
Volts	?

Appendix B4

Portable Diesel Plants – Data Sheet

	Unit 1	Unit 2
Engine Manufacturer	Caterpillar	Caterpillar
Model	D-349	D-349
Serial No.	61P476	61P809
Rating (HP)	980	980
rpm	1,800	1,800
Generator Manufacturer	Tamper Camron	Brown Boveri
Model	SG-1473	715
Serial No.	363-088-101	C-360-690-601
kW	700	670
rpm	1,800	1,800
Volts	347 / 600	347 / 600
Phases	3	3
Cycles (Hz)	60	60
Power Factor	0.85	0.85

Appendix B5

Pennecon Diesel Lease Unit – Data Sheet

Engine Manufacturer	Marlin / Detroit Diesel
Commissioning Year	1990
Model	91637316
Type	16V-149T1
Unit No.	16E0010426
Serial No.	5401154
Spec.	7645
Cylinders	16 cyl. 2 Cycle
Rating (HP)	2,000
rpm	1,800

Generator Manufacturer	Kato Engineering Ltd.
Model	A250890000
Type	25089
Serial No.	97874-04
Catalogue No.	4P62450P
kW	1,500
rpm	1,800
Volts	347 / 600
Phases	3
Cycles (Hz)	60

Trailer Model	4P6-245OP
Trailer Serial No.	97847-04

Appendix C

Diesel Plant Cost Information

Newfoundland Power Diesel Plant Fuel Costs / Efficiency

St. John's Diesel

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Averages
Production (kWh)	18080	800	27608	12160	34480	0	3120	7280	26000	0	12952.8
Fuel (Litres)	5268	159	7122	3386	8690	0	883	1979	7854	0	3533.1
Fuel Cost ($)	$ 1,524.16	$ 50.05	$ 2,102.11	$ 998.19	$ 2,561.81	$ -	$ 296.13	$ 604.16	$ 2,125.29	$ -	$ 1,026.19
Fuel Efficiency (kWh/L)	3.44	5.03	3.88	3.59	3.97	0.00	3.53	3.68	3.31	0.00	3.043
Cost Efficiency ($/kWh)	$ 0.084	$ 0.063	$ 0.076	$ 0.082	$ 0.074	$ -	$ 0.095	$ 0.083	$ 0.082	$ -	0.064

Normalized Cost Efficiency @ $0.3060 per Litre 0.101

Port Union Diesel

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Averages
Production (kWh)	6570	4620	3560	3320	7160	4070	7040	6780	1000	1140	4526
Fuel (Litres)	2340	1616	1269	914	2444	1305	3029	2201	357	480	1595.5
Fuel Cost ($)	$ 786.24	$ 437.95	$ 326.39	$ 235.46	$ 623.08	$ 291.99	$ 213.14	$ 574.57	$ 94.66	$ 112.85	$ 369.63
Fuel Efficiency (kWh/L)	2.81	2.86	2.81	3.63	2.93	3.12	2.32	3.08	2.80	2.38	2.873
Cost Efficiency ($/kWh)	$ 0.120	$ 0.095	$ 0.092	$ 0.071	$ 0.087	$ 0.072	$ 0.030	$ 0.085	$ 0.095	$ 0.099	0.084

Normalized Cost Efficiency @ $0.3060 per Litre 0.106

Port Aux Basques Diesel

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Averages
Production (kWh)	44498	177640	228230	139669	149493	65716	85347	105027	58000	89300	114292
Fuel (Litres)	16779	49678	66953	43619	44967	19046	25178	31421	16924	25126	33969.1
Fuel Cost ($)	$ 3,953.00	$ 12,789.67	$ 19,862.99	$ 12,649.33	$ 12,404.17	$ 5,190.06	$ 6,500.55	$ 8,425.49	$ 4,450.63	$ 6,300.68	$ 9,252.66
Fuel Efficiency (kWh/L)	2.65	3.58	3.41	3.20	3.32	3.45	3.39	3.34	3.43	3.55	3.333
Cost Efficiency ($/kWh)	$ 0.089	$ 0.072	$ 0.087	$ 0.091	$ 0.083	$ 0.079	$ 0.076	$ 0.080	$ 0.077	$ 0.071	0.080

Normalized Cost Efficiency @ $0.3060 per Litre 0.092

Portable Diesel #1

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Averages
Production (kWh)	33830	0	23080	22610	26120	15280	25410	27940	14000	28180	21645
Fuel (Litres)	8385	0	6498	7538	7811	4513	7697	8607	4187	8916	6415.2
Fuel Cost ($)	$ 2,029.17	$ -	$ 1,998.43	$ 2,048.73	$ 2,015.10	$ 1,042.47	$ 2,452.30	$ 2,465.15	$ 1,122.70	$ 2,259.08	$ 1,743.11
Fuel Efficiency (kWh/L)	4.03	0.00	3.55	3.00	3.34	3.39	3.30	3.25	3.34	3.16	3.037
Cost Efficiency ($/kWh)	$ 0.060	$ -	$ 0.087	$ 0.091	$ 0.077	$ 0.068	$ 0.097	$ 0.088	$ 0.080	$ 0.080	0.073

Normalized Cost Efficiency @ $0.3060 per Litre 0.101

Portable Diesel #2

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Averages
Production (kWh)	13000	0	410	17900	19660	12700	21290	23230	10000	24090	14228
Fuel (Litres)	3176	0	177	5966	6164	3822	6683	7085	3232	7633	4393.8
Fuel Cost ($)	$ 768.60	$ -	$ 52.57	$ 1,612.67	$ 1,583.65	$ 884.66	$ 1,762.46	$ 1,830.67	$ 869.56	$ 1,940.44	$ 1,130.53
Fuel Efficiency (kWh/L)	4.09	0.00	2.32	3.00	3.19	3.32	3.19	3.28	3.09	3.16	2.864
Cost Efficiency ($/kWh)	$ 0.059	$ -	$ 0.128	$ 0.090	$ 0.081	$ 0.070	$ 0.083	$ 0.079	$ 0.087	$ 0.081	0.076

Normalized Cost Efficiency @ $0.3060 per Litre 0.107

Pennecon Lease Unit

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Averages
Production (kWh)										142625	142625
Fuel (Litres)										41759	41759
Fuel Cost ($)										$ 10,339.32	$ 10,339.32
Fuel Efficiency (kWh/L)										3.42	3.415
Cost Efficiency ($/kWh)										$ 0.072	0.072

Normalized Cost Efficiency @ $0.3060 per Litre 0.090

Notes:

1. The cost [illegible]"All In" cost including fuel, labour, materials, etc.

Diesel Operating Costs 1990 - 1999

	1990			1991			1992			1993			1994		
Plant	Total Operating Cost	Fuel Cost	Net Operating Cost	Total Operating Cost	Fuel Cost	Net Operating Cost	Total Operating Cost	Fuel Cost	Net Operating Cost	Total Operating Cost	Fuel Cost	Net Operating Cost	Total Operating Cost	Fuel Cost	Net Operating Cost
St. John's Diesel	$ 19,480.00	$ 1,524.00	$ 17,956.00	$ 12,795.00	$ 50.00	$ 12,745.00	$ 44,719.00	$ 2,102.00	$ 42,617.00	$ 4,428.00	$ 998.00	$ 3,430.00	$ 8,152.00	$ 2,562.00	$ 5,590.00
Port Union Diesel	$ 1,308.00	$ 786.00	$ 522.00	$ 189.00	$ 438.00	$ (249.00)	$ 681.00	$ 326.00	$ 355.00	$ 762.00	$ 235.00	$ 527.00	$ 1,404.00	$ 623.00	$ 781.00
Port Aux Basques	$ 57,055.00	$ 3,953.00	$ 53,102.00	$ 75,130.00	$ 12,788.00	$ 62,342.00	$ 69,490.00	$ 19,863.00	$ 49,627.00	$ 54,553.00	$ 12,649.00	$ 41,904.00	$ 55,784.00	$ 12,404.00	$ 43,380.00
Portable Diesel #1	$ 2,029.00	$ 2,029.00	$ -	$ 3,335.00	$ -	$ 3,335.00	$ 45,576.00	$ 1,996.00	$ 43,580.00	$ 4,458.00	$ 2,049.00	$ 2,409.00	$ 3,013.00	$ 2,015.00	$ 998.00
Portable Diesel #2	$ 4,858.00	$ 769.00	$ 4,089.00	$ 3,850.00	$ -	$ 3,850.00	$ 13,827.00	$ 52.00	$ 13,775.00	$ 4,769.00	$ 1,613.00	$ 3,156.00	$ 4,332.00	$ 1,584.00	$ 2,748.00
Pennecon Lease Diesel	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

	1995			1996			1997			1998			1999		
Plant	Total Operating Cost	Fuel Cost	Net Operating Cost	Total Operating Cost	Fuel Cost	Net Operating Cost	Total Operating Cost	Fuel Cost	Net Operating Cost	Total Operating Cost	Fuel Cost	Net Operating Cost	Total Operating Cost	Fuel Cost	Net Operating Cost
St. John's Diesel	$ 6,927.00	$ -	$ 6,927.00	$ 6,915.00	$ 298.13	$ 6,616.87	$ 5,254.00	$ 604.16	$ 4,649.84	$ 26,296.00	$ 2,125.00	$ 24,171.00	$ 19,037.00	$ -	$ 19,037.00
Port Union Diesel	$ 314.00	$ 292.00	$ 22.00	$ 3,855.00	$ 213.14	$ 3,641.86	$ 360.00	$ 574.57	$ (214.57)	$ 24,678.00	$ 95.00	$ 24,583.00	$ 8,766.00	$ 113.00	$ 8,653.00
Port Aux Basques	$ 42,115.00	$ 5,190.00	$ 36,925.00	$ 48,222.00	$ 6,500.55	$ 41,721.45	$ 40,109.00	$ 8,425.49	$ 31,683.51	$ 24,401.00	$ 4,451.00	$ 19,950.00	$ 24,296.00	$ 6,301.00	$ 17,995.00
Portable Diesel #1	$ 2,371.00	$ 1,042.00	$ 1,329.00	$ 4,331.00	$ 2,452.30	$ 1,878.70	$ 7,032.00	$ 2,465.15	$ 4,566.85	$ 2,456.00	$ 1,123.00	$ 1,333.00	$ 2,259.00	$ 2,259.00	$ -
Portable Diesel #2	$ 6,658.00	$ 885.00	$ 5,773.00	$ 4,177.00	$ 1,782.46	$ 2,414.54	$ 3,120.00	$ 1,830.67	$ 1,289.33	$ 999.00	$ 870.00	$ 129.00	$ 2,532.00	$ 1,940.00	$ 592.00
Pennecon Lease Diesel	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$ 18,804.69	$ 10,339.00	$ 8,465.69

1990 - 1999

Plant	Total Operating Average	Total Fuel Cost Average	Total Net Average	Insurance Cost	Municipal Taxes	Depreciation Expense	Other Costs
St. John's Diesel	$ 15,400.30	$ 1,026.13	$ 14,374.17	$ 2,726.82	$ 1,680.00	$ 26,104.00	$ -
Port Union Diesel	$ 4,231.70	$ 369.57	$ 3,862.13	$ 146.04	$ 200.00	$ 2,864.00	$ -
Port Aux Basques Main Plant	$ 42,099.00	$ 4,282.06	$ 37,816.94	$ 1,182.72	$ 785.40	$ 18,571.00	$ -
Port Aux Basques Unit 10	$ 7,016.50	$ 4,765.04	$ 2,251.46	$ 606.97	$ 138.60	$ 13,172.00	$ -
Portable Diesel #1	$ 7,686.00	$ 1,743.05	$ 5,942.96	$ 37.87	$ -	$ 3,597.00	$ -
Portable Diesel #2	$ 4,892.20	$ 1,130.61	$ 3,761.59	$ 71.22	$ -	$ 6,764.00	$ -
Pennecon Lease Diesel	$ 18,804.69	$ 10,339.00	$ 8,465.69	$ 373.75	$ -	$ -	$ 10,000.00

Pennecon Lease Amount

Total Variable Cost	Variable Labour Cost per kWh	Normalized Fuel Cost per kWh	Total Variable Cost per kWh
$ 1,156.13	$ 0.010	$ 0.101	$ 0.111
$ 597.07	$ 0.050	$ 0.106	$ 0.156
$ 4,669.56	$ 0.015	$ 0.116	$ 0.131
$ 5,637.54	$ 0.010	$ 0.086	$ 0.096
$ 2,515.55	$ 0.036	$ 0.101	$ 0.137
$ 1,660.61	$ 0.037	$ 0.107	$ 0.144
$ 12,716.50	$ 0.017	$ 0.090	$ 0.107

Fixed Cost per kW	Tax, Insur., & Other Cost per kW	Fixed Cost per kW
$ 5.70	$ 12.20	$ 17.90
$ 7.27	$ 6.42	$ 13.69
$ 22.55	$ 12.38	$ 34.93
$ 0.55	$ 5.57	$ 6.12
$ 7.39	$ 5.19	$ 12.58
$ 4.25	$ 8.99	$ 13.25
$ 4.06	$ 6.92	$ 10.97

Average Annual Cost per kW	Annual Cost per kWh
$ 18.48	$ 3.57
$ 15.11	$ 1.67
$ 37.07	$ 2.28
$ 9.47	$ 0.27
$ 16.60	$ 0.54
$ 16.30	$ 0.85
$ 21.12	$ 0.22

What about depreciation charges per year?

Plant	Average Operating Hours	Average Generation (kWh)	Installed Capacity (kW)	Asset Book Value 03/27/00 ($CDN)
St. John's Diesel	5.2	12953	2500	$ 7,295,827.00
Port Union Diesel	9.1	4526	500	$ 390,745.00
Port Aux Basques Main Plant	16.3	27006	1659	$ 3,164,486.00
Port Aux Basques Unit 10	34.9	67250	2500	$ 1,623,992.00
Portable Diesel #1	30.9	21645	700	$ 101,315.00
Portable Diesel #2	21.2	14228	760	$ 190,546.00
Pennecon Lease Diesel	85.1	142625	1500	$ 1,000,000.00

Notes:

1. Total variable cost is based upon operating hours per year multiplied by a labour cost of $25/hr plus actual fuel costs.
2. Variable cost per year is based on operating hours per year times $25/hr divided by the average generation for the years 1990 to 1999 (Reference Cost Efficiency Table)
3. Normalized fuel cost from Diesel Cost Efficiency Table. Fuel costs normalized to December 1999 fuel costs.
4. Fixed cost is total operating average subtract the total variable cost divided by the installed capacity.
5. The Pennecon Leased Diesel has a renewable yearly lease of a cost of $10,000/yr as listed in Other Costs.
6. Diesel insurance is for structures and property only at a rate of 0.0325 mils/$100 of assets. The equipment premium is considered insignificant.
7. Asset Book Value as of March 27, 2000 was used to calculate the insurance cost per plant.
8. PAB diesel generation split based on installed capacity. Operating cost split based on the number of units installed in the plant.
9. Fuels costs for PAB plant are based on Unit #10 efficiency and calculated net plant efficiency. Taxes split based on land area occupied by Main Plant and Unit #10.
10. The depreciation expense is the cost per plant associated with depreciation which is incurred by the Company. These costs were given by Pam Woodford for 1999.

Capital Expenditures - 1996 through 1999 (Excluding GEC)

St. John's Diesel Plant	1998	70645	Fuel Flow Meter, etc	7,380.30
Port Union Diesel	1998	70647	Tachometer	2,181.17
	1999	70646	Fuel Flow Meter	59.44
	1999	70834	Battery	1,451.10
	1999	70834	Charger	2,038.20
Port Aux Basques - Main Plant	1998	70616	Paint Fuel Tank	5,554.80
Port Aux Basques - Unit # 10	1999	70619	Fuel Flow Meter	1,046.00
Portable # 1	1999	70648	Fuel Flow Meter	29.73
Portable # 2	1998	70674	Chassis Replacement	226.47
	1999	70650	Fuel Flow Meter	560.90
Pennecon Leased Diesel			No Capital Investments	-
				20,528.11

Required Maintenance for Diesel Plants

St. John's Diesel
Capacity 2500 kW

Item	Description				
1	Unit Overhaul	$ 150,000.00			
2	Exhaust Stack Painting	$ 5,000.00			
3	Oil / Water Separator		$ 30,000.00		
4	Instrumentation Replacement		$ 10,000.00		
5	Switchgear Replacement		$ 250,000.00		
6	Governor Overhaul	$ 2,000.00			
	Operating & Capital Sub-Totals	$ 157,000.00	$ 290,000.00		
	Financing Costs for Capital Total		$ 87,000.00		
	Operating & Capital Totals	$ 157,000.00	$ 377,000.00	$ 534,000.00	
	Average Annual Cost		10 Yr Extended Life	$ 85,735.14	
	Average Annual Cost per kW			$ 34.29	

Port Union Diesel
Capacity 500 kW

Item	Description				
1	Turbocharger Bearing Housing Seals		$ 10,000.00		
2	Protective Relay Maintenance	$ 1,000.00			
3	Oil / Water Separator		$ 10,000.00		
4	Instrumentation Calibration	$ 1,000.00			
5	Instrumentation Upgrades		$ 10,000.00		
6	Turbo Compressor Impeller Repl		$ 20,000.00		
7	Water Line Replacement		$ 1,000.00		
8	Auxiliary Gear Train Repairs	$ 10,000.00			
	Operating & Capital Sub-Totals	$ 12,000.00	$ 51,000.00		
	Financing Costs for Capital Total		$ 15,300.00		
	Operating & Capital Totals	$ 12,000.00	$ 66,300.00	$ 78,300.00	
	Average Annual Cost		10 Yr Extended Life	$ 12,571.28	
	Average Annual Cost per kW			$ 25.14	

Required Maintenance for Diesel Plants

Port Aux Basques Main Diesel
Capacity 1659 kW

Item	Description				
1	Plant Ventilation		$ 15,000.00		
2	Exhaust Pipe Insulation		$ 20,000.00		
3	Oil / Water Separator		$ 30,000.00		
4	Unit #2 Rewind		$ 20,000.00		
5	Switchgear Replacement		$ 500,000.00		
6	Anti-Condensation Strip Htrs Gener		$ 5,000.00		
7	Powerhouse Painting	$ 3,000.00			
8	Muffler Repairs, Units 2,4,5 and 8	$ 5,500.00			
9	Window Replacement in Powerhouse		$ 5,000.00		
10	Instrumentation Replacements		$ 15,000.00		
11	Generator Stator/Rotor Cleaning	$ 5,000.00			
12	Governor Overhauls	$ 12,000.00			
	Operating & Capital Sub-Totals	$ 25,500.00	$ 610,000.00		
	Financing Costs for Capital Total		$ 183,000.00		
	Operating & Capital Totals	$ 25,500.00	$ 793,000.00	$ 818,500.00	
	Average Annual Cost		10 Yr Extended Life	$ 131,412.38	
	Average Annual Cost per kW			$ 79.21	

Port Aux Basques Unit #10 Diesel
Capacity 2500 kW

Item	Description				
1	Unit and Radiator Overhaul	$ 190,000.00			
2	Fuel Flow Meter		$ 2,000.00		
3	Oil / Water Separator		$ 30,000.00		
4	Enclosure Replacement		$ 112,000.00		
5	Governor Overhaul & Calibration	$ 5,000.00			
6	Cooling Air Louvre Controls		$ 1,000.00		
7	Instrumentation Calibration	$ 3,500.00			
8	Protective Relaying Calibration	$ 1,000.00			
	Operating & Capital Sub-Totals	$ 199,500.00	$ 145,000.00		
	Financing Costs for Capital Total		$ 43,500.00		
	Operating & Capital Totals	$ 199,500.00	$ 188,500.00	$ 388,000.00	
	Average Annual Cost		15 Yr Extended Life	$51,996.74	
	Average Annual Cost per kW			$ 20.80	

Required Maintenance for Diesel Plants

Portable Diesel #1

Capacity 700 kW

Item	Description				
1	Clean Generator, Rad & Fan	$ 5,500.00			
2	Relay Replacement		$ 2,000.00		
3	Fuel Flow Meter		$ 2,000.00		
4	Instrumentation Replacement		$ 10,000.00		
5	Chassis Repairs / Painting	$ 10,000.00			
6	Relay Maintenance	$ 1,000.00			
7	Unit Overhaul	$ 20,000.00			
8	Secondary Fuel Containment		$ 10,000.00		
9	Governor Overhaul	$ 2,000.00			
	Operating & Capital Sub-Totals	$ 38,500.00	$ 24,000.00		
	Financing Costs for Capital Total		$ 7,200.00		
	Operating & Capital Totals	$ 38,500.00	$ 31,200.00	$ 69,700.00	
	Average Annual Cost	10 Yr Extended Life		$ 11,190.52	
	Average Annual Cost per kW			$ 15.99	

Portable Diesel #2

Capacity 670 kW

Item	Description				
1	AVR Repair	$ 1,000.00			
2	Relay Replacements		$ 2,000.00		
3	Fuel Flow Meter		$ 2,000.00		
4	Instrumentation Replacement		$ 10,000.00		
5	Alternator Repairs	$ 500.00			
6	Clean Generator, Rad & Fan	$ 5,500.00			
7	Chassis Replacement		$ 50,000.00		
8	Secondary Fuel Containment		$ 10,000.00		
9	Unit Overhaul	$ 20,000.00			
10	Governor Overhaul	$ 2,000.00			
	Operating & Capital Sub-Totals	$ 29,000.00	$ 74,000.00		
	Financing Costs for Capital Total		$ 22,200.00		
	Operating & Capital Totals	$ 29,000.00	$ 96,200.00	$ 125,200.00	
	Average Annual Cost	10 Yr Extended Life		$ 20,101.20	
	Average Annual Cost per kW			$ 30.00	

Required Maintenance for Diesel Plants

Pennecon Lease Diesel
Capacity 1500 kW

Item	Description				
1	Unit Overhaul	$ 20,000.00			
2	Relay Maintenance	$ 2,000.00			
3	Fuel Flow Meter		$ 2,000.00		
4	Instrumentation Replacement		$ 5,000.00		
5	Clean Generator, Rad & Fan	$ 5,500.00			
6	Repairs to Fire Damaged Wiring	$ 5,000.00			
7	Chassis Repairs / Painting	$ 10,000.00			
8	Governor Overhaul	$ 2,000.00			
	Operating & Capital Sub-Totals	$ 44,500.00	$ 7,000.00		
	Financing Costs for Capital Total		$ 2,100.00		
	Operating & Capital Totals	$ 44,500.00	$ 9,100.00	$ 53,600.00	
	Average Annual Cost		20 Yr Extended Life	$6,579.49	
	Average Annual Cost per kW			$ 4.39	

These expenditures would only be made by Newfoundland Power should the unit be purchased.

Notes:
1. Annual cost is composed of the projected Capital and Operating expenses.
2. St. John's, Port Union, PAB Main Plant, & Portables have an assumed extended life of ten years. PAB10 and Pennecon Diesel have an assumed extended life of 15 and 20 years respectively.
3. Capital Cast Financing assumed at 30% per year.
4. WACOC at 12.5%.

Appendix D

Photographs of Diesel Units

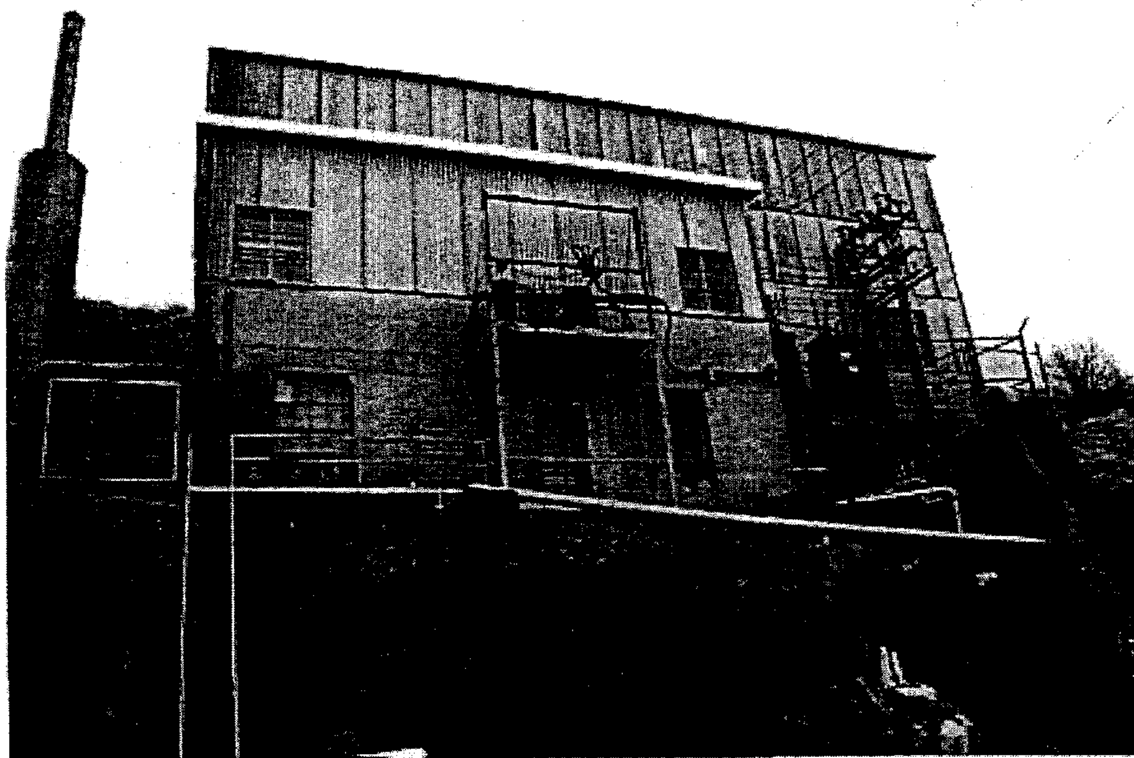


Photo 1 St. John's Diesel Powerhouse as seen from the Southside Road.

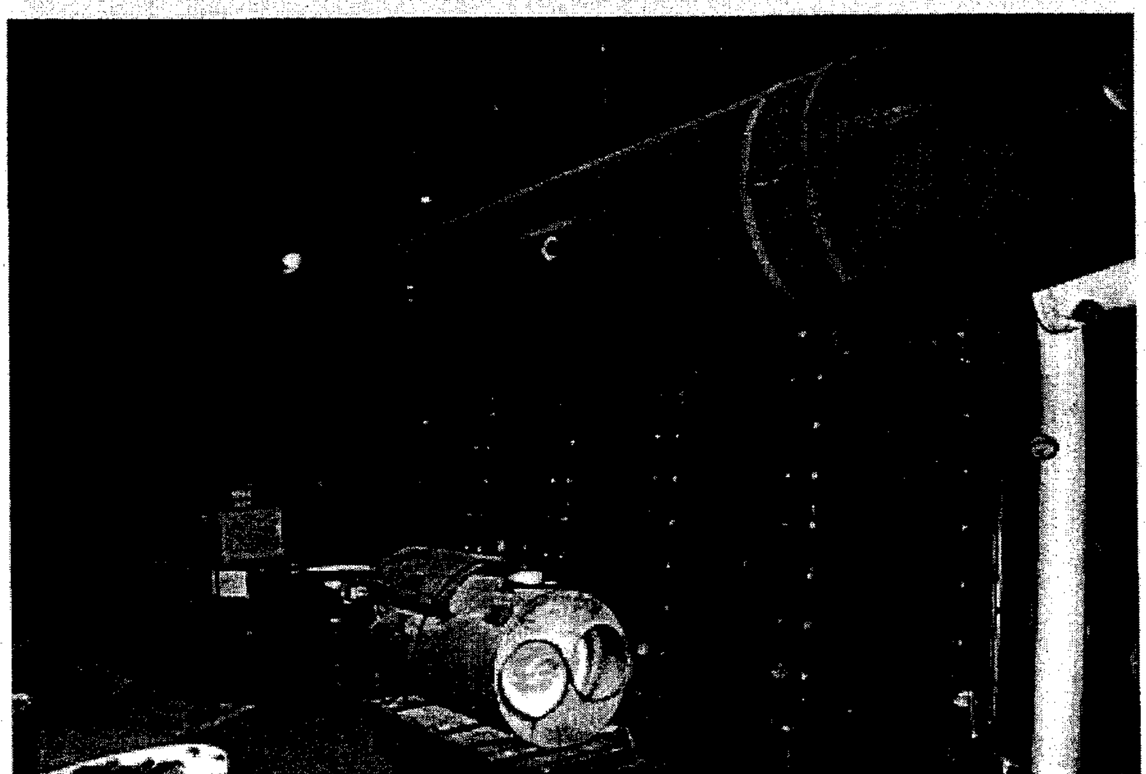


Photo 2 The 2,500 kW St. John's Diesel unit manufactured by Nordberg.

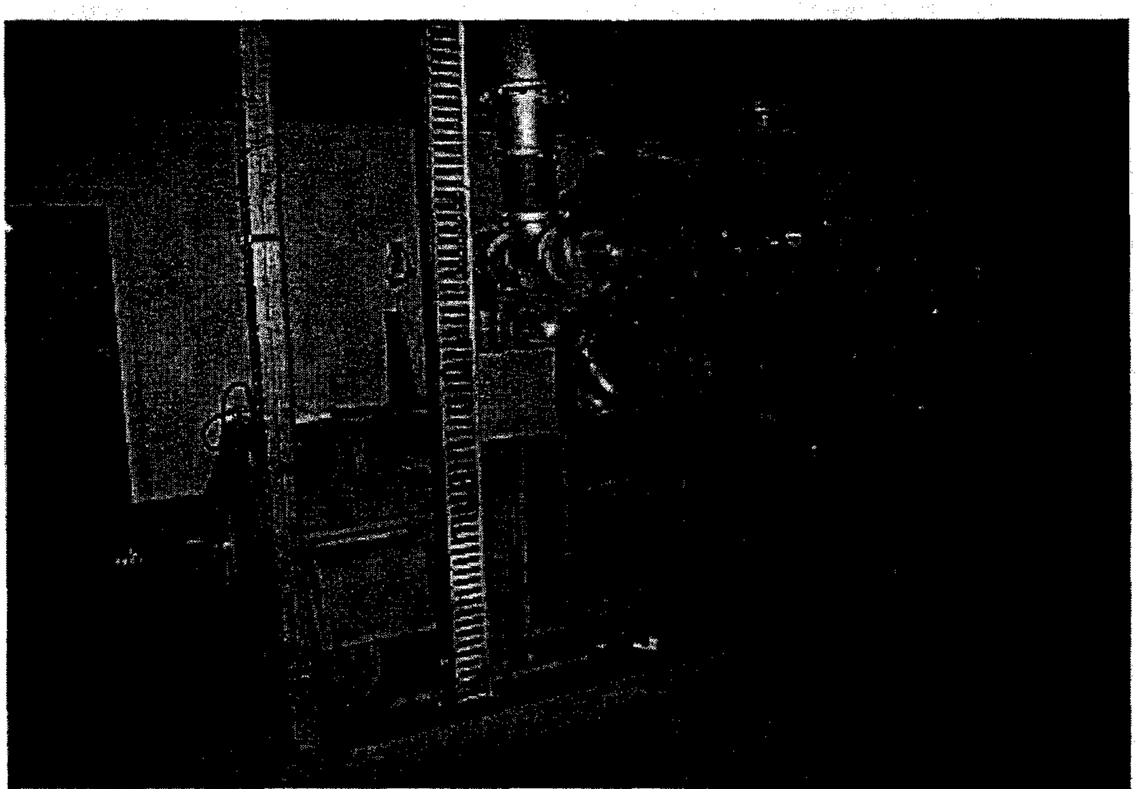


Photo 3 The 500 kW Port Union Diesel unit manufactured by Caterpillar.

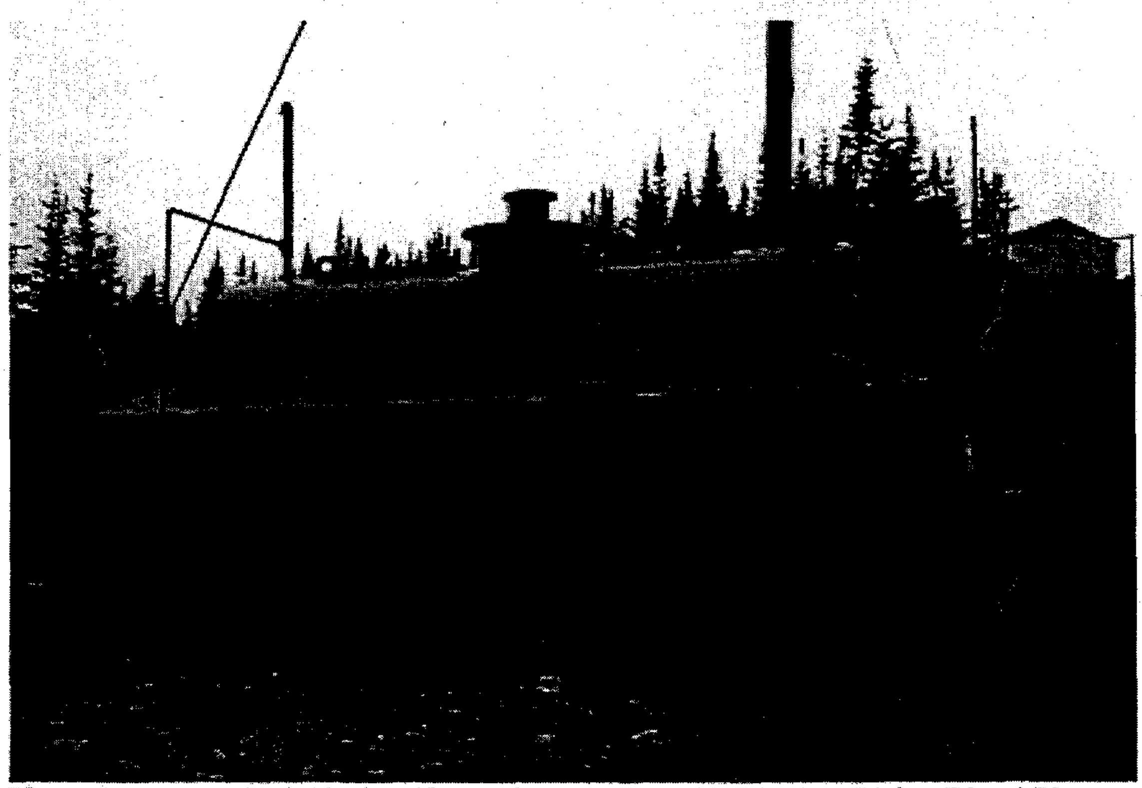


Photo 4 The 9,100 L self-dyked steel fuel tank at the Port Union Diesel Plant.

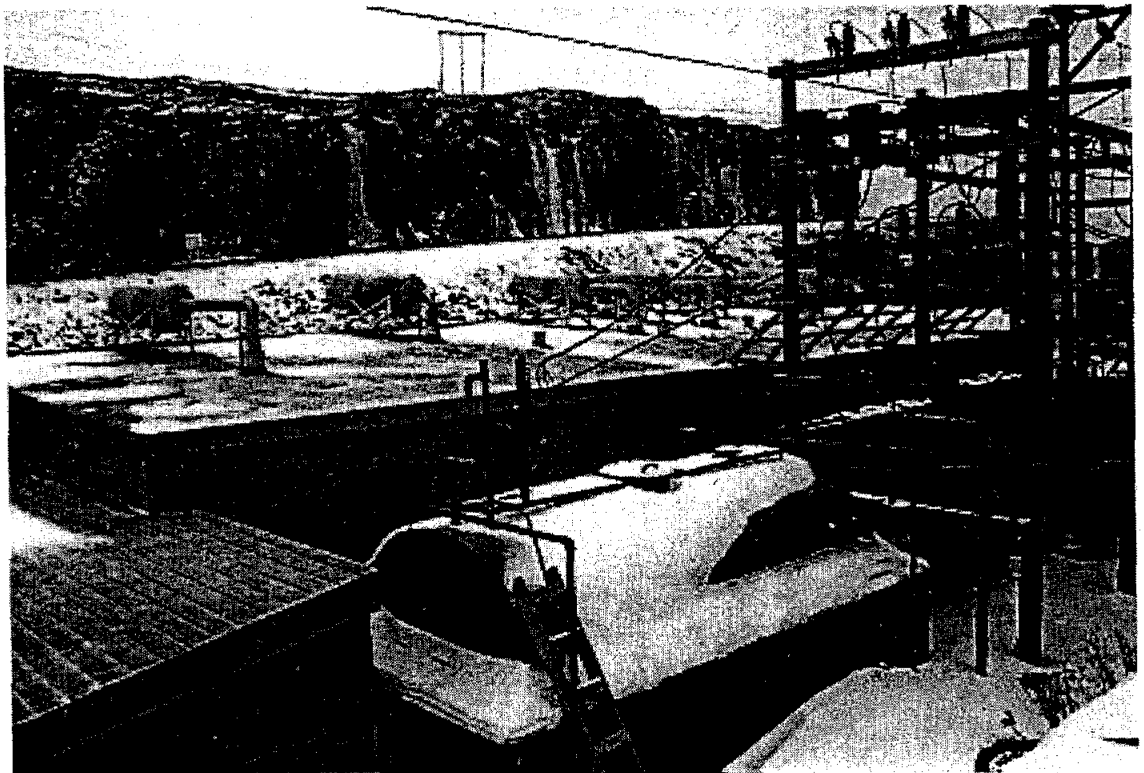


Photo 5 View of the Port aux Basques Main Plant Powerhouse with fuel tank in the foreground.

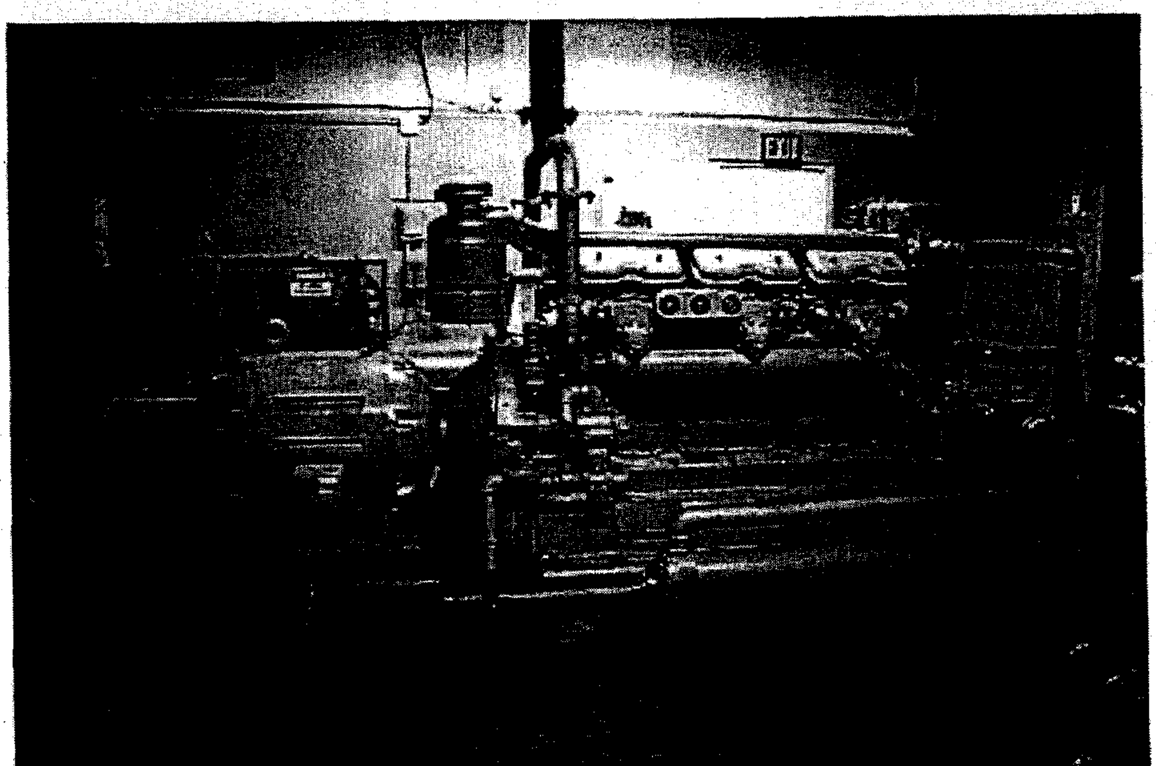


Photo 6 Port aux Basques Main Plant Unit #5 at 250 kW.

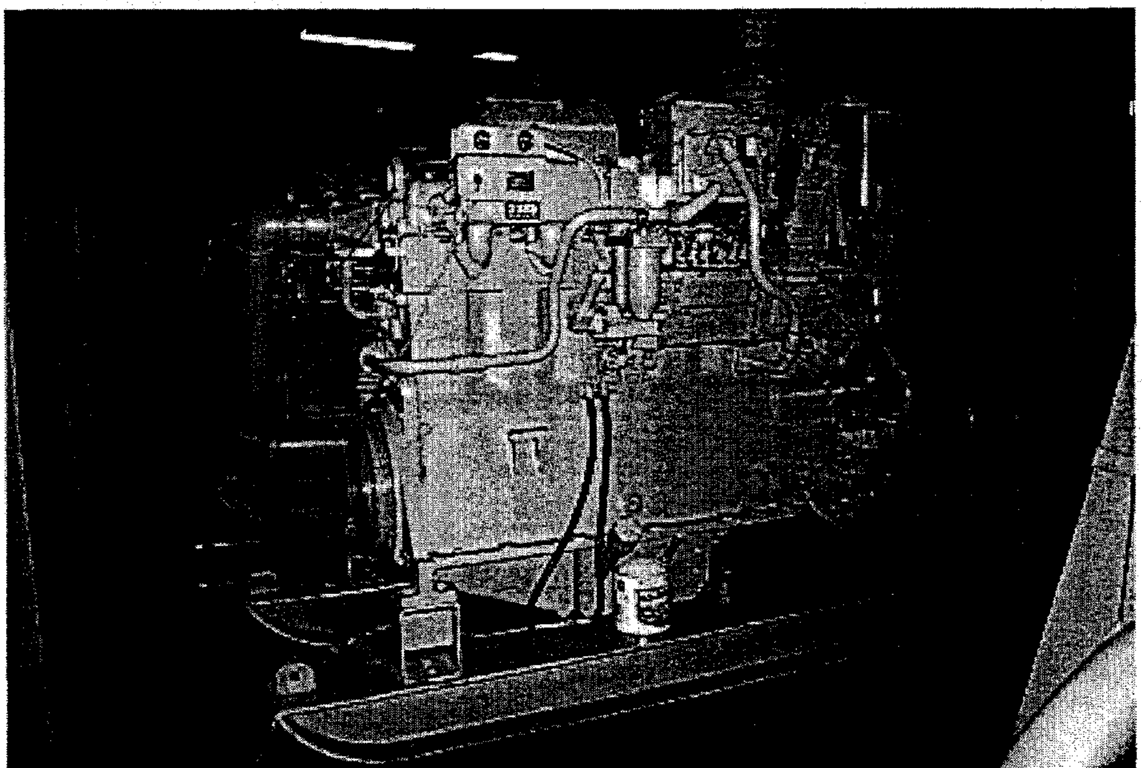


Photo 7 Port aux Basques Main Diesel plant unit manufactured by Caterpillar.

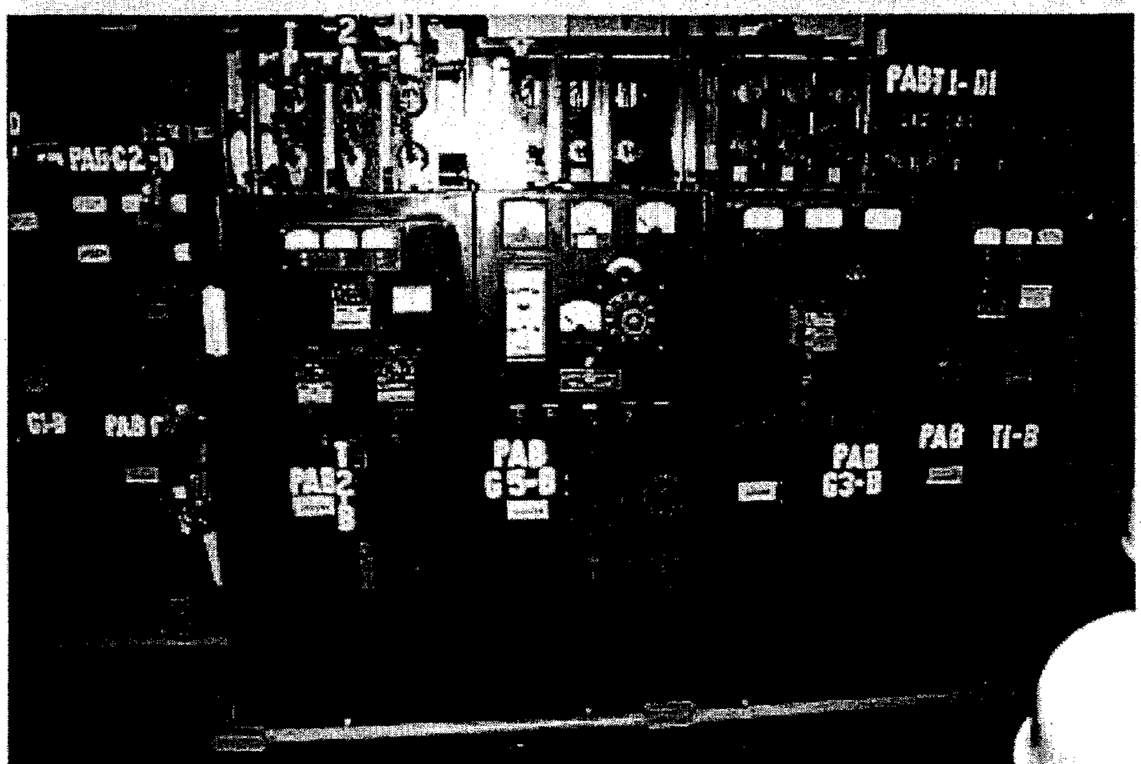


Photo 8 Port aux Basques Main Diesel plant open contact-type switchgear.

Photo 9 The Port aux Basques Unit #10 General Motors EMD Diesel Unit.

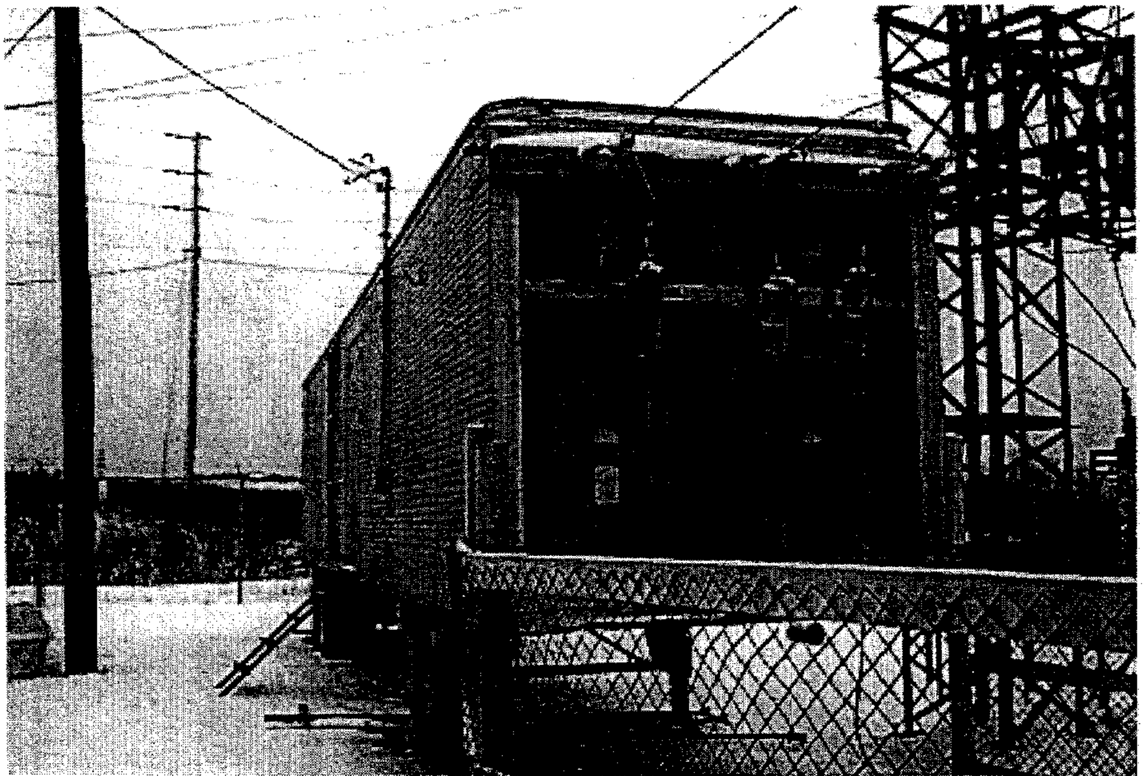


Photo 10 View of Portable Diesel #1 unit with trailer unit and transformers.

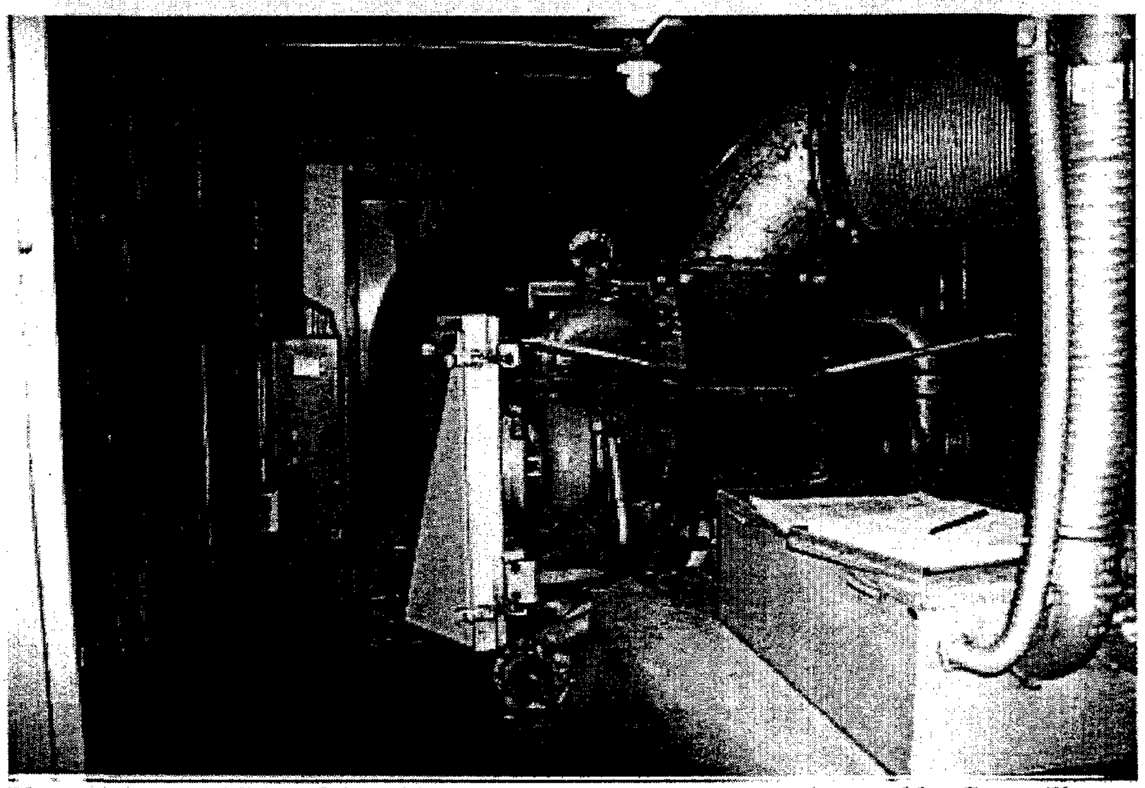


Photo 11 View of the 700 kW Portable Diesel #1 manufactured by Caterpillar.

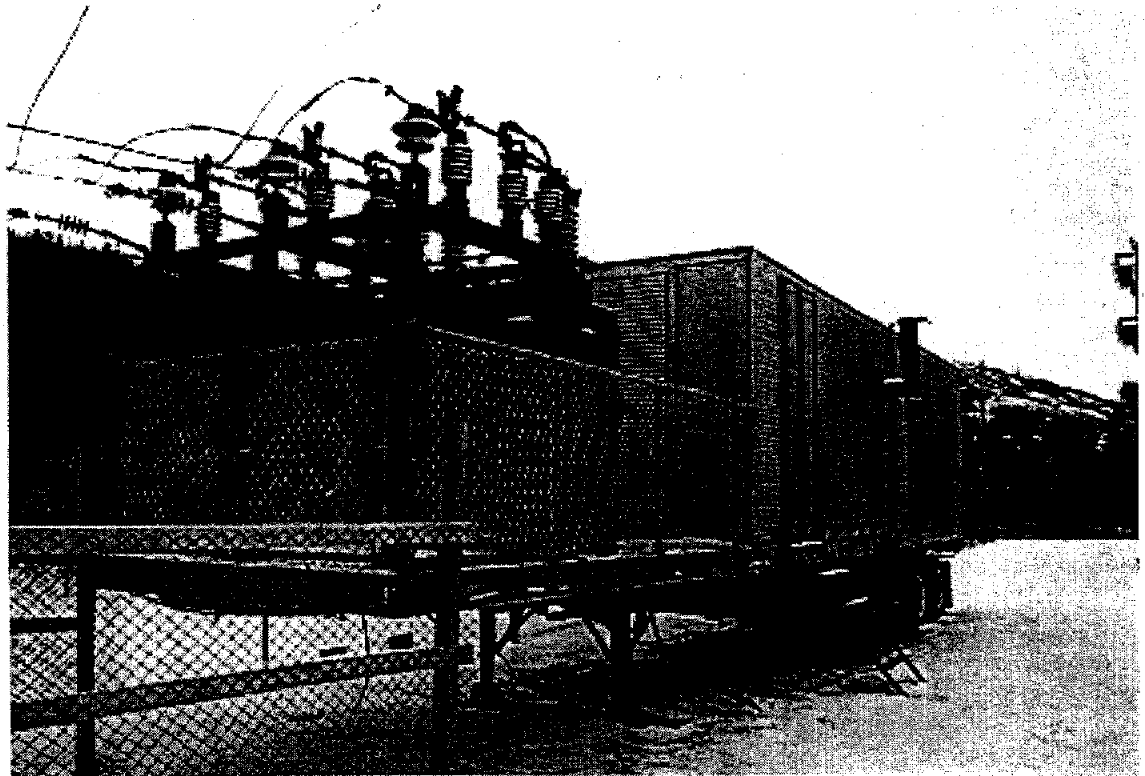


Photo 12 View of Portable Diesel #2 unit with trailer unit and transformer.

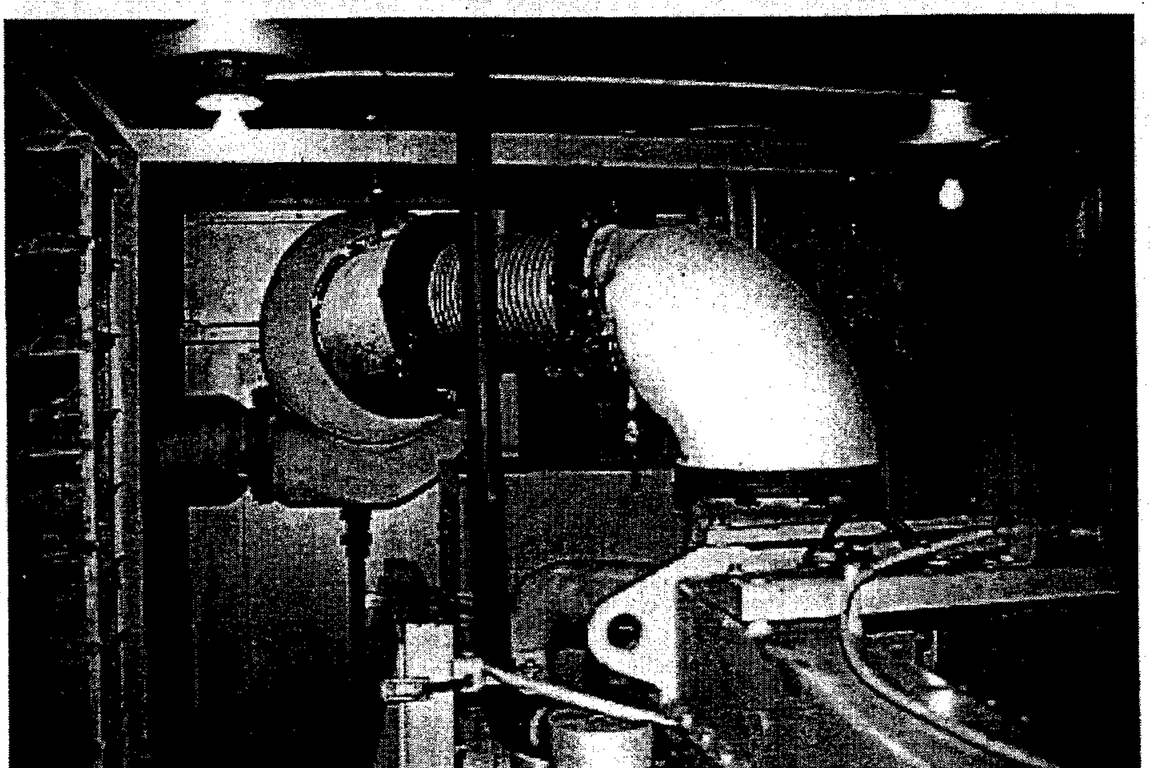


Photo 13 View of the 670 kW Portable Diesel #2 manufactured by Caterpillar.

Appendix E

Supporting Documentation

Budget Pricing Information on Portable Gas Turbine Units

EXPECTED PRICING

Prices of equipment to be offered will vary relative to your requested scope of supply. However, this chart can be used for 'indicative' pricing and generally follows the preceeding pricing information summary sheets and sample 3.6 MVA specification. All prices in U.S. funds, F.O.B. works, GST extra with 42 week delivery A.R.O. basis:

MVA Rating		1.5 MVA	2.5 MVA	3.6 MVA	4.8 MVA
1.1	Base Price	1,600,000	1,890,000	2,100,000	2,450,000
Options					
1.2	Dedicated Truck	199,000	199,000	199,000	199,000
1.3	Auxiliary Trailer	446,000	446,000	446,000	446,000
1.4	Fire System For Auxiliary Trailer	16,800	16,800	16,800	16,800
1.5	Bolt-on Stairs (Unit Price, Ea)	1,315	1,315	1,315	1,315
1.6	Motorized Cable Reel	13,850	13,850	13,850	13,850
1.7	Power Cable	160	160	160	160
1.8	Fuel Supply Hose (Per Meter)	213	213	213	213
1.9	Fuel Tank Containment	7,640	10,780	12,500	16,800
1.10	Spares/Tools	42,000	66,000	90,000	140,000
1.11	Training/Commissioning	11,600	11,600	11,600	11,600

Budget Pricing on Portable Diesel Engines

Pricing

Pricing for various approaches is subject to the specifics requirements of any application and is affected by US Dollar exchange rates. The major equipment components enter Canada duty free from NAFTA plants.

The following table summarises typical costs for various sized 5 kV power plants and technologies:

	3512B	3516B	3516B HD	Mercury 50
Type	Reciprocating	Reciprocating	Reciprocating	Turbine
Rated output	1.36 MW	1.825 MW	2.0 MW	4.0 MW
Emissions (NOx)	5 g/HPh	5 g/HPh	5 g/HPh	25 PPM
Fuel eff. (kWh/litre)	3.8	3.9	4.0	3.8
Basic engine-generator set	$ 320,000	$ 420,000	$ 520,000	$ 2,500,000
Controls and utility grade switchgear	$ 220,000	$ 220,000	$ 220,000	$ 245,000
Enclosure – standard	$ 140,000	$ 180,000	$ 180,000	$ 260,000
Enclosure – 85 dBA	$ 200,000	$ 225,000	$ 238,000	$ 300,000
Enclosure – 72 dBA	$ 260,000	$ 310,000	$ 325,000	$ 315,000
Arctic grade start/operate	$ 35,000	$ 35,000	$ 35,000	$ 230,000
Transport chassis	$ 15,000	$ 15,000	$ 18,000	$ 15,000

Budget Pricing on General Motors EMD Stationary Diesel Units

JULY 27, 1999

NEWFOUNDLAND POWER INC.
REQUEST FOR INFORMATION
PROVISION OF EMERGENCY POWER SYSTEMS

Package Number	Product	Quantity Required	Genset Unit Cost	Genset Total Cost	Switchgear and Controls Unit Cost	Switchgear and Controls Total Cost	Enclosure Unit Cost	Enclosure Total Cost	Transformer Unit Cost (pre-owned)	Transformer Total Cost (pre-owned)	Initial Package Cost	Total kW	$/kW
1	EMD 20-645, pre-owned, standby rated at 3,151 kW, 3,939 kVA	2	980000	1960000	75000	150000	200000	400000	30000	60000			
	Spectrum 1750 DS4, standby rated at 1,750 kW, 2,188 kVA	1	310000	310000	75000	75000	100000	100000	30000	30000			
	Totals			2270000		225000		500000		90000	3085000	8052	383.1
2	EMD 20-710, standby rated at 3,960 kW, 4,950 kVA	2	1600000	3200000	75000	150000	200000	400000	30000	60000	3810000	7920	481.1
3	Spectrum 2000DS4, standby rated at 2,000 kW, 2,500 kVA	4	405000	1620000	75000	300000	100000	400000	30000	120000	2440000	8000	305.0
4	EMD 20-645, pre-owned, standby rated at 3,151 kW, 3,939 kVA	1	960000	960000	75000	75000	200000	200000	30000	30000			
	Spectrum 1500DS4 standby rated at 1500 kw, 1875 kVA	2	375000	750000	75000	150000	100000	200000	30000	60000			
	Spectrum 2000DS4, standby rated at 2000 kw, 2500 kVA	1	405000	405000	75000	75000	100000	100000	30000	30000			
	Totals			2115000		300000		500000		120000	3035000	8151	376.9

Port Union Diesel Inspection – Diesel Injection Inc. 1998

SERVICE REPORT

Newfoundland Power
Port Union Power Plant
12 Cylinder CAT – D398A

August 31 – September 11, 1998

Report Summary

When I arrived on site, I was under the impression that the four cylinder heads were being refitted as routine maintenance. Upon arrival I became aware that there were specific engine symptoms that facilitated the refitting of the heads . The cylinder heads did receive some work. A number of worn valve guides and stems were replaced and a general cleaning was completed. My feeling was that the heads were not the sole reason for the symptoms the engine was exhibiting. Further investigation revealed ***starboard turbocharger problems, cracked pistons, glazed liners and gear train wear.*** At this point in time Kent Nicholson arrived on site and provided a work list to be completed (to assess the extent of the problems) before the cylinder heads were installed. It was also agreed at this time that Diesel Injection Sales & Service Ltd. would not be responsible for engine damage on failure as a result of the above concerns. (Agreement attached). The work dictated in Kent's list (Attached) resulted in extra work not included in our original quotation.

Note: Included is a typed copy of field notes (as requested) which in effect are a detailed log of the work carried out as well as problems encountered in refitting the four cylinder heads on the engine & should be self explanatory.

Constantine's Cylinder Head Reconditioning (Problems Incurred)

1. **Valve Stem Seals** – failure to install. This was an oversight as apparently most CAT cylinder heads do not contain stem seals. This repair was carried out on site at no expense to Newfoundland Power and no time was lost.

2. **Injection Chamber Seals** – Leaking. This would now appear to be result of Constantine's not being aware of a partition between the water channels in the cylinder heads leading them to believe that they had a satisfactory test performed on the heads, when in fact they did not. However, I still do not have a satisfactory explanation as to why my initial instructions on refitting the heads were not carried out. It is sufficient to say that this problem was corrected at their expense and no extra costs were incurred by Newfoundland Power. The end result was that the cylinders were satisfactory.

Difficulty Obtaining CAT Parts – Local Dealer

This is probably best explained as a lack of parts information & listings at this location, possibly as a result of the engines age (33 years). However, it should be noted that once Toromont Cat in Toronto was contacted, the necessary parts were identified and located and the problem was resolved.

Description of Extra Word Required

It should be noted that in addition to the extra work requested prior to installing the heads on the engine, there was also extra work required after 11:00 AM on September 10, 1998. (after heads were installed) At this time the engine was ready to be started up. The problems that surfaced at this time were not related to the cylinder heads and are as follows:

1. Leaking water pipes (2 incidents)
2. Switch gear problems
3. Starting battery problems.

The leaking water pipes led to the engine having to be drained down and refilled twice and resulted in oid residue entering the tailrace and river. The incident was reported by Newfoundland Power staff and a boom was deployed and slight oil residue cleaned up by absorbent mats. In effect it was simply an accident and was totally unpreventable.

Recommendations

As of 12:00 PM September 11, 1998 the engine has been proven operational as far as the cylinder heads are concerned. However the following problems remain to be addressed.

1. **Turbo – Seals Leaking**
2. **Wear in gear train**
3. **Cylinder liner glazing**
4. **Leaking heat exchanger**
5. **Fuel lines in poor condition**
6. **Aged water lines**
7. **Cracked pistons**
8. **Excessive wear / Cold Starting**

A detailed description of problem and solution follows...

1. **Starboard Turbocharger Seals Leaking** – Compressor fan bottoming on backing plate.

   Concerns: - Turbo could fail and seriously damage engine.
   - Possibility of fire from leaking oil.

   Solution: - Refit or replace same

2. **Wear In Auxiliary Gear Train** – lube oil pump

   Concerns: - gear and pump failure, oil pressure loss, damage to engine.

   Solution: - replace defective bearings

3. **Cylinder Liner Glazing**

   Concerns: - piston rings not seating, oil consumption, loss of power & smoke

   Solution: - Replace liners

   - Wear measurement taken by Newfoundland Power staff indicate no noticeable wear. Protrusion measurements (attached) are within specifications. Possibly some consideration should be given to honing (de-glazing) existing liners. To facilitate piston rings and seating, I would recommend carrying out a compression check to determine piston ring condition before considering this option.

4. **Leaking Heat Exchanger**

   Concerns: - Water loss from closed system – engine over heating.

   Solution: - Replace defective parts. Remove and pressure test to determine cause of leaks.

5. Fuel Lines In Poor Condition

Concerns: - Lines leaking – pressurized fuel spraying on hot engine, perils, fire.

Solution: - Replace all lines.

6. Aged And Corroded Water Lines

Concerns: - Coolant loss, engine overheating and damage.

Solution: - Replace all suspect water lines

Note: Consideration should be given to the use of an approved rust inhibitor in the cooling system.

7. Cracked Pistons – Two of four pistons exceed CAT criteria for replacement.

Note: Four pistons have not been inspected (Two heads not removed)

Concerns: - Piston failure resulting in severe engine damage.

Solution:
- Remove remaining two heads, inspect four pistons.
- Replace all pistons exceeding CAT criteria.
- As noted with cylinder liners, consideration should be given to honing and de-glazing liners and replacing all piston rings.

8. Excessive Wear / Cold Starting – Signicant engine wear re engine hours

Concerns: - Wear on internal engine parts due to cold startups.

Solution: - Installation of engine preheat system.

Note: The above recommendations have only been given as a second solution and as cost saving option. It is my firm belief that the engine is in need of a complete rebuilding. That is the only acceptable option if a warranty is to be provided. Also, in any engine valve clearances should be checked after approximately ten hours running under load.

Acre's Diesel Generator Review 1997

Newfoundland Light & Power Co. Limited
St. John's, Newfoundland

Diesel Generator Review

March 1997

ACRES

Acres International Limited
St. John's, Newfoundland

Table of Contents

Executive Summary

The Newfoundland Power generation facilities evaluated in this Diesel Generator Review report consist of eight low-speed and ten high-speed diesels located in various parts of the Province. The purpose of the Review is to assess the general Mechanical and Electrical condition of the units and make recommendations on their maintenance requirements for a further 10 years of operation, and to advise where further operation is not recommended.

The units operate under emergency conditions only, when the power normally purchased from Newfoundland and Labrador Hydro is not available due to transmission line outages caused by ice storms, or by the rare coincidental events of inadequate water to drive hydroelectric generation equipment at the same time as the Holyrood Thermal Plant is unavailable for power generation due to an outage.

The units are mostly old to very old, having been installed over the period from 1945 to 1976, and the historic average annual operating hours over the period 1990 to 1995, varies from a minimum of 0.4 hrs/year at Gander to a maximum of 34.5 hrs/year at Port-aux-Basques.

Older diesel generators were well made, over designed, very rugged, and capable of an almost indefinite life given the appropriate operations and maintenance attention. However, they were designed for continuous base-load operation under constant observation and suffer serious deterioration when sitting idle and unattended.

Despite their ruggedness they are built using older materials and do not have the benefit of modern alloys, construction methods and the use of ceramics, teflon, silicone and other modern materials. Thus they require more frequent maintenance and deteriorate more rapidly than modern standby machines when idle for long periods.

Visits were made to generation sites at St. John's, Salt Pond, Port Union, Gander, Aguathuna and Port-aux-Basques. At each site the inspections included an overall assessment of the site, structures, auxiliary equipment, a survey of the engines, and operational tests. Detailed inspections of the machine internals were not carried out, and prior to maintenance of any units this would be necessary to establish their precise condition and replacement parts requirements. Safety concerns were addressed and photographs taken to better illustrate this report. Recommendations were developed on the basis of the inspections and tests, and confirmed after subsequent evaluation of parts availability and probable cost of rehabilitation.

Following the site visits, investigations were made into the availability and costs of spare parts for the engines, and it was found that in a number of cases parts were available, and in others they were not.

The recommendations are as follows

St. John's

The unit should be given a detailed inspection to verify that the favorable condition apparent during the inspection and test run is correct and confirm that there are no hidden defects. Given a favorable result, the general plant improvements outlined in the site inspection report may be carried out, assuming the City of St. John's would benefit from the availability of 2,500 kW emergency power. Alternatively the plant should be decommissioned.

Salt Pond

These units are the oldest in the system and have numerous problems associated with equipment condition and safety considerations. They have a utilization of only 2.7 hrs/year, and parts for these 1940s vintage engines are expensive and on long delivery, providing they are available at all. Given these circumstances it is recommended that the Worthington Units be decommissioned.

Port Union

This unit is in good condition and it is recommended that minor repair mainly in instrumentation work be carried out and the unit remain in service.

Gander

These units are estimated to have run for about 100,000 hrs when they operated continuously from 1949 to 1969. The present average annual use is only 0.4 hrs, the lowest of all the plants inspected. Although parts availability has been established, a substantial investment is required to make the plant safe and operable for a further 10 years. It is therefore recommended that the plant be decommissioned.

Aguathuna

The single unit at Aguathuna was built by a manufacturer no longer making engines, and no source of parts has been identified. It is possible some parts could be made by a specialist manufacturer, but these would be expensive. The machine shows substantial wear and important safety devices are non-functional. Bearing in mind the extensive costs that would be involved in rehabilitating this unit, and the health and safety aspects identified, it is recommended that the unit be decommissioned.

Port-aux-Basques

Unit No. 10 was manufactured and engineered with standby duty in mind and has performed satisfactorily and economically during the last 28 years. The enclosure has corroded at the radiator end and there is insufficient space around the engine for maintenance, therefore moving this unit into the adjacent power plant is to be recommended.

The six Caterpillar units operated fairly well, but the speed adjustment problem and associated switchgear deficiencies, also safety concerns, indicate that retirement or relocation of the better ones to a site requiring fewer units would be the best options. If this recommendation produces a shortage of emergency power at this location a second E.M.D. unit should be considered.

The portable units at Port-aux-Basques should undergo maintenance on the engine instrumentation, and control panel instrument calibration should also be performed. Unit 2 trailer should be refurbished, if future portability is required. Following this work the units can remain in service.

In addition to determining parts costs and availability, an estimate was developed to show that the labor costs for a typical six cylinder engine overhaul would be of the order of $100,000. Alternative means of replacement generation capacity were outlined, and costs shown for medium- and high-speed diesel generation equipment. A 2,500 kW medium speed unit can be purchased new for about $520/kW, a smaller high speed unit for $250/kW. In larger unit sizes gas turbines could be more competitive.

1 Introduction

In response to the Newfoundland Light and Power Co. Limited (Newfoundland Power) request for proposal dated December 16, 1996, to carry out a Diesel Generator Review, Acres International Limited, in association with D.G. Champion Engineering Limited, submitted a successful proposal for the work. This report describes the implementation of this Review and the recommendations forthcoming from it.

Newfoundland Power has a mixture of thermal power generation plant made up of different types and a variety of sizes, all of which are used for emergency power generation or as reserve capacity for power generated by Newfoundland and Labrador Hydro and purchased by Newfoundland Power.

This situation has existed for some 30 years and the thermal plants have only been required to operate on relatively few occasion, particularly in recent years. The need to operate the plants comes about when there are transmission line outages due to ice storms or on the rare occasions when there is a shortage of water to operate hydroelectric stations and this coincides with the forced outage of the Holyrood Thermal Plant.

While the thermal plants include gas turbines and diesels, the larger number are diesel engine powered, either slow speed or high speed.

The purpose of the review forming this report is to assess the general mechanical and electrical condition of the diesel generator units, which are installed at six different sites and consist of eight low-speed diesels and ten high-speed diesels which were installed between 1945 and 1976.

The prime objective of the review is to provide adequate information to Newfoundland Power (NP) management to assist in deciding if the existing diesel generation units should be refurbished to enable at least 10 more years of operation, or if they should be decommissioned and/or replaced.

The installed capacity is approximately 14 MW, but due to the low utilization of the units, the average annual generation has only been approximately 200,000 kWh. This is equivalent to 14 hours of operation per year based on the installed capacity, and although some units operate fewer hours and others more, none of the units typically operate for more than 40 hours per year.

Because of this low utilization and many hours standing idle mostly unattended, it is to be expected that the units would have deteriorated to a greater extent than their accumulated operating hours might suggest.

2 Review Approach

The review was carried out in essentially three stages, commencing with an initial review of available data on the units and preparation of spreadsheets for assembling data prior to, during, and subsequent to, site inspections.

Following the data assembly stage, visits were made to all of the sites where the facilities and equipment were inspected and the generating units given a test run.

The final phase of the work was to evaluate the findings of the site visits and to examine the feasibility and related costs, including input from suppliers, with a view to determining the availability of parts and the overall economics of carrying out what is, in effect, a 10-year life extension of the diesel generator units.

The first step was to review the following Newfoundland Power reports:

Thermal Power Plant Inspection Report dated July, 1991

and

Diesel Power Plant Review dated June, 1996

From these reports, enough basic data on the diesel generators was available to provide a preliminary input to the preparation of information spreadsheets. Spreadsheets were then developed for each category of data as follows:

- General Information
- Historical Data
- Mechanical Data
- Electrical Data
- Engine Test Data.

The spreadsheets became the main information gathering tool used during the site inspections and tests, and were updated each day on a portable computer.

The data gathered can be seen on the completed spreadsheets which form Appendix 'A' to the report.

The site inspections and tests were carried out during the period February 4 to February 12, 1997 and the inspection team consisted of a Diesel Specialist and a Mechanical Engineer from the Acres St. John's, Newfoundland office, who were accompanied by Newfoundland Power's Supervisor of Mechanical Maintenance.

Details of the site inspections and tests are provided in Section 3 of the report, and color photographs taken of plant buildings and equipment at each site during the visit are included in Appendix 'B' of the report.

The inspections consisted of examinations of the externals of the buildings, diesel generator units and auxiliaries, and where practical internal inspections of the diesels with measurements of crankshaft deflections being taken by dial indicator to establish whether foundations had settled. In addition, the general cleanliness of the engine internals were noted and any points of apparent wear of components were recorded as and when seen.

Most of the units were subsequently given a test run to identify any signs of distress or malfunction which might occur. During each test, various readings of temperatures, pressures, power output, etc., were recorded for comparison with normal operating parameters at loaded conditions.

In addition to the inspections and tests, brief reviews of available operating records were made. Discussions were had with operations and maintenance (O&M) personnel to identify the approach to O&M activities and to confirm any concerns which might exist over the general condition of the machines, operational problems and maintenance programs, etc.

Finally, a list of available spare parts was identified at each site. Appendix 'C' lists the spare components which were held in stock.

The remaining step was to confirm availability and typical costs for replacement parts for each machine where possible. Various suppliers and agents were contacted with a view to determine whether Original Equipment Manufacturer (OEM) or parts of other makers were available, and at what cost. Section 4 of the report discusses this topic and responses from various suppliers are shown in Appendix 'D'.

Section 5 of the report provides options and related capital costs for replacing lost capacity due to decommissioning of existing generation capacity.

3 Plant Inspection Reports

The examinations and tests carried out at each site are discussed below. Each site is dealt with as a subsection, written in the order in which the sites were visited. The arrangement of site photographs in Appendix 'B' follow the same sequence.

Each subsection covers, for each site, the following major topics:

- Plant History
- Plant Description and Survey
- Engine Survey
- Unit Operational Test
- Safety Considerations
- Summary
- Recommendations.

3.1 St. John's

Plant History

The plant was built in 1953 comprising a single Nordberg diesel generator. The 3,580 HP engine is of the two-cycle principle arranged with eight cylinders in-line to operate at 225 rpm. The General Electric alternator is direct connected, stator shift with V-belt driven floor mounted exciter outside of the generator single pedestal bearing. The generator is rated 2,500 kW, 6,600 volts, 0.8 power factor. The unit has operated practically maintenance free during its life time necessitating the replacement of an air start valve in 1994 and a complete oil change in 1990.

The installation's primary function was to provide black start capability to the nearby Southside Steam Plant and power to the grid when needed. The unit had operated a total of 2,425 hours without experiencing any significant failure. From 1991 to 1995 the plant generated approximately 75,000 kWh with an estimated additional operating period of approximately 38 hours. Routine operational checks have been carried out with monthly runs at no load and loaded operations quarterly. When operated on February 4, 1997, the unit ran very smoothly accepting full load after warmup and carried full load with all operating pressures and temperatures within acceptable limits, negligible vibration and a clear exhaust.

Plant Description and Survey

The plant is located on the south side of St. John's harbor on the side of the hill above the Southside Road. The foundations are securely tied to bed rock. The building has asbestos siding which is in good condition. The plant has poor interior lighting. The space around the engine is used as storage for old equipment (i.e., wind turbine, etc.). Some minor water leakage through the foundation from the surrounding hill was reported. The engine air intake is built into the foundation of the building with wooden shutters to close the intake when the engine is not in use. An electric forced air heater has been installed in the air passage to preheat the air, thereby avoiding condensation within the engine cylinders and on other engine parts due to direct connection with the outdoor changeable atmospheric conditions. Aspiration air passage to the engine is clean and dry. Heat exchangers for the engine cooling system are supplied with city water. The air compressor and receivers are in good working order, requiring inspection by the Department of Labor annually and certified within the last twelve months.

The fuel system consists of a main outdoor storage tank at the rear of the building and a 200 gallon day tank in the building located below the engine. The main fuel tank is of riveted construction. The fuel level is kept below the half full mark as the upper section is dented. The tank is located in a concrete dyke which appears in good condition. The tank fill line from the Irving dock has been disconnected and deliveries are now made by truck with the hose being dragged around the building and up to the top of the tank where filling is performed through the manhole. This would appear to be a difficult and dangerous task particularly in the winter when the tank and surrounding area is iced covered. The day tank is not fitted with a high level alarm and safety cut-off to shut down the pump when full, and this has resulted in minor spills when the operator has been distracted while filling the tank. Also, there was a recent failure of the tank gauge which resulted in a minor spill of diesel fuel within the building.

The battery pack and charger for switchgear operations requires replacement. Switchgear is open contact type, old and dangerous to operate. There are no markings to tell its age but is estimated to be of 1950's vintage or earlier. The transformer is also of the same vintage as the switchgear and is located in the building. Instrumentation is obsolete, rendering safety alarm and shutdown devices unreliable.

Engine Survey

Crankshaft deflections were taken with a maximum deflection reading of 7/1,000 inches indicating that the outboard pedestal bearing requires adjustment and the generator air gap should be checked at the same time. Internals of the crankcase were found to be very clean in every respect indicating the absence of piston blow-by. The foundations and grouting around the engine display minor surface decay which requires scraping and painting only. The engine itself is very clean relative to age with some minor surface rusting, otherwise the engine appears to be very sound.

The air compressor was operated without difficulty and modulated as required. The main electric motor driven auxiliary lubricating oil pump was operated satisfactorily and the oil inside the engine flowed freely and was clean. The engine barred over freely. The main engine glycol cooling water system circulating pumps were put into operation without difficulty.

Unit Operational Test

The engine test data sheet was completed.

The engine started without hesitation and was allowed to warm up gradually and put on light load with gradual increases to 2,400 kW. The unit carried full load satisfactorily for the duration of the test. Performance was very smooth and relatively quiet, all temperatures and pressures were within normal operating range and the exhaust gas was completely clear. The test may be considered successful.

Safety Considerations

The method of filling the fuel tank is a potentially dangerous operation due to the length of hose and the requirement of filling through the top manhole. The age of the tank and suspected pin holes would warrant its replacement at the earliest opportunity considering its location, near the harbor, and the recent problems experienced by other tank owners in the area as well as the strong public concern regarding fuel storage in the area. The plant is considered somewhat unsafe to operators due to poor lighting, the operating floor generally littered with stored equipment and the potential hazard of the fuel system during normal power plant operations.

Summary

The test was carried out without difficulty and the engine, generator and auxiliary items performed well. All necessary improvements are of a minor nature and there appears to be no reason to question the ability of this plant to continue Standby service indefinitely, given a higher level of attention to mitigate against the natural decline associated with idle machinery of this type.

Recommendations

It is recommended that the engine and all related equipment undergo a more detailed inspection to confirm that the February 4, 1997 brief inspection and short run did not miss any serious defect. If this confirms there are no major problems, general plant improvements, as described above, should be carried out. The main improvement would be to rehabilitate all instrumentation and fit new reliable alarm and shut-down protection devices, and replaee the fuel tank.

3.2 Salt Pond

Plant History

The plant was built in 1963 accommodating three diesel generators acquired from Fort Pepperrell. The Units were operated at Fort Pepperrell from 1941 to 1963 and accumulated between 15,000 and 17,000 operating hours. The engines are of Worthington, Buffalo, New York manufacture with six cylinders, vertically in-line, having an operational speed of 327 rpm and producing 670 HP each. The engines are four cycle, normally aspirated and are the largest units in the system calculated on the basis of output per unit of space occupied, delivering only 165 Watts/cubic foot rendering them the most costly in terms of building space, heating and associated maintenance factors. Worthington Corporation abandoned engine production in the 1960s. The Electric Machinery alternators are directly connected to the engine and have a directly connected exciter. The generators are rated at 500 kW, 4,160 volts, 0.8 power factor.

Some 26 years ago, Unit No. 1 suffered damage to a large end bearing which badly scored a crankshaft journal from which time operation has continued with that piston and connecting rod removed from the engine. The original seawater cooling system utilizing heat exchangers was discarded several years ago and replaced with direct town water cooling operated manually. In recent years, the plant has been on a standby basis only. The units are started monthly and only synchronized for operation on-load quarterly.

Plant Description and Survey

The plant is located on level ground near the ocean in Salt Pond, Burin. The building is of structural steel construction with metal siding, well insulated and with good lighting. Interior and exterior are tidy and well kept. A 2,000 lb wire rope electric winch, 1 ton endless chain with manually operated traveling beam is located within the building. No "load-rating" markings were indicated on the crane beam. The building is used as a transformer storage and repair facility with the area around Unit No. 1 congested with equipment.

The fuel system consists of two main tanks in a concrete dyke outside the building. Only one tank is now in use as the second tank was disconnected and used for storage of used transformer oil until a new steel self-dyked tank was installed. The tank is presently empty. The tanks are surrounded by a concrete dyke which is in good condition and leaks have not been reported. The operator indicated that the dyke drain valve had not been closing properly and water was freely draining from the dyke. This has since been corrected by modifying the valve handle to permit the valve to be more tightly closed.

Each engine has an elevated 300 gallon fuel day tank located above the engine. Uninsulated exhaust pipes run within 6 inches of each of these fuel tanks. There are no high level alarm or shut-off devices on the tanks and one is stained from over filling, diesel fuel having run down the tank and over the instrument panel directly below. The tanks vent inside the building with overflow piping directed into trenches in the floor below.

The multiple floor trenches contain pools of oil and the electrical cables, pipes, etc. within the trenches are soaked with oil. There is a strong smell of fumes in the building, from the transformers under repair in the area next to Unit No. 1, also from the fuel oil day tank vents and from the trenches.

Engine exhausts and air intakes are in good condition but the outdoor piping and silencers require painting. The air compressors and air receivers are in good condition. Building foundations are in generally good condition but leak during heavy rain and spring run-off periods. Water occasionally has to be pumped from the generator pits and floor trenches.

Engine Survey

Unit No. 1 Crankshaft deflections recommended by the manufacturer for these engines should not exceed 1.5/1,000 inches and the maximum reading for this Unit was 3/1,000 inches indicating a slight shimming of the outboard pedestal bearing is necessary. The engine barred over freely. Crankcase and internal motion parts were clean; however, there was evidence of oil/water emulsion in the lubricating oil system. The modified cooling system was traced and found to be contrary to manufacturer's recommendations regarding temperature differential from water inlet to the cylinder jackets and water outlet from the cylinder heads.

Unit No. 2 The maximum crankshaft deflection was measured at 4/1,000 inches indicating a slight shimming of the outboard pedestal is necessary. Evidence of excessive cooling water leaks around the engine blocks and cylinder heads was observed (see Photograph No. 10 in Appendix B). Other remarks are as for Unit No. 1.

Unit No. 3 Attention was drawn to the missing piston and connecting rod from Cylinder No. 5. The oil retaining clamp at the crankshaft journal was removed and the journal inspected. Surface damage is judged to be too serious for operation but no major gouging or depth penetration has taken place and there was no evidence of high temperature with resultant surface cracking. It is judged that the journal could be reground. In-situ crankshaft grinding could be performed, which is available from several countries outside Canada.

Operation of this unit with a missing piston has been successful in the past with an absence of vibration, but concern has to be expressed over crankshaft torsional oscillations, which would be created by the absence of one piston and connecting rod.

Unit Operational Tests

The test sheet data was collected for each engine.

Unit No. 1 Difficulty was experienced in the air start system and the main pilot operated air-start valve had to be opened up and freed before a start was possible. After a warm up period, a 500 kW load was carried for 1 hour. However, difficulty was experienced recording the operating parameters because most of the instrumentation was broken or inaccurate. Safety shut down and alarm devices were not functional.

A serious problem was noted relative to the modified engine cooling system which is a manually operated once-through town water supply without proper temperature regulation compared with what was provided with the original closed circuit installation. This results in extremely cold water entering the lower part of the water jackets which is not recommended. Worthington recommend a temperature differential of water entering the jacket to leaving the cylinder head of not more than 30°F. Observation of the test sheet shows that this differential varied considerably due to periodic manual control and very cold town water. As much as 100°F differential was observed indicating severe thermal stresses would be occurring in the engine block, cylinder liners and cylinder heads. The excessive water temperature rise has resulted in numerous water leaks at those parts of the engine, and created a potential for engine block and cylinder head cracking.

Exhaust gas fumes emanated from the cylinder covers and inspection of that area indicated blow-by at the exhaust valve guides as well as from some exhaust manifold gaskets. In other respects, the 500 kW load was carried without black smoke at the exhaust pipe or excessive vibration throughout the unit.

Unit No. 2 The unit started on the first attempt and performed similarly to Unit No. 1 with greater quantities of water leaking from the upper block area.

Unit No. 3 The unit was not run on judgement that the absent piston would seriously alter the torsional oscillation characteristics of the system with the possibility of excessive oscillations at Cylinder No. 5. With this the possibility of crankshaft failure sooner or later could be expected, and there was no reason, on the day, to expose personnel to unnecessary danger.

Safety Considerations

The plant appears to be violating several fundamental aspects of personnel safety particularly fire hazard. The 34 years of lubricating oil and fuel oil seepage and spillage and dripping into the trenches has left deposits that are extremely difficult to remove but present a serious fire hazard. A variety of cleaning methods might be considered but the mix of piping and electrical cable make most methods impractical or excessively costly. Other plants suffering this difficulty have installed fire suppression systems within the trenches which trigger automatically and require swift personnel evacuation. Exacerbating the situation are the three fuel oil day tanks which vent within the building and allow overflow into the trenches, with evidence of previous spillages, as shown by Photographs 7 and 8 in Appendix 'B'. The combined danger arising from the trenches and fuel oil system raises serious safety concerns.

Summary

These engines have operated beyond the usual manufacturer's recommended major overhaul period, but historical records do not identify major overhaul or minor overhauls having taken place, other than repairs as necessary. Therefore, to continue operating Units No. 1 and 2 would involve a major expense. The cooling system is not suitable for the service intended and these heavy robust engines are particularly vulnerable to thermal stress. A second problem with direct flow-through cooling is the accumulation of deposits on the internal surfaces of the engine, oil cooler and pipework, etc., which rapidly lowers efficiency of the cooling system.

Major expense would be required to rehabilitate Unit No. 3. The inability to start Unit No. 1 without spending 15 to 20 minutes freeing up corroded parts illustrated that the basic design of these older slow speed, heavy duty diesels does not lend itself to sitting idle in readiness for an occasional start as is required in their present day Standby mode.

Plant rehabilitation would include at least the following:

- major overhaul of all three units
- new glycol secondary cooling system
- fire suppression in trenches
- new fuel day tank ventilation and overflow piping, etc.

The Salt Pond plant represents the poorest utilization of space relative to the available power (Watts/cubic ft) and includes the oldest engines in the system dating back nearly 60 years.

Recommendations

In order to rectify equipment related problems, overhaul the engines and address safety concerns, a considerable expenditure would be required. The units would still remain the oldest in the system and they are relatively inefficient compared with the other sites. They also have the low average utilization factor of 2.7 hrs/year. Given these circumstances, it is recommended that the Salt Pond plant be decommissioned.

3.3 Port Union

Plant History
The diesel generator located in the Port Union hydro plant was installed in 1962. It is an electric start Caterpillar Model D398A, four cycle, turbocharged engine capable of 750 HP at 1,200 rpm. The GE alternator is direct connected but without a common underbase and is rated for 500 kW, 2,400 volts, 0.8 power factor. The generator is used for emergency service in the event of transmission line failure. From 1991 to 1995, the unit produced 22,730 kWh for an estimated operating period of 45 hours. No information on maintenance or the total running hours was available. Routine operational checks have been carried out with monthly runs at no load and loaded operations quarterly.

Plant Description and Survey
The generator is located in the Port Union Hydro Plant. The building has concrete walls and a wooden roof. It is in good condition, the facility was clean, tidy and well maintained. A high build-up of paint on the floor makes it slippery when wet. There is no craneage available to facilitate repairs. No leaks or foundation problems were reported or noted.

The diesel fuel system consists of a steel self-dyked tank outside the building, installed in 1993. The engine muffler was rusty externally, but appeared to reduce sound level satisfactorily when the unit ran. Engine aspiration air is drawn from within the building and the exhaust insulation is in good repair. Engine cooling is accomplished by heat exchanger utilizing river water. The engine had been recently painted.

Unit Operational Test
The engine started on the first attempt, assisted with a spray of ether which is common practice with Caterpillar engines. Following a brief warm-up, the engine was put on full load and ran smoothly for the 1 hour test. Engine instrumentation is limited but all gauges read in the normal range. Engine exhaust was clear. The test may be considered a success.

Summary
The test was carried out successfully and the engine generator performed well. No improvements are necessary with the exception of painting the exterior portion of the exhaust. Parts for this unit are readily available and based on its performance can be expected to provide many more years of reliable service.

Recommendation
The unit should be kept in service and minor repair work carried out.

3.4 Gander Plant

Plant History
The plant was built for the federal government in 1949 and was run continuously until 1969. It is in a very spacious building and is well laid out to accommodate the three units. The building is of concrete wall construction with flat roof and generous headroom. The units are self supporting with fuel supply onsite. Units are cooled using evaporative type coolers with equipment mounted indoors. Switchgear is open-face construction of 1940s vintage, transformers are located outdoors. The main fuel tank is located behind the building and is enclosed in a steel dyke and elevated above the ground. Control room, store rooms and toilet facilities are included in the building.

The engines are two cycle type with 'dry sump', whereby, the lubricating oil is stored in a rectangular steel tank situated several feet below grade. The engines are Swedish made and are extremely robust for base-load continuous power generation and might originally have been expected to last many years, rendering reliable performance. The Nohab-Polar engines have seven cylinders, in-line, rated for 1,470 HP at 300 rpm with direct connected CGE alternators rated at 1,000 kW, 2,300 volts, 0.8 power factor, stator shift and belt driven exciters.

The plant was built to a high standard, being laid out in a very spacious manner with massive concrete foundations, high head room and overhead travelling crane. Good artificial lighting is supplemented by large windows in the upper portion of the walls.

During the life of the plant, the individual units have operated an average of 15 years and assuming an annual operating duty between 6,000 and 7,000 hours it may be estimated that the accumulated operating life for each unit is in the order of 100,000 hours. From 1966 to 1996 the plant has served as standby service operating 1 to 2 hours per month for another 700 or 800 hours per unit.

Plant Description and Survey
Exterior of the building is showing signs of wear, the concrete walls have minor cracks and the concrete facing is spalling, the woodwork requires painting. There is continuous water seepage into the engine pits. Fluid from the pits leaks into the

surrounding land resulting a continual seep of oil which is collected with absorbent. The interior of the building is tidy and well maintained. The overhead crane is not serviceable because the wire rope requires replacing and the chain falls are deemed to be unsafe. The fuel is stored in a steel tank with steel dyke similar to a steel self-dyked tank. The tank was originally of riveted construction and has since had the rivets removed and the joints welded. It is in good condition. Three 2,000 liter day tanks are located within the building, one for each engine. Exhaust stacks are in good condition but the Unit No. 2 stack is stained black externally with oil carried over from the engine. Air receivers have been reconditioned, ultrasonic testing was performed and steel liners installed in the pits to prevent contact with ground water which has been a problem in the past. Air compressors functioned properly. The switchgear is old but functional, there is a new battery pack, and one voltmeter does not function. No problems were experienced when the plant was put on line. Air intakes have viscous oil filters located inside the building and are in good condition. The evaporative coolers are a type which require a high level of maintenance. Each engine is cooled with glycol in a closed circuit. There is a continuously operated lubricating oil heating and circulating system, as shown in Photograph No. 27. Warm lubricating oil is circulated through the engine utilizing a 1.5 HP motor and two 6 kW emersion heaters keeping the engine reasonably warm and ready for starting.

Engine Survey

Unit No. 1 Crankshaft deflections of 2/1,000 inches indicate that the generator outboard bearing pedestal requires minor adjustment. The engine barred over freely. The engine and generator foundations showed no cracking other than superficial. Instrumentation, pressure gauges and thermometers were either lacking or unreliable. Safety alarm and shutdown devices for high operating water temperature and low lubricating pressure, etc. were either not fitted or non-operational.

Unit No. 2 Crankshaft deflections indicated that the generator outboard pedestal required adjustment due to a 5/1,000 inch deflection. The engine barred over freely and other comments are as for Unit No. 1.

Unit No. 3 Crankshaft deflections indicate a serious problem because of a 10/1,000 inch deflection which was consistent with the severe cracking present in the foundations at the generator end, see Photograph No. 26. The engine was very hard barring over and while barring over a nasty knock was evident in the scavenge blower drive mechanism. Instrumentation and safety devices are as for Unit No. 1.

Unit Operational Tests

The Test Sheet operating data was collected for each engine.

Unit No. 1 — Repeated attempts were unsuccessful in getting the engine to start and it was diagnosed that either an air start valve or an air start pilot valve was sticking which caused a drain down of the 600 psig starting air receiver. After repeated attempts the test had to be canceled.

Unit No. 2 — Unit started on the first attempt and was allowed to idle for a 20 minute warm-up period. During the starting cycle, several cylinder relief cocks lifted making an alarmingly loud noise. This was due to over fueling on several cylinders and is not deemed to be a serious defect. Operators had no difficulty synchronizing with the bus and closing the breaker. The engine was run for 10 minutes on 100 kW and the load then gradually raised to 875 kW. Two problems developed, an excessive amount of black tarry oil dripped from the exhaust manifold and the piston cooling oil temperature quickly became excessive at the discharge from all seven pistons. The engine manual recommends 60°C piston cooling outlet oil running temperature; however, the average of the seven outlets was 76°C after 25 minutes which is close to the danger point for the engine lubrication system. The load was reduced to 500 kW and the temperature began to decline. The cooling pumps and fans were inspected and found to be functioning correctly.

Unit No. 3 — Two problems developed similarly to Unit No. 2. The scavenge blower has some axial movement and the generator outboard pedestal bearing support beam has come free from the concrete at one side resulting in movement of the bearing during operation. The engine was warmed up for 1 hour and then placed on light load of 100 kW for 40 minutes and then gradually raised to 700 kW. The lubricating oil temperature immediately rose to an average of 78°C and the load had to be removed. The evaporator fan motor was found to be tripped out on the breaker. The fan was restarted and the load raised to 500 kW where the oil temperature stabilized but remained above normal.

Safety Considerations

Several potentially dangerous operating conditions were identified, particularly by the operational tests at loaded conditions, generally as follows.

Unit No. 1 Failure to start confirmed concern that non operational conditions are detrimental to the unit, when the engine is left idle for long periods, perhaps equally, if not more seriously than continuous operating conditions. Though the unit had sat idle only for several weeks, functional features had changed and the air start system had become unoperational causing one engine test run to be abandoned. The engine cannot be considered capable of reliable emergency duty if allowed to sit unattended for more than a few days.

Unit No. 2 Suspicion of a dangerous operating condition was aroused when operating personnel drew attention to the black oil on the exterior of the outdoor stack which must have arrived there due to some abnormal circumstance. During the load test, copious quantities of oil leaked from the hot exhaust manifold, as can be seen in Photographs No. 28 and 29. This provided evidence that the manifold was partially flooded with residue oil which, from experience, would be mostly lubricating oil mixed with unburned fuel oil. Danger to the plant and personnel is a very serious matter unless operators are familiar with this phenomena and know how to deal with an engine exhaust manifold fire.

Unit No. 3 There has to be considerable alarm relative to the cracked foundation and the presence of an excessive crankshaft deflection which confirms misalignment of the generator in relationship to the engine crankshaft. The direct outcome of crankshaft misalignment is a broken crankshaft which is obviously expensive and can be very dangerous if the engines motion works grind metal on metal, in the presence of oil vapors inside the crankcase.

Summary

Excessive oil leaks at the exhaust manifold are typical of two-cycle engines which pump oil particularly during light loading situations and generate a specific danger of exhaust manifold fires. The blow-through of lubricating oil on Unit No. 2 which left deposits on the exhaust stack emphasizes this danger and extreme care has to be taken with engines of this type when called upon to produce a high level of load after frequent starts and stops and operation at light loads.

The high lubricating oil operating temperatures experienced during the test will be due to general engine wear and tear and the accumulation of scale throughout the cooling water surfaces in the engine, pipework, evaporative coolers and also the oily side of the lubricating oil cooler.

These faults and other observations would indicate that the engines and auxiliary systems are in need of substantial repair. The deteriorated foundation on Unit No. 3 requires major repair, see Photograph No. 26, as does the drive mechanism at the scavenger blower of that unit.

The inability of Unit No. 1 to start is a direct result of non operation conditions where condensation and other atmospheric conditions cause shafts, spindles, glands and similar sliding surfaces and motion works to stick and cause minor malfunction and occasionally total failure as illustrated on February 6, 1997.

Several years ago, Wartsila Diesel Company of Finland purchased the Swedish Nohab Polar Company but the K57 model had long since been discontinued. Present-day parts availability has been established, as discussed in Section 4.

Rehabilitation of the Gander plant requires at least

- considering the baseload continuous operation for 18 years and accumulation of approaching 100,000 operating hours, the units are overdue for a major overhaul

- major concrete work is needed to repair Unit No. 3's deteriorated foundation

- evaporative cooler coils, water boxes, pipework, etc., to be descaled and engine jackets, heat exchangers, pumps, etc., to be descaled and overhauled

- all instrumentation and controls to be replaced

- future manning levels and engine checks to be increased.

Remarks

Contrary to common belief the deterioration of these early design of engines takes place just as rapidly and frequently more rapidly than when they are left idle and not operated in the manner for which they were designed. The engine and the entire plant relies on conventional packings, glands, and manual lubricating points all of which were designed in the 1940's and 1950's strictly with the intention of an experienced operator being continuously in attendance with extensive knowledge of the particular type of equipment in question.

Recommendations

In view of the substantial investment required to make the Gander units safe and reliable for a further 10 years of operation, and considering the fact that the plant has the lowest annual average hours of operation, at 0.4 hours, of all the plants, it is recommended that the plant be decommissioned.

3.5 Aguathuna

Plant History

The plant was installed in 1962 with a single Harland and Wolff 8 cylinder, in-line, diesel generator rated at 1,200 kW when running at 327 rpm. The engine is complete with plant auxiliaries such as lubricating oil circulation, glycol cooling, outdoor radiator, switchgear, etc. The plant is a steel frame, metal sided building with concrete foundations located adjacent to the ocean. Transformers are located at the front of the building, fuel is stored in a relatively new steel self-dyked tank. The building has a storeroom, switchgear room, overhead crane, large engine room and washroom.

The single engine is of the four cycle principle with "dry sump" whereby the lubricating oil is stored in a rectangular steel tank situated several feet below grade. The engine is of Irish manufacture and is massive relative to the modest 1,200 kW output rating; however, this maybe better understood by stating that the intent was to operate on Bunker C fuel. As originally installed, this slow speed machine would be capable of many years operation in a reliable manner.

The plant is of high quality and is laid out in a very spacious manner with massive concrete foundations under the engine and generator. There is high headroom and a 10 ton overhead traveling crane.

The Newfoundland Power 1996 Diesel Power Plant Review states the operating hours of the Harland Wolff Unit up to 1991 was 10,086. Since which time, the Unit has generated 30,000 kWh with an estimated additional operating time between 30 and 40 hours. Compared to this operating history the Harland and Wolff operating manual recommends a major overhaul after 4,000 to 6,000 hours. Indications are that the engine is overdue for a major overhaul.

Plant Survey

The plant is generally in good condition. Building exterior shows some rust stains where windows have been replaced with steel plate. The fuel tank is relatively new. Half of the plant space is used for the repair of transformers. The work space is kept reasonably tidy, but the storeroom needs to be cleaned out and spares catalogued. Water supply is shut off to the basin in the washroom. Building is heated with a forced air furnace located in the machinery space. Site was snow covered at the time of inspection but appears to be well kept. Some water leakage was reported to occur through the foundation into the switchgear room during spring thaw, otherwise concrete is in good condition. The overhead crane is rated for 10 ton and functions well. Air receivers and compressors function properly. Indoor fuel day tank is in good condition and is positioned above a concrete containment dyke. Exhaust stack is heavily rusted but this is a result of the location of the plant near salt water. A comprehensive engine control panel is located in the control room with indicating lamps to warn of a variety of sensitive operating conditions, several instruments are either damaged or inaccurate.

Engine Survey

Crankshaft defections indicate that the generator outboard pedestal requires no adjustment. The engine barred over freely. Engine foundations showed no cracking other than superficial. The Harland Wolff engine is turbocharged but there is no intercooling stage.

Inspection inside the crankcase identified a very sludgy black carbon film deposited on all surfaces with the sump containing sludgy oil with evidence of water/oil emulsion indicating that combustion gases were flowing past the piston rings contaminating the lubricating oil in the crankcase. An attempt was made to carry out static compression "blow-down" tests to confirm that there was blow-by at the piston rings, and results indicated that some cylinders are considerably worse than others.

Blow-down tests were performed on each of the eight cylinders of the engine to evaluate the extent of piston blow-by. The test consisted of attaching an air hose to the cylinder cocks and pressurizing the cylinder with air. The air supply was then shut-off and the cylinder cock opened. The time for the air to vent from the cylinder was recorded. If air was leaking past the piston rings the length of time to vent the air would be reduced as a portion of the volume would have escaped to the crankcase. Due to a lack of fittings and gauges available at the time of the test, the air hose was hand held over the valve during pressurizing. The results therefore provide only a relative indication of the piston blow-by. All pistons were aligned in a similar position to provide a comparable cylinder volume. The results were as follows:

Cylinder No.	Blowdown Time
1	6 sec.
2	7 sec.
3	8 sec.
4	11 sec.
5	9 sec.
6	9 sec.
7	6 sec.
8	10 sec.

Examination of the governor linkage identified the emergency overspeed "collapsible link" was frozen tight, a condition that would prevent the emergency overspeed trip mechanism from functioning, giving rise to a potential overspeed engine and generator destructive condition.

Unit Operational Test
The test operating data was collected for the engine.

The engine started at the first attempt and was allowed to idle for 10 minutes before light load was applied, followed by load increases to 1,100 kW at which condition operation was observed for a 1 hour period. One cylinder appeared to be laboring under excessive load but this could not be confirmed due to non-function of the exhaust gas pyrometer. The cooling system functioned satisfactorily as far as could be ascertained by non functional instruments, and operating conditions soon stabilized. Observation of the exhaust stack indicated black smoke approximately number two on the Bacharach scale indicating a slight overload condition.

The crankcase breather soon started to emit crankcase vapors. The volume increasing as the engine oil and piston cooling circuit reached normal operating temperatures, the excessive flow, which represents piston blow-by is best illustrated by Photograph No. 36 in Appendix 'B'.

Numerous minor water and oil leaks were noted. Asbestos wrap at the exhaust outlet elbows were in badly deteriorated condition, as seen is Photograph No. 37.

Safety Considerations

The asbestos breakdown at the exhaust manifolds requires removal and replacement with modern materials. The excessive and continuous flow of gases escaping from the crankcase breather into the plant atmosphere soon caused eye irritation and presents a health hazard. If allowed to continue, these vapors eventually condense on walls and ceilings creating a fire hazard as well as poor aesthetics. Discovery of a seized overspeed "collapsible link" in the governor safety system revealed a very dangerous condition whereby the overspeed mechanism would not have shut down the engine in a case such as inadvertent breaker trip, rendering the Unit vulnerable to catastrophic failure and the high probability of personal injury.

Summary

The operational test for a period of 1 hour was successfully completed and identified several points requiring attention.

- The engine is overdue for a major overhaul.
- The piston blow-by creates a health and a fire hazard.
- The disabled overspeed protection mechanism creates a serious danger.

The above conditions indicate that this machine should no longer be operated in an unsafe condition.

Remarks

As with other slow speed plants within the system, this inspection/survey identified the difficulty that exists in maintaining heavy duty baseload plant in what has to be termed an emergency Standby mode.

Recommendations
As the above inspection and test indicates, this unit will require substantial funds to be invested to bring it back to a safely operable condition for a 10-year period. The manufacturer is no longer making diesel engines and it is doubtful if any parts are available. It is not considered practical or economic to keep the unit in service. Decommissioning is therefore recommended.

3.6 Port-aux-Basques

Plant History
Portable Unit No. 1 was purchased in 1973 and has been used as a mobile unit since that time. It is equipped with a Caterpillar Model D-349, four cycle, V-12 cylinder engine capable of delivering 980 HP when operating at 1,800 rpm. The generator is Tamper-Canron rated at 700 kW, 600 V. To the present time, the Unit has logged 4,659 operating hours.

Present day operational mode requires cranking over weekly and operation once per month synchronized to the system and run at full load for not less than 1 hour.

Portable Unit No. 2 was purchased in 1976 and has been used as a mobile Unit since that time. It is equipped with a Caterpillar Model D-349, four cycle, V-12 cylinder engine capable of delivering 980 HP when operating at 1,800 rpm. The generator is Brown-Boveri rated at 670 kW, 600 V. To the present time, the Unit has logged 1,966 operating hours but the meter is believed to be inaccurate.

Present day operation requires the Unit to be cranked over weekly and operated once per month synchronized to the system and run at full load for not less than 1 hour.

The main Port-aux-Basques plant was put into operation in the 1940's. The present Caterpillar equipment was installed at various times starting in 1949. The six units consist of a range of Caterpiller models. In 1969, a "Packaged" Electro Motive Diesel (EMD) generator was purchased and located adjacent to the main power plant building. The Caterpillar Units supplied base load continuous power until 1968 when they were placed on Standby duty. The GM unit has only operated 1,654 hours up to the time of this inspection.

Plant Description and Survey
Inspections and tests were carried out February 8, 9 and 10. The two portables are located in the Grand Bay substation outside Port-aux-Basques. Portable

No. 1 is located in a steel framed enclosed tractor trailer. The Unit is complete with a generator room, transformers, two 250 gallon steel fuel tanks and a switchgear/office room. The fuel tanks are similar to the those used for home heating oil storage and are located inside the trailer behind a wooden partition. They can not be inspected as the partition wall is permanently fixed in place. The trailer has a valid licence for 1997 and is presently connected to the grid. The trailer access stairs are constructed of checker plate and can be slippery in winter conditions. The trailer is heated. Engine cooling is by a radiator located at one end of the trailer with fan driven off the end of the engine, glycol is used.

Portable No. 2 is contained in a steel frame enclosed tractor trailer similar to Portable No. 1. The steel under frame is badly corroded and should be inspected and strengthened prior to the next move. The siding is in good condition. The interior is clean and dry and contains a generator room and an office/switchgear room. The trailer has a valid licence for 1997. The 500 gallon fuel storage tanks are attached beneath the trailer and have been recently refurbished. The trailer is heated and is presently connected to the grid. Engine cooling is by a radiator located at one end of the trailer with fan driven off the end of the engine, glycol is used.

The main Port-aux-Basques plant is located near the old railway bed on the road through the town. It is a concrete and wood building in good condition with new exterior wood siding. The building contains six Caterpillar diesels of various models and output. The plant is well lighted and reasonably well laid out with ample space for engine maintenance. It contains a workshop/storeroom and office where switchgear for the self-contained EMD diesel is located. A moveable A-frame hoist is located within the building. The engine exhausts are mounted on the roof and appear to be in good condition though the 1995 NP Diesel Power Plant Report identifies that some work needs to be done on the mufflers. Engine cooling is accomplished by shell and tube heat exchangers utilizing town water. Switchgear for the Caterpillar diesels is obsolete, some dating back to 1937. Engine instrumentation is minimal. The main transformers for the plant are located at the rear of the building.

The EMD diesel is located adjacent to the main plant in a self contained steel enclosure complete with separate engine, generator, and radiator compartments. The engine and generator compartments are cramped. The enclosure is in relatively good condition however. The interior of the radiator compartment is heavily corroded with a number of small holes in the bottom of one main panel.

The stack and exhaust were recently rebuilt. Engine cooling is accomplished by a radiator at the front of the enclosure, glycol is used.

Fuel for the main plant and EMD diesel is supplied from two steel self-dyked tanks at the rear of the main building which are in good condition. The EMD has a day tank within the enclosure.

Engine Survey

Unit No. 10 Crankshaft deflection measurements are not practical in this type of engine but generator coupling alignment should be checked in the near future according to EMD Diesel instructions. The upper cylinder head camshaft and rocker gear area was fully exposed for inspection under the expansive top covers where everything appeared clean and satisfactory. Removal of the air box covers permitted close examination of pistons, piston rings, and inner area of cylinder liner through the air inlet ports. Photograph No. 45 was taken. The air box enclosure was somewhat covered by an oily carbon sludge but this condition is common to this class of two cycle engine breathing arrangement. No broken piston rings were found but the tell tale piston wear-down markings indicate some worn top compression rings, but significant life remains. Interior of the cylinders and exterior of piston skirt were very clean and deposits above the top ring are minimal relative to 1,654 operating hours.

A special feature which makes the EMD engine attractive to operators and economical for maintenance is the "Power Pack" arrangement for replacing a complete line including cylinder head, cylinder liner, piston and connecting rod, all in one assembly as indictated in Appendix 'D'.

Caterpillar The six units were given a visual inspection. Unit No. 2 was out of service due to a generator winding failure. Unit No. 4 and 5 are normally aspirated and produce low power relative to their physical size. All other units are turbo charged and all units operate at 1,200 rpm. Units 2 and 8 are electric start while the remaining are started with compressed air.

All machines were very clean and appeared to have been maintained to a high standard which might be misleading when considering their age and previous hard work when supplying the only source of power for many years.

Unit Operational Tests

Unit No. 10 The unit started at first cranking and settled at idle speed (400 rpm) in the automatic mode before moving up to 900 rpm synchronous speed as controlled by the automatic start sequence. What had been described as a suspicious turbocharger noise was observed before the unit came up to full load, but the unit settled down very smoothly without any unusual noise or vibration. Discussions with the supplier indicate that the bearings could be wearing out, but this is by no means certain and the unit is probably best left until the problem worsens, which may not occur. The supplier indicates catastrophic failure is most unlikely. The cost of a remanufactured turbocharger is around $35,000, taking about 2 days of labor to install, which NP could carry out themselves. The manufacturer can supply a service Engineer if necessary. The 2,700 kW full load condition was sustained for 1 hour without incident, all pressures and temperatures quickly settling down within normal parameters. The exhaust smoke was clear. Voltage and load control were very steady throughout the test. At the end of the test, the unit responded correctly to automatic commands to cool down at idle speed, and eventually stopping.

Caterpillars The six caterpillar units were put on load about 2 pm after a suitable warm-up period and carried various levels of load. However, electrical instrumentation is not sufficiently reliable to determine if the units were on high load or overload. In this respect, Unit No. 3 was noted to have a red hot exhaust manifold and turbocharger casing requiring the load to be reduced for safety's sake.

Several problem areas regarding the overall installation should be recorded.

- Rapid rise of plant interior temperature to 34°C.
- Engine speed control had to be carried out at the engine governor rather than utilization of speed "raise/lower" switch mounted in the switchgear.

- Rapid deterioration of breathing conditions within the plant due to crankcase breathers emitting fumes considered to be excessive.
- Reports of periodic heat exchanger tube failure likely caused by high velocity turbulent city water.
- Unit No. 8 - a faulty lubricating oil pressure switch had to be held open during start up to prevent shutdown while engine was getting up to speed.
- All Units needed ether spray for starting. However, although it is common practice, the use of ether on an engine located in a heated building should not be necessary and indicates the engine is worn and has insufficient compression for a normal start.

Load was carried on the five Units for 1 hour necessitating periodic manual adjustments to the governor controls to maintain the required load sharing levels.

Portables No. 1 and No. 2

Portable No. 1: The engine started easily using ether and was left to idle for 5 minutes while Portable No. 2 was started. Following warmup an attempt was made to synchronize the generator and put the unit on-line. The breaker was activated when the arm on the synchronizing clock reached 12 o'clock but the breaker did not immediately react and the hand was approaching the 6 o'clock position when the breaker attempted to close resulting in an explosion and flash of flame from the bottom of the switch gear. The test was cancelled and the engine shut down.

Portable No. 2: The engine was somewhat hard to start and required a generous application of ether sprayed into the intakes. Once started, the engine was warmed up and put on load. The Unit ran at full load for 1 hour. The crankcase vent was checked 45 minutes into the test and was found to be issuing a steady flow of vapour. The exhaust temperature rose to 950°F and remained constant throughout the test. The pyrometer is located after the turbocharger and 950°F is considered a safe maximum temperature. The engine did not show any signs of overheating but this was due to the cold air flowing over the exhaust manifolds which are located next to the trailer air inlet louvers.

Safety Considerations

The obsolete open faced line up of switchgear at the main plant is regarded as detrimental to personnel safety due to the inaccuracy of many instruments and the potential hazard of operator contact with so many live components unguarded. Most of the exhaust pipes from the engine to the ceiling were without insulation and the operator needs only slip to reach out and be seriously injured. The heat radiated from these exposed metal parts presents a clear danger of engine overheating due to excessively high aspiration air temperature because the air for all units is drawn from within the plant. During the test all engine speed control functions and breaker closure that was required to synchronize and load the diesel generators, was performed by two NP staff members. Apparently, for most of the time the plant is put on line in an emergency by a single person who would be under considerable pressure to work at top speed and escape the numerous dangers that exist. Health aspects of the fumes which particularly cause eye soreness needs consideration. The openness of the switchgear appears to be dangerous compared to present day enclosures but regard has to be given to the lack of incident over 50 years of existence, one section having being manufactured in 1937.

Summary

Unit No. 10 The Unit is self serving in the Standby mode (without daily or weekly attention) and prepares itself, self primes, self starts, idles, moves to synchronous speed, closes the breaker and moves to supply load automatically with all steps being performed for maximum safety and maximum reliability. This report has recorded space utilization in terms of power available relative to cubic space and the EMD Unit has the best ratio of all units, i.e., Watts/cubic ft. Exact operating and maintenance records are not available and can not be assembled from old log books but interviews indicate that this machine requires a minimum of man hours year after year.

Since 1969, the EMD "Package" has suffered corrosion in, on and around the open cooling system end and the resulting process gradually worsens and consideration should be given to removing the equipment to an indoors location and disposing of the enclosure before repair costs rise and unit reliability is impaired.

Newfoundland Power operators stated that their preference would be to operate the Caterpillars in the order of 80 to 90 percent of rated output but find that under emergency conditions there is a need to sustain high load and even overload to meet electrical demand of the area. The large number of Units make this a complex plant to manage and also to operate when an emergency conditions prevail. There are heath and safety conditions to be addressed which must be weighed against the amount of potential work involving six Units with 60 cylinders in a spacious building for a total maximum rated output of 1,200 kW which realistically offers a reliable continuous supply of only 1,020 kW.

Recommendations

It is recommended that Unit No. 10 be retained in service but it would be better relocated into the adjacent power house to minimize further deterioration and to provide better access for maintenance.

Although the six caterpiller units operate reasonably well there are deficiencies in switchgear equipment and speed adjustments in addition to safety concerns. It is recommended that the units be retired and replaced with a larger unit or units. They could alternatively be refurbished and relocated to sites needing smaller numbers of machines.

The portables should undergo rehabilitation of engine instruments and safety devices, and calibration of control panel instrumentation. The trailer base of Unit 2 should be refurbished, if there is any future requirement for portability. Both units can be retained in service.

4 Spare Parts Availability & Engine Overhaul Costs

4.1 Spare Parts Availability

Many manufacturers of diesel engines left the business after World War II (WWII) and on into the 1950s, but the designs and ongoing parts business were purchased by competitors. Manufacture of those engines did not continue as more advanced designs were introduced, usually at higher running speeds. As the population of existing units declined, major companies let the business pass to a variety of machine shop dealers etc., often termed "Parts Pirates". Some Pirates do reliable work and others are to be avoided. The present day status for units owned and operated by NP is as follows:

Nohab Polar/Polar Atlas
Nohab Polar was purchased by Wartsila of Finland over 20 years ago, but parts are still available as per letter in Appendix 'D'. Engineering Products and Services of Lincoln, England, have established a good reputation for supply of obsolete diesel parts, and they can supply some parts for Polar Atlas units, as per letter in Appendix 'D'.

Harland & Wolff
This major U.K. Shipyard discontinued manufacture of diesel engines soon after WWII. Their range of engines were mostly built under licencing agreements and parts availability for the Aguathuna unit is considered to be reliant on remanufacture by machine shops like Marsh Engineering Limited of Port Colborn, Ontario, who do specialize in diesel engine repair.

Nordberg
Cooper Bessemer owned the Nordberg designs for a number of years, but abandoned further supply about 1985. Hatch and Kirk and Jack Purpus Enterprises stock some running parts today but main parts like pistons and cylinder liners are very costly with long deliveries. Jack Purpus Enterprises do extensive business in Canada and their response to a request for typical parts availability and pricing was obtained; See Appendix 'D'.

Electro Motive Division/G.M.
Midwest Power Products Inc. of Winnipeg are the exclusive authorized distributor in Canada and stock a wide range of spares for the Model '645' of which there are 20 to 30 in industrial service in Canada. There will be several

thousand of these locomotive engines in Canada, mainly with C.N. and C.P. The 'Powerpack' arrangement coupled with Midwest Unit Exchange programme means EMD parts are readily available at most competitive prices, as illustrated in Appendix 'D'.

Worthington

This is one of many Power Plant class of equipment supported today by Ingersoll Rand, division of Dresser Industries, Painted Post, NY. State. Parts are very expensive and on very long delivery for these 1940s vintage engines, and although helpful with technical support, Ingersoll Rand may be expected to recommend retirement of the equipment. The factory has not in recent years found it economical to hold on to patterns, molds, drawings, etc., mainly due to a declining population (demand) of engines in service.

Caterpillar

As indicated in Appendix 'D' some of the units can be supplied with spare parts but in other cases they are no longer available.

4.2 Engine Overhaul

Typical Six Cylinder Worthington

For the purposes of this estimate it is being assumed that NP would contract the work out rather than use their own resources, therefore a charge-out rate of $60.00/hour is being used.

To strip down the engine to expose the crankshaft and remove all main bearings for inspection, pull pistons and cylinder liners, dismantle cylinder heads, camshaft, camshaft and governor drive, expose internal water cooling surfaces, generally examine all working parts. To clean components and prepare for re-assembly, measure interface wear and compare to maximum allowable running tolerance. All as needed to carry out major overhaul.

Estimated Manpower	4
(Includes one labourer for cleaning)	
Estimated Project Duration	8 weeks
Estimated Cost	
4 men x 40 hours/week x 8 weeks x $60.00/hour =	$76,800
	for one Unit, Labor only

Estimated cost of a complete set of gaskets, packings, jointing compound, cleaning materials	\$1,500/cylinder x 6 = \$9,000
Labor in Salt Pond or similar area will call for accommodation, food and transportation to and from site.	Estimate \$120/man/day
Estimate: 4 men x 5 days/ week x 8 weeks x \$120/man/day =	\$19,200
Total Estimate = \$76,800 + \$9,000 + \$19,200 =	\$105,000

This labor cost would be similar, on a per cylinder basis, to that required for the Nordberg (8 cylinder) or Harland and Wolff (8 cylinder) units at St. John's and Aguathuna respectively, i.e., increasing the labor cost to about \$140,000 or perhaps slightly higher due to the larger physical size of the units.

Note:

(a) Required new or refurbished parts cost would be extra.

It is very difficult to establish what parts might be needed without a detailed inspection. However, at least fuel pump overhaul (at \$1,500) and injector overhaul (at \$750 per cylinder) would be needed. With regard to replacement of major components such as cylinders and/or pistons, all that can be said at this stage is that the Nordberg unit appeared to be less likely to need major components than the Worthington or Harland and Wolff units.

A limited inspection by using a borescope to inspect inside the cylinder after removing the fuel injectors could identify if serious wear is apparent in the cylinders. Such inspections could be completed in about 2 days per unit. Similarly, entry into the engine crankcase and bottom-bearing removal could reveal any crankshaft/bearing wear which needed machining work to be carried out.

It must be iterated that only detailed inspections, which were not part of the scope of the review, will ascertain for certain if replacement parts are required. Cylinder liners and pistons, if needed, would cost around \$8,500 and \$6,800 respectively each, and cylinder covers \$4,800, based on quotations for Nordberg parts.

(b) Expenditure of \$105,000 on modern new replacement diesel generating capacity would purchase about 350 kW.

4.3 Instrumentation and Safety Devices

The following is a typical list of key engine instruments and safety devices required for a Standby Diesel Generator. All units remaining in service should be fitted with these items as a minimum.

High Speed Units	Low Speed Units
Oil Pressure	Oil pressure before and after filter: Low Oil Pressure, Alarm and Shutdown
Jacket Water Outlet Temperature Indicator	Jacket Water Outlet Temperature Alarm and Shutdown
Fuel Pressure	Fuel Pressure
Exhaust (Stack) Temp	Exhaust Temperature:- At each Cylinder Before turbocharger At stack Boost Air Pressure Boost Air Temperature Jacket Water Pressure
Overspeed (shutdown)	Overspeed (shutdown) Vibration (alarm)
Coolant Level	Coolant Level

The engines do have some instrumentation installed at the moment, but a full inventory was not taken. However, an estimate of average costs would be about $1,500 labor and $1,000 for parts for Caterpillar units, about $3,500 for labor and parts for the larger units.

5 Alternative Means of Power Generation

The review has concentrated on establishing whether or not it is practical or worthwhile to rehabilitate the existing units at various locations around Newfoundland. The units are intended, in part at least, to provide emergency power to areas which might be isolated from the electricity grid due to transmission line outages during ice storms, and can also provide peak generation.

In recommending decommissioning of a number of the units, the report recognizes that it is not economic to replace most of the decommissioned units with new units at the same sites. This does mean that replacement power from a centralized site provided by a new generating plant will not reach an isolated site in the event of transmission line failure.

The alternative means for generating replacement power is most practically met by installing new or used gas turbine generators or diesel generators.

The total installed capacity is approximately 14 MW, and depending upon how much of this capacity it is decided to replace, unit sizes are available in relatively small increments to cover the entire range from less than 1 MW to 14 MW, assuming a minimum of two units in order to retain some redundancy against outages, this would mean the maximum unit size would be 7 MW.

In general, the larger the unit size the lower the cost would be, but anomalies can be found when selecting from a manufacturer's range or comparing with another manufacturer's model. A thorough examination of the flexibility in selecting unit size and type should be made in order to minimize expenditure.

For the purposes of identifying typical unit costs, current prices were obtained for the latest production model of the Electro-Motive Diesel Unit installed as Unit 10 at Port-aux-Basques. This machine is a medium-speed diesel generator and can be purchased in skid mounted form for installation in a powerhouse at a cost of $1,300,000 (Canadian funds) or remanufactured to as-new condition for $900,000 to $1,000,000. At a unit output of 2,500 kW, this represents an investment of $360 to $520/kW, to which must be added infrastructure costs. Confirmation of these budget costs can be found in the fax from Midwest Power Products included in Appendix 'D'. This cost can be considered as an expected price to pay for replacement power generation equipment in the size range given.

Replacement costs for higher speed but smaller units have been estimated by Toromont/Cat of Toronto who recently purchased control of Newfoundland Tractor. For sizes ranging 100 kW to 500 kW an estimating cost of $300/kW is suggested. for sizes ranging 500 kW to 1,500 kW an estimating cost of $250/kW is suggested. These units operate at 1,800 rpm and are generally complete with radiator cooling, switchgear and control panel.

The use of gas turbines should also be considered, as on a capital-cost basis they are frequently cheaper than diesels in larger unit sizes. Their lower thermal efficiency is of less importance in an emergency plant which operates infrequently, than in a base-load plant.

Appendix A
Inspection Sheets

- General Information
- Historical Data
- Mechanical Data
- Electrical Data
- Engine Test Data

General Information

Unit Ref. No. (At site)	Location	Fuel Storage Tanks	Building Space and Condition, Foundations	Exhausts and air intakes	Compressors and air Receivers	Oil and Water Leaks	Condition of Switchgear, Transformers and Batteries	Remarks and Observations
1 (1)	Salt Pond	2 Exterior tanks and day tanks in building	ok	ok	See Remarks	yes	Good	Day tanks located close to uninsulated exhaust pipes
2 (2)	Salt Pond		ok	ok	See Remarks	yes	Good	
3 (3)	Salt Pond		ok	ok	See Remarks	see remarks	Good	Not put on test. #5 cylinder piston removed.
4 (1)	Aguathuna	Geep + daytank Ok	ok	Rusty, ok	ok	yes	ok	Repair necessary
5 (1)	St. Johns	Needs replacing	ok	ok	ok	none	old but works, batteries need to be replaced	Engine in sound condition, used equipment cluttering engine space.
6 (1)	Gander	ok	ok	ok	ok	see report	old	Engine would not start
7 (2)	Gander	ok	ok	exhaust stained black	ok	yes	old	Oil leaking from exhaust manifold and crankcase doors Repairs necessary
8 (3)	Gander	ok	Engine foundation cracked	ok	ok	yes	old	Oil leaking from exhaust manifold and crankcase doors Repairs necessary
9 (1)	Port-aux-Basques	All engines	ok	ok	Electric start	yes	Hewitt/ok	Trailer mounted unit Instrumentation unreliable
10 (2)	Port-aux-Basques	supplied from	ok	ok	Electric start		Hewitt/ok	Trailer mounted unit Instrumentation unreliable
11 (1)	Port-aux-Basques	two GEEP	ok	ok	air equipment for air start	yes	All switch gear open contact type	
12 (2)	Port-aux-Basques	located outside	ok	ok	diesels in good	no	old and obselete. Some is 1937	
13 (3)	Port-aux-Basques	building.	ok	ok	condition	no	vintage. No govenor control	Test stopped when exhaust and turbo ran red hot
14 (4)	Port-aux-Basques		ok	ok		no	on switch panel	
15 (5)	Port-aux-Basques		ok	ok				
16 (8)	Port-aux-Basques		ok	ok				Large volume of gas venting from pev valve during test

General Information - 2

Unit Ref. No. (At site)	Location	Fuel Storage Tanks	Building Space and Condition, Foundations	Exhausts and air intakes	Compressors and air Receivers	Oil and Water Leaks	Condition of Switchgear, Transformers and Batteries	Remarks and Observations
17 (10)	Port-aux-Basques		ok	ok	n/a	no		
18 (1)	Port Union	GEEP (93)	ok	ok	n/a	minor leak during operation	good	Unit performed well

Historical Data

Unit Ref. No. (At site)	Location	Make	Model	Serial No.	Rating HP	Year Installed	Age Years	Total Hours Run	L x W x H
1 (1)	Salt Pond	Worthington	EE-6-STD	VO-1633	670	1941	56	16,935[1]	28 x 9 x 12
2 (2)	Salt Pond	Worthington	EE-6-STD	VO-1635	670	1941	56	17,112[1]	28 x 9 x 12
3 (3)	Salt Pond	Worthington	EE-6-STD	VO-1680	670	1941	56	14,562[1]	28 x 9 x 12
4 (1)	Aguathuna	Harland & Wolff	one of a kind	2476	2000	1962	35	10,086	36 x 10 x 14
5 (1)	St. Johns	Nordberg	TS-218	2012-0804	3580	1953	44	2,425	45 x 7 x 18
6 (1)	Gander	Polar Atlas	K57M	86190	1470	1949	48	not available	28 x 9 x 10
7 (2)	Gander	Nohab-Polar	K57M	1611	1470	1957	40	not available	28 x 9 x 10
8 (3)	Gander	Nohab-Polar	K57M	1466	1470	1953	44	not available	28 x 9 x 10
9 (1)	Port-aux-Basques	Caterpillar	D349 (portable)	61P476	980	1973	24	4,659	16 x 5 x 6
10 (2)	Port-aux-Basques	Caterpillar	D349 (portable)	61P809	980	1976	21	1,966	10 x 5 x 6
11 (1)	Port-aux-Basques	Caterpillar	D397	41B1388	505	1945	52	1,910	13 x 5 x 6
12 (2)	Port-aux-Basques	Caterpillar	D353D	46B1667	380	1953	44	9,153	11 x 5 x 7
13 (3)	Port-aux-Basques	Caterpillar	D397	48B1181	505	1954	43	10,555	12 x 6 x 5
14 (4)	Port-aux-Basques	Caterpillar	D386	15B1	344	1958	39	3,856	17 x 5 x 6
15 (5)	Port-aux-Basques	Caterpillar	D386	15B54	364	1965	32	7,803	16 x 6 x 5
16 (8)	Port-aux-Basques	Caterpillar	D353	46B1663	380	1965	32	6,680	11 x 5 x 7
17 (10)	Port-aux-Basques	GM	20-645-E4	69E11081	3600	1969	28	1,654[2]	29 x 8 x 6
18 (1)	Port Union	Caterpillar	D398A	661B127 SER. A	750	1962	35	not available	13 x 5 x 6

[1] At Salt Pond since 1963 only

[2] 1993 air filter changed, louvers repaired, rebuilt exhaust
1996 replaced coolant heater, changed oil
1992 changed oil, changed belts on fan, changed coolant, replaced rubber seals on valve covers.

Mechanical Data

Unit Ref. No. (At site)	Location	RPM	Turbo or N/A	Type of Governor	Number of Cylinders	Start Method	Cooling Method	Common Under Base	Average Fuel Rate KWh L
1 (1)	Salt Pond	327	Normally Aspirated	Pickering	6	Air in cylinder	Direct city water	no	Total Plant 1.98
2 (2)	Salt Pond	327	Normally Aspirated	Pickering	6	Air in cylinder			
3 (3)	Salt Pond	327	Normally Aspirated	Pickering	6	Air in cylinder			
4 (1)	Aguathuna	327	Napier Turbo Blower	Woodward UG-32	8	Air in cylinder	Glycol & Radiator	no	3.54
5 (1)	St. Johns	225	Supercharged Roots Blower	Woodward 1C500	8	Air in cylinder	Heat exchng. city water	no	3.98
6 (1)	Gander	300	Supercharged by Centrifugal Blower	Polar	7	Air in cylinder	Glycol & evaporator	no	Total Plant 1.72
7 (2)	Gander	300		Polar	7	Air in cylinder	Glycol & evaporator	no	
8 (3)	Gander	300		Polar	7	Air in cylinder	Glycol & evaporator	no	
9 (1)	Port-aux-Basques	1800	Tubrocharged	Woodward UG-8	16	Electric	Glycol & Radiator	yes	3.46
10 (2)	Port-aux-Basques	1800	Turbocharged	Woodward UG-8	16	Electric	Glycol & Radiator	yes	3.18
11 (1)	Port-aux-Basques	1200	Turbocharged	Woodward UG-8	12	Air Motor	Heat exchng. City water	yes	Total Plant 2.57
12 (2)	Port-aux-Basques	1200	Turbocharged	Woodward UG-8	6	Electric	Heat exchng. City water	yes	
13 (3)	Port-aux-Basques	1200	Turbocharged	Woodward UG-8	12	Air Motor	Heat exchng. City water	yes	
14 (4)	Port-aux-Basques	1200	Normally Aspirated	Woodward UG-8	12	Air Motor	Heat exchng. City water	no	
15 (5)	Port-aux-Basques	1200	Normally Aspirated	Woodward UG-8	12	Air Motor	Heat exchng. City water	no	
16 (8)	Port-aux-Basques	1200	Turbocharged	Woodward UG-8	6	Electric	Heat exchng. City water	yes	
17 (10)	Port-aux-Basques	900	Turbocharged	Woodward EGB-10	20	Electric	Radiator	yes	3.49
18 (1)	Port Union	1200	Turbocharged	Woodward UG-8	12	Electric	Heat exchng. River water	no	3.03

Electrical Data

Unit Ref. No. (At site)		Location	Generator Make	Generator Serial No.	Rating kW	Power Factor	Service Factor	Voltage	Excitation Method	Remote or Local Start	Transformers and Switchgear, Date of Mfr. (TFMR. Rewound?)
1	(1)	Salt Pond	Electric Machinery	82363	500	0.8		4,160	DC Gen.	Local	G.E.
2	(2)	Salt Pond	ElectricMachinery	83539	500	0.8		4,160	DC Gen.	Local	G.E.
3	(3)	Salt Pond	Electric Machinery	82362	500	0.8		4,160	DC Gen.	Local	G.E.
4	(1)	Aguathuna	Harland & Wolff	18180	1200	0.8		2,400	DC Gen.	Local	G.E.
5	(1)	St. Johns	General Electric		2500	0.8		6,600	DC Gen.	Local	Metro. Vickers
6	(1)	Gander	CGE	404125	1000	0.8		2,300	DC Gen.	Local	
7	(2)	Gander	CGE	604571	1000	0.8		2,300	DC Gen.	Local	
8	(3)	Gander	CGE	604318	1000	0.8		2,300	DC Gen.	Local	
9	(1)	Port-aux-Basques	Tamper-Camron	363-088-101	700	0.8	1.0	347/600	DC Gen.	Local	
10	(2)	Port-aux-Basques	Brown-Boveri	C360-690-	670	0.85	1.0	347/600	DC Gen.	Local	
11	(1)	Port-aux-Basques	Caterpillar	850RN60	350	0.80		2,400	DC Gen.	Local	Gen. Burnt Out
12	(2)	Port-aux-Basques	Caterpillar	2505N17	250	0.80		2,400	DC Gen.	Local	
13	(3)	Port-aux-Basques	Caterpillar	350RN2	350	0.80		2,400	DC Gen.	Local	
14	(4)	Port-aux-Basques	General Electric	6842237	209	0.80		2,400	DC Gen.	Local	
15	(5)	Port-aux-Basques	Caterpillar	6917550	250	0.80		2,400	DC Gen.	Local	
16	(8)	Port-aux-Basques	Caterpillar	2050N16	250	0.80		2,400	DC Gen.	Local	
17	(10)	Port-aux-Basques	Caterpillar	69E11199	2500	0.80		4,160	DC Gen.	Local	
18	(1)	Port Union	General Electric	754784	500	0.80		2,400	DC Gen.	Local	

ENGINE TEST DATA

Unit Ref. No.	Location	Time of Start	Time of Stop	Test Duration mins	Time to Sync. mins	AMPS	Load kW	Pressures (psi)					Temperatures (°F)		
								Lube oil	Boost	Jacket Water	Fuel	Other	Lube oil	Jacket Water	Exhaust
Worthington recommend operating temperatures and pressures							500	20		40			165	130	800
1	Salt Pond	09:15	10:30	75	1	55 to 60	500	32		13	2		76	45 inlet 120 outlet	660
			10:30			55 to 60	500	27		13	2		95	45 inlet 150 outlet	
2	Salt Pond	09:10	10:30	80	1	75 to 80	540 to 600	39		13	2		105	45 inlet 130 outlet	600
		10:30				75 to 80	540 to 600	34		12	2		110	45 inlet 120 outlet	600
3	Salt Pond	Not run as piston missing for #5 Cylinder													
General Notes:	Numerous water and oil leaks. Unit#2 leaking water severely from around exhaust manifold. Fuel pressure is based on static head of elevated day tanks. Approx. 5 '.														
Nordberg recommended operating temperatures and pressures							2500								
1	St. John's	10:20	10:45	25	5	200	2400	30	1.6	21	20		105	102	400
General Notes:	Engine ran smoothly without any problems, clear exhaust, all temperatures & pressures normal														
1	Port Union	03:10	04:10	60	1	130	500	45	No gauges on engines except parameters indicated						
General Notes:	Minor oil leak on lubrication line to tubrocharger, clear exhaust, limited instrumentation, smooth running														

ENGINE TEST DATA

Unit Ref. No,	Location	Time of Start	Time of Stop	Test Duration mins	Time to Sync. mins	AMPS	Load kW	Pressures (psi) Lube oil	Boost	Jacket Water	Fuel	Other	Temperatures (°F) Lube oil	Jacket Water	Exhaust
Nohab Polar recommended operating pressures and temperatures							1000	28	2.4	14.5	43		140	122	500
2	Gander	02:25			1	280	875	25	1.1	16	43		140	104	270
		02:50				280	850	25	1.1	16	43		162	126	320
		Load cut back to 600 kW at 2:55 due to high lubricating oil temperatures (Maximum permissible 158 degress F)													
		03:06				230	500	25	1.1	16	43		169	136	250
		03:25				230	480	25	1.1	16	43		162	129	220
General Notes:		White smoke from exhaust stack. Numerous oil leaks from exhaust manifold													
3	Gander	02:30			1	200	100	25	2.6		30		131	122	200
		Load raised to 725 kW at 3:05 pm													
		03:10				320	700	15	2.6		30		165	169	360
		Load reduced due to high lubricating oil temperature, reduced to 250 kW													
		Load reduced to 0 at 3:22 pm. Evaporator blower not functioning. Breaker reset and unit placed back on load.													
		03:25				220	500	20	2.6		30		172	147	300
General Notes:		White smoke from exhaust stack													

Unit Ref. No,	Location	Time of Start	Time of Stop	Test Duration mins	Time to Sync. mins	AMPS	Load kW	Pressures (psi) Lube oil	Boost	Jacket Water	Fuel	Other	Temperatures (°F) Lube oil	Jacket Water	Exhaust
Harland & Wolff recommended operating pressures and temperatures							1200	15 min.					160 max	165 normal	
1	Aquathuna	04:05		60	1		0	20	0.6				90	110	
		04:25				240	900	20	3.6				110	126	
		04:30				270	1100	20	5		(No Instruments)		114	128	
		04:45				270	1100	20	5				120	130	
		04:55				270	1100	20	5				120	130	

General Notes:

Steady flow of smoke from PCV valve.
Grey smoke from stack at full load
Numerous minor oil leaks from all joints
Leaks around exhaust manifold
Exhaust pyrometer not functioning

ENGINE TEST DATA

Unit Ref. No.	Location	Time of Start	Time of Stop	Test Duration mins	Time to Sync. mins	AMPS	Load kW	Pressures (psi) Lube oil	Boost	Jacket Water	Fuel	Other	Temperatures (°F) Lube oil	Jacket Water	Exhaust
GM recommended operating pressures and temperatures							2500	125 cold 29 at speed			12 at start 25 at speed			180	
10	Port-aux-Basques EMD GM	11:25		65	0		0	105			15			80	
		11:30				370	2500	115			25			90	
		11:45				395	2600	95			25			150	
		12:00				400	2700	80			22			150	
		12:15				400	2650	80			22			155	
		12:30				400	2700	75			21			160	
General Notes:	Clear exhaust, no problems														
Caterpillar Units Main Plant Port-aux-Basques (limited instrumentation)															
1	Port-aux-Basques	01:52	02:55	63	1	90	280	Minor oil leaks							
2	Port-aux-Basques							Not tested, generator burnt out							
3	Port-aux-Basques	01:50	02:45	55	1	95	305	Test stopped early due to overheating, turbocharger red hot, head gaskets leaking oil							
4	Port-aux-Basques	01:51	02:55	64	1	37	160								
5	Port-aux-Basques	01:45	02:55	70	1	66	220								
8	Port-aux-Basques	01:50	02:55	65	1	90	235	Steady flow of gas from crankcase vent							
Protable Units Grand Bay Substation (limited instrumentation)															
1	Port-aux Basques	09:00	09:10	10				Breaker blew while trying to synchronize. Flash from bottom of breaker panel. Test stopped							
2	Port-aux-Basques	09:10		65	1	0	0								800
		09:15				640	580								900
		09:25				740	660	All temperatures in normal range							950
		09:40				720	660								950
		09:50				730	660								950
		10:05				720	660								950
		10:15				760	660								950
General Notes:	Vapor issuing from crankcase vent, exhaust temperature is measured after turbo, clear exhaust, minor oil leaks														