Q. **Reference: "2022/2023 General Rate Application," Newfoundland Power, May 27, 2021, Volume 2, Section 3.**

Please provide any reports and the data and data analysis prepared on the future of Newfoundland Power's existing gas turbine facilities.

A. Newfoundland Power has 4 separate gas turbine facilities. These gas turbines are used to provide standby and emergency generation, both locally and for the Island Interconnected System, and to minimize customer outages during scheduled maintenance on transmission, distribution or substation assets.

Three of the units are stationary. These include the Wesleyville gas turbine, Greenhill gas turbine, and the Mobile Gas Turbine ("MGT").[1] One of the gas turbines, Mobile Gas Turbine #2 ("MG2"), is a mobile unit.

The Wesleyville gas turbine was brought into service in 1969. MGT was brought into service in 1974. The Greenhill gas turbine was brought into service in 1975. MG2 was brought into service in 2019.

A report on the condition and remaining service life of the MGT and the end of its service life as a mobile unit is provided in Appendix A to the report *Purchase Mobile Generation* filed with Newfoundland Power's *2018 Capital Budget Application*.[2] Attachment A provides the report *Purchase Mobile Generation*.

Both the Greenhill and Wesleyville gas turbines are nearing the end of their service life. Attachment B includes an engineering assessment completed by Stantec Consulting Ltd. in December 2020 of the Greenhill and Wesleyville gas turbines including options for refurbishment or replacement. This engineering assessment is part of an ongoing system planning study to inform the long-term plan for these gas turbines.

---

[1] MGT is no longer able to be transported due to the deteriorated condition of the trailer chassis. It is now permanently stationed at the Company's Grand Bay ("GBS") Substation on the southwest coast of Newfoundland.

[2] See Newfoundland Power's *2018 Capital Budget Application, Report 1.2 Purchase Mobile Generation*.

Newfoundland Power
Purchase Mobile Generation
July 2017

Purchase Mobile Generation

July 2017

Prepared by:

Monty Hunter, P. Eng.

REGISTERED PROFESSIONAL ENGINEER
M. C. HUNTER
SIGNATURE
June 23, 2017
PROVINCE OF NEWFOUNDLAND

Table of Contents

1.0 Introduction

Newfoundland Power owns one mobile gas turbine ("MGT"), which is rated at 6,750 kW and one mobile diesel generator, which is rated at 2,500 kW. A condition assessment done on the MGT in 2015 recommended that it soon be retired from mobile operation due to the deteriorating condition of the trailer chassis.[1] In addition to the issues with the trailer chassis, prime mover components, namely the Orenda gas generator and power turbine, are no longer manufactured. The dwindling number of similar units in service has resulted in fewer overhaul facilities with the necessary expertise to refurbish this equipment.

The existing MGT has been traditionally used for: (i) support for customer outages; (ii) construction projects; and (iii) system support. The availability of mobile generation can ensure the reliability of electrical service to customers and provide flexibility to operating and maintenance staff when responding to extended customer outages in both planned and unplanned situations.

The existing MGT is 43 years old and approaching the end of its service life. This report provides an assessment of the benefits of maintaining mobile generation and options for replacing the MGT.

2.0 Function of Mobile Generation

2.1 Support for Customer Outages

Mobile generation serves 2 main reliability roles: emergency generation and system backup generation. Emergency generation is the capability to provide power to an area of the system that has sustained severe damage where it is expected to take more than 48 hours to repair the damage.[2]

System backup generation is a benefit provided to areas that have below average reliability and few economical options for improving reliability performance through traditional means. Mobile generation can serve as end-of-line generation for customers served by radial distribution or transmission lines. In this case, when not required for construction projects or long-duration emergency outages, mobile generation is stored at a location that would reduce outage time in the event of issues with the radial lines.

The existing MGT had been historically stationed at the Grand Bay Substation in Port aux Basques during the winter months due to the risk of outages on Newfoundland and Labrador Hydro's ("Hydro") TL214 and TL215 – the 2 radial transmission lines that supply the Port aux Basques area. Reliability improvements have been made to transmission lines TL214 and TL215 by Hydro and, as a result, the MGT has been stationed elsewhere during the winter months.[3]

1 A copy of the MGT condition assessment is included as Appendix A to this report.

2 The MGT typically takes 48 hours to dismantle, transport, reassemble and prepare for generation. The existing MGT has been deployed several times over its service life to Bonavista, Bell Island and the Trepassey areas due to transmission line issues caused by severe weather events.

3 The MGT returns to Grand Bay Substation for planned annual maintenance outages on the Hydro transmission lines.

Most recently, the MGT has been stationed on the Avalon Peninsula during the winter months. For portions of the 2012-13 and 2013-14 winter seasons, prior to the installation of the black start diesel generators at Hydro's Holyrood Thermal Generating Station, the MGT was stationed at Holyrood to support station service requirements. The MGT was then stationed at Whitbourne during the winter of 2014-15 and 2015-16. The rationale for locating the MGT at Whitbourne was that it is more central for emergency dispatch, as well as being able to provide generation support, if required, to the Avalon Peninsula during times of high demand or low generation. In December 2016, the MGT returned to Port aux Basques to provide generation support following the loss of a single turbine at the Rose Blanche Hydroelectric Plant.[4]

2.2 Construction Projects

Mobile generation is used during selected construction projects to minimize the number and duration of customer outages. Depending on the location and amount of line or substation work involved, mobile generation is an alternative to hot-line work to minimize the duration of customer outages. Otherwise, hot-line work methods must be employed if customer outages are to be avoided.[5]

For example, to replace structures on a radial transmission line serving remote, rural communities, mobile generation may be able to supply these customers while the transmission line is de-energized, allowing work to proceed. In this situation, customers would typically experience a brief switching outage in the morning and evening of each day that construction proceeds. Otherwise, customers would experience long duration daily outages for the planned construction until the project is completed.

In 2015, Newfoundland Power deployed the MGT in 4 locations to avoid hot-line work and extensive customer outages: Trepassey, Abrahams Cove, Lewisporte and Twillingate. In these cases, approximately 28 million customer outage minutes were avoided. The MGT also operates regularly at Port aux Basques where it is used along with the mobile and Port aux Basques diesel generators, as well as the Rose Blanche hydro plant, during Hydro's annual maintenance on transmission lines TL214 and TL215. In 2015, in Port Aux Basques it was used to avoid approximately 6 million customer outage minutes and in 2016 it was used to avoid approximately 4 million customer outage minutes. It was also used at the Pulpit Rock Substation (Torbay) to complete scheduled transmission line maintenance in 2016, avoiding approximately 725,000 customer outage minutes.

2.3 System Support

Mobile generation can be used to provide generation and voltage support to the Island Interconnected System during times of high demand or low generation reserve.

[4] It is anticipated that the MGT will remain in Port aux Basques for the winter of 2017/2018 as the refurbishment of the Rose Blanche turbine will not be completed prior to the onset of winter.

[5] Working on energized equipment requires the use of hot-line work methods, which have inherent safety risks and additional costs associated with extended time to complete certain construction projects.

As noted by the historical operation in Figure 1, the existing MGT has been utilized significantly to provide system support at the request of Hydro. In addition, in areas where voltage problems may occur, the MGT has been dispatched to provide voltage support.

3.0 Historical Operation of MGT

A review of the past 10 years of operation indicates that the average annual generation for the MGT is 488 MWh at an average load of 3.51 MW. The past 5 years of operation had an average annual generation of 639 MWh at an average load of 3.96 MW. A summary of the historic operation of the MGT over the 10 and 5-year periods is shown in Figure 1.

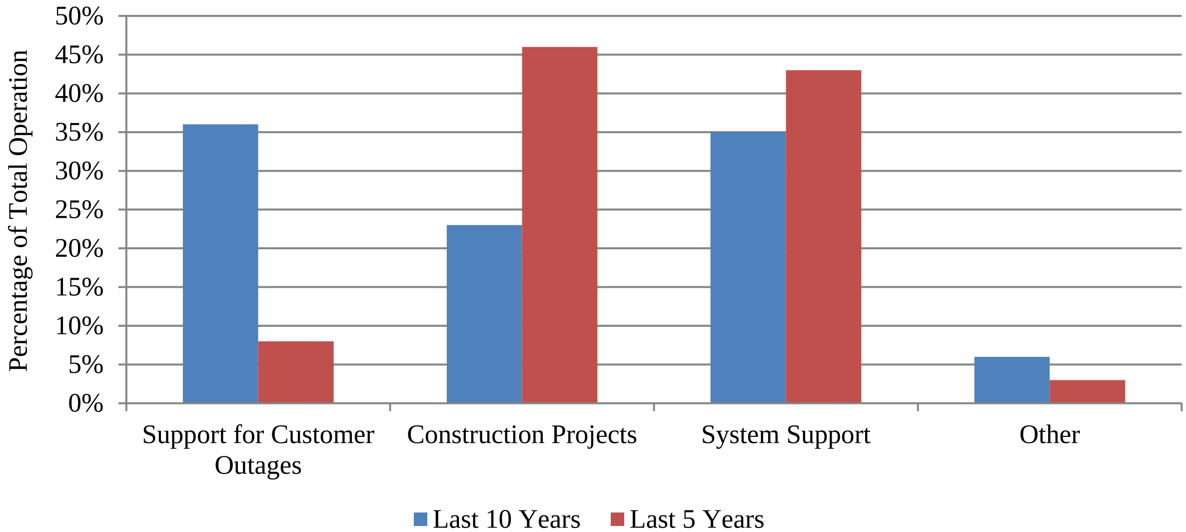


Figure 1: Historical Operation of MGT by Function

The use of the MGT for system support has increased in the last 5 years. This can be attributed to it being located on the Avalon Peninsula during this period, and the more frequent requests by Hydro for generation support related to the Avalon Peninsula reserve requirements. The use of the MGT to support customer outages has been less in the last 5 years than it was during the past 10 years. This is related to the timing of storms that caused damage to the Company's transmission and distribution systems.[6]

[6] For example, in March 2010, the MGT was stationed at Catalina on the Bonavista Peninsula and at Old Perlican on the Avalon Peninsula to provide emergency generation following a severe ice storm. During these outages the MGT operated for 123 hours producing 442 MWh of generation.

4.0 Existing MGT Condition

In 2015, a condition assessment was completed on the major components of the existing MGT.[7]

The gas generator was last overhauled in 2003. This component and the power turbine are no longer supported by the original equipment manufacturer. The instrumentation and controls were also upgraded in 2003 with the addition of programmable logic controls, digital synchronizer, voltage regulator and relays, as well as new field sensors, such as vibration and exhaust gas temperature sensors. The switchgear and power transformer are original, but underwent major overhauls in 2003.

The trailers that house the gas turbine components are deteriorating. The undercarriage is susceptible to heavy corrosion with major repairs done in 2010. In late 2016, extensive chassis and axle repairs to the two trailers were again necessary to make the MGT roadworthy. The undercarriage continues to deteriorate. The enclosures are also in very poor condition with water leaks into the trailers occurring.[8]

As a result of the poor condition of the trailers that support and house the gas turbine components, the existing MGT will be retired from mobile service over the next 3 years and then moved to a permanent location until the other major components reach the end of their service lives, which is anticipated to be between 5 and 10 years for each of the various subsystems.[9]

5.0 Mobile Generation Options

Utility-sized mobile generation units are typically provided using 2 types of technology: diesel generators and gas turbines. The appropriate choice of technology depends on several factors.

Diesel generation technology is well proven. Newfoundland Power has 2 diesel generators, including a 2.5 MW stationary unit located at Port aux Basques Substation and a 2.5 MW mobile unit (MD3) purchased in 2003. In addition, Hydro has several large stationary units located on both rural interconnected and isolated networks.[10] As a result, the resources to operate, service and maintain utility-sized diesel generators are readily available in the province.

Due to their inherent high rotating inertia, diesel generators have good load pickup capability. The major disadvantages of mobile diesel units are their physical size and weight. The largest practical size of a mobile diesel is 2.0 MW to 2.5 MW. Newfoundland Power's rural feeders typically have peak loads in the 3.0 MW to 4.5 MW ranges, so multiple diesel units would be required to serve most locations. Operating multiple diesel generators in parallel increases the complexity of necessary control equipment and operation.

[7] A copy of the MGT condition assessment is included as Appendix A to this report.
[8] Pictures 13 through 25 of Attachment B to Appendix A show the extent of the deterioration that exists on the undercarriage and enclosure.
[9] Table 3 of Appendix A includes information on the remaining service life of the various subsystems that comprise the MGT.
[10] Hydro also has a number of black-start diesel generators at the Holyrood Thermal Generating Station capable of providing support to the Island Interconnected System.

Gas turbines are more compact than diesels for the same load generating capacity and are better suited for applications where the load requirements exceed 2.5 MW. Newfoundland Power has operated gas turbines for many years, including the existing MGT along with the Wesleyville and Greenhill gas turbine facilities. Gas turbines are more complex to operate and maintain than diesel generators, but Newfoundland Power has experienced personnel qualified to operate and maintain gas turbines. As well, out-of-province expertise is readily available to assist, if required.

In some situations, the load pickup capability of a gas turbine is more limited than that of a diesel generator, but this may be managed by sectionalizing the distribution system to operate within the unit's limitations.

Given the size of the loads typically required, based on historical operation of the existing MGT, a new mobile gas turbine will be purchased to replace the existing unit.

The criteria for the new gas turbine will be:

- Fully self-contained and able to be set up with minimum site preparation;
- Capable of burning locally available No. 2 diesel fuel;
- Have black start capability (i.e., no external AC power available);
- Able to operate isolated (isochronous) or in parallel with the provincial power grid;
- Complete with a step-up transformer capable of providing 60 Hz power at both 12,500 and 25,000 volts through the use of field-selectable taps;
- Compliant with current industry, regulatory, environmental and safety performance standards; and
- Capable of travelling the province's roads and bridges.[11]

6.0 2018 Project

6.1 Project Description

Potential suppliers have been identified to determine the available unit sizes and approximate purchase cost. There are units available in the 3.5 MW to 7.5 MW range, which is suitable for most applications. High-level pricing was obtained and internal costs added to determine a probable cost range. The unit supply costs obtained were in US dollars and are susceptible to the changing currency rate. For the units identified, the estimated costs are between $12,000,000 and $14,000,000, for an all-in, per-kW cost of $2,600/kW to $2,770/kW.[12] Deliveries for the new unit, from date of ordering, would be approximately 12 months. Engineering, procurement, and commissioning is expected to be done over an 18-month to 24-month period.

An alternative to procuring a new unit would be to procure 10 to 15-year-old, zero-hour rated, refurbished unit. This may result in lower equipment cost, but a full evaluation of the equipment would be necessary. All major components would need to be commercially available and supported by the original equipment manufacturer. As well, all controls, protection and

[11] The maximum allowable weight per single axle is 9,000 kg and 17,500 kg per tandem axle.
[12] All cost estimates are in Canadian dollars.

switchgear would need to be upgraded to modern standards. Trailer sub frames and enclosures would need to be in excellent condition and suitable for the provincial climate and road conditions.[13]

A Request for Proposals will be prepared for both new and refurbished portable gas turbine units in the 3.5 MW to 7.5 MW range.

An analysis will be completed to determine the optimum location for stationing the new MGT when it is not required for immediate service so it can provide system backup generation. This will be done by considering the potential reliability improvements that could be achieved at various substations if the unit were located there. This will be balanced against accessibility for dispatch to other areas of the system, should it be required for emergency service.

6.2 Project Cost

The total project cost for the supply of a new mobile gas turbine is estimated at $13,915,000. Table 1 below summarizes the cost breakdown.

Table 1
Project Cost
(000s)

Cost Category	2018	2019	Total
Material	$4,731	$5,869	$10,600
Labour - Internal	35	195	230
Labour - Contract	-	-	-
Engineering	154	231	385
Other	1,080	1,620	2,700
Total	**$6,000**	**$7,915**	**$13,915**

7.0 Conclusion

A detailed engineering assessment has been completed of the existing MGT and, given the overall poor condition of the chassis and enclosures, the unit will be retired from mobile service within the next 3 years.

A new mobile gas turbine system in the 3.5 MW to 7.5 MW size range is required to provide support for customer outages, construction projects, and system support to the Island Interconnected System.

Based upon the condition of the existing MGT and the considerations outlined in this report, the project will proceed over the 2018-19 timeframe.

[13] The opportunity to purchase a refurbished unit will depend upon the availability of such units at the time the RFP is released. The market for these type units is small and the availability of suitable units cannot be easily predicted.

Appendix A:
Mobile Gas Turbine
Condition Assessment

December 2015

Table of Contents

1.0 Introduction

The mobile gas turbine ("MGT") is a 6,750 kW combustion turbine assembled on 2 trailers. One trailer houses the gas generator, power turbine, speed reduction gearbox and AC generator. The second trailer houses the unit switchgear, controls, batteries and chargers, power transformer, recloser and auxiliary power unit. Fuel for the gas turbine is provided either by a separate stationary dyked storage tank in some areas or by leased tanker trucks in other areas. The single line diagram for the existing MGT is provided in Attachment A.

The MGT is utilized for emergency power in the event of system outages following storms or other significant events. It is also used during construction projects on transmission and distribution lines to reduce the need for hot-line work and to minimize outages to customers during construction projects.

The typical life expectancy of a gas turbine is 25 years. The MGT was purchased in 1974 and has undergone several upgrades, including gas generator overhauls and control system upgrades. This has extended the unit's service life.[1]

Deterioration and aging of the non-gas turbine components are becoming the determining factors on the unit's service life. A review of the various components has been undertaken to provide a recommendation for the MGT's future.

2.0 Description

2.1 Gas Generator

The gas generator is an Orenda OT-390 Model 2G originally manufactured by Hawker Siddeley, Orenda Aerospace division. The unit has undergone 2 overhauls: 1 in 1990 by Hawker Siddeley and the most recent in 2003 by S&S Turbine Services Ltd. At the time of the 2003 overhaul, the unit was found to be in good overall condition. The most recent boroscope inspection was done in March 2015 by S&S Turbine Services during a vibration investigation. Generally, the unit was found to be in good condition.[2]

2.2 Power Turbine

The power turbine (Orenda, OT-3, Model 6) was also manufactured by Hawker Siddeley, specifically for use with the gas generator. During the gas generator refurbishment in 2003, the stage 2 turbine nozzles were replaced with refurbished parts. In 2010, the power turbine inlet duct underwent repairs.

[1] The MGT's maintenance history is included in Attachment C.
[2] The S&S Turbine Services March 2015 inspection report is included in Attachment D.

2.3 Speed Reduction Gearbox

The speed reduction gearbox was manufactured by Philadelphia Gear. The gearbox reduces the output speed of the power turbine from 7,200 rpm to 3,600 rpm required by the AC generator to operate at synchronous speed. The gearbox also drives the power turbine lubricating pump.

There is no record of any major maintenance being required on this component and it has operated reliably.

2.4 AC Generator

The AC generator was manufactured by Electric Machinery Manufacturing Company and operates at 4,160 volts at 3,600 rpm. There has been no major maintenance done on the generator over its life. Generator service life is typically 30 to 40 years. Normal testing has not indicated any issues with the AC generator.

2.5 Instrumentation/Controls

The original controls were replaced in 2003 by Allan Bradley programmable logic controller based controls, synchronizer and digital voltage regulator.[3] New digital relays, vibration monitoring system, exhaust gas temperature thermocouples and speed sensing were installed. New power cables and a new motor control centre were installed.

2.6 Switchgear

The switchgear, including the unit breaker, is original equipment. The last major maintenance performed on the switchgear was completed during the 2003 MGT overhaul.

2.7 Auxiliary Power Unit

The auxiliary power unit is a 40 kW, 208 volt, 3-phase Kohler diesel generator used to provide station service and for starting the gas turbine under black start conditions. The original auxiliary power unit was replaced in 1995 with the current unit. No major maintenance has been done on the Kohler diesel generator. The exterior enclosure is exhibiting rust, as are some minor components of the engine auxiliaries.

2.8 Power Transformer

The power transformer is original, manufactured by Federal Pioneer, and is rated at 7.5 MVA. The transformer can be configured to operate at 2 different voltages: 25 kV and 12.5 kV. Most frequently, it is used at the 12.5 kV voltage level.

[3] The Allan Bradley programmable logic controller based controls, synchronizer, and digital voltage regulator are standard technologies used by Newfoundland Power in all of its gas turbines and hydro plants that have been refurbished since 2000. Standardizing on these digital technologies, and their most recent upgrades, has reduced the cost of training and spares inventory to support these critical control systems.

The last major maintenance performed on the power transformer was completed during the 2003 unit overhaul. Other than regular maintenance, the power transformer has not undergone any major upgrades since 2003.

2.9 Trailers

The gas turbine components are mounted on 2 trailers originally manufactured by Bartlett Trailer Corporation. The undercarriage structures have experienced heavy corrosion. The undercarriage was assessed by Hatch in 2010. As a result of the assessment, the cross members were replaced and undercoating repaired. Also in 2010, the trailer suspension, wheels and brakes of both trailers were inspected and repairs were made where necessary.

The repairs done are considered a short-term measure to keep the unit operational. Recent inspections indicated that the chassis still appears to be in reasonable condition, but the undercoating is starting to deteriorate again and, as a result, the underlying steel components are exposed to the elements and corrosion is prevalent throughout.[4]

The enclosures on the trailers that house the equipment are in very poor condition. There is some damage to the enclosure envelope, allowing water to leak into the enclosures, which could jeopardize the equipment inside. Where possible, leaks are repaired, but often reoccur once the unit is moved. The doors and sills are in particularly poor condition.

In addition to the condition of the trailers, there is a safety concern associated with accessing the tops of the trailers to install the power cables, remove covers and install the exhaust stacks. The existing roof-mounted railing system was retrofitted to the trailers and is of the collapsible type, which is stored for transportation. The railing system is slight. It is not possible to install a more rigid system as the enclosures do not have adequate structure to which the railings can be attached. Maintenance staff currently uses a boom truck to connect fall arrest lanyards or, where there is inadequate room for this, scaffolding is erected to provide a safety barrier.

[4] Attachment B has numerous photographs showing the condition of the undercarriage.

3.0 Operating History

The annual production of the MGT over the past 10 years is shown in Table 1.

Table 1
Annual Production

Year	Generation (kWh)	Run Time (hours)	Avg. Generation Load (kW)
2006	155,183	36.95	4,199.8
2007	98,489	34.62	2,844.9
2008	652,193	215.42	3,027.5
2009	189,620	66.76	2,840.3
2010	614,866	172.44	3,565.7
2011	126,928	42.65	2,974.4
2012	388,811	125.23	3,104.8
2013	241,828	73.75	3,279.0
2014[5]	960,984	195.60	4,913.0
2015[6]	1,160,140	338.27	3,429.6
Average	**473,137**	**130.17**	**3,418.07**

The average annual production over the past 10 years was 473 MWh, with an average load supplied of 3.42 MW.

4.0 Incapability Factor

A unit's incapability factor ("ICBF") is the ratio of the total equivalent outage time to the number of hours the unit has been in service. The total equivalent outage time includes the total forced outage time, planned outage time, and maintenance time, as well as adjusted derated times. Adjusted derated time is the time transformed into an equivalent outage time. For example, if a generating unit is derated to 80 per cent of its maximum capability for 5 hours, which would be equivalent to a full outage for 1 hour (i.e., 20 per cent of 5 hours equals 1 hour).

5 Increased generation and run time hours related to system support are the result of requests by Newfoundland and Labrador Hydro for additional supply.

6 Increased generation and run time hours related to use for construction projects on 94L, 114L, 140L and 410L.

The ICBF was determined for the MGT over the period 2007 to 2015. The Canadian Electrical Association ("CEA") provided data for the period 2008 to 2012 for comparison. Table 2 compares the ICBF of the MGT with the CEA average.

Table 2
Incapability Factor

Plant	ICBF
MGT	0.14%
CEA Average	13.8%

The ICBF is very good, but consideration should be given to the fact that the unit is mostly on standby and, relatively speaking, has had very little operation. There have also been no major overhauls or repairs carried out over the period from 2007 to 2015.

5.0 Industry Trends

5.1 Orenda Gas Generator

There were approximately 150 Orenda hot gas generators produced for use in gas turbine packages for gas compression, oil pumping and electricity generation. Repair and overhaul services for the units appear limited. They are currently provided by Magellan Aerospace and S&S Turbines.

5.2 Power Turbine

The power turbine is no longer manufactured but is supported by Magellan Aerospace and S&S Turbines. As with the hot gas generator, replacement components are either salvaged or fabricated.

5.3 Speed Reduction Gearbox

The gearbox was manufactured by Philadelphia Gear and the company is still in operation. As well, there are numerous third-party manufacturers that could perform overhaul and maintenance services. As the gearbox was custom made for the application, any replacements would either have to be salvaged or fabricated.

5.4 AC Generator

The manufacturer of the generator, Electric Machinery Manufacturing Company, is still in business. As well, as the generator is not particularly specialized, it can be replaced or maintained by a number of third-party generator manufacturers or maintenance facilities.

5.5 Enclosures and Trailers

The enclosures and trailer components were specifically designed and manufactured for the application. The original manufacturer is no longer in business. It is possible that replacements may be reverse engineered, but given the vintage of the unit and available technical information, it may prove difficult.

5.6 Balance of Plant

The balance of plant systems are not proprietary in nature and may be replaced or maintained as required.

6.0 Remaining Service Life

The 2015 Depreciation Study estimated the remaining life of the various components. Table 3 includes those estimates.

Table 3
Remaining Service Life

Component	Years
Engine	10
Power Turbine (incl. gearbox)	5
Generator	5
Governor	10
Enclosure	5
Building Services	5
Instrumentation & Controls	10
Switchgear	5
Trailers	3
Balance of Plant	5

7.0 Environmental

The MGT has a 470 litre day tank used to fuel the hot gas generator. This is refilled by a tanker truck or from a dyked steel storage tank depending on location. The day tank is single-walled and original.

The unit lube oil tank has a capacity of 1,100 litres and is single-walled.

The auxiliary power unit has a fuel tank capacity of 20 litres and is single-walled.

The power transformer contains 2,700 litres of insulating oil. This is a single-walled component.

Given the vintage of the MGT, it is unlikely to meet current emission standards, particularly for Nitrous Oxide. As the unit is only used for emergency purposes and construction projects, it would be unlikely to emit any significant amount of contaminants.

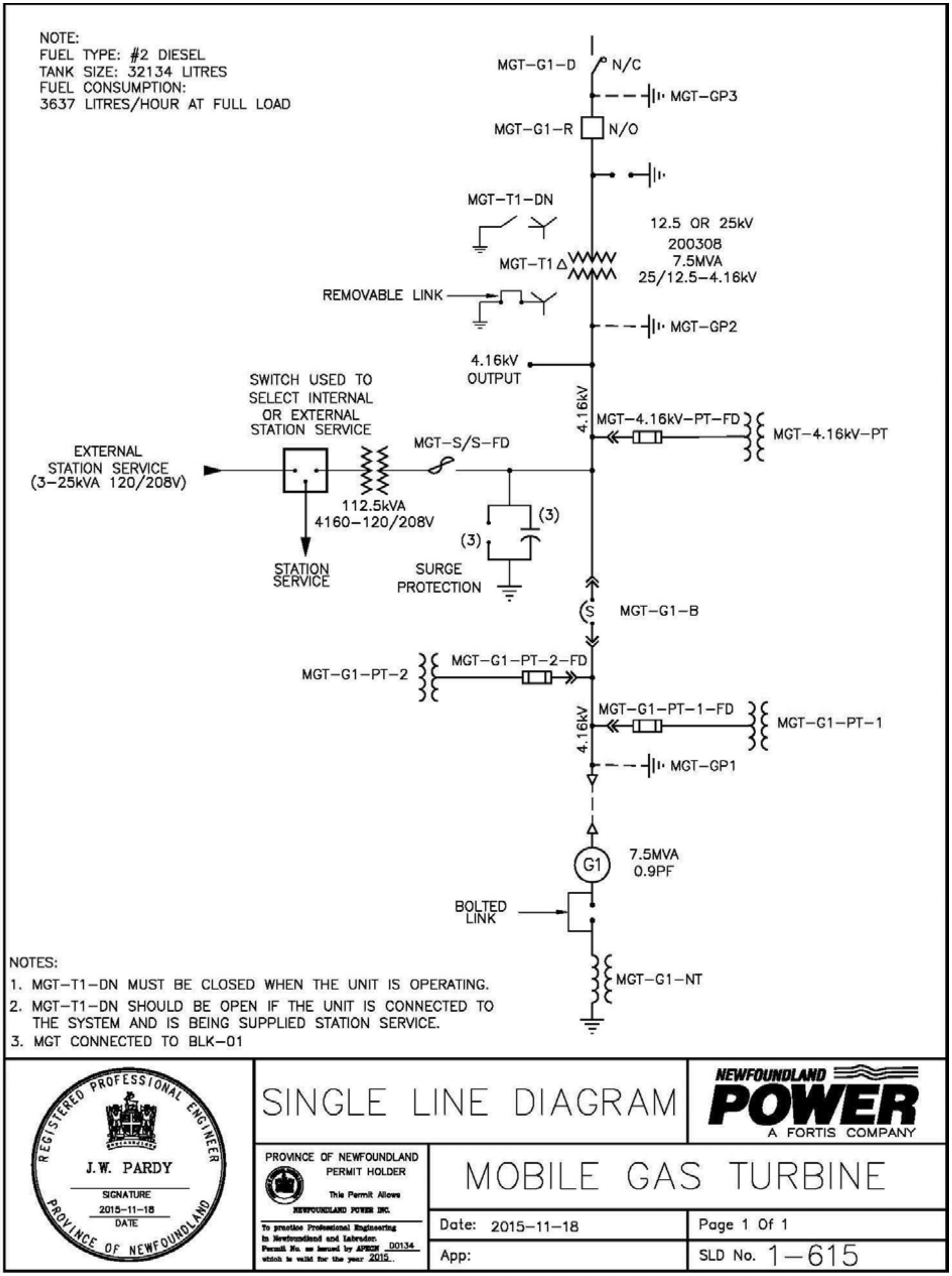
Determination of the various levels of air pollutants from the MGT would require source testing and air dispersion modeling. The modeling would be site specific due to the impact of local topography. For a mobile unit, air dispersion modeling would be impractical.

8.0 Recommendations

Given the current condition of the rolling components, the MGT should be retired from mobile service over the next 3 years.

The remaining service lives of the other parts of the MGT are estimated to range from 5 to 10 years, so it may be stationed at a fixed location until it is fully retired from service. A review of siting should be undertaken to identify the most appropriate location based on potential reliability considerations.

Attachment A:
MGT Single Line Diagram


NOTE:
FUEL TYPE: #2 DIESEL
TANK SIZE: 32134 LITRES
FUEL CONSUMPTION:
3637 LITRES/HOUR AT FULL LOAD
MGT–G1–D
N/C
MGT–GP3
MGT–G1–R
N/O
MGT–T1–DN
12.5 OR 25kV
200308
7.5MVA
25/12.5–4.16kV
MGT–T1
REMOVABLE LINK
MGT–GP2
4.16kV
OUTPUT
SWITCH USED TO
SELECT INTERNAL
OR EXTERNAL
STATION SERVICE
4.16kV
MGT–4.16kV–PT–FD
MGT–4.16kV–PT
EXTERNAL
STATION SERVICE
(3–25kVA 120/208V)
MGT–S/S–FD
112.5kVA
4160–120/208V
(3)
(3)
STATION
SERVICE
SURGE
PROTECTION
S
MGT–G1–B
MGT–G1–PT–2
MGT–G1–PT–2–FD
MGT–G1–PT–1–FD
MGT–G1–PT–1
4.16kV
MGT–GP1
G1
7.5MVA
0.9PF
BOLTED
LINK
MGT–G1–NT
NOTES:
1. MGT–T1–DN MUST BE CLOSED WHEN THE UNIT IS OPERATING.
2. MGT–T1–DN SHOULD BE OPEN IF THE UNIT IS CONNECTED TO THE SYSTEM AND IS BEING SUPPLIED STATION SERVICE.
3. MGT CONNECTED TO BLK–01
REGISTERED PROFESSIONAL ENGINEER
J.W. PARDY
SIGNATURE
2015–11–18
DATE
PROVINCE OF NEWFOUNDLAND
SINGLE LINE DIAGRAM
NEWFOUNDLAND
POWER
A FORTIS COMPANY
PROVINCE OF NEWFOUNDLAND
PERMIT HOLDER
This Permit Allows
NEWFOUNDLAND POWER INC.
To practice Professional Engineering in Newfoundland and Labrador.
Permit No. as issued by APEGN D0134 which is valid for the year 2015.
MOBILE GAS TURBINE
Date: 2015–11–18
Page 1 Of 1
App:
SLD No. 1–615

Attachment B:
Photographs of the MGT

Picture 1: General View

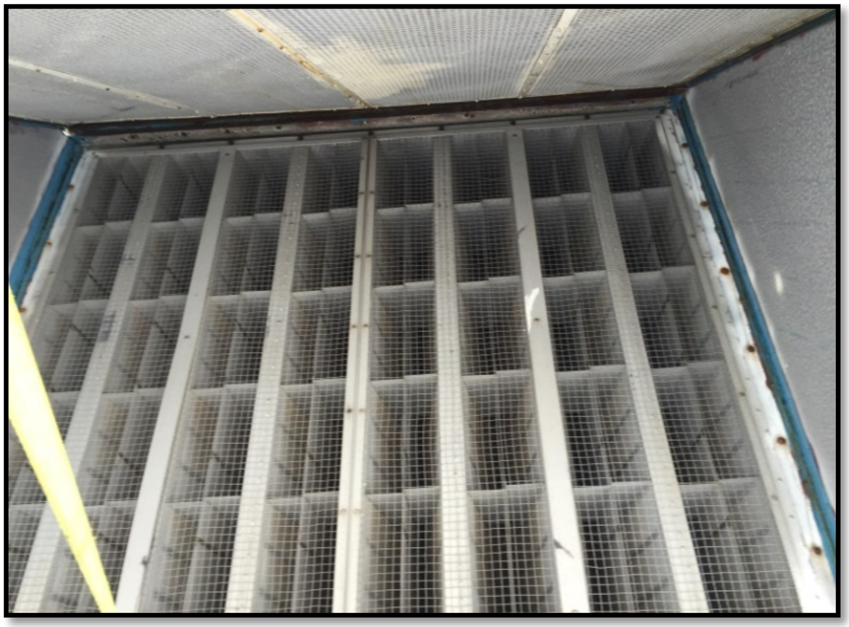
Picture 2: Turbine Trailer

Picture 3: Control Trailer

Picture 4: Transformer

Picture 5: Exhaust Stacks

Picture 6: APU Enclosure

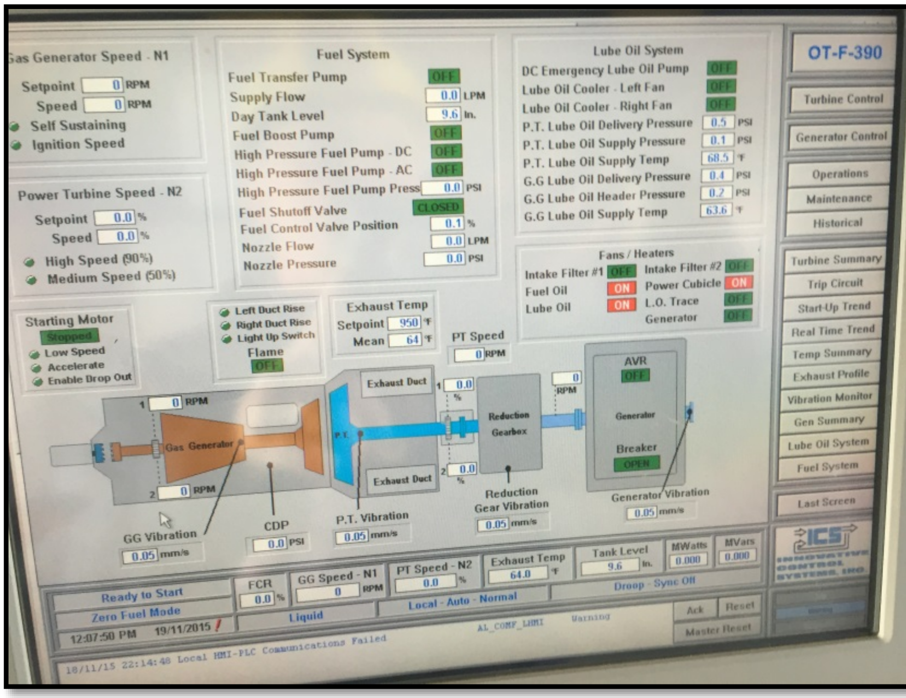


Picture 7: HGG Air Intake

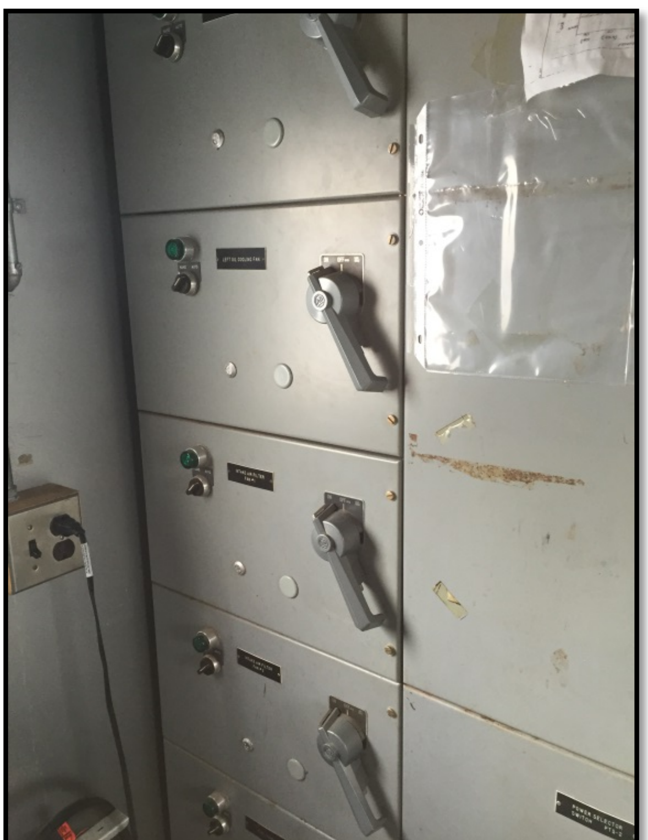
Picture 8: Gas Generator

Picture 9: Controls

Picture 10: Generator



Picture 11: Control Screen



Picture 12: Motor Control Center

Picture 13: Enclosure – Old Repair

Picture 14: Enclosure Condition

Picture 15: Enclosure Door Hinge

Picture 16: Enclosure Door

Picture 17: Chassis

Picture 18: Chassis

Picture 19: Support Leg

Picture 20: Undercarriage

Picture 21: Undercarriage Frame

Picture 22: Undercarriage Frame

Picture 23: Undercarriage

Picture 24: Undercarriage

Picture 25: Undercarriage

Attachment C:
Maintenance History

Maintenance History

The following is a list of major maintenance and life extension activities undertaken on the Mobile Gas Turbine over the past 30 years.

1990	Gas Generator Overhaul/Repair
1992	Trailer Roof Replacement
1994	Air Lift Axle Replacement
1994	Auxiliary Power Unit Replacement
1999	Control Improvements
2001	New Gas Generator Burners/Igniters
2002-03	Gas Generator Overhaul
2002-03	Control System Replacement, Transformer Overhaul, and Recloser Added
2009	Lube Oil Cooler Replacement
2010	Fire Suppression System Upgrade
2010	Gas Generator Combustion Chamber Refurbishment
2010	Trailer Structural Refurbishment
2015	Condition Assessment
2015	S&S Turbines investigated vibration issue

Attachment D:
MGT Inspection

March 16, 2015

S&S Turbine Services LTD.

Field Service Report

Newfoundland Power

Model OT-F-390

Sn 5907

March 10, 2015 S&S Turbines LTD. attended 96 Markland Road Whitbourne, NL. to aid staff in determining the cause of vibration and shut down on loading of portable generator.

The unit would start and ramp to sync speed normally. Over all vibration increased with loading above 0.7 MW and unit shut down by 1.2 MW. Alarm / Shut down points were observed at 30 and 40 mm/s PK-PK respectively.

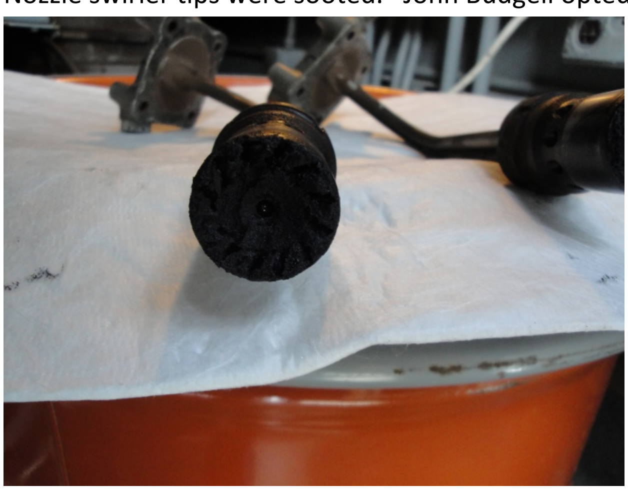
Prior to arriving John Budgell had verified vibration with a portable analyzer. An FFT Spectrum taken at Alarm conditions indicated predominant 1X with a large 2X component.

Observations

Upon arrival the generator skid appeared not to be plumb. The trailer was sloping rear to front with a noticeable wave in the support of the port side of the skid.

- Intake screen was removed to inspect Bellmouth and Compressor forward.
    - Silencer cabinet corroded with perforations.
    - Stage 1 and 2 blading and stators were slightly corroded with no evidence of impact damage.
    - Verified Stage 1 and Stage 2 blades were free to move.
    - Bellmouth touching rear intake wall at bottom.
    - Witness marking on engine side of engine / intake seal indicating engine had moved downward relative rear intake wall.

- Fuel Nozzles were numbered and removed to allow bore scope inspection of combustors and turbine nozzles.
  - Nozzle swirler tips were sooted. John Budgell opted to change out with spare set.



- Removed Combustor #5 to better inspect compressor OGV and stage 10 compressor blading.
  - o Found slight impact damage approximately mid blade on the trailing edge of 2 consecutive stage 10 compressor blades.

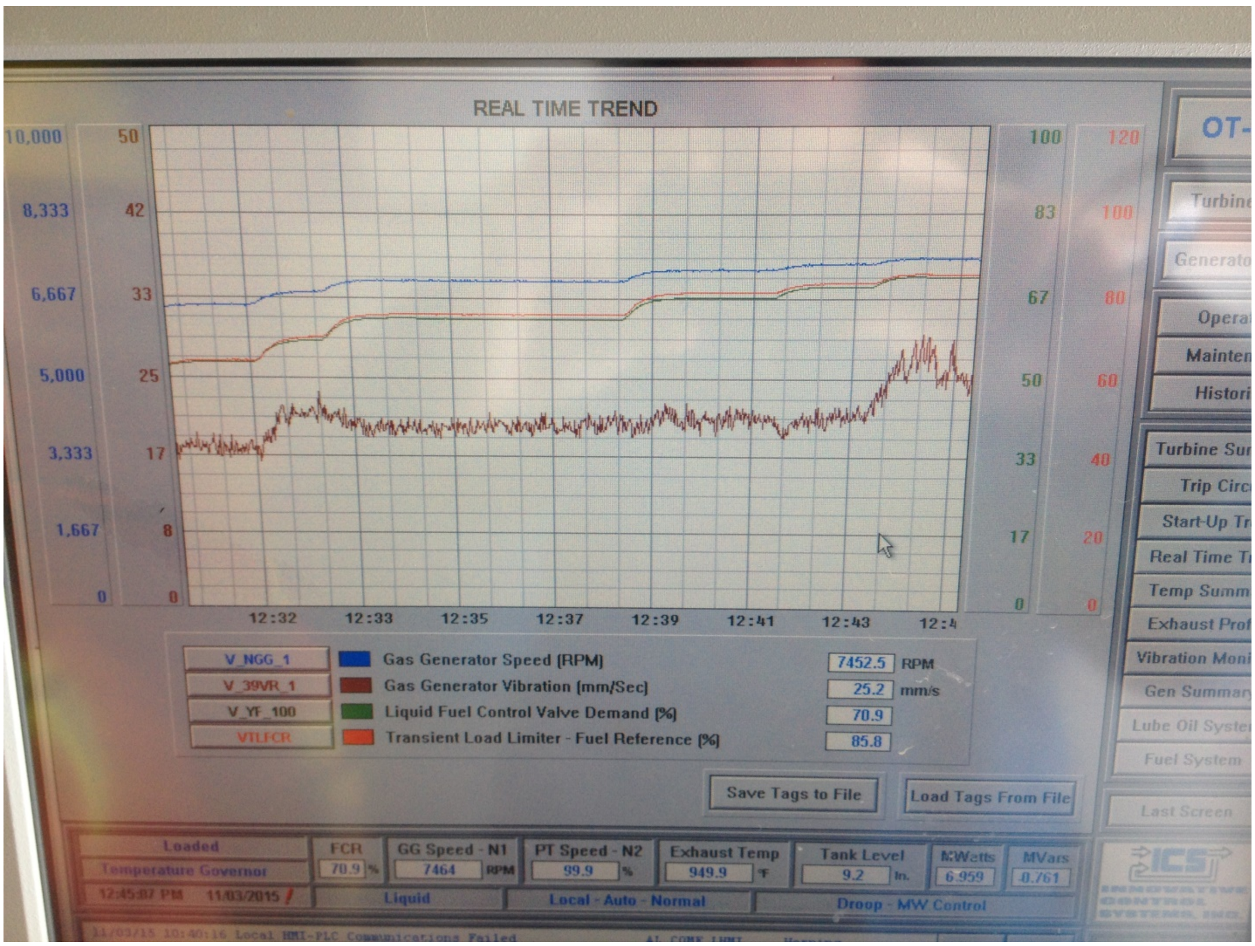
  - o Combustor liner, turbine nozzles and blading appear in serviceable condition.

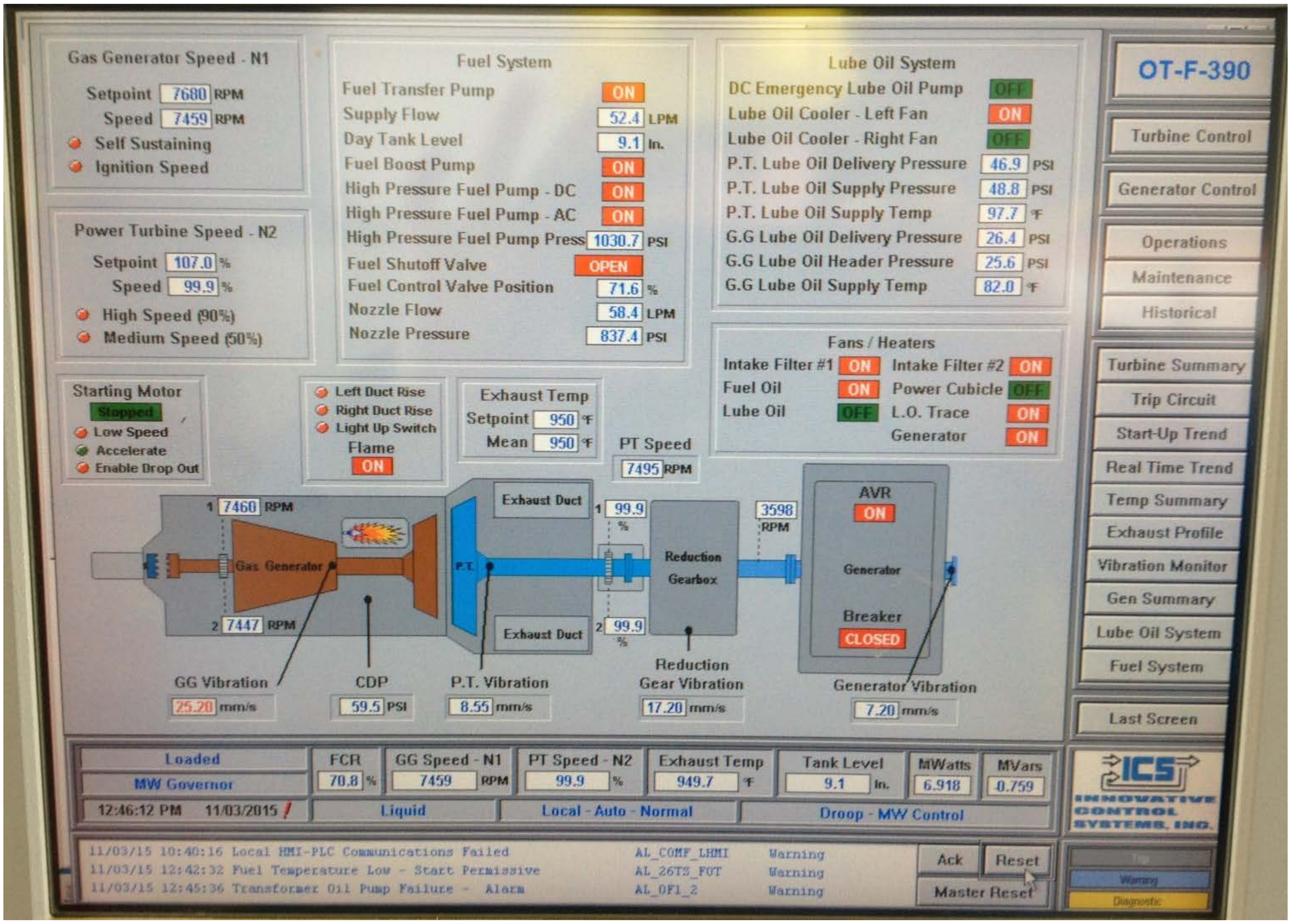
- Completed Bore scope inspection of remaining combustors.
  - o All combustor liners, turbine nozzles appear in serviceable condition.

- Newfoundland Power Technicians removed main magnetic plug and all oil scavenge screens. Plug was clean. #2 and #3 scavenge screens had no notable debris.

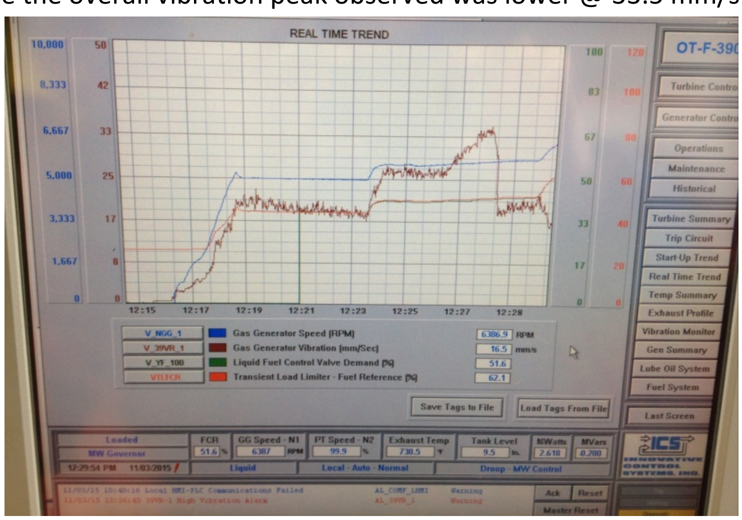
- Replaced Inlet screen, oil lines and magnetic plug, #5 combustor and fuel nozzles. Secured, lock wired and checked all disturbed hardware. Vacuumed debris from intake.
- Used a 4’ bubble level to survey the installation of the generator trailer. Found the forward supports slightly off level from side to side. Lowered port forward support more than 1/8” and then lowered both the port and starboard forward supports 1/4".
- Cold rolled unit on starter to verify oil pressure, listen for rubs and bearing noise.
- Started unit and checked again for oil and fuel leaks. Physically felt unit to verify smooth operation at all 3 bearing sumps.
- When loading the engine overall vibration levels increased to 30 mm/s Pk-Pk or alarm levels at approximately 0.8 MW rising to 36.5 mm/s Pk-Pk 0.9 MW or 5400 RPM Gas generator speed.

- In an effort to raise over all vibration levels to near shut down level for analysis we increased the load on the generator. Above 0.9 MW vibration fell to approximately 17 mm/s Pk-Pk.
- Increased load to EGT limit of the engine.
  - o Used Pruftechnik portable analyser to verify vibration monitoring equipment and take FFT spectrum at all 3 engine bearing supports.
  - o On the mount next to the engine vibration probe the Pruftechnik analyser indicated.
    Gas Generator 7440 RPM
    1X Peak @ 19.8 mm/s Pk-Pk
    Overall @ 22.7 mm/s Pk-Pk





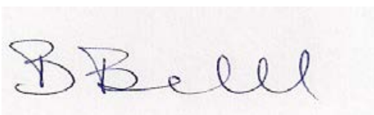
- Reduced load to observe descending vibration characteristics.
  - Observed no increase in vibration levels as load on engine decreased.
- Over the course of the test run we had full load shut down due to low fuel level and a normal unload shutdown. Both roll downs were monitored for rub and bearing noise. During the second load sequence the overall vibration peak observed was lower @ 33.5 mm/s Pk-Pk.



Conclusion

We were unable to duplicate the shutdown conditions on loading at this time. However the vibration spectrum information gathered previously by John Budgell indicating a large 2X component of the overall vibration reading leads to S&S Turbines Services LTD. to recommend the following.

1. Generator skid supports to be leveled with a quality sight level any time the generator is relocated and verify level seasonally.
2. Once generator skid has been verified level. Check alignment of all components of the generator in particular engine to PT. Ensure alignment is with in manufacturer's specification.
3. Ensure there is no contact or binding such as observed at the bell mouth to intake silencer rear wall.



Bill Burchell

S&S Turbine Services LTD.

Stantec Consulting Ltd.
Combustion Turbine Assessment
and Options
December 2020

Combustion Turbine Assessment and Options

GREENHILL AND WESLEYVILLE, NL

December 11, 2020

Prepared for:

Newfoundland Power

Prepared by:

Stantec Consulting Ltd

Revision	Description	Author		Quality Check		Independent Review	
A	60% Review		MG		RG		GO
B	Final Review		MG		RG		GO

This document entitled Combustion Turbine Assessment and Options was prepared by Stantec Consulting Ltd. ("Stantec") for the account of Newfoundland Power (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by ______________________________
(signature)

Rick Grey

Reviewed by ______________________________
(signature)

Murray Gordon

Approved by ______________________________
(signature)

Greg Oliver

REGISTERED PROFESSIONAL ENGINEER
GREG OLIVER
SIGNATURE
11 Dec 2020
DATE
NEWFOUNDLAND & LABRADOR

PROVINCE OF NEWFOUNDLAND AND LABRADOR
pegnl ENGINEERING PERMIT J0291
STANTEC CONSULTING LTD.
04114
Signature or Member Number
(Member-in-Responsible Charge)

Table of Contents

LIST OF APPENDICES

Executive Summary

Stantec has been engaged by Newfoundland Power to perform a high-level assessment of two of Newfoundland Power's combustion turbine generator installations at Greenhill, NL and Wesleyville, NL. As part of this assessment, other components have been evaluated including protection and control devices, switchgear, buildings and enclosures, fuel storage and associated piping systems.

NP has provided previous reports and test data which has been reviewed and evaluated, with some of the information forming part of this assessment and conclusions.

The following are the findings and conclusions based on our on-site assessment and from the various reports provided by Newfoundland Power:

1. Greenhill CTG has reached the end of its service life, due to its age, condition, and lack of vendor support. The estimated costs for replacement generation at Greenhill is noted below:

Table E1 Capital Cost Projections of Greenhill Alternatives

Option	Description	Cost Projection (2020 $)	Comments
A	Replace with New 24 MW Package Combustion Turbine (Titan 250)	$36,700,000	Source – Solar Turbines / Powercon

2. Wesleyville CTG, which is presently de-rated to 8 MW, has four options for continued operation, as listed below in Table E2. Options A and B are refurbishment schemes to extend the useful life of the existing vintage equipment by replacing various sections and systems as outlined in the options below.

   Options C and D are alternatives to provide longer term solutions with new equipment.

Table E2 Capital Cost Projections of Wesleyville Alternatives

Option	Description	Cost Projection (2020 $)	Comments
A	Replace power turbine seals, replace gearbox, replace stack and silencer, and replace or rewind generator stator and rotor.	$3,575,000	Source – Alba Power
B	Replace center section of unit (power turbine, exhaust volute and gearbox), replace stack and silencer, and replace or rewind generator stator and rotor.	$3,900,000	Source – Alba Power
C	Replace with New 16 MW Package Combustion Turbine (Titan 130)	$27,200,000	Source – Solar Turbines / Powercon
D	Purchase second 5.5 MW Mobile CTG, and locate both Mobile units in Wesleyville seasonally (December-April)	$18,750,000	Source – OnPower / NP

Abbreviations

AVR	Automatic Voltage Regulator
CTG	Combustion Gas Turbine
GG	Gas Generator
MCC	Motor Control Center
NP	Newfoundland Power
NLH	Newfoundland and Labrador Hydro
OEM	Original Equipment Manufacturer
PT	Power Turbine
P&C	Protection and Control
RR	Rolls Royce

1.0 OVERVIEW

Newfoundland Power operates two liquid fueled combustion turbine generators (CTGs) located on the Island of Newfoundland. The CTGs are utilized as emergency back-up power generators and for electrical power system support. The two units include:

- 25 MW Greenhill CTG located in community of Grand Bank off Route 210 on the Burin Peninsula. CTG is connected to the island grid via transmission lines 301L and 305L which operate at 66 kV.
- 14.7 MW Wesleyville CTG located in the community of New-Wes-Valley off Route 320. CTG is connected to the island grid via 116L which operates at 66 kV.

Both CTGs were originally purchased in the 1969-1975 timeframe and have undergone a number of equipment upgrades and modernization over the years. Given the vintage of the equipment and infrastructure, Newfoundland Power has engaged Stantec to provide a high-level review of the units with regards to long-term viability of continued investment in the assets and to evaluate various options for rehabilitation, replacement or retirement.

2.0 GREENHILL CTG

2.1 GREENHILL GENERAL

The 25 MW Greenhill CTG Power Plant consists of a Rolls Royce Industrial Olympus “C” gas generator (GG) coupled with a Curtis-Wright power turbine (PT), and a Brush AC generator. The plant was originally commissioned in 1975 by Newfoundland Power and has been in standby mode for most of its operating life, with limited service as a synchronous condenser. The Olympus combustion turbine generator is fired with liquid fuel (diesel) only and does not utilize any form of emission controls of NOX abatement.

The electrical generator power output is stepped up from 12 kV to 69 KV through a single step-up transformer in the substation for transmission to the local Newfoundland Power grid.

2.2 GREENHILL GAS GENERATOR/POWER TURBINE AND AUXILIARY SYSTEMS

2.2.1 System Overview

Significant capital maintenance has been completed on the CTG since the plant was originally commissioned in 1975. The first significant upgrades took place in 1995 when the facility was 20 years old. The Olympus HGG was overhauled, and a cracked PT casing (See Section 2.2.3) was replaced with a used casing from a similar unit in 1995. Additional remediation work was completed in 2016.

2.2.2 Gas Generator

The Rolls Royce Industrial Olympus Type C Gas Generator (GG) was purchased in 1975 and was overhauled in 1995. Following an engine module fire in 1998, it was returned to Rolls Wood Group for cleaning and repair. In 2016, the gas generator (GG) was sent to Alba Power for a complete overhaul.

The unit has been operating in standby mode and as a synchronous condenser, as required. The annual run times have generally been limited to less than 100 hours per year in recent years, mostly for regular testing of the unit, rather than system demand. It was used for system support at the request of NLH during the “DarkNL” event in 2013/2014.

In 2012, the original air starter was replaced with an electric starting motor.

Production of the RR Industrial Olympus gas generators ended in 1990 with over 320 sets having been sold in 21 countries. As of 2017, around 125 units remained in service. Some of the units which remain in service today, provide backup power in case of a loss of grid electrical power at nuclear power stations. NLH’s four Olympus gas generators at Stephenville and Hardwoods are planned to for retirement by 2022. In 2006, Rolls Royce announced that it would be discontinuing support for the unit, because of the reduced fleet size due to retirements and the increasing cost of parts from suppliers. RR’s factory support for the Industrial Olympus totally ended in 2015. Third-party vendors still provide maintenance and limited parts support.

2.2.3 Power Turbine

The Curtis-Wright power turbine (PT) has had known casing cracking problems identified by the OEM in 1984 as a critical service issue. To limit the crack propagation the unit had been de-rated from 25 MW to 20 MW, to limit the exhaust gas temperatures as per recommendations from the OEM. In 1995, Newfoundland Power installed a surplus original OEM casing and replaced the internal bolting/fastening components with new. The cracking is monitored on an annual basis.

In 2003 much of the instrumentation was replaced and the PT was reinsulated and realigned. The exhaust stack, compressor piping and stator blade spacers were repaired in 2008 and 2009.

Inspections in 2014 by Alba Power discovered a portion of the PT shrouding protruding into the gas path. Continued cracking of the casing and shrouds were noted and replacement of the casing was recommended. Fern Engineering previously had a modification available to address these cracking issues, however this modification has not been installed at Greenhill.

In general, the PT should be considered for replacement for any continued operation.

2.2.4 Gearbox / Clutch

There is no gearbox on this unit since the PT and generator are direct coupled and operate at 3600 RPM. However, there is a clutch system allowing the unit to operate as a synchronous condenser.

2.2.5 Lube Oil System.

The oil system utilizes glycol cooling from outside coolers through heat exchangers in the building.

With the exception of the external glycol cooler, the lube oil system is in reasonable condition. The glycol cooler requires replacement due to deterioration.

2.3 GREENHILL FUEL OIL SYSTEM

2.3.1 Fuel Unloading and Storage

The storage tanks are showing signs of rust deterioration. There is noticeable rusting on the top of the two older tanks.

There are 2 older storage tanks, installed in 2002 with each having a capacity of 90,000 litres. These tanks need to be inspected and coating replaced, for continued operation.

A third tank with similar capacity of 90,000 litres was installed in 2014 and appears to be in good condition.

2.3.2 Fuel Forwarding

The fuel pumps at the tanks and in the building are in fair shape.

2.3.3 Fuel Piping

The fuel lines are original and are not suitable for continued operation. The piping requires inspection and most likely replacement with insulation missing on several locations along the fuel piping, and rusting pipe stands.

2.4 GREENHILL GENERATOR SYSTEM

2.4.1 System Description

The Brush 31.8 MVA, type BDAX 70-76 generator is in relatively good shape with the exception of a potential rotor retaining ring cracking issue. The unit's AVR is old and outdated. An upgrade is required for on-going operation.

The generator is a direct-driven, two-pole type driven at 3,600 rpm. A clutch is between the PT and the generator to enable it to operate as a synchronous condenser without the power turbine components.

From our review of the electrical test data, the generator appears to be in good condition.

2.4.2 General Assessment

The AC generator stator winding condition was tested in recent years, with results showing the unit is in good condition electrically. One of the parameters, the polarization index, indicated that the insulation resistance of the stator winding is adequate for continued operation, and is monitored annually for trending. The rotor retaining rings, manufactured from 18 Mn-5 Cr are known to be susceptible to stress corrosion cracking, and the OEM has recommended they be replaced with a new different material for the rings. There is no way to determine if the cracking exists without a total rotor disassembly. Even if no cracking was found, due to the material, it could occur in future, so replacement is advised.

In 2016 Brush recommended the following maintenance work:

- Stator rewinding
- Rotor replacement which would include new retaining rings.
- AVR Upgrade
- Enclosure repainting and bearing shaft seal refurbishment

2.4.3 Operational and Maintenance Issues

The main issue with the generator is the potential stress corrosion cracking of the rotor retaining rings, noted above.

2.4.4 Excitation System Review

The Brush AVR system, a brushless type exciter is original and has not been upgraded since the original installation. This equipment is at "end-of-life" and should be replaced. This unit is obsolete, with parts difficult to obtain. Brush has recommended that the excitation system be upgraded or replaced.

2.5 GREENHILL ELECTRICAL SYSTEMS

Most of the electrical systems are original with some upgrades to the batteries and the control system in recent years.

2.5.1 Switchgear

Switchgear equipment including the generator breaker is located in a separate building, is original and has not been upgraded. The equipment is obsolete, with parts difficult to obtain. This equipment is at "end-of-life" and should be replaced.

2.5.2 AC and DC Motor Control Centers

The Westinghouse AC and DC MCC's are original using older mechanical relays. Potential transformers are contained within the cubicles. The equipment is at its "end-of-life" and recommended to be replaced, due to it age and lack of replacement parts.

2.5.3 DC System – Station Battery and Charger

The C-CAN Battery Charger and the associated Absolyte batteries are less than 10 years and in good condition. There are original vintage Westinghouse DC breakers that are at their end-of-life, similar to the MCC's, due to their age and lack of parts.

The Battery Room should be setup for proper ventilation of sealed batteries . Standards such as CSA Std C22.1; Section 26-506 and IEEE Std 1187-2013 Recommended Practice for Design and Installation of Valve-Regulated Lead-Acid Batteries for Stationary Application – Section 5.4, recommend ventilation for rooms housing sealed and VRLB batteries. Even though sealed batteries do not emit as much hydrogen gas as normal vented lead-acid batteries, small amounts of hydrogen are emitted and should be removed.

2.5.4 Protection Relays

The protective relays at the station are a combination of new digital type relays and older mechanical type relays. The new digital relays include:

- Schneider PowerLogics ION7550 digital wattmeter for the generator
- New digital governor and controls including a new Basler Auto-Synchronizer PRS-210

Older vintage Westinghouse and GE mechanical relays are used for generator protection and should be modernized for continued operation. The protection relays for the substation are a combination of old mechanical relays and newer digital relays.

2.5.5 Motors

There are several AC motor manufacturers such as Emerson, Somer and Westinghouse. All of these motors are original, and electrical testing should be performed to confirm their operational status and suitability for continued usage or replacement.

There are some original vintage Westinghouse DC motors which are obsolete and should be replaced for continued operation of the unit, due to their age since original installation.

The DC Starting system was supplied by Alba Power in 2012.

2.5.6 Auxiliary Power Unit

The Cummins GGKC-5566945 – 600V/140 KW auxiliary power unit is in reasonably good condition. The propane tank serving the unit is in poor condition.

2.5.7 Emergency Transfer Switch

The Cummins – PowerCommand Transfer Switch appears to be in good shape with relatively new Siemens disconnect switches.

2.6 GREENHILL CONTROLS AND INSTRUMENTATIONS

The protection and control systems were upgraded in 2003 including a new Bentley Nevada accelerometer-based vibration monitoring system. The Rolls Royce FT125 upgrade also included a digital governor control system and fuel control module. The upgraded control package is based on the standard Allen Bradley Controllogix PLC technology.

All the HMI screens are Allen Bradley Controllogix HMI's and viewed on an Allen Bradley Panelview 1000 screen.

2.7 GREENHILL BUILDINGS

2.7.1 General Overview

The buildings are old, with signs of wear with many rust spots showing, and overall poor condition of the building envelope. The GG and PT enclosures are deteriorated due to rust. The service building is also impacted by rust and there are reports of some roof leaks.

The air intake was refurbished in 2002, however there is significant evidence of rust on the face of the intake.

2.7.2 Control Building

The main building is in poor condition with signs of rust and cladding deterioration

2.7.3 Turbine Enclosure Air Intake and Exhaust

The air intake housing is rusting and requires maintenance for any continued operation.

The exhaust stack was replaced in 2003 with new, complete with snow doors. The exhaust volute, though original, is considered “fit-for-service”.

2.7.4 Switchgear Building

There is a separate building for the switchgear to facilitate the generator breaker, switchgear, instrument transformers, and surge protection. The building is in fair condition and is original to the CTG installation.

3.0 WESLEYVILLE CTG

3.1 WESLEYVILLE GENERAL

The Wesleyville power plant was originally installed in Salt Pond, Burin in 1969. It was relocated to Wesleyville in 2003/2004. The plant consists of a single Rolls Royce AVON Mark 1533-52L gas generator (GG), an AEI (Associated Electrical Industries) size B AP1 power turbine, and an AEI speed reduction (4:1) gearbox, driving a 1200 rpm AEI type AG 80/100 14.7 MW generator which was manufactured in 1966.

This unit cannot operate as a synchronous condenser.

3.2 WESLEYVILLE GAS GENERATOR/POWER TURBINE AND AUXILIARY SYSTEMS

3.2.1 System Overview

The core equipment in the plant has approximately fifty years of service, with limited operating hours.

The Wesleyville plant was constructed in 2003 and involved the relocation of major equipment from the Salt Pond facility. The relocation project included significant upgrades to balance of plant systems including a new building to accommodate the equipment.

3.2.2 Gas Generator

In 2005, the original Royal Royce Avon gas generator was replaced by Siemens with another Avon 1533 zero-hour rated refurbished unit of similar vintage. In 2014, the unit underwent a major overhaul due to the failure of the front bearing.

The RR Avon gas generator was in production until 2009 and is considered one of the most reliable gas turbine engines built. Approximately 1200 Industrial Avon units were manufactured and approximately 800 are still operating around the world today.

Overall, the present gas generator is in good condition. Although the Avon is no longer manufactured by Rolls Royce, spare parts are available from the OEM (now Siemens) and from third party vendors.

3.2.3 Power Turbine

In 2014, inspection of the PT showed that there was foreign object damage to the stationary nozzle blades, and that the rotor disc had pitting around the blade root area.

In addition to the major maintenance completed on the unit, borescope inspections have been conducted most recently in 2013.No maintenance work was performed resulting from these inspections.

Cracking of the inlet duct was repaired in 2014. The oil pump and PT bearing were refurbished in 2016.

The Power Turbine rotor disc space runs hot due to exhaust gas leakage. There is also a high PT inboard (closest to the power turbine) bearing temperature. The high temperatures are limiting the operation time of the unit as it must be shut down when the allowable temperatures are exceeded, to avoid further damage.

A 2020 inspection of the PT by Newfoundland Power found that the PT inlet cone and PT disc showed no further signs of deterioration other than sone corrosion attack. Some cracking in the welds of 15 stator vanes was identified. Alba Power reviewed the inspection and advised that the cracking is not an immediate concern, but that a more detailed inspection should be carried out in the coming 12 months to establish overhaul or repair requirements to ensure the long term integrity of the assembly.

3.2.4 Gearbox

Following the relocation of the CTG unit from Salt Pond to Wesleyville, it has experienced on-going gearbox problems.

The gearbox system is showing significant and increasing vibration levels. The unit has been derated to 8 MW to operate below acceptable levels. The high vibration is due to damage sustained to the gears as a result of a breakdown of insulation which caused by circulating eddy currents. This phenomenon lead to erosion or metal pitting of the gear faces. It was recommended by Alba Power, that the gearbox system be replaced with a refurbished unit.

Newfoundland Power have set a load limit on this machine not to operate above 8 MW as vibration levels along with power turbine inboard bearing temperature heating start to increase to unacceptable levels. For continued operation, the gearbox requires replacement.

3.2.5 Lube Oil System

The Lubrication oil pump flexible drive coupling membranes were showing signs of bowing. Checks were carried out and no cracks were noted. Although bowing is not cause for rejection, the membranes should be checked for cracking on a regular basis as this would pose a risk of losing drive to the pump.

The lube oil cooler was replaced in 2016 and the system is working well. Temperature issues caused by the fact that, during idle periods some oil is outside in the cooler, have been resolved. Procedures have been implemented to bring the oil up to temperature during start-up. NP may wish to consider a glycol-based system for future improvements, due to the local climatic conditions.

3.3 WESLEYVILLE FUEL OIL SYSTEM

3.3.1 Fuel Unloading and Storage

There was a new storage facility installed in 2003 and remains in very good condition.

3.3.2 Fuel Forwarding

The fuel system consists of a 2003 vintage Woodward Fuel Shutoff Cock Driver and Woodward Fuel Throttle Valve Driver.

3.3.3 Fuel Piping

Piping is in very good condition.

3.4 WESLEYVILLE GENERATOR SYSTEM

3.4.1 System Description

The generator is a brushless alternating generator manufactured by AEI (Associated Electrical Industries) in Great Britain in 1966. Neither the stator or rotor have been rewound or reinsulated.

The generator is a six-pole type driven at 1,200 rpm via a speed reduction gearbox. The power turbine operates at 4,800 rpm. This system does not have a clutch for synchronous condenser operation.

3.4.2 General Assessment

Power factor (PF) testing and capacitance testing of the generator stator was performed in October 2014 and were compared with previous tests conducted in 2007. Both the PF and capacitance readings were slightly elevated from the 2007 baseline. Based on the recent electrical testing, the IR and PI results would suggest that the generator, stator and rotor, should be refurbished with a complete rewind. The PI reading was 1.12 which is very low suggesting a possible issue with the winding insulation, and is suggested for re-testing in the near future.

3.4.3 Operational and Maintenance Issues

The unit's instrument transformers and their associated fuses and wiring are exposed and protected by a chain link fence near the generator. There is a high potential for arc flash conditions to occur, due to the lack of enclosures for this equipment.

Stantec suggests that an arc flash assessment be conducted, and that arc flash resistant enclosures and improved protection be installed to limit the potential exposure for personnel when the machine is running. In the meantime, Stantec recommends that no personnel should be in this part of the building when the machine is operating.

3.4.4 Excitation System Review

In 2014, a new Basler Digital Exciter Control System was installed with associated existing analog meters and switches which appears to be excellent condition.

There is a newer vintage Schneider Digital Metering on the exciter cabinet.

3.5 WESLEYVILLE ELECTRICAL SYSTEMS

Generally, the electrical systems are in good shape. There should be another 20 to 30 years of life remaining in these systems.

3.5.1 Switchgear

There is no switchgear in this system. The output of the generator is directly coupled via a substation breaker to the dedicated step-up transformer, both located in the substation yard.

The high voltage bus work, including potential and current transformers are exposed in several areas in the building producing a potential arc flash hazard. It is recommended that these components be housed in an arc flash rated cabinet and a complete arc flash assessment be conducted on the facility.

3.5.2 AC and DC Motor Control Centers

The MCCs are Cutler Hammer Freedom Series 2100. This lineup is recent, installed in 2004 and is in good working order, complete with Arc Flash warning signs and levels. These systems are in good condition for continued operation.

3.5.3 DC System – Station Battery and Charger

The station battery chargers SAFT TPR with GNB type batteries. These systems appear to be in good shape. The associated DC distribution panel is a Square-D I-Line Panel in good condition, with associated DC breakers.

3.5.4 Protection Relays

All the relays are digital and have been upgraded in 2004. These include:

- Alstom MiCoM Generation Protection digital relay
- Basler BE1-25A Automatic Synchronizing Relay

3.5.5 Motors

The DC Motors by AEI are in reasonable shape. Additional assessment would be required for the older motors. Final assessment to be determined.

3.5.6 Auxiliary Power Unit

The auxiliary power unit is a Kohler Model 65GGHB 65 kW unit fired with propane from tanks installed when the unit was installed in 2003. All equipment appears to be well maintained and in good operational shape.

3.5.7 Emergency Transfer Switch

The Onan Transfer Switch OT-125 (rated at 125 Amps) is in very good shape, with associated Siemens disconnect switch and AC panel board. All components are in good shape.

3.6 WESLEYVILLE CONTROLS AND INSTRUMENTATIONS

The control system is a Rolls Royce Energy Systems – Entronic Controls. The system is about 10 years old with continued support from Rolls Royce. The system utilizes Allen Bradley Panel View 1000 HMI with the associated screens and Allen-Bradley Controllogic hardware.

The controls and instrumentation systems consist of the following:

- Vibration System is a Bentley Nevada 3500, which is out of production, but parts are still available from GE.
- Alstom MiCoM Generation Protection digital relays
- Majority of the instrumentation is new (eg: Rosemount) and appears to be in good condition.

3.7 WESLEYVILLE BUILDING

3.7.1 General Overview

A new building was constructed in 2003 when the unit was relocated and remains in good condition. A new roof was installed in 2014. There are minor leaks in the roof which require attention. The water supply for the kitchen and washroom is not functioning. An improved water supply system is required.

3.7.2 Turbine Building, Air Intake and Exhaust

When this unit was relocated from Salt Pond to Wesleyville, a new filter house air intake system was installed, which is currently in good condition. There are, however, some areas of corrosion starting to appear which will require cleaning and painting.

The exhaust volute and stack are original to the 1969 Salt Pond installation and are in fair condition. The exhaust silencers have been removed from the stack due to deterioration and as such there is no sound dampening. Replacement of the stack and volute would be required under any repowering plan.

4.0 CAPITAL COST ESTIMATES OF OPTIONS

Stantec has developed high level Class V cost estimates for possible options for each CTG as noted below. These estimates are based on assessment of initial viability with evaluation of alternative solutions for long range capital planning, concept design factors, with some inputs from suitable vendors. For the purposes of this report, a 30% contingency has been added to represent a reasonable estimate of costs.

4.1 GREENHILL CTG

4.1.1 Maintain Existing Unit

The long-term continued operation of the Greenhill CTG is considered not viable due to its age, the condition of the CTG, generator rotor endcap concerns, auxiliary equipment, and building. In addition, OEM support for the gas generator and power turbine makes long term operation impractical.

4.1.2 Replace with New Industrial Gas Turbine-Generator Package

The approximate cost of replacing the Greenhill CTG with a new 23.1 MW Industrial Gas Turbine (Solar Titan 250) is as follows:

Equipment Costs (US$11,500 K)	$ 15,500,000
Additional Owner Requirements (TBD)	$ 2,000,000
Shipping	$ 500,000
Removal and installation (vendor)	$ 2,000,000
Building and Equipment Mod's	$ 4,000,000
Upgrade Station Services	$ 200,000
Engineering and PM	$ 4,000,000
Contingency (30%)	$ 8,500,000
Total cost for a replacement package:	***$ 36,700,000***

Please note: this cost estimate excludes NP internal costs

4.1.3 Retirement

Retire and remove the Greenhill CTG, enclosure, and control building. A new smaller substation control building would be required. With the two transmission lines in the area, the CTG may not be required. If emergency generation is required, then a portable generation system could be considered which could be deployed elsewhere for emergencies and for transmission line/substation construction and maintenance. The typical size of a portable gas turbine is 5 – 7 MW so a number would be required to replace the existing capacity.

4.1.4 Run to Failure

The option of running the unit to failure is not acceptable due to potential damage to property and danger to personnel.

4.2 WESLEYVILLE CTG

4.2.1 Maintain Existing Unit

The following costs to maintain the existing CTG are based on budget pricing received from Alba Power:

4.2.1.A Replace Seals in Power Turbine, Replace Gearbox and Rewind Generator

Power Turbine Seal Replacement:	
Rotating Seal Replacement	$ 300,000
Static Seal Replacement	$ 100,000
Installation Costs	$ 50,000
Stack & silencer	$ 800,000
Engineering and PM	$ 100,000
Subtotal	$1,350,000
Gearbox Replacement:	
Equipment Supply	$ 350,000
Shipping	$ 50,000
Removal and Installation	$ 100,000
Engineering and PM	$ 100,000
Subtotal	$ 600,000
Generator Replacement or Rewind:	
Equipment Supply	$ 550,000
Shipping	$ 50,000
Removal and Installation	$ 100,000
Engineering and PM	$ 100,000
Subtotal	$ 800,000
Contingency (30%)	$ 825,000
Total	$3,575,000

Please note: this cost estimate excludes NP internal costs

4.2.1.B Replace Center Section of Unit (Power Turbine, Exhaust Volute and Gearbox) and Rewind Generator

Replace Center Section of Unit:	
Equipment Costs	$ 950,000
Shipping	$ 100,000
Removal and Installation	$ 150,000
Stack & silencer	$ 800,000
Engineering and PM	$ 200,000
Subtotal	$2,200,000
Generator Replacement or Rewind:	
Equipment Supply	$ 550,000
Shipping	$ 50,000
Removal and Installation	$ 100,000
Engineering and PM	$ 100,000
Sub total	$ 800,000
Contingency (30%)	$ 900,000
Total	$3,900,000

Please note: this cost estimate excludes NP internal costs

To reduce the risk of parts mismatch and installation/alignment issues; Option B - Replacement of Center Section of Unit, is suggested to be more prudent than Option A. Replacing the complete power turbine, instead of just the PT seals, will resolve issues with cracks in the PT outer casing and in the nozzle shroud, foreign object damage to the stationary nozzles, and pitting and corrosion of the turbine disk. However, there continue to be risks of ongoing maintenance and failures due to the inherent age of the original equipment package.

4.2.2 Replace with New Industrial Gas Turbine-Generator Package

The approximate cost of replacing the Wesleyville CTG with a new 16 MW Industrial Gas Turbine (Solar Titan 130) is as follows:

New 16 MW Industrial Gas Turbine (Solar Titan 130) and removal of existing:	
Equipment Costs (US$8,500 K)	$ 11,700,000
Additional Owner Costs (TBD)	$ 2,000,000
Shipping	$ 500,000
Removal and installation	$ 1,500,000
Building and Equipment Mod's	$ 2,000,000
Upgrade Station Services	$ 200,000
Engineering and PM	$ 3,000,000

Contingency (30%	$ 6,300,000
Total cost for a replacement package:	$ 27,200,000

Please note: this cost estimate excludes NP internal costs

4.2.3 Purchase 5.5 MW Mobile CTG Package

The cost of one (1) mobile CTG packages, similar to the OnPower unit purchased by NP in 2019, is approximately $18,750,000 (includes supply, shipping, delivery, engineering and owners' costs). The two mobile CTG's could be located in Wesleyville on a seasonal basis to provide emergency generation.

New mobile CFG package	$	14,000,000
Site Preparation Work (NP)	$	150,000
Fuel System Modifications (NP)	$	50,000
Paralleling Control Equipment	$	250,000
Contingency (30%)	$	4,300,000
Total Cost for Mobile CTG	$	18,750,000

4.2.4 Retirement

This option has not been reviewed.

4.2.5 Run to Failure

The option of running the unit to failure is not acceptable due to potential damage to property and danger to personnel.

5.0 CONCLUSIONS

5.1 GREENHILL CTG

The Greenhill CTG has reached the end of its service life and it is no longer practical to keep it in service due to its age, condition, and lack of vendor support. A new replacement CTG would cost approximately $36,700,000. Mobile CTG units could be considered but 4 to 5 of them would be required to replace the current capacity of 25 MW.

5.2 WESLEYVILLE CTG

The Wesleyville CTG may be considered for refurbishment to extend its life for a limited period by replacing select components including the power turbine, exhaust volute, exhaust stack and gearbox) and rewinding or replacing the generator. The estimated cost for this refurbishment and return to rated nominal nameplate capacity is $3,900,000

The estimated cost for a new industrial gas turbine – generator package is $27,200,000.

Alternately mobile CTG's could be considered, with two units required to provide nameplate capacity of 11 MW. This would require purchase of a second 5.5MW mobile gas turbine, similar to the existing NP unit, and locating both mobile CTG's seasonally at the Wesleyville site, for an estimated cost of $18,750,000.

Appendix A

Select Equipment Photographs

Appendix A

The following are pictures which outline the systems at Greenhill and Wesleyville as outlined in Sections 2 and 3.

A.1 GREENHILL CTG

The following are pictures of the Greenhill CTG and associated systems.

A.1.1 Greenhill Site and Building

Various views of the CTG building

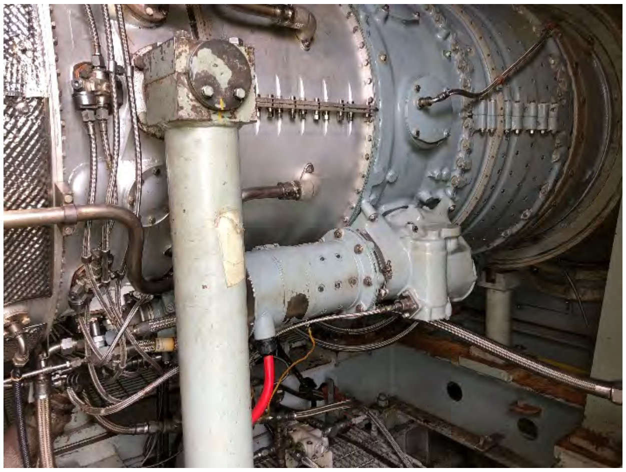


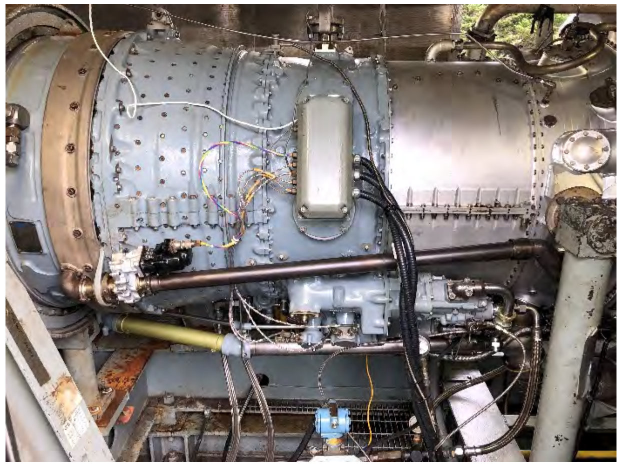


1202

A.1.2 Greenhill Gas Generator

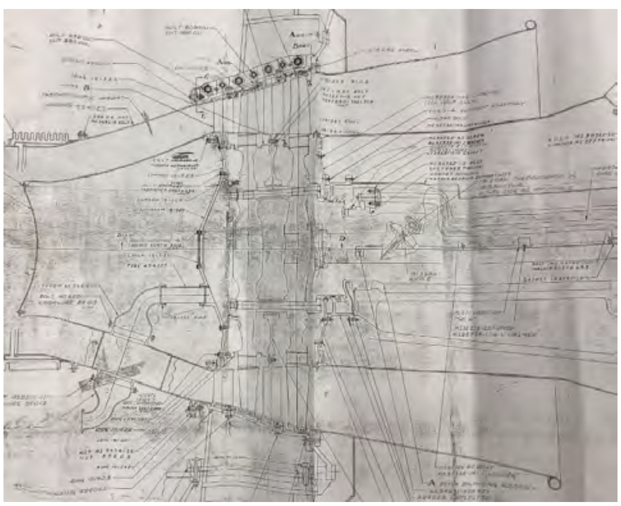
Rolls Royce Olympus Type C Gas Generator





A.1.3 Greenhill Power Turbine

Picture and outline of PT.

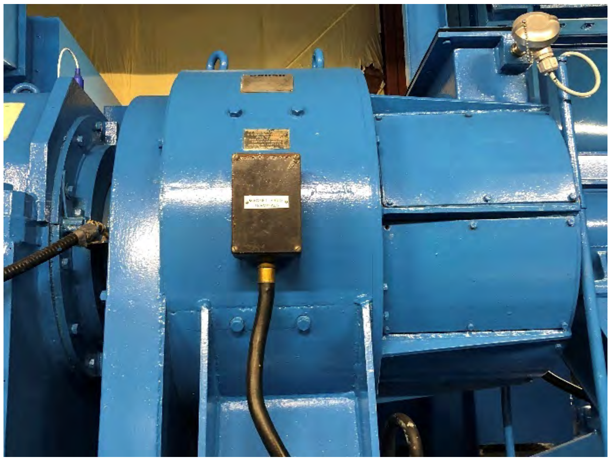


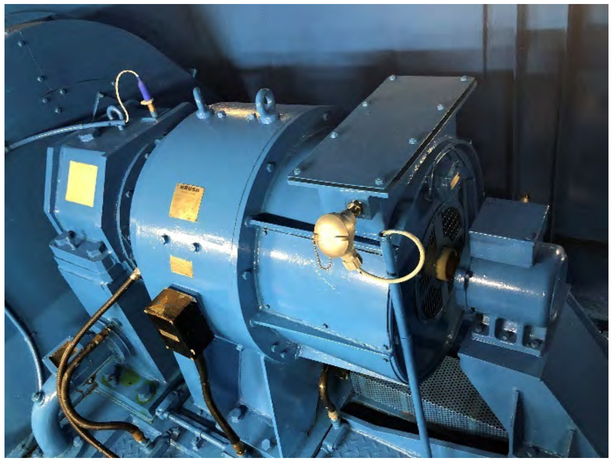
A.1.4 Greenhill Gearbox

As Greenhill does not have a gearbox, pictures are not shown.

A.1.5 Greenhill Generator

Brush Generator and exciter



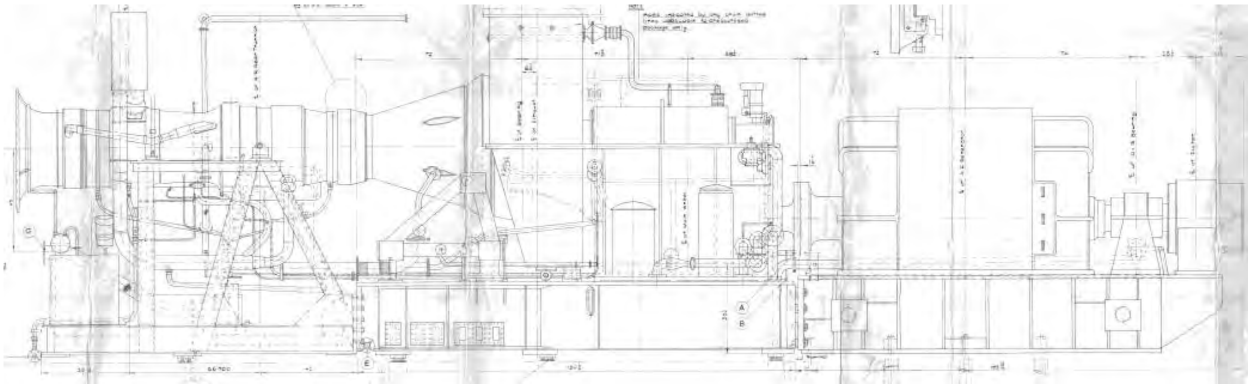


A.1.6 Greenhill Fuel System

The following pictures show the bulk fuel storage tanks and propane tanks.

A.2 WESLEYVILLE CTG

The following are pictures of Wesleyville CTG. Below is an outline drawing of the CTG.

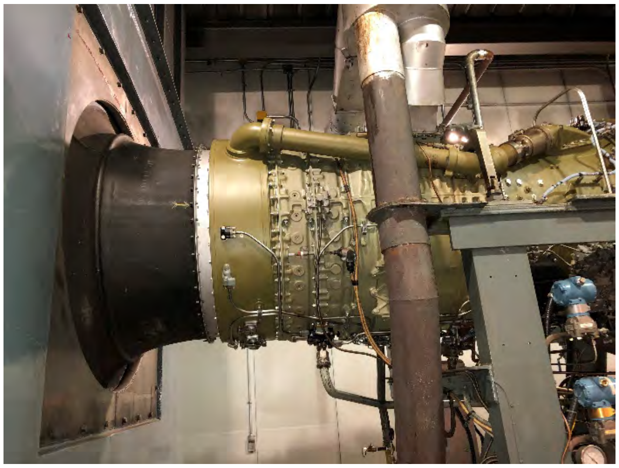


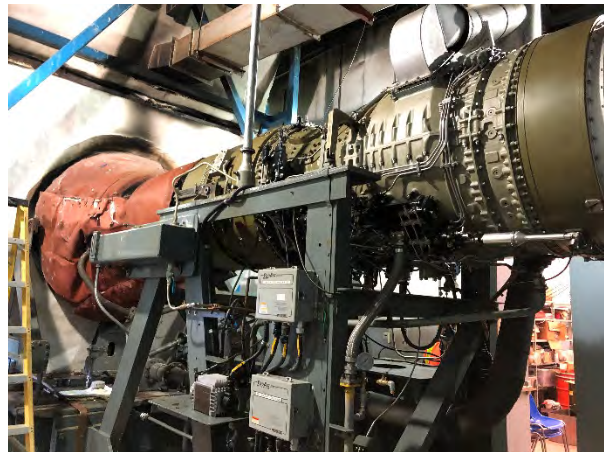
A.2.1 Wesleyville Site and Building

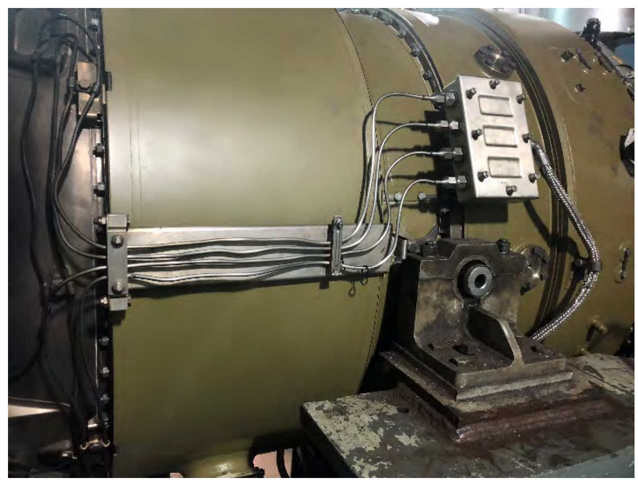
CTG building

A.2.2 Wesleyville Gas Generator

Multiple views of the Rolls Royce AVON 1533 gas generator.

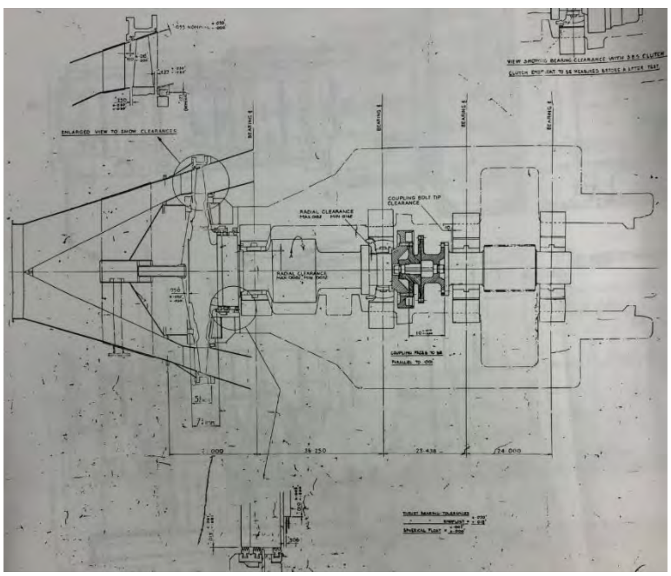






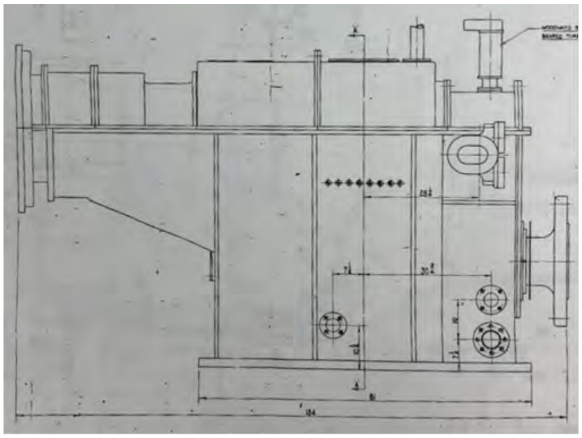
A.2.3 Wesleyville Power Turbine

Various views of the power turbine with the AVON engine, including an outline of the PT.



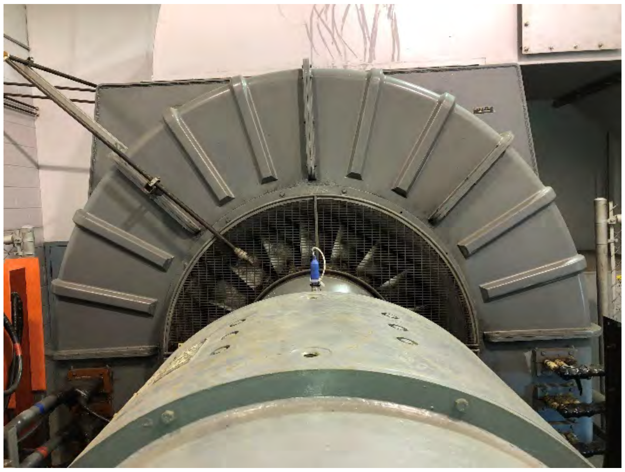
A.2.4 Wesleyville Gearbox

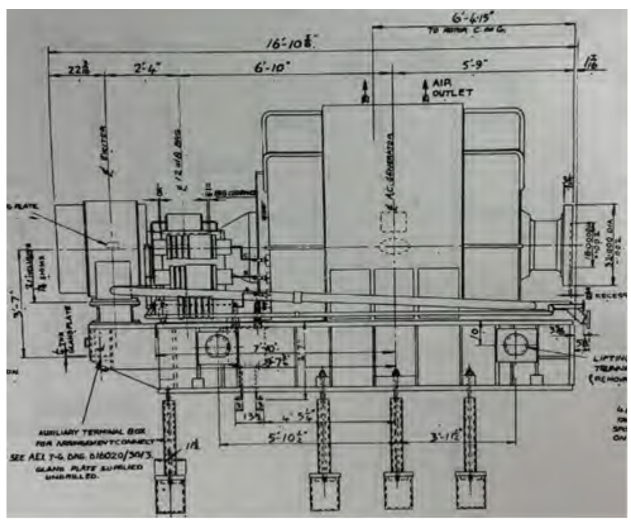
Drawing and top view of the gearbox.



A.2.5 Wesleyville Generator

AEI Generator and exciter with drawing outline.





A.2.6 Wesleyville Fuel System

The following pictures show the bulk fuel storage tanks and propane tanks