Portable Diesel Generation:

Reliability Analysis, Sizing and Unit Location Review

October 2002

Introductory Note

The following report *Portable Diesel Generation: Reliability Analysis, Sizing and Unit Location Review* addresses options for replacement of Newfoundland Power's existing portable diesel generating units which are at the end of their useful lives. The report summarizes the results of engineering studies, analyses and assessments performed by Newfoundland Power's Engineering & Energy Supply Department.

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Executive Summary

Newfoundland Power presently owns three portable generation units: one portable gas turbine and two portable diesels. *The Existing Portable Diesel Generation – Condition Assessment & Review* recommends that due to their age and condition, the two portable diesel units be de-commissioned.

Portable units can be employed in a number of different roles. During the winter months, the units are typically stationed at the end of long radial transmission or distribution lines to serve as backup generation in the event of unscheduled outages on these lines. In the event of sustained outages (such as sleet storms) the units may be relocated to harder hit areas in order to provide power until such time as line crews can rectify the damage to the transmission and distribution system. Finally, portable generation can be employed during scheduled line and/or substation work in order to minimize or prevent outages required to complete the work.

The availability of portable generating units can significantly improve the reliability of electrical service to customers and can provide greater flexibility to operating and maintenance staff in providing this service. This study recommends that portable diesel units of larger size would better meet the intended purposes of reducing customer outages in selected circumstances. The study further recommends preferred locations to station the portable diesel units on a semi-permanent basis.

To service the full load of the majority of NP's feeders, a total portable diesel generating capacity of at least 5 MW is required. It is recommended that NP replace its existing two portable diesel-generating units with 5 MW of new portable diesel generating capacity through the 2003 and 2004 capital program in increments of 2.5 MW per year. This capacity is expected to be available in 2 self-contained 2.5 MW diesel units capable of being used separately or in tandem. The cost of both units and ancillary equipment is estimated at approximately $3,000,000. Fully refurbished diesel units should be considered as an alternative if available.

It is recommended that one of these units be located on a semi-permanent basis at a substation in the Avalon area (possibly Trepassey or Old Perlican) and another in the Stephenville area (possibly Abraham's Cove or Port Aux Basques).

Introduction

Newfoundland Power presently owns three portable generation units: one portable gas turbine (GT) and two portable diesels. The portable gas turbine is rated at 7200 kW. Portable diesel #1 is rated at 700 kW and Portable #2 is rated at 670KW. The *Existing Portable Diesel Generation – Condition Assessment & Review* recommended that due to their age and condition, the two portable diesel units be de-commissioned.

The benefits of portable generation may be divided into three categories:

- The reduced duration of customer outages when the unit(s) is deployed to hard hit areas during sleet storms or other similar events. In this case, the benefit is calculated as the number of customer minutes of outage on an individual feeder exceeding an initial duration of 24 hours (which represents the time required to mobilize, transport and set-up the generating unit).
- When not deployed as described above for long-duration outages, the portable generator(s) serves as local, end-of-line generation for customers served by radial transmission or distribution lines. In this role, the benefit is calculated in terms of customer minutes of outage exceeding an initial duration of 3 hours on the individual feeder where the unit is parked when not deployed elsewhere. The 3 hours represents the time required to start the unit and to begin supplying power at the unit's semi-permanent location.
- The reduced cost of certain line construction projects for which the use of portable generation will permit de-energizing the line and avoiding the premium costs associated with conducting the maintenance or reconstruction work using hot-line methods.

Through these categories of benefits, the availability of portable generating units can greatly improve the reliability of electrical service to customers and can provide greater flexibility to operating and maintenance staff in providing this service. The first two categories of benefits may be described in terms of reliability improvements (reductions in customer minutes of outage) while the third category may be expressed in terms of estimated dollar savings. This report assesses the benefits of portable generation in each of these categories. A recommendation is made regarding the siting of new portable generation and the general types and sizes of unit(s) that should be considered.

Reliability & Siting Analysis

Portable generating units are expected to serve two main reliability roles: mobile emergency generation and semi-permanent backup generation. Mobile emergency generation refers to the capability of these units to provide power to any area of the system that has sustained severe damage which is expected to require 24 hours or more to restore.

The second category of reliability benefits refers to the backup generating capability provided to the units' semi-permanent location. This could be a substation or feeder with less than desirable reliability and few economical options for improving this performance. Several locations are examined in detail in this report to assess the benefits that new generating capacity may provide

to each and recommendations are made as to the preferred semi-permanent location for the new units.

An estimate of the reliability improvements that the availability of portable generation would achieve at various locations was used as the basis for determining the optimum semi-permanent location of the unit(s). The improvement resulting from the semi-permanent location of the unit were a primary basis for this decision, but an analysis of which geographic areas of NP's service area would benefit most from the availability of mobile emergency generation was also considered.

As a means of estimating the improvement in reliability of service to customers, the analysis uses the corporate 10 year history of customer outages. The database used for this study is a record of every documented outage for the period from January 1992 to December 2001. Each record in the database contains the feeder on which the outage occurred, the duration of the outage, the number of customers effected, and further information such as why the outage occurred and whether it was a planned or unplanned outage.

While the past, in this circumstance, is the best information for projecting the future, it is not without its problems. There have been many improvements in the power system over the past ten years, and many of them focus on the areas that have the worst reliability. The use of the statistics for purposes of this analysis also focuses on the worst reliability areas. Care has to be taken in using the data, that a possible benefit of portable generation has not already been addressed through the rebuilding of a transmission line or feeder in recent years. In addition to reliability improvements in some areas, deterioration of other lines has also occurred and to some extent these two factors will offset one another. In general though, NP's system has seen a net improvement in reliability over the past 10 years and as a result the improved reliability estimated from this analysis may be slightly overstated.

Mobile Emergency Generation

An analysis of NP outage statistics (1992-2001) provides an indication of events that would call for the use of portable generating units. An example of such an event would be a major sleet storm, for which outage durations can be extremely long and few other practical reliability improvement options are available. These data also provide a basis for estimating the potential benefits (in terms of the reduction in customer minutes of outage) and capacity requirements of portable generating units. To begin with, the unscheduled outage data (including all categories of unscheduled loss of supply, unscheduled NP transmission, and unscheduled NP distribution) were filtered to display only those outages exceeding 24 hours in duration and affecting more than 50 customers. The 24-hour duration was selected as it is assumed to require a period of 24 hours to fully move the generating unit to the trouble location and begin supplying power to customers. That is it requires 18 to 24 hours to: diagnose the outage; make the decision to deploy portable generation; get the unit(s) to site; commission and pick up customer load.

Some outages (out of the filtered dataset) were excluded from the list if was determined that portable generation would not have been helpful in reducing the customer minutes of outage. Outages were removed from the list based on the following criteria:

- The outage was caused by a weather-related event that would have prevented transporting a portable generating unit to the area.
- The outage was located on an urban or suburban feeder for which the use of portable generation would be impractical due to restrictions in setting up and operating the unit.
- The outage was located on a feeder that has since been substantially reconfigured as part of other reliability initiatives.

Based on these criteria and the subjective assessment of the filtered outage data, a total of 11 events over the past 10 years were identified which would have benefited from the deployment of portable generation. Two of these 11 outages represent major storm events affecting one area of the province (shown as shaded rows in the table below). In these 2 cases, one location was chosen which would have been accessible to portable generation and which would benefit substantially from the presence of this generating capacity by shortening of the outage duration. These outages and the estimated reductions in customer minutes of outage are presented in Table 1. From these 11 events it was determined that over the past 10 years, the maximum number of customers experiencing an outage meeting the above criteria was 920. At an estimated average load per domestic customer of 5 kW, portable generating capacity of about 5 MW would be required to achieve all of the outage reductions in Table 1.

Table 1

Feeder	*Month*	*Peak Load (Mva-est.)*	*No. of Customers*	*Duration (min)*	*Customer-minutes*	*Reduction (cust-min)*
SPO-01	Mar 92	0.5	75	2,010	150,750	42,750
VIC-02	May 92	1.4	331	1,622	536,882	60,242
TRP-01	Feb 93	0.7	100	1,522	152,200	8,200
ILC-01	**Dec 94**	**5.2**	**920**	**2,486**	**2,287,120**	**962,320**
ABC-02	Dec 96	1.0	200	1,530	306,000	18,000
OPL-01	Mar 98	2.0	380	2,790	1,060,200	513,000
LAU-01	Apr 98	4.6	704	2,080	1,464,320	450,560
BLK-02	Aug 98	0.3	70	1,662	116,340	15,540
ABC-02	Feb 99	4.5	912	1,916	1,747,392	434,112
RVH-01	**Apr 99**	**4.7**	**875**	**5,966**	**5,220,250**	**3,960,250**
GBY-03	Dec 00	0.2	60	1,515	90,900	4,500
Maximum		5.2	920	**Totals**	13,132,354	6,469,474

The reductions in customer minutes of outage were determined on the basis of the generating capability being available within 24 hours of the start of the outage (i.e. the outage duration was shortened by outage time in excess of 24 hours). Using this methodology, 5 MW of portable generating capacity would result in an average annual reduction of 500,000 customer minutes of outage on the basis of mobile emergency generation alone.

Semi-Permanent Backup Generation Benefits

One of the challenges in this study is to identify possible substation locations to park the portable generating unit. In such circumstances, if an outage were to occur, it is assumed that it would take 3 hours on average to get the generation on-line. Substation locations are chosen (as

opposed to locations remote from the substations, out on the feeders) due to the difficulty in maintaining proper facilities, grounding and security at locations outside a substation yard. This was not considered a limitation for mobile emergency generation as described above.

In order to further analyze the semi-permanent backup generation benefits, a sub-database of outages was established that includes only outage durations of 3 hours or greater resulting from unplanned transmission failures or loss of supply. A further limitation of outages affecting greater than 50 customers was also applied. The benefit of portable generation was then calculated on the basis of only that portion of these outages in excess of 3 hours.

Table 2 contains a list of substations for which outages in excess of 3 hours were the most severe. The list of substations was shortened on the basis of the following criteria:

- total customer minutes of outages in excess of 3 hours greater than 1,000,000 customer minutes over the last 10 year period, or
- greater than 500,000 customer minutes over the last 5 year period, or
- the feeder outage durations in excess of 3 hours was greater than either 1,400 minutes over the last 10 year period, or
- greater than 700 minutes over the last 5 years

In examining the table, there are a significantly greater number of substations on this list in the last 10 year period than in the last 5 year period, even accounting for the much longer time frame. This likely reflects, in some measure, an improved electrical power system. In limiting the list to substations that exceed the severe criteria in all four categories, it is reduced to the following 4 stations: Abraham's Cove, Trepassey, Port Aux Basques and Old Perlican. Using this as a measure, it is proposed that one of the 2.5 MW portables be located at a substation in the Stephenville area and the other at an Avalon area substation. On the basis of its role as semi-permanent backup generation, 5 MW of portable generating capacity would result in an average annual reduction of 400,000 customer minutes of outage.

When considering the other substations appearing in Tables 1 and 2, it would seem that many of the less reliable areas in NP's system are be found in the Stephenville and Avalon areas. Therefore, locating portable generation in these areas will shorten the response time of these units in the majority of outages for which portable generation would be deployed. Potential sites in these areas include Abraham's Cove, Port Aux Basques, Trepassey and Old Perlican.

Construction

Portable generation can be utilized in conjunction with major transmission or distribution construction initiatives to provide greater flexibility in completing the necessary work. These units can be employed at the end of radial transmission or distribution lines to back-feed customers supplied by the lines being maintained or rebuilt.

TABLE 2: SUMMARY OF 3 HOUR OUTAGES FOR PORTABLE DIESEL STUDY
(includes only unscheduled outages of duration >3 hours due to transmission system related problems)
(only substations with worst performance shown)
outages during storms 199405-06 and 19941207-13 removed

SUBSTATION	10 YEAR OUTAGES (1992-2001) (sum of feeder outage durations > 180 minutes) (sum of customer minutes of outage > 180 minutes) (# of feeder outages in excess of 180 minutes)	5 YEAR OUTAGES (1997-2001) (sum of feeder outage durations > 180 minutes) (sum of customer minutes of outage > 180 minutes) (# of feeder outages in excess of 180 minutes)
HWD	**1,774** **1,455,832** 12	40 49,200 1
KBR	**1,780** **729,277** 20	448 158,182 8
MOL	**2,875** **2,523,812** 24	0 0 0
SJM	**2,453** **1,044,581** 16	0 0 0
CLK	**2,120** **1,945,912** 11	0 0 0
OPL	**1,917** **1,825,418** 22	**821** **823,316** 7
RVH	**1,700** **1,221,458** 8	172 111,198 2
TRP	**4,907** **3,693,727** 13	**2,274** **1,706,164** 3
MKS	**1,295** 500,519 7	**1,122** 425,734 5
TWG	1,305 649,360 15	**747** 371,104 9
LEW	1,191 **1,034,133** 14	0 0 0
ABC	**5,184** **4,158,196** 14	**4,258** **3,424,063** 6
DOY	**2,637** **2,462,915** 10	**976** 858,179 5
LGL	**3,003** **1,721,169** 27	**758** 446,771 8
PAB	**2,269** **1,599,857** 19	**1,585** **1,074,759** 11
ROB	**1,401** **1,527,129** 4	57 66,861 1
STG	**1,927** **1,109,656** 7	29 11,067 2

The benefits of having portable generation for construction support are:

- The decreased risks and increased productivity possible when working on de-energized lines (as opposed to hot-line work), and/or
- The reduction or elimination of outages to customers needed to complete such work.

Extensive discussions with current and former Regional Superintendents were conducted in an attempt to establish these benefits. These discussions indicated that the cost of hot-line work could be expected to be 2 times that of similar work under de-energized conditions. From this benefit, the costs associated with relocating and operating the portable generating unit(s) must be subtracted. The safety benefits cannot be quantified but should certainly be considered as a significant intangible benefit in this analysis.

Over the past 3 years, 5 Newfoundland Power line construction projects have utilized portable generation in order to avoid hot line work. The average annual cost of line labour on this type of project was $115,000. Assuming that this recent experience is representative of the future and that 5 MW of portable generating capacity is adequate to back-up the loads being served by these lines, the net present value of 5 MW of portable generation may be estimated to be $1,100,000 over the 30 year life of this asset, excluding operating and fuel costs. If these costs are included, the net present value is estimated to be $440,000 (see Appendix A).

Portable Generating Unit Selection and Cost Considerations

Two primary technologies are available for large portable generating units: gas turbines and diesels. The best choice of technology depends on several factors as discussed in Appendix B. In 1999, an RFI was issued for new and refurbished generating equipment suppliers. The responses from this RFI form the basis for much of the cost data and equipment descriptions contained in this report. Diesel units appear to be the preferred option for any new portable generation acquired by NP. Refurbished units should be considered if available in the appropriate unit sizes and configurations.

Appendix B also contains a budgetary cost estimate for the project and an estimate of the operating and deployment cost of portable generation.

Other Benefits

In addition to the two main categories of benefits described above, portable generating units also have some ancillary benefits. In areas where voltage problems may occur, portable generating units may be used to provide voltage support. For instance, when maintenance must be conducted on transmission line 123L at times of even average load on the Bonavista Peninsula, the 66 kV system (110L/111L) cannot maintain the required voltages without the help of portable generation or other means of voltage support such as a portable capacitor bank.

Recommendations

It is recommended that NP purchase 5 MW of new portable diesel generating capacity through the 2003 and 2004 capital programs as replacements for the two existing portable diesel generation units. This capacity is expected to be available in 2 self-contained diesel units capable of being used separately or in tandem. The cost of both units and ancillary equipment is estimated at approximately $3,000,000. Fully refurbished diesel units should be considered as an alternative if available.

The purchase of these units may be completed over two or more years (i.e. one 2.5 MW portable diesel unit in each year). However, to service the full load of the majority of NP's feeders, a total portable diesel generating capacity of at least 5 MW should eventually be permanently acquired. In cold load pickup situations (as will be the case in many instances for which these units will be employed), additional portable generating capacity may be required.

It is recommended that one of these units be located on a semi-permanent basis at a substation in the Avalon area (possibly Trepassey or Old Perlican) and another in the Stephenville area (possibly Abraham's Cove or Port Aux Basques).

Appendix A
Present Worth Analysis of Construction Benefits

Net Present Value Calculation
Construction Related Benefits of Portable Generation

Excluding Incremental Operating Costs

Year	Line Const. $	Deployment Cost	Hot Line Premium	Benefit	NPV	Cum. NPV
1	$ 115,000	$ 25,000	2	$ 90,000	$ 90,000	$ 90,000
2	$ 115,000	$ 25,000	2	$ 90,000	$ 83,721	$ 173,721
3	$ 115,000	$ 25,000	2	$ 90,000	$ 77,880	$ 251,601
4	$ 115,000	$ 25,000	2	$ 90,000	$ 72,446	$ 324,047
5	$ 115,000	$ 25,000	2	$ 90,000	$ 67,392	$ 391,439
6	$ 115,000	$ 25,000	2	$ 90,000	$ 62,690	$ 454,130
7	$ 115,000	$ 25,000	2	$ 90,000	$ 58,317	$ 512,446
8	$ 115,000	$ 25,000	2	$ 90,000	$ 54,248	$ 566,694
9	$ 115,000	$ 25,000	2	$ 90,000	$ 50,463	$ 617,157
10	$ 115,000	$ 25,000	2	$ 90,000	$ 46,943	$ 664,100
11	$ 115,000	$ 25,000	2	$ 90,000	$ 43,667	$ 707,767
12	$ 115,000	$ 25,000	2	$ 90,000	$ 40,621	$ 748,388
13	$ 115,000	$ 25,000	2	$ 90,000	$ 37,787	$ 786,175
14	$ 115,000	$ 25,000	2	$ 90,000	$ 35,151	$ 821,326
15	$ 115,000	$ 25,000	2	$ 90,000	$ 32,698	$ 854,024
16	$ 115,000	$ 25,000	2	$ 90,000	$ 30,417	$ 884,441
17	$ 115,000	$ 25,000	2	$ 90,000	$ 28,295	$ 912,736
18	$ 115,000	$ 25,000	2	$ 90,000	$ 26,321	$ 939,056
19	$ 115,000	$ 25,000	2	$ 90,000	$ 24,484	$ 963,541
20	$ 115,000	$ 25,000	2	$ 90,000	$ 22,776	$ 986,317
21	$ 115,000	$ 25,000	2	$ 90,000	$ 21,187	$ 1,007,504
22	$ 115,000	$ 25,000	2	$ 90,000	$ 19,709	$ 1,027,213
23	$ 115,000	$ 25,000	2	$ 90,000	$ 18,334	$ 1,045,547
24	$ 115,000	$ 25,000	2	$ 90,000	$ 17,055	$ 1,062,602
25	$ 115,000	$ 25,000	2	$ 90,000	$ 15,865	$ 1,078,467
26	$ 115,000	$ 25,000	2	$ 90,000	$ 14,758	$ 1,093,225
27	$ 115,000	$ 25,000	2	$ 90,000	$ 13,728	$ 1,106,954
28	$ 115,000	$ 25,000	2	$ 90,000	$ 12,771	$ 1,119,724
29	$ 115,000	$ 25,000	2	$ 90,000	$ 11,880	$ 1,131,604
30	$ 115,000	$ 25,000	2	$ 90,000	$ 11,051	**$ 1,142,655**

Including Incremental Operating Costs

Year	Line Const. $	Deployment Cost	Hot Line Premium	Benefit	NPV	Cum. NPV
1	$ 115,000	$ 80,000	2	$ 35,000	$ 35,000	$ 35,000
2	$ 115,000	$ 80,000	2	$ 35,000	$ 32,558	$ 67,558
3	$ 115,000	$ 80,000	2	$ 35,000	$ 30,287	$ 97,845
4	$ 115,000	$ 80,000	2	$ 35,000	$ 28,174	$ 126,018
5	$ 115,000	$ 80,000	2	$ 35,000	$ 26,208	$ 152,226
6	$ 115,000	$ 80,000	2	$ 35,000	$ 24,380	$ 176,606
7	$ 115,000	$ 80,000	2	$ 35,000	$ 22,679	$ 199,285
8	$ 115,000	$ 80,000	2	$ 35,000	$ 21,096	$ 220,381
9	$ 115,000	$ 80,000	2	$ 35,000	$ 19,625	$ 240,006
10	$ 115,000	$ 80,000	2	$ 35,000	$ 18,255	$ 258,261
11	$ 115,000	$ 80,000	2	$ 35,000	$ 16,982	$ 275,243
12	$ 115,000	$ 80,000	2	$ 35,000	$ 15,797	$ 291,040
13	$ 115,000	$ 80,000	2	$ 35,000	$ 14,695	$ 305,735
14	$ 115,000	$ 80,000	2	$ 35,000	$ 13,670	$ 319,404
15	$ 115,000	$ 80,000	2	$ 35,000	$ 12,716	$ 332,120
16	$ 115,000	$ 80,000	2	$ 35,000	$ 11,829	$ 343,949
17	$ 115,000	$ 80,000	2	$ 35,000	$ 11,004	$ 354,953
18	$ 115,000	$ 80,000	2	$ 35,000	$ 10,236	$ 365,189
19	$ 115,000	$ 80,000	2	$ 35,000	$ 9,522	$ 374,710
20	$ 115,000	$ 80,000	2	$ 35,000	$ 8,857	$ 383,568
21	$ 115,000	$ 80,000	2	$ 35,000	$ 8,239	$ 391,807
22	$ 115,000	$ 80,000	2	$ 35,000	$ 7,665	$ 399,472
23	$ 115,000	$ 80,000	2	$ 35,000	$ 7,130	$ 406,602
24	$ 115,000	$ 80,000	2	$ 35,000	$ 6,632	$ 413,234
25	$ 115,000	$ 80,000	2	$ 35,000	$ 6,170	$ 419,404
26	$ 115,000	$ 80,000	2	$ 35,000	$ 5,739	$ 425,143
27	$ 115,000	$ 80,000	2	$ 35,000	$ 5,339	$ 430,482
28	$ 115,000	$ 80,000	2	$ 35,000	$ 4,966	$ 435,448
29	$ 115,000	$ 80,000	2	$ 35,000	$ 4,620	$ 440,068
30	$ 115,000	$ 80,000	2	$ 35,000	$ 4,298	**$ 444,366**

Appendix B
Portable Generation
Selection & Cost Considerations

New Portable Generation

Two primary technologies are available for large portable generating units: gas turbines and diesels. The best choice of technology depends on several factors as will be discussed in the following sections. In 1999, an RFI was issued for new and refurbished generating equipment suppliers. The responses from this RFI form the basis for much of the cost data and equipment descriptions contained in this report.

Diesel Units

Diesel generating units are rugged and dependable. This technology is well proven in this province and elsewhere for portable applications. As a result, diesels are ideal for applications where they will be utilized by a variety of semi-skilled operators in diverse settings. The level of knowledge required to operate and maintain diesel units is well represented within Newfoundland Power and in numerous mechanical repair shops throughout the province. Any unscheduled downtime due to breakdowns is usually very brief, as the units can be quickly repaired. This makes diesels well suited to the emergency backup generator role.

Diesels also have superior load pickup capability. Due to their size and weight, diesel gensets have sufficient inertia to permit close to 100% load pickup without extreme frequency or voltage implications. This is a very desirable feature of emergency generators as the serviced loads can vary substantially and quickly. For a stationary gas turbine, the load can be sectionalized to overcome this limitation. However, as portable units are required for any number of locations on various feeders, sectionalizing the load becomes impractical.

The main disadvantage of diesel generating units is their size. While portable diesel units of up to 4 MW may be found, the largest practical size for a portable unit is 2-2.5 MW. As many of NP's rural feeders have peak loads in the range of 3-4.5 MW, a single diesel unit would not normally be adequate to backup a feeder. Therefore, multiple portable diesel units would be required to operate in tandem to serve most feeders. While this is technically feasible, it adds complexity in terms of the controls and switchgear required, the space required and the cost of moving and setting up such a configuration.

From a cost standpoint, diesel generating units are very economical. Based on the information obtained from the 1999 RFI, a cost curve ($/kW versus unit size) for diesel units was developed (see Figure 1 – bottom curve). This curve was based on new units only. Refurbished diesel units are also available, with discounts typically on the order of 25% of the cost of new units. The curve is based on a relatively small number of quotes and therefore the relationship described between cost and unit size should be considered as a rough guideline only. In the 1.0-2.5 MW range, the cost ($/kW) of diesel units is nearly constant with respect to unit size at approximately $450/kW. These costs include the unit, generator, controls, and transport chassis. Costs associated with transformation, additional switchgear, fuel storage, and site preparation would be over and above this figure.

Gas Turbine Units

Gas turbines are more compact for the same load capability, and therefore may be considered better suited for portable applications where loads exceed 2.5 MW. While NP has owned and operated gas turbine generating units for many years, the required operating knowledge and experience is limited to the two areas of the island where these units have historically been stationed: Burin and Port Aux Basques.

Gas turbines are more complex to operate and troubleshoot and therefore the training required to develop a capable operator(s) is more involved than would be the case for diesel units. Gas turbines are also considerably more complex to maintain. Unscheduled (breakdown) maintenance of this type of unit may require out-of-province expertise to get the unit back in service.

Unlike diesel units, the load pickup capability of gas turbines is limited. Gas turbines are far lighter per unit of electrical power output and therefore they are limited to about 10% load pickup capability (or a maximum of 25% under extreme frequency and voltage conditions). As noted previously, load pickup capability is an important feature of emergency generating units as the majority of starts will be to provide power to customers who have experienced prolonged outages and in circumstances of considerable local (or even widespread) system damage.

The cost of mobile gas turbine generating units is substantially higher than that of diesel units. Again using the quotes obtained from the 1999 RFI, a cost curve for gas turbines was developed (Figure 1 – black curve). This curves was also based on new units only, with refurbished gas turbine units available at discounts typically on the order of 40-50%. The gas turbine curve is also based on a small number of quotes and therefore the relationship described between cost and unit size should be considered as a rough guideline only. In general, the cost per kW of gas turbine units is relatively constant at unit sizes greater than about 4.5 MW. Smaller gas turbine units become more costly per kW as unit size decreases. These costs per kW include the unit, generator, controls, and transport chassis. Costs associated with transformation, additional switchgear, fuel storage, and site preparation would be over and above this figure.

Costs of Deploying Portable Generation

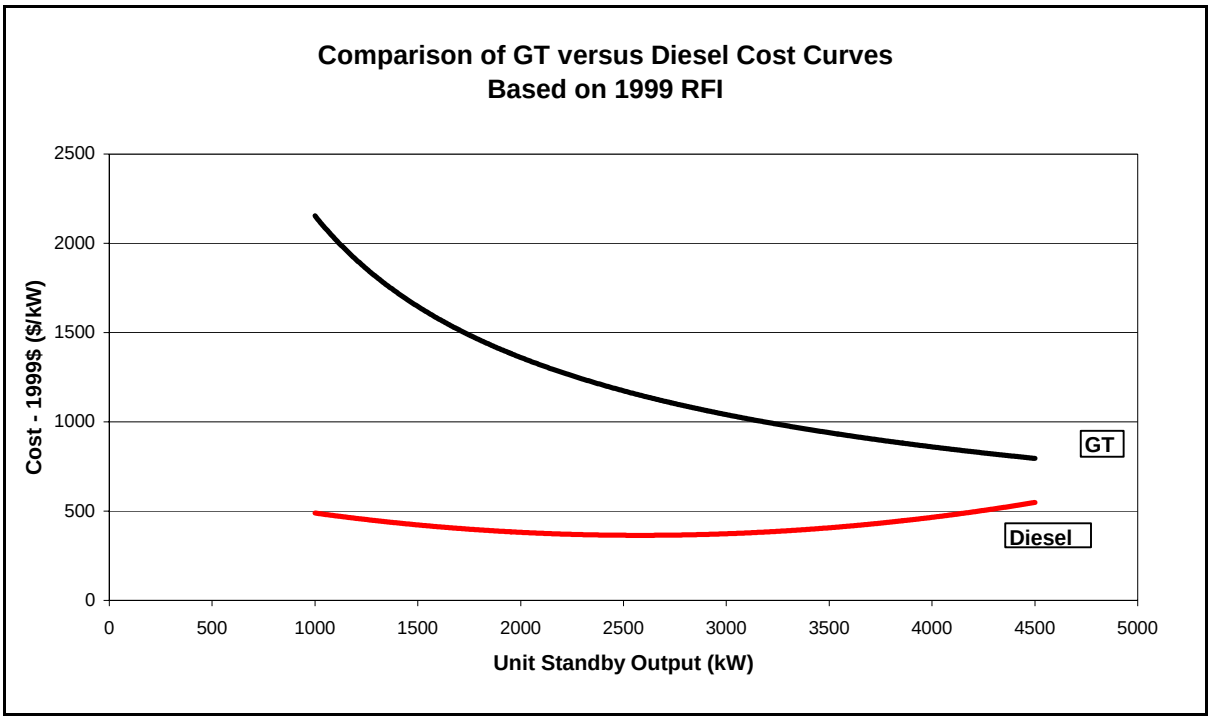
It is difficult to obtain actual costs associated with the deployment of NP's portable generating units. In addition to the infrequency with which NP's portable generation has historically been deployed, there appears to have been little effort made to track the specific costs associated with the set-up, breakdown and maintenance of the portable generators during such events.

However, for the purposes of this report these costs must be estimated. Based on input from Regional Superintendents, it has been determined that set-up of a single portable generating unit can be completed by 2 persons in approximately 6 hours, once the unit is on-site. For many locations, a line crew will also be required for at least a portion of this time. An itemized cost estimate for a typical set-up is attached to this report. Based on these figures, an order-of-magnitude cost estimate of $15,000 will be used for this study. Total net operating cost (excluding mobilization costs) may be roughly estimated at $650 per hour of operation.

For the purposes of this study, a lump sum cost of $500,000 has been added to the total cost estimate to provide for flexibility in the design of controls, switchgear and transformation options. In order to maximize the benefits of any portable generating units purchased, these items will be essential components of the overall configuration. A more detailed cost estimate is contained on pages 4 to 7 of this report.

In addition to the above costs, further allowances must be made for the provision of fuel storage and handling systems to accompany the unit(s). Each 25,000 liter double-walled tank (including lines) will cost approximately $40,000. An allowance of $45,000 has also been included in the project budget for substation and/or line modifications at the unit(s) semi-permanent location.

Figure 1



Portable Generation Study
New Mobile Diesels - Cost Estimate

ITEM				TOTAL
Mobile Diesel Unit # 1	2500 kW	@	$450 /kW	$1,125,000
Mobile Diesel Unit # 2	2500 kW	@	$450 /kW	$1,125,000
Fuel Tanks	2 x 25,000 l	@	$40,000 ea.	$80,000
Site Modifications (incl. grading & grounding)	2	@	$12,500 ea.	$25,000
Line Modifications	2	@	$10,000 ea.	$20,000
Transformation/Controls Allowance	2	@	$250,000 ea.	$500,000
Contingency		@	20%	$125,000
Project Total				**$3,000,000**

Notes:

1. Cost per kW of mobile diesel generation assumes new units. This may be lowered through purchase of refurbished unit(s).
2. Contingency NOT applied to purchase cost of mobile diesel unit(s).

Mobile Diesel Operating Costs Estimation Program

Cells highlighted Yellow may be modified to suit the particular situation.
Cells highlighted Light Green are calculations and should not be modified.

Fixed Assumptions		
Cost of No.2 Diesel Fuel =	$ 0.35	$ / Litre
Full Load Fuel Consumption =	2,000	Litres/hour
Fuel Tanker Rental =	$ -	$ / day
Maintenanceman Rate =	$ 30.00	$ / hour (includes Overhead for Vacation, CPP, etc.)
Rated Unit Capacity =	5,000	kW
Purchased Power Rate =	$ 0.04531	$ / kWh
Variables		
Days of Operation =	6	days
Hours per Day of Operation =	8	hours
Total Operating Hours =	48	hours
Fraction of Full Load Operation =	75%	%
Electrical / Mechanical / Labour	2	(# employees to operate turbine)
Employees Requiring Hotel =	2	(# of employees requiring hotel rooms)
Airfares Required	2	(# of employees requiring airfare)
Rental Vehicles Required =	2	
Calculations		
Fuel Costs		
Total Fuel Consumption =	84,000	Litres
Total Cost of Fuel Consumed =	$ 29,400.00	
Labour		
Craft Labour Costs	$ 2,880.00	
Supervisory Labour Costs	$ 420.00	(Supervisory Labour 1/4 Time @ $35/hour)
Total Labour Costs	$ 3,300.00	
Miscellaneous Costs		
Boom Truck Rental	$ 250.00	
Fuel Tanker Rental	$ -	
Consumables ($250/day) =	$ 1,500.00	
Hotel Expenses	$ 900.00	($75/day/employee)
Per Diem Expenses	$ 516.00	($43/day/employee)
Air Fare Expenses	$ 1,700.00	($425/employee/week)
Rental Vehicles	$ 900.00	($75/vehicle/day including fuel costs)
Mobilization Expenses =	$ 7,397.50	
Demobilization Expenses =	$ 7,397.50	
Subtotal =	$ 53,261.00	
Contingency (@ 5%) =	$ 2,663.05	
Total Job Costs =	**$ 55,924.05**	
Maximun Anticipated Production =	180,000	kWh
Produced Power Cost =	**31.07**	cents per kWh
Reduced Purchased Power Credit =	$ 8,155.80	
Net Job Cost =	**$ 47,768.25**	

Mobile Diesel Mobilization Costs

(Involves Moving Diesel from "Home Base" to Remote Site)

Cells highlighted Yellow may be modified to suit the particular situation.
Cells highlighted Light Green are calculations and should not be modified.

Fixed Assumptions			
Maintenanceman Rate =	$ 30.00	$ / hour	(includes Overhead for Vacation, CPP, etc.)
Tractor Trailer Rental Cost =	$ 1,000.00	$ / trip	
Variables			
Mobilization/Setup Days =	2.5	days	
Hours per Day of Work =	8	hours	
Total Labour Hours =	20	hours	
Electrical / Mechanical / Labour=	3		(# employees to tear down and setup turbine)
Airfares Required =	2		(# of employees requiring airfare)
Employees Requiring Hotel =	4		(# of employees requiring hotel rooms)
Tractor Rentals Required =	2		(# of Tractor Units for Hauling Unit)
Rental Vehicles Required =	2		
Labour			
Craft Labour Costs	$ 1,800.00		
Supervisory Labour Costs	$ 175.00		(Supervisory Labour 1/4 Time @ $35/hour)
Total Labour Costs	$ 1,975.00		
Miscellaneous Costs			
Boom Truck Rental	$ 500.00		
Tractor Trailer Rentals	$ 2,000.00		(2 Tractor Units required)
Consumables ($250/day) =	$ 625.00		
Hotel Expenses	$ 750.00		($75/day/employee)
Per Diem Expenses	$ 322.50		($43/day/employee)
Air Fare Expenses	$ 850.00		($425/employee/week)
Rental Vehicles	$375.00		($75/vehicle/day including fuel costs)
Total Mobilization Costs =	**$ 7,397.50**		

Mobile Diesel Demobilization Costs

(Involves Moving Diesel from Remote Site to "Home Base")

Cells highlighted Yellow may be modified to suit the particular situation.
Cells highlighted Light Green are calculations and should not be modified.

Fixed Assumptions			
Maintenanceman Rate =	$ 30.00	$ / hour	(includes Overhead for Vacation, CPP, etc.)
Tractor Trailer Rental Cost =	$ 1,000.00	$ / trip	
Variables			
Mobilization/Setup Days =	2.5	days	
Hours per Day of Work =	8	hours	
Total Labour Hours =	20	hours	
Electrical / Mechanical / Labour=	3		(# employees to tear down and setup turbine)
Airfares Required =	2		(# of employees requiring airfare)
Employees Requiring Hotel =	4		(# of employees requiring hotel rooms)
Tractor Rentals Required =	2		(# of Tractor Units for Hauling Unit)
Rental Vehicles Required =	2		
Labour			
Craft Labour Costs	$ 1,800.00		
Supervisory Labour Costs	$ 175.00		(Supervisory Labour 1/4 Time @ $35/hour)
Total Labour Costs	$ 1,975.00		
Miscellaneous Costs			
Boom Truck Rental	$ 500.00		
Tractor Trailer Rentals	$ 2,000.00		(2 Tractor Units required)
Consumables ($250/day) =	$ 625.00		
Hotel Expenses	$ 750.00		($75/day/employee)
Per Diem Expenses	$ 322.50		($43/day/employee)
Air Fare Expenses	$ 850.00		($425/employee/week)
Rental Vehicles	$375.00		($75/vehicle/day including fuel costs)
Total Demobilization Costs =	**$ 7,397.50**		