Q. Please provide a copy of the 2011 AMEC Consulting report on the condition assessment of the Holyrood Gas Turbine.

A. Please refer to NP-NLH-022 Attachment 1, Revision 1.

19 December 2011

Mr. Todd Collins, P. Eng.
Mechanical Design Engineer, Engineering Services
NALCOR Energy
Hydro Place, 500 Columbus Drive
PO Box 12400
St John's, NL, Canada
A1B 4K7

Dear Todd,

Holyrood Thermal Generating Station (Holyrood) Gas Turbine Condition Assessment & Options Study – Final Report

As per our Agreement, we have completed the Holyrood Thermal Generating Station Gas Turbine Condition Assessment. I trust that the report satisfies your needs.

Thank you for the opportunity to work on this very interesting project.

Yours truly,

Blair Seckington
Director, Power Technology
Direct Tel.: 905-403-5004
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BRS/brs
c: C. Woodall
c. R. Livet
c: A. Duplessis

Holyrood Thermal Generating Station

Gas Turbine Condition Assessment & Options Study

December 19, 2011

Holyrood Thermal Generating Station
Gas Turbine Condition Assessment & Options Study

Blair Seckington
Prepared by: Date

Ian Leach
Checked by: Date

Bob Livet
Approved by: Date

Rev.	Description	Prepared By:	Checked:	Approved	Date
A	Draft Report	Blair Seckington			
0	Final Report	Blair Seckington	Ian Leach		30 Aug 2011
1	Final Report	Blair Seckington		Bob Livet	19 Dec 2011

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HOLYROOD THERMAL GENERATING STATION GAS TURBINE CONDITION ASSESSMENT & OPTIONS STUDY

EXECUTIVE SUMMARY

The Holyrood gas turbine generator is a nominally 13.5 MW packaged generating unit system. It serves as a black start unit for the station and is occasionally used for system support. Due to the critical nature of the role that the Holyrood GT plays, it must operate with a high degree of operational reliability.

The gas turbine went in service at Holyrood in 1986. As of December 2010, the unit had a total of approximately 4717 operating hours, +386,000 idle hours, and 2548 starts. Due to the age of the gas turbine and balance of plant, the large number of idle hours, and its exposure to a marine environment, it was necessary to perform a comprehensive condition assessment and life extension study. In general, the unit and balance of plant equipment requires refurbishment or replacement work to continue operating with a high degree of reliability to its required end of life of 2020. The study will identify the measures that need to be taken to ensure reliable operation of the gas turbine (GT) and balance of plant. AMEC Americas Limited (AMEC) was contracted by NL Hydro to conduct a Condition Assessment and Refurbishment/Replacement Study for the Holyrood BlackStart Gas Turbine Generator and balance of plant equipment.

The scope of work consists of an engineering study that will assess the condition of the Holyrood Thermal Generating Station (HTGS) gas turbine and balance of plant and make recommendations for work including cost estimates that will be required to extend its useful life to 2020 with the same high degree of reliability as that experienced in the past. The engineering study will include a Level 2 study as per the guidelines of the Electrical Power Research Institute (EPRI). During the 1970's and 1980's, EPRI developed a three level methodology for performing condition assessment and life extension studies within the utilities industry in which the level of sophistication and detail increases progressively through Level I, Level II, and Level III studies. AMEC shall apply this process to the gas turbine generator and balance of plant equipment.

Part A of the study is primarily a detailed condition assessment and refurbishment study of the existing gas turbine plant located at HTGS with recommendations and cost estimates to extend the life of the gas turbine plant as a highly reliable operation to the year 2020.

Part B of the study examines the replacement of the existing gas turbine plant with a new or good used mobile generating plant considering either:

a) A GT plant consisting of two 5 MW mobile/transportable units.

b) A diesel generating plant consisting of five 2 MW diesel units.

As a result of the assessment, AMEC makes the following conclusions and recommendations:

ASSESSMENT BASIS

1. A black-start installation of ten (10) megawatts (MW) is required at the Holyrood Thermal Generating Station site to ensure the capability of the Holyrood units to quickly return to service in the event of a major system failure.
2. The black-start capability must be maintained during any refurbishment or replacement period. This particularly impacts the existing GTG refurbishment option since refurbishment of the existing unit may take an outage of months during which another standby generation unit may be needed and its costs borne by the project. For the existing unit, the lease cost can vary from about $170,000 for the

lease of a reconditioned gas generator and power turbine to swap into the existing unit to about $4.7 million for the lease of a complete 10 MW portable/transportable installation including all associated balance of plant systems and installation.

3. Each of the options has a "terminal value" at the end of the 2020 period. The amount is a function of both the age and condition and market value of the units at that time, and/or of its internal value for redeployment for other uses within Hydro post 2020 (i.e. regional distribution line outage/maintenance support). Potential short term alternative uses prior to 2020 may also have value, but were not assessed.

TERMINAL VALUES IN 2020

Option	Purchased Equipment Cost M$	System Terminal Value in 2020 M$	Comment
Option 0 - Refurbished Existing Unit	$3.0	$0	Terminal value covers cost for demolition
Option 1 - New 2 x 5 MW GT	$10.9	$7.0	Low use, essentially new condition.
Option 1A - Nearly New 2 x 5 MW GT	$9.2	$4.0	Lower percent recovery than new given prior use.
Option 2 - New 5 x 2 MW Diesel Genset	$8.6	$5.0	Lower market value – more available.
Option 2A - Nearly New 5 x 2 MW Diesel Genset	$7.5	$3.0	Lower percent recovery than new given prior use.

4. The system failure cost" of each of the options during the period to the end of 2020. This is a function of the expected or predicted difference in reliability between the options and the cost per hour of electric system black-out/disruption. The situation assumed to occur would be similar to the 1986 island blackout which lasted about 30 hours

ECONOMIC VALUES – FAILURE TO OPERATE ASSUMPTIONS

Failure To Operate		% Probability once over 2013-2020	Value of Hr Shutdown	# Hrs Per Shutdown	Probable $/Incident
		% (A)	MM$/Hr (B)	Hrs (C)	MM$ (D) = AxBxC
Option 0	Refurbished Unit	10%	$5	20	$10
Option1 & 1A	New/Used 2 x 5 MW GT	0%	$5	20	$0
Option 2 & 2A	New/Used 5x2 MW Diesel	4%	$5	20	$4

Notes:
Value/ Hr Shutdown = $5 MM (Impact to Newfoundland Economy)
Probability risk is relative to the new 2 x 5MW GT option
One occurrence assumed nominally in 2016
Probable $/incident increases proportional to (A), (B), or (C)

CONCLUSIONS

Existing Gas Turbine Generator Unit

1. The existing GT generator should not be operated (started, operated, shutdown) except in an emergency situation, and in such an emergency its operation should be observe remotely to ensure personnel safety.
    - i) Fire from lube oil system gearbox seals remains a possible safety issue.
    - ii) Catastrophic failure of the power turbine disk is a possibility due to corrosion and high stress that may be present at blade roots and attachments
2. The existing GT generator requires extensive overhaul and repair work:
    - i) Power turbine disk may require replacement (9 month manufacturing lead time)
    - ii) One or more power turbine blades may require replacement or significant repair
    - iii) Gas generator blading requires cleaning and recoating
    - iv) Inlet filter media requires replacement and inlet duct requires refurbishment (including cooling air duct to power turbine disk)
    - v) Exhaust stack requires replacement or extensive repairs
    - vi) Gearbox lube oil system requires modification and refurbishment
        - a. Seals require replacement/modification
        - b. Venting system modifications required to reduce lube oil pressure buildup
        - c. Lube oil pump system requires upgrade for start-ups.
        - d. Lube oil cooling fan is experiencing some leaks and snow and ice and water build-ups in its containment can cause start-issues
    - vii) Gearbox bearings likely worn and need refurbishment or replacement and/or unit re-alignment
    - viii) Unit generator requires significant testing and possibly rewind
    - ix) Unit generator exciter needs refurbishment and likely replacement
3. GT electrical and controls system has elements that are not in compliance with current standards and/or are obsolete and hence necessitates replacement:
    - i) Unit AVR
    - ii) Unit MCC’s
4. The GT and generator enclosure rooms require modification to their fire detection and suppression systems to provide better coverage, as evidenced by the failure of the system to initially detect or suppress the gearbox lube oil fire in 2010.
5. GT fuel oil receiving, forwarding, and delivery system are in operable condition, but climatic conditions (icing, snow-buildup, water build-ups from rain, rusting from salty ambient air) result in significant periods where starts may fail or be significantly delayed. The GT generator building is in generally good condition, except for:
    - i) Major leaks in and around the GT exhaust stack which are impacting the gas turbine power turbine volute and back end blades;
    - ii) Minor leaks at generator ventilation stack; and
    - iii) Minor air leaks as a result of minor siding holes (corrosion) which require repair/ refurbishment
6. The electrical services room require expansion to allow for new electrical systems and current systems to be in compliance with current standards (i.e. space, separation distance for arc flash).

7. The earliest in-service dates for refurbishing the existing unit and returning it to service:
    a. Without back-up during the existing unit outage, but restricting the outage to lower risk, late spring to early fall periods is October 2013, with a roughly six month outage.
    b. With a nearly new 2 x 5 MW GT leased unit required during an existing unit outage is July 2013 with the existing unit on outage about five months.
    c. With shorter duration engineering and procurement times for BOP, fuel system and electrical systems, the in-service can theoretically be advance two to three months, but outage scheduling would likely mitigate this.

    Note: Using leased parts during outage, or procuring used parts and refurbishing them, has no significant positive impact.
8. The capital cost for refurbishing the existing unit is between $4.5 and $5 million, depending on the amount of additional work found during refurbishment. If leasing a replacement 2 x 5 MW unit is required to avoid any outage, then the total capital cost would be between $9.5 and $10.0 million, depending on the market price and availability of portable/mobile equipment. There is some opportunity to slightly reduce costs if used parts for the unit, and in particular the power turbine disk, are available.

New and Nearly-New 2 x 5MW Portable/Transportable Gas Turbine Generator Units

1. The two 5 MW transportable gas turbine units option is consistent with the requirements for black start power, the need to start a 3 MW power block (one boiler feed pump motor), and simplicity of managing the number of black start units in parallel.
2. The space requirements for the two 5 MW transportable gas turbine units (2 trailers each plus a common electrical building) cannot be accommodated in the existing GT area.
3. Space and civil requirements support the use of the existing well graded area behind the old security building as the best location.
4. Two new 5 MW transportable gas turbine units could be readily purchased, with a manufacturing time of about 12 months.
5. Two nearly new, used 5 MW transportable GT units may be possible to acquire to a shorter time. Their availability and cost are functions of the market place. The units may also have to be adapted to suit Holyrood conditions (motor and start voltages, applicable codes, design fuel combustors, NOx levels).
6. Emissions, particularly NOx emissions, will have to be addressed:
    i) NOx emissions are dependent on the nitrogen content of the diesel fuel oil used.
    ii) NOx emissions will be lower than those of the current GTG units, but being oil fuelled units will be challenged to meet Canadian Council of Ministers of the Environment (CCME gas turbine NOx emission guidelines
    iii) Newfoundland & Labrador environmental regulations require Best Available Control Technology (BACT), although the regulations have provisions relaxing BACT requirements for both economic impacts as well as flexibility of approval by the Minister considering roles.
        a. The current designs do not have special technology (i.e. Selective Catalytic Reduction (SCR)). Their costs, the impacts of the technology on black start readiness and reliability, and the costs and impacts of ammonia use and storage for SCR use, make their consideration unreasonable for the roles contemplated.

b. A project going forth will have to seek approval for an exemption from the BACT requirement, and will likely have restrictions placed on the unit such as a limit on the number of operating hours per year.

7. Five MW units are likely the upper limit of useful unit size for redeployment in support of transmission and distribution line maintenance support either post 2020 or periods up to 2020.
8. The earliest in-service date for procuring and installing 2 x 5 MW new gas turbine generators is May 2013. The earliest in-service date for procuring and installing 2 x 5 MW nearly new/used gas turbine generators is March 2013.
9. The capital cost for procuring and installing 2 x 5 MW new gas turbine generators is $13.3 million. The capital cost for procuring and installing 2 x 5 MW nearly new/used gas turbine generators is $11.5 million.

<u>New and Nearly-New 5 x 2MW Portable/Transportable Diesel Engine Generator Units</u>

1. The five 2 MW transportable diesel engine generator units option is potentially consistent with the requirements for black start power, but:
   i) The units may have significant difficulty responding to a block load start of 3 MW power block (one boiler feed pump motor), and
   ii) Islanded synchronous operation during start-up of five units may be difficult to maintain and affect overall system capacity available and overall system start-up reliability. It will also likely require a more complex control system.
2. The space requirements for the five 2 MW transportable diesel engine generator units (5 trailers plus two electrical trailers plus a common electrical building) cannot be accommodated in the existing GT area.
   i) Space and civil requirements suggested that use of the existing well graded area behind the old security building was the best location.
   ii) Spacing requirements are increased by separation requirements between units
3. Five new 2 MW transportable diesel engine generator units could be readily purchased, with a manufacturing time of about 12 months.
4. Five nearly new, used 2 MW transportable diesel engine generator units may be possible to acquire to a shorter time. Their availability and cost are functions of the marketplace and the units may have to be adapted to suit Holyrood conditions (motor and start voltages, applicable codes, design fuel combustors, NOx levels).
5. Emissions, particularly NOx emissions, will have to be addressed:
   i) NOx emissions are dependent on the nitrogen content of the diesel fuel oil used.
   ii) NOx emissions, particularly for some used engines, may not be lower than those of the existing GT unit. They will have higher emission levels than the GT options.
   iii) Applicable diesel engine generator emission regulations in the US and Canada are in flux, with significantly more stringent requirements likely for units coming into service in the 2012 through 2015 period. Emergency power non-mobile (i.e. not on road or off-road units) will face significant but less stringent levels, but will have their operation limited to emergency use only (in effect similar to the restriction imposed on the existing GT).
   iv) Newfoundland & Labrador environmental regulations require BACT, although the regulations have provisions relaxing BACT requirements for both economic impacts as well as flexibility of approval by the Minister considering roles.
      a. The current designs do not have special technology (i.e. Selective Catalytic Reduction (SCR)). Their costs, the impacts of the technology on black start

readiness and reliability, and the costs and impacts of ammonia use and storage for SCR use, make their consideration unreasonable for the roles contemplated.

b. A project going forth will have to seek approval for an exemption from the BACT requirement, and will likely have restrictions placed on its role and likely a limit on the number of operating hours per year.

6. Two MW units are good candidates for redeployment in support of transmission and distribution line maintenance support either post 2020 or in possible periods up to 2020. They are typical of larger unit sizes deployed for that purpose now.
7. The earliest in-service date for procuring and installing 5 x 2 MW new diesel gensets is May 2013. The earliest in-service date for procuring and installing 5 x 2 MW nearly new/used diesel gensets is March 2013.
8. The capital cost for procuring and installing 5 x 2 MW new diesel gensets is $10.8 million. The capital cost for procuring and installing 5 x 2 MW nearly new/used diesel gensets is $9.6 million.

Overall Economics

Using the Assessment Basis,

1. The base capital cost comparison of the options is as follows:

BASE CAPITAL COST COMPARISON OF OPTIONS

Capital Cost Comparison
Capital cost estimate $1,000 Can 2011

Option Number	0	1	1A	2	2A
Option	Existing GT Refurb	New 2 x 5 MW GT	Used 2 x 5 MW GT	New 5 x 2 MW Diesel	Used 5 x 2 MW Diesel
GT/Diesel Cost	$2,950	$10,865	$9,234	$8,553	$7,453
Civil Works	$224	$131	$131	$131	$131
Electrical Works	$541	$759	$759	$801	$801
BOP Systems	$330	$129	$129	$129	$129
Existing Unit Demolition & Removal	$0	$7	$7	$7	$7
Sub-Total - Directs and Indirects	$4,046	$11,891	$10,260	$9,620	$8,520
Project Engineering	$324	$625	$544	$513	$458
Project Management	$283	$832	$718	$673	$596
Total	$4,652	$13,348	$11,522	$10,807	$9,575

+ Standby = Total	$4,825
+ New Rental Stdby = Total	$9,421

- The life cycle cost comparison of the options in 1) un-escalated non-discounted (not present worthed), 2) un-escalated discounted (present worthed), 3) escalated non-discounted (not present worthed), and 4) escalated discounted (present worthed) costs is as follows.

The existing unit refurbishment option costs include the lower cost standby option assuming that a replacement gas generator and power turbine are leased and installed while the existing units are sent out for refurbishment. This adds only about $170,000 to the base cost. The existing unit refurbishment option costs assuming the standby option using a complete, installed 2 x 5 MW nearly new GT leased option would add an additional $4.7 M. The options include a cost for differences in the likelihood of a failure occurring once during the period – an additional $10 million (2011 Cdn $) in 2016 for the existing GT and $4 million in 2016 for the 5 x 2 MW diesel options.

		Refurbished Unit, Use of Spare Gas Generator & Power Turbine					
		Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
1	UNESCALATED	$14,825	$1,885	$1,408	$18,118	($1,648)	$16,470
2	UNESCALATED, DISCOUTED CASHFLOW	$11,454	$1,291	$959	$13,704	($1,122)	$12,582
3	ESCALATED CASHFLOW	$16,260	$2,159	$1,660	$20,079	($1,943)	$18,136
4	ESCALATED, DISCOUTED CASHFLOW	$11,521	$1,302	$992	$13,815	($1,161)	$12,654

		Option 1 New 2x5 MW GT					
		Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
1	UNESCALATED	$6,348	$1,714	$1,237	$9,300	($1,648)	$7,652
2	UNESCALATED, DISCOUTED CASHFLOW	$8,766	$1,175	$842	$10,783	($1,122)	$9,661
3	ESCALATED CASHFLOW	$4,940	$1,963	$1,459	$8,362	($1,943)	$6,419
4	ESCALATED, DISCOUTED CASHFLOW	$8,731	$1,185	$871	$10,787	($1,161)	$9,626

	Option 1A Used 2x5 MW GT					
	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
1	$7,522	$1,714	$1,237	$10,473	($1,648)	$8,826
2	$8,632	$1,175	$842	$10,649	($1,122)	$9,527
3	$6,815	$1,963	$1,459	$10,236	($1,943)	$8,294
4	$8,618	$1,185	$871	$10,674	($1,161)	$9,513

		Option 2 New 5x2MW Diesel					
		Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
1	UNESCALATED	$9,807	$323	$1,237	$11,366	($1,648)	$9,719
2	UNESCALATED, DISCOUTED CASHFLOW	$10,231	$220	$842	$11,293	($1,122)	$10,171
3	ESCALATED CASHFLOW	$9,358	$370	$1,459	$11,187	($1,943)	$9,244
4	ESCALATED, DISCOUTED CASHFLOW	$10,232	$222	$871	$11,325	($1,161)	$10,164

	Option 2A Used 5x2MW Diesel					
	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
1	$10,575	$323	$1,237	$12,134	($1,648)	$10,487
2	$10,128	$220	$842	$11,190	($1,122)	$10,068
3	$10,593	$370	$1,459	$12,422	($1,943)	$10,479
4	$10,143	$222	$871	$11,236	($1,161)	$10,075

RECOMMENDATIONS

1. The existing gas turbine generator should not be operated (started, operated, shut down), except in an emergency situation, and in such an emergency its operation should be observed remotely.
2. Using the Assessment Basis, the preferred option is Option 1, the 2 x 5 MW new GT installation.
3. Hydro should review the Assessment Basis and any impacts of changes in it as part of its internal decision-making process on the options.
4. Hydro should proceed with a preferred option as soon as practically possible, given that the likelihood of safely and successfully starting the existing GT unit in an emergency condition in its existing state is very poor and likely to decrease rapidly with time idle.
5. If Hydro internally chooses refurbishment of the existing GT generator as its preferred option, then the existing GT generator should undergo an extensive overhaul and repair program, including:

   i) Gas Turbine Unit

      a. Power turbine disk replacement (9 month manufacturing lead time);
      b. Power turbine damaged blades replacement (one or more) or significant repair;
      c. Gas generator blading cleaning and recoating;
      d. Inlet filter media replacement and inlet duct refurbishment (including cooling air duct to power turbine disk); and
      e. Exhaust stack replacement or extensive repairs

   ii) Gearbox lube oil system modification and refurbishment

      a. Seals replacement/modification;
      b. Venting system modifications to reduce lube oil pressure buildup;
      c. Lube oil pump system upgrade for start-ups; and

d. Lube oil cooling fan replacement

iii) Gearbox bearings refurbishment or replacement and/or unit re-alignment

iv) GT Generator testing and refurbishment

a. Unit generator electrical testing and possible rewind; and
b. Unit generator exciter testing, and refurbishment/replacement as necessary

v) GT electrical and controls system update to compliance with current standards and/or obsolescence replacement

a. Unit AVR
b. Unit MCC's

vi) The GT and generator enclosure rooms' fire detection and suppression systems modifications to provide better coverage (as evidenced by the failure of the system to initially detect or suppress the gearbox lube oil fire in 2010).

vii) GT fuel oil receiving, forwarding, and delivery system replacement in an enclosed shed.

viii) GT generator building repairs:

a. Major leaks in and around the gas turbine exhaust stack
b. Minor leaks at generator ventilation stack
c. Minor air leaks as a result of minor siding holes (corrosion)

ix) Expansion of the electrical services room to allow for new electrical systems and current systems to be in compliance with current standards (i.e. space, separation distance for arc flash)

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GLOSSARY

°F or oF	Degree Fahrenheit
°C or oC	Degree Celsius
ATS	Automatic Transfer Switch
BTU	British Thermal Unit
CO2	Carbon dioxide
CW	Circulating or cooling water
DCS	Distributed Control System
DG	Diesel Generator
Gen	Generator (Only)
GTG	Gas Turbine Generator
HP	High Pressure
JB	Junction Box
kV	Kilovolt
kVAR	Kilovolt ampere reactive
kW	Kilowatt
kWh	Kilowatthour
LP	Low pressure
Max	Maximum
MCC	Motor control centre
MCR	Maximum continuous rating
mm	Millimetres
Mg	Megagrams
mg	Milligrams
MOT	Main output transformer
MTS	Manual Transfer Switch
MVA	Megavoltampere
MVAR	Megavolt ampere reactive
MW/MWg/MWn	Megawatt /megawatt gross/megawatt net
MWh/MWhg/MWhn	Megawatt hour/ megawatthour gross megawatthour net
Min	Minute
O2 or O_2	Oxygen
psig or psi_g	Pound per hour pounds per square inch gauge
psia or psi_a	Pounds per square inch absolute
ppmvd or ppm_{vd}	Parts per million (dry volume basis)
%	Percentage
PT	Power Turbine
Rpm	Revolutions per minute
Scfh	Standard cubic feet per hour
T9	Transformer #9
TGS	Thermal generating station
VAR	Vars
V	Volts

HOLYROOD THERMAL GENERATING STATION
GAS TURBINE CONDITION ASSESSMENT & OPTIONS STUDY

1 INTRODUCTION

1.1 Holyrood Thermal Generating Station and Black Start Gas Turbine Generator

1.1.1 Holyrood Thermal Generating Station (Holyrood)

Holyrood Thermal Generating Station is a three unit, nominally 500 MW, heavy oil fired, steam cycle fossil generating station. It is located on the south shore of Conception Bay in the province of Newfoundland and Labrador, between the towns of Holyrood and Conception Bay South. Holyrood was constructed in two stages - Units 1 and 2 in the late 1960’s and Unit 3 in 1977.

When all three units are in operation at full MCR (maximum continuous rating), Holyrood is capable of supplying approximately 33% of the Newfoundland and Labrador electricity demand. Typically, the units operate during the late fall to spring peak period and supply a minimum load of between 80 MW and 150 MW. The Unit 3 generator is also capable of synchronous condenser operation for grid voltage control.

1.1.2 Holyrood Black Start Gas Turbine Generator (GT)

The Holyrood gas turbine generator is a nominally 13.5 MW packaged generating unit system. It serves as a black start unit for the station and is occasionally used for system support. Due to the critical nature of the role that the Holyrood GT plays, it must operate with a high degree of operational reliability.

The gas turbine generator is comprised of a number of components: inlet plenum, AVON 1533-70L gas generator and power turbine, exhaust system, gearbox, generator, fuel oil system, governor/fuel control and lubricating oil system.

Ambient air enters the intake structure, passes through an intake air filter and enters the inlet air plenum. The air is compressed via a 17- stage axial flow compressor in the forward section of an AVON 1533-70L.gas generator. Fuel is supplied to an eight burner combustion section between the gas generator air compressor section and its turbine section. Combustion of the fuel results in a rapid increase in the temperature and velocity of the axial hot combustion gas flow. A three-stage turbine in the back end of the AVON 1533-70L uses a portion of the axial combustion gas flow to increase compressor rotational speed and to boost delivery. The high temperature, high velocity gas is then used to drive the power turbine and generator through a gearbox. The engine has its own on-board lubrication system complete with circulating pumps and a reservoir. The combustion gases then pass through an exhaust volute and to the atmosphere via an exhaust stack.

1.2 Project Description & Scope

The gas turbine went in service at Holyrood in 1986. As of December 2010, the unit had a total of approximately 4717 operating hours, +386,000 idle hours, and 2548 starts. Due to the age of the gas turbine and balance of plant, the large number of idle hours, and its exposure to a marine environment, it was necessary to perform a comprehensive condition assessment and life extension study. In general, the unit and balance of plant equipment requires refurbishment or replacement work to continue operating with a high degree of reliability to its required end of life of 2020. The study will identify the measures that need to be taken to ensure reliable operation of the gas turbine (GT) and balance of GT. AMEC Americas Limited (AMEC) was contracted by NL Hydro to conduct a Condition Assessment and Refurbishment/Replacement Study for the Holyrood BlackStart Gas Turbine Generator.

The scope of work consists of an engineering study that will assess the condition of the Holyrood Thermal Generating Station (HTGS) gas turbine and balance of plant and make recommendations for work including cost estimates that will be required to extend its useful life to 2020 with the same high degree of reliability as that experienced in the past. The engineering study will include a Level 2 study as per the guidelines of the Electrical Power Research Institute (EPRI). During the 1970's and 1980's, EPRI developed a three level methodology for performing condition assessment and life extension studies within the utilities industry in which the level of sophistication and detail increases progressively through Level I, Level II, and Level III studies. AMEC shall apply this process to the gas turbine generator and balance of plant equipment.

Part A of the study is primarily a detailed condition assessment and refurbishment study of the existing gas turbine plant located at HTGS with recommendations and cost estimates to extend the life of the gas turbine plant as a highly reliable operation to the year 2020.

Some GT equipment vendors had already issued their condition reports to Hydro. Hydro made these reports available to AMEC. Following an analysis of the reports and consultation with vendors, AMEC shall make recommendations for refurbishment work necessary to extend the life of the gas turbine plant as a highly reliable operation until the year 2020. Cost estimates shall be provided for the recommendations, in addition to giving consideration to the vendor reports.

Part B of the study examines the replacement of the existing gas turbine plant with a new or good used mobile generating plant considering either:

a) A gas turbine plant consisting of two 5 MW mobile/transportable units.

b) A diesel generating plant consisting of five 2 MW diesel units.

If used generating plants are considered, they are required to be relatively new and in good condition.

The new plants are to be able to support start-up block loads up to 3 MW in a smooth and stable manner. The scope would include the decommissioning of the existing plant and removing it from site. The new units would be installed such that uninterrupted black start power availability would be provided to HTGS until new mobile installations are commissioned.

AMEC shall determine the annual operating and maintenance (O&M) cost for each of the alternatives up to the year 2020.

1.3 Study Basis

The basis for the study is as follows:

In-Service: Summer 2013

End of Life (EOL):

- **Holyrood Black Start:** Dec 2020 in Holyrood black start service
- **System Support:** Post 2020 for replacement options - transportable for transmission/ distribution system maintenance to various locations for further 10 to 15 years

Operating Pattern:

- **To 2020:** 1 start every 2 weeks to 50%+ load for two hours in winter; 1 start per month in summer; System use – 20 to 40 hrs/year
- **Post 2020:** Maximum 1 month/year operation on transmission line outage support – Maximum 720 hours per year , 6 starts/year

Capacity Targets: 10 MW gross peak capacity; Continuous capacity – vendor capacity based on gross peak capacity

Energy Targets: No specific energy production targets – Capacity and Operating Pattern define role.

Reliability Targets:

Start Reliability:	80% (2nd start – 96%, 3rd start – 99 %)
Black Start Ops Reliability:	98%
Peaking Reliability:	95%
Availability:	93% (Summer maintenance)

Health & Safety Target; Maximum Practically Achievable Safety

- Minimum fire risk
- Minimum catastrophic equipment failure risk

Environmental & Regulatory Target: Meet Newfoundland & Labrador environmental and regulatory requirements for the technology and role of the facility

1.4 Methodology

1.4.1 Part A – Existing Unit Refurbishment

GT equipment vendors previously issued their condition assessment reports to Hydro. Hydro made these reports available to AMEC. An analysis of these reports, and consultation with vendors, forms the basis for AMEC's recommendations for refurbishment work necessary to extend the life of the gas turbine plant as a highly reliable operation until the year 2020. Cost estimates were not provided by the vendors for the recommendations in their assessments. In addition to giving consideration to the vendor reports AMEC shall perform the following tasks in completing the Project.

1. Conduct Equipment Inspections – Balance of Plant (BOP)

AMEC developed a plan, including a schedule, to perform detailed inspections of the remaining gas turbine balance of plant systems and sub systems and identify refurbishment needs. Following the completion of the inspection, AMEC formulated recommendations for refurbishment work complete with cost estimates, including a schedule, that are required to extend the life of the balance of plant systems until the year 2020. The OEM's and other specialists were consulted as required to assist in the study. AMEC contacted OEM's and other specialists to provide this information to AMEC. The remaining gas turbine BOP systems and sub systems addressed by this study included the following:

1. Fuel oil system
    i. Fuel tanks
    ii. Fuel oil piping
    iii. Fuel offloading pumps
    iv. Valves
    v. Fuel supply pumps (to the gas turbine)
    vi. Strainers and filters
    vii. Fuel flow meter
    viii. Fire system trip valve
2. Electrical and controls
    i. Foxboro DCS system
    ii. DCS logic
    iii. MCC
    iv. Switchgear
    v. Governor system
    vi. Battery room
3. Compressed air system
    i. Compressor unit
    ii. Instrument air dryer
    iii. Control panel
    iv. Nitrogen back-up bottle supply
4. Building
    i. Structure
    ii. Fire protection system
    iii. Crane hoist and track system

2. Major Upgrades and Repairs

A number of major upgrades and repairs have been performed on the HTGS gas turbine and balance of plant since it went into service in 1986. AMEC reviewed available plant records pertaining to major equipment upgrades and repairs and evaluate their impact on achieving 2020 service life.

3. Determine Remaining Equipment Life

AMEC assessed the remaining lifetimes of the gas turbine plant major components and systems along with the balance of plant, consulting as required with OEM's and reviewing the historical life cycle information for similar type facilities to assess the requirements to reach an end of life of the gas turbine plant of 2020.

4. Determine Annual Operating and Maintenance Cost

AMEC determined the annual operating and maintenance (O&M) cost for the gas turbine plant up to the year 2020, both with the recommended refurbishments and without completing the recommended refurbishment work. AMEC contacted OEM's and other specialists as required to support development of this information.

1.4.2 Part B – Existing Unit Replacement

AMEC developed a scope of work and cost estimate to replace the existing gas turbine plant with a new or good used mobile generating plant considering alternative arrangements as noted below. If used generating plants are considered they are required to be relatively new and in good condition.

a) A gas turbine plant consisting of two 5 MW mobile units.

b) A diesel generating plant consisting of five 2 MW mobile diesel units.

The alternative arrangements were configured such that the new plants would be able to support start-up block loads up to 3 MW in a smooth and stable manner. In addition, cost estimates included decommissioning of the existing plant and removing it from site. The alternatives considered were such that uninterrupted black start power availability would be provided to HTGS until new mobile installations are commissioned.

AMEC determined the annual operating and maintenance (O&M) cost for each of the alternatives up to the year 2020.

The study methodology included the following steps:

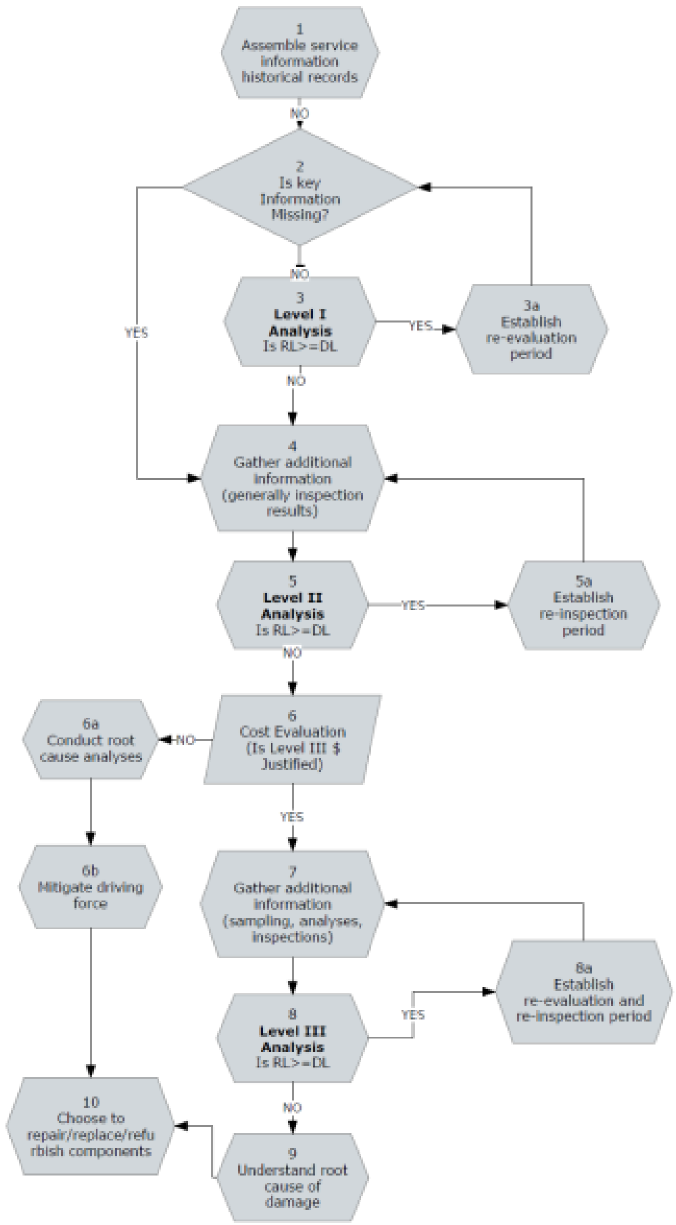
- Initial kick-off meeting and site visit
- Site review and equipment/facility inspections
- Review of the Holyrood Plant Maintenance Program – existing information/background data and staff interviews
- Review and analysis of information and data obtained through:
    2. Existing studies on condition assessment, life expectancy, previous studies of life extension, and the associated costs (capital and O & M) of such programs
    3. Previously noted physical inspection reports of equipment
    4. Equipment lost time analysis data
    5. Interviews and discussions with NL Hydro management
    6. Interviews and discussions with Holyrood Operations and Maintenance personnel
    7. Analysis of power demands vs. Holyrood generation capabilities
- Analysis of the impact and value of capital upgrades and operational and maintenance improvements
    1. Determination of remaining equipment and facility life – using existing information, experience, and OEM consultations as required to develop life cycle curves for major critical equipment and facilities not expected to exceed the 2020 end of life date; and
    2. Conduct equipment risk of failure analysis for major plant components, equipment, systems, and the entire facility which is not expected to exceed the 2020 end of life date.

3. Identify any components or systems that require further investigation; and make recommendations for work that will be required to extend the plant's useful life to 2020 with the same high degree of reliability as experienced in the past.

To the extent practical, the approach followed the intent of the EPRI Condition Assessment Level 2 process or a reasonable alternative approach as determined by individual technology experts. The basic approach consistent with the EPRI Level 2 approach is:

- Examine design or overall service parameters
- Perform Level 2 inspections (physical only, no testing)
- Compare, using conservative considerations, the expected residual life to the required 2020 service period (or the interval to the next inspection whichever is less)
- Incorporate service and measurement information where practical, available and useful including:
    1. Unit running hours
    2. Numbers of starts and stops – hot, warm, cold, trips, ramp rates
    3. Unit load records
    4. Failure history and analyses reports
    5. Maintenance activities
    6. Specifics of past component repairs and replacements
    7. Materials of construction composition checks
    8. Dimensional checks
    9. Design parameters

The generic EPRI condition assessment methodology is illustrated in Figure 1-1. This chart includes step numbers used in the report to identify where in the process various systems and equipment are considered to be.



NOTE: Remaining Life (RL) is the estimated reliable remaining life of a piece of equipment or system based on available inspection and equipment data. Desired Life (DL) is the desired life of the component, but for decision making is the earlier of the desired end of life (EOL) date or the next inspection that can yield date for life assessment purposes.

FIGURE 1-1 GENERIC EPRI CONDITION ASSESSMENT METHODOLOGY

For mechanical systems, it considers aspects such as:

Feature	Level I	Level II	Level III
Failure History	Plant records	Plant records	Plant records
Dimensions	Design or nominal	Measured or nominal	Measured
Condition	Records or nominal	Inspection	Detailed inspection
Temperature and pressure	Design or operational	Operational or measured	Measured
Stresses	Design or operational	Simple calculation	Refined analysis
Material properties	Minimum	Minimum	Actual material
Material samples required?	No	No	Yes

More rigorous assessment →

More accurate operation data required →

More accurate estimate of equipment RL →

FIGURE 1-2 EPRI METHODOLOGY – INFORMATION REQUIREMENTS

The Level 2 analysis considers several issues, such as:

- Has the unit component operation exceeded its design parameters (i.e. temperature, pressure) for significant periods of time or by significant amounts?
- Will the required future service requirement exceed significant design parameters (i.e. cycling, two-shifting capacity) without suitable modification?
- Has unit maintenance and reliability shown that the operating philosophy and materials have not been conservative since the units was operational?
- Has the failure history been excessive?

The intent in Level 2 is to address items with insufficient information to make decisions going forward. For example in the chart below, Level 1 allows selection of a number of components to replace, repair or refurbish, but leaves the majority as uncertain. Level 2 further refines the uncertain portion of Level 1.

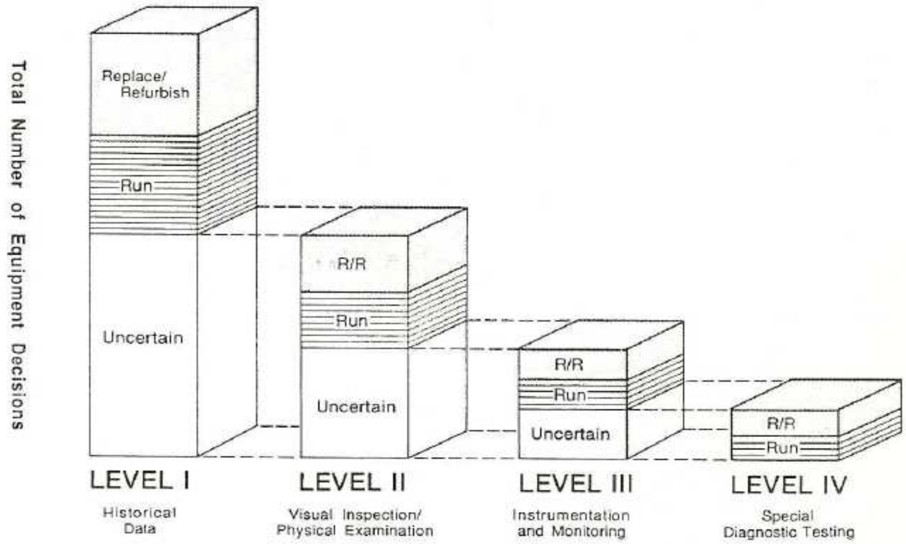


FIGURE 1-3 FOUR-LEVEL ELECTRICAL COMPONENT LIFE ASSESSMENT

1.5 Background Information and Studies

The key background information and studies included the following:

- Identification of key equipment;
- Identification of recent improvements/changes – fuel, major modifications, etc.;
- Vendor consultation;
- Current/planned station budgets and plans;
- Timing of changes – likelihood;
- Staffing, Operating, Maintenance and Administration (OMA) plans;
- Criteria for operation and operating parameters;
- Major equipment to be considered;
- Present design and operating data – e.g. temperatures, vibration data, cooling water and oil temperatures, etc. at typical load points;
- Facility drawings as required;
- Maintenance data for major pieces of equipment, especially from the last major maintenance outage. Details of known limitations, and operating concerns; and
- Details of major repairs performed on major equipment.

1.6 Field Investigation

It was agreed that the scope and results of field investigative work, analyses undertaken, variables examined, and operational considerations would address:

- Operating hrs and cold/warm/hot starts;
- Major outages and associated reports (planned, major maintenance);

- Major plant equipment and system changes (i.e. equipment change-out, major gas turbine modifications and generator modifications) since in-service (particularly in last 10 years) including the scope and timing of the changes;
- Major inspections (and associated reports) on key equipment and systems;
- Unit performance – capacity, heat rate, availability;
- Current budget and business plan information details; and
- Occurrences where the actual operating conditions exceeded the equipment design conditions.

1.7 Scope, Key Features and Parameters of Study

The study scope was discussed with NL Hydro during an initial kick-off meeting and it was agreed that:

- AMEC would adapt the Holyrood asset register as the primary index.
- The generic EPRI Condition Assessment approach illustrated in Figure 1-1 is the methodology employed. A more generic approach, using industry and individual expert experience, taking into account Holyrood specific information, was applied in many cases.
- The intent is to provide an assessment of requirements including schedule and cost. Given the stage of and eventual scope of the work, as well as the economic environment, an accuracy of +/- 10-15% is a target typically achieved during detailed quotes on actual work, and the overall costs are practically speaking more of a +10/-25% quality, typical of this stage of the work.

The following key features of the study were identified:

- No new detailed information was developed. The assessment was based on existing information obtained through existing documents and studies, plant interviews, and readily undertaken visual inspections
- The findings of existing studies are taken into account.
- The intent of the EPRI Level 2 methodology is to determine whether a piece of equipment or system can either reach it's intended planned life or reach its next major inspection and overhaul. If it is indeterminable as to whether the equipment can or cannot reach its planned life or next major inspection/overall, then a Level 3 condition assessment is necessary.
- The study focuses primarily on key equipment systems required for black start operation up to 2020
- Inspection and analysis has been done by others on the major gas turbine OEM equipment as per the RFP document. AMEC will use this condition and cost information as the basis for its gas turbine assessment.
- No inspections were required for equipment identified in the Level 1 study as satisfactory – for example: fuel tanks, building siding, recent electronics equipment additions.
- EPRI Level 2 inspections were limited to equipment identified as BOP and for which visible and practical inspections are possible in AMEC's judgment.
- Inspections were only undertaken per above and only on key equipment that is not considered covered under regular OMA, but represented a life limiting issue having a probable and significant impact on the reliable operation of the unit in AMEC's judgment.
- No specific equipment testing was undertaken as a Level 2 exercise.
- Remaining life was determined and reported on for those major systems and pieces of equipment which are expected to fail before 2020 and have a significant reliability impact on the gas turbine unit in AMEC's judgment.

1.8 Cost Estimating and Schedule

AMEC developed cost estimates and schedule for both Part A and Part B options - to complete a GT refurbishment as well as to replace the existing gas turbine unit with either 2 x 5 MW gas turbine generators or 5 x 2 MW diesel engine generators. Where practical, the cost estimate targeted an accuracy range of +/- 10-15%. It was identified and agreed that this would not be practical in many cases given the stage of work and the labour and materials marketplace and any key considerations pertinent to completing the cost estimate and schedule provided.

1.9 Site Visits

AMEC staff visited Holyrood in May-June 2011:

- A one-week visit by Rupert Merer (GT expert) and Blair Seckington; and
- Various short term visits by several of AMEC St John's office staff with Civil, Structural, Electrical & Controls, and Mechanical expertise.

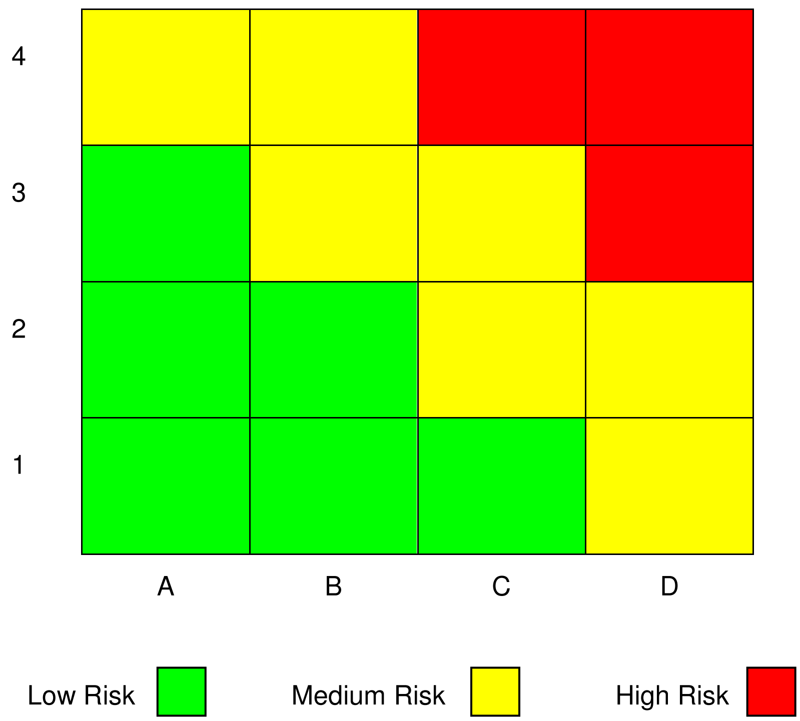
In the course of these visits, meetings and interviews included the following staff:

- Plant management team as a whole – kick-off, scope, areas of responsibility, and general information sharing;
- Terry LeDrew (Plant Manager) – key plant issues and asset history;
- Jeff Vincent (Manager-Long Term Asset Planning) – various plant asset conditions, capital plans, Instrumentation and Controls (I&C), Electrical, and organization;
- Wayne Rice (Manager-Work Execution) – various equipment and system conditions and plant staffing;
- Sean Mullowney (Plant Electrical Engineer) – various technical issues and programs regarding electrical systems, instrumentation, and controls;
- Jamie Curtis (Quality Assurance Engineer) – NDE and test program results;
- Christian Thangasamy (Plant Mechanical Engineer) – various technical issues and programs related to condensers, boilers, synchronous condenser, steam turbine generator, motors, and pumps;
- Mike Manuel (Manager-Environment, Health and Safety) – reliability;
- Alonso Pollard (Performance Specialist) – performance data (reliability and availability);
- Gerard Cochrane (Manager - Operations) – plant and equipment performance issues, plant operations issues;
- Plant Shift Supervisors and Operators (various) – plant operations issues and performance;
    - Ron MacDoanald, Willis Young
- Ron LeDrew (Emergency Response Coordinator) – Emergency Response Team (ERT) activities;

1.10 Technological Risk of Failure Analysis

The risk assessment model has been developed based on methods proposed by the American Petroleum Institute (API RP 580), in lieu of a model specific to the power utility industry. The basic concept consists of a 4 x 4 matrix with the consequence measured in cost terms on the base or horizontal axis and the likelihood or frequency of the event on the vertical axis. The study risk of failure analysis was performed using the model illustrated below in Table 1-1.

TABLE 1-1 TECHNOLOGICAL RISK OF FAILURE ANALYSIS MODEL



Likelihood of Failure Event:

1. Greater than 10 years
2. 5 to 10 years
3. 1 to 5 years
4. Immanent (< 1 year)

Consequence of Failure Event:

A. Minor ($10k-$100k or derating/1 day outage)
B. Significant ($100k-$1m or 2-14 days outage)
C. Serious ($1m-$10m or 15-30 days outage)
D. Major (>$10m or >1 month outage)

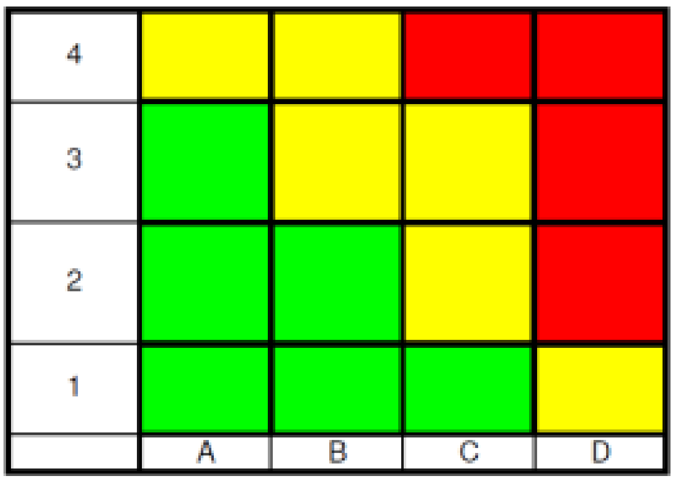
Actions:

- Items that do not apply are not ranked
- Low Risk: Monitor long term (within 5 years)
- Medium Risk: Investigate and monitor short term. Take action where beneficial
- High Risk: Corrective action required short term

1.10.1 Safety Risk Failure Analysis

In addition to the technological risk of failure analysis, a preliminary safety risk of failure analysis was undertaken at NL Hydro's request. Its basic format is based on that of the technological risk assessment model above and is somewhat of a hybrid of the more complex "Real Hazard Index" model used by the US Department of Defence. The modified model is presented below in Table 1-2.

TABLE 1-2 SAFETY RISK FAILURE ANALYSIS MODEL



Low Risk Medium Risk High Risk

<u>Likelihood of Safety Incident Event:</u>

1. Improbable – so that it can be assumed not to occur
2. Unlikely to occur during life of specific item/process
3. Will occur once during life of specific item/process
4. Likely to occur frequently

<u>Consequence of Safety Incident Event:</u>

A. Minor - will not result in injury, or illness
B. Marginal - may cause minor injury, or illness
C. Critical - may cause severe injury, or illness
D. Catastrophic - may cause death

<u>Actions</u>:

- Items that do not apply are not ranked;
- Low Risk: Monitor, take action where beneficial;
- Medium Risk: Investigate and monitor short term. Take action where beneficial; and
- High Risk: Unacceptable. Corrective action required short term

1.11 Priority Rating

A numbered priority was assigned to the various “Recommended Actions”, “Level 3 Inspections”, and “Capital Enhancements” of this report. The scale used was from “1” to “4”. A “1” is the highest priority and essentially means that this activity should definitely be undertaken and where practical in or about the timing identified. A “4” is the lowest priority and essentially means that the item is essentially low risk and low impact and may be much more readily delayed or undertaken in some other fashion. The priority ranking is a subjective relative ranking by AMEC, meant to be an aid to Hydro in allocating resources and assessing trade-offs and program delays.

The priority ranking is not based on a rigorous process, but does take into consideration a number of aspects such as:

1. The impact (likely and worst case) of the item under consideration on achieving the end of life (EOL) goal, on plant operation health and safety, and on environmental and regulatory requirements;
2. The urgency of the need for action on the item under consideration;
3. The degree of certainty of the requirement for the item under consideration;
4. The experience at Holyrood and in the broader industry context with the item;
5. The ability to mitigate or address the issue in other ways;
6. The timing of the recommended response to the item under consideration;
7. The cost of the item under consideration relative to others; and
8. The ability of existing and planned or ongoing actions to address the item in a timely and successful manner.

The priority value of any item should be read in the context of its recommended timing. An item can be a “1”, but be scheduled for a later date if it is deemed that sufficient information exists to be confident of the minimal likely impact of the deferral (usually to tie in with a planned major activity such as an overhaul).

2 EXISTING GAS TURBINE CONDITION ASSESSMENT

2.1 Gas Turbine Unit and Equipment/Processes

Unit #:	GAS TURBINE
Asset Class #	BU 1273 Gas Turbine
SCI & System:	7202 Gas Turbine System
Sub-Systems:	7058 GT Power Turbine & G/B 7308 GT Avon Jet Engine 7309 GT Generator

2.1.1 Description of Holyrood API Gas Turbine

The Holyrood API gas turbine is a 10/12 MW aeroderivative packaged power plant using a Rolls Royce Avon gas generator. It was designed for peaking duty to provide black start capability to the Holyrood Generating Station. The Holyrood unit is the first API produced, and had guaranteed ratings, at ISO conditions, of 12 MW peak and 8.4 MW base load. It was originally installed at Hardwoods, but moved to Holyrood in 1970. In 1986 the plant was removed from its enclosure and re-installed in a custom building with a new exhaust stack with exhaust silencer and inlet filter house.

The gas turbine generator is comprised of a number of components: inlet plenum, AVON 1533-70L power turbine, exhaust system, gearbox, generator, fuel oil system, governor/fuel control and lubricating oil system.

Ambient air enters the intake structure, passes through an intake air filter and enters the inlet air plenum. The air is compressed via a 17- stage axial flow compressor in the forward section of an AVON 1533-70L.gas generator. Fuel is supplied to an eight burner combustion section between the gas generator air compressor section and its turbine section. Combustion of the fuel results in a rapid increase in the temperature and velocity of the axial hot combustion gas flow. A three-stage turbine in the back end of the AVON 1533-70L uses a portion of the axial combustion gas flow to increase compressor rotational speed and to boost delivery. The high temperature, high velocity gas is then used to drive the power turbine and generator through a gearbox. The engine has its own on-board lubrication system complete with circulating pumps and a reservoir. The combustion gases then pass through an exhaust volute and to the atmosphere via an exhaust stack.

The whole unit was re-housed in a custom building in 1986 with new filter house, generator filters, control room and exhaust stack. New stainless steel inlet splitters were installed. A new exhaust silencer and stack were installed with exhaust hoods, a number of control upgrades have been made, and the generator compartment was provided with new filter elements.

GTG Inlet Plenum

The inlet plenum is designed to provide approximately 140,000 cubic feet per minute of combustion air to the jet intake. This plenum is constructed of structural steel plate and framing supported by a concrete foundation. To reduce compressor damage and blade fouling, the inlet air must be free of dust and dirt.

Filtration is currently accomplished using a two stage filter. The first stage is designed for water removal, while the second was a high efficiency media type filter. It has 72 high efficiency "Farr" filter assemblies supported on tubular columns above the intake. The inlet silencer consists of acoustical splitters in a steel shell that is designed with round leading edges to create a bell-mouth entry. The trailing edges are tapered to ensure a low pressure drop and uniform flow characteristics. The plenum chamber is built from 10 cm (4 inch) thick noise-shield panels, packed with acoustic fill and secured to a rigid steel frame.

GTG Gas Generator

The gas generator employs a Rolls-Royce AVON 1533-70L (#37029) aeroderivative gas turbine manufactured by Associated Electrical Industries (AEI) of Manchester, England. Manufacture of this type generating unit began in the mid 1960's. The unit supplied to the Newfoundland and Labrador Power Commission in 1966 was the first one off the drawing board and was considered to be a development model. The three stage turbine in the aft end of the AVON 1533-70L uses a portion of the axial air flow to increase compressor rpm and boost delivery. The high temperature, high velocity gas exits the jet through an exhaust transition duct which is used to drive the Power Turbine and thus the generator through a gearbox.

The compressor of the Rolls Royce Avon is a single shaft axial compressor unit, with a 17 stage compressor giving a pressure ratio of approximately 10 in industrial service, 8 combustors in an annular arrangement and a 3 stage turbine.

The Rolls Royce Avon gas generator is a single shaft axial unit which was developed in the late 1940s and early 1950s as a prototype axial compressor unit. It is a first generation aero engine, with no bypass. It powered a number of aircraft in the 1950s and early 1960s and very successful adapted as a gas generator, especially in gas compressor drive applications where it established new standards in the late 1960s and 1970s for overhaul life or time between overhauls. TransCanada pipelines, and other North American pipelines, standardized on the Avon until more efficient second generation units became available.

GTG Power Turbine

The power turbine is an Associated Electric Industries Ltd. (AEI) design, manufactured in Manchester, England in early 1966. The power turbine is a single stage overhung machine designed for a normal operational speed of approximately 4900 rpm. The power turbine is connected to its generator via a gearbox and its output is converted to 1200 RPM in a vertical pinion and wheel gearbox (ratio of 4:1). The power turbine and gearbox are mounted on the centre section of the unit bedplate with this section also forming the main lubricating oil tank. Auxiliary and emergency oil pumps are mounted on this same base plate. The power turbine casings (volute) were replaced in 1986.

The power turbine uses heavy duty steam turbine construction techniques in contrast to the Avon. The power turbine shaft and disk are solid, although the inner cylinder which constrains the gas flow is fabricated from nimonic materials (nickel based alloys with high temperature tolerance). The power turbine disk is a low alloy ferritic material and it is probable that it has an operating limit of about 535 Deg C. It is cooled by a mixture of bleed air from the Avon and outside air. The power turbine diaphragm and moving blades are nimonic. The power turbine blading is nimonic and uses axially serrated roots, which are now common on modern gas turbines but were only used by AEI in the 1960s for highly stressed locations.

GTG Gearbox

The main gearbox was manufactured by AEI in Manchester, England. It is designed to provide an approximate 4:1 speed ratio from the power turbine shaft to the main generator shaft. The power turbine operates at about 4800 RPM and its output is converted to 1200 RPM in a vertical pinion and wheel gearbox. AEI had built quite complex marine and other gearboxes and the API unit was well within their experience. The gear train is fitted to the power turbine rotor by semi-flexible coupling housed within the gearbox. The gears are of the single helical, single reduction type with the pinion mounted directly above the wheel. A removable top cover allows for inspection without disturbing the alignments.

GTG Exhaust System

The exhaust casing (volute) is a welded fabrication divided along the horizontal centreline. It turns the combustion gasses transversely to the machine and vertically upwards to the exhaust silencer.

The exhaust stack is constructed of heavy gauge steel plate with light gauge steel cladding on the exterior. The exterior cladding of the lower half of the exhaust stack is constructed of heavy gauge steel plate. This stack was replaced during the 1986 major upgrade. The snow doors on the exhaust stacks are pneumatically actuated and were a new addition in 1986 to reduce corrosion of the volute and power turbine from infiltration of snow and rain water which promoted corrosion within the unit. New limit switches installed on the doors in 2009 indicate the position (opened or closed) of each door at the control station.

FIGURE 2-1 GTG GAS ENGINE & GENERATOR

Generator

The generator is an air-cooled, 14 MW, 13.8 kV, 3 phase, Type AG 80/100, built by Associated Electric Industries (AEI) of Rugby, England in 1966. It has a rotating-field, salient-pole tube with 6 poles and rotates at 1200 rpm. The brushless exciter eliminates the danger of contamination by carbon dust and minimizes maintenance. Semi-conductor rectifiers rotating within the generator/exciter shaft provide excitation for the main generator field.

Governor and Fuel Control

The standard Avon fuel control system is used without alteration as a basis for the API governing and fuel control system. The throttle valve is used as a generator valve and the H.P. cock as a fuel shut-off valve for normal and emergency shut-downs. The governing system is of the sensitive oil type in which fluid pressure is used to transmit the movement of the governor pilot valve to the operating mechanism of the governor valve, in this case the Avon throttle.

The governor is manufactured by Woodward and is driven via gearing from the end of the high speed pinion shaft. The governor is a fly-weight type and carries its own oil supply. Woodward Governor suggests that the present system has a reliability of about 50%. In addition, spare parts for this system are not carried and would have to be fabricated requiring long delivery times.

Excitation System

The exciter is a rotating brushless type mounted on a stub to the main rotating shaft. It was designed to ANSI Specification C50-1 3. The AC output from the exciter armature is fed through a set of diodes that are mounted on the rotor and are used to produce a DC voltage. The voltage is fed directly to the field winding of the main generator which is also mounted on the same rotating shaft.

The excitation control system consists of a "Normal" and "Standby" automatic voltage regulator (AVR) backed up by a "Manual" control mode. The AVR controls the strength of the magnetic field in the exciter by varying the amount of current through the stationary exciter field windings.

2.1.2 Operating History

Original Manufactured/Delivered	1966
In-Service Date at Hydro	1970
Rehoused at Holyrood	1986
End of Planned Life Date	2020
Last Combustion System Inspection/Overhaul	2009
Next Major Overhaul/Inspection/Refurbish/Replace	2012/13 (Recommended)

The gas turbine generator system at the plant serves as a black start unit for the station. It is occasionally used for system support as well. The hours associated with the unit are provided in Table 2-1 below.

To date, the gas turbine has operated for 4770 hours and 2548 starts. The numbers of hours operated during different phases are shown in the table, below.

TABLE 2-1 HOLYROOD API OPERATING HISTORY

	Hours	Starts	Hours/yr	Starts/yr	Starts/hr	Idle/hr
1966-1978	1749	611	140	47	3.0	85,000
1979-1985	390	185	65	32	2.0	85,000
1986-1995	1336	644	134	64	2.0	85,000
1996-2005	332	585	33	59	0.5	85,000
2006-2011	961	523	174	87	0.5	51,600
TOTALS	4770	2548				391,600

Peaking units traditionally operate for between 500-1000 hours per year, but the Holyrood API has averaged closer to 100 hours per year, and many of these hours, at least in recent years, have come from monthly test runs.

Some parts have been refurbished or replaced. The pattern used for the hours of operation and starts to the end of life date of 2020 is:

TABLE 2-2 HISTORICAL AND FORECAST OPERATING PATTERN

	Year To Dec 31	GT Ops Hrs		GT Idle Hrs		GT Starts		GT Ops Hrs/Yr		GT Starts/Yr	
		Low	High	Low	High	Low	High	Low	High	Low	High
Balance of Plant	1966	0		0		0					
	1978	1749		85000		611		139.9		48.9	
	1985	2139		170000		796		55.7		26.4	
	1995	3475		256000		1440		133.6		64.4	
	2005	3807		343000		2025		33.2		58.5	
	2010	4717		386000		2548		182.0		104.6	
	2011	4737	4737	394740	394740	2558	2563	20	20	10	15
	2012	4737	4737	403500	403500	2558	2563	0	0	0	0
	2013	4809	4887	412188	412110	2585	2635	72	150	27	72
	2014	4881	5037	420876	420720	2612	2707	72	150	27	72
	2015	4953	5187	429564	429330	2639	2779	72	150	27	72
	2016	5025	5337	438252	437940	2666	2851	72	150	27	72
	2017	5097	5487	446940	446550	2693	2923	72	150	27	72
	2018	5169	5637	455628	455160	2720	2995	72	150	27	72
	2019	5241	5787	464316	463770	2747	3067	72	150	27	72
	2020	5313	5937	473004	472380	2774	3139	72	150	27	72
Combustor:	2020	713	1337			1174	1539	72	150	27	72
PT Volute:	2020	2213	3837			1974	2339	72	150	27	72

The unit has operated for an average of about 100 hours per year and about 50 starts per year, consistent with use for emergency peaking. Although distillate fuel is used resulting in high unit energy costs, little attention has been given to efficiency due to the peaking/emergency roles of the unit. The station operators have demonstrated that they can usually start the unit fairly quickly, although it often takes several attempts. The station does not record starting reliability, which is one of the most important criteria for a normal peaking emergency unit.

One interesting aspect for early Avon units without corrosion protection was that each standby hour may have consumed the equivalent of 0.3 hours of running life. (Maintenance and Support of Mature Gas Turbines – M. Hudson, Siemens 2005)

2.1.3 Major Maintenance History

The API unit was originally supplied in its own packaging, but in 1986 the unit was relocated into a custom building with a new inlet filter house and exhaust stack. At that time a GEM80 PLC was installed.

The unit has had significant overhauls/repairs in 1978, 1986, 1991, and 2007.

The following is a summary of significant work completed since 2003. No major overhauls have been completed on the entire machine since 1991. No details of the overhaul work in 1991 (or prior) were available for this study. Limited data on the maintenance of the unit before 1986 was available, with the exception of the Avon.

16 October 2003

- Annual boroscope inspection;
- Slight erosion on casing. Re-protect next shop visit;
- Normal amount of carbon build up on nozzle heads;
- Boroscope inspection satisfactory; and
- Intake plenum contained debris, chipped floor and flaking paint. Recommended clean up.

10 August 2004

- Annual hot section inspection & failure to start;
- Housing found to have corrosion on struts, will require protective coating next shop visit;
- Air plenum cleaner than last visit, holes still visible in walls;
- Compressor rotor and stator vane blades in dirty condition;
- Normal amount of carbon build up on nozzle heads;
- Slight damage to #7 Combustion Can; and
- Starting motor replaced, due to seizure. (Solved starting issue).

27 September 2005

- Annual inspection and boroscope inspection;
- Front Bearing Housing, outer bushes loose;
- Front Bearing Housing, Corrosion/ pitting;
- Corrosion/ Rust found in Plenum;
- HP NGV's have slight erosion of the leading edges and minor cracks in the trailing edges;
- Flame tubes have minor erosion on some of the wiggle strips and some carbon build up within the flame tube, especially around the dish where liquid fuel has collected;
- Normal amount of carbon build up on nozzle heads; and
- Hot gas leakage at Exhaust Transition duct to power turbine.

13 March 2006

- Leak in each end of the gearbox at the bearing seals. (Caused fire when oil leaked into insulation around PT and dripped onto top of tank). Greenray discovered turbine shaft/seal modifications, recommended machining and reconditioning.

13 April 2006

- Fuel oil leak on underside of gas turbine at IGV Ram, seal deterioration.

25 May 2007

- AVON repair and boroscope inspection: IGV ram leak, ignitor failure, hot air leak from #6 burner, bellmouth nuts loose, combustion casing boroscope port bolts loose, bleed valve ducting broken and separated, fuel lag at idle and struggling at speed;
- Significant sparking coming from PT splash plate (rubbing shaft). Suggests bearings are worn and thus damaged seal;
- 2 IGV bushes replaced due to wear in the bush. (Majority of bushes and retaining nuts were replaced as well as the locking bush);
- Rebuild of the intake with securing bolts torque and locked;
- IGV ram replaced due to leak;
- Fuel filter replaced due to feed issues;
- Bolts holding PT seal were not tight, seal incorrectly installed;
- Ignitor, lead and box were replaced;
- High fuel consumption noticed at fuel drain valve, suspect worn seals on FCU and fuel pumps;
- Additional breather recommended for rear of gearbox unit, to reduce leaks;
- Compressor section; front bearing housing, inlet guide vanes have significant corrosion and coating loss;
- Combustion cans show signs of cracking, material loss (could lead to further turbine damage);
- IP nozzle guide vanes and HP nozzle guide vanes show signs of cracking on trailing edges;
- Change PT lube oil filters; and
- Replace/ Repair exhaust snow doors.

21 May 2008

- Package filtration inspection;
- Plenum survey;
- Windmill inspection of compressor;
- Boroscope of compressor and VIGV;
- Fuel/oil system: connection, fuel pump/ oil pump, pipelines, oil level & quality, filter and basket removal (replacement consumables);
- On engine review: bleed valves, IGV ram (filter review), gearbox inspection (filters, speed pick up, consumable change), fuel control unit review, oil cooler, fuel filter change, burner removal (ultrasonic cleaning), fuel rail inspection, drain valve operation, thermocouple inspection (terminal cleaning), transition inspection, removal of insulation, rectify leaks, inspect LP blades;
- Boroscope inspection: rear of compressor, snout area, combustion can, HP nozzle guide vanes, cooper beams (crooks washers), turbine section;
- PT and gearbox review; and
- Controls review.

10 June 2008

- Water pooling noted in intake plenum along with holes in structure and loose debris;
- Compressor showing significant corrosion and pitting on front bearing housing, inlet guide vanes and compressor stages, physical signs of salt evident;
- Combustion cans need to be replaced due to extensive corrosion, #1 and #2 burners removed for inspection. Seized bolts prevented removal of others;

- Hard impact damage evident in turbine stages, suspect debris from combustion cans and/or intake plenum;
- Suggested unit overhaul for blade recoating etc.; and
- Fuel pump and FCU to be repaired.

15 October 2009

- Engine removed and placed on site, in vertical stand for repairs (combustion cans);
- Combustion cans were replaced and FCU and fuel pump repaired;
- Loose discharge nozzles, due to broken brackets (2 off) to be replaced in future;
- PT inspection showed signs of light blade rub, none on stators. Diaphragm free of damage;
- PT inlet cone cranks, to be repaired;
- Thermocouple damage, quick fixed. To be upgraded;
- Exhaust stack needs replacement, lower components noted in good condition. Door opening components to be serviced; and
- Transition duct piston rings seals to be replaced.

20 November 2009

- Commissioning;
- Fuel control solenoid valve burnt out and replaced;
- Multiple start trips due to; low fuel pressure, low oil pressure, incomplete start sequence; determined igniter box malfunction, N2 probe incorrectly connected & FCU actuator tuning;
- Exhaust transition lagging replaced due to fuel saturation;
- Split air manifold cracks, to be repaired; and
- Suggest monitoring setup for the 8 EGT thermocouples.

2011

In the years 2010 and 2011, NL Hydro undertook a number of activities with vendors that have the Original Equipment Manufacturer (OEM) rights to the gas turbine sections in order to conduct internal inspections of the individual sections and prepare field inspection reports complete with refurbishment estimates.

1. Rolls Wood Group (OEM rights to the Avon gas generator) in 2011 conducted detailed internal inspections of the front end bearing assembly, compressor rotor, compressor casings, combustion assembly, nozzle casing, rear bearing housing, turbine assembly, exhaust unit, and accessory equipment and have prepared a field inspection report. Some refurbishment estimates were provided separately.
2. Greenray Turbines (Lincoln) Limited (OEM rights to the power turbine and gearbox) in 2011 performed detailed internal inspections of the power turbine and the gearbox gears, bearings, and seals.
3. Siemens (OEM rights to 14.150 MW generator including the direct couple cooling fan, the 73.5 KW brushless AC exciter, the AC lube oil pump motor, the DC back-up lube pump motor, and the 25 HP outside fuel off loading pump motor) performed detailed internal inspections and testing of the above noted equipment.

4. Braden Manufacturing is a company that specializes in the design and manufacturing of combustion turbine air filtration systems, air inlet systems, and exhaust systems. They were recently contracted by NL Hydro to perform detailed inspections of the gas turbine air inlet plenum, air filtration system, air inlet plenum support structure, exhaust stack and exhaust stack support structure.

GTG Inlet Plenum

When the API gas turbine was constructed, there was little experience of packaging units of this size and the API package was not adequate for the tough marine duty that the unit experienced. The inlet filters, exhaust silencer, exhaust stack and other components corroded quite rapidly and were all replaced in 20 years or less. The original inlet filters were the inertial type which was fairly standard at the time and were still the standard type of filter on TransCanada Pipeline (TCPL) units until the early 1970s. Inertial filters gave good performance in inland locations and places where the dust loading was not excessive. They were not completely satisfactory in icing conditions as the by-pass doors sometimes opened on overpressure, and TCPL suffered a number of cases of ice damage to Avon units. Inertial filters are not capable of handling a high salt content in the inlet air. The original stack had an internal liner which corroded rapidly and did not protect the outer layer against high temperatures. We have limited information on the original silencer splitters but the exhaust unit appears to have corroded very rapidly. We assume that it was not constructed from stainless steel.

The whole unit was re-housed in a custom building in 1986 with new filter house, generator filters, control room and exhaust stack. A new Farr filter building was purchased using a two stage filter- the first stage being designed for water removal while the second was a high efficiency media type filter. This filter was probably quite efficient when new, but with modern experience of high salt environments, largely gained from marine gas turbines, it is clear that its design was not adequate for a location within 200 ft of the ocean, where strong winds are common. Such a location would now require a 3 stage filter with one stage specifically designed for the removal of saline droplets. It is clear that the performance of the filter has deteriorated through time, and in recent years there has been increased evidence of salt ingestion in the Avon. The filter now has air gaps between the filter elements, due to rusting.

New stainless steel inlet splitters were installed and appear to have suffered little deterioration in the subsequent 25 years. A new exhaust silencer and stack were installed with exhaust hoods, and the stack has been severely corroded for a number of years. At the time a number of control upgrades were made, and the generator compartment was provided with new filter elements.

GTG Gas Generator - Avon

The early Avons were designed to have a Time Between Overhaul (TBO) of 1500 hours in peaking mode, and 8000 hours or more at base load. Later units achieved much higher base load overhaul intervals, but with some component upgrades. These overhaul intervals probably don't apply for a unit operating for fewer than 200 hours per year, but there is no established criteria for adjusting TBO for long periods of inactivity.

In any case the overhaul life of the Holyrood unit is much more influenced by the high salt atmosphere in which it operates, and the quality of inlet filtration. If the unit had operated entirely at base load in a clean environment, it would probably not require a hot end overhaul or the replacement of any hot end parts in less than 8000 hours.

Between 1966 and 1991, NL Hydro regularly sent the Avon unit to Rolls Royce Canada or other overhaul facilities, at significant expense.

The Avon was overhauled on the dates shown in Table 2-3 below.

TABLE 2-3 HISTORY OF AVON OVERHAULS

Year	Overhaul By	Overhaul Scope
1978	Not Available	Comp #7,8 replaced Titanium. Compressor recoated.
1986	Not Available	Overhaul
1991	GTC Scotland	Overhaul
1993	RR Canada	Hot End inspection
1997	RR Canada	Hot End inspection
1998	RR Canada	Inspection; replace IGV rams
1999	Onsite TCT	Boroscope and report. Minor work
2001	Onsite TCT	Boroscope and report. Minor work
2002	Onsite TCT	Boroscope and report. Minor work
2003	Onsite TCT	Boroscope and report. Minor work
2004	Onsite TCT	Boroscope and report. Minor work
2005	Onsite TCT	Boroscope and report. Minor work
2007	Onsite Alba	Boroscope and report. Minor work
2008	Onsite Alba	Boroscope and report. Minor work
2009	Onsite Alba	Replaced combustor cans.

The Avon has been inspected at regular intervals, as shown in Table 2-3. It has not been shipped to Rolls Royce or an OEM since 1991.

Since 1991, Hydro has arranged for a boroscope inspection at regular intervals, but the unit has not left the site. On each of the six inspections between 1999 and 2006, the inspection report stated that the unit appeared to be in satisfactory condition. A number of minor repairs have been made since 1991. They included replacement of inlet guide vanes (IGV) bushings and IGV rams, tightening of nuts and replacement of minor components but no major gas path component was replaced until 2009, when the combustor cans were replaced.

In recent years, the Avon has generally operated reliably. However, there is evidence of accelerated corrosion and pitting resulting from deterioration of the inlet filter. The filter is badly corroded and is now allowing unfiltered air to enter the plenum and the engine.

GTG Power Turbine

No major maintenance has been done on the power turbine since 1986. Access to the rotor and disk is difficult and until 2010, the only boroscope inspections which were done were performed from the front.

This allowed reasonable inspections of the inlet cones and the diaphragm ring, but not the rear of the turbine disk or the blade roots. In 2010, Greenway obtained a very limited boroscope picture of the power turbine blade roots. We have seen no record of any earlier inspection of the rotor, disk, blade roots or the whole of the moving blades.

GTG Gear Box

As early as 1970, the AEI engineers supervising the move of the unit to Holyrood noted several problems with the gearbox. These problems included leakage from the drive end bearing cover on the high speed pinion,) leakage from the generator end low speed shaft, and inadequate gearbox venting. The first of these problems was resolved by machining a groove in the cover plate and inserting an 'O' ring. The second issue was subjected to various adjustments and minor modifications so that the leakage was reduced to an acceptable level. The AEI Engineer's notes refer to components ordered from the factory to further reduce leakage, but the correspondence doesn't indicate what changes were made, and whether the new materials were ever fitted.

We do not have written records of any other gearbox leakage before 2005, but verbal discussions with operators suggest that it has been a growing problem for at least 20 years, and possibly longer. Some time before 2007, it was thought that gearbox oil pooling under the exhaust volute had caused a fire. However, when Alba Power inspected the unit later that year, it was noted that the fire had been the result of leaking fuel oil from failed start attempts on the Avon.

In March 2010, there was a fire under the exhaust stack, and the events following this fire are fully documented in NL Hydro's "Sequence of Events Report" which is included in Appendix 2. The fire caused justifiable safety concern with the operators, and it was reported to the Provincial Department of Occupational Health and Safety, who imposed an operating restriction on the unit.

Alba Power was asked to review and repair the lube oil system and a number of oil leaks were eliminated or reduced:

- Leaks in the auxiliary lube oil piping around the AC, DC and shaft driven pumps were re-gasketed, with the leakage eliminated.
- A new set of seals were manufactured for the generator end of the power turbine gearbox and a large temporary containment dish was installed under this leaking seal. This reduced leakage to what Alba described as "an acceptable level"
- Oil was weeping from the top of the power turbine casing, an instrumentation line and the aux trip bolt mechanism. Repairs eliminated these leaks

After 12 hours of operation at 10 MW, smoke was still seen coming from the top of the gas turbine gearbox in the vicinity of the stack. NL Hydro staff assumed that the seal on the front of the high speed gearbox shaft was also leaking. While a prudent assumption, it is possible that any front end leakage may actually come from another location. The unit has not operated since.

The only conclusions which could be drawn from AMEC's site visit, when the unit was not operating and was fully assembled, were:

- The only visible evidence of fire is a relatively small black charred area above the gearbox on the exhaust volute.
- The existing fire detection equipment is inadequate and did not detect the 2010 fire.
- No ignition source has yet been determined.
- While the new Inergen fire suppression system is safe for operators, it may not be capable of extinguishing an oil fire in the GT compartment, as presently configured, because of the large flow of ventilation air in the compartment. Given that the compartment should be unmanned

during operation, the fire detection and suppression systems should be capable of detecting and controlling fires without the entry of Hydro operating personnel. The overall fire detection and fire protection status of the unit should be reviewed in detail.

At least three or four causes have been suggested for the labyrinth oil seal leakage at the generator end (low speed shaft) and drive end (high speed shaft). There is some evidence to support two of the leakage mechanisms, which may compound each other. The principal causes which have been proposed are:

1. The seal between the power turbine shaft and the front bearing support structure (which is an extension of the gearbox casing) is a double labyrinth which is sealed in the middle by air taken from an Avon compressor bleed. Alba noted, in their May 2007 report, that the pressure in the gearbox (measured by a gauge mounted on the gearboxes casing) rises with load and have suggested that the gearbox is being pressurized by the Avon bleed air. At a load of 10 MW the pressure in the gearbox was 3 inches water gauge. Alba tried to resolve this by adding another oil tank vent, which appeared to reduce the leakage.

   This problem has occurred on other gas turbines and one of the upgrade options offered by GE for their Frame 5 and 6 units, with outputs of 17.5 MW to 40 MW, is to install an oil tank vent blower with coalescer, which maintains a small vacuum in the gearbox and coalesces the oil taken from the tank and returns it via a drain.

2. The bearings may have suffered severe wear due to a number of possible causes (misalignment, gear backlash, or low gearbox oil pressure). In 2008, Alba noted that the splash plate behind the generator end seal was making contact with the shaft, which indicates heavy bearing wear.
3. Misalignment has been proposed as a cause of the leakage, but there is no direct evidence of this.
4. The rear labyrinth seal appears, from the limited data available to us, to be too short. An ideal labyrinth seal should have at least 3 labyrinth sections with oil drains between the sections. The existing seal seems to have only two sections with no oil drain.

Generator and Exciter

The Generator, Exciter, AVR and controls were standard at the time of their installation. There has been no major maintenance on the generator or the exciter since 1986. NL Hydro established a draft maintenance procedure in 2009, which included performing insulation integrity tests every second year on both the generator and exciter (resistance to ground, polarization, and resistance phase to phase). The trends of these readings can mean as much as the absolute values, but no figures for them were available before the Siemens tests of 2011.

2.1.4 Condition Assessment & Remaining Life

GTG Gas Generator

It is now industry practice to specify the overhaul life of a gas turbine in terms of “Hot end overhauls”, during which the high temperature components such as the combustors and turbine blading are refurbished or replaced and “Major maintenance overhauls”, where the hot end and other components are repaired or replaced. The most expensive element of gas turbine maintenance is normally the replacement of high temperature components, and on newer machines this represents up to half of the total cost of a major overhaul. Many high temperature components may have an expected life between refurbishment of over 20,000 hours but can be refurbished one or more times.

The Avon overhaul life was originally established as 1500 hours in peaking mode and up to 8000 hours at base load. With experience, these figures were increased to 4000/5000 for peak load and 25,000/30,000 for base load.

Rolls Royce (RR) now does not directly support older Avon units but there are a number of experienced companies providing support. These companies do not generally differentiate between “Hot end” and “Major” overhauls but offer “Standard overhauls”. It is expected that all of the parts of Avon can be replaced because parts for the Mk-1533 Avon units are plentiful and generally inexpensive. Avon turbine blading has relatively simple metallurgy and cooling arrangements, so it is inexpensive compared to the blading of newer gas turbines.

It is difficult to determine how much of its overhaul life the Avon has expended. All of the recent boroscope reports suggest that it is in reasonable condition, but none of the turbine components have been replaced in the last 20 years, according to our records, and the HP turbine blading and IP vanes have not been replaced or refurbished for over 25 years .

The unit was examined by Rolls-Woods in Nov 2010 and Alba power in 2009 and a summary of their findings is provided below:

- Rolls Woods state that generally the engine appears to be in reasonably good and serviceable condition. The compressor stator components, compressor stators, bleed valves and outer casing were all in reasonably good condition, with most components showing some loss of coating and light corrosion. Components that have deteriorated in the past, such as the front bearing housing and IGV bushings appear to be in good condition. Hot end components also appear to be in good condition with minimal visible damage.
- Alba report that the Avon is in good condition, but are concerned about the loss of coatings, especially on the compressor. It is their opinion that further loss of coating may damage components to the point that they cannot be refurbished.

Normally, the overhaul life of a peaking unit is influenced most by high temperature fatigue while a base load unit is normally limited more by creep, oxidation and corrosion. Boroscope inspections give only limited data on fatigue and creep life expenditure. It is possible that the unit may have operated at its Peak output, earlier in its history, as there are signs of overheating in some of the generator coils (although these could be the result of phase imbalances). Because the engine is rarely washed and has extensive corrosion and pitting, it is likely to have suffered significant performance degradation, which might have reduced its output by up to 10%. (some early US navy gas turbines suffered up to 15% output degradation). The base load output of a degraded unit at high ambient temperatures, would be below 8 MW and the operators may unwittingly have operated at peak, at some time in the unit’s 45 year history.

Our estimate of the Avon’s equivalent operating hours is shown in Table 2-4, below.

The time between overhauls for the existing Avon unit, which are nominally 8,000 hours at peak load and 25,000/30,000 at base load, have to be adjusted for 5 factors, discussed below:

- Between 30 and 40 years ago, Rolls Royce introduced a starts factor making each start equivalent to 10 hours of operation. This factor is somewhat subjective. Most large modern aeroderivative units do not have such a factor, and the manufacturers claim that the number of starts has little effect on overhaul life, if starts are limited to a reasonable number. RR’s current guidance on the Avon is that the equivalence factor is dependent on the type of fuel and the ratio of hours per start. Given that the Holyrood machine burns liquid fuel and has an operating hours to starts ratio of below 3, each start should be counted as ten hours of base load maintenance life.

- The unit operates in a very high salt environment and during the first 19 years of its operating life, and the last five or more years, it has had inadequate inlet filtration. This has affected the compressor blading and casing more than the turbine. There has been a significant loss of compressor coatings.
- The unit operates for very few hours per year. There is little data on how this influences maintenance life, but at Holyrood it seems to have had little effect.
- The unit burns distillate which reduces maintenance life when compared to natural gas.
- The Avon is a very early unit, without many of the later modifications introduced to increase overhaul life.

TABLE 2-4 CALCULATION OF EQUIVALENT OPERATING HOURS

	Equivalent operating hours since 1991	Total equivalent operating hours
Components affected	HP vanes, IP turbine blading, misc other	Many components have never been refurbished
Operating hours	2,000 approx	4,700
Hours equivalent of starts @ 10 hrs per start	14,000	25,000
Discount for oil fuel. Typically 25% adder on other gas turbine types	4,000	7,425
Discount for corrosion	See note below	See note below
Approximate totals	20,000 plus	38,000 plus

Note on Corrosion: Corrosion appears to have affected the compressor blading and casing more than the turbine. Given that compressor components should have a longer operating life than the turbine, corrosion may not be the key factor in determining overhaul life. Also salt appears to have affected the coatings on the compressor more than those of the turbine . The former are designed to protect the blades, while turbine coatings reduce heat flux and protect the rotor and disk from excessive temperatures. We note that the turbine rotor was replaced before 1986.

The data which is available to AMEC suggests that most of the turbine components are original, with the exception of HP nozzle blades and IP turbine blades. On the Avon the turbine nozzles usually suffer more deterioration than the moving blades. Table 2-4 suggests that, as a minimum, the HP turbine blading and IP nozzles may require refurbishment.

There are many other components on the Avon which cannot be seen during a boroscope inspection, so their condition is unknown.

The Avon requires an overhaul to replace coatings and repair or replace turbine blading and other components which have suffered cracking or other damage. It is expected that when the Avon has been overhauled and the inlet filters replaced, it will not require a further significant overhaul before life end in 2020. In addition, the future annual maintenance costs would be less than $10,000 per year.

Power Turbine

The power turbine has received little attention since 1986. A boroscope photograph from 2011 is the only one that we have seen that shows the power turbine blading roots. This shows only a small number of blade roots but the disk material in the axially serrated root appears to be severely corroded. The photos do not show the bulk of the disk itself so we have no way of knowing if this corrosion is present on the remainder of the disk, and whether it is superficial or deep. In the photo, it appears to extend under the root. Steam turbines can suffer from blade root corrosion caused by materials collecting in the root, and it is possible that salt particles have collected in the complex root form. The corrosion may be more serious in highly stressed areas, such as the root. Alternatively, the whole disk may be corroded. In either case, the roots are very vulnerable to stress corrosion cracking.

It should be noted that the turbine cooling air is taken directly from the environment, without filtration. Cooling air passes through an ejector, using Avon bleed air, so that the air reaching the disk is a mixture of filtered air from the Avon and unfiltered air. The disk cooling system has probably operated for 45 years with a significant salt loading.

The Power turbine disk material is a low alloy ferritic steel selected for its high transition temperature. It seems likely that such a material has a service limit of 535 C or lower. The Avon exhaust cone temp (ECT) is close to 640 deg C at the full peak rating, so clearly the design of the API depends on effective disk and blade root cooling. It is probable that the blade root is highly stressed at full load, even with its design cooling. The axially serrated root was the most expensive blade root used by AEI, and so they only used it for highly stressed locations.

Greenray, who now legally represent AEI gas turbines and hold all rights to their technology, do not think that the power turbine should be operated in its present condition, and AMEC agrees with this recommendation.

Based on the information available to AMEC, it appears that the turbine disk should be replaced, using most or all of the existing moving blades. Welding repairs are required on the inlet cones, struts, heat shield, etc and can be used for slightly damaged blades. The cooling air system should be examined carefully as it is essential for the integrity of the power turbine disk and blading. With these measures, there should be no problem operating the power turbine for another ten years or more. The highest risk is the loss of a diaphragm or moving blade.

Gearbox

The gearbox pinion and wheel were examined briefly by Alba in 2007 and appeared to be in good condition at that time. A gearbox of this type should operate for many years without problem, and if the bearings and seals are replaced, the gearbox should not present a large risk. The cause of the low oil pressure from the mechanical pump and the oil leak on the low speed drive shaft must be determined and rectified. Although the high speed gearbox shaft has more complex labyrinth seals than those of the generator end, and an air seal, it is probably prudent to assume that this seal is also leaking.

The only conclusions which could be drawn from AMEC's site visit, when the unit was not operating and was fully assembled, were:

- The only visible evidence of fire is a relatively small black charred area above the gearbox on the exhaust volute.
- The existing fire detection equipment is inadequate and did not detect the 2010 fire.
- No ignition source has yet been located.

- While the new Inergen fire suppression system is safe for the operators, it is important to confirm that it is capable of extinguishing an oil fire in the GT compartment, as presently configured, and with all ventilation is shut off in the event of a fire. Given that the compartment should be unmanned during operation, the fire detection and suppression systems should be capable of detecting and controlling fires without the entry of Hydro operating personnel. The overall fire detection and fire protection status of the unit requires a detailed review.

At least three or four causes have been suggested for the labyrinth oil seal leakage at the generator end (low speed shaft) and drive end (high speed shaft). There is some evidence to support two of the leakage mechanisms, which may complement each other. The principal causes which have been proposed are:

a. The seal between the power turbine shaft and the front bearing support structure (which is an extension of the gearbox casing) is a double labyrinth which is sealed in the middle by air taken from an Avon compressor bleed. Alba noted, in their May 2007 report, that the pressure in the gearbox (measured by a gauge mounted on the gearboxes casing) rises with load and they suggested that the gearbox is being pressurized by the Avon bleed air. At a load of 10 MW the pressure in the gearbox was 3 inches water gauge. Alba tried to resolve this by adding another oil tank vent, which appeared to reduce the leakage.

   This problem has occurred on other gas turbines and one of the upgrade options offered by GE for their Frame 5 and 6 units, with outputs of 17.5 MW to 40 MW, is to install an oil tank vent blower with coalescer, which maintains a small vacuum in the gearbox and coalesces the oil taken from the tank and returns it via a drain.

b. The bearings may have suffered severe wear due to a number of possible causes (misalignment, gear backlash, or low gearbox oil pressure). In 2008, Alba noted that the splash plate behind the generator end seal was making contact with the shaft, which indicates heavy bearing wear.
c. Misalignment has been proposed as a cause of the leakage, but there is no direct evidence of this. Another GE upgrade on older gas turbine models is an improved flexible coupling between gas turbine and the load gear.
d. The rear labyrinth seal appears, from the limited data available to us, to be too short. An ideal labyrinth seal should have at least 3 labyrinth sections with oil drains between the sections. The existing seal seems to have only two sections with no oil drain.

Both Alba Power and Greenray, have quoted for the repair of the gearbox, and the bids of both of these companies suggest that the problem can be resolved by restoring the unit to its original design, with better venting. The adequacy of this proposed repair is reinforced by the fact that the Newfoundland Power Commission API unit at Salt Pond has not suffered from oil leaks, and that both Alba and Greenray have experience of other API units.

Since 1991, NL Hydro has arranged for a boroscope inspection at regular intervals, but the unit has not left the site. On each of the six inspections between 1999 and 2006, the inspection reports indicated that the unit appeared satisfactory. A number of minor repairs have been made since 1991, including replacement of IGV bushings and IGV rams, tightening of nuts, and replacement of minor components. However, no major gas path component was replaced until 2009, when the combustor cans were replaced.

GTG Inlet Plenum

It is clear that in the high saline atmosphere at Holyrood, operating with an increasingly ineffective inlet filter, the unit has suffered considerable degradation during very few hours of operation. For example, Alba Power reported that between May 2007 and June 2008, the unit had only ran 26 hours with 54 starts and there was considerable degradation of the combustors and other components, which may have corresponded to less than one month of operation in a normal base load unit. The unit is rarely washed because washing is normally performed largely to maintain efficiency. However, it would be beneficial to wash the Holyrood unit because of the buildup of salt on the first stages of the compressor. At present, the engine shows signs of pitting, salt deposition, corrosion and loss of coatings on the Avon gas generator. There is also cracking in the turbine section.

Without replacement, the Avon and PT will degrade rapidly. The inlet air filter/media should be replaced and/or brought back to reasonable condition.

Generator

Siemens inspected the generator in 2011 and performed (resistance to ground tests (megger), polarization index of machine windings, and phase to phase resistance measurements. They also visually inspected the stator laminations, windings, and the rotor.

The generator has only 4700 operating hours and NL Hydro records show that in recent years, it has rarely operated at above 10 MW. It is rated 14.15 MW. It should have a design life of over 40 years, but its insulation has suffered from age and possibly from rapid thermal cycling and condensation. The API unit can start and ramp to full load in about 2 minutes and during a fast start, the coils will suffer some thermal stress. Also, the unit experiences large temperature differences between the windings and the cooling air. There are no anti-condensation heaters. If the generator had operated with a high capacity factor for 45 years it would likely require a rewind.

Siemen's report shows that the insulation has deteriorated and there is a phase imbalance on the stator. Siemens recommend rewinding the stator. Table 2-5 compares the measured test results of the generator, exciter and major motors. The polarization readings of the generator stator are reasonable, and considerably better than those of the Exciter stator and the major motors. However the stator phase imbalance is quite high and the cost of a stator rewind has been included in the refurbishment estimate.

TABLE 2-5 COMPARISON OF SIEMENS TEST RESULTS ON GENERATOR AND MOTORS

	Resistance to Ground @ 1 Minute M ohm	Polarization of Windings	Phase to Phase Resistance
Generator Stator	534	1.93	30% imbalance
Generator Rotor	2.67	1.1	
Exciter Stator	534	.96	
Exciter Rotor	2060	2.14	Within 0.7%
AC Oil Pump Motor	4600	1.15	Within 0.17%
DC Oil Pump Motor	185	0.93	
AC Lube Oil Cooler Fan	5520	1.37	Within 0.67%
Fuel Oil Motors	7920/1250	1.56/0.95	Within 0.18%

Generator Exciter

Siemens recommended an overhaul of the exciter, but there is some concern that an overhaul is not practical because the 45 year old unit is no longer supported by the OEM. Parts may not be available. On the other hand, it may be difficult to support the purchase of a new unit for a 8 year life extension.

Summary

In general, the unit is currently in poor condition and overdue for a major overhaul of many components. A tabular summary of the condition assessment of the gas turbine genset is provided below in Table 2-6:

TABLE 2-6 CONDITION ASSESSMENT – GAS TURBINE GENSETS

BU # 1	Asset # 2	Asset # 3	Asset # 4	Asset Level 3	Description	Detail	Cond. Summ. ID#	Condition	Status Identifier	Original Life (Base Load) Ops Hrs (Yrs)	Current Expected Minimum Remaining Life Years (Subject to Test)	End of Life (EOL) Required	Capability to Reach EOL	In Service
1273	7202	0	0	GAS TURBINE SYSTEM	GAS TURBINE SYSTEM		GTG1	44 years old and has accumulated to 2010 about 4,717 hours with 1,548 starts. Four significant overhauls/repairs in 1978, 1986, and 1991 and a combustor replacement in 2007	4/10	150,000 (30)	1	2020	No	1969
1273	7202	7308	0	GAS TURBINE AVON JET ENGINE	GAS TURBINE AVON GAS GENERATOR	General	GTG2	Overall Rolls Wood group inspection in 2010 concluded that the engine appears in reasonably good and serviceable condition.The engine shows signs of pitting, salt deposition, corrosion and loss of coatings on the Avon gas generator. Coatings and some turbine blading and other components have suffered cracking or other damage. Corrosion/cracking from seaside moisture and starts. Buildup of salt on the first stages of the compressor. There is also cracking in the turbine section. Overdue for overhaul.Rear bearing housing in good condition..	4/10	150,000 (30)	2	2020	No	1969
1273	7202	7058	0	GAS TURBINE AVON JET ENGINE	GAS TURBINE AVON GAS GENERATOR	Compressor and Intake	GTG3	Rolls Wood reported: front bearing housing in good condition with medium loss of coating and corrosion,; VIGV bushes in good condition;bleed valves in good condiion, compressor stators in good clean condition with no defects; compressor casing surfaces in reasonably good condition with light to medium loss of coating and corrosion in some areas; compressor outlet casing in good condition with OGV having minor to medium loss of coating and corrosion to most surfaces;	4/10	150,000 (30)	2	2020	No	1969
1273	7202	7058	0	GAS TURBINE AVON JET ENGINE	GAS TURBINE AVON GAS GENERATOR	Combustor	GTG4	Rolls Wood reported: carbon deposits on head sections and streaks down flame tube length;All in good conddition.	4/10	150,000 (30)	10	2020	Yes	2008
1273	7202	7058	0	GAS TURBINE AVON JET ENGINE	GAS TURBINE AVON GAS GENERATOR	Turbine Rotor	GTG5	Rolls Wood reported: HP,IP andLP turbine blades intact and free of obvious defects. Exhaust assembly in good condition with minor surface corrosion.	4/10	150,000 (30)	5	2020	No	1969
1273	7202	7058	0	GAS TURBINE POWER TURB & G/B	GAS TURBINE POWER TURBINE	Power Turbine	GTG6	Received little attention since 1986 with very limited boropscope views of blade roots. Disk material in these limited views in the axially serrated root appears to be severely corroded.No way of knowing if corrosion is present on the remainder of the disk, and whether superficial or deep. Appears to extend under the root. It is possible that salt particles have collected in the complex root form. The corrosion may be more serious in highly stressed areas, such as the root. Alternatively the whole disk may be corroded. In either case the roots are very vulnerable to stress corrosion cracking.Overdue for overhaul. Greenray (legal representive of AEI gas turbines, hold all rights to their technology)do not think that the power turbine should be operated in its present condition.	4/10	150,000 (30)	2	2020	No	1969
1273	7202	7058	0	GAS TURBINE POWER TURB & G/B	GAS TURBINE POWER TURBINE	Power Turbine	GTG7	Greenray in its 2011 inspection noted: several circumferential cracks on inlet duct iner cone (previously seen in 2006) - no/limited propogation apparent; weld repairs on cone spokes inner downstream edges may be starting to fail; nozzle blade track corroded, heavily in places, and could cause failure of nozzle segment and shroud; blade tps irregular,possibly rubbed (little other evidence of blade tip rub); geneal corrosion (most light) on blading; rotor disc fir tree posts (for blades) heavily corroded in visible areas highly stressed areas - fialure could lead to catastrophic effect on power turbine components and appear to be propogating under rotor blade shoulder which could cause premature failure.; diffuser/volue generally corroded - effect on volute welding.	4/10	150,000 (30)	2	2020	No	1969
1273	7202	7058	0	GAS TURBINE POWER TURB & G/B	GAS TURBINE POWER TURBINE	Cooling Air	GTG8	Turbine cooling air is taken directly from the environment, without filtration. Cooling air passes through an ejector, using Avon bleed air, so that the air reaching the disk is a mixture of filtered air from the Avon and unfiltered air. The disk cooling system has probably operated for 45 years with a significant salt loading.	4/10	150,000 (30)	2	2020	No	1969
1273	7202	7058	0	GAS TURBINE POWER TURB & G/B	GAS TURBINE POWER GEARBOX	Gearbox	GTG9	Alba in 2007 indicated gearbox appeared to be in good condition and that if the bearings and seals are replaced the gearbox should not present a large risk. Issues remain on the cause of the low oil pressure from the mechanical pump and the oil leak on the low speed drive shaft and must be determined and rectified. The high speed gearbox shaft seals are leaking and were the cause of a 2010 fire at the power turbine end of the gearbox which has resulted in the unit being limited to emergency use only. At least three or four causes have been suggested for the labyrinth oil seal leakage at the generator end (low speed shaft) and drive end (high speed shaft). Tests on the pressure in the gearbox (measured by a gauge mounted on the gearboxs casing) showed a rise with load and suggested that the gearbox is being pressurized by the Avon bleed air. Greenray 2011 inspection: Gear wheels and internals appeared in pristne condition with normal marks. Outer wiper of leaking low speed gear wheel lube oil gland may be touching top of shaft and have some clearance at bottom (opposite to normal) and may indicate driven machine out of alignment with gearbox output shaft The bearings may have suffered severe wear due to a number of possible causes (misalignment, gear backlash, or low gearbox oil pressure). In 2008 Alba noted that the splash plate behind the generator end seal was making contact with the shaft, which indicates heavy bearing wear. Overdue for overhaul.	4/10	150,000 (30)	2	2020	No	1969
1273	7202	7309	0	GAS TURBINE GENERATOR	GAS TURBINE GENERATOR	Generator	GTG10	Siemen's report shows that the insulation has deteriorated and there is a phase inbalance on the stator. The polarization readings of the generator stator are reasonable, and considerably better than those of the Exciter stator and the major motors. However the stator phase inbalance is quite high. The generator compartment was provided with new filter elements which are in good condition, except that there are some holes in the building siding that allows some air to bypass them.	4/10	200000 (40)	5	2020	No	1969
1273	7202	7309	0	GAS TURBINE GENERATOR	GAS TURBINE GENERATOR	Generator	GTG11	Siemen's report rotor appears in good condition, that stator iron and wedging in good condition, some stator coil overheating, Stator insulation appeared dregraded, dry and flaking throughout,	4/10	200000 (40)	5	2020	No	1969
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	GAS TURBINE EXHAUST STACK	Exhaust Stack	GTG12	Severly corroded, leaking,Braden 2011 inspection: exterior significant carbon steel crystallization and peeling of carbon steel; no fatigue/cracking of welds, sulging of stack on south side, several holes in exhaust. Snow hood no apparent issues (some operation issues with functionality). Transition duct (external insulation) not visible for inspection. Expansion joint belt in good condition. reported	4/10	(20)	1	2020	No	1986
1273	7202	7311	99003602	GAS TURBINE AUXILIARY SYSTEMS	GAS TURBINE AIR INLET PLENUM CHAMBER & MEDIA	Filter Material	GTG13	Inlet housing and filtration system were replaced in 1986. Its stainless steel inlet splitters appear to have suffered little deterioration Water leaking into plenum.Filter media is considered inappropriate for its marine environment. The filter now has air gaps between the filter elements, due to rusting The high saline atmosphere means that the unit is operating with an increasingly ineffective inlet filter and the unit has suffered considerable degradation.	4/10	(30)	2	2020	No	1986
1273	7202	7311	99003602	GAS TURBINE AUXILIARY SYSTEMS	GOVENOR & FUEL CONTROL		GTG14	No specific informatioon on govenor and fuel control. Fuel control was an issue in 2007 Alba report with a recommendation to upgrade to address failed starts due to fuel control. Appears to have been completed..	4/10	(30)	5	2020	No	1986/2008
1273	7202	7311	99003602	GAS TURBINE AUXILIARY SYSTEMS	EXCITATION SYSTEM		GTG15	Siemens recommended an overhaul of the exciter and steam cleaning of windings, VPI testing of insulation. There is some concern that it is a 45 year old unit which is not supported. The polarization readings of the Exciter stator are poor.	4/10	(30)	2	2020	No	1986

Notes: 1. A "(bracketed)" value in the "Current Expected Remaining Life" column is a highly probable minimum value that is considered subject to some subsequent verification during further investigation, including at the next test or overhaul. It may be addressed as part of a Level 2 test. A value identified as "(X/Y)" has been included where the recommended minimum value is the lower of the two, but that the higher may be achievable at a higher level of failure risk and/or unreliability.

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Holyrood Thermal Generating Station
Gas Turbine Condition Assessment & Options Study

2.1.5 Risk Assessment

TABLE 2-7 RISK ASSESSMENT – GAS TURBINE GENSETS

BU # 1	Asset # 2	Asset # 3	Asset # 4	Asset Level 3	Description	Detail	Cond. Summ. ID#	Condition	Major Issues	Remaining Life Years	TECHNO-ECO RISK ASSESS MODEL			SAFETY RISK ASSESS MODEL			Possible Failure Event	Mitigation
										(Insufficient Info - Inspection Required Within (x) Years)	Likeli-hood	Conse-quence	Risk Level	Likeli-hood	Conse-quence	Safety Risk		
1273	7202	0	0	GAS TURBINE SYSTEM	GAS TURBINE SYSTEM		GTG1	44 years old and has accumulated to 2010 about 4,717 hours with 1,548 starts. Four significant overhauls/repairs in 1978, 1986, and 1991 and a combustor replacement in 2007	Major systems need overhaul	1/10	4	C	High	3	D	High	Major/catastrophic failure of unit or fire	Overhaul or replace
1273	7202	7308	0	GAS TURBINE AVON JET ENGINE	GAS TURBINE AVON GAS GENERATOR		GTG2	Overall Rolls Wood group inspection in 2010 concluded that the engine appears in reasonably good and serviceable condition.The engine shows signs of pitting, salt deposition, corrosion and loss of coatings on the Avon gas generator. Coatings and some turbine blading and other components have suffered cracking or other damage. Corrosion/cracking from seaside moisture and starts. Buildup of salt on the first stages of the compressor. There is also cracking in the turbine section. Overdue for overhaul.Rear bearing housing in good condition..	Blade failure or material realease causes downstream collateral damage.	2	3	C	Medium	1	D	Medium	Catastrophic failure of downstream equipment	Overhaul or replace
1273	7202	7058	0	GAS TURBINE POWER TURB & G/B	GAS TURBINE POWER TURBINE	Power Turbine	GTG6/7	Received little attention since 1986 with very limited boropscope views of blade roots. Disk material in these limited views in the axially serrated root appears to be severely corroded.No way of knowing if corrosion is present on the remainder of the disk, and whether superficial or deep. Appears to extend under the root. It is possible that salt particles have collected in the complex root form. The corrosion may be more serious in highly stressed areas, such as the root. Alternatively the whole disk may be corroded. In either case the roots are very vulnerable to stress corrosion cracking.Overdue for overhaul. Greenray (legal representive of AEI gas turbines, hold all rights to their technology)do not think that the power turbine should be operated in its present condition.	Power turbine rotor disck high stress blade root failure	2	4	C	High	3	D	High	Blade root failure of disk - catastrophic faiure	Replace/repair disk and overhaul unit.
1273	7202	7058	0	GAS TURBINE POWER TURB & G/B	GAS TURBINE POWER TURBINE	Power Turbine	GTG8	Turbine cooling air is taken directly from the environment, without filtration. Cooling air passes through an ejector, using Avon bleed air, so that the air reaching the disk is a mixture of filtered air from the Avon and unfiltered air. The disk cooling system has probably operated for 45 years with a significant salt loading.	Corrosion of power turbine blade roots.	2	4	C	High	3	D	High	Blade root failure of disk - catastrophic faiure	Modify air inlet. Replace/repair disk and overhaul unit.
1273	7202	7058	0	GAS TURBINE POWER TURB & G/B	GAS TURBINE POWER GEARBOX	Gearbox	GTG9	Alba in 2007 indicated gearbox appeared to be in good condition and that if the bearings and seals are replaced the gearbox should not present a large risk. Issues remain on the cause of the low oil pressure from the mechanical pump and the oil leak on the low speed drive shaft and must be determined and rectified. The high speed gearbox shaft seals are leaking and were the cause of a 2010 fire at the power turbine end of the gearbox which has resulted in the unit being limited to emergency use only. At least three or four causes have been suggested for the labyrinth oil seal leakage at the generator end (low speed shaft) and drive end (high speed shaft). Tests on the pressure in the gearbox (measured by a gauge mounted on the gearboxs casing) showed a rise with load and suggested that the gearbox is being pressurized by the Avon bleed air. Greenray 2011 inspection: Gear wheels and internals appeared in pristne condition with normal marks. Outer wiper of leaking low speed gear wheel lube oil gland may be touching top of shaft and have some clearance at bottom (opposite to normal) and may indicate driven machine out of alignment with gearbox output shaft The bearings may have suffered severe wear due to a number of possible causes (misalignment, gear backlash, or low gearbox oil pressure). In 2008 Alba noted that the splash plate behind the generator end seal was making contact with the shaft, which indicates heavy bearing wear. Overdue for overhaul.	Gearbox oil leaks; gearbox misalignment/wear	2	4	C	High	3	D	High	Lube oil fires. (Gearbox failure (bearings/misalgnment)	Gearbox overhaul - seals, alignment, bearings
1273	7202	7309	0	GAS TURBINE GENERATOR	GAS TURBINE GENERATOR		GTG10/11	Siemen's report shows that the insulation has deteriorated and there is a phase inbalance on the stator. The polarization readings of the generator stator are reasonable, and considerably better than those of the Exciter stator and the major motors. However the stator phase inbalance is quite high. The generator compartment was provided with new filter elements which are in good condition, except that there are some holes in the building siding that allows some air to bypass them.	Generator insulation condiion and potential for failure	5	3	C	Medium	3	C	Medium	Generator winding failure and collateraldamage	Generator overhaul. Rewinds if necessary.
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	GAS TURBINE EXHAUST STACK	Exhaust Stack	GTG12	Severly corroded, leaking,Braden 2011 inspection: exterior significant carbon steel crystallization and peeling of carbon steel; no fatigue/cracking of welds, sulging of stack on south side, several holes in exhaust. Snow hood no apparent issues (some operation issues with functionality). Transition duct (external insulation) not visible for inspection. Expansion joint belt in good condition. reported	Stack water leakage into power turbine	1	4	C	High	3	C	Medium	Power turbine corrosion/failure. Stack failure	Replace stack
1273	7202	7311	99003602	GAS TURBINE AUXILIARY SYSTEMS	GAS TURBINE AIR INLET PLENUM CHAMBER & MEDIA	Filter Material	GTG13	Inlet housing and filtration system were replaced in 1986. Its stainless steel inlet splitters appear to have suffered little deterioration Water leaking into plenum.Filter media is considered inappropriate for its marine environment. The filter now has air gaps between the filter elements, due to rusting The high saline atmosphere means that the unit is operating with an increasingly ineffective inlet filter and the unit has suffered considerable degradation.	Corrosion impact on gas generator and power turbine causing failure	2	3	C	Medium	3	C	Medium	Corrosion of gas generator and power turbine accelerates.	Replace filter media; overhaul/repair housing.
1273	7202	7311	99003602	GAS TURBINE AUXILIARY SYSTEMS	GOVENOR & FUEL CONTROL		GTG14	No specific informatioon on govenor and fuel control. Fuel control was an issue in 2007 Alba report with a recommendation to upgrade to address failed starts due to fuel control. Appears to have been completed..	Failed starts and speed/load control	5	2	B	Low	2	B	Low	Unit start and control	Check status and refurbish as required as part of overhaul.
1273	7202	7311	99003602	GAS TURBINE AUXILIARY SYSTEMS	EXCITATION SYSTEM		GTG15	Siemens recommended an overhaul of the exciter and steam cleaning of windings, VPI testing of insulation. There is some concern that it is a 45 year old unit which is not supported. The polarization readings of the Exciter stator are poor.	Exciter failure; unit extended outage.	2	3	C	Medium	3	C	Medium	Failure of exciter leads to extended shutdown of unit.	Replace exciter.

2.1.6 Actions

TABLE 2-8 ACTIONS – GAS TURBINE GENSETS

BU # 1	Asset # 2	Asset # 3	Asset # 4	Asset Level 3	Description	Detail	Cond. Summ. ID#	Capital Item	Date	Priority
1273	7202	0	0	GAS TURBINE SYSTEM	GAS TURBINE SYSTEM		GTG1			
1273	7202	7308	0	GAS TURBINE AVON JET ENGINE	GAS TURBINE AVON GAS GENERATOR	General	GTG2	No specific capital projects - major unit overhaul.	2012	1
1273	7202	7308	0	GAS TURBINE AVON JET ENGINE	GAS TURBINE AVON GAS GENERATOR	Compressor and Intake	GTG3	No specific capital projects - major unit overhaul.	2012	1
1273	7202	7308	0	GAS TURBINE AVON JET ENGINE	GAS TURBINE AVON GAS GENERATOR	Combustor	GTG4	No specific capital projects - major unit overhaul.	2012	1
1273	7202	7308	0	GAS TURBINE AVON JET ENGINE	GAS TURBINE AVON GAS GENERATOR	Turbine Rotor	GTG5	No specific capital projects - major unit overhaul.	2012	1
1273	7202	7058	0	GAS TURBINE POWER TURB & G/B	GAS TURBINE POWER TURBINE	Power Turbine	GTG6/7	Purchase power turbine disk. No other specific capital projects - major unit overhaul.	2012	1
1273	7202	7058	0	GAS TURBINE POWER TURB & G/B	GAS TURBINE POWER TURBINE	Cooling Air	GTG8	Modify cooling air to power turbine to eliminate salt ingress - part of major unit overhaul.	2012	1
1273	7202	7058	0	GAS TURBINE POWER TURB & G/B	GAS TURBINE POWER GEARBOX	Gearbox	GTG9	No specific capital projects - major unit overhaul.	2012	1
1273	7202	7309	0	GAS TURBINE GENERATOR	GAS TURBINE GENERATOR		GTG10/11	No specific capital projects - major unit overhaul.	2012	1
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	GAS TURBINE EXHAUST STACK	Exhaust Stack	GTG12	Replacement stack and installation	2012	1
1273	7202	7311	99003602	GAS TURBINE AUXILIARY SYSTEMS	GAS TURBINE AIR INLET PLENUM CHAMBER & MEDIA	Filter Material	GTG13	No specific capital Requirement - new fiolter media	2012	2
1273	7202	7311	99003602	GAS TURBINE AUXILIARY SYSTEMS	GOVENOR & FUEL CONTROL		GTG14	None		
1273	7202	7311	99003602	GAS TURBINE AUXILIARY SYSTEMS	EXCITATION SYSTEM		GTG15	Refurbish exciter (Replace as necessary in refurbishment)	2012	1

2.1.7 Life Assessment - Life Cycle Curves (Where equipment is not to be overhauled/replaced and life <2020 and has major unit operation impacts.)

The gas turbine *generator unit essentially requires all of its major components to be overhauled* or replaced as soon as practical. After such an overhaul, there should be no further major repairs required before 2020. Given this, no life cycle curves are presented for the gas turbine generator system.

2.1.8 Level 3 Inspections Required

The refurbishment of the unit can be done in two ways;

- NL Hydro can disassemble the unit and perform Level 3 inspection assessments on key equipment. After the assessments, NL Hydro will be able to obtain firm bids for replacement components and place orders for them. This will be a lengthy process and it will require Hydro to authorize a two phase investment; the first on disassembly and inspection and reassembly and the second for the purchase and fitting of replacement parts at some future date.
- Once NL Hydro makes a decision to refurbish the existing GT unit instead or replacing it with new GT or diesel generator facilities, those components identified as likely to require replacement should be ordered and the units overhauled. No level 3 inspections will be performed, although detailed inspections when during overhauls may show the need to refurbish other components. Large additional as-found overhaul costs are unlikely since a conservative approach in that any further major items will be required. Under this alternative independent Level 3 assessments are eliminated. This approach is recommended by AMEC.

Generally if the AMEC Recommended Approach is taken, no other “Level 3” inspections/tests are required.

If the first approach is taken, the most important Level 3 assessments are:

- Avon Gas Generator
- Power Turbine blade root condition
- Gearbox bearing wear/alignment and gearbox seals
- Disk cooling system

This approach may result in some savings in the final overhaul, but would require an additional outage and detailed inspections, and possibly additional delay in completing the final overhaul required.

2.1.9 Capital Enhancements

TABLE 2-9 SUGGESTED TYPICAL CAPITAL ENHANCEMENTS – GAS TURBINE GENSETS

BU # 1	Asset # 2	Asset # 3	Asset # 4	Asset Level 3	Description	Detail	Cond. Summ. ID#	Capital Item	Date	Priority
1273	7202	0	0	GAS TURBINE SYSTEM	GAS TURBINE SYSTEM		GTG1			
1273	7202	7308	0	GAS TURBINE AVON JET ENGINE	GAS TURBINE AVON GAS GENERATOR	General	GTG2	No specific capital projects - major unit overhaul.	2012	1
1273	7202	7308	0	GAS TURBINE AVON JET ENGINE	GAS TURBINE AVON GAS GENERATOR	Compressor and Intake	GTG3	No specific capital projects - major unit overhaul.	2012	1
1273	7202	7308	0	GAS TURBINE AVON JET ENGINE	GAS TURBINE AVON GAS GENERATOR	Combustor	GTG4	No specific capital projects - major unit overhaul.	2012	1
1273	7202	7308	0	GAS TURBINE AVON JET ENGINE	GAS TURBINE AVON GAS GENERATOR	Turbine Rotor	GTG5	No specific capital projects - major unit overhaul.	2012	1
1273	7202	7058	0	GAS TURBINE POWER TURB & G/B	GAS TURBINE POWER TURBINE	Power Turbine	GTG6/7	Purchase power turbine disk. No other specific capital projects - major unit overhaul.	2012	1
1273	7202	7058	0	GAS TURBINE POWER TURB & G/B	GAS TURBINE POWER TURBINE	Cooling Air	GTG8	Modify cooling air to power turbine to eliminate salt ingress - part of major unit overhaul.	2012	1
1273	7202	7058	0	GAS TURBINE POWER TURB & G/B	GAS TURBINE POWER GEARBOX	Gearbox	GTG9	No specific capital projects - major unit overhaul.	2012	1
1273	7202	7309	0	GAS TURBINE GENERATOR	GAS TURBINE GENERATOR		GTG10/11	No specific capital projects - major unit overhaul.	2012	1
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	GAS TURBINE EXHAUST STACK	Exhaust Stack	GTG12	Replacement stack and installation	2012	1
1273	7202	7311	99003602	GAS TURBINE AUXILIARY SYSTEMS	GAS TURBINE AIR INLET PLENUM CHAMBER & MEDIA	Filter Material	GTG13	No specific capital Requirement - new fiolter media	2012	2
1273	7202	7311	99003602	GAS TURBINE AUXILIARY SYSTEMS	GOVENOR & FUEL CONTROL		GTG14	None		
1273	7202	7311	99003602	GAS TURBINE AUXILIARY SYSTEMS	EXCITATION SYSTEM		GTG15	Refurbish exciter (Replace as necessary in refurbishment)	2012	1

2.1.10 Capital/Refurbishment and Overhaul Costs (Capital)

The Avon requires an overhaul to replace coatings and repair or replace turbine blading and other components which have suffered cracking or other damage. It is expected that when the Avon has been overhauled and the inlet filters replaced the Avon will not require further significant overhaul before life end in 2020, and that future annual maintenance costs would be less than $10,000 per year.

The first approach whereby limited funding is approved for disassembly and then make a second purchase decision when the equipment is examined is likely to be a slow process and possibly difficult administratively for NL Hydro. AMEC made assumptions based on data available, experience and recommendations from vendors such as Greenray, Alba Power, etc, and prepared an estimate covering all equipment which will probably be required for life extension. This is likely a quicker route to meet the project requirements, but has a risk of purchasing too much equipment.

AMEC received quotations from the following companies.

- Alba Power, Scotland.
- Greenray- the owner of AEI's original technology
- Camfil Farr- supplier of the inlet filter
- Braden - supplier of exhaust stacks
- SS Turbine services Ltd. - a small Canadian aero engine overhaul company.

In addition, AMEC has the quotation provided by 'Rolls Woods to NL Hydro for an Avon overhaul. This 2010 quotation is posted on Newfoundland Power Commission's website.

The pricing provided by Alba Power covers the entire plant, while other companies have only bid for their own equipment. The attached table shows the Alba Power bid, in column 1, with the bids from other companies in column 2. Column's 3 shows AMEC's estimate for the cost of providing a comprehensive rehabilitation to make the unit suitable for another 8 or more years of operation, with minimum risk. The major components, including the Avon, Power turbine, gearbox, generator, inlet filter and exhaust filter would be restored to the same condition as 1986. Column 3 is an amalgamation of the quotations received from the different companies, plus AMEC estimates for some minor costs.

The table assumes an exchange rate of 1.6 for the UK pound, and a modest 10% allowance for duty and freight.

Alba's cost of a complete "Standard Overhaul" of the Avon is included in column 3 but Alba did not include the cost of any required replacement parts. A full standard overhaul by Alba would therefore cost significantly more than the $500,000 which they bid, but it would give the Avon another 20,000 to 30,000 of life. S and S turbine have quoted $450,000 for a full overhaul including parts, which would include a proving test run after completion of the work. Even the work covered by this bid is probably excessive for the 8 year life extension required, but AMEC cannot judge how much work will be needed until the engine is disassembled. We have therefore allowed $500,000 for the Avon overhaul, including transportation.

Alba state that the unit will operate until 2020 with almost no additional cost, if the proposed overhaul is completed. In contrast to the comprehensive overhaul which Alba propose for the Avon, they have proposed simple on-site repairs of the inlet filter and exhaust stack, and a low cost overhaul of the generator and exciter.

TABLE 2-10 CAPITAL COST ESTIMATE $ 1,000 CDN$

	Option 1 Alba total package	Option 2 Split supply	Composite estimate	Comments
		Pound @ $1.6		
Avon	500		500	Alba estimate is for a complete standard overhaul. O/H reports suggest some of this is not required. (note 1)
Replacement components				Woods Rolls estimate $1.3 million for a complete Avon OH
				S and S turbine quote $450,000 including parts.
Power Turbine	300			
Disassemble/reassemble		136	75	Greenray estimate is substantially too high
New Disk		331	331	Alba also have a disk; no quotation provided yet.
Moving blades		See comment	93	1 blade incl Greenway price- See note 1
Rotor rehabilitation		282	282	Includes shipment to UK
Inlet structure repairs			15	Small amount of welding is required
Thermocouples				excluded from this estimate
Diaphragm section			40	
Heat shield				
Bearings		70	70	
Exhaust volute			30	Allow for minor repairs
Gearbox				
Bearings		114	114	
Disassemble/reassemble				
Inspect, crack detection				
Gearbox venting			25	Contingency against Greenray estimate
Contingency; 2nd opinion			25	Contingency against Greenray estimate
Generator and aux	87		900	Alba confident cleaning & varnishing will improvelife
				Rewind estimate requires confirmation.
Exciter			50	Refurbish (Replace as necessary during refurbishment)
Inlet filter	30	588	150	Camfil Farr est includes SS filter hours & new plenum.
				For 8 year life extension new plenum not required,
Exhaust stack	34	267	50	For 8 year life extens existing stack with refurb adequate.
Oil and fuel	45		0	This item covered by AMEC St Johns as BOP
Commission unit			50	
Contingency excl Avon			150	
TOTAL	996	1788	2951	

Note 1. Alba quote $500,000 excluding parts, but overhaul scope is very extensive and can be reduced. S & S turbine is a smaller shop but quote $450,000 including all required parts.
Note 2. New PT blades from Greenray are very expensive. These blades can be welded, and as efficiency is not important we have estimate is based on a total of 4 new blades and weld repairs to others.

Assume 10% duty and shipping

Schedule

The refurbishment of the unit can be done in two ways:

1. With the first alternative, NL Hydro can disassemble the unit in order to perform level 3 assessments on key equipment. After the Level 3 assessments, NL Hydro will be able to obtain firm bids for replacement components and place orders for them. This will be a lengthy process and it will require Hydro to authorize two separate contracts separated by several months. The first would cover disassembly and inspection and reassembly while the second would cover the purchase and fitting of replacement parts.

2. With the second alternative, AMEC will identify which components are likely to require replacement and that these are ordered if NL Hydro decides to refurbish the unit. Under this alternative, the unit will not receive any level 3 inspections until new components are available. It is possible that the detailed inspections will show the need for other component replacement, but AMEC thinks that it is unlikely that any further major long lead items will be required. The most expensive item which may have to be purchased is the power turbine disk, but NL Hydro will have the choice of purchasing a stock unit from Alba, if it is still available, or a new unit from Greenray.

The most important level 3 assessments are:

- Avon Gas Generator (The actual scope of the overhaul will be adjusted when the unit is inspected at the beginning of the overhaul).
- Gearbox and seals
- Power turbine Disk cooling system
- Power turbine disk
    - Diaphragms and diaphragm ring

The schedule suggested by Greenway for the Power Turbine, with some additions identified for the other components, is shown in Table 2-11:

TABLE 2-11 HOLYROOD GT REFURBISHMENT SCHEDULE

Newfoundland and Labrador Hydro. Holyrood GT refurbishment

	week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
Manufacture Disc																																										
Strip and dissassemble plant																																										
Ship Rotor to overhaul plant																																										
Overhaul and balance Rotor																																										
Ship Rotor to Holyrood																																										
Rebuild and commission unit																																										
Avon overhaul																																										
Generator Refurbish (Rewind as necessary)																																										

2.2 Electrical & Controls Equipment/Processes

Unit #:	GAS TURBINE
Asset Class #	BU 1273 Gas Turbine
SCI & System:	7202 Gas Turbine System
Sub-Systems:	7310 HRD GT E&C

2.2.1 Description of Existing System

Holyrood GS consists of three thermal units (2x175 MW and 1x150 MW). Each unit supplies its own station service 4160V bus when on line. The Common station service for Unit #1 and #2 is fed from a 69KV/4160V 10.5/14MVA transformer SST-12. The Common station services of Unit #1 are fed from a 69KV/4160V 10.5/14MVA transformer SST-34. When the unit is shutdown (off line) its unit station service bus is transferred to the Common station services source (Reference - Holyrood Single Line Electrical Diagram).

During a total loss of all station service supply the station can be re-started from blackout condition with the 13.5 MW, 13.8 KV Emergency Gas Turbine (GT) connected to the 4160V station service bus through a 10.5 MVA step down transformer (T9). The station service buses all have a ground fault current limited to 1000A by a Neutral Ground Resister (NGR) of 2.4 Ohms.

References:

- NFL Holyrood Single Line Drawing # A)-1403-500-E-001 Rev 16
- IEEE C62.92-1989 Guide for the application of Neutral Grounding in Electrical Utility System Part II Grounding of Synchronous generator system.

Within the GT building, the Electrical and Control systems consist of a rotting brushless exciter, an automatic voltage regulator (AVR), a start rectifier, Distributed Control System (DCS) control modules, motor control centre (MCC), electronic governors, synchronizer, and protection and monitoring equipment.

The brushless exciter, AVR and start rectifier were manufactured by AEI Limited of Manchester, England in the mid-1960's. The governor, synchronizer and monitoring equipment were newly installed in 1986. The exciter and AVR unit controls its stator terminal voltage (13.8 kV) and MVAr delivery. The start rectifier converts station AC current into the high DC current necessary to rotate the jet engine to ignition. The governor consists of two Woodward units: one that controls the jet acceleration on start-up and the second that controls the power turbine/generator during synchronization and megawatt (MW) loading. In 1987, the Gem 80/500 PLC replaced all relay logic, but in 2009 this was again replaced by a Foxboro (Invensys) system which is in communication with the Plant DCS, and is now the primary controlling medium for the gas turbine.

The excitation control system consists of a “Normal” and “Standby” automatic voltage regulator (AVR) backed up by a “Manual” control mode. The AVR controls the strength of the magnetic field in the exciter by varying the amount of current through the stationary exciter field windings.

Governor and Fuel Control: The standard Avon fuel control system is used without alteration as a basis for the API governing and fuel control system. The throttle valve is used as a generator valve and the HP cock as a fuel shut-off valve for normal and emergency shut-downs. The governing system is of the sensitive oil type in which fluid pressure is used to transmit the movement of the governor pilot valve to the operating mechanism of the governor valve, in this case the Avon throttle.

The governor is manufactured by Woodward and is driven via gearing from the end of the high speed pinion shaft. The governor is a fly-weight type and carries its own oil supply.

Woodward Governor suggests that the present system has a reliability of about 50%. In addition spare parts for this system are not carried and would have to be fabricated requiring long delivery times.

The governor, synchronizer and monitoring equipment were newly installed in 1986. The governor consists of two Woodward units: one that controls the jet acceleration on start-up and the second that controls the power turbine/generator during synchronization and MW loading.

Excitation System: The exciter is a rotating brushless type mounted on a stub to the main rotating shaft. It was designed to ANSI Specification C50-13. The AC output from the exciter armature is fed through a set of diodes that are mounted on the rotor and are used to produce a DC voltage. The voltage is fed directly to the field winding of the main generator which is also mounted on the same rotating shaft.

The excitation control system consists of a “Normal” and “Standby” automatic voltage regulator (AVR) backed up by a “Manual” control mode. The AVR controls the strength of the magnetic field in the exciter by varying the amount of current through the stationary exciter field windings.

Switchgear: Primary voltage generated by the GT is 13,300 Volts. The installed GT capacity is 13.5 MW, however based on limiting factors the unit sees normal operation of ~12 MW. Originally this power was fed through a 13.8 kV oil circuit breaker and then through a 13.8 kV fusible switch. The oil circuit breaker is no longer functional but remains installed due to the current transformer (CT’s) in this breaker. These CT’s are essential to the protection of the generator and the 13.8 kV/4.160 14 MVA transformer. Power is then fed from the transformer at 4.160 kV to breaker SSB-2 in station panelboard SB12. Power from the CT or station power also feeds a 13.8 kV fused disconnect switch through a 75 kVA 13.8 kV/575 V transformer that provides power back to the station system.

600V Standby Power: GT 600 V standby power for the MCC and auxiliaries is fed from the diesel generator bus DB34 or power centre ‘C’ via a manual transfer switch in the control room. This item feeds into an automatic transfer switch which alternately is fed from the 112 kVA transformer in the previous paragraph.

Battery Room: A battery room is located adjacent to the room that contains the MCC and switchgear. The room (approximately 1800mm-2700mm) controls a bank of batteries for the purpose of powering the DC powered emergency lubrication pumps for the GT lubrication system should the shaft driver and the AC driver lubricating pumps fail during operation of the GT. The battery system also provides a source of power to the DC lube oil pump, should the AC power supply from the station Diesel Generators or Utility power to the GT building be lost.

GTG Control System

The control system has been incrementally improved through the unit’s life. In 1970, a PLC was installed to improve overall startup and unit control. In 1986, the Gem 80/500 PLC replaced all relay logic and was the primary controlling medium for the gas turbine. In 2009, it was replaced with an Invensys (Foxboro) DCS and the PLC logic was converted to DCS logic. The DCS controls the sequencing functions of the GT as did the PLC. It is set up on the plant DCS network so that the screens can be viewed by the plant operator in the main control room. In 2009, this was replaced by a Foxboro DCS system, which has greatly improved graphics.

Control Room & MCC/Switchgear Room

Within the gas turbine building, the electrical and control systems consist of a rotating brushless exciter, an automatic voltage regulator (AVR), a start rectifier, PLC control modules, motor control centre (MCC), electronic governors, synchronizer, and protection and monitoring equipment. The brushless exciter, AVR and start rectifier were manufactured by AEI Limited of Manchester, England in the mid-1960s. The programmable logic controller (PLC), governor, synchronizer and monitoring equipment were newly installed in 1986. The exciter and AVR unit act in combination to supply a controlled DC current to the wound rotor of the main generator which in turn controls its stator terminal voltage (13.8 kV) and MVar delivery. The start rectifier converts station AC current into the high DC current necessary to rotate the jet engine to ignition. The governor consists of two Woodward units: one that controls the jet acceleration on start-up and the second that controls the power turbine/generator during synchronization and MW loading.

Switchgear

The primary voltage generated by the GT is 13,300 Volts. The installed GT capacity is 13.5 MW. However, based on limiting factors, the unit sees normal operation of less than 12 MW.

Originally, this power was fed through a 13.8 kV oil circuit breaker and then through a 13.8 kV fusible switch. The oil circuit breaker is no longer functional but remains installed due to the current transformer (CT's) in this breaker. These CT's are essential to the protection of the generator and the 13.8 kV/4.160 14 MVA transformer. Power is then fed from the transformer at 4.160 kV to breaker SSB-2 in station panelboard SB1 2. Power from the CT or station power also feeds a 13.8 kV fused disconnect switch through a 75 kVA 13.8 kV/575 V transformer that provides power back to the station system.

2.2.2 Major Maintenance History

In 1987, the original control panel and sequencing system was removed and replaced with a state of the art programmable control and sequence system (Pratt & Whitney). This system was subsequently replaced in 2009 by a Foxboro (Invensys) DCS system. The original AEI/GEC control system was removed and replaced with a Woodward Governor 2301 Control System driving an EGP3 actuator.

Other than the decision to bypass the 13.8kV oil circuit breaker, no major maintenance has been carried out.

The following is a summary of significant work completed since 2003. No major overhauls have been completed on the entire machine.

25 May 2007

- Ignitor, lead and box were replaced;

21 May 2008

- Controls review.

10 June 2008

- Fuel pump and fuel control unit (FCU) to be repaired.

15 October 2009

- Thermocouple damage, quick fixed. To be upgraded;

20 November 2009

- Commissioning;
- Fuel control solenoid valve burnt out and replaced;
- Multiple start trips due to low fuel pressure, low oil pressure, and incomplete start sequence. Several issues identified - igniter box malfunction, N2 probe incorrectly connected & poor FCU actuator tuning;
- Suggest monitoring setup for the 8 EGT thermocouples.

NL Hydro has since undertaken a number of activities with vendors that have the OEM rights to the GT sections in order to conduct detailed internal inspections of the individual sections and prepare field inspection reports complete with refurbishment estimates. None dealt specifically with the electrical and control (E&C) systems.

2.2.3 Condition Assessment & Remaining Life

TABLE 2-12 CONDITION ASSESSMENT – GT ELECTRICAL & CONTROLS

BU # 1	Asset # 2	Asset # 3	Asset # 4	Asset Level 3	Description	Detail	Cond. Summ. ID#	Condition	Status Identifier	Original Life (Base Load) Ops Hrs (Yrs)	Current Expected Minimum Remaining Life Years (Subject to Test)	End of Life (EOL) Required	Capability to Reach EOL	In Service
	7202	7310	0	Elect and Control	800A, 13.8 kV Generator Main Breaker (AEI, Type BRP17 / BVRP17)	2.3.3.2 a)	EC1	The breaker has been by-passed, but does not comprimise the protection of the Generator or T9 Transformer, as the protection still disables the excitation and trips SSB-2 on Statron Board SB12, and at the same time removes internal faults on the Generator and T9 Transformer	4/10		N/A	N/A	No	1969
	7202	7310	0	Elect and Control	13.8 kV fusible switch (J.G. Statter, Ltd. Type VLMK2)	2.3.3.2 b)	EC2	Support and spares are unavailable	4/10		N/A	N/A	No	1969
	7202	7310	0	Elect and Control	112 kVa, 13.8 kV: 600V 3ph Transformer (Cart 6 Electrical)	Part of - 2.3.3.2 c)	EC3	Good Condition	4/10		10+	2020	Yes	1969
	7202	7310	0	Elect and Control	200A, 600V, 3ph manual transfer switch (Square D)	N/A	EC4	Fair Condition, but no spares available	4/10		10+	2020	Yes	1969
	7202	7310	0	Elect and Control	200A, 600V, 3ph automatic transfer switch (Taylor Industrial Controls)	N/A	EC5	Fair Condition, but no spares available	4/10		10+	2020	Yes	1969
	7202	7310	0	Elect and Control	600V, 3ph, Dist. Panel	N/A	EC6	Fair condition, but distribution board and branch breakers are old with no spares available and have been superceeded by up-to-date equipment.	4/10		0	2020	No	1969
	7202	7310	0	Elect and Control	30 kVa, 600V: 230/115V, 1ph lighting transformer (Hammond, Type F Car E79B)	Part of - 2.3.3.2 e)	EC7	Good Condition	4/10		10+	2020	Yes	1969
	7202	7310	0	Elect and Control	MCC (AEI, Type MMC Series 1000)	2.3.3.2 d)	EC8	Contains 600V, 3ph, 230V, 3ph and 100V dc bussing. The MCC is not only obsolete, with no spares or documentation available, but also violates CEC C22.1 working space in front of the MCC is less than 1 metre and when a starter is drawn out there is a safety hazard in front of the MCC.	4/10		0	2012	No	1969
	7202	7310	0	Elect and Control	100A, 230V, 3ph lighting panel	N/A	EC9	Fair condition, but distribution board and branch breakers are old with no spares available and have been superceeded by up-to-date equipment.	4/10		1	2020	No	1969
	7202	7310	0	Elect and Control	120V dc dist. Panel	N/A	EC10	Fair condition, but distribution board and branch breakers are old with no spares available and have been superceeded by up-to-date equipment.	4/10		1	2020	No	1969
	7202	7310	0	Elect and Control	120V dc motor starters fused disconnect	N/A	EC11	Part of existing MCC	4/10		0	2020	No	1969
	7202	7310	0	Elect and Control	230V, 3ph, starter and disconnect	N/A	EC12	Part of existing MCC	4/10		0	2020	No	1969
	7202	7310	0	Elect and Control	Battery Charger (SAFT NIFE, Model SLRF 120-30)	N/A	EC13	Good Condition	4/10		10+	2020	Yes	1995
	7202	7310	0	Elect and Control	129V dc battery bank (C&D technologies)	N/A	EC14	The battery has a life expectancy of 18-25 years. Being situated in a good environment, not over-stressed and receiving regular maintenance. Product is current with replacement cells and spare parts available.	4/10		10+	2020	Yes	1995
	7202	7310	0	Elect and Control	Start rectifier (AEI)	2.3.3.2 g)	EC15	No maintenance or servicing has been carried out by the present maintenance staff.	4/10		0	2020	No	1969
	7202	7310	0	Elect and Control	Automatic voltage regulator/excitor (AEI)	2.3.3.2 g)	EC16	No maintenance or servicing has been carried out by the present maintenance staff.	4/10		0	2020	No	1969
	7202	7310	0	Elect and Control	Protection and Controls (Pratt & Whitney)	N/A	EC17	Very good condition, with spares available for the unforseen future	4/10		10+	2020	Yes	1986
	7202	7310	0	Elect and Control	DCS (Foxboro/Invensys)	N/A	EC18	Good condition - replaces the GEN80 PLC system and communicates direct into the plant DCS. DCS in operation considered "state-of-the-art" and replacement service agreement renders the system current.	4/10		10+	2020	Yes	2009
1325	5983	5983	61-00-69576	TRANSFORMERS	TRANSFORMER T9	13.8 kV	EC19	Installed in 1970, the unit is at a high level of risk due to its age. No significant issues were identified in Doble tests last done in 2001. Maintenance in 2000, 2004 and 2006 was for various gauges/relays. Silica gel was replaced in 2002 and a Dielectric test performed in 1983. The latest Planned Maintenance was in 2006. Insulating oil tests in 2009 suggests higher power loss when under operation, and also the oil has a higher solubility of polar contaminants and oxidation products.	4	(45)	5+	2020	Yes	1970

2.2.4 Risk Assessment/

TABLE 2-13 RISK ASSESSMENT – GT ELECTRICAL & CONTROLS

BU # 1	Asset # 2	Asset # 3	Asset # 4	Asset Level 3	Description	Detail	Cond. Summ. ID#	Condition	Major Issues	Remaining Life Years	TECHNO-ECO RISK ASSESS MODEL			SAFETY RISK ASSESS MODEL			Possible Failure Event	Mitigation
										(Insufficient Info - Inspection Required Within (x) Years)	Likeli-hood	Conse-quence	Risk Level	Likeli-hood	Conse-quence	Safety Risk		
	7202	7310	0	Elect and Control	800A, 13.8 kV Generator Main Breaker (AEI, Type BRP17 / BVRP17)	2.3.3.2 a)	EC1	The breaker has been by-passed, but does not comprimise the protection of the Generator or T9 Transformer, as the protection still disables the excitation and trips SSB-2 on Statron Board SB12, and at the same time removes internal faults on the Generator and T9 Transformer	Arc flash	0	1	D	Medium	1	4	Medium	Arc Flash on breaker resulting in potential for serious injury.	Breaker has been by-passed
	7202	7310	0	Elect and Control	13.8 kV fusible switch (J.G. Statter, Ltd. Type VLMK2)	2.3.3.2 b)	EC2	Support and spares are unavailable	Not able to maintain	0	4	A	Low	4	1	Medium	None likely in current configuration.	replace with new fusible switch
	7202	7310	0	Elect and Control	112 kVa, 13.8 kV: 600V 3ph Transformer (Cart 6 Electrical)	Part of - 2.3.3.2 c)	EC3	Good Condition	None	10+	1	B	Low	1	C	Low	N/A	Monitor condition.
	7202	7310	0	Elect and Control	200A, 600V, 3ph manual transfer switch (Square D)	N/A	EC4	Fair Condition, but no spares available	Not able to maintain	10+	1	A	Low	1	A	Low	N/a	Monitor condition.
	7202	7310	0	Elect and Control	200A, 600V, 3ph automatic transfer switch (Taylor Industrial Controls)	N/A	EC5	Fair Condition, but no spares available	Not able to maintain	10+	1	A	Low	1	A	Low	N/A	Monitor condition.
	7202	7310	0	Elect and Control	600V, 3ph, Dist. Panel	N/A	EC6	Fair condition, but distribution board and branch breakers are old with no spares available and have been superceeded by up-to-date equipment.	Not able to maintain	0	4	A	Low	3	A	Low	N/A	Monitor condition.
	7202	7310	0	Elect and Control	30 kVa, 600V: 230/115V, 1ph lighting transformer (Hammond, Type F Car FZ9P)	Part of - 2.3.3.2 e)	EC7	Good Condition	None	10+	1	B	Low	1	C	Low	N/A	Monitor condition.
	7202	7310	0	Elect and Control	MCC (AEI, Type MMC Series 1000)	2.3.3.2 d)	EC8	Contains 600V, 3ph, 230V, 3ph and 100V dc bussing. The MCC is not only obsolete, with no spares or documentation available, but also violates CEC C22.1 working space in front of the MCC is less than 1 metre and when a starter is drawn out there is a safety hazard in front of the MCC.	Obsolete unable to maintain. Does not conform to Candian Standards Maintance and Arc	0	4	C	High	3	D	High	Arc flash and threat of personell serios injury	Replace the MCC and Re-Cable the 600V, 230V and 110V DC power.
	7202	7310	0	Elect and Control	100A, 230V, 3ph lighting panel	N/A	EC9	Fair condition, but distribution board and branch breakers are old with no spares available and have been superceeded by up-to-date equipment.	Not able to maintain	1	4	A	Low	3	B	Medium	Lighting failure - staff safety	Replace the Start Rectifier
	7202	7310	0	Elect and Control	120V dc dist. Panel	N/A	EC10	Fair condition, but distribution board and branch breakers are old with no spares available and have been superceeded by up-to-date equipment.	Not able to maintain	1	4	C	Medium	3	C	Medium	Unit failure to start- extended period.	Replace the Start Rectifier
	7202	7310	0	Elect and Control	120V dc motor starters fused disconnect	N/A	EC11	Part of existing MCC	Obsolete unable to maintain. Does not conform to Candian Standards Maintance and Arc	0	3	C	High	2	D	High	Arc flash and threat of personell serios injury	Replace the Starter and the Fused Disconnect
	7202	7310	0	Elect and Control	230V, 3ph, starter and disconnect	N/A	EC12	Part of existing MCC	Obsolete unable to maintain. Does not conform to Candian Standards Maintance and Arc	0	4	C	High	3	D	High	Arc flash and threat of personell serios injury	Replace the Starter and the Fused Disconnect
	7202	7310	0	Elect and Control	Battery Charger (SAFT NIFE, Model SLRF 120-30)	N/A	EC13	Good Condition	None	10+	1	A	Low	1	B	Low	N/A	Monitor condition.
	7202	7310	0	Elect and Control	129V dc battery bank (C&D technologies)	N/A	EC14	The battery has a life expectancy of 18-25 years. Being situated in a good environment, not over-stressed and receiving regular maintenance. Product is current with replacement cells and spare parts available.	None	10+	1	A	Low	1	B	Low	N/A	Monitor condition.
	7202	7310	0	Elect and Control	Start rectifier (AEI)	2.3.3.2 g)	EC15	No maintenance or servicing has been carried out by the present maintenance staff.	Not able to maintain	0	1	C	Medium	3	C	Medium	Unit failure to start- extended period.	Replace the Start Rectifier
	7202	7310	0	Elect and Control	Automatic voltage regulator/excitor (AEI)	2.3.3.2 g)	EC16	No maintenance or servicing has been carried out by the present maintenance staff.	Not able to maintain	0	1	C	Medium	3	C	Medium	Unit failure to start- extended period.	Replace the Automatic Voltage Regulator
	7202	7310	0	Elect and Control	Protection and Controls (Pratt & Whitney)	N/A	EC17	Very good condition, with spares available for the unforseen future	None	10+	1	A	Low	1	B	Low	N/A	Monitor condition.
	7202	7310	0	Elect and Control	DCS (Foxboro/Invensys)	N/A	EC18	Good condition - replaces the GEN80 PLC system and communicates direct into the plant DCS. DCS in operation considered "state-of-the-art" and replacement service agreement renders the system current	None	10+	1	A	Low	1	B	Low	N/A	Monitor condition.
1325	5983	5983	61-00-69576	TRANSFORMERS	TRANSFORMER T9	13.8 kV	EC19	Installed in 1970, the unit is at a high level of risk due to its age. No significant issues were identified in Doble tests last done in 2001. Maintenance in 2000, 2004 and 2006 was for various gauges/relays. Silica gel was replaced in 2002 and a Dielectric	Transformer failure	5+	2	C	Medium	2	C	Medium	Transformer core failure; oil leak etc.	Monitor condition and gas and oil tests per schedule.

2.2.5 Actions

TABLE 2-14 ACTIONS – GT ELECTRICAL & CONTROLS

BU # 1	Asset # 2	Asset # 3	Asset # 4	Asset Level 3	Description	Detail	Cond. Summ. ID#	Action	Year	Priority
	7202	7310	0	Elect and Control	800A, 13.8 kV Generator Main Breaker (AEI, Type BRP17 / BVRP17)	2.3.3.2 a)	EC1	replace 13.8kV breaker, and recommend that a new SSB-2, vacuum interrupting type , 4160V, be installed in station board Sb12, complete with Rm trip and arc flash maintenance reduction switch.	2012	1
	7202	7310	0	Elect and Control	13.8 kV fusible switch (J.G. Statter, Ltd. Type VLMK2)	2.3.3.2 b)	EC2	Replace fusable switch	2012	1
	7202	7310	0	Elect and Control	112 kVa, 13.8 kV: 600V 3ph Transformer (Cart 6 Electrical)	Part of - 2.3.3.2 c)	EC3	No recommended action		
	7202	7310	0	Elect and Control	200A, 600V, 3ph manual transfer switch (Square D)	N/A	EC4	No recommended action		
	7202	7310	0	Elect and Control	200A, 600V, 3ph automatic transfer switch (Taylor Industrial Controls)	N/A	EC5	No recommended action		
	7202	7310	0	Elect and Control	600V, 3ph, Dist. Panel	N/A	EC6	Recommend replacing with new dist. Panel and breakers	2012	2
	7202	7310	0	Elect and Control	30 kVa, 600V: 230/115V, 1ph lighting transformer (Hammond, Type F Car FZ9P)	Part of - 2.3.3.2 e)	EC7	No reocmmended action		
	7202	7310	0	Elect and Control	MCC (AEI, Type MMC Series 1000)	2.3.3.2 d)	EC8	Replace with new MCC for the 600V, 3ph system (also reference items 11 and 12)	2012	1
	7202	7310	0	Elect and Control	100A, 230V, 3ph lighting panel	N/A	EC9	Recommend replacing with new lighting panel and breakers	2012	2
	7202	7310	0	Elect and Control	120V dc dist. Panel	N/A	EC10	Recommend replacing with new dist. Panel and breakers	2012	1
	7202	7310	0	Elect and Control	120V dc motor starters fused disconnect	N/A	EC11	Recommend replacing with a new starter for the Hyd, Gov Pump and new disconnect for the 100V dc panel feed.	2012	1
	7202	7310	0	Elect and Control	230V, 3ph, motor starter and fused disconnect		EC12	Recommend replacing with a new starter for the air compressor and new disconnect for the new ACR controls	2012	1
	7202	7310	0	Elect and Control	battery charger		EC13	No recommended action		
	7202	7310	0	Elect and Control	129V dc battery bank		EC14	No recommended action		
	7202	7310	0	Elect and Control	Start rectifier		EC15	Recommend replacing with a new system	2012	1
	7202	7310	0	Elect and Control	AVR		EC16	Recommend replacing with a new system	2012	1
	7202	7310	0	Elect and Control	Prot. & Controls		EC17	No recommended action		
	7202	7310	0	Elect and Control	DCS		EC18	No recommended action		

2.2.6 Life Assessment - Life Cycle Curves (Where Equipment Is Not To Be Overhauled/replaced and Life <2020 and has Major Unit Operation Impacts)

No Life Cycle Curves are presented. The newer equipment (Controls, battery chargers, batteries) can all meet the 2020 end date. The balance (AVR, MCC, etc.) essentially should be replaced as part of any refurbishment program. Post refurbishment in line with the proposals in this report, there should be no further major significant repairs required before 2020.

2.2.7 Level 3 Inspections Required

No incremental to refurbishment Level 3 assessments are required.

2.2.8 Capital Enhancements

The suggested capital projects for the GT E&C systems are presented in Table 2-15.

TABLE 2-15 SUGGESTED TYPICAL CAPITAL ENHANCEMENTS – GAS TURBINE ELECTRICAL & CONTROLS

Asset # 2	Asset # 3	Asset # 4	Asset Level 3	Description	Detail	Cond. Summ. ID#	Capital Item	Date	Priority
7202	7310	0	Elect and Control	800A, 13.8 kV Generator Main Breaker (AEI, Type BRP17 / BVRP17)	2.3.3.2 a)	EC1	Removal of existing breaker and installation of new breaker, trays and new JB. Run power cables from new breaker to generator and to T9 tranformer, Termination of existing CT's, PT's and control cables in new JB, and extending new CT, PT and control cables from new JB to the new breaker, Extend grounding as necessary. Function test and commission.	2012	1
7202	7310	0	Elect and Control	13.8 kV fusible switch (J.G. Statter, Ltd. Type VLMK2)	2.3.3.2 b)	EC2	Removal of existing fusible switch and installation of new fusible switch, plus installation of cabling to 112 kVA transformer. Ground as necessary. Function test and commission	2012	1
7202	7310	0	Elect and Control	112 kVa, 13.8 kV: 600V 3ph Transformer (Cart 6 Electrical)	2.3.3.2 c)	EC3	Cable from 112kVA Transformer to new 13.8kV Fusible Switch	2012	1
7202	7310	0	Elect and Control	MCC (AEI, Type MMC Series 1000)	2.3.3.2 d)	EC8	Replace the MCC and Re-Cable the 600V, 230V and 110V DC power.	2012	1
7202	7310	0	Elect and Control	30 kVa, 600V: 230/115V, 1ph lighting transformer (Hammond, Type F Car FZ9P) ; New 230V, 3ph, Auxiliary Distribution Panel	2.3.3.2 e)	EC7	Install New 230V, 3ph, Auxiliary Distribution Panel. Relocate 30kVA, 3ph, 550:230V Transformer and Connect to MCC and New 230V, 3ph, Auxiliary Distribution Panel	2012	1
7202	7310	0	Elect and Control	120V dc motor starters fused disconnect	2.3.3.2 f)	EC11	New 110VDC,. NEMA 1 Breaker, new NEMA1 Splitter, new DC Starters, and Existing 100A DC Distribution Panel. New Feeders from Splitter to DC Starters and DC Distribution Panel	2012	1
7202	7310	0	Elect and Control	Start rectifier (AEI)	2.3.3.2 g)	EC15	Replace the Start Rectifier	2012	1
7202	7310	0	Elect and Control	Automatic voltage regulator/excitor (AEI)		EC16	Replace the Automatic Voltage Regulator	2012	1
7202	7310	0	Elect and Control	Miscellaneous	2.3.3.2 h)	EC20	Miscellaneous Hardware, Tray and 4/0 Grounding	2012	1
7202	7310	0	Elect and Control	Commissioning		EC21	Commissioning	2012	1
7202	7310	0	Elect and Control	Protection and Controls (Pratt & Whitney)		EC17	No Capital Required		
7202	7310	0	Elect and Control	DCS (Foxboro/Invensys)		EC18	No Capital Required		
5983	5983	61-00-69576	TRANSFORMERS	TRANSFORMER T9		EC19	No Capital Required		
7202	7310	0	Elect and Control	200A, 600V, 3ph manual transfer switch (Square D)		EC4	No Captial Requirement		
7202	7310	0	Elect and Control	200A, 600V, 3ph automatic transfer switch (Taylor Industrial Controls)		EC5	No Captial Requirement		
7202	7310	0	Elect and Control	600V, 3ph, Dist. Panel		EC6	No Capital Required		
7202	7310	0	Elect and Control	100A, 230V, 3ph lighting panel		EC9	No Captial Requirement	2012	2
7202	7310	0	Elect and Control	120V dc dist. Panel		EC10	No Captial Requirement	2012	2
7202	7310	0	Elect and Control	120V dc motor starters fused disconnect		EC11	Replace the Starter and the Fused Disconnect	2012	1
7202	7310	0	Elect and Control	230V, 3ph, starter and disconnect		EC12	Replace the Starter and the Fused Disconnect	2012	1
7202	7310	0	Elect and Control	Battery Charger (SAFT NIFE, Model SLRF 120-30)		EC13	No Capital Required		
7202	7310	0	Elect and Control	129V dc battery bank (C&D technologies)		EC14	No Capital Required		

2.2.9 Capital/Refurbishment and Overhaul Costs (Capital)

The suggested equipment and installation costs (Refurbishment of Existing Equipment) for the GT E&C systems are presented in Table 2-16.

TABLE 2-16 CAPITAL COST ESTIMATE – GAS TURBINE ELECTRICAL & CONTROLS

Asset #2	Asset #3	Asset #4	Asset Level 3	Description	Detail	Cond. Summ. ID#	Capital Item	Date	Priority	Desciption	Qty	Unit	Material	Labour	Total	Comments
7202	7310	0	Elect and Control	800A, 13.8 kV Generator Main Breaker (AEI, Type BRP17 / BVRP17)	2.3.3.2 a)	EC1	Removal of existing breaker and installation of new breaker, trays and new JB. Run power cables from new breaker to generator and to T9 tranformer, Termination of existing CT's, PT's and control cables in new JB, and extending new CT, PT and control cables from new JB to the new breaker, Extend grounding as necessary. Function test and commission.	2012	1	Installation of new 800A, 13.8 kV, 3ph, 60Hz Generator Main Breaker	1	ea	126860	12800	139660	
										Removal of Existing Main Breaker	1	lot	-	1600	1600	
										Installation of Cable Tray	20	m	3500	1250	4750	
										Installation of New Junction Box	1	ea	1000	480	1480	
										Removal of Existing Power Cables from Existing Breaker to Generator and T9 Transformer	1	lot	-	1600	1600	
										Installation of New Power Cables from New Breaker to Generator (2 x 500kcmil) and T9 Transformer (2x500kcmil)	180	m	50,000	10,000	60,000	
										Connection of Existing and Used CT, PT and Control Cables in New JB, and run the new CT, PT and Control Cables from new JB to new 13.8 kV Main Breaker (4 x 4c10, 1 x 4c12, 1 x 12c12).	1	lot	600	1600	2200	
7202	7310	0	Elect and Control	13.8 kV fusible switch (J.G. Statter, Ltd. Type VLMK2)	2.3.3.2 b)	EC2	Removal of existing fusible switch and installation of new fusible switch, plus installation of cabling to 112 kVA transformer. Ground as necessary. Function test and commission	2012	1	Installation of New 13.8kV Fusible Switch	1	ea	-	-		included with cost of 13.8kV
										Removal of Existing 13.8 kV Fusible Switch	1	lot	-	1600	1600	
7202	7310	0	Elect and Control	112 kVa, 13.8 kV: 600V 3ph Transformer (Cart 6 Electrical)	2.3.3.2 c)	EC3	Cable from 112kVA Transformer to new 13.8kV Fusible Switch			Install 3c2AWG, Teeck, 15kV, Cable from 112kVA Transformer to new 13.8kV Fusible Switch	10	m	750	300	1050	
7202	7310	0	Elect and Control	MCC (AEI, Type MMC Series 1000)	2.3.3.2 d)	EC8	Replace the MCC and Re-Cable the 600V, 230V and 110V DC power.	2012	1	Remove Existing MCC	1	ea	-	8000	8000	
										Install New MCC	1	ea	30000	8000	38000	
										Install Cable Tray	1	lot	1600	900	2500	
										Install New Incoming and Feeder Cables for 600V Circuits						
										3C12, Teck, 1000V, (Seven Circuits)	280	m	1260	525	1785	
										3c10, Teck, 1000V, (One Circuit)	40	m	240	120	360	
										3c6, Teck, 1000V, (Five Circuits)	200	m	1025	350	1375	
										3c2, Teck, 1000V, (One Circuit)	40	m	1040	200	1240	
7202	7310	0	Elect and Control	30 kVa, 600V: 230/115V, 1ph lighting transformer (Hammond, Type F Car FZ9P) ; New 230V, 3ph, Auxiliary Distribution Panel	2.3.3.2 e)	EC7	Install New 230V, 3ph, Auxiliary Distribution Panel. Relocate 30kVA, 3ph, 550:230V Transformer and Connect to MCC and New 230V, 3ph, Auxiliary Distribution Panel			Install New 230V, 3ph, Auxiliary Distribution Panel	1	ea	650	350	1000	
										Relocate 30kVA, 3ph, 550:230V Transformer and Connect to MCC and New 230V, 3ph, Auxiliary Distribution Panel	1	lot	-	3000	3000	
										3c12, Teck, 1000V (One Circuit)	40	m	180	75	255	
										3c10, Teck, 1000V, (Two Circuits)	40	m	120	60	180	
7202	7310	0	Elect and Control	120V dc motor starters fused disconnect	2.3.3.2 f)	EC11	New 110VDC,. NEMA 1 Breaker, new NEMA1 Splitter, new DC Starters, and Existing 100A DC Distribution Panel. New Feeders from Splitter to DC Starters and DC Distribution Panel			Install new 110VDC,. NEMA 1 Breaker, new NEMA1 Splitter, new DC Starters, and Existing 100A DC Distribution Panel	1	lot	31000	6400	37400	
										Install New Feeders from Splitter to DC Starters and DC Distribution Panel						
										3c12, Teck, 1000V (One Circuit)	40	m	180	75	255	
										3c10, Teck, 1000V, (One Circuit)	35	m	210	120	330	
										3c2, Teck 1000V (One Circuit)	16	m	410	140	550	
7202	7310	0	Elect and Control	Start rectifier (AEI)	2.3.3.2 g)	EC15	Replace the Start Rectifier	2012	1	Remove Existing AVR/Start Rectifier	1	ea	-	1600	1600	
7202	7310	0	Elect and Control	Automatic voltage regulator/excitor		EC16	Replace the Automatic Voltage Regulator	2012	1	Install New AVR/Start Rectifier	1	ea	145,000	20,000	165,000	
7202	7310	0	Elect and Control	Miscellaneous	2.3.3.2 h)	EC20	Miscellaneous Hardware, Tray and 4/0 Grounding	2012	1	Miscellaneous Hardware, Tray and 4/0 Grounding	1	lot	7500	7500	15000	
7202	7310	0	Elect and Control	Commissioning		EC21	Commissioning	2012	1	Commissioning Costs			-	50,000	50000	

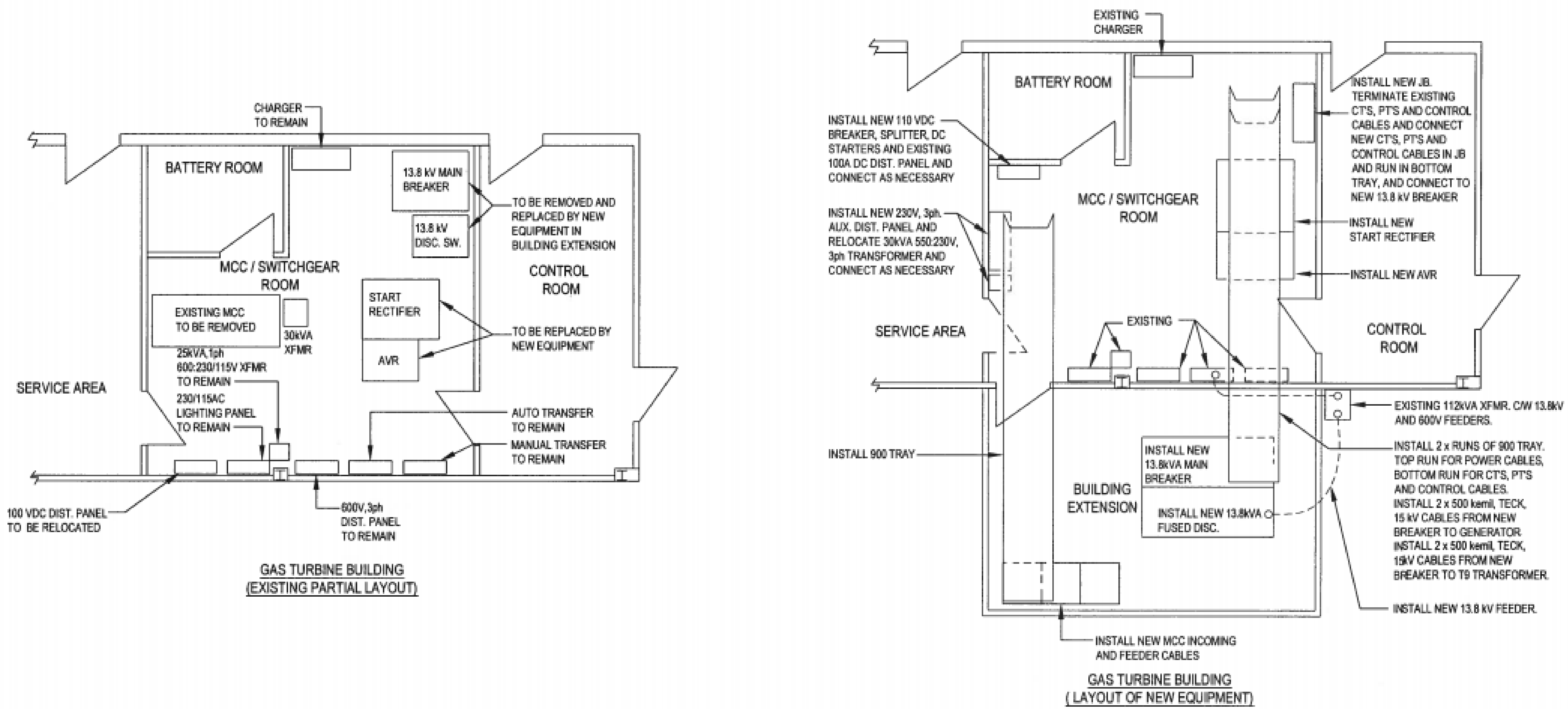


FIGURE 2-2 GAS TURBINE BUILDING – ELECTRICAL & CONTROLS – CURRENT AND PROPOSED

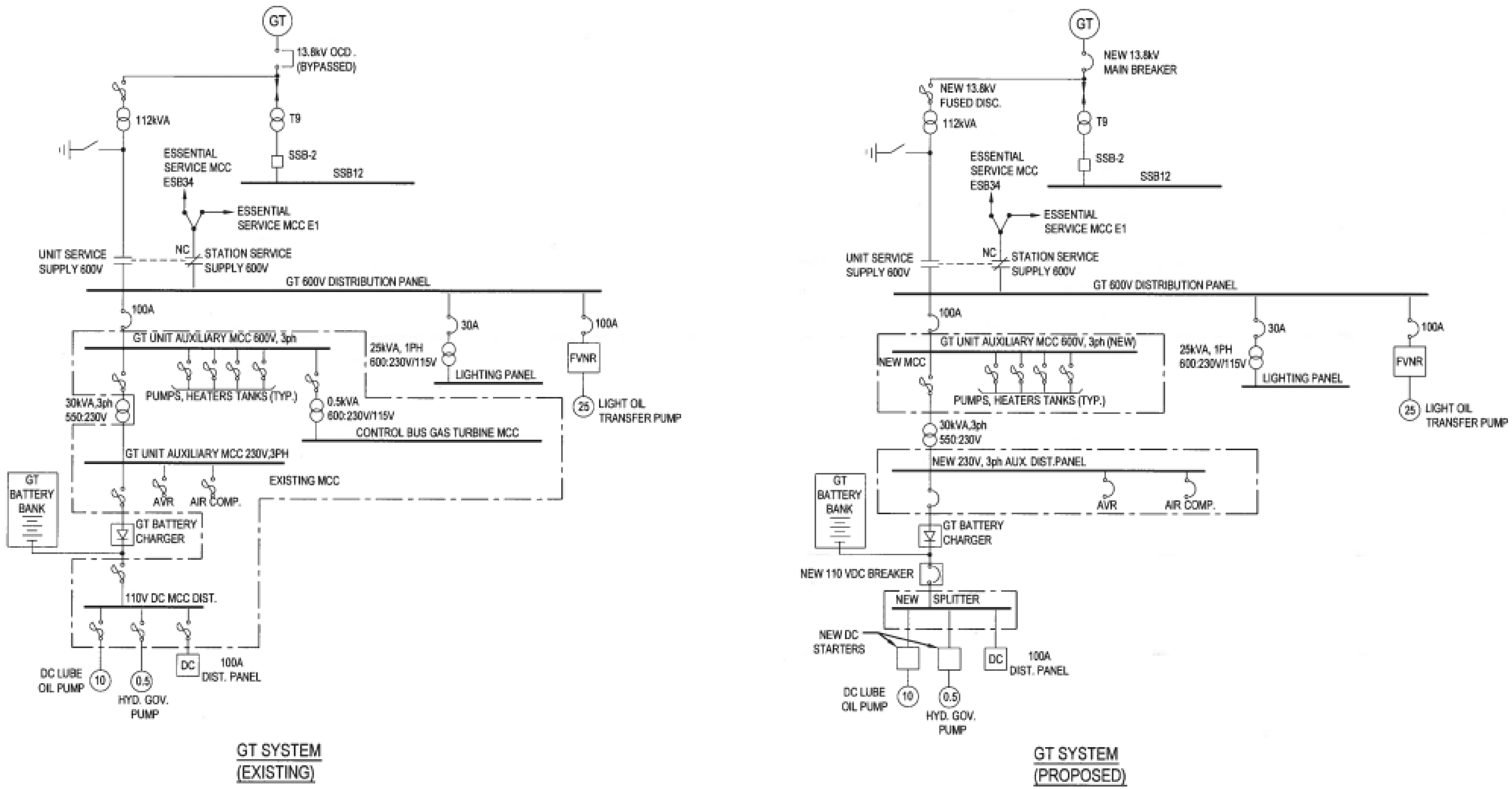


Figure 2-3 Gas Turbine Single Line Diagrams – Current and Proposed

2.3 Gas Turbine Balance of Plant (BOP) Equipment/Processes

Unit #:	GAS TURBINE
Asset Class #	BU 1273 Gas Turbine
SCI & System:	7202 Gas Turbine System
Sub-Systems:	7311 GT Aux Systems

2.3.1 Description

AC Lube Oil Cooler: The AC Lube Oil Cooler is located outside the GT building. The cooler has experienced a substantial amount of surface corrosion due to the environment. The fan is controlled by temperature logic in the lubricating oil loop. A thermostatically controlled valve is used to circulate sufficient oil flow to the cooler to maintain temperature. From discussions with site personnel the system appears to function adequately. In February 2011, the system was assessed by Siemens who noted in their report that it generally appeared in good condition but recommended some reconditioning.

Fire Protection System: The fire system is an Ansul Inergen total-flooding type system that can operate automatically via fire detection or manually via pull stations. The system is comprised of Inergen storage containers, piping, nozzles, control panel, actuators, detection and alarm devices, and pressure relief dampers. It was installed in 2000 to replace the Halon fire system in respect of the ozone depleting substance regulations.

Compressed Air & Nitrogen System: The compressed air system consists of a single 600 volt motor/compressor unit, a 310 L (82 gallon) storage tank, a Pall instrument air dryer, and a small control and monitoring panel. The system is designed to supply 700 kPa instrument air to operate the power turbine snow doors, the main generator exhaust and intake louvers, and the jet engine intake and exhaust cooling air louvers. It also has provisions for a four-bottle nitrogen back-up supply in the event of a compressor system failure. The control panel provides pressure indication for the system and a transfer valve to the nitrogen supply.

Diesel Generators: The Stage 1 and Stage 2 Diesel Generators and auxiliaries are not located within the GT building and are not part of the scope of this study. Nevertheless, they are critical to the operation of the GT units and are discussed briefly here. Two diesel units located within the main generating facility provide 600 V power for blackstart operation and start of the existing GT. They are anticipated to be required for any replacement black start generator as well.

Both diesel gensets are designed for controlled safe shutdown of the units. They have the necessary auxiliaries to be stand-alone – controls, switchgear, cooling, and lubrication.

The Stage 1 diesel was replaced in the last five years, and the Stage 2 diesel is currently planned to be replaced in 2015.

FIGURE 2-4 LIGHT OIL RECEIVING & LUBE OIL RADIATOR

EXHAUST STACK

AIR INTAKE

FIGURE 2-5 GTG EXHAUST STACK & AIR INTAKE

2.3.2 Major Maintenance History

The following is a summary of significant work completed since 2003. No major overhauls have been completed on the entire machine.

16 October 2003

- Intake plenum contained debris, chipped floor and flaking paint. Recommended clean up.

10 August 2004

- Air plenum cleaner than 2003 visit, holes still visible in walls.

27 September 2005

- Annual inspection and boroscope inspection;
- Corrosion/ Rust found in Plenum; and
- Hot gas leakage at Exhaust Transition duct to power turbine.

13 March 2006

- Leak in each end of the gearbox at the bearing seals. (Caused fire when oil leaked into insulation around PT and dripped onto top of tank). Greenray discovered turbine shaft/seal modifications, recommended machining and reconditioning.

13 April 2006

- None

25 May 2007

- Rebuild of the intake with securing bolts torque and locked; and
- Replace/ Repair exhaust snow doors.

21 May 2008

- Package filtration inspection;
- Plenum survey;
- Fuel/oil system: connection, fuel pump/ oil pump, pipelines, oil level & quality, filter and basket removal (replacement consumables); and
- On engine review: bleed valves, IGV ram (filter review), gearbox inspection (filters, speed pick up, consumable change), fuel control unit review, oil cooler, fuel filter change, burner removal (ultrasonic cleaning), fuel rail inspection, drain valve operation, thermocouple inspection (terminal cleaning), transition inspection, removal of insulation, rectify leaks, inspect LP blades.

10 June 2008

- Water pooling noted in intake plenum along with holes in structure and loose debris.

15 October 2009

- Exhaust stack needs replacement, lower components noted in good condition. Door opening components to be serviced; and
- Transition duct piston rings seals to be replaced.

20 November 2009

- Commissioning;

- Exhaust transition lagging replaced due to fuel saturation; and
- Split air manifold cracks, to be repaired.

2011

NL Hydro undertook a number of activities with vendors that have the OEM rights in order to conduct detailed internal inspections of the individual sections and prepare field inspection reports complete with refurbishment estimates.

- Rolls Wood Group has the OEM rights to the front end bearing assembly, compressor rotor, compressor casings, combustion assembly, nozzle casing, rear bearing housing, turbine assembly, exhaust unit, and accessories. They were recently contracted by NL Hydro to conduct detailed internal inspections of the above noted equipment and have prepared a field inspection report complete with refurbishment estimates.
- Braden Manufacturing is a company that specializes in the design and manufacturing of combustion turbine air filtration systems, air inlet systems, and exhaust systems. They were recently contracted by NL Hydro to perform detailed inspections of the GT air inlet plenum, air filtration system, air inlet plenum support structure, exhaust stack and exhaust stack support structure.

2.3.3 Condition Assessment & Remaining Life

TABLE 2-17 CONDITION ASSESSMENT – GAS TURBINE BOP

BU # 1	Asset # 2	Asset # 3	Asset # 4	Asset Level 3	Description	Detail	Cond. Summ. ID#	Condition	Status Identifier	Original Life (Base Load) Ops Hrs (Yrs)	Current Expected Minimum Remaining Life Years (Subject to Test)	End of Life (EOL) Required	Capability to Reach EOL	In Service
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	Fire System	Fire System	BOP1	Fire system upgraded in 2000 to Ansul Inergen total-flooding type (automatic via fire detection or manually via pull stations). All of existing Inergen system (storage containers, piping, nozzles, control panel, actuators, detection and alarm devices, and pressure relief dampers) are in good condition. Detection and suppression system did not detect 2010 GT gearbox fires - likely require some improvements.	4/10	(30)	10+	2020	Yes	2000
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	Lube Oil Cooler/Radiator	Radiator	BOP2	The cooler has experienced a substantial amount of surface corrosion due to the environment.Motor appears in good condition, but dirty. Corrosion has led to some tube leaks in 2010. Some ice freezing within containment area. Fan thermostatically controlled valve is working adequately. In February 2011 Siemens noted that the system appeared generally in good shape but recommended some reconditioning.	4	(20)	3	2020	No	1986
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	Lube Oil System	Lube Oil	BOP3	Overdue for overhaul. Gearbox lube oil seal leaks and subsequent fires have led to regulatory restriction on unit operation to emergency only.	4	(30)	0	2020	No	1986
1273	7202	7311	99003602	GAS TURBINE AUXILIARY SYSTEMS	Lube Oil Pumps	AC & DC pumps	BOP4	Siemens indicated AC and DC lube oil pumps in good condition, but no internal inspection or vibration test practical. Plant experienced that lube oil delivery engine driven pump was not maintaining sufficient main pressure, requiring the AC pump to operate continuously.	4/10	(30)	2	2020	No	1986
1297	7199	7205	0	COMPRESSED AIR SYSTEMS	Compressed Air Systems	N/A	BOP5	The single 600 volt motor/compressor unit, 310 L (82 gallon) storage tank, Pall instrument air dryer and small control and monitoring panel are fairly new and in good condition.The pressure vessels are inspected annually in accordance with government regulations. No indication of any significant degradation.	4	30	10+	2020	Yes	2000
1297	7199	7205	7231	COMPRESSED AIR SYSTEMS	Nitrogen(Compressed Air Back-up) System	N/A	BOP6	The four-bottle nitrogen back-up supply (used in the event of a compressor system failure) and its control panel driven transfer valve are in good operable condition. No issues identified.	4	30	10+	2020	Yes	2000

Notes: 1. A "(bracketed)" value in the "Current Expected Remaining Life" column is a highly probable minimum value that is considered subject to some subsequent verification during further investigation, including at the next test or overhaul. It may be addressed as part of a Level 2 test. A value identified as "(X/Y)" has been included for the steam turbine and generator where the recommended minimum value is the lower of the two, but that the higher may be achievable at a higher level of failure risk and/or unreliability.

The current inspection and maintenance program for the diesels is reasonable and should suffice to allow the units to reach their normal end of life. If the existing level II generator replacement is delayed this will impact the reliability of the overall system to operate in black start.

The maintenance required on the AC lube oil cooler recommended by Siemens in the February 2011 report should be completed to ensure reliability.

Review of the information available on the fires on the existing GT does not mention any activation of the Inergen system. It was noted from inspection of the system in the turbine room that there appears to be only one discharge nozzle in which is located above the compressor section of the GT. This was later confirmed during a review of existing drawings. The fires occurred on the opposite side of the room behind the exhaust stack which would likely have reduced the effectiveness of the system in the event of a discharge. The three detectors in the room also appear to be heat detectors and not smoke which is possibly why the system did not react to the fires which have been described as a small amount of flame and smoke. These fires were extinguished by several portable units.

In general, the lube oil system is in poor shape and in need of refurbishment as part of the overhaul. The fire system, while relatively new and capable of lasting beyond 2020, requires modification for functionality reasons. The air compressor and nitrogen systems are relatively new and will last beyond 2020 with reasonable maintenance.

2.3.4 Risk Assessment

TABLE 2-18 RISK ASSESSMENT – GAS TURBINE BOP

BU # 1	Asset # 2	Asset # 3	Asset # 4	Asset Level 3	Description	Detail	Cond. Summ. ID#	Condition	Major Issues	Remaining Life Years (Insufficient Info - Inspection Required Within (x) Years)	TECHNO-ECO RISK ASSESS MODEL Likeli--hood	TECHNO-ECO RISK ASSESS MODEL Conse-quence	TECHNO-ECO RISK ASSESS MODEL Risk Level	SAFETY RISK ASSESS MODEL Likeli-hood	SAFETY RISK ASSESS MODEL Conse-quence	SAFETY RISK ASSESS MODEL Safety Risk	Possible Failure Event	Mitigation
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	Fire System	Fire System	BOP1	Fire system upgraded in 2000 to Ansul Inergen total-flooding type (automatic via fire detection or manually via pull stations). All of existing Inergen system (storage containers, piping, nozzles, control panel, actuators, detection and alarm devices, and pressure relief dampers) are in good condition. Detection and suppression system did not detect 2010 GT gearbox fires - likely require some improvements.	Fire detection failure and suppression failure exists.	10/0	4	C	High	3	D	High	Failure to detect and suppress fire	Modify detection and suppression system. In GTG area cameras for external monitoring.
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	Lube Oil Cooler/Radiator	Radiator	BOP2	The cooler has experienced a substantial amount of surface corrosion due to the environment.Motor appears in good condition, but dirty. Corrosion has led to some tube leaks in 2010. Some ice freezing within containment area. Fan thermostatically controlled valve is working adequately. In February 2011 Siemens noted that the system appeared generally in good shape but recommended some reconditioning.	Lube Oil cooler failure and leak - containment limits risk. Unit 8navailability.	3	3	B	Medium	3	A	Low	Tube failures. Unavailable due to ice freeze up.	Repair/replace with winter icing protection.
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	Lube Oil System	Lube Oil	BOP3	Overdue for overhaul. Gearbox lube oil seal leaks and subsequent fires have led to regulatory restriction on unit operation to emergency only.	Gearbox seal oil leaks exist and fires have occurred.	0	4	C	High	4	D	High	Fire	New seals; gearbox lube oil air vents; monitor. Improve fire detection and suppression.
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	Lube Oil Pumps	AC & DC pumps	BOP4	Siemens indicated AC and DC lube oil pumps in good condition, but no internal inspection or vibration test practical. Plant experienced that lube oil delivery engine driven pump was not maintaining sufficient main pressure, requiring the AC pump to operate continuously.	Lube oil system AC pump overuse	2	4	B	Medium	4	A	Low	Pump failure (DC back-up and shutdown)	Repair
1297	7199	7205	0	COMPRESSED AIR SYSTEMS	Compressed Air Systems	N/A	BOP5	The single 600 volt motor/compressor unit, 310 L (82 gallon) storage tank, Pall instrument air dryer and small control and monitoring panel are fairly new and in good condition.The pressure vessels are inspected annually in accordance with government regulations. No indication of any significant degradation.	None	10+	1	D	Low	1	A	Low	High pressure air storage failure. Winter stack doors don't open (N2 back-up)	Monitor
1297	7199	7205	7231	COMPRESSED AIR SYSTEMS	Nitrogen(Compressed Air Back-up) System	N/A	BOP6	The four-bottle nitrogen back-up supply (used in the event of a compressor system failure) and its control panel driven transfer valve are in good operable condition. No issues identified.	None	10+	1	D	Low	1	A	Low	High pressure N2 storage failure. Winter stack doors don't open	Monitor

2.3.5 Actions

TABLE 2-19 ACTIONS – GAS TURBINE BOP

BU # 1	Asset # 2	Asset # 3	Asset # 4	Asset Level 3	Description	Detail	Action Summ. ID#	Action	Year	Priority
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	Fire System	Fire System	BOP1	Modify fire detection and suppression system. Install GTG room cameras	2012	1
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	Lube Oil Cooler/Radiator	Radiator	BOP2	Replace/Repair/refurbish and eliminate icing issues. If re-conditioned, stem clean motor and perform no load and vibration tests.	2012	2
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	Lube Oil System	Lube Oil	BOP3	New seals; gearbox lube oil air vents; monitor. Improve fire detection and suppression.	2012	1
1273	7202	7311	99003602	GAS TURBINE AUXILIARY SYSTEMS	LUBE OIL PUMPS		BOP4	Overhaul AC and DC motors (steam clean). Perform VPI test for insulation. Perform no load and vibration tests. Install anti-condensation heaters.	2012	1
1297	7199	7205	0	COMPRESSED AIR SYSTEMS	COMPRESSED AIR SYSTEMS	N/A	BOP5	None - monitor		
1297	7199	7205	7231	COMPRESSED AIR SYSTEMS	NITROGEN (COMPRESSOR BACK-UP) SYSTEM	N/A	BOP6	None - monitor		

2.3.6 Life Assessment - Life Cycle Curves (Where Equipment Is Not To Be Overhauled/replaced and Life <2020 and Has Major Unit Operation Impacts)

No Life Cycle Curves are presented. The newer equipment and systems (compressed air, nitrogen) can all meet the 2020 end date with normal maintenance. The lube oil system requires refurbishment and with normal maintenance, should be able to meet the 2020 end date. The AC lube oil cooler fan is recommended to have the repairs recommended by Siemens to maximize the remaining life of the system or be replaced. It will then, with regular intervals of repair and maintenance, last to 2020.

The Stage 1 diesel, not a part of this assessment, but is relatively new and therefore expected to be operational until at least 2020. The Stage 2 diesel is original equipment, installed in 1979. It is at the end of its normal useful life.

2.3.7 Level 3 Inspections Required

No incremental to refurbishment Level 3 assessments are required.

2.3.8 Capital Enhancements

The suggested capital projects for the GT E&C systems are presented in Table 2-20.

TABLE 2-20 SUGGESTED TYPICAL CAPITAL ENHANCEMENTS – GAS TURBINE BOP

BU # 1	Asset # 2	Asset # 3	Asset # 4	Asset Level 3	Description	Detail	Cond. Summ. ID#	Capital Item	Date	Priority
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	Fire System	Fire System	BOP1	Modification of detection and suppression system for better protection and coverage. New monioring camera system.	2012	1
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	Lube Oil Cooler/Radiator	Radiator	BOP2	New lube oil cooler	2012	1
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	Lube Oil System	Lube Oil	BOP3	New gear box seals, lube oil venting	2012	1
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	Lube Oil Pumps	AC & DC pumps	BOP4	No Captial Requirement		
1297	7199	7205	0	COMPRESSED AIR SYSTEMS	Compressed Air Systems	N/A	BOP5	No Captial Requirement		
1297	7199	7205	7231	COMPRESSED AIR SYSTEMS	Nitrogen(Compressed Air Back-up) System	N/A	BOP6	No Captial Requirement		

2.3.8.1 Capital Refurbishment Requirements and Costs

The Stage 2 diesel and its auxiliary systems should be replaced to achieve 2020.

The AC lube oil cooler fan requires refurbishment as recommended by Siemens.

Since there is a likelihood of a fire in the area near the exhaust stack and above the gearbox, it is recommended that additional nozzles be added to the turbine room above the gearbox near the stack, and under the turbine in the vicinity of the origin of the fires to ensure unobstructed effective dispersion of the Inergen gas. It is also recommended that the addition of infrared flame detectors be considered as thermal lag on fixed temperature detectors can delay the activation of the system as can a slowly developing fire on rate of rise detectors. The flame detector effectiveness will depend on the ambient heat radiation from the gas turbine which can decrease its effectiveness.

The suggested typical capital enhancements for the gas turbine BOP include:

TABLE 2-21 CAPITAL COST –GAS TURBINE BOP

Capital cost estimate $ 1,000 Can 2011

BOP Systems		Material	Labour	Total	Range
	Fuel enclosure (See Civil/Structural)				
	Fuel piping	$60	$15	$75	$60-$90
	Stack removal	$0	$30	$30	$25-$35
	Inergen system	$7	$3	$10	$7-$15
	Lube oil cooler	$130	$20	$150	$75-$175
	Sub-Total	**$197**	**$68**	**$265**	**$150-$320**
10%	**Contingency**	**$20**	**$7**	**$27**	
	TOTAL BOP	**$217**	**$75**	**$292**	**$180-$350**

2.4 Gas Turbine/Fuel Oil Equipment/Processes

Unit #:	Common
Asset Class #	BU 1297 - Assets Common
SCI & System:	7199 HRD Common Systems
Sub-System	7209 Light Oil System
Components:	To Be Added

2.4.1 Description - Gas Turbine Generator Light Fuel Oil System

Light fuel oil (No.2 diesel) is delivered by truck to the unloading skid adjacent to the existing GT generator building. The single 600 volt off-loading pump with local start / stop control is located outdoors at the northwest corner of the gas turbine building and has above-ground piping connecting it to the bulk storage tanks. Power for the motor is supplied from the gas turbine MCC control centre. The two 100,000 litre above-ground fuel tanks were fabricated in 1998 to ULC-S601-93 standards with double wall construction and have a total storage capacity of 200,000 litres. The offloading system is comprised of a single 600 volt pump arrangement with local start / stop control. Power for the motor is supplied from the GT MCC control centre.

The piping installation is typical with a 3 inch Y strainer, isolation valves and piping to the storage tanks. Two 100%, 600 volt, centrifugal forwarding pumps provides low pressure No.2 diesel fuel for the jet engine. The fuel passes through a duplex suction strainer and a 5 micron discharge filter before reaching the jet engine. The fuel line also incorporates a fuel flow/totalizing meter and a fire system trip valve prior to entering the building.

Light oil (No.2 fuel oil) from the light oil fuel oil storage tanks is gravity fed. The light oil pressure at the main units is maintained through constant recirculation back to the light oil storage tanks through a pressure control valve and piping arrangement.

The existing fuel supply system to the GT, fire alarm fuel shut off valve, and fuel offloading system are located adjacent to the GT building and is exposed to a harsh marine environment and as a result, has heavy surface corrosion.

The fuel lines in the dike area are in better condition likely as a result of being at least partially protected from the elements.

Some fuel forwarding pumps are located in a small enclosure to protect them from the elements. The concrete containment system in which the pumps sit was filled with approximately 4 inches of oily water at the time of the inspection.

FIGURE 2-6 LIGHT OIL RECEIVING SYSTEM AND STORAGE TANKS

2.4.2 Major Maintenance History

Light Oil Storage Tanks & Receiving System: The light oil storage tanks are approximately 13 years old. Aside from the issue that the interstitial pressure was outside its normal design levels, we are not aware of any major maintenance items on these tanks. Inspection information was not considered given the relatively short duration since their in-service date. They are subject to API regulatory inspection.

Pipelines: The lines under the roadway have been replaced as part of road repair work carried out in 2007.

2.4.3 Condition Assessment & Remaining Life

The condition assessment of the fuel systems (light oil) is illustrated below in Table 2-22.

TABLE 2-22 CONDITION ASSESSMENT – GAS TURBINE FUEL OIL SYSTEM

BU # 1	Asset # 2	Asset # 3	Asset # 4	Asset Level 3	Description	Detail	Cond. Summ. ID#	Condition	Status Identifier	Original Life (Base Load) Ops Hrs (Yrs)	Current Expected Minimum Remaining Life Years (Subject to Test)	End of Life (EOL) Required	Capability to Reach EOL	In Service
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	LIGHT FUEL OIL SYSTEM									
1297	7199	7209	0	LIGHT OIL SYSTEM	GENERAL	General	LFO1	Exposed receiving and delivery system componets corroded. Build-ups of snow and ice freeze up in containment areas common.	4	(40)	(2)	2020	No	1986
1297	7199	7209	0	LIGHT OIL SYSTEM	PIPING	N/A	LFO2	Significant external corrosion and pitting.due to the marine environment, including the lines to the light oil storage tanks. Recent ultrasonic testing (Oct 2010) indicates that the piping is within acceptable wall thickness tolerances despite the external corrosion at the moment. The fuel pumps located in the small enclosures are not readily accessible and would be less so during the winter.significant weather that may prevent emergency repairs on the exposed fuel equipment in the event of a black start requirement.	4	(40)	(2)	2020	No	1986
1297	7199	7209	0	LIGHT OIL SYSTEM	GT TRANSFER PUMPS AND FILTERS	N/A	LFO3	The fuel pumps and filters are located in small enclosures are not readily accessible. Siemens indicated that motors appear in fair condition with some surface corrosion. Conduit appeared in good condition. A full assessment was not possible due to accessibility. The enclosures still fill somewhat with water and snow. The concrete containment system in which the pumps sit was filled approximately 4" with oily water at the time of the visit. THis may freeze in winter and snow makes them less accessible during the winter which may prevent emergency repairs on the exposed fuel equipment in the event of a black start requirement.	4	(40)	(2)	2020	No	1986
1297	7199	7209	0	LIGHT OIL SYSTEM	FUEL RECEIVING/FORWARDING PUMPS	N/A	LFO4	The fuel receiving/transfer pumps, fire alarm fuel shut off valve, and fuel offloading system are located adjacent to the Gas Turbine Building and exposed to a harsh marine environment and have heavy surface corrosion as a result. Snow and ice in winter makes them less accessible and may prevent emergency repairs on the exposed fuel equipment in the event of a black start requirement.	4	(40)	(2)	2020	No	1986
1297	7199	7209	99034713	LIGHT OIL SYSTEM	OIL STORAGE TANK	General	LFO5	Relatively new, about 13 years. No inspections that station are aware of.	3a	(40)	10+	2020	Yes	1998
1297	7199	7209	99034713	LIGHT OIL SYSTEM	OIL STORAGE TANK	N/A	LFO6	Interstitial vacuum pressure on both tanks are -35 and -38 mm Hg. Very faded warning stickers on the tanks indicated if the vacuum pressure was less than – 42 mm Hg the manufacturer should be contacted. While the gauges still indicate a high vacuum in each tank, there is a concern tahta Holyrood management acknowledged this as an ongoing issue with the tanks that they were aware of.	3a	(40)	10+	2020	Yes	1998
1297	7199	7209	99034713	LIGHT OIL SYSTEM	OIL STORAGE TANK	N/A	LFO7	Fuel oil tank penetrations on the top of the tank are showing heavy corrosion. No other data available.	3a	(40)	10+	2020	Yes	1998

Notes: 1. A "(bracketed)" value in the "Current Expected Remaining Life" column is a highly probable minimum value that is considered subject to some subsequent verification during further investigation, including at the next test or overhaul. It may be addressed as part of a Level 2 test. A value identified as "(X/Y)" has been included for the steam turbine and generator where the recommended minimum value is the lower of the two, but that the higher may be achievable at a higher level of failure risk and/or unreliability.

A review of the 2006 SGE Acres report "Evaluation of Fuel Oil Storage Tanks, Associated Pipelines and dike Drainage System Holyrood Thermal Generating Station" was used to determine the existing condition of the tanks in conjunction with a walkthrough of the tank farm. During examination of the two light oil tanks, it was noted that the interstitial vacuum pressure on both tanks are -35 and -38 mm HG . Very faded warning stickers on the tanks indicated if the vacuum pressure was less than 42 mm hg the manufacture should be contacted. While the gauges still indicate a high vacuum in each tank, the concern was brought forward to Holyrood management and was acknowledged as an ongoing issue with the tanks that they were aware of.

It was also noted that the fuel oil tank penetrations on the top of the tank are showing heavy corrosion. Since these tanks are critical to the operation of diesel gensets, the black start gas turbine, and main unit ignition it is recommended that this corrosion be addressed through regular maintenance.

The light oil receiving, pumping and piping system located at the gas turbine building is operational, but have experienced significant external corrosion due to the marine environment, including the lines to the light oil storage tanks and to the powerhouse ignition oil system. Some data was made available on ultrasonic testing of the lines from October 2010, it appears from preliminary review of the results that the piping is within acceptable wall thickness tolerances despite the external corrosion at the moment. The fuel pumps located in the small enclosures are not readily accessible and would be less so during the winter.

The piping exterior is in poor condition due to its prolonged exposure to the marine environment. Extreme weather may prevent emergency repairs on the exposed fuel equipment during a black start event. Given their exposure to the harsh marine environment, the existing fuel supply system to the gas turbine, the fire alarm fuel shut off valve, and the fuel offloading system located adjacent to the G Building is not expected to continue to 2020. While the majority of the components are fairly standard and off the shelf, a failure of the Gas Turbine fuel system during black start would be costly both financially and in terms of time.

2.4.4 Risk Assessment

TABLE 2-23 RISK ASSESSMENT – GAS TURBINE FUEL OIL SYSTEM

BU # 1	Asset # 2	Asset # 3	Asset # 4	Asset Level 3	Description	Detail	Cond. Summ. ID#	Condition	Major Issues	Remaining Life Years (Insufficient Info - Inspection Required Within (x) Years)	TECHNO-ECO RISK ASSESS MODEL Likeli–hood	TECHNO-ECO RISK ASSESS MODEL Conse-quence	TECHNO-ECO RISK ASSESS MODEL Risk Level	SAFETY RISK ASSESS MODEL Likeli-hood	SAFETY RISK ASSESS MODEL Conse-quence	SAFETY RISK ASSESS MODEL Safety Risk	Possible Failure Event	Mitigation
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	LIGHT FUEL OIL SYSTEM													
1297	7199	7209	0	LIGHT OIL SYSTEM	GENERAL	General	LFO1	Exposed receiving and delivery system componets corroded. Build-ups of snow and ice freeze up in containment areas common.	Oil Leak; failure to operate and access easily.	(2)	3	A	Low	4	A	Medium	Modest oil spill within containment; inability to start unit until ice cleared	Install new fuel receing/handling shed
1297	7199	7209	0	LIGHT OIL SYSTEM	PIPING	N/A	LFO2	Significant external corrosion and pitting.due to the marine environment, including the lines to the light oil storage tanks. Recent ultrasonic testing (Oct 2010) indicates that the piping is within acceptable wall thickness tolerances despite the external corrosion at the moment. The fuel pumps located in the small enclosures are not readily accessible and would be less so during the winter.significant weather that may prevent emergency repairs on the exposed fuel equipment in the event of a black start requirement.	Oil Leak; failure to operate and access easily.	(2)	3	A	Low	4	A	Medium	Modest oil spill within containment; inability to start unit until ice cleared	Install new fuel receing/handling shed
1297	7199	7209	0	LIGHT OIL SYSTEM	GT TRANSFER PUMPS AND FILTERS	N/A	LFO3	The fuel pumps and filters are located in small enclosures are not readily accessible. The enclosures still fill somewhat with water and snow. The concrete containment system in which the pumps sit was filled approximately 4" with oily water at the time of the visit. THis may freeze in winter and snow makes them less accessible during the winter which may prevent emergency repairs on the exposed fuel equipment in the event of a black start requirement.	Oil Leak; failure to operate and access easily.	(2)	3	A	Low	4	A	Medium	Modest oil spill within containment; inability to start unit until ice cleared	Install new fuel receing/handling shed
1297	7199	7209	0	LIGHT OIL SYSTEM	FUEL RECEIVING/FORWARDING PUMPS	N/A	LFO4	The fuel receiving/transfer pumps, fire alarm fuel shut off valve, and fuel offloading system are located adjacent to the Gas Turbine Building and exposed to a harsh marine environment and have heavy surface corrosion as a result. Snow and ice in winter makes them less accessible and may prevent emergency repairs on the exposed fuel equipment in the event of a black start requirement.	Oil Leak; failure to operate and access easily.	(2)	3	A	Low	4	A	Medium	Modest oil spill within containment; inability to start unit until ice cleared	Install new fuel receing/handling shed
1297	7199	7209	99034713	LIGHT OIL SYSTEM	OIL STORAGE TANK	General	LFO5	Relatively new, about 13 years. No inspections that station are aware of.	Regulatory out of complince.	10+	2	A	Low	2	B	Medium	Ensure regulatoy inspection compliance undertaken.	Tank inspection.
1297	7199	7209	99034713	LIGHT OIL SYSTEM	OIL STORAGE TANK	N/A	LFO6	Interstitial vacuum pressure on both tanks are -35 and -38 mm Hg. Very faded warning stickers on the tanks indicated if the vacuum pressure was less than – 42 mm Hg the manufacturer should be contacted. While the gauges still indicate a high vacuum in each tank, there is a concern tahta Holyrood management acknowledged this as an ongoing issue with the tanks that they were aware of.	Operating outside vendor recommended limits. Leak..	10+	3	A	Low	2	B	Medium	Modest oil spill within containment; inability to start unit until ice cleared	Investigate rezson and repair. Replace warning stickers.

2.4.5 Actions

TABLE 2-24 ACTIONS – GAS TURBINE FUEL OIL SYSTEM

BU # 1	Asset # 2	Asset # 3	Asset # 4	Asset Level 3	Description	Detail	Action Summ. ID#	Action	Year	Priority
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	LIGHT FUEL OIL SYSTEM					
1297	7199	7209	0	LIGHT OIL SYSTEM	GENERAL	General	LFO1			
1297	7199	7209	0	LIGHT OIL SYSTEM	PIPING	N/A	LFO2	Replace fuel piping downstream of filters with stainless. Refurbsih remaining piping, vales etc. Enclose building related equipment in fuel shed.	2012	2
1297	7199	7209	0	LIGHT OIL SYSTEM	GT TRANSFER PUMPS AND FILTERS	N/A	LFO3	Replace fuel receiving and transfer piping. Enclose in fuel shed.	2012	1
1297	7199	7209	0	LIGHT OIL SYSTEM	FUEL RECEIVING/FORWARDING PUMPS	N/A	LFO4	Replace fuel receiving and transfer piping. Enclose in fuel shed.	2012	1
1297	7199	7209	99034713	LIGHT OIL SYSTEM	OIL STORAGE TANK	General	LFO5			
1297	7199	7209	99034713	LIGHT OIL SYSTEM	OIL STORAGE TANK	N/A	LFO6	Inspect per regulatory and maintain	2012	1
1297	7199	7209	99034713	LIGHT OIL SYSTEM	OIL STORAGE TANK	N/A	LFO7	Investigate interstial vacuum difference and repair. Replace warning stickers.	2012	2

2.4.6 Life Assessment - Life Cycle Curves (Where Equipment Is Not To Be Overhauled/Replaced and Life <2020 and Has Major Unit Operation Impacts)

No Life Cycle Curves are presented. The system should be capable of meeting the 2020 end date with reasonable maintenance. Modifications including stainless steel piping from filters to the GT, and the installation of a fuel shed and replacement of system to address winter weather impacts. The issue is primarily problems resulting from extreme weather impacts and less with the equipment itself. The oil storage tanks should with maintenance and regulatory inspection make the 2020 end date.

2.4.7 Level 3 Inspections Required

Given the condition historical data reviewed and recommended changes, no Level 3 analyses are necessary.

2.4.8 Capital Enhancements

The suggested capital projects for the GT E&C systems are presented in Table 2-25.

TABLE 2-25 SUGGESTED TYPICAL CAPITAL ENHANCEMENTS – GAS TURBINE FUEL OIL SYSTEM

BU # 1	Asset # 2	Asset # 3	Asset # 4	Asset Level 3	Description	Detail	Cond. Summ. ID#	Capital Item	Date	Priority
1273	7202	7311	0	GAS TURBINE AUXILIARY SYSTEMS	LIGHT FUEL OIL SYSTEM					
1297	7199	7209	0	LIGHT OIL SYSTEM	GENERAL	General	LFO1	New fuel shed.	2012	1
1297	7199	7209	0	LIGHT OIL SYSTEM	PIPING	N/A	LFO2	New stainless steel piping from filters to GTG	2012	1
1297	7199	7209	0	LIGHT OIL SYSTEM	GT TRANSFER PUMPS AND FILTERS	N/A	LFO3	New system	2012	1
1297	7199	7209	0	LIGHT OIL SYSTEM	FUEL RECEIVING/FORWARDING PUMPS	N/A	LFO4	New system	2012	1
1297	7199	7209	99034713	LIGHT OIL SYSTEM	OIL STORAGE TANK	General	LFO5	No Captial Requirement		
1297	7199	7209	99034713	LIGHT OIL SYSTEM	OIL STORAGE TANK	N/A	LFO6	No Captial Requirement		
1297	7199	7209	99034713	LIGHT OIL SYSTEM	OIL STORAGE TANK	N/A	LFO7	No Captial Requirement		

2.4.9 Capital/Refurbishment and Overhaul Costs (Capital)

It is recommended that the fuel system, fire alarm fuel shut off valve and fuel offloading system be refurbished/replaced and be enclosed in a full sized shelter. This will help protect the exposed equipment and allow for safe operation and repairs unhindered by weather and enclosures too small to work in.

The suggested equipment and installation costs (refurbishment of existing equipment) for the system are presented in Table 2-26.

TABLE 2-26 CAPITAL COST ESTIMATE – GAS TURBINE FUEL OIL SYSTEM

Item	Cost
Fuel enclosure	$40,000
Fuel piping	$75,000
Stack removal	$ 30,000
Inergen system	$10,000
Lube oil cooler	$150,000

2.5 Building and Structural/Civil Equipment

Unit #:	COMMON
Asset Class #	BU 1297 – Assets Common
SCI & System:	7255 HRD Buildings & Site
Sub-Systems:	272255 HRD Buildings
Components:	7307 HRD Gas Turbine Building
Sub-Components:	7307 HRD Gas Turbine Building

2.5.1 Description

The GT building at the plant houses the GT that is used in the event of a black start. The existing gas turbine building was constructed in 1986. The building is of pre-engineered, galvanized metal-panel construction, 40 ft in width and 50 ft in length with R20 exterior wall insulation. The foundation is of conventional reinforced concrete pier/wall and floor slab construction and incorporates the original turbine and module slabs. A full height concrete block partition wall was installed to completely separate the turbine/generator sections from the remaining building area. It houses a one tonne hoist/track provision to move equipment to the service area. The electrical area is divided into a battery room, a control room and an MCC/switchgear section. It has an oil drain provision for both the service and turbine rooms complete with a reinforced concrete trap. A rolling service door between the turbine and work area is provided for fire containment but easily removed for heavy equipment.

2.5.1.1 Gas Turbine Building Asbestos

Pinchin Leblanc undertook an “Asbestos Materials Re-Assessment” study of Holyrood for NL Hydro in 2010 (Pinchin Leblanc Project 02-02-004-01, November 19, 2010).

The study was not exhaustive and rather a review of areas identified previously, some of which had been addressed. It did not appear to address the GT building specifically, but did indicate that the metal sheet siding of some of the out buildings on the site were made of a material called Galbestos which had a backing of non-friable tarpaper containing chrysotile asbestos. The study indicated that this siding material should be repaired or removed following Type 1 (low risk) asbestos abatement procedures.

Given that the GT building was installed at the Holyrood site in 1986, it is unlikely that the siding material was Galbestos. Nevertheless, before any modification work is undertaken on the siding or other building components, the presence or absence of asbestos should be verified.

No cost or time has been allowed for asbestos evaluation or removal in this assessment, as the likelihood of its presence is low and the risk associated with its removal is identified by the report as being low.

2.5.2 Major Maintenance History

No inspection records specific to the turbine building were identified. A visual walkthrough of the gas turbine building was performed to gauge the existing condition of the building.

Structural: The structural systems that comprise the building are in excellent condition with very little corrosion found and no major structural deficiencies noted. There was significant surface corrosion found on the structural members located below the exhaust stack that sits on the roof of the building over the turbine.

Roofs & Siding: The siding and roof of the gas turbine building, specifically in the area around the stack, at the roofliner, and at the base of the building, show evidence of significant corrosion.

Exhaust Stack: The exhaust stack is extensively corroded with leaks into the building and into the turbine, and should be replaced.

Picture shows corroded exhaust stack

Picture shows corroded exhaust stack

Picture shows corroded exhaust stack

Picture shows corroded exhaust stack

FIGURE 2-7 CORRODED EXHAUST STACK (GAS TURBINE PLANT

2.5.3 Condition Assessment & Remaining Life

The condition assessment of the buildings and building M and E system is illustrated below in Table 2-27.

TABLE 2-27 CONDITION ASSESSMENT – GAS TURBINE BUILDINGS AND BUILDING M AND E SYSTEM

BU # 1	Asset # 2	Asset # 3	Asset # 4	Asset Level 3	Description	Detail	Cond. Summ. ID#	Condition	Status Identifier	Original Life (Base Load) Ops Hrs (Yrs)	Current Expected Minimum Remaining Life Years (Subject to Test)	End of Life (EOL) Required	Capability to Reach EOL	In Service
1297	7255	272255	7307	BUILDINGS	GAS TURBINE BUILDING	N/A	BLDG1	Generally in good condition with modest corrosion and no significant structural deficiencies noted, except where related to gas turbine intake and exhaust. Some surface corrosion on structural members located below the exhaust stack. Sidings and roofs of the Gas Turbine Building have some corrosion requiring repair.	4	(40)	10+	2020	Yes	1986
1273	7202	7311	0	GAS TURBINE BUILDING	Structure - General	Structure	BLDG2	The structural systems that comprise the building are in excellent condition with very little corrosion found and no major structural deficiencies noted. There was significant surface corrosion found on the structural members in the turbine room located immediately below the exhaust stack that sits on the roof of the building over the turbine.	4/10	(20)	10+	2020	Yes	1986
1273	7202	7311	0	GAS TURBINE BUILDING	Service Room:	Service Room:	BLDG3	Visible structural steel in service room is in excellent condition with paint covering the members and no signs of corrosion or major structural deficiencies. The masonry wall dividing the service room and turbine room is in excellent condition on this side.	4/10	(20)	10+	2020	Yes	1986
1273	7202	7311	0	GAS TURBINE BUILDING	Turbine Room	Turbine Room	BLDG4	Structural steel is in good condition except in the immediate vicinity of the exhaust stack. The steel members in this area have moderate corrosion owing to water infiltration around the stack. The masonry wall dividing the service room and turbine room is in excellent condition on this side.	4/10	(20)	10+	2020	Yes	1986
1273	7202	7311	0	GAS TURBINE BUILDING	Generator Room	Generator Room	BLDG5	Visible structural steel in generator room is in good condition except in the immediate vicinity of the exhaust stack. Steel members directly surrounding the exhaust ducting has minor corrosion owing to water infiltration at the roof. This evidenced by rust running down the side of the ducting.	4/10	(20)	10+	2020	Yes	1986
1273	7202	7311	0	GAS TURBINE BUILDING	Battery Room /MCC Room /Control Room	Battery Room	BLDG6	These rooms have their own infill structure that is covered by finishes. There does not appear to be any structural deficiencies in these areas. The building structural steel above these rooms is somewhat visible from the Service Room and looks to be in the same good condition as the steel in that room.	4/10	(20)	10+	2020	Yes	1986
1273	7202	7311	0	GAS TURBINE BUILDING	Roofing	Roofing	BLDG7	The roof of the gas turbine building, specifically in the area around the stack, at the roof liner, shows evidence of moderate corrosion. Unless these areas are repaired there is a risk the deterioration might accelerate and begin to affect the primary structural members. (ie. columns, beams)	4/10	(20)	10/1	2020	No	1986
1273	7202	7311	0	GAS TURBINE BUILDING	Siding	Siding	BLDG8	The siding of the gas turbine building, specifically at the base of the building, show evidence of significant corrosion. Unless these areas are repaired there is a risk the deterioration might accelerate and begin to affect the primary structural members. (ie. columns, beams)	4/10	(20)	10/1	2020	No	1986
1273	7202	7311	0	GAS TURBINE BUILDING	Hoists / Lifting	Hoists / Lifting	BLDG9	There is a main monorail which spans between the Service Room and Turbine Room. This monorail is excellent condition with no signs of corrosion or structural deficiencies. There are two minor lifting beams between the power generator and power turbine. These monorails are in good condition with only minor surface corrosion and no major structural deficiencies. There is a monorail in the generator room which is in excellent conditions with no signs of corrosion or structural deficiencies.	4/10	(20)	10+	2020	Yes	1986
1273	7202	7311	0	GAS TURBINE BUILDING	Exhaust Stack Structure	Exhaust Stack Structure	BLDG10	The steel support frame is good condition with only moderate corrosion, with paint covering the majority of the frame surface and no sign of major structural deficiencies. The structural frame holding up the exhaust cannot be assessed visually as it rests above the main structure obscured from view inside and above the roofline it is covered in flashing. The lifting lugs are in good condition with no signs of major corrosion. The sealant used to weather proof the connection of the frame to the roof is cracking and it should be assumed the frame exhibits similar corrosion as the primary structural steel inside. While not technically a structural item, the exhaust stack itself is extensively corroded above the roof line allowing water to leak into the building causing corrosion.	4/10	(20)	10/0	2020	No	1986

Notes: 1. A "(bracketed)" value in the "Current Expected Remaining Life" column is a highly probable minimum value that is considered subject to some subsequent verification during further investigation, including at the next test or overhaul. It may be addressed as part of a Level 2 test. A value identified as "(X/Y)" has been included for the steam turbine and generator where the recommended minimum value is the lower of the two, but that the higher may be achievable at a higher level of failure risk and/or unreliability.

2.5.4 Risk Assessment

TABLE 2-28 RISK ASSESSMENT – GAS TURBINE BUILDINGS AND BUILDING M AND E SYSTEM

BU # 1	Asset # 2	Asset # 3	Asset # 4	Asset Level 3	Description	Detail	Cond. Summ. ID#	Condition	Major Issues	Remaining Life Years	TECHNO-ECO RISK ASSESS MODEL			SAFETY RISK ASSESS MODEL			Possible Failure Event	Mitigation
										(Insufficient Info - Inspection Required Within (x) Years)	Likeli-hood	Conse-quence	Risk Level	Likeli-hood	Conse-quence	Safety Risk		
1297	7255	272255	7307	BUILDINGS	GAS TURBINE BUILDING													
1273	7202	7311	0	GAS TURBINE BUILDING	Structure - General	Structure	BLDG1	The structural systems that comprise the building are in excellent condition with very little corrosion found and no major structural deficiencies noted. There was significant surface corrosion found on the structural members in the turbine room located immediately below the exhaust stack that sits on the roof of the building over the turbine.	Stack leaks causing structural member surface corrosion.	10+	1	B	Low	1	C	Medium	Structural steel member sigifican corrosion. Stack support failure.	Monitor. Replace/repair leaks in area of stack and check support.
1273	7202	7311	0	GAS TURBINE BUILDING	Service Room:	Service Room:	BLDG2	Visible structural steel in service room is in excellent condition with paint covering the members and no signs of corrosion or major structural deficiencies. The masonry wall dividing the service room and turbine room is in excellent condition on this side.	None	10+	1	A	Low	A	B	LOW	None expected.	Monitor
1273	7202	7311	0	GAS TURBINE BUILDING	Turbine Room	Turbine Room	BLDG3	Structural steel is in good condition except in the immediate vicinity of the exhaust stack. The steel members in this area have moderate corrosion owing to water infiltration around the stack. The masonry wall dividing the service room and turbine room is in excellent condition on this side.	Stack support failure 9eventual).	10+	3	B	Medium	1	C	Medium	Structural steel member sigifican corrosion. Stack support failure.	Monitor. Replace/repair leaks in area of stack and check support.
1273	7202	7311	0	GAS TURBINE BUILDING	Generator Room	Generator Room	BLDG4	Visible structural steel in generator room is in good condition except in the immediate vicinity of the exhaust stack. Steel members directly surrounding the exhaust ducting has minor corrosion owing to water infiltration at the roof. This evidenced by rust running down the side of the ducting.	Stack support failure 9eventual).	10+	3	B	Medium	1	C	Medium	Structural steel member sigifican corrosion. Stack support failure.	Monitor. Replace/repair leaks in area of stack and check support.
1273	7202	7311	0	GAS TURBINE BUILDING	Battery Room /MCC Room /Control Room	Battery Room	BLDG5	These rooms have their own infill structure that is covered by finishes. There does not appear to be any structural deficiencies in these areas. The building structural steel above these rooms is somewhat visible from the Service Room and looks to be in the same good condition as the steel in that room. MCC Requirements require more space.	Regulatory compliance re MCC's and other electrical equipment spacing.	1-Oct	3	B	Medium	3	C	Medium	Electrtical equipment failure in limited space. Regulatory non-compliance.	Increase space when replacing MCC's and/or other electrical room equipment.
1273	7202	7311	0	GAS TURBINE BUILDING	Roofing	Roofing	BLDG6	The roof of the gas turbine building, specifically in the area around the stack, at the roof liner, shows evidence of moderate corrosion. Unless these areas are repaired there is a risk the deterioration might accelerate and begin to affect the primary structural members. (ie. columns, beams)	Roof failure. Water damage in gas turbine causing major damage.	10/1	4	C	High	3	C	Medium	Power turbine water in-leakage causing failure. Stack support failure.	Replace/repair leaks in area of stack and check support. Replace stack.
1273	7202	7311	0	GAS TURBINE BUILDING	Siding	Siding	BLDG7	The siding of the gas turbine building, specifically at the base of the building, show evidence of significant corrosion. Unless these areas are repaired there is a risk the deterioration might accelerate and begin to affect the primary structural members. (ie. columns, beams)	Inleakage of marine salt laden air causing increased corrosion.	10/1	4	A	Medium	4	a	Medium	Structural steel member sigifican corrosion. Stack support failure.	Repair existing holes and sections. Check for asbestos.
1273	7202	7311	0	GAS TURBINE BUILDING	Hoists / Lifting	Hoists / Lifting	BLDG8	There is a main monorail which spans between the Service Room and Turbine Room. This monorail is excellent condition with no signs of corrosion or structural deficiencies. There are two minor lifting beams between the power generator and power turbine. These monorails are in good condition with only minor surface corrosion and no major structural deficiencies. There is a monorail in the generator room which is in excellent conditions with no signs of corrosion or structural deficiencies.	None	10+	1	C	Low	1	C	LOW	Failure during GT part lift.	Monitor
1273	7202	7311	0	GAS TURBINE BUILDING	Exhaust Stack Structure	Exhaust Stack Structure	BLDG9	The steel support frame is good condition with only moderate corrosion, with paint covering the majority of the frame surface and no sign of major structural deficiencies. The structural frame holding up the exhaust cannot be assessed visually as it rests above the main structure obscured from view inside and above the roofline it is covered in flashing. The lifting lugs are in good condition with no signs of major corrosion. The sealant used to weather proof the connection of the frame to the roof is cracking and it should be assumed the frame exhibits similar corrosion as the primary structural steel inside. While not technically a structural item, the exhaust stack itself is extensively corroded above the roof line allowing water to leak into the building causing corrosion.	Water inleakage into power turbine and gearbox area.	10/0	4	C	High	3	C	Medium	Power turbine failure. Stack support failure.	Replace stack and repair roof leaks.

2.5.5 Actions

TABLE 2-29 ACTIONS – GAS TURBINE BUILDINGS AND BUILDING M AND E SYSTEM

BU # 1	Asset # 2	Asset # 3	Asset # 4	Asset Level 3	Description	Detail	Action Summ. ID#	Action	Year	Priority
1297	7255	272255	7307	BUILDINGS	GAS TURBINE BUILDING	N/A	BLDG1	Generally repair areas of moisture penetration and air leaks.	2012	2
1273	7202	7311	0	GAS TURBINE BUILDING	Structure - General	Structure	BLDG2	Maintain and monitor	2012	2
1273	7202	7311	0	GAS TURBINE BUILDING	Service Room:	Service Room:	BLDG3	Maintain and monitor	2012	4
1273	7202	7311	0	GAS TURBINE BUILDING	Turbine Room	Turbine Room	BLDG4	Fix roof near stack and stack	2012	1
1273	7202	7311	0	GAS TURBINE BUILDING	Generator Room	Generator Room	BLDG5	Fix roof near stack and stack	2012	1
1273	7202	7311	0	GAS TURBINE BUILDING	Battery Room /MCC Room /Control Room	Battery Room & MCC Room /Control Room	BLDG6	Expand room per current codes when replacing equipment	2012	1
1273	7202	7311	0	GAS TURBINE BUILDING	Roofing	Roofing	BLDG7	Repair roofing around stack. Inspect and maintain balance.	2012	1
1273	7202	7311	0	GAS TURBINE BUILDING	Siding	Siding	BLDG8	Repair current corrosion areas	2012	2
1273	7202	7311	0	GAS TURBINE BUILDING	Hoists / Lifting	Hoists / Lifting	BLDG9	None - Inspect and monitor ongoing		
1273	7202	7311	0	GAS TURBINE BUILDING	Exhaust Stack Structure	Exhaust Stack Structure	BLDG10	Fix roof near stack and stack	2012	1

2.5.6 Life Assessment - Life Cycle Curves (Where Equipment Is Not To Be Overhauled/replaced and Life <2020 and Has Major Unit Operation Impacts)

No Life Cycle Curves are presented. The building with the recommended modifications and repairs can all meet the 2020 end date.

2.5.7 Level 3 Inspections Required

A higher level of inspection is required to confirm the lifting capability of the existing expansion joint / skid which exhaust fan is framed into. It was not confirmed if the existing building contains asbestos. If the roof is disturbed to service/replace the exhaust duct testing should be completed to determine if there is any asbestos in the roofing materials.

Removal of small sections of interior paneling and insulation in areas where corrosion exists in the turbine and power generator rooms should be carried out determine the condition of steel columns in areas where exterior siding has corroded through. These are considered outside of the scope of this assessment and part of the GT overhaul or facility asbestos program,

2.5.8 Capital Enhancements

The suggested capital projects for the GT building and building M and E systems are presented in Table 2-30.

TABLE 2-30 SUGGESTED TYPICAL CAPITAL ENHANCEMENTS – GAS TURBINE BUILDINGS AND BUILDING M AND E SYSTEM

BU # 1	Asset # 2	Asset # 3	Asset # 4	Asset Level 3	Description	Detail	Cond. Summ. ID#	Capital Item	Date	Priority
1297	7255	272255	7307	BUILDINGS	GAS TURBINE BUILDING	N/A	BLDG1	Expansion of building for electrical system requirements and for fuel oil shed.	2012	1
1273	7202	7311	0	GAS TURBINE BUILDING	Structure - General	Structure	BLDG2	No Captial Requirement		
1273	7202	7311	0	GAS TURBINE BUILDING	Service Room:	Service Room:	BLDG3	No Captial Requirement		
1273	7202	7311	0	GAS TURBINE BUILDING	Turbine Room	Turbine Room	BLDG4	No Captial Requirement		
1273	7202	7311	0	GAS TURBINE BUILDING	Generator Room	Generator Room	BLDG5	No Captial Requirement		
1273	7202	7311	0	GAS TURBINE BUILDING	Battery Room /MCC Room /Control Room	Battery Room /MCC Room /Control Room	BLDG6	Expansion of building for electrical system requirements.	2012	1
1273	7202	7311	0	GAS TURBINE BUILDING	Roofing	Roofing	BLDG7	No Captial Requirement		
1273	7202	7311	0	GAS TURBINE BUILDING	Siding	Siding	BLDG8	No Captial Requirement		
1273	7202	7311	0	GAS TURBINE BUILDING	Hoists / Lifting	Hoists / Lifting	BLDG9	No Captial Requirement		
1273	7202	7311	0	GAS TURBINE BUILDING	Exhaust Stack Structure	Exhaust Stack Structure	BLDG10	New stack	2012	1

2.5.9 Capital/Refurbishment Requirements and Costs

The following are the requirements for the complete refurbishment of the building:

- Repair sections of roofing and siding that are corroded and allowing water infiltration. Cost = Approximately $5,000;
- The addition of a building extension to shelter the turbine fuel line mechanical equipment from the elements, likely single span pre-engineered lean-to. Cost = Approximately $40,000;
- Addition of electrical building Cost = Approximately $40,000

2.6 Existing Unit De-Commissioning and Demolition in 2020

No significant incremental costs were identified for existing unit de-commissioning and/or demolition. It was felt that the value of the materials derived from the demolition could offset the cost to the contractor. If required as a sensitivity, then a value such as $40,000 (2011$) might be used, but this would not be expected to either sway the selection of a preferred option, nor impact the overall cost but rather be part of an overall project contingency regardless of any option selected.

2.7 Project Engineering and Management, Owner's Costs

It was assumed that the facility implementation would be undertaken largely as an engineer, procure, construct (EPC) external contract. NL Hydro would be responsible for getting the project approved and the necessary environmental and regulatory approvals. It may be necessary to maintain a schedule for NL Hydro to either procure a power turbine disk or at least a manufacturing slot for the materials and manufacturing pending an EPC which would be free-issued the same (with some guarantee provision exclusions likely).

EPC Costs

For the EPC contractor, the project engineering and management costs are based on the total project costs and a percentage for engineering and for management. For the purposes of this estimate, the engineering costs are estimated to be about 8% of direct costs. The project management and commissioning costs (excluding fuel, NL Hydro staff costs) are estimated to be 8% of direct costs.

Owner's Costs

Owner's costs are not included in the estimates, but are likely to be comparable regardless of the selected option. NL Hydro is assumed to undertake all the necessary environmental and regulatory permitting entirely internally or with some measure of external support (i.e. environmental modeling and engineering support, or full external scope). This cost is also not included but likely on the order of $55,000.

For the actual project implementation, the assumption is that NL Hydro would assume its own costs of this initial development and then assign a project manager for the life of the project to monitor and assure its successful completion. These and other NL Hydro costs (insurance, legal, supply chain, interest, owners' contingency, Holyrood station participation, commissioning fuel, commissioning labour) are not identified or included herein. It is likely that the Owner costs could amount to in the order of 1.5% of directs or about $150,000.

2.8 Existing GTG Refurbishment - Total Cost Estimate

The total existing GT refurbishment cost estimate is shown in Table 2-31. Details are provided in Appendix 7.

TABLE 2-31 EXISTING GTG REFURBISHMENT COST ESTIMATE

Capital cost estimate $1,000 Can 2011

Option Number	**0**
Option	**Existing GT Refurb**
GT/Diesel Cost	$2,950
Civil Works	$224
Electrical Works	$541
BOP Systems	$330
Existing Unit Demolition & Removal	$0
Sub-Total - Directs and Indirects	$4,046
Project Engineering	$324
Project Management	$283
Total	$4,652

+ Standby = Total	$4,825
+ New Rental Stdby = Total	$9,421

Owner's costs were not included, but are expected to be in the order of about 1.5% of direct and indirect cost, plus any taxes and interest where applicable. It should be noted that it may be possible to obtain a used power turbine disk and refurbish it, as opposed to buying a new disk. This may slightly reduce the overall cost slightly. The availability of other parts is considered to be relatively good, but uncertain until a formal tender is issued.

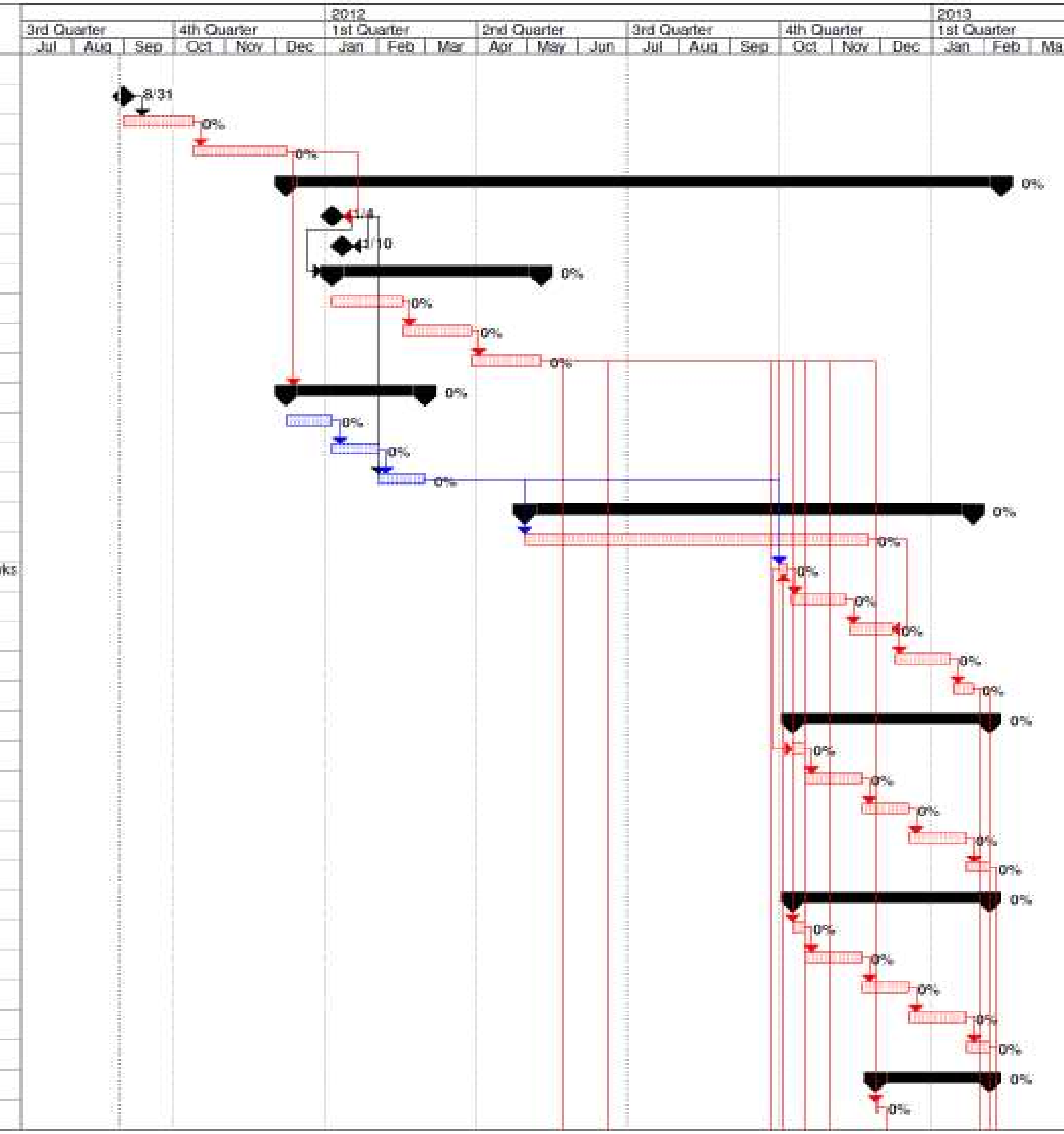
2.8.1 Schedule

The basic "earliest return to service" schedule for the existing GTG unit refurbishment is shown in Figure 2-8 below. Its in-service date is in February 2013. It assumes no replacement unit in six month outage window from September 2012 to February 2013. It is based on an EPC RFP, with the exception of the procurement of a Power Turbine disk which is then free-issued to the EPC contractor.

The outage occurs when Holyrood is normally required to operate. It is likely that the schedule would be allowed to slip to an in-service date in Oct 2013 to have the outage in April to Oct 2013.

FIGURE 2-8 EXISTING GTG REFURBISHMENT – BASE SCHEDULE (NO OUTAGE REPLACEMENT CAPACITY)

ID		Task Name	Duration	Start	Finish	Constraint Type	Predecessors
1							
2		Condition Assessment Study	0 wks	Wed 8/31/11	Wed 8/31/11	ish No Earlier Than	
3		Hydro Internal Capital Budget Proposal Development	6 wks	Thu 9/1/11	Wed 10/12/11	s Soon As Possible	2
4		Submission - Public Utilities Board & Approval	6 wks	Thu 10/13/11	Wed 12/7/11	s Soon As Possible	3
5		**Refurbish Unit**	**308 days**	**Thu 12/8/11**	**Mon 2/11/13**	**Soon As Possible**	
6		Project Limited Notice to proceed (LNTP) Approval	0 days	Wed 1/4/12	Wed 1/4/12	s Soon As Possible	4FF+4 wks
7		Project Full Notice to proceed (NTP)	0 days	Tue 1/10/12	Tue 1/10/12	s Soon As Possible	6FF+4 days
8		**Request for Proposal (RFP) - Engineer/Procure/Co**	**90 days**	**Thu 1/5/12**	**Wed 5/9/12**	**Soon As Possible**	6
9		Prepare	30 days	Thu 1/5/12	Wed 2/15/12	s Soon As Possible	
10		Bid	30 days	Thu 2/16/12	Wed 3/28/12	s Soon As Possible	9
11		Award	30 days	Thu 3/29/12	Wed 5/9/12	s Soon As Possible	10
12		**RFP for Power Turbine Disc Manufacture**	**60 days**	**Thu 12/8/11**	**Wed 2/29/12**	**Soon As Possible**	4
13		Prepare	20 days	Thu 12/8/11	Wed 1/4/12	s Soon As Possible	
14		Bid	20 days	Thu 1/5/12	Wed 2/1/12	s Soon As Possible	13
15		Award	20 days	Thu 2/2/12	Wed 2/29/12	s Soon As Possible	14,6
16		**Power Turbine**	**195 days**	**Mon 4/30/12**	**Fri 1/25/13**	**Soon As Possible**	
17		Manufacture Disc	30 wks	Mon 4/30/12	Fri 11/23/12	As Late As Possible	15
18		Strip and dissassemble plant	1 wk	Mon 10/1/12	Fri 10/5/12	s Soon As Possible	15,42,11FS+2 wks
19		Ship Rotor to overhaul plant	5 wks	Mon 10/8/12	Fri 11/9/12	s Soon As Possible	18
20		Overhaul and balance Rotor	4 wks	Mon 11/12/12	Fri 12/7/12	s Soon As Possible	17FF+2 wks,19
21		Ship Rotor to Holyrood	5 wks	Mon 12/10/12	Fri 1/11/13	s Soon As Possible	20
22		Rebuild and commission unit	2 wks	Mon 1/14/13	Fri 1/25/13	s Soon As Possible	21
23		**Gear Box Overhaul**	**85 days**	**Tue 10/9/12**	**Mon 2/4/13**	**Soon As Possible**	
24		Strip and dissassemble plant	1 wk	Tue 10/9/12	Mon 10/15/12	As Late As Possible	18SS
25		Ship to overhaul plant	5 wks	Tue 10/16/12	Mon 11/19/12	As Late As Possible	24
26		Overhaul and balance Rotor	4 wks	Tue 11/20/12	Mon 12/17/12	As Late As Possible	25
27		Ship to Holyrood	5 wks	Tue 12/18/12	Mon 1/21/13	s Soon As Possible	26
28		Rebuild and commission unit	2 wks	Tue 1/22/13	Mon 2/4/13	s Soon As Possible	27
29		**Avon Gas Generator Overhaul**	**85 days**	**Tue 10/9/12**	**Mon 2/4/13**	**Soon As Possible**	
30		Strip and dissassemble plant	1 wk	Tue 10/9/12	Mon 10/15/12	As Late As Possible	11FS+2 wks
31		Ship Rotor to overhaul plant	5 wks	Tue 10/16/12	Mon 11/19/12	As Late As Possible	30
32		Overhaul and balance Rotor	4 wks	Tue 11/20/12	Mon 12/17/12	As Late As Possible	31
33		Ship Rotor to Holyrood	5 wks	Tue 12/18/12	Mon 1/21/13	s Soon As Possible	32
34		Rebuild and commission unit	2 wks	Tue 1/22/13	Mon 2/4/13	s Soon As Possible	33
35		**Generator Rewind**	**49 days**	**Wed 11/28/12**	**Mon 2/4/13**	**Soon As Possible**	
36		Strip and dissassemble plant	2 days	Wed 11/28/12	Thu 11/29/12	As Late As Possible	11FS+2 wks



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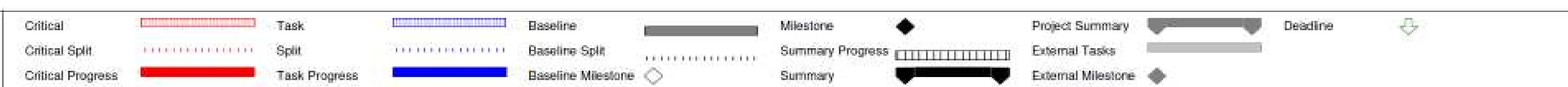

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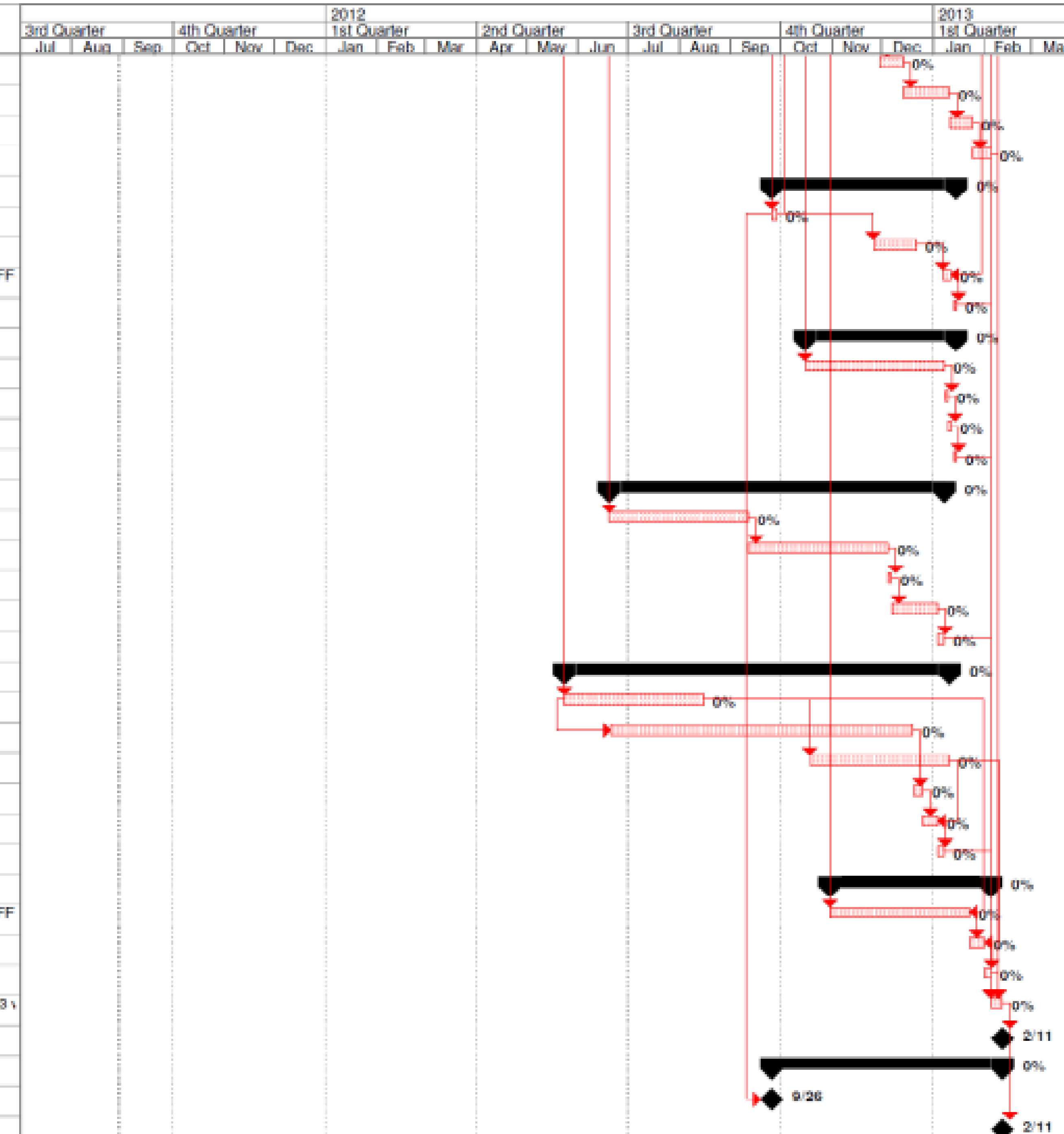
ID		Task Name	Duration	Start	Finish	Constraint Type	Predecessors
37		Ship Rotor to overhaul plant	2 wks	Fri 11/30/12	Thu 12/13/12	As Late As Possible	36
38		Overhaul, rewind, and balance Rotor	4 wks	Fri 12/14/12	Thu 1/10/13	As Late As Possible	37
39		Ship Rotor to Holyrood	2 wks	Fri 1/11/13	Thu 1/24/13	s Soon As Possible	38
40		Rebuild and commission unit	7 days	Fri 1/25/13	Mon 2/4/13	s Soon As Possible	39
41		**Exhaust Stack**	**79 days**	**Wed 9/26/12**	**Mon 1/14/13**	**Soon As Possible**	
42		Remove	3 days	Wed 9/26/12	Fri 9/28/12	As Late As Possible	11FS+2 wks
43		Repair/Replace	4 wks	Mon 11/26/12	Fri 12/21/12	As Late As Possible	42
44		Re-install	5 days	Mon 1/7/13	Fri 1/11/13	As Late As Possible	43FS+2 wks,22FF
45		Commission unit	1 day	Mon 1/14/13	Mon 1/14/13	s Soon As Possible	44
46		**Intake media**	**65 days**	**Tue 10/16/12**	**Mon 1/14/13**	**Soon As Possible**	
47		Order & Manufacture Filter media	12 wks	Tue 10/16/12	Mon 1/7/13	As Late As Possible	11FS+2 wks
48		Remove	2 days	Tue 1/8/13	Wed 1/9/13	As Late As Possible	47
49		Repair/Replace	2 days	Thu 1/10/13	Fri 1/11/13	As Late As Possible	48
50		Commission unit	1 day	Mon 1/14/13	Mon 1/14/13	s Soon As Possible	49
51		**Fuel System Refurbishments**	**144 days**	**Wed 6/20/12**	**Mon 1/7/13**	**Soon As Possible**	
52		Engineer	12 wks	Wed 6/20/12	Tue 9/11/12	As Late As Possible	11FS+2 wks
53		Order, Manufacture, Deliver	12 wks	Wed 9/12/12	Tue 12/4/12	As Late As Possible	52
54		Remove	2 days	Wed 12/5/12	Thu 12/6/12	As Late As Possible	53
55		Repair/Replace	4 wks	Fri 12/7/12	Thu 1/3/13	As Late As Possible	54
56		Commission unit	2 days	Fri 1/4/13	Mon 1/7/13	s Soon As Possible	55
57		**Electrical & Control Systmes**	**166 days**	**Thu 5/24/12**	**Thu 1/10/13**	**Soon As Possible**	
58		Engineer	12 wks	Thu 5/24/12	Wed 8/15/12	As Late As Possible	11FS+2 wks
59		Order & Manufacture Elect & Control Equip	26 wks	Thu 6/21/12	Wed 12/19/12	As Late As Possible	58SS+4 wks
60		GT Building Addition	12 wks	Fri 10/19/12	Thu 1/10/13	As Late As Possible	58
61		Remove Existing	4 days	Thu 12/20/12	Tue 12/25/12	As Late As Possible	59
62		Install New System	7 days	Wed 12/26/12	Thu 1/3/13	As Late As Possible	61,60FF-1 wk
63		Commission unit	2 days	Fri 1/4/13	Mon 1/7/13	s Soon As Possible	62
64		**Building & Systmes**	**69 days**	**Wed 10/31/12**	**Mon 2/4/13**	**Soon As Possible**	
65		Engineer	12 wks	Wed 10/31/12	Tue 1/22/13	As Late As Possible	11FS+2 wks,58FF
66		Modify and Refurbish	7 days	Wed 1/23/13	Thu 1/31/13	As Late As Possible	65,60FF
67		Commission unit	2 days	Fri 2/1/13	Mon 2/4/13	s Soon As Possible	66
68		Complete Unit Test	5 days	Tue 2/5/13	Mon 2/11/13	s Soon As Possible	34,40,22,45FS+3 v
69		Gas Turbine (GT) In-service (I/S)	0 days	Mon 2/11/13	Mon 2/11/13	s Soon As Possible	68
70		**UNIT OUTAGE**	**99 days**	**Wed 9/26/12**	**Mon 2/11/13**	**Soon As Possible**	
71		Unit Outage Start	0 days	Wed 9/26/12	Wed 9/26/12	s Soon As Possible	42SS
72		Unit Outage End	0 days	Mon 2/11/13	Mon 2/11/13	s Soon As Possible	68



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Critical	Task	Baseline	Milestone	Project Summary	Deadline
Critical Split	Split	Baseline Split	Summary Progress	External Tasks	
Critical Progress	Task Progress	Baseline Milestone	Summary	External Milestone	

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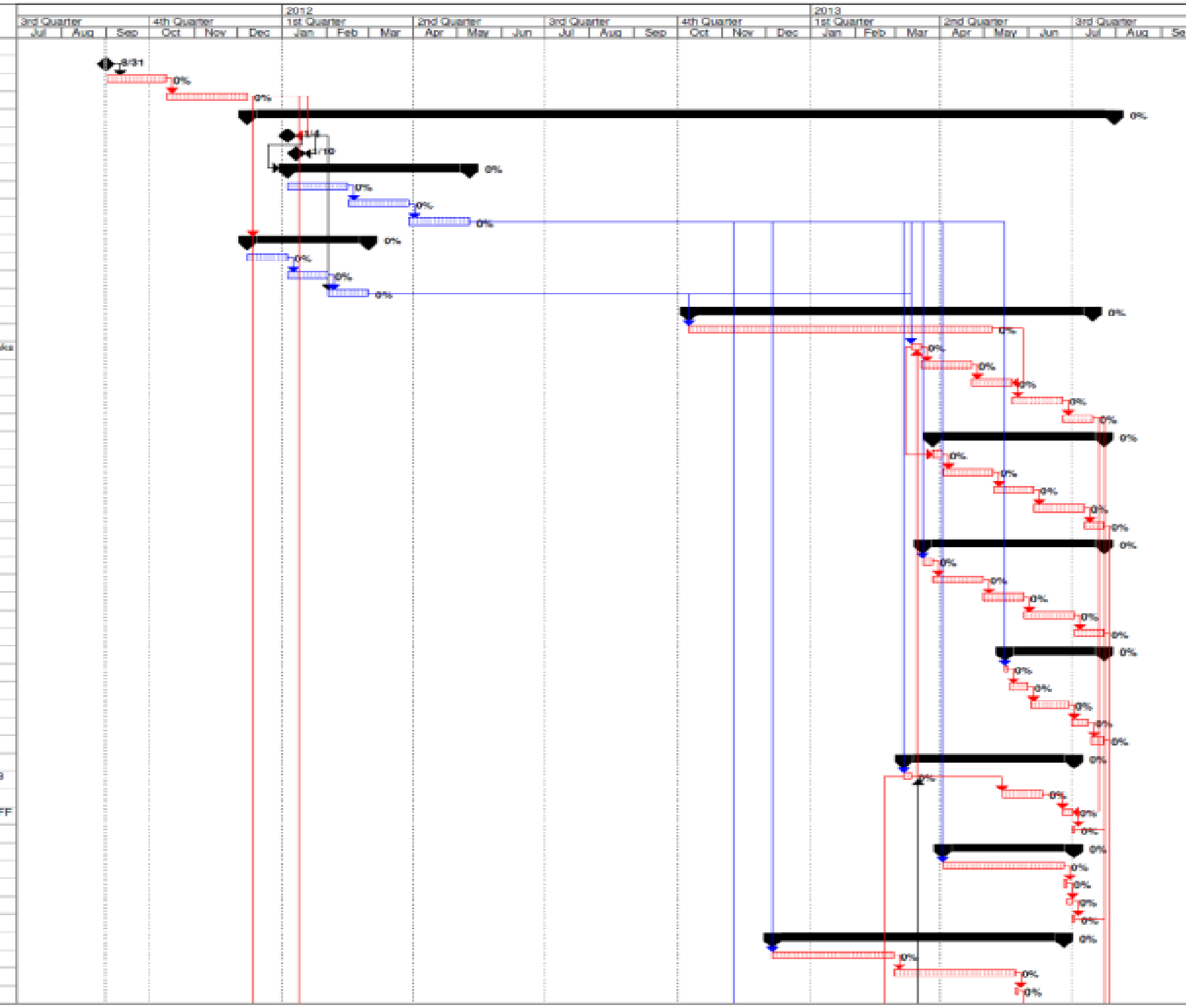
Figure 2-9 presents a variation of the basic "earliest return to service" schedule for the existing GTG unit refurbishment. It includes a replacement nearly new 2 x 5 MW GT during the outage window of the existing unit. The nearly new units would be in-service in March 2013. The resulting existing unit in-service date is end of July 2013, with a five month existing unit outage window from March to July 2013. It also is based on an EPC RFP, with the exception of the procurement of a Power Turbine disk which is free-issued to the EPC contractor. There is no significant period when black start capability is not available. A new 2 x 5MW unit would increase the schedule by about two months.

FIGURE 2-9 EXISTING GTG REFURBISHMENT – ALTERNATE SCHEDULE 1 (NEARLY NEW 2 X 5 MW GT REPLACEMENT DURING OUTAGE)

ID	Task Name	Duration	Start	Finish	Constraint Type	Predecessors
1						
2	Condition Assessment Study	0 wks	Wed 8/31/11	Wed 8/31/11	Finish No Earlier Than	
3	Hydro Internal Capital Budget Proposal Development	6 wks	Thu 9/1/11	Wed 10/12/11	As Soon As Possible	2
4	Submission - Public Utilities Board & Approval	8 wks	Thu 10/13/11	Wed 12/7/11	As Soon As Possible	3
5	**Refurbish Unit**	**429 days**	**Thu 12/8/11**	**Tue 7/30/13**	**As Soon As Possible**	
6	Project Limited Notice to proceed (LNTP) Approval	0 days	Wed 1/4/12	Wed 1/4/12	As Soon As Possible	4FF+4 wks
7	Project Full Notice to proceed (NTP)	0 days	Tue 1/10/12	Tue 1/10/12	As Soon As Possible	6FF+4 days
8	**Request for Proposal (RFP) - Engineer/Procure/Cor**	**90 days**	**Thu 1/5/12**	**Wed 5/9/12**	**As Soon As Possible**	**6**
9	Prepare	30 days	Thu 1/5/12	Wed 2/15/12	As Soon As Possible	
10	Bid	30 days	Thu 2/16/12	Wed 3/28/12	As Soon As Possible	9
11	Award	30 days	Thu 3/29/12	Wed 5/9/12	As Soon As Possible	10
12	**RFP for Power Turbine Disc Manufacture**	**60 days**	**Thu 12/8/11**	**Wed 2/29/12**	**As Soon As Possible**	**4**
13	Prepare	20 days	Thu 12/8/11	Wed 1/4/12	As Soon As Possible	
14	Bid	20 days	Thu 1/5/12	Wed 2/1/12	As Soon As Possible	13
15	Award	20 days	Thu 2/2/12	Wed 2/29/12	As Soon As Possible	14,6
16	**Power Turbine**	**200 days**	**Tue 10/9/12**	**Mon 7/15/13**	**As Soon As Possible**	
17	Manufacture Disc	30 wks	Tue 10/9/12	Mon 5/6/13	As Late As Possible	15
18	Strip and disassemble plant	1 wk	Tue 3/12/13	Mon 3/18/13	As Late As Possible	15,42,11FS+2 wks
19	Ship Rotor to overhaul plant	5 wks	Tue 3/19/13	Mon 4/22/13	As Late As Possible	18
20	Overhaul and balance Rotor	4 wks	Tue 4/23/13	Mon 5/20/13	As Late As Possible	17FF+2 wks,19
21	Ship Rotor to Holyrood	5 wks	Tue 5/21/13	Mon 6/24/13	As Soon As Possible	20
22	Rebuild and commission unit	3 wks	Tue 6/25/13	Mon 7/15/13	As Soon As Possible	21
23	**Gear Box Overhaul**	**85 days**	**Wed 3/27/13**	**Tue 7/23/13**	**As Soon As Possible**	
24	Strip and disassemble plant	1 wk	Wed 3/27/13	Tue 4/2/13	As Late As Possible	18SS
25	Ship to overhaul plant	5 wks	Wed 4/3/13	Tue 5/7/13	As Late As Possible	24
26	Overhaul and balance Rotor	4 wks	Wed 5/8/13	Tue 6/4/13	As Late As Possible	25
27	Ship to Holyrood	5 wks	Wed 6/5/13	Tue 7/9/13	As Soon As Possible	26
28	Rebuild and commission unit	2 wks	Wed 7/10/13	Tue 7/23/13	As Soon As Possible	27
29	**Avon Gas Generator Overhaul**	**90 days**	**Wed 3/20/13**	**Tue 7/23/13**	**As Soon As Possible**	
30	Strip and disassemble plant	1 wk	Wed 3/20/13	Tue 3/26/13	As Late As Possible	11FS+2 wks
31	Ship Rotor to overhaul plant	5 wks	Wed 3/27/13	Tue 4/30/13	As Late As Possible	30
32	Overhaul and balance Rotor	4 wks	Wed 5/1/13	Tue 5/28/13	As Late As Possible	31
33	Ship Rotor to Holyrood	5 wks	Wed 5/29/13	Tue 7/2/13	As Soon As Possible	32
34	Rebuild and commission unit	3 wks	Wed 7/3/13	Tue 7/23/13	As Soon As Possible	33
35	**Generator Rewind**	**49 days**	**Thu 5/16/13**	**Tue 7/23/13**	**As Soon As Possible**	
36	Strip and disassemble plant	2 days	Thu 5/16/13	Fri 5/17/13	As Late As Possible	11FS+2 wks
37	Ship Rotor to overhaul plant	2 wks	Mon 5/20/13	Fri 5/31/13	As Late As Possible	36
38	Overhaul, rewind, and balance Rotor	4 wks	Mon 6/3/13	Fri 6/28/13	As Late As Possible	37
39	Ship Rotor to Holyrood	2 wks	Mon 7/1/13	Fri 7/12/13	As Soon As Possible	38
40	Rebuild and commission unit	7 days	Mon 7/15/13	Tue 7/23/13	As Soon As Possible	39
41	**Exhaust Stack**	**84 days**	**Thu 3/7/13**	**Tue 7/2/13**	**As Soon As Possible**	
42	Remove	3 days	Thu 3/7/13	Mon 3/11/13	As Late As Possible	11FS+2 wks,108
43	Repair/Replace	4 wks	Tue 5/14/13	Mon 6/10/13	As Late As Possible	42
44	Re-install	5 days	Tue 6/25/13	Mon 7/1/13	As Late As Possible	43FS+2 wks,22FF
45	Commission unit	1 day	Tue 7/2/13	Tue 7/2/13	As Soon As Possible	44
46	**Intake media**	**65 days**	**Wed 4/3/13**	**Tue 7/2/13**	**As Soon As Possible**	
47	Order & Manufacture Filter media	12 wks	Wed 4/3/13	Tue 6/25/13	As Late As Possible	11FS+2 wks
48	Remove	2 days	Wed 6/26/13	Thu 6/27/13	As Late As Possible	47
49	Repair/Replace	2 days	Fri 6/28/13	Mon 7/1/13	As Late As Possible	48
50	Commission unit	1 day	Tue 7/2/13	Tue 7/2/13	As Soon As Possible	49
51	**Fuel System Refurbishments**	**144 days**	**Thu 12/6/12**	**Tue 6/25/13**	**As Soon As Possible**	
52	Engineer	12 wks	Thu 12/6/12	Wed 2/27/13	As Late As Possible	11FS+2 wks
53	Order, Manufacture, Deliver	12 wks	Thu 2/28/13	Wed 5/22/13	As Late As Possible	52
54	Remove	2 days	Thu 5/23/13	Fri 5/24/13	As Late As Possible	53



Project: Project1 Exist & Repla near ne
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Critical | Critical Split | Critical Progress | Task | Split | Task Progress | Baseline | Baseline Split | Baseline Milestone | Milestone | Summary Progress | Summary | Project Summary | External Tasks | External Milestone | Deadline

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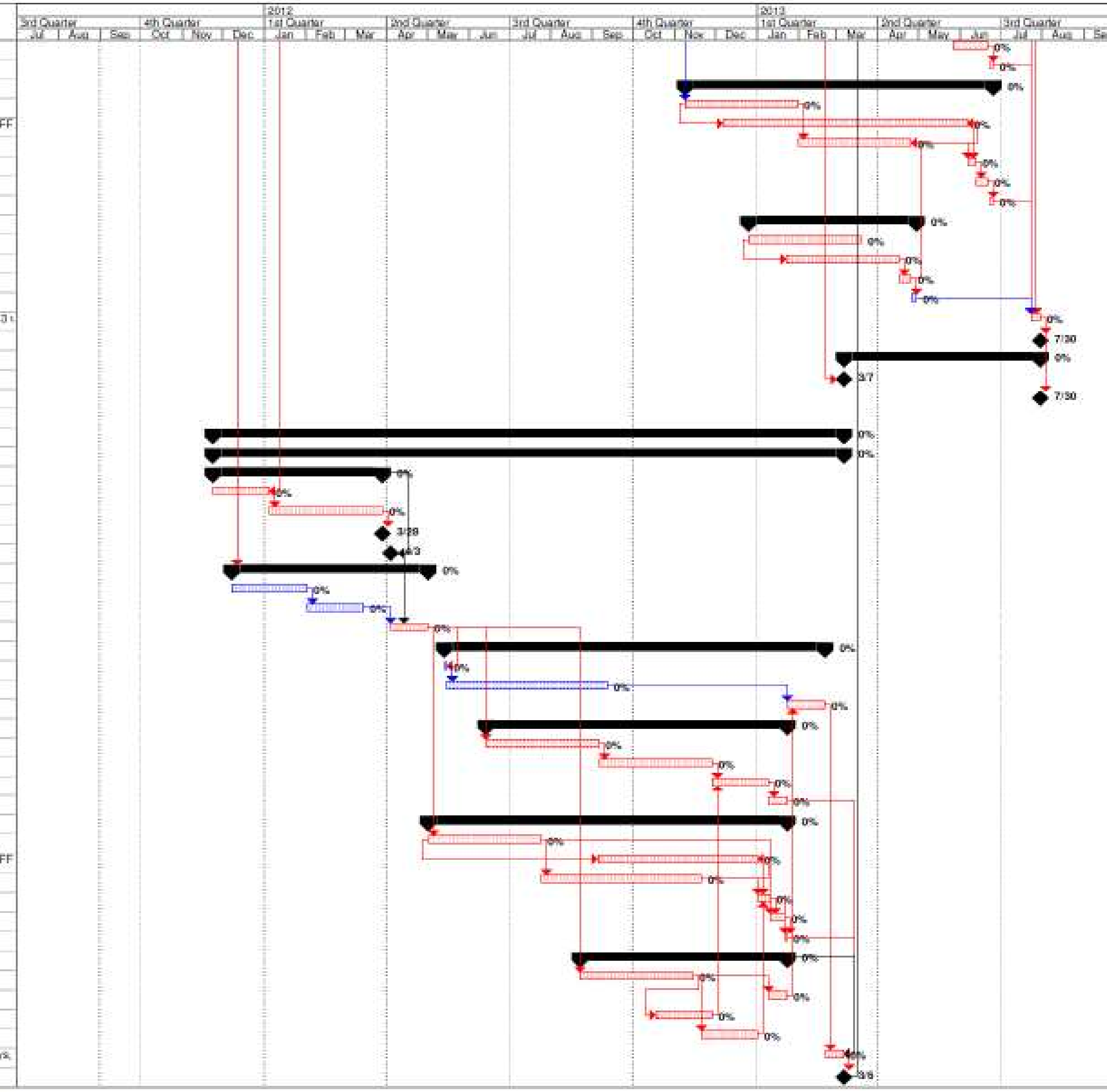
Newfoundland and Labrador Hydro a NALCOR Energy Co.
Holyrood Thermal Generating Station
Gas Turbine Condition Assessment & Options Study

ID	Task Name	Duration	Start	Finish	Constraint Type	Predecessors
55	Repair/Replace	4 wks	Mon 5/27/13	Fri 6/21/13	As Late As Possible	54
56	Commission unit	2 days	Mon 6/24/13	Tue 6/25/13	As Soon As Possible	55
57	**Electrical & Control Systmes**	**163 days**	**Fri 11/9/12**	**Tue 6/25/13**	**As Soon As Possible**	
58	Engineer	12 wks	Fri 11/9/12	Thu 1/31/13	As Late As Possible	11FS+2 wks
59	Order & Manufacture Elect & Control Equip	26 wks	Fri 12/7/12	Thu 6/6/13	As Late As Possible	58SS+4 wks,60FF
60	GT Building Addition	12 wks	Fri 2/1/13	Thu 4/25/13	As Late As Possible	58,67FF
61	Remove Existing	4 days	Fri 6/7/13	Wed 6/12/13	As Late As Possible	60,59
62	Install New System	7 days	Thu 6/13/13	Fri 6/21/13	As Late As Possible	61
63	Commission unit	2 days	Mon 6/24/13	Tue 6/25/13	As Soon As Possible	62
64	**Building & Systmes**	**89 days**	**Wed 12/26/12**	**Mon 4/29/13**	**As Soon As Possible**	
65	Engineer	12 wks	Wed 12/26/12	Tue 3/19/13	As Late As Possible	
66	Order & Manufacture Elect & Control Equip	12 wks	Wed 1/23/13	Tue 4/16/13	As Late As Possible	65SS+4 wks
67	Modify and Refurbish	7 days	Wed 4/17/13	Thu 4/25/13	As Late As Possible	66
68	Commission unit	2 days	Fri 4/26/13	Mon 4/29/13	As Soon As Possible	67
69	Complete Unit Test	5 days	Wed 7/24/13	Tue 7/30/13	As Soon As Possible	34,40,22,45FS-3 ...
70	Gas Turbine (GT) In-service (I/S)	0 days	Tue 7/30/13	Tue 7/30/13	As Soon As Possible	69
71	**UNIT OUTAGE**	**104 days**	**Thu 3/7/13**	**Tue 7/30/13**	**As Soon As Possible**	
72	Unit Outage Start	0 days	Thu 3/7/13	Thu 3/7/13	As Soon As Possible	42SS
73	Unit Outage End	0 days	Tue 7/30/13	Tue 7/30/13	As Soon As Possible	69
74						
75	**REPLACEMENT UNIT**	**335 days**	**Thu 11/24/11**	**Wed 3/6/13**	**As Soon As Possible**	
76	**Nearly New gas Turbine (GT) Generator Units**	**335 days**	**Thu 11/24/11**	**Wed 3/6/13**	**As Soon As Possible**	
77	**Project Environmental & Regulatory Approvals**	**90 days**	**Thu 11/24/11**	**Wed 3/28/12**	**As Soon As Possible**	
78	Prepare Dispersion Modelling & Submission	30 days	Thu 11/24/11	Wed 1/4/12	As Soon As Possible	4FF+4 wks
79	Regulatory Review and Approval	60 days	Thu 1/5/12	Wed 3/28/12	As Soon As Possible	78
80	Environmental Approval	0 days	Wed 3/28/12	Wed 3/28/12	As Soon As Possible	79
81	Project Full Release	0 days	Tue 4/3/12	Tue 4/3/12	As Soon As Possible	77FF+4 days
82	**Request for Proposal (RFP) for Engineer/Proc**	**104 days**	**Thu 12/8/11**	**Tue 5/1/12**	**As Soon As Possible**	4
83	Prepare	40 days	Thu 12/8/11	Wed 2/1/12	As Soon As Possible	
84	Bid	6 wks	Thu 2/2/12	Wed 3/14/12	As Soon As Possible	83
85	Award	20 days	Wed 4/4/12	Tue 5/1/12	As Soon As Possible	81,84
86	**Nearly New GT or Diesel Engine Generator**	**203 days**	**Mon 5/14/12**	**Wed 2/20/13**	**As Soon As Possible**	
87	Award GT/Diesel Engine Contract	2 days	Mon 5/14/12	Tue 5/15/12	As Soon As Possible	85FF-10 days
88	Manufacture & Deliver Transportable Engine	17 wks	Wed 5/16/12	Tue 9/11/12	As Soon As Possible	87
89	Install and Commission	4 wks	Thu 1/24/13	Wed 2/20/13	As Soon As Possible	88,104
90	**Fuel System**	**160 days**	**Thu 6/14/12**	**Wed 1/23/13**	**As Soon As Possible**	
91	Engineer	12 wks	Thu 6/14/12	Wed 9/5/12	As Late As Possible	85
92	Order, Manufacture, Deliver	12 wks	Thu 9/6/12	Wed 11/28/12	As Late As Possible	91
93	Install new fuel lines and receiving system	6 wks	Thu 11/29/12	Wed 1/9/13	As Late As Possible	92,105
94	Commission System	2 wks	Thu 1/10/13	Wed 1/23/13	As Late As Possible	93
95	**Electrical & Control Systmes**	**191 days**	**Wed 5/2/12**	**Wed 1/23/13**	**As Soon As Possible**	
96	Engineer	12 wks	Wed 5/2/12	Tue 7/24/12	As Late As Possible	85
97	Order & Manufacture Elect & Control (E&C) E	17 wks	Wed 9/5/12	Tue 1/1/13	As Late As Possible	96SS+4 wks,98FF
98	Electrical Building Manufacture, Delivery, Ins	17 wks	Wed 7/25/12	Tue 11/20/12	As Late As Possible	96
99	Install New System	7 days	Wed 1/2/13	Thu 1/10/13	As Late As Possible	97,98,106
100	RE-align Existing Plant Systems	7 days	Fri 1/11/13	Mon 1/21/13	As Late As Possible	96,99
101	Commission unit	2 days	Tue 1/22/13	Wed 1/23/13	As Soon As Possible	99,100
102	**Site Civil Work**	**110 days**	**Thu 8/23/12**	**Wed 1/23/13**	**As Soon As Possible**	
103	Engineer	12 wks	Thu 8/23/12	Wed 11/14/12	As Late As Possible	85
104	Generator area clearing and civil	2 wks	Thu 1/10/13	Wed 1/23/13	As Late As Possible	103FS-6 wks
105	Fuel line civil work	6 wks	Thu 10/18/12	Wed 11/28/12	As Late As Possible	103FS-4 wks
106	Electrical an contro cable civil work	6 wks	Wed 11/21/12	Tue 1/1/13	As Late As Possible	103FS-2 wks
107	Complete Unit Test	10 days	Thu 2/21/13	Wed 3/6/13	As Soon As Possible	89,94FF+30 days,
108	GT In-Service (I/S)	0 days	Wed 3/6/13	Wed 3/6/13	As Soon As Possible	107



Project: Project1 Exist & Repla near ne
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Critical — Critical Split — Critical Progress — Task — Split — Task Progress — Baseline — Baseline Split — Baseline Milestone — Milestone — Summary Progress — Summary — Project Summary — External Tasks — External Milestone — Deadline

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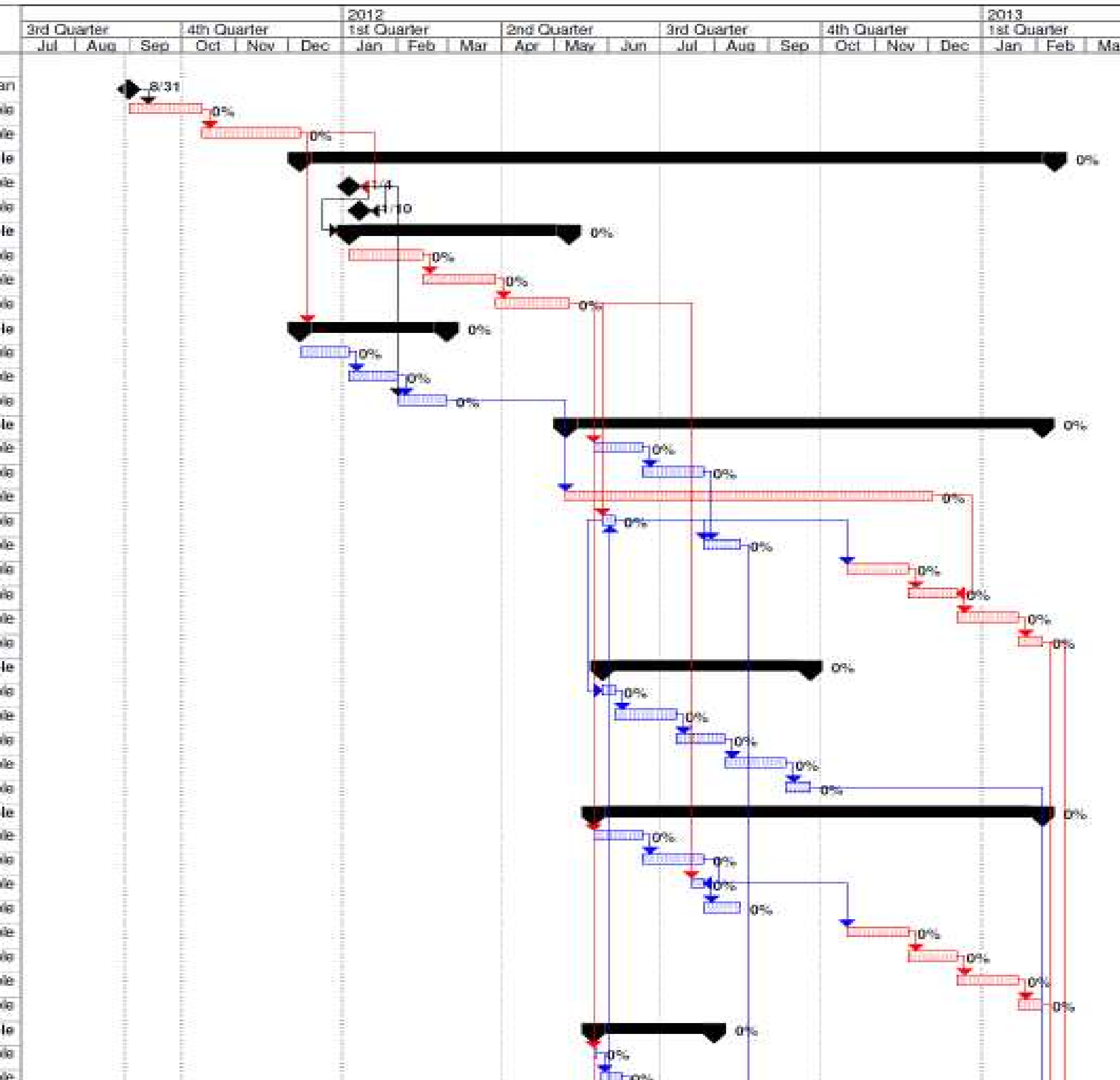
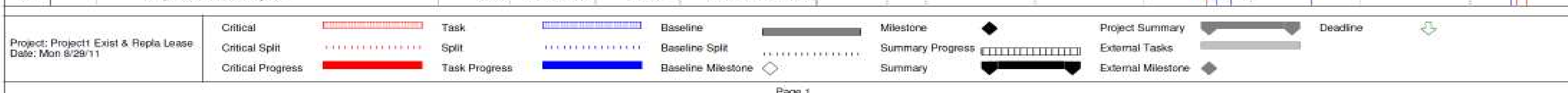
Figure 2-10 presents a second variation of the basic “earliest return to service” schedule for the existing GTG unit refurbishment. It assumes leased used replacements parts for the existing GT unit (the gas generator, the power turbine) to minimize the outage window, but does not. The in-service date is still February 2013, but with a longer outage window of 9 months from May 2012 to February 2013. The outage also occurs when Holyrood is normally required to operate, and given its duration would not be impacted by schedule shifting.

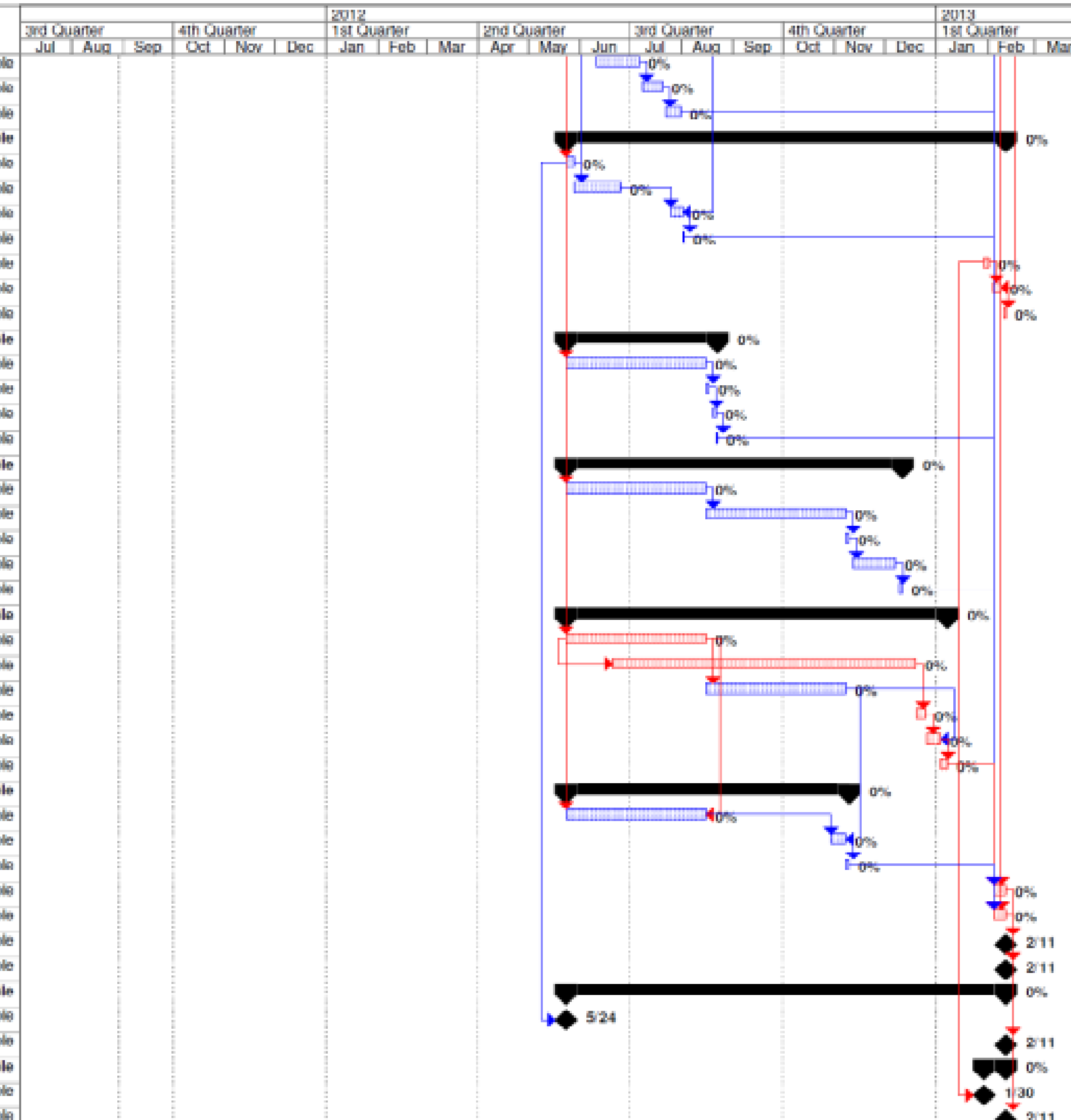
FIGURE 2-10 EXISTING GTG REFURBISHMENT – ALTERNATE SCHEDULE 2 (LEASED USED GAS GENERATOR AND POWER TURBINE DURING OUTAGE)

ID	Task Name	Duration	Start	Finish	Constraint Type
1					
2	Condition Assessment Study	0 wks	Wed 8/31/11	Wed 8/31/11	Finish No Earlier Than
3	Hydro Internal Capital Budget Proposal Development	6 wks	Thu 9/1/11	Wed 10/12/11	As Soon As Possible
4	Submission - Public Utilities Board & Approval	8 wks	Thu 10/13/11	Wed 12/7/11	As Soon As Possible
5	**Refurbish Unit**	**308 days**	**Thu 12/8/11**	**Mon 2/11/13**	**As Soon As Possible**
6	Project Limited Notice to proceed (LNTP) Approval	0 days	Wed 1/4/12	Wed 1/4/12	As Soon As Possible
7	Project Full Notice to proceed (NTP)	0 days	Tue 1/10/12	Tue 1/10/12	As Soon As Possible
8	**Request for Proposal (RFP) - Engineer/Procure/Construct (I**	**90 days**	**Thu 1/5/12**	**Wed 5/9/12**	**As Soon As Possible**
9	Prepare	30 days	Thu 1/5/12	Wed 2/15/12	As Soon As Possible
10	Bid	30 days	Thu 2/16/12	Wed 3/28/12	As Soon As Possible
11	Award	30 days	Thu 3/29/12	Wed 5/9/12	As Soon As Possible
12	**RFP for Power Turbine Disc Manufacture**	**60 days**	**Thu 12/8/11**	**Wed 2/29/12**	**As Soon As Possible**
13	Prepare	20 days	Thu 12/8/11	Wed 1/4/12	As Soon As Possible
14	Bid	20 days	Thu 1/5/12	Wed 2/1/12	As Soon As Possible
15	Award	20 days	Thu 2/2/12	Wed 2/29/12	As Soon As Possible
16	**Power Turbine**	**195 days**	**Tue 5/8/12**	**Mon 2/4/13**	**As Soon As Possible**
17	Procure Lease Disc and PT Assembly	4 wks	Thu 5/24/12	Wed 6/20/12	As Soon As Possible
18	Refurbish PT Replacement	5 wks	Thu 6/21/12	Wed 7/25/12	As Soon As Possible
19	Manufacture NEW PT Disc	30 wks	Tue 5/8/12	Mon 12/3/12	As Late As Possible
20	Strip and dissassemble plant	1 wk	Tue 5/29/12	Mon 6/4/12	As Soon As Possible
21	Rebuild and commission unit - Lease part	3 wks	Thu 7/26/12	Wed 8/15/12	As Soon As Possible
22	Ship Rotor to overhaul plant	5 wks	Tue 10/16/12	Mon 11/19/12	As Late As Possible
23	Overhaul and balance Rotor	4 wks	Tue 11/20/12	Mon 12/17/12	As Late As Possible
24	Ship Rotor to Holyrood	5 wks	Tue 12/18/12	Mon 1/21/13	As Soon As Possible
25	Replace lease part, rebuild and commission unit	2 wks	Tue 1/22/13	Mon 2/4/13	As Soon As Possible
26	**Gear Box Overhaul**	**85 days**	**Tue 5/29/12**	**Mon 9/24/12**	**As Soon As Possible**
27	Strip and dissassemble plant	1 wk	Tue 5/29/12	Mon 6/4/12	As Soon As Possible
28	Ship to overhaul plant	5 wks	Tue 6/5/12	Mon 7/9/12	As Soon As Possible
29	Overhaul and balance Rotor	4 wks	Tue 7/10/12	Mon 8/6/12	As Soon As Possible
30	Ship to Holyrood	5 wks	Tue 8/7/12	Mon 9/10/12	As Soon As Possible
31	Rebuild and commission unit	2 wks	Tue 9/11/12	Mon 9/24/12	As Soon As Possible
32	**Avon Gas Generator Overhaul**	**183 days**	**Thu 5/24/12**	**Mon 2/4/13**	**As Soon As Possible**
33	Procure Lease Disc and PT Assembly	4 wks	Thu 5/24/12	Wed 6/20/12	As Soon As Possible
34	Refurbish PT Replacement	5 wks	Thu 6/21/12	Wed 7/25/12	As Soon As Possible
35	Strip and dissassemble plant	1 wk	Thu 7/19/12	Wed 7/25/12	As Soon As Possible
36	Rebuild and commission unit - Lease part	3 wks	Thu 7/26/12	Wed 8/15/12	As Soon As Possible
37	Ship Rotor to overhaul plant	5 wks	Tue 10/16/12	Mon 11/19/12	As Late As Possible
38	Overhaul and balance Rotor	4 wks	Tue 11/20/12	Mon 12/17/12	As Late As Possible
39	Ship Rotor to Holyrood	5 wks	Tue 12/18/12	Mon 1/21/13	As Soon As Possible
40	Replace lease part, rebuild and commission unit	2 wks	Tue 1/22/13	Mon 2/4/13	As Soon As Possible
41	**Generator Rewind**	**49 days**	**Thu 5/24/12**	**Tue 7/31/12**	**As Soon As Possible**
42	Strip and dissassemble plant	2 days	Thu 5/24/12	Fri 5/25/12	As Soon As Possible
43	Ship Rotor to overhaul plant	2 wks	Mon 5/28/12	Fri 6/8/12	As Soon As Possible





ID	Task Name	Duration	Start	Finish	Constraint Type
44	Overhaul, rewind, and balance Rotor	4 wks	Mon 6/11/12	Fri 7/6/12	As Soon As Possible
45	Ship Rotor to Holyrood	2 wks	Mon 7/9/12	Fri 7/20/12	As Soon As Possible
46	Rebuild and commission unit	7 days	Mon 7/23/12	Tue 7/31/12	As Soon As Possible
47	**Exhaust Stack**	**188 days**	**Thu 5/24/12**	**Mon 2/11/13**	**As Soon As Possible**
48	Remove	3 days	Thu 5/24/12	Mon 5/28/12	As Soon As Possible
49	Repair/Replace	4 wks	Tue 5/29/12	Mon 6/25/12	As Soon As Possible
50	Re-install	5 days	Thu 7/26/12	Wed 8/1/12	As Soon As Possible
51	Commission unit	1 day	Thu 8/2/12	Thu 8/2/12	As Soon As Possible
52	Remove new stack	3 days	Wed 1/30/13	Fri 2/1/13	As Late As Possible
53	Re-install	5 days	Mon 2/4/13	Fri 2/8/13	As Late As Possible
54	Commission unit	1 day	Mon 2/11/13	Mon 2/11/13	As Soon As Possible
55	**Intake media**	**65 days**	**Thu 5/24/12**	**Wed 8/22/12**	**As Soon As Possible**
56	Order & Manufacture Filter media	12 wks	Thu 5/24/12	Wed 8/15/12	As Soon As Possible
57	Remove	2 days	Thu 8/16/12	Fri 8/17/12	As Soon As Possible
58	Repair/Replace	2 days	Mon 8/20/12	Tue 8/21/12	As Soon As Possible
59	Commission unit	1 day	Wed 8/22/12	Wed 8/22/12	As Soon As Possible
60	**Fuel System Refurbishments**	**144 days**	**Thu 5/24/12**	**Tue 12/11/12**	**As Soon As Possible**
61	Engineer	12 wks	Thu 5/24/12	Wed 8/15/12	As Soon As Possible
62	Order, Manufacture, Deliver	12 wks	Thu 8/16/12	Wed 11/7/12	As Soon As Possible
63	Remove	2 days	Thu 11/8/12	Fri 11/9/12	As Soon As Possible
64	Repair/Replace	4 wks	Mon 11/12/12	Fri 12/7/12	As Soon As Possible
65	Commission unit	2 days	Mon 12/10/12	Tue 12/11/12	As Soon As Possible
66	**Electrical & Control Systmes**	**163 days**	**Thu 5/24/12**	**Mon 1/7/13**	**As Soon As Possible**
67	Engineer	12 wks	Thu 5/24/12	Wed 8/15/12	As Soon As Possible
68	Order & Manufacture Elect & Control Equip	26 wks	Thu 6/21/12	Wed 12/19/12	As Soon As Possible
69	GT Building Addition	12 wks	Thu 8/16/12	Wed 11/7/12	As Soon As Possible
70	Remove Existing	4 days	Thu 12/20/12	Tue 12/25/12	As Soon As Possible
71	Install New System	7 days	Wed 12/26/12	Thu 1/3/13	As Soon As Possible
72	Commission unit	2 days	Fri 1/4/13	Mon 1/7/13	As Soon As Possible
73	**Building & Systmes**	**122 days**	**Thu 5/24/12**	**Fri 11/9/12**	**As Soon As Possible**
74	Engineer	12 wks	Thu 5/24/12	Wed 8/15/12	As Soon As Possible
75	Modify and Refurbish	7 days	Tue 10/30/12	Wed 11/7/12	As Soon As Possible
76	Commission unit	2 days	Thu 11/8/12	Fri 11/9/12	As Soon As Possible
77	Complete Unit Test - Lease Parts	5 days	Tue 2/5/13	Mon 2/11/13	As Soon As Possible
78	Complete Unit Test - Original Replacement	5 days	Tue 2/5/13	Mon 2/11/13	As Soon As Possible
79	Gas Turbine (GT) In-service (I/S) - Lease Parts	0 days	Mon 2/11/13	Mon 2/11/13	As Soon As Possible
80	Gas Turbine (GT) In-service (I/S) - Original	0 days	Mon 2/11/13	Mon 2/11/13	As Soon As Possible
81	**UNIT OUTAGE -Lease Parts**	**188 days**	**Thu 5/24/12**	**Mon 2/11/13**	**As Soon As Possible**
82	Unit Outage Start	0 days	Thu 5/24/12	Thu 5/24/12	As Soon As Possible
83	Unit Outage End	0 days	Mon 2/11/13	Mon 2/11/13	As Soon As Possible
84	**UNIT OUTAGE - Original**	**9 days**	**Wed 1/30/13**	**Mon 2/11/13**	**As Soon As Possible**
85	Unit Outage Start	0 days	Wed 1/30/13	Wed 1/30/13	As Soon As Possible
86	Unit Outage End	0 days	Mon 2/11/13	Mon 2/11/13	As Soon As Possible



Project: Project1 Exist & Repla Lease
Date: Mon 8/29/11

Critical | Critical Split | Critical Progress | Task | Split | Task Progress | Baseline | Baseline Split | Baseline Milestone | Milestone | Summary Progress | Summary | Project Summary | External Tasks | External Milestone | Deadline

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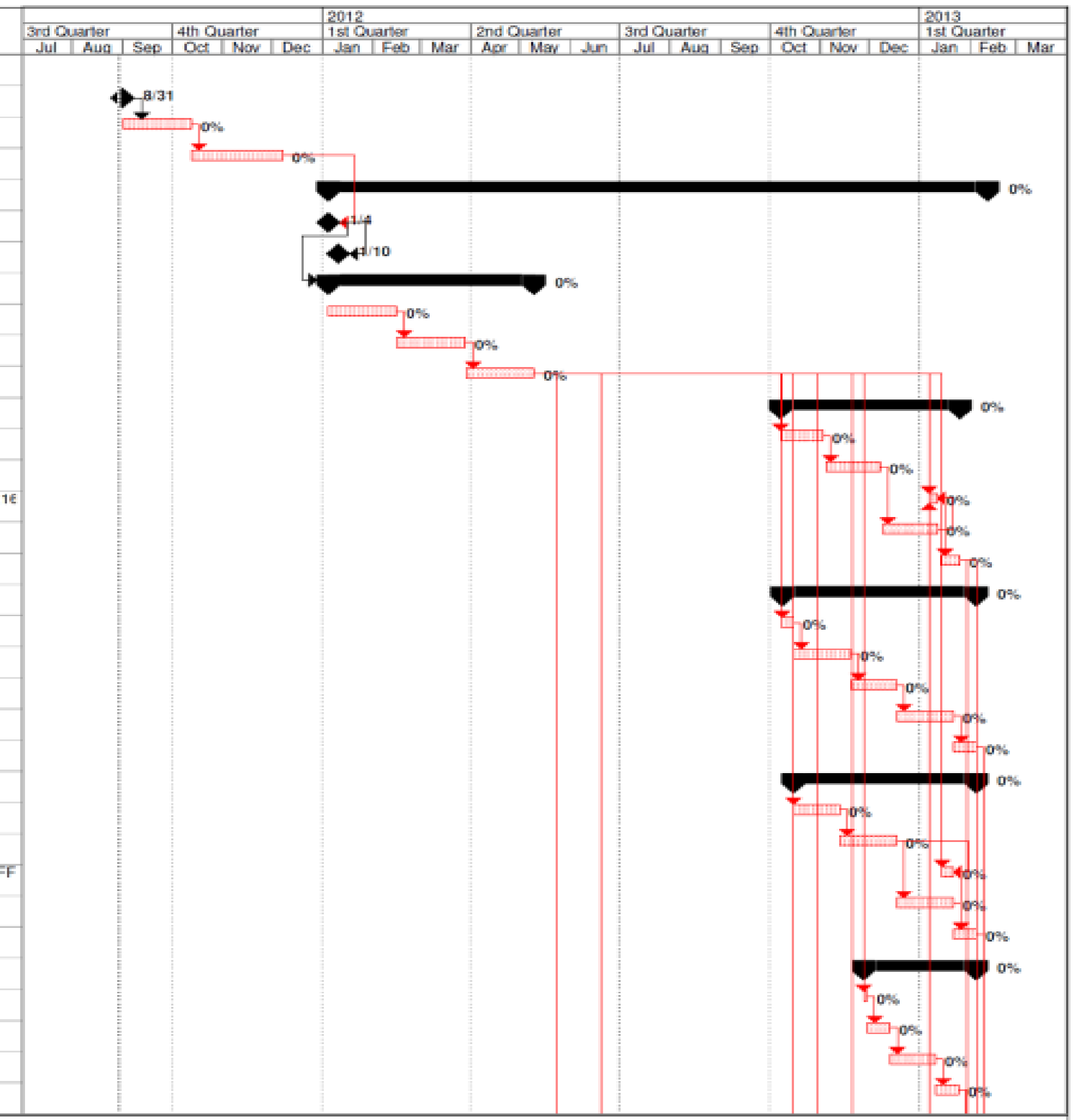
Figure 2-11 presents a third variation of the basic “earliest return to service” schedule for the existing GTG unit refurbishment. It assumes the purchase and refurbishment for use of used replacements parts for the existing GT unit (the gas generator, the power turbine) to minimize the outage window. Its in-service date is February 2013, but with an outage window of only four months from November 2012 to February 2013. The outage also occurs when Holyrood is normally required to operate, and the actual schedule would likely be shifted six months to allow for a May 2013 to August 2013 outage and August 2013 in-service.

FIGURE 2-11 EXISTING GTG REFURBISHMENT – ALTERNATE SCHEDULE 3 (USE OF PROCURED AND REFURBISHED GAS GENERATOR AND POWER TURBINE DURING OUTAGE)

ID		Task Name	Duration	Start	Finish	Constraint Type	Predecessors
1							
2		Condition Assessment Study	0 wks	Wed 8/31/11	Wed 8/31/11	Finish No Earlier Than	
3		Hydro Internal Capital Budget Proposal Development	6 wks	Thu 9/1/11	Wed 10/12/11	As Soon As Possible	2
4		Submission - Public Utilities Board & Approval	8 wks	Thu 10/13/11	Wed 12/7/11	As Soon As Possible	3
5		**Refurbish Unit**	**288 days**	**Wed 1/4/12**	**Mon 2/11/13**	**As Soon As Possible**	
6		Project Limited Notice to proceed (LNTP) Approval	0 days	Wed 1/4/12	Wed 1/4/12	As Soon As Possible	4FF+4 wks
7		Project Full Notice to proceed (NTP)	0 days	Tue 1/10/12	Tue 1/10/12	As Soon As Possible	6FF+4 days
8		**Request for Proposal (RFP) - Engineer/Procure/Co**	**90 days**	**Thu 1/5/12**	**Wed 5/9/12**	**As Soon As Possible**	6
9		Prepare	30 days	Thu 1/5/12	Wed 2/15/12	As Soon As Possible	
10		Bid	30 days	Thu 2/16/12	Wed 3/28/12	As Soon As Possible	9
11		Award	30 days	Thu 3/29/12	Wed 5/9/12	As Soon As Possible	10
12		**Power Turbine (PT)**	**80 days**	**Mon 10/8/12**	**Fri 1/25/13**	**As Soon As Possible**	
13		Procure Refurbished Disc and PT Assembly	4 wks	Mon 10/8/12	Fri 11/2/12	As Late As Possible	11
14		Refurbish PT Replacement	5 wks	Mon 11/5/12	Fri 12/7/12	As Late As Possible	13
15		Strip and dissassemble plant	1 wk	Mon 1/7/13	Fri 1/11/13	As Late As Possible	37,11FS+2 wks,1
16		Ship Rotor to Holyrood	5 wks	Mon 12/10/12	Fri 1/11/13	As Soon As Possible	14
17		Rebuild and commission unit	2 wks	Mon 1/14/13	Fri 1/25/13	As Soon As Possible	16,15
18		**Gear Box Overhaul**	**85 days**	**Tue 10/9/12**	**Mon 2/4/13**	**As Soon As Possible**	
19		Strip and dissassemble plant	1 wk	Tue 10/9/12	Mon 10/15/12	As Late As Possible	11FS+4 wks
20		Ship to overhaul plant	5 wks	Tue 10/16/12	Mon 11/19/12	As Late As Possible	19
21		Overhaul and balance Rotor	4 wks	Tue 11/20/12	Mon 12/17/12	As Late As Possible	20
22		Ship to Holyrood	5 wks	Tue 12/18/12	Mon 1/21/13	As Soon As Possible	21
23		Rebuild and commission unit	2 wks	Tue 1/22/13	Mon 2/4/13	As Soon As Possible	22
24		**Avon Gas Generator Overhaul**	**80 days**	**Tue 10/16/12**	**Mon 2/4/13**	**As Soon As Possible**	
25		Procure Refurbished Disc and PT Assembly	4 wks	Tue 10/16/12	Mon 11/12/12	As Late As Possible	11
26		Refurbish PT Replacement	5 wks	Tue 11/13/12	Mon 12/17/12	As Late As Possible	25
27		Strip and dissassemble plant	1 wk	Tue 1/15/13	Mon 1/21/13	As Late As Possible	11FS+2 wks,26FF
28		Ship Rotor to Holyrood	5 wks	Tue 12/18/12	Mon 1/21/13	As Soon As Possible	26
29		Rebuild and commission unit	2 wks	Tue 1/22/13	Mon 2/4/13	As Soon As Possible	28,27
30		**Generator Rewind**	**49 days**	**Wed 11/28/12**	**Mon 2/4/13**	**As Soon As Possible**	
31		Strip and dissassemble plant	2 days	Wed 11/28/12	Thu 11/29/12	As Late As Possible	11FS+2 wks
32		Ship Rotor to overhaul plant	2 wks	Fri 11/30/12	Thu 12/13/12	As Late As Possible	31
33		Overhaul, rewind, and balance Rotor	4 wks	Fri 12/14/12	Thu 1/10/13	As Late As Possible	32
34		Ship Rotor to Holyrood	2 wks	Fri 1/11/13	Thu 1/24/13	As Soon As Possible	33



Project: Project1 Exist Repla GT parts
Date: Mon 8/29/11

Critical | Task | Baseline | Milestone | Project Summary | Deadline
Critical Split | Split | Baseline Split | Summary Progress | External Tasks
Critical Progress | Task Progress | Baseline Milestone | Summary | External Milestone

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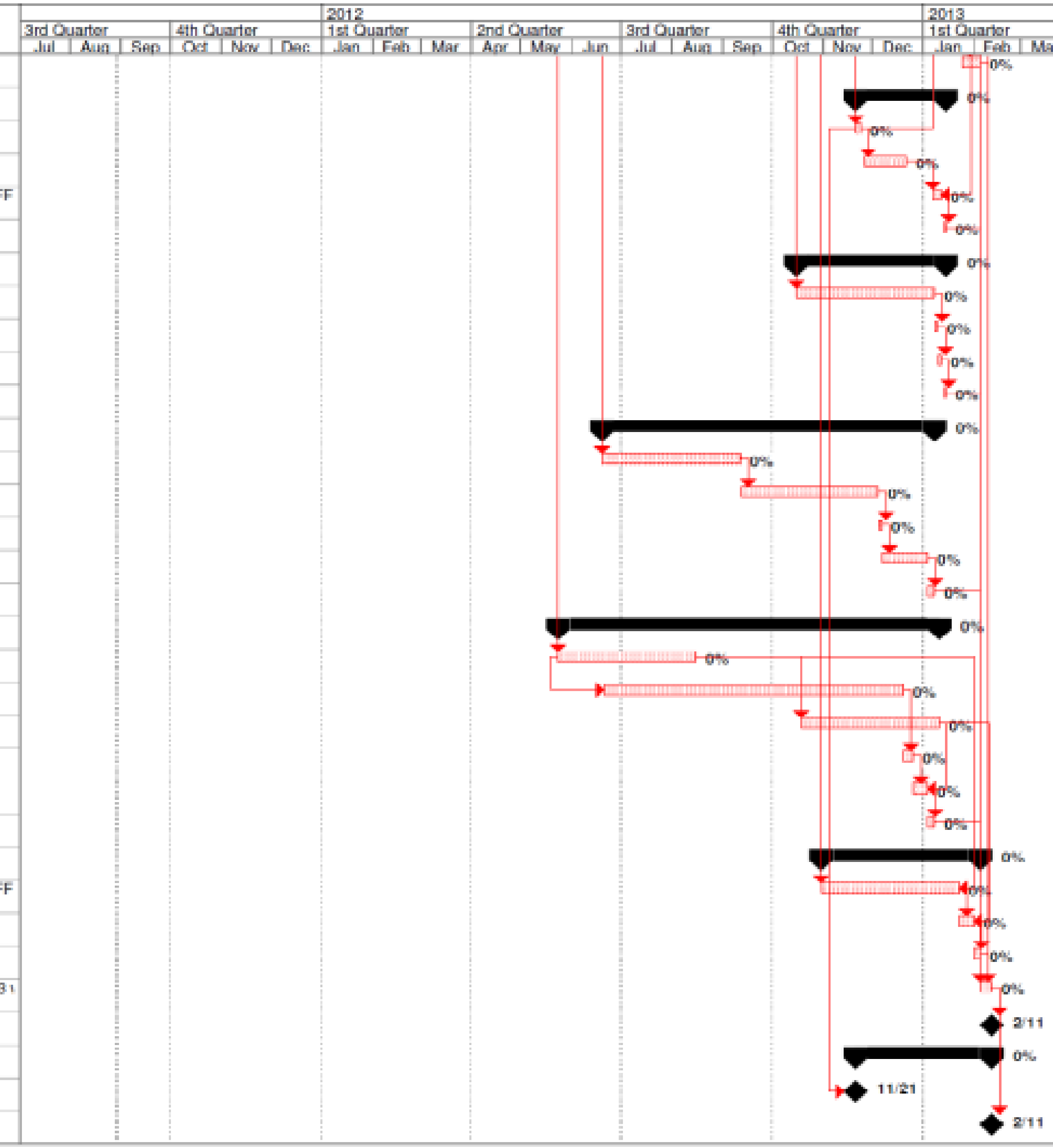
Newfoundland and Labrador Hydro a NALCOR Energy Co.
Holyrood Thermal Generating Station
Gas Turbine Condition Assessment & Options Study

ID		Task Name	Duration	Start	Finish	Constraint Type	Predecessors
35		Rebuild and commission unit	7 days	Fri 1/25/13	Mon 2/4/13	As Soon As Possible	34
36		**Exhaust Stack**	**39 days**	**Wed 11/21/12**	**Mon 1/14/13**	**As Soon As Possible**	
37		Remove	3 days	Wed 11/21/12	Fri 11/23/12	As Late As Possible	11FS+2 wks
38		Repair/Replace	4 wks	Mon 11/26/12	Fri 12/21/12	As Late As Possible	37
39		Re-install	5 days	Mon 1/7/13	Fri 1/11/13	As Late As Possible	38FS+2 wks,17FF
40		Commission unit	1 day	Mon 1/14/13	Mon 1/14/13	As Soon As Possible	39
41		**Intake media**	**65 days**	**Tue 10/16/12**	**Mon 1/14/13**	**As Soon As Possible**	
42		Order & Manufacture Filter media	12 wks	Tue 10/16/12	Mon 1/7/13	As Late As Possible	11FS+2 wks
43		Remove	2 days	Tue 1/8/13	Wed 1/9/13	As Late As Possible	42
44		Repair/Replace	2 days	Thu 1/10/13	Fri 1/11/13	As Late As Possible	43
45		Commission unit	1 day	Mon 1/14/13	Mon 1/14/13	As Soon As Possible	44
46		**Fuel System Refurbishments**	**144 days**	**Wed 6/20/12**	**Mon 1/7/13**	**As Soon As Possible**	
47		Engineer	12 wks	Wed 6/20/12	Tue 9/11/12	As Late As Possible	11FS+2 wks
48		Order, Manufacture, Deliver	12 wks	Wed 9/12/12	Tue 12/4/12	As Late As Possible	47
49		Remove	2 days	Wed 12/5/12	Thu 12/6/12	As Late As Possible	48
50		Repair/Replace	4 wks	Fri 12/7/12	Thu 1/3/13	As Late As Possible	49
51		Commission unit	2 days	Fri 1/4/13	Mon 1/7/13	As Soon As Possible	50
52		**Electrical & Control Systmes**	**166 days**	**Thu 5/24/12**	**Thu 1/10/13**	**As Soon As Possible**	
53		Engineer	12 wks	Thu 5/24/12	Wed 8/15/12	As Late As Possible	11FS+2 wks
54		Order & Manufacture Elect & Control Equip	26 wks	Thu 6/21/12	Wed 12/19/12	As Late As Possible	53SS+4 wks
55		GT Building Addition	12 wks	Fri 10/19/12	Thu 1/10/13	As Late As Possible	53
56		Remove Existing	4 days	Thu 12/20/12	Tue 12/25/12	As Late As Possible	54
57		Install New System	7 days	Wed 12/26/12	Thu 1/3/13	As Late As Possible	56,55FF-1 wk
58		Commission unit	2 days	Fri 1/4/13	Mon 1/7/13	As Soon As Possible	57
59		**Building & Systems**	**69 days**	**Wed 10/31/12**	**Mon 2/4/13**	**As Soon As Possible**	
60		Engineer	12 wks	Wed 10/31/12	Tue 1/22/13	As Late As Possible	11FS+2 wks,53FF
61		Modify and Refurbish	7 days	Wed 1/23/13	Thu 1/31/13	As Late As Possible	60,55FF
62		Commission unit	2 days	Fri 2/1/13	Mon 2/4/13	As Soon As Possible	61
63		Complete Unit Test	5 days	Tue 2/5/13	Mon 2/11/13	As Soon As Possible	29,35,17,40FS+3 ι
64		Gas Turbine (GT) In-service (I/S)	0 days	Mon 2/11/13	Mon 2/11/13	As Soon As Possible	63
65		**UNIT OUTAGE**	**59 days**	**Wed 11/21/12**	**Mon 2/11/13**	**As Soon As Possible**	
66		Unit Outage Start	0 days	Wed 11/21/12	Wed 11/21/12	As Soon As Possible	37SS
67		Unit Outage End	0 days	Mon 2/11/13	Mon 2/11/13	As Soon As Possible	63



Project: Project1 Exist Repla GT parts
Date: Mon 8/29/11

Critical | Critical Split | Critical Progress | Task | Split | Task Progress | Baseline | Baseline Split | Baseline Milestone | Milestone | Summary Progress | Summary | Project Summary | External Tasks | External Milestone | Deadline

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2.9 Annual OMA Cost Estimate to 2020

2.9.1 Historical OMA

Historical operations, maintenance and administration (OMA) data was obtained from the station cost database for the period 2000 to 2011. Information prior to that was not available. Also provided were several recent purchase order invoices from Alba Power for recent boroscope and physical inspections that are assumed to be included in the work order totals, but which may be somewhat out of synchronization. Copies of the "Cost Report by Work Order/Asset" are attached in Appendix 3.

TABLE 2-32 HISTORICAL OMA COST ASSUMPTIONS

OMA

	Maintenance		Fueling	Ops	Total
Year	Work Order k$/Yr OMA	PO Data k$/Yr OMA	k$/Yr Fuel	PO Data k$/Yr OMA	Work Order k$/Yr OMA
2000-2002	$10				
2003	$14		$37	$33	$83
2004	$31		$37	$33	$100
2005	$19		$37	$33	$89
2006	$129	$100	$201	$59	$388
2007	$34	$74	$201	$59	$293
2008	$45	$15	$201	$59	$304
2009	$283	$182	$201	$59	$542
2010	$45	$50	$201	$59	$304
2011	$182		$22	$8	$212
Av/Yr Hist	$68	$84	$126	$44	$257

Most of the historical costs are for relatively minor repairs and do not include major changes such as controls change outs or other major capital modifications. These major costs are not particularly relevant to the OMA analyses going forward.

Several interesting issues arose during the period:

- Ice and snow blockage of parts of lube oil cooler and fuel oil system (led to enclosure of pumps and filters) identified beginning in 2004 and beyond
- GT generator vibration checks (issue) in 2007
- Leak and pressure check on GT gearbox in 2006. Filter not cleaned regularly. Issue in 2003 (last cleaned filter). Fittings change. Gearbox drain valve change -
- Modify/Addition of gear box lube oil vent to relieve pressure in 2007 and 2008
- Lube oil at gearbox cleanup in 2008, 2009, Attempt to fix by Alba 2010; Increase generator end gearbox bearing drain. Fire 2010/2011.
- Several issues in recent years with snow doors operation and rusting, annual checks done
- 2008 lube oil radiator leak

Several major systems had been replaced/modified: controls (twice), gearbox seals, lube oil radiator

2.9.2 Estimated Future OMA

Operating and maintenance (O&M) costs going forward for completely refurbished or new units are not significantly relevant given their level of operation. Most such O&M costs will be for ongoing annual inspection costs. Significant maintenance costs as have been seen recently with the existing unit should not occur if regular inspection and maintenance is undertaken. For completeness, the costs were assumed to include the ongoing maintenance costs (annual inspections, repairs, etc.), the operations costs (costs to run the unit on test), the fuelling costs (fuel costs to run the tests), and an electricity value credit.

The operating costs are shown for both a refurbished case and a non-refurbished case. The assumptions used for fuel, operations, and electricity value are illustrated in Table 2-33. The "electricity value" is a revenue stream premised on recovering fuelling costs plus marginal operating and maintenance costs. The maintenance costs are based on historical maintenance data and information from vendors. The fuelling and electricity prices are intended as representative and based on running the units 150 hours per year, whereas actual hours could be as half of this.. The actual values (average run capacity, sent out heat rate (SOHR) and hence fuel and electricity depend on how the testing is actually done.

TABLE 2-33 EXISTING GTG – FUTURE OMA COST ASSUMPTIONS

Assumptions

		Fuelling
#2 Oil Fuel Price (A)	$/MMBTU	$21.47
Unit Efficiency (B)	BTU/kWh	13,656
Average Running Capacity (C)	MW	4
Average Running Cost (D) = AxBxC/1000	$/Hr	$1,173
Electricity Value (E) = AxB/1000 + $50 Mtce	$/MWh	$343
Electricity Value (F) = E*C	$/Hr OP	$1,373

Operations	
2	Persons/Start (U)
4	Hrs/Start (V)
$70	$/PersonHr (W)
$560	$/Start (Z) = UxVxW

The following OMA costs have been assumed going forward. The non-refurbished case includes an assumption of an equipment failure with modest consequential damage in 2016. "Electricity value" is a revenue stream for electricity sold during testing.

TABLE 2-34 EXISTING GTG – FUTURE OMA COSTS

Existing Unit
1000's Cnd $ - 2011/Yr

	Maintenance		Operations		Fuelling		Sub-Total		Electricity Value		Total	
	With Rehab	Without Rehab	With Rehab	Without Rehab	With Rehab	Without Rehab	With Rehab	Without Rehab	With Rehab	Without Rehab	With Rehab	Without Rehab
2012	$15	$15	$0	$0	$0	$0	$15	$15	$0	$0	$15	$15
2013	$20	$15	$40	$0	$176	$0	$236	$15	($206)	$0	$30	$15
2014	$20	$15	$40	$0	$176	$0	$236	$15	($206)	$0	$30	$15
2015	$20	$15	$40	$0	$176	$0	$236	$15	($206)	$0	$30	$15
2016	$20	$1,500	$40	$1	$176	$88	$236	$1,589	($206)	($103)	$30	$1,486
2017	$20	$15	$40	$0	$176	$0	$236	$15	($206)	$0	$30	$15
2018	$20	$15	$40	$0	$176	$0	$236	$15	($206)	$0	$30	$15
2019	$20	$15	$40	$0	$176	$0	$236	$15	($206)	$0	$30	$15
2020	$0	$0	$40	$0	$176	$0	$216	$0	($206)	$0	$10	$0
TOTAL	$155	$1,605	$323	$1	$1,408	$88	$1,885	$1,694	($1,648)	($103)	$238	$1,591

The actual maintenance costs going forward can be expected to vary widely and could easily be twice those noted, depending on the actual operation of the unit. The costs for operations and for fuel, as well as fuel value are comparable in value or larger.

3 TASK B – REPLACEMENT OPTIONS ASSESSMENT

3.1 Task Details

Mobile/transportable GT and diesel generators were evaluated for their ability to provide Holyrood Thermal Generating Station with black start capability until the year 2020. Following 2020, it is expected the Holyrood plant will no longer be operating as a generating facility**.** The mobile/transportable gas turbine and diesel generators would be available post-2020 for other temporary power uses within NL Hydro's system, and possibly for similar uses prior to 2020 as warranted.

3.2 Assessment Basis

The assessment will be based on an evaluation of Hydro and vendor supplied information regarding the existing Holyrood infrastructure, and new or nearly new transportable power generation units which will either be GT or diesel.

TABLE 3-1 ASSESSMENT CRITERIA

Criteria	Description
Generator	1) Gas Turbine Gen Set 5 MW X 2 – new or nearly new/used 2) Diesel Gen Set 2 MW X5 – new or nearly new/used
Transportability	Transportability - system must be capable of being set up within a week, to ensure that the system can be used elsewhere as needed, particularly after its service has ended at Holyrood. Must comply with local road regulations.
Footprint	Minimize space site requirement of the generator. Set selected must be able to fit on the parking lot adjacent to the emergency response building. This site was selected through discussions with Nalcor personnel.
Electrical output	The system must be able to generate at 13.8 KV, combined system output to be approximately 10 MW peak, with a block load of about 3 to 3.5 MW.
Black Start	Systems must be capable of black start function for the plant and require no more than 600 volt 316 kW for black start
Fuel Type	Must use No. 2 fuel oil
Site Preparation	Unit trailers must be self levelling and require no concrete foundation.
Certification	CSA Certification
Emissions	**Diesel Gensets**: The equipment is assumed to be classified as stationary. The province has jurisdiction, and all existing regulations apply. (In Ontario, the generally accepted practice is that a unit is considered to be stationary if it remains within the same municipal boundaries for 12 continuous months regardless if it's mounted on wheels or not.) Regulations require a dispersion model be prepared to demonstrate compliance with regulations of ground level concentrations of pollutants at the property boundaries or nearest critical receptor. The key parameter is oxides of nitrogen (NOx) and the permitted concentration limit is, for non-emergency generation,

	400 micro-grams per cubic meter of air. The emergency generator limit permitted in NL is not readily identifiable (Ontario NO_x concentration limit for emergency generators is 1880 mg/m3 of air). Newfoundland & Labrador air emissions regulations do require Best Available Control Technology (BACT), but provide for reasonable economics and also for Ministerial exemptions. This would need to be addressed in environmental regulatory approvals. **GT Gensets:** Canadian Council of Ministers of the Environment (CCME) 1992 National Emission Guidelines for Stationary Combustion Turbines may be followed. They do not apply to "Emergency" or "Standby GT" (a unit not normally required for the supply of energy or motive power to meet normal system operational requirements. A "Peaking GT" is a unit ordinarily used to supply electric or motive power in periods of high demand but typically has restricted hours (<3000 hours over 5 years in summer; <7500 hours over 5 years total). The GT Emission Guideline values for diesel fuel are as follows. These units may, however, still have to meet ground level concentration limits, assumed to be 400 ug/m^3 of air, based on dispersion modeling. Peaking Emergency NO_X 530 g/GJ Exempt Notes: g/GJ = grams of NOx as nitrogen dioxide (NO2) per gigajoule (GJ) of net electrical energy output (where 1 megawatthour (MWh) of electricity = 3.6 GJ. AMEC has assessed the diesel emission regulations and considers that the installation would be considered a "stationary source". It is likely to also be considered an emergency unit.

3.3 Options 2 – 2 x 5 MW GT (New, Nearly-New)

3.3.1 Description

In this option, two 5 MW units would be utilized to provide black start capability. Sizing at 5 MW each would allow the units to be more transportable than larger units. Both units would be required to operate simultaneously to provide sufficient power for black start. Vendor information was received from TOROMONT CAT, PETERSON Power Systems CAT, Solar Turbines, and Rolls Royce/Allison Turbine.

These will be mobile units supplied by a vendor and will not require a GT building. Several items will however be required, such as:

- Turbine trailers area with site work to ensure sufficient ground support for the mobile turbines.
- A pre-engineered shelter for electrical equipment, including concrete foundation and floor slab. Approximately 30 ft x 30 ft.
- A reinforced concrete pipe/trench for cables running from the turbines to the main building and from the turbines to the existing fuel lines.
- Electrical and I&C connections to the existing plant facilities

3.3.2 Performance Characteristics

The performance characteristics are based on information from Solar Turbines Taurus 60, (**APPENDIX 4).** Vendors are Peterson, Toromont, and Solar. Peterson also sells used Taurus 60 gen packages.

TABLE 3-2 TURBINE PERFORMANCE CRITERIA

Criteria	Value
KW Gross Output @ ISO Conditions	5,510kW
Voltage	13.8 KV
Site Ambient Temperature for Performance Analysis:	15 C (59 F)
Site Elevation for Performance Analysis:	320 Feet
Site Ambient Relative Humidity for Performance Analysis:	60%
Turbine Inlet Pressure Loss:	4” H20 (inches of water gauge pressure)
Turbine Outlet Pressure Loss:	4”H20
Turbine Fuel Consumption @ specified site conditions (Lower Heating value(LHV)	59 MBTU/hr (Millions of British Thermal Units Per Hour)
KW Gross Output @ specified site conditions:	5,301 kW
Turbine Auxiliary Power Consumption:	15 kW
Net Turbine Power Production	5,286 kW
Black Start kW Requirement (Turbine Generator Set Only)	A 250kW, 480VAC, 3 phase, Black Start Generator is required for turbine starting in the event 13.8kV power is not available.
Fuel Consumption	8.0 gallons per minute (gpm) (30 Liters/min (L/min)). This implies for black start with two units running there would be a total of 16 gpm (60 L/min) and assuming a 24 hour period would require almost 24,000 gallons (90,849 L) of fuel. The current fuel oil tanks as previously noted are 26,417 gallons (100,000 L) each.
Inlet Filter Media	Suitable for Marine Environment

3.3.2.1 Emission Requirements

For a peaking GT unit on oil emission limits would be:

NO_x (Oxides of Nitrogen (NO,NO_2):	530 g (NO_x as NO_2)/ GJ electric energy (1 MWh = 3.6 GJ).
SO_2 (Sulphur dioxide):	970 g SO_2/GJ of electric output. Current 0.2% sulphur (S) in oil (specification) = approximately1572 grams as NO_2/GJ output
CO (Carbon Monoxide):	50 ppm at full load (corrected to 15% O2, dry basis)

Operating time limits could be placed on peaking units. An emergency unit for black start only might be exempt, but could thereby limit its future.

No specific GT applicable Newfoundland air pollution regulations were identified. There is however a general requirement for Best Available Control Technology (BACT), with provisions for an exemption based on economics and on a Ministerial exemption for practical purposes. The typical emission performance for Solar GT units on diesel oil is presented in Table 3-3.

TABLE 3-3 SOLAR GT TYPICAL EMISSIONS

Exhaust Emissions At Stack (Solar)	Measurement	Per Unit
NO_x	parts per million (ppm) @ 15% O2 in flue gas	74
	lb/MMBTU, HHV (Pounds/Million BTU, Higher Heating Value)	0.284
	Pounds/Hour (lb/hr)	17.8
	tons/year	78
CO (Carbon Monoxide)	ppm @ 15% O2	25
	lb/MMBTU, HHV	0.058
	lb/hr	3.7
	tons/year	16
UHC (Unburnt Hydrocarbons	ppm @ 15% O2	25
	lb/MMBTU, HHV	0.033
	lb/hr	2.1
	tons/year	9.2
VOC Volatile Organic Compounds	ppm @ 15% O2	25
	lb/MMBTU, HHV	0.033
	lb/hr	2.1
	tons/year	9.2
$PM_{10}/PM_{2.5}$ (Particulate Matter – Less than 10 and 2.5 microns in size)	lb/hr	2.4
	lb/MMBTU, HHV	0.039
	tons/year	10.7
SO_2	lb/hr	12.91
	lb/MMBTU, HHV	0.20555
	tons/year	56.5
Greenhouse Gas Emissions	lbs of carbon dioxide (CO_2)/MMBTU (HHV)	162

SO_2 emissions depend upon the fuel's sulfur content. The SO_2 estimate is based upon the assumption of 100% conversion of fuel sulphur to SO_2, using assumed values for various fuels that may not reflect actual fuel composition.

3.3.2.2 Transition

The existing GT system is to remain active while new system is independently installed. A short outage will be required during a transition period during which final connections to the electrical, instrumentation and controls, and fuel systems are made.

3.3.2.3 Decommissioning

The existing GT unit will be decommissioned, including those parts of the fuel system and electrical connections not required for the new units. This will occur once the new transportable units are in place and operational. A modified fuel offloading/receiving system will remain.

3.3.3 General Arrangement Sketch

See attached GA sketch based on dimensional information provided by Solar Turbines located in Appendix 4.

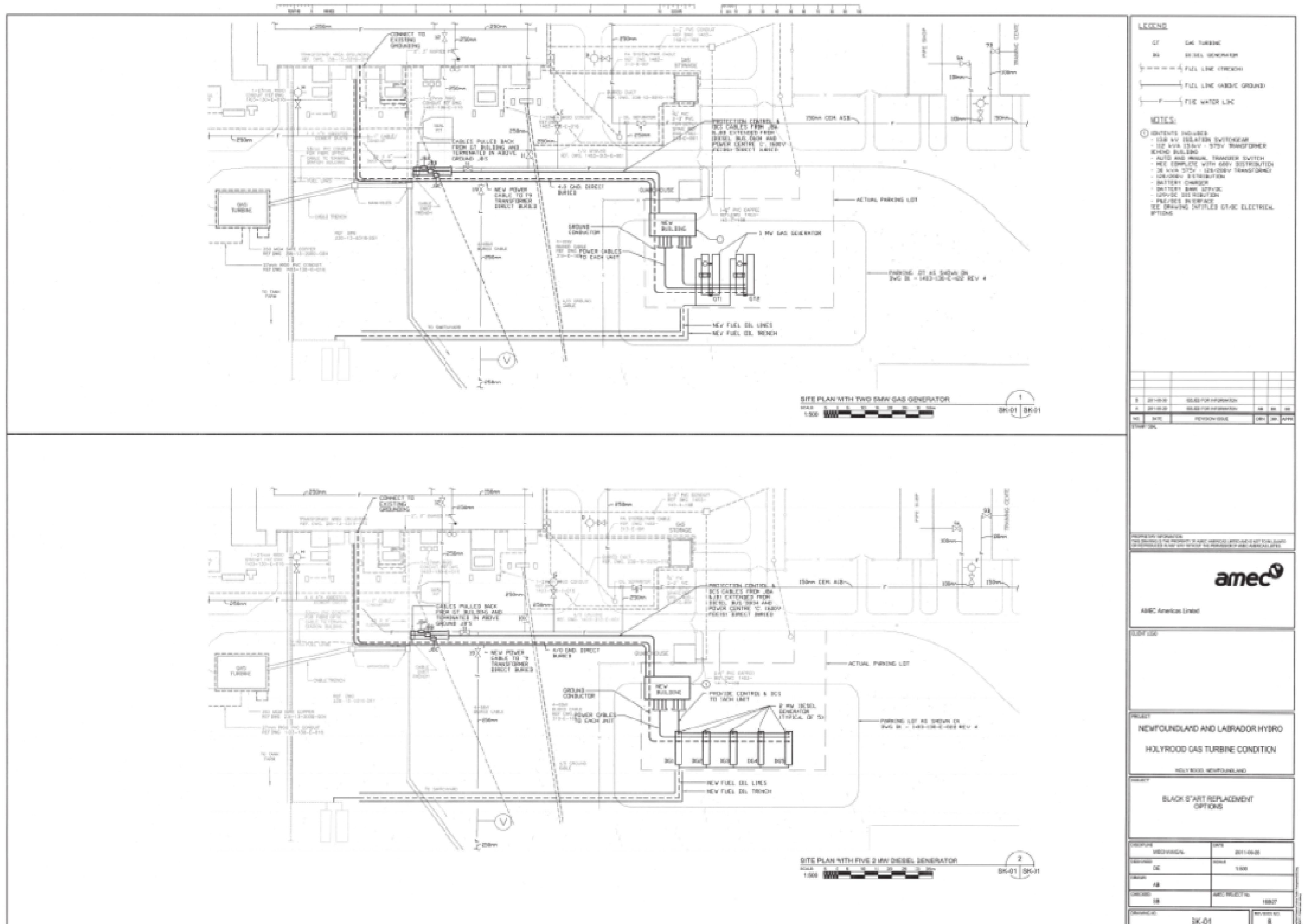


FIGURE 3-1 GENERAL ARRANGEMENT - 2 X 5 MW GAS TURBINE GENERATORS

3.3.4 Capital Cost Estimate

The following estimates are based on budgetary information provided by Solar Turbines (Details in Appendix 4) and Peterson Power Systems (Details in Appendix 5), and Rolls Royce (details in Appendix 6). Following a review of the vendor information, it appears that used units can be available much quicker than a new purchase. The vendors contacted noted that they did not typically have many of these systems available and that they are sold fairly quickly. On Power Inc who use the Rolls Royce 501 turbine noted that they have 4 units being refurbished for sale which may be able to convert to a mobile configuration. The price would be approximately $ 1 M less than a new package.

Note that Peterson Power Systems deals with the rental and sale of used Taurus mobiles whereas Solar Turbines deals with the sale only of new Taurus mobiles. Rolls Royce has indicated that they would require about 1 year for delivery.

There is not expected to be a significant difference in price between the New and Nearly New options, the advantage between these options is the possibility that a Nearly New set of units will be available and lead/delivery times are significantly reduced.

TABLE 3-4 SOLAR TURBINE QUOTE FOR NEW TRANSPORTABLE GTG

Item	Description	Unit Price	Quantity	Cost
1.	Liquid Fuel TAURUS 60-7901S Mobile Power Unit Turbine Generator Set (New) Solar Quote **APPENDIX 4**	$4,535,000.00	2	$9,070,000.00
2.	Commissioning Parts, Start-up, and Site Testing	$70,000	2	$140,000
3	Shipping	$92,100	2	$184,200
4	6% Balance of Plant Contingency	$5,500	2	$11,000
5	Estimation of cost per ISO rating kilowatt for selected equipment	$853		$0
6*	Training*	$9720	1	$29,160
7	Mobile Winterization Package (-40 C)	$219,000	2	$438,000
8	Marine Grade Inlet Air filter	$12,000	2	$24,000
				$9,896,360

- Duties and taxes not included in estimate.
- This quote is provided for budgetary purposes only and does not represent a firm quote.
- Based on Peterson rates.

TABLE 3-5 ROLLS ROYCE QUOTE FOR NEW TRANSPORTABLE GTG

Item	Description	Unit Price	Quantity	Cost
1.	Rolls Royce Allison 501-KB7 mobile GenSet, **APPENDIX 6**	$4,300,000.00	2	$8,600,000.00
2.	Commissioning Parts, Startup, and Site Testing	$70,00.00	2	$140,000.00
3	Shipping	$92,100.00	2	$184,200.00
4	6% Balance of Plant Contingency	$5,500.00	2	$11,000.00
5	Estimation of cost per ISO rating kilowatt for selected equipment	$853.00		$0.00
6	Training	$9720.00	3	$29,160.00
7	Mobile Winterization Package (-40 C)	$219,000.00	2	$438,000.00
8	Marine Grade Inlet Air filter	$12,000.00	2	$24,000.00
				$9,426,360.00

TABLE 3-6 PETERSON QUOTE FOR NEARLY NEW/USED GT'S

Item	Description	Unit Price	Quantity	Cost
1.	Liquid Fuel TAURUS T60 Mobile Power Unit Turbine Generation I Generator Set (Used) Peterson Quote (APPENDIX 5)	$3,800,000.00		$7,600,000
2.	Commissioning Parts, Startup, and Site Testing	$ 63,900.00		$127,800
3	Shipping	$ 92,100.00		$184,200
4	6% Balance of Plant Contingency	$ 5,500.00		$11,000
5	Estimation of cost per ISO rating kilowatt for selected equipment	$ 853.00		$0
6	Training	$ 9,720.00		$29,160
7	Mobile Winterization Package (-40 C)	$ 219,000.00		$438,000
8	Marine Grade Inlet Air filter	$ 12,000.00		$24,000
				$8,414,160

3.3.4.1 Gas Turbine Trailer Units

For consideration under this project, GT packaged trailer systems shall have the following systems and items included with the gas turbine trailer or support trailer. The following is based on information provided by Solar Turbine (Appendix 4).

TABLE 3-7 TRANSPORTABLE GAS TURBINE PACKAGE COMPONENTS

Component	Description
Turbine MODULE:	5.2 MW Output, 13.8 Kilovolts, 60 Hertz, Direct drive starter and lube system, Lube oil cooler, Turbine Weatherproof acoustic enclosure, Power control room weatherproof acoustic enclosure, Fuel oil filter, High Temperature Detection and Alarm, Auxiliary Systems, Lights, On Crank and On Line Water Wash, Ventilation Silencers and Fans, CO2 Fire Suppression System, Fire Detection and Gas Monitoring System, High Efficiency Combustion Air Barrier Filter and Silencer, Trailer mounted exhaust stack and silencer, Control System with local and remote interface and monitoring.
TURBINE TRAILER (Model TK95LCS)	Tri-Axle Transport Trailer with Two Axle Pivoting Booster Length 48' + 14'1" Booster (removable at site) Width 8'6", 9'0" across trailer axles 133" Swing Clearance 49" 5th wheel Height (loaded) Air Ride Suspension and Air Raise and Lowering Kit Steel Disc Wheels with 275/70R x 22.5 Tire Three Tail Light Package Landing Gear (2) 6 Additional Landing Gears with Soil Bearing Plates for Levelling/Stabilization at Site Overall transport height: 14'2" Approximate transport weight: 118,000 lbs (without tractor)
POWER CONTROL MODULE (consists of the following):	Power Control Room (PCR) mounted on Two Axle Transport Trailer, Power Control Room HVAC system, Generator Main Circuit Breaker, Single interface point to power grid, Auxiliary Transformer Feeder Circuit Breaker, Bus PTs, Feeder CTs, Metering CTs and PTs, Beckwith M-3425 Protective Relay Module with the following relays:- Impedance (21), Reverse Power Protection (32), Loss of Field Protection (40), Negative Phase Sequence Protection (46), PT Blown Fuse Protection (60), Time Overcurrent Protection (50/51 V), Neutral Overcurrent Protection (51 N) – utilized in grounded site design, Bus Ground Fault Detection (59N) – utilized in ungrounded site design, Generator Differential Fault Protection (87 G), One High Speed Tripping Relay (86) for Circuit Breaker Trip, Lockout, and Turbine Shutdown Settings, Programming, and Testing, Lightning Arrestor and Surge Capacitor, Motor Control Center. Serves Turbine Generator Auxiliary Loads, 120VDC Turbine Generator Battery System with Charger, Dedicated 120VDC Switchgear Battery System with Charger, Start Motor Variable Frequency Drive (VFD), DC Backup Lube Oil Pump Contactor, Interior Lighting, Photocell Controlled Exterior Lighting at Access Doors, Emergency Eyewash Station, Ancillary Equipment. Installed onto the Power Control Room Module are the following: Gas Turbine Lube Oil Cooler, Neutral Ground Resistor, Auxiliary Load Transformer
Power Control Room Trailer (Model TK70LCS)	Two Axle Transport Trailer, Trailer Length 46' Overall, Width 8'6", 49" 5th wheel Height (loaded), Air Ride Suspension and Air Raise and Lower Kit, Steel Disc Wheels with 255/70R x 22.5 Tires, Three Tail Light Package, Landing Gear, 4 Additional Landing Gears with Soil Bearing Plates for Levelling/Stabilization at Site, Overall Transport Height: 14'0", Approximate transport weight: 48,000 lbs. (without tractor)

3.3.4.2 Site Civil Works

Site/civil works requirements are primarily related to the gas turbine generator trailer site, and to electrical and fuel connections. The major costs are expected to be:

- Confirming the bearing capacity of soil = $4,000
- Pre-engineered shelter for elec. equipment = $45,000
- Concrete cable trench = $70,000

Oil piping excavation is included in the cost of the piping.

3.3.4.3 Gas Turbine Generator Unit Modifications

For this application, the gas turbine units should be provided with air filter media suitable for use in a marine environment as well as have coatings on external components designed for such environments.

3.3.4.4 New Gas Turbine Generator Mechanical Requirements

Aside from fuel oil supply, it is expected that the gas turbine units would be self contained and not require any additional mechanical equipment. If required for the water wash system, a water line would be provided.

Connection and Changes to Existing Oil System

From supplier information, each turbine at its maximum output would consume fuel at a rate of about 8.0 gpm (30 L/min). This implies for black start with two units running there would be a total of 16 gpm (60 L/min). For a 24 hour period, the fuel oil storage requirement would be about 24,000 gallons (90,849 L) of fuel. The current Fuel oil tanks as previously noted are 26,417 gal (100,000 L) each.

The fuel requirement makes portable tanks impractical for the 8 year solution and this will also have to be considered in the gas turbine transportability consideration. The new gas turbine units will be located approximately 160 m from the existing GT building and will require new fuel oil supply and return piping from the existing system. Since two gas turbines would be provided under this option it is anticipated that only two line connections would be required. Piping could be routed through a trenched containment system.

TABLE 3-8 NEW GTG – MECHANICAL SYSTEM COSTS

Item	Cost
3” supply and return fuel line	$77,100.00
Project Engineering Costs Mechanical	$17,000.00

3.3.5 New Gas Turbine Option – Electrical, Instrumentation, and Control Requirements

Option 1 is 2 x 5 MW gas turbine generators rated at 13.8 kV. This option involves the replacement of the existing GTG with two (2) GT units rated at 5 MW. Each has a generator output voltage of 13.8kV and is connected to the delta primary of the existing T9 transformer.

3.3.5.1.1 Connections to the Existing Electrical and Control System

Each GT unit will be a completely self contained capable of operating in 'isochronous' or 'droop' mode, having its own main breaker (52), AVR, control and protection, synchronizing, load sharing, paralleling, monitoring and ability to connect to the existing station DCS.

All these functions will connect to a new building. Each generator breaker will be cabled to an item of isolating switchgear. The isolating switchgear will consist of two (2) 13.8kV disconnect switches, one (1) fused disconnect for auxiliaries, and one disconnect for connection of the zig-zag grounding transformer.

An isolation switch allows the individual GT unit to be taken out of service at any time. Each generator breaker (52) is synchronized for connection to the station service bus through the 13.8kV:4160V transformer T9, either individually or as a pair of generators.

The two GT units will be designed with high resistance grounding consisting of a grounding transformer and NGR to limit the ground fault current to less than 10A as normal standard.

The governor and voltage regulation control of the two units is common in utilities. Another advantage is the reliability of the emergency supply source and it is felt the probability of successful starts of one of the two units is better than one GT. For essential auxiliaries loads it requires only one unit running to secure the station during total loss of AC power (black-out).

The 13.8kV fused disconnect FSWI will feed a 112 kVA, 13.8 kV:575 V, 3 phase transformer to provide 600 V service via a new 600 A, 600 V, 3 phase, 60 Hz, 3 W MCC. The MCC will typically provide starters or fused disconnects for pumps, heating, 120/208 V distribution via a 30 kVA transformer and the battery charger. The battery charger supplies the 129 VDC battery and distribution.

Alternative supplies to the MCC will be via an automatic transfer switch (ATS) and a manual transfer switch (MTS), and will be from the diesel bus DB34 and power centre 'C', both in the powerhouse.

Protection and Control/DCS (P&C/DCS) interfaces will combine the requirements of the new units with the requirements of the existing T9 transformer and 4160V breaker SSB2.

3.3.5.1.2 Changes to existing El and C System

The existing protection, control and DCS cables entering the present GT building will be pulled back and terminated in a weatherproof Junction Box (JB). New teck cables will be connected to these existing cables and direct-buried from the JB to the P&C/DCS interface in the new building.

Similarly, the 600 V feeds from the diesel bus DB34 and power centre 'C' will be pulled-back and terminated in weatherproof JB's. New teck cables will be connected to these existing cables and direct-buried from the JB's to the manual transfer switch (MTS) in the new 'building'.

All new weatherproof JB's will be mounted above ground.

Power cables from the common bus of the isolating switchgear to the existing T9 transformer will replace the existing cables, and will be direct-buried from T9 transformer to the switchgear.

Changes will be made as necessary to the P&C located in Panel 13 (in the powerhouse) and also in Panel 2 (in the powerhouse). Screens will be reconfigured in the control room involving the two new units and their monitoring, control, indication, and alarm functions.

Each unit will be capable of operating in parallel when connected to an isolated 4160 V bus through a transformer (T9 Step-down), i.e. isochronous mode load sharing.

Each unit will be capable of energizing step-down transformer T9 to pick-up essential loads on the 4160 V bus.

The two unit operation will be controlled through a master controller to direct which unit is to pick-up dead-bus, and which unit is to synchronize with the other unit.

The start/stop commands are given from the master controller for auto-operation or manually from the control room.

Voltage Drop on the 4160 V Bus

The voltage drop on the 4160 V bus during starting the largest MV motor - 3000 horsepower (hp) boiler feed pump (BFP) motor under the condition of both 5 MW units running (in islanded mode) is about 10% below the recommended minimum of 80% by NEMA MGI. At the same time, starting of a 3000 hp BFP with isolation transformer was found to be unacceptable following preliminary simulation calculations from ETAP. Therefore a detailed procedure must be prepared for the black-start of MV motors.

3.3.5.2 4160 V Generator Voltage Option

The 2 x 5 MW generators with outputs at 4160 V are no longer considered for the following reasons:

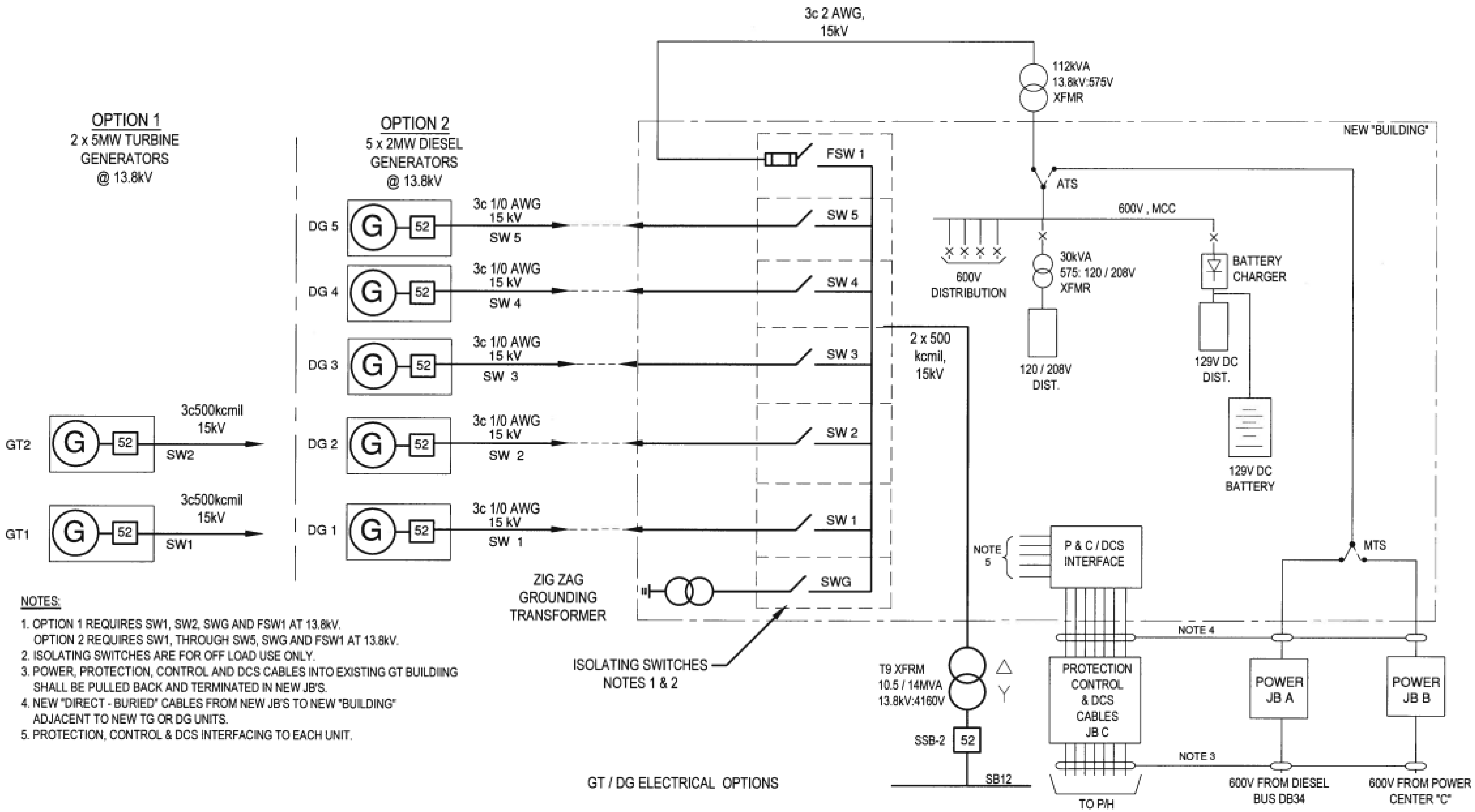
1. The 4160 V generator characteristics are not suitable for large motor starting, even without the step-down transformer.

2. The distance between the generators and the 4160 V bus is long (+200 M), therefore the voltage drop will be more, which results in costly power cables.

3. The existing ground fault current of the 4160 V bus is 1000 A, therefore the generators must have the generator neutral current of 1000 A. With low grounding resistance there is the possibility of third harmonic current circulating from one generator to another. The 4160 V diesel gensets submitted by the vendor cannot be connected to 4160 V because of them being unable to withstand the 1000 A ground fault on the 4160 V bus.

4. With generator connected directly to the 4160 V bus which is normally fed from the grid, three-phase short circuit current contribution from the grid (to the internal fault near the line end of the generator winding), is significant which results in more damage to the generator windings.

In conclusion, this option is not preferred compared to the other option of 2 x 5 MW units.



NOTES:
1. OPTION 1 REQUIRES SW1, SW2, SWG AND FSW1 AT 13.8kV.
   OPTION 2 REQUIRES SW1, THROUGH SW5, SWG AND FSW1 AT 13.8kV.
2. ISOLATING SWITCHES ARE FOR OFF LOAD USE ONLY.
3. POWER, PROTECTION, CONTROL AND DCS CABLES INTO EXISTING GT BUILDIING SHALL BE PULLED BACK AND TERMINATED IN NEW JB'S.
4. NEW "DIRECT - BURIED" CABLES FROM NEW JB'S TO NEW "BUILDING" ADJACENT TO NEW TG OR DG UNITS.
5. PROTECTION, CONTROL & DCS INTERFACING TO EACH UNIT.

Figure 3-2 Single Line Sketch – New Gas Turbine Genset

TABLE 3-9 ELECTRICAL & CONTROL EQUIPMENT AND INSTALLATION COSTS (OPTION 1) 2 X 5MW TG'S

Item #	Desciption	Qty	Unit	Material	Labour	Total	Comments
1	3c500 kemil, Teck 15kV cable (2 runs)	550	m	112,750	10000	122,750	Power from T9 to switchgear and to generators
2	13.8kV isolating switchgear (3+1 fused switch)	1	ea	95,000	10,000	105,000	
3	P&C/DCS interface	1	ea	55,000	10,000	65,000	Will contain interfacing requirements of the new units to T9 and SSB2.
4	10 x 3c12AWG, Teck, 1000V cable	250	m	960	2250	3210	from P&C/DCS interface to GTI and GT2 for protection and control
5	2 x 25c16AWG, Teck, 1000V cable	350	m	8505	3150	11655	Cables from P&C/DCS interface to junction box JBC
	4 x 4c12AWG, Teck, 1000V cable	700	m	3290	6300	9590	Cable from FSWI to 112kV transformer
	1 x 12C12AWG, Teck, 1000V cable	175	m	2240	1575	3815	Cable ATS to MTS and JBA/JBB to MTS
6	3c2AWG, Teck, 15kV cable	15	m	945	250	1195	
7	2 x 3c1/0, Teck, 1000V cable	125	m	4500	1125	5625	
8	112kVA, 13.8kV:575V, 3ph, 60Hz transformer	1	ea	30000	3000	33000	
9	200A, 600V, 3ph, 60Hz automatic transfer switch	1	ea	5336	1500	6836	
10	200A, 600V, 3ph, 60Hz manual transfer switch	1	ea	2000	1000	3000	
11	MCC, 600A, 600V, 3ph, 3W	1	ea	30000	5000	35000	
12	30kVA, 575:120/280V, 3ph, 60Hz transformer	1	ea	1000	500	1500	
13	129VDC distribution panel, motor starters and disconnects	1	ea	35000	6500	41500	
14	100A, 120/208V, 3ph, 60Hz distribution panel c/w breakers	1	ea	1418	350	1768	
15	600V, battery charger, 129VDC output	1	ea	16,000	3220	19,220	
16	129VDC battery bank	1	ea	39,000	7500	46,500	
17	All interconnecting cabling	1	lot	16000	12000	28000	Includes MCC feeders, heating and lighting
18	Miscellaneous 4/0 ground wire, conducts trays and hardware	1	lot	16000	9000	25000	
19	Reconfiguration of DCS screens, and existing system	1	lot		25,000	25000	
20	25kVA, 13.8kV, 3ph, 60Hz, zig-zag grounding transformer	1	ea	31,000	2,000	33,000	
	Commissioning			-	63,000	63,000	
	Totals			505,944	184220	690,164	

3.3.6 Existing Unit De-Commissioning and Demolition

No significant incremental costs were identified for existing unit de-commissioning and/or demolition. It was felt that the value of the materials derived from the demolition could offset the cost to the contractor. If required as sensitivity, then a value such as $40,000 might be used, but this would not be expected to either sway the selection of a preferred option, or impact the overall cost but rather be part of an overall project contingency regardless of any option selected.

3.3.7 Project Engineering and Management, Owner's Costs

It was assumed that the facility implementation would be undertaken largely as an engineer, procure, construct (EPC) external contract. Hydro would be responsible for getting the project approved and the necessary environmental and regulatory approvals.

EPC Costs

For the EPC contractor, the project engineering and management costs are based on the total project costs and a percentage for engineering and for management. For the purposes of this estimate, the engineering costs are estimated to be 5% of direct costs of the GT or diesel package and 10% of the balance of plant. The project management and commissioning costs (excluding fuel, Hydro staff costs) are estimated to be 7% of total direct costs. .

Owner's Costs

Owner's costs are not included in the estimates, but are likely to be comparable regardless of the selected option. NL Hydro is assumed to undertake the early steps to get its Public Utilities Board (PUB) approvals as part of its ongoing operations cost. Hydro is also assumed to undertake all the necessary environmental and regulatory permitting entirely internally or with some measure of external support (i.e. environmental modeling and engineering support, or full external scope). This cost is also not included but likely on the order of $55,000.

For the actual project implementation, the assumption is that NL Hydro would assume its own costs of this initial development and then assign a project manager for the life of the project to monitor and assure its successful completion. These and other NL Hydro costs (insurance, legal, supply chain, interest, owners' contingency, Holyrood station participation, commissioning fuel, commissioning labour) are not identified or included herein. It is likely that Owner costs could amount to on the order of 1.5% of directs or about $150,000.

3.3.8 Total New and Nearly New 2 x 5MW GTG Capital Cost Estimate

The total New and Nearly New 2 x 5 MW GTG cost estimate is as follows. The difference in the New and Nearly New is mostly in the capital costs. It should be noted that there may be some additional costs required to retrofit nearly new units to meet the same or required standards as the new units that are designed to meet Holyrood requirements.

TABLE 3-10 CAPITAL COST ESTIMATE – TRANSPORTABLE GTG

Capital Cost Comparison
Capital cost estimate $1,000 Can 2011

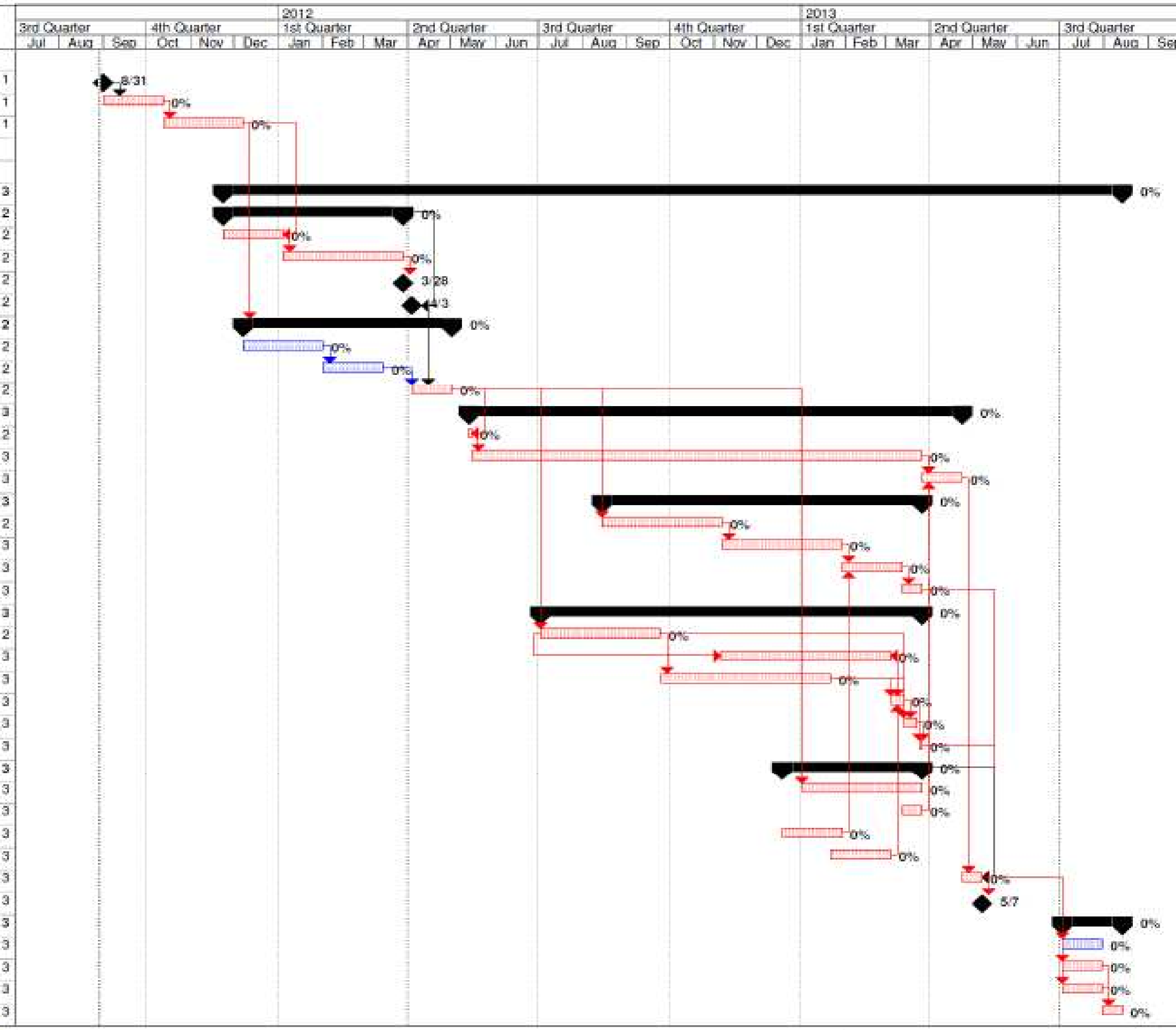
Option Number	1	1A
Option	New 2 x 5 MW GT	Used 2 x 5 MW GT
GT/Diesel Cost	$10,865	$9,234
Civil Works	$131	$131
Electrical Works	$759	$759
BOP Systems	$129	$129
Existing Unit Demolition & Removal	$7	$7
Sub-Total - Directs and Indirects	$11,891	$10,260
Project Engineering	$625	$544
Project Management	$832	$718
Total	$13,348	$11,522

3.3.9 Schedule

The schedules for the new and nearly new 2 X 5 MW GTG are illustrated below. The basic schedule highlights are as follows:

Task	New GT	Nearly New GT
Review of Options Report	Sept 2011	
Project Approvals and Release	Sept 2011 - Dec 2011	
Engineer, Procure, Construct Contract	May 2012	
In-Service of New 2 x 5 MW GT	May 2013	March 2013
Decommission Existing GT	Aug/Dec 2013	Aug/Dec 2013

ID	Task Name	Duration	Start	Finish
1				
2	Condition Assessment Study	0 wks	Wed 8/31/11	Wed 8/31/11
3	Hydro Internal Capital Budget Proposal Development	6 wks	Thu 9/1/11	Wed 10/12/11
4	Submission - Public Utilities Board & Approval	8 wks	Thu 10/13/11	Wed 12/7/11
5				
6				
7	**New GT or Diesel Units**	**449 days**	**Thu 11/24/11**	**Tue 8/13/13**
8	**Project Environmental & Regulatory Approvals**	**90 days**	**Thu 11/24/11**	**Wed 3/28/12**
9	Prepare Dispersion Modelling & Submission	30 days	Thu 11/24/11	Wed 1/4/12
10	Regulatory Review and Approval	60 days	Thu 1/5/12	Wed 3/28/12
11	Environmental Approval	0 days	Wed 3/28/12	Wed 3/28/12
12	Project Full Release	0 days	Tue 4/3/12	Tue 4/3/12
13	**Request for Proposal (RFP) for Engineer/procure/Cons**	**104 days**	**Thu 12/8/11**	**Tue 5/1/12**
14	Prepare	40 days	Thu 12/8/11	Wed 2/1/12
15	Bid	6 wks	Thu 2/2/12	Wed 3/14/12
16	Award	20 days	Wed 4/4/12	Tue 5/1/12
17	**New Gas Turbien or Diesel Engine Generator**	**247 days**	**Mon 5/14/12**	**Tue 4/23/13**
18	Award Gas Turbine (GT)/Engine Contract	2 days	Mon 5/14/12	Tue 5/15/12
19	Manufacture & Deliver Transportable Engines	45 wks	Wed 5/16/12	Tue 3/26/13
20	Install and Commission	4 wks	Wed 3/27/13	Tue 4/23/13
21	**Fuel System**	**160 days**	**Wed 8/15/12**	**Tue 3/26/13**
22	Engineer	12 wks	Wed 8/15/12	Tue 11/6/12
23	Order, Manufacture, Deliver	12 wks	Wed 11/7/12	Tue 1/29/13
24	Install new fuel lines and receiving system	6 wks	Wed 1/30/13	Tue 3/12/13
25	Commission System	2 wks	Wed 3/13/13	Tue 3/26/13
26	**Electrical & Control Systmes**	**191 days**	**Tue 7/3/12**	**Tue 3/26/13**
27	Engineer	12 wks	Tue 7/3/12	Mon 9/24/12
28	Order & Manufacture Elect & Control (E&C) Equip	17 wks	Tue 11/6/12	Mon 3/4/13
29	Electrical Building Manufacture, Delivery, Install	17 wks	Tue 9/25/12	Mon 1/21/13
30	Install New System	7 days	Tue 3/5/13	Wed 3/13/13
31	RE-align Existing Plant Systems	7 days	Thu 3/14/13	Fri 3/22/13
32	Commission unit	2 days	Mon 3/25/13	Tue 3/26/13
33	**Site Civil Work**	**70 days**	**Wed 12/19/12**	**Tue 3/26/13**
34	Engineer	12 wks	Wed 1/2/13	Tue 3/26/13
35	Generator area clearing and civil	2 wks	Wed 3/13/13	Tue 3/26/13
36	Fuel line civil work	6 wks	Wed 12/19/12	Tue 1/29/13
37	Electrical an contro cable civil work	6 wks	Tue 1/22/13	Mon 3/4/13
38	Complete Unit Test	10 days	Wed 4/24/13	Tue 5/7/13
39	Gas Turbine (GT) In-Service (I/S)	0 days	Tue 5/7/13	Tue 5/7/13
40	**Decommission Existing GT**	**30 days**	**Wed 7/3/13**	**Tue 8/13/13**
41	Fuel delivery system	4 wks	Wed 7/3/13	Tue 7/30/13
42	Electrical & Controls	4 wks	Wed 7/3/13	Tue 7/30/13
43	GT	4 wks	Wed 7/3/13	Tue 7/30/13
44	Building	2 wks	Wed 7/31/13	Tue 8/13/13



Project: Project1 New.mpp
Date: Mon 8/29/11

Critical | Task | Baseline | Milestone | Project Summary | Deadline
Critical Split | Split | Baseline Split | Summary Progress | External Tasks
Critical Progress | Task Progress | Baseline Milestone | Summary | External Milestone

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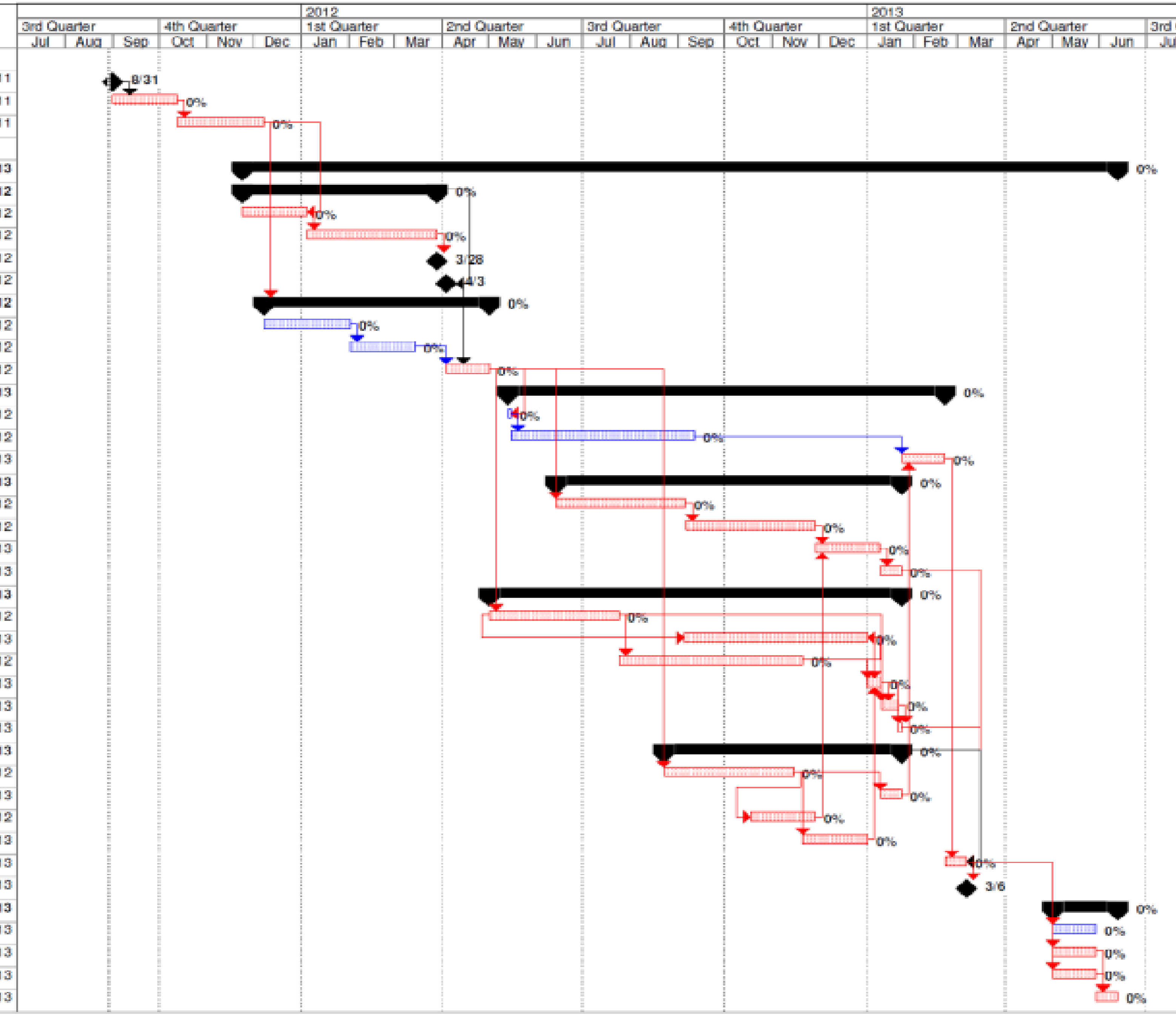
FIGURE 3-3 SCHEDULE – NEW TRANSPORTABLE 2 X 5 MW GTG

ID	Task Name	Duration	Start	Finish
1				
2	Condition Assessment Study	0 wks	Wed 8/31/11	Wed 8/31/11
3	Hydro Internal Capital Budget Proposal Development	6 wks	Thu 9/1/11	Wed 10/12/11
4	Submission - Public Utilities Board & Approval	8 wks	Thu 10/13/11	Wed 12/7/11
5				
6	**Nearly New gas Turbine (GT) or Diesel Generator Units**	**405 days**	**Thu 11/24/11**	**Wed 6/12/13**
7	**Project Environmental & Regulatory Approvals**	**90 days**	**Thu 11/24/11**	**Wed 3/28/12**
8	Prepare Dispersion Modelling & Submission	30 days	Thu 11/24/11	Wed 1/4/12
9	Regulatory Review and Approval	60 days	Thu 1/5/12	Wed 3/28/12
10	Environmental Approval	0 days	Wed 3/28/12	Wed 3/28/12
11	Project Full Release	0 days	Tue 4/3/12	Tue 4/3/12
12	**Request for Proposal (RFP) for Engineer/Procure/Construct (**	**104 days**	**Thu 12/8/11**	**Tue 5/1/12**
13	Prepare	40 days	Thu 12/8/11	Wed 2/1/12
14	Bid	6 wks	Thu 2/2/12	Wed 3/14/12
15	Award	20 days	Wed 4/4/12	Tue 5/1/12
16	**Nearly New GT or Diesel Engine Generator**	**203 days**	**Mon 5/14/12**	**Wed 2/20/13**
17	Award GT/Diesel Engine Contract	2 days	Mon 5/14/12	Tue 5/15/12
18	Manufacture & Deliver Transportable Engines	17 wks	Wed 5/16/12	Tue 9/11/12
19	Install and Commission	4 wks	Thu 1/24/13	Wed 2/20/13
20	**Fuel System**	**160 days**	**Thu 6/14/12**	**Wed 1/23/13**
21	Engineer	12 wks	Thu 6/14/12	Wed 9/5/12
22	Order, Manufacture, Deliver	12 wks	Thu 9/6/12	Wed 11/28/12
23	Install new fuel lines and receiving system	6 wks	Thu 11/29/12	Wed 1/9/13
24	Commission System	2 wks	Thu 1/10/13	Wed 1/23/13
25	**Electrical & Control Systmes**	**191 days**	**Wed 5/2/12**	**Wed 1/23/13**
26	Engineer	12 wks	Wed 5/2/12	Tue 7/24/12
27	Order & Manufacture Elect & Control (E&C) Equip	17 wks	Wed 9/5/12	Tue 1/1/13
28	Electrical Building Manufacture, Delivery, Install	17 wks	Wed 7/25/12	Tue 11/20/12
29	Install New System	7 days	Wed 1/2/13	Thu 1/10/13
30	RE-align Existing Plant Systems	7 days	Fri 1/11/13	Mon 1/21/13
31	Commission unit	2 days	Tue 1/22/13	Wed 1/23/13
32	**Site Civil Work**	**110 days**	**Thu 8/23/12**	**Wed 1/23/13**
33	Engineer	12 wks	Thu 8/23/12	Wed 11/14/12
34	Generator area clearing and civil	2 wks	Thu 1/10/13	Wed 1/23/13
35	Fuel line civil work	6 wks	Thu 10/18/12	Wed 11/28/12
36	Electrical an contro cable civil work	6 wks	Wed 11/21/12	Tue 1/1/13
37	Complete Unit Test	10 days	Thu 2/21/13	Wed 3/6/13
38	GT In-Service (I/S)	0 days	Wed 3/6/13	Wed 3/6/13
39	**Decommission Existing GT**	**30 days**	**Thu 5/2/13**	**Wed 6/12/13**
40	Fuel delivery system	4 wks	Thu 5/2/13	Wed 5/29/13
41	Electrical & Controls	4 wks	Thu 5/2/13	Wed 5/29/13
42	GT	4 wks	Thu 5/2/13	Wed 5/29/13
43	Building	2 wks	Thu 5/30/13	Wed 6/12/13



Project: Project1 Nearly New.mpp
Date: Mon 8/29/11

Critical | Critical Split | Critical Progress | Task | Split | Task Progress | Baseline | Baseline Split | Baseline Milestone | Milestone | Summary Progress | Summary | Project Summary | External Tasks | External Milestone | Deadline

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FIGURE 3-4 SCHEDULE – NEARLY NEW/USED TRANSPORTABLE 2 X 5 MW GTG

3.3.10 OMA Cost Estimate to 2020

Operating costs were assumed to include the ongoing maintenance costs (annual inspections, repairs, etc.), the operations costs (costs to run the unit on test), the fuelling costs (fuel costs to run the tests), and an electricity value credit. The operating costs shown are the same for both the new and nearly new cases. For the type of operation required, peak and emergency operation (typically <=60 Hrs/Yr, the GT packages normally would require only an annual service and inspection by qualified service personnel. Most utilities would exercise the equipment once a month to verify proper operation.

The costs were assumed to include the ongoing maintenance costs (annual inspections, repairs, etc.), the operations costs (costs to run the unit on test), the fuelling costs (fuel costs to run the tests), and an electricity value credit. The vendor indicated that for the 6 month inspection the cost was to be $10,000 and for the yearly it was $18,000 and that these costs would be the same for both new and nearly new. A lower value was actually used reflecting their very limited use – essentially an annual inspection similar to what is done now.

The assumptions used for fuel, operations, and electricity value are illustrated below. The electricity value is premised on receiving the same value per MWh as the existing units would if they were to recover their fuelling costs plus marginal operating and maintenance costs. The fuelling and electricity prices are intended as representative and based on running the units 150 hours per year, whereas actual hours could be as half of this.. The actual values (average run capacity, sent out heat rate (SOHR) and hence fuel and electricity depend on how the testing is actually done.

The assumptions used for fuel, operations, and electricity value are illustrated below. The electricity value is premised on recovering fuelling costs plus marginal operating costs.

TABLE 3-11 NEW GTG OMA COST ASSUMPTIONS

Assumptions

#2 Oil Fuel Price (A)	$/MMBTU	$21.47
Unit Efficiency (B)	BTU/kWh	12,000
Average Running Capacity (C)	MW	4
Average Running Cost (D) = AxBxC/1000	$/Hr	$1,031
Electricity Value (E) = Value for existing GT	$/MWh	$343.25
Electricity Value (F) = E*C	$/Hr OP	$1,373

2	Persons/Start (U)
4	Hrs/Start (V)
$70	$/PersonHr (W)
$560	$/Start (Z) = UxVxW

TABLE 3-12 NEW GTG OMA COSTS

New/Near New GT
1000's Cnd $ - 2011/Yr

	Maintenance	Operations	Fuelling	Sub-Total	Electricity Value		Total
2012	$15	$0	$0	$15	$0		$15
2013	$20	$40	$155	$215	($206)		$9
2014	$20	$40	$155	$215	($206)		$9
2015	$20	$40	$155	$215	($206)		$9
2016	$20	$40	$155	$215	($206)		$9
2017	$20	$40	$155	$215	($206)		$9
2018	$20	$40	$155	$215	($206)		$9
2019	$20	$40	$155	$215	($206)		$9
2020	$0	$40	$155	$195	($206)		($11)
TOTAL	$155	$323	$1,237	$1,714	($1,648)		$67

3.4 Option 2 – 5 x 2 MW Diesel Engine Generator (DG) at 13.8kV (New and Nearly New Option)

3.4.1 Description

In this option, five 2 MW diesel engine generator units would be utilized to provide black start capability. Sizing at 2 MW each would allow the units to be more transportable than larger units. In addition, this is approximately the maximum size available for portable units. With this arrangement, all five of the units would be required to operate simultaneously to provide sufficient power for black start. A generator voltage of 13.8 kV connected to the delta primary of the existing T9 transformer would be utilized. Other units from Cummins Diesel are available as packaged two 1 MW units. However, NL Hydro expressed reliability and operational concerns with 10 diesel units and they have not been considered further.

Vendor information was received from TOROMONT CAT. These will be mobile units supplied by a vendor and will not require a diesel building. Several items will however be required, such as:

- Turbine trailers areas with site work to ensure sufficient ground support for the mobile diesel genset units.
- A pre-engineered shelter for electrical equipment, including concrete foundation and floor slab. Approximately 30 ft x 30 ft.
- A reinforced concrete pipe/trench for cables running from the diesel gensets to the main building and from the diesel gensets to the existing fuel lines.
- Electrical and I&C connections to the existing plant facilities

3.4.2 Connections to the Existing E and C System

Each diesel/generator unit will be a completely self contained unit capable of operating in isochronous or droop mode, having its own main breaker (52), AVR, control and protection, synchronizing, load sharing, paralleling, monitoring and ability to connect to the existing station DCS.

All these functions will connect to a new building. Each generator output breaker will be cabled to an item of isolating switchgear. The isolating switchgear will consist of five (5) 13.8 kV disconnect switches, one (1) fused disconnect for auxiliaries, and one disconnect for connection of the zig-zag grounding transformer.

An isolation switch allows the individual GT unit to be taken out of service at any time. Each generator breaker (52) is synchronized for connection to the station service bus through the 13.8 kV:4160 V transformer (T9), either individually or as any combination of generators.

The five DG units will be designed with high resistance grounding consisting of a grounding transformer and NGR to limit the ground fault current to less than 10 A as normal standard.

The 13.8KV fused disconnect fused switch #1 (FSWI) will feed a 112 kVA, 13.8 kV:575 V, 3 phase transformer to provide 600 V service via a new 600 A, 600 V, 3phase, 60 Hz, 3 W MCC. The MCC will typically provide starters or fused disconnects for pumps, hearing, 120/208 V distribution via a 30 kVA transformer and the battery charger. The battery charger supplies the 129 VDC battery and distribution.

Alternative supplies to the MCC will be via an automatic transfer switch (ATS) and a manual transfer switch (MTS) and will be from the diesel bus DB34 and power center 'C', both located in the powerhouse.

Protection & Control/DCS interfaces will combine the requirements of the new units with the requirements of the existing T9 transformer and 4160 V breaker SSB2.

3.4.2.1.1 <u>Changes to Existing EI&C Systems</u>

The existing protection, control and DCS cables entering the present GT building will be pulled-back and terminated in a weatherproof JB. New teck cables will be connected to these existing cables and direct-buried from the JB to the P&C/DCS interface in the new building.

Similarly the 600 V feeds from the diesel bus DB34 and power centre 'C' will be pulled-back and terminated in weatherproof JB's. New teck cables will be connected to these existing cables and direct-buried from the JB's to the MTS in the new 'building'.

All new weatherproof JB's will be mounted above ground.

Power cable from the common bus of the isolating switchgear to the existing T9 transformer will replace the existing cables, and will be direct-buried from T9 to the switchgear.

Changes will be made as necessary to P&C in Panel 13 (in the powerhouse) and also in Panel 2 (in the powerhouse). Screens will be reconfigured in the control room involving the five new units and their monitoring, control, indication, and alarm functions.

3.4.3 Performance Characteristics

Diesel gensets have several ratings.

> Standby – Applicable for supplying continuous electrical power (at variable load) in the event of a utility power failure. No overload is permitted on these ratings. The generator on the generator set is peak prime rated (as defined in ISO8528-3) at 30° C (86° F).
>
> Prime – Applicable for supplying continuous electrical power (at variable load) in lieu of commercially purchased power. There is no limitation to the annual hours of operation and the generator set can supply 10% overload power for 1 hour in 12 hours.

NL Hydro noted that for blackstart only, their requirement is for the standby rating. Information on prime is provided for comparison.

TABLE 3-13 DIESEL PERFORMANCE CRITERIA

Generator Set Technical Data	Units	60 Hz Prime	60 Hz Standby
Performance Specification		DM8264	DM8264
Power Rating	kW (kVA)	1825 (2281)	2000 (2500)
Lubricating System Oil pan capacity	L (gal)	401.3 (106)	401.3 (106)
Fuel System Fuel Consumption 100% load 75 % load 50 %load Fuel tank capacity Running time @ 75% rating	L (gal) L (gal) L (gal) L (gal) Hours	483.2 (127.6) 380 (100.4) 270.5 (71.5) 4731 (1,250) 12.5	525.7 (138.9 408.2 (107.8) 294.2 (77.7) 4731 (1,250) 11.5
Cooling System Radiator coolant capacity including engine	L (gal)	630 (166)	630 (166)
Air Requirements Combustion air flow Maximum air cleaner restriction Generator cooling air	m3/min (cfm) kPa (in H2O) m3/min (cfm)	174.7 (6169) 6.2 (24.9) 168 (4,995)	180.3 (6367) 6.2 (24.9) 168 (4,995)
Exhaust System Exhaust flow at rated kW Exhaust stack temperature at rated kW dry exhaust	m3/min (cfm) °C (°F)	404 (14,260) 387 (728)	428.6 (15,137) 405 (762)
Noise Rating (with enclosure) @ 7 meters (23 feet) @15 meters (50 feet)	dB(A) dB(A)	78 74	79 75

3.4.3.1 Emission Requirements

For new diesel units on oil, the requirement is uncertain. In the United States, the United States Environmental protection Agency (USEPA) is clearly moving to even tighter diesel genset limits. Canada has only adopted those for mobile (on-road) sources, not stationary sources. There is also the issue of emergency use (black-start would apply) and non-emergency (distribution support, grid support is likely to apply):

- For stationary (including transportable genset units) in emergency use (i.e. black start only)
  - In US would likely be a USEPA Tier 2 (a diesel requiring advanced combustion systems)
  - In Canada, no specific regulations could be identified. Diesel units are likely similar to those required in the US, or comparable to the Canadian guideline requirement for gas turbines above

- For stationary (including transportable genset) in a non-emergency use (i.e. distribution support).
  - In the US, a USEPA Tier 4 (a diesel unit required to have advanced combustion and post combustion control such as selective catalytic reduction (SCR) using ammonia or urea and would also require ultralow sulphur diesel fuel (15 ppm sulphur)
  - In Canada, no specific regulations identified – the study assumes for the role required that Tier 2 would suffice. A question may arise where the plan is for their use in distribution system support. This should likely be considered an emergency role and not result in more onerous restrictions. At worst, assuming a requirement comparable to that for gas turbines above for peaking purposes is reasonable.

Operating time limits could be placed on peaking units. An emergency unit for black start only might be exempt, but could thereby limit its future.

No specific diesel genset applicable to Newfoundland air pollution regulations were identified. There is however a general requirement for BACT, with provisions for an exemption based on economics and on a ministerial exemption for practical purposes.

In emergency and non-emergency applications, dispersion modeling is likely required to demonstrate ground level concentrations are acceptable.

3.4.3.2 Transition

The existing gas turbine system is to remain active while the new system is independently installed. A short outage will be required during a transition period during which final connections to the electrical, instrumentation and controls, and fuel systems are made.

3.4.3.3 Decommissioning

The existing GT unit will be decommissioned, including those parts of the fuel system and electrical connections not required for the new units. This will occur once the new transportable units are in place and operational. A modified fuel offloading/receiving system will remain.

3.4.4 General Arrangement Sketch

See attached GA sketch based on dimensional information provided by TOROMONT CAT (APPENDIX 3).

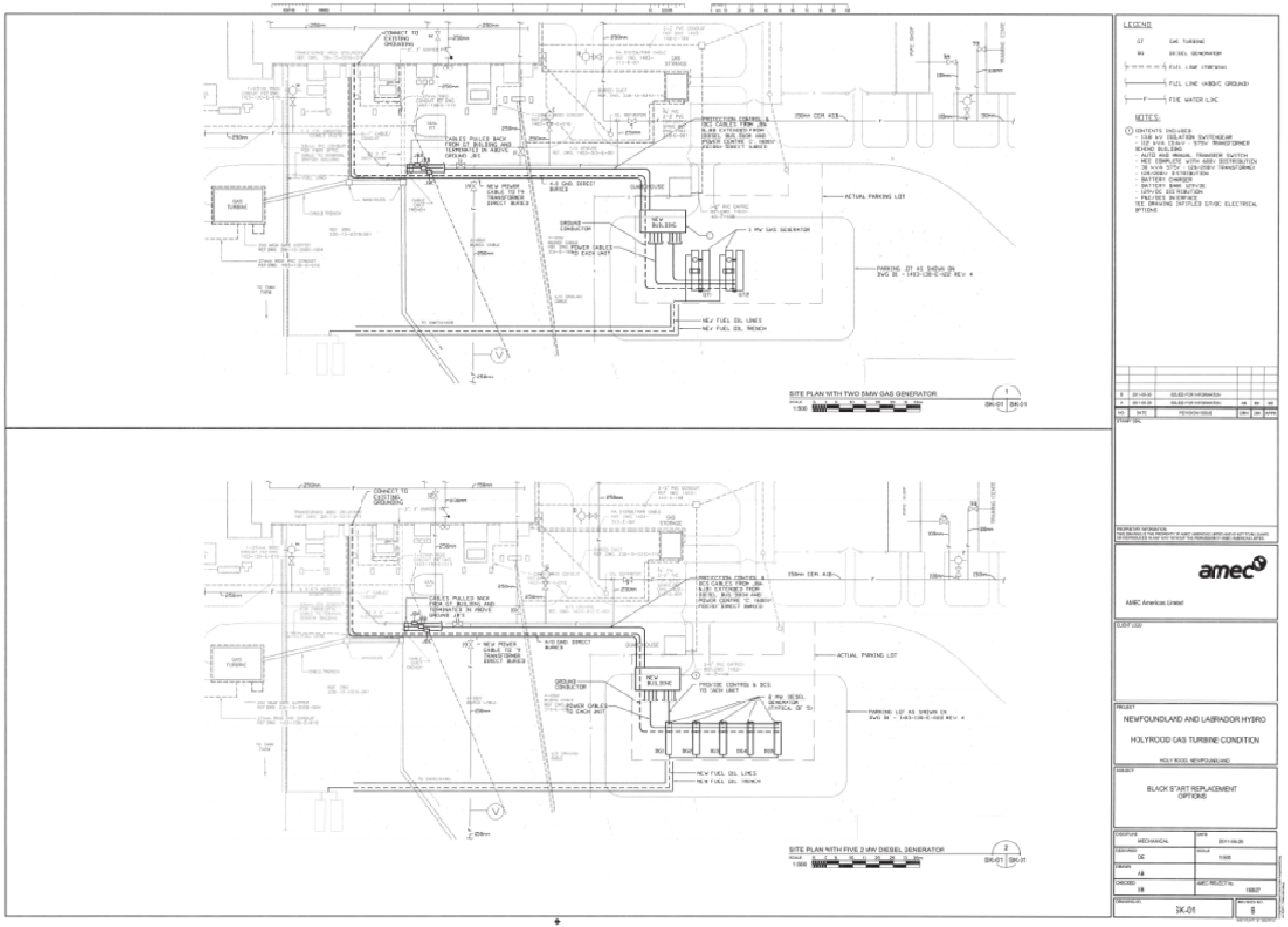


FIGURE 3-5 GENERAL ARRANGEMENT – 5 X 2 MW DIESEL GENSETS

3.4.5 Capital Cost Estimate (Differentiate New and Nearly New Option)

Budget pricing supplied by CAT indicated that the transportable diesel genset cost would be in the order of $1,500,000.00 per unit. However, there could be a 50% increase in price if the units are required to meet more stringent emission limits in emission regulations likely to be adopted soon by the federal government. AMEC has requested this information but as not received any additional details on these requirements, and their applicability to this application for black start capability and short term distribution system maintenance support.

There is not expected to be a significant difference in price between the New and Nearly New options. The advantage between these options is the possibility that a Nearly New set of units will be available and lead/delivery times are significantly reduced.

TABLE 3-14 DIESEL GENSET CAPITAL COST

Item	Description	Unit Price	Quantity	Cost
1.	XQ2000 with 13.8kv output $1.5m per unit (x5) under current emissions rules.	$1,500,000	5	$7,500,000
2.	Commissioning Parts, Start-up, and Site Testing	$20,000	5	$100,000
4	Shipping	$25,000	5	$125,000
5	Training	$5,000	5	$25,000
6	Marine Grade Filter (Included)			
				$7,750,000

- Duties and taxes not included in estimate.
- This quote is provided for budgetary purposes only and does not represent a firm quote.

3.4.5.1 Diesel Trailer Units

TABLE 3-15 DIESEL PACKAGE COMPONENTS

Component	Description
Engine	▪ EPA approved Tier 2 3516C Caterpillar engine ▪ Heavy duty air cleaner with service indicator ▪ 60-Amp charging alternator ▪ Fuel filters – primary and duplex secondary with integral water separator and change-over valve ▪ Lubricating oil system with spin-on, full flow oil filters and water cooled oil cooler ▪ Oil drain lines routed to engine rail ▪ Jacket water heater ▪ Fuel cooler and priming pump ▪ Electronic ADEM™ A3 controls ▪ 24V electric starting motors with battery rack and cables

Component	Description
	▪ 110% spill containment of onboard engine fluids
Generator	▪ SR-4B brushless, permanent magnet excited, three-phase with Caterpillar digital voltage regulator (CDVR),space heater, 6-lead design, Class H insulation operating at Class F temperature for extended life, ▪ winding temperature detectors and anti-condensation space heaters (120/240 V 1.2 kW)
Containerized Module	▪ 40' ISO high cube container, CSC certified ▪ 3-axle, 40' ISO container chassis ▪ Seven (7) sound attenuated air intake louvers and 4 lockable personnel doors with panic release ▪ Side bus bar access door, external access load connection bus bars ▪ Shore power connection via distribution block connections for jacket water heater, battery charger, space heaters, and generator condensate heaters ▪ Standard lighting 3 AC/4 DC, one (1) single duplex service receptacle, 2 external break-glass emergency stop push buttons ▪ 1,250 gal fuel tank, UL listed, double wall, 9 hr runtime @ prime rating ▪ Sound attenuated 75 dB(A) @ 50 ft ▪ Spill containment 110% of all engine fluids ▪ Four (4) oversized maintenance-free batteries, battery rack and 20-Amp battery charger ▪ Hospital grade, internally insulated, rectangular exhaust silencer with vertical discharge ▪ Vibration isolators, corrosion resistant hardware and hinges ▪ External drain access to standard fluids ▪ Fire extinguishers (Qty 2) ▪ Standard Cat rental decals and painted standard Cat power module white ▪ Interior walls and ceilings insulated with 100 mm of acoustic paneling ▪ Floor of container insulated with acoustic glass and covered with galvanized steel
Cooling	▪ Standard cooling provides 43° C ambient capability (60 Hz) at prime +10% rating ▪ Vertically mounted, separate ATAAC and JW cores with vertical air discharge

Component	Description
Generator Paralleling Control	▪ Custom switchgear control with EMCP 3.3 genset mounted controller and wall mounted paralleling controls Provides single unit and/or multi-unit/utility paralleling components. Standby, load sense/load demand, import, export, and base load modes. Comes standard with Basler Utility Multi-function Relay IPS-100. ▪ Exclusive Caterpillar Digital Voltage Regulator (CDVR) Three-phase sensing and adjustable Volts-per- Hertz regulation give precise control, excellent block loading, and constant voltage in the normal operating range. ▪ Automatic start/stop with cool down timer ▪ Protections: 25, 27/59, 40, 32, 81 O/U ▪ Utility multi-function relay protections: 25,27/59, 32, 47, 50/51, 62, 67, 81 O/U ▪ UMR is IEEE1547-2003 compliant in most applications ▪ Reverse compatibility module provided for interface to legacy power modules ▪ Touch screen controls with event log ▪ Multi-mode operation (island, multi-island and utility parallel), load sharing (multi-unit only) ▪ Import & export control (utility parallel only), manual and automatic paralleling capability ▪ Touch screen display (status and alarms) ▪ Metering display: voltage, current, frequency, power factor, kW, WHM, kVAR, and synchroscope
Quality	▪ Standard genset and package factory tested ▪ UL, NEMA, ISO and IEEE standards
Other	

3.4.5.2 Site Civil Works – Trailer Site and Electrical & Gas Connections

Site/civil works requirements are primarily related to the diesel generator trailer site, and to electrical and fuel connections. The major costs are expected to be:

- Confirming the bearing capacity of soil = $4,000
- Pre-engineered shelter for elec. equipment = $45,000
- Concrete cable trench = $70,000

Oil piping excavation is included in the cost of the piping.

3.4.5.3 Existing Gas Turbine Generator Unit Modifications

For this application the gas turbine units should be provided with air filter media suitable for use in a marine environment as well as have coatings on external components designed for such environments.

3.4.5.4 New Diesel Genset Mechanical Requirements

Aside from fuel oil supply, it is expected that the diesel genset units would be self contained and not require any additional mechanical equipment. Specific to diesel engine trailers, each trailer must have 15.6 m clearance on both sides to ensure adequate ventilation and combustion airflow.

<u>Connection to Fuel Oil System and Changes to Existing Oil System</u>

From supplier information each turbine at its maximum output would consume fuel at a rate of 2.3 gpm (8.7 L/min). This implies for black start with five units running there would be a total of 11.5 gpm (43.5 L/min). For a 24 hour period, the fuel oil storage requirement would be about 16,500 gallons (62, 459 L) of fuel. The current fuel oil tanks as previously noted are 26,417 gal (100,000 L) each.

The new diesel units will be located approximately 160 m away from the existing GT building and will require new fuel oil supply and return piping from the existing system. Since five diesels would be provided under this option, it is anticipated that five connections would be required. Due to spacing requirements of the diesels gen sets this manifold system would be quite extensive. Piping could be routed through a trenched containment system. Preliminary sizing indicates that the supply and return lines would be 3 inch with a total length of 130 m each.

TABLE 3-16 DIESEL GENSET – MECHANICAL SYSTEM COSTS

Item	Cost
3” supply and return fuel line	$77,100.00
Project Engineering Costs Mechanical	$15,000.00

3.4.6 New Diesel Genset Option – Electrical, Instrumentation, and Control Requirements

With generators connected directly to the 4160 V bus which is normally fed from the grid, the three-phase short circuit current contribution from the grid (to the internal fault near the line end of the generator winding) is significant which results in more damage to the generator windings.

With the 5 X 2 MW generators, the calculated voltage drop at the 4160 V bus results are improved, but potential drawbacks are expected as follows:

1. The starting reliability of 5 generators (following total loss of station AC supply) is questionable. The successful starting of 5 units is not easy to achieve. With our experience of multiple diesel starting at once, there is a high probability that 100% success is not easily achieved compared to two 5 MW units on the assumption that one 5 MW unit is suitable for plant essential loads.

2. The isochronous load sharing of 5 units requires 5 electronic governors and a complicated master controller. This is necessary to manage the paralleling operation of 5 units during isochronous mode, particularly during starting of MV motors. This will cost more.

3. With the same contribution of fault current from the grid through the I0 MVA step-down transformer, may exceed the damaging level of the 2 MW generator for internal fault of the stator (close to line end of windings).

4. The 13.8 kV switchgear line-up would be much larger than the 2 X 5 MW option.

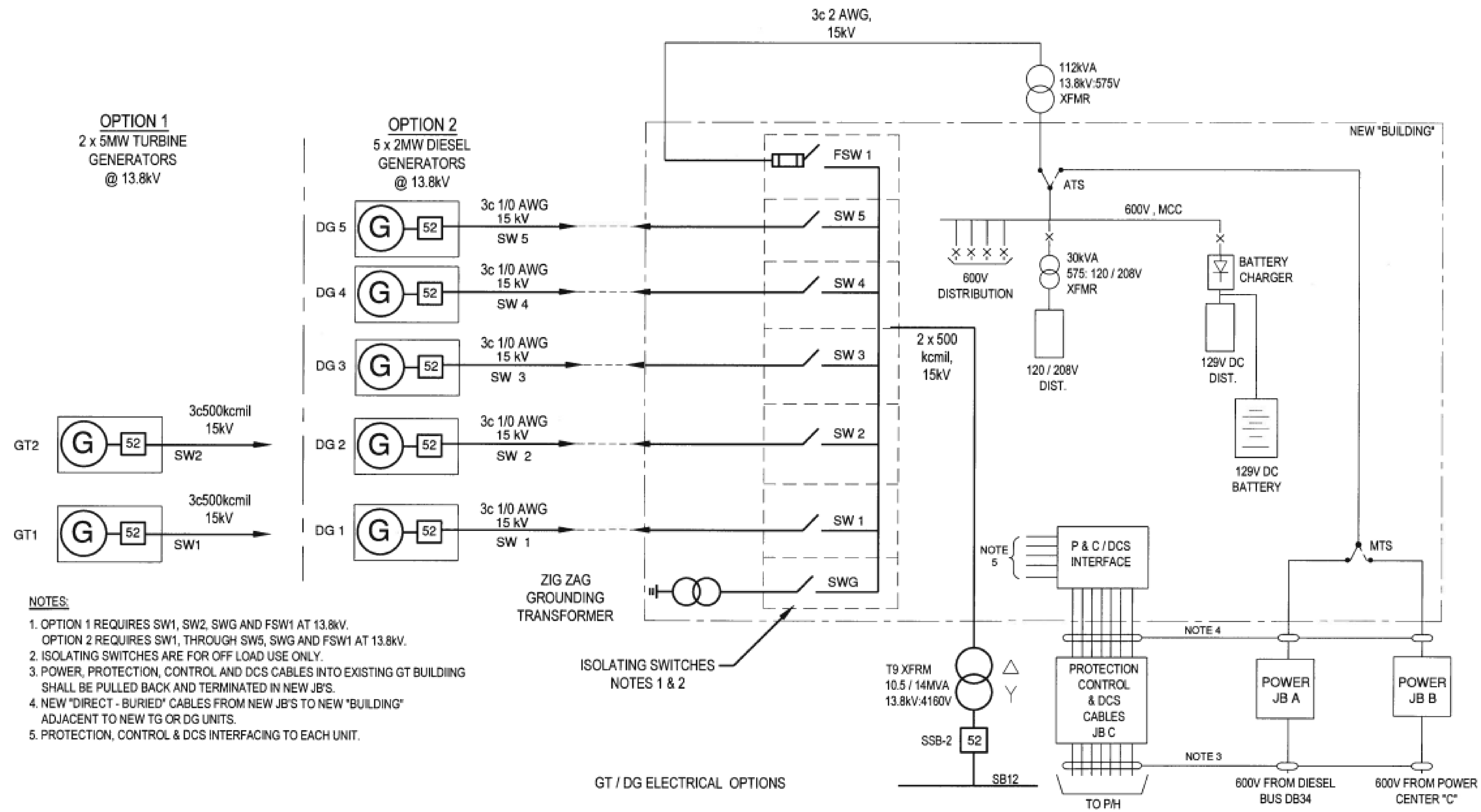


FIGURE 3-6 SINGLE LINE SKETCH – NEW DIESEL GENSET

3.4.6.1 Equipment & Installation Costs – Electrical & Controls

TABLE 3-17 ELECTRICAL & CONTROL EQUIPMENT AND INSTALLATION COSTS (OPTION 2) – 5 X 2 MW TGS @ 4160 V.

Item #	Desciption	Qty	Unit	Material	Labour	Total	Comments
1	3c500 kemil, Teck 15kV cable (2 runs)	440	m	90,200	10,000	100,200	Power from switchgear to generators T9 and grounding transformer
2	3C 1/0 AWG Teck 15kV cable	300	M	10,800	4,000	14,800	
3	13.8kV isolating switchgear (6+1 fused switch)	1	ea	144700	15000	159,700	
4	P&C/DCS interface	1	ea	65,000	10,000	75,000	Will contain interfacing requirements of the new units to T9 and SSB2
5	10 x 3c12AWG, Teck, 1000V cable	500	m	1920	4500	6420	from P&C/DCS interface to DG1 through DG5 for protection and control
6	2 x 24c16AWG, Teck, 1000V cable	350	m	8505	3150	11,655	Cables from P&C/DCS interface to junction box JBC
7	4 x 4c12AWG, Teck, 1000V cable	700	m	3290	6300	9590	Cable from FSWI to 112kV transformer
8	1 x 12C12AWG, Teck, 1000V cable	175	m	2240	1575	3815	Cable ATS to MTS and JBA/JBB to MTS
9	3c2AWG, Teck, 15kV cable	15	m	945	135	1080	
10	2 x 3c1/0, Teck, 1000V cable	125	m	4500	1125	5625	
11	112kVA, 13.8kV:575V, 3ph, 60Hz transformer	1	ea	30000	3000	33000	
12	200A, 600V, 3ph, 60Hz automatic transfer switch	1	ea	5336	1500	6836	
13	200A, 600V, 3ph, 60Hz manual transfer switch	1	ea	2000	1000	3000	
14	MCC, 600A, 600V, 3ph, 3W	1	ea	30000	5000	35000	
15	30kVA, 575:120/280V, 3ph, 60Hz transformer	1	ea	1,000	500	1,500	
16	129VDC distribution panel, motor starters and disconnects	1	ea	35000	6500	41500	
17	100A, 120/208V, 3ph, 60Hz distribution panel c/w breakers	1	ea	1418	350	1768	
18	600V, battery charger, 129VDC output	1	ea	16,000	3220	19,220	
19	129VDC battery bank	1	ea	39,000	7500	46,500	
20	All interconnecting cabling	1	lot	16000	12000	28000	Includes MCC feeders, heating and lighting
21	Miscellaneous 4/0 ground wire, tray and hardware	1	lot	16000	9000	25,000	
22	Reconfiguration of DCS screens, and existing system	1	lot	-	25,000	25,000	
23	25 kVA, 13.8kV, 3ph, 60Hz, zig-zag grounding transformer	1	ea	31,000	2,000	33,000	
24	Commissioning			-	69,000	69,000	
	Totals			554,854	201,355	756,209	

3.4.7 Existing Unit De-Commissioning and Demolition

No significant incremental costs were identified for existing unit de-commissioning and/or demolition. It was felt that the value of the materials derived from the demolition could offset the cost to the contractor. If required as a sensitivity, then a value such as $40,000 might be used. This would not be expected to either sway the selection of a preferred option or impact the overall cost. It should be considered as part of an overall project contingency regardless of any option selected.

3.4.8 Project Engineering and Management, Owner's Costs

It was assumed that the facility implementation would be undertaken largely as an engineer, procure, construct (EPC) external contract. NL Hydro would be responsible for getting the project approved and the necessary environmental and regulatory approvals.

EPC Costs

For the EPC contractor, the project engineering and management costs are based on the total project costs and a percentage for engineering and for management. For the purposes of this estimate, the engineering costs are estimated to be 5% of direct costs of the GT or diesel package and 10% of the balance of plant. The project management and commissioning costs (excluding fuel, Hydro staff costs) are estimated to be 7% of total direct costs. .

Owner's Costs

Owner's costs are not included in the estimates, but are likely to be comparable regardless of the selected option. NL Hydro is also assumed to undertake all the necessary environmental and regulatory permitting entirely internally or with some measure of external support (i.e. environmental modeling and engineering support, or full external scope). This cost is also not included but likely on the order of $55,000.

For the actual project implementation, the assumption is that NL Hydro would assume its own costs of this initial development and then assign a project manager for the life of the project to monitor and assure its successful completion. These and other NL Hydro costs (insurance, legal, supply chain, interest, owners' contingency, Holyrood station participation, commissioning fuel, commissioning labour) are not identified or included herein. It is likely that Owner costs could amount to on the order of 1.5% of directs or about $150,000.

3.4.9 Total New and Nearly New 5 x 2MW Diesel Generator Capital Cost Estimate

The total New and Nearly New 5 x 2 MW diesel generator cost estimate is as follows. The difference in the New and Nearly New is mostly in the capital costs. It should be noted that there may be some additional costs required to retrofit nearly new units to meet the same or required standards as the new units that are designed to meet Holyrood requirements.

TABLE 3-18 CAPITAL COST ESTIMATE – TRANSPORTABLE DIESEL GENSET

Capital Cost Comparison

Capital cost estimate $1,000 Can 2011

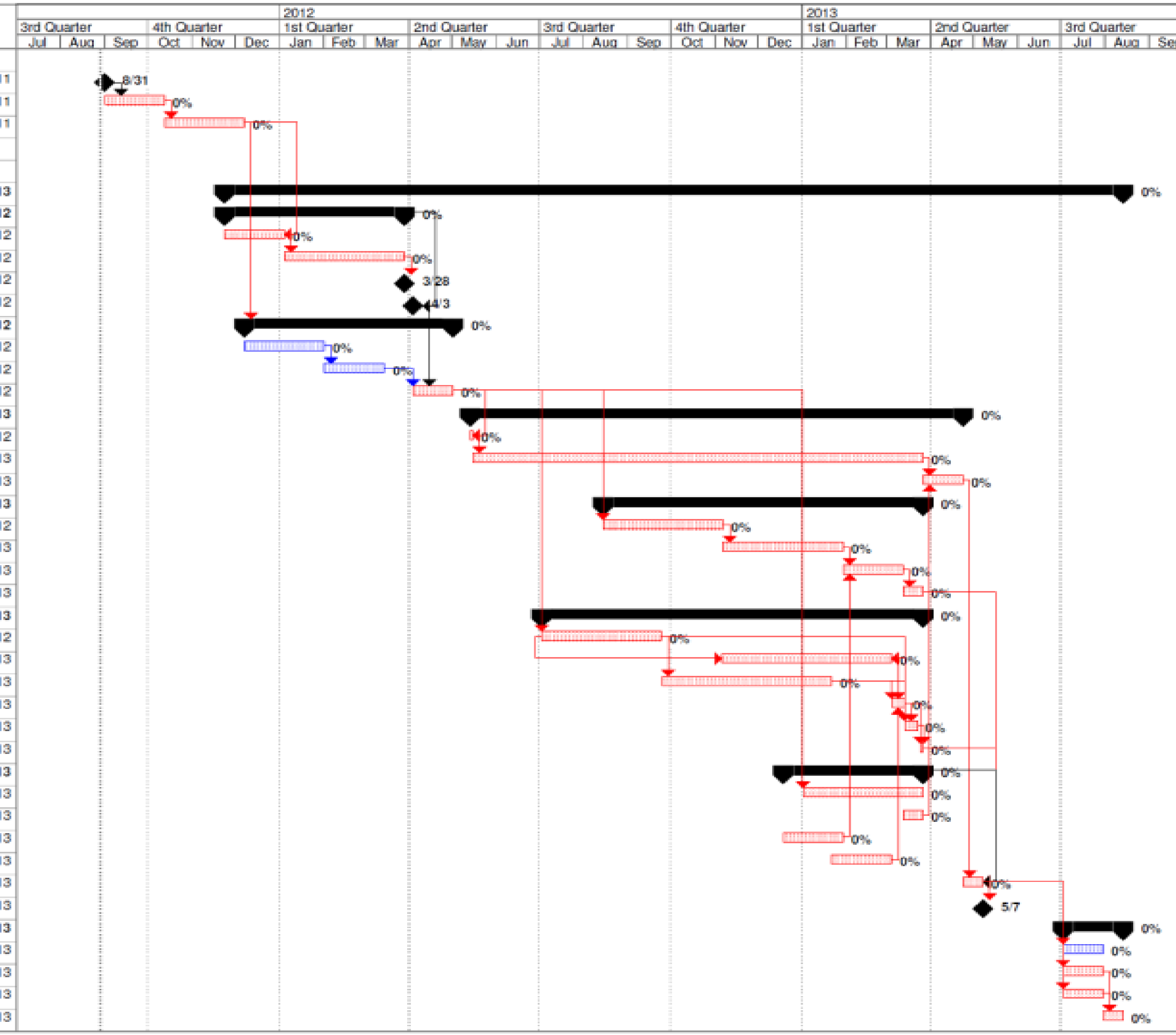
Option Number	2	2A
Option	New 5 x 2 MW Diesel	Used 5 x 2 MW Diesel
GT/Diesel Cost	$8,553	$7,453
Civil Works	$131	$131
Electrical Works	$801	$801
BOP Systems	$129	$129
Existing Unit Demolition & Removal	$7	$7
Sub-Total - Directs and Indirects	$9,620	$8,520
Project Engineering	$513	$458
Project Management	$673	$596
Total	$10,807	$9,575

3.4.10 Schedule

The schedules for the new and nearly new five 2 MW diesel generator are illustrated below. The basic schedule highlights are as follows:

Task	New Diesel Genset	Nearly New Diesel Genset
Review of Options Report	Sept 2011	
Project Approvals and Release	Sept 2011 - Dec 2011	
Engineer, Procure, Construct Contract	May 2012	
In-Service of New 2 x 5 MW GT	May 2013	March 2013
Decommission Existing GT	Aug/Dec 2013	Aug/Dec 2013

ID	Task Name	Duration	Start	Finish
1				
2	Condition Assessment Study	0 wks	Wed 8/31/11	Wed 8/31/11
3	Hydro Internal Capital Budget Proposal Development	6 wks	Thu 9/1/11	Wed 10/12/11
4	Submission - Public Utilities Board & Approval	8 wks	Thu 10/13/11	Wed 12/7/11
5				
6				
7	**New GT or Diesel Units**	**449 days**	**Thu 11/24/11**	**Tue 8/13/13**
8	**Project Environmental & Regulatory Approvals**	**90 days**	**Thu 11/24/11**	**Wed 3/28/12**
9	Prepare Dispersion Modelling & Submission	30 days	Thu 11/24/11	Wed 1/4/12
10	Regulatory Review and Approval	60 days	Thu 1/5/12	Wed 3/28/12
11	Environmental Approval	0 days	Wed 3/28/12	Wed 3/28/12
12	Project Full Release	0 days	Tue 4/3/12	Tue 4/3/12
13	**Request for Proposal (RFP) for Engineer/procure/Cons**	**104 days**	**Thu 12/8/11**	**Tue 5/1/12**
14	Prepare	40 days	Thu 12/8/11	Wed 2/1/12
15	Bid	6 wks	Thu 2/2/12	Wed 3/14/12
16	Award	20 days	Wed 4/4/12	Tue 5/1/12
17	**New Gas Turbien or Diesel Engine Generator**	**247 days**	**Mon 5/14/12**	**Tue 4/23/13**
18	Award Gas Turbine (GT)/Engine Contract	2 days	Mon 5/14/12	Tue 5/15/12
19	Manufacture & Deliver Transportable Engines	45 wks	Wed 5/16/12	Tue 3/26/13
20	Install and Commission	4 wks	Wed 3/27/13	Tue 4/23/13
21	**Fuel System**	**160 days**	**Wed 8/15/12**	**Tue 3/26/13**
22	Engineer	12 wks	Wed 8/15/12	Tue 11/6/12
23	Order, Manufacture, Deliver	12 wks	Wed 11/7/12	Tue 1/29/13
24	Install new fuel lines and receiving system	6 wks	Wed 1/30/13	Tue 3/12/13
25	Commission System	2 wks	Wed 3/13/13	Tue 3/26/13
26	**Electrical & Control Systmes**	**191 days**	**Tue 7/3/12**	**Tue 3/26/13**
27	Engineer	12 wks	Tue 7/3/12	Mon 9/24/12
28	Order & Manufacture Elect & Control (E&C) Equip	17 wks	Tue 11/6/12	Mon 3/4/13
29	Electrical Building Manufacture, Delivery, Install	17 wks	Tue 9/25/12	Mon 1/21/13
30	Install New System	7 days	Tue 3/5/13	Wed 3/13/13
31	RE-align Existing Plant Systems	7 days	Thu 3/14/13	Fri 3/22/13
32	Commission unit	2 days	Mon 3/25/13	Tue 3/26/13
33	**Site Civil Work**	**70 days**	**Wed 12/19/12**	**Tue 3/26/13**
34	Engineer	12 wks	Wed 1/2/13	Tue 3/26/13
35	Generator area clearing and civil	2 wks	Wed 3/13/13	Tue 3/26/13
36	Fuel line civil work	6 wks	Wed 12/19/12	Tue 1/29/13
37	Electrical an contro cable civil work	6 wks	Tue 1/22/13	Mon 3/4/13
38	Complete Unit Test	10 days	Wed 4/24/13	Tue 5/7/13
39	Gas Turbine (GT) In-Service (I/S)	0 days	Tue 5/7/13	Tue 5/7/13
40	**Decommission Existing GT**	**30 days**	**Wed 7/3/13**	**Tue 8/13/13**
41	Fuel delivery system	4 wks	Wed 7/3/13	Tue 7/30/13
42	Electrical & Controls	4 wks	Wed 7/3/13	Tue 7/30/13
43	GT	4 wks	Wed 7/3/13	Tue 7/30/13
44	Building	2 wks	Wed 7/31/13	Tue 8/13/13



Project: Project1 New.mpp
Date: Mon 8/29/11

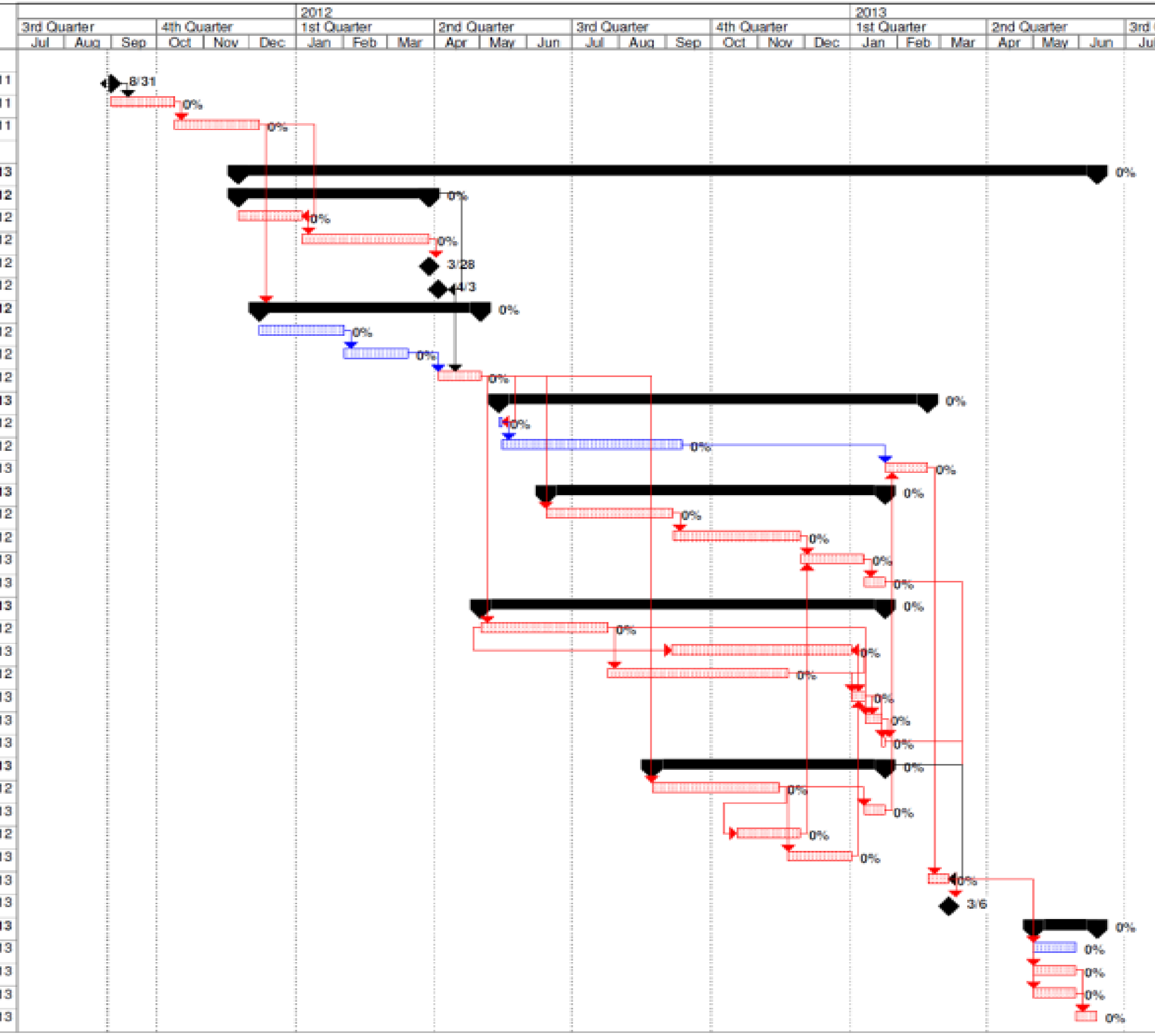
Critical / Critical Split / Critical Progress / Task / Split / Task Progress / Baseline / Baseline Split / Baseline Milestone / Milestone / Summary Progress / Summary / Project Summary / External Tasks / External Milestone / Deadline

Page 1

FIGURE 3-7 SCHEDULE – NEW DIESEL GENSET

amec

ID	Task Name	Duration	Start	Finish
1				
2	Condition Assessment Study	0 wks	Wed 8/31/11	Wed 8/31/11
3	Hydro Internal Capital Budget Proposal Development	6 wks	Thu 9/1/11	Wed 10/12/11
4	Submission - Public Utilities Board & Approval	8 wks	Thu 10/13/11	Wed 12/7/11
5				
6	**Nearly New gas Turbine (GT) or Diesel Generator Units**	**405 days**	**Thu 11/24/11**	**Wed 6/12/13**
7	**Project Environmental & Regulatory Approvals**	**90 days**	**Thu 11/24/11**	**Wed 3/28/12**
8	Prepare Dispersion Modelling & Submission	30 days	Thu 11/24/11	Wed 1/4/12
9	Regulatory Review and Approval	60 days	Thu 1/5/12	Wed 3/28/12
10	Environmental Approval	0 days	Wed 3/28/12	Wed 3/28/12
11	Project Full Release	0 days	Tue 4/3/12	Tue 4/3/12
12	**Request for Proposal (RFP) for Engineer/Procure/Construct (**	**104 days**	**Thu 12/8/11**	**Tue 5/1/12**
13	Prepare	40 days	Thu 12/8/11	Wed 2/1/12
14	Bid	6 wks	Thu 2/2/12	Wed 3/14/12
15	Award	20 days	Wed 4/4/12	Tue 5/1/12
16	**Nearly New GT or Diesel Engine Generator**	**203 days**	**Mon 5/14/12**	**Wed 2/20/13**
17	Award GT/Diesel Engine Contract	2 days	Mon 5/14/12	Tue 5/15/12
18	Manufacture & Deliver Transportable Engines	17 wks	Wed 5/16/12	Tue 9/11/12
19	Install and Commission	4 wks	Thu 1/24/13	Wed 2/20/13
20	**Fuel System**	**160 days**	**Thu 6/14/12**	**Wed 1/23/13**
21	Engineer	12 wks	Thu 6/14/12	Wed 9/5/12
22	Order, Manufacture, Deliver	12 wks	Thu 9/6/12	Wed 11/28/12
23	Install new fuel lines and receiving system	6 wks	Thu 11/29/12	Wed 1/9/13
24	Commission System	2 wks	Thu 1/10/13	Wed 1/23/13
25	**Electrical & Control Systmes**	**191 days**	**Wed 5/2/12**	**Wed 1/23/13**
26	Engineer	12 wks	Wed 5/2/12	Tue 7/24/12
27	Order & Manufacture Elect & Control (E&C) Equip	17 wks	Wed 9/5/12	Tue 1/1/13
28	Electrical Building Manufacture, Delivery, Install	17 wks	Wed 7/25/12	Tue 11/20/12
29	Install New System	7 days	Wed 1/2/13	Thu 1/10/13
30	RE-align Existing Plant Systems	7 days	Fri 1/11/13	Mon 1/21/13
31	Commission unit	2 days	Tue 1/22/13	Wed 1/23/13
32	**Site Civil Work**	**110 days**	**Thu 8/23/12**	**Wed 1/23/13**
33	Engineer	12 wks	Thu 8/23/12	Wed 11/14/12
34	Generator area clearing and civil	2 wks	Thu 1/10/13	Wed 1/23/13
35	Fuel line civil work	6 wks	Thu 10/18/12	Wed 11/28/12
36	Electrical an contro cable civil work	6 wks	Wed 11/21/12	Tue 1/1/13
37	Complete Unit Test	10 days	Thu 2/21/13	Wed 3/6/13
38	GT In-Service (I/S)	0 days	Wed 3/6/13	Wed 3/6/13
39	**Decommission Existing GT**	**30 days**	**Thu 5/2/13**	**Wed 6/12/13**
40	Fuel delivery system	4 wks	Thu 5/2/13	Wed 5/29/13
41	Electrical & Controls	4 wks	Thu 5/2/13	Wed 5/29/13
42	GT	4 wks	Thu 5/2/13	Wed 5/29/13
43	Building	2 wks	Thu 5/30/13	Wed 6/12/13



Project: Project1 Nearly New.mpp
Date: Mon 8/29/11

Critical		Task		Baseline		Milestone		Project Summary	
Critical Split		Split		Baseline Split		Summary Progress		External Tasks	
Critical Progress		Task Progress		Baseline Milestone		Summary		External Milestone	

Deadline

Page 1

FIGURE 3-8 SCHEDULE – NEW DIESEL GENSET

3.4.11 OMA Cost Estimate to 2020

Operating costs were assumed to include the ongoing maintenance costs (annual inspections, repairs, etc.), the operations costs (costs to run the unit on test), the fuelling costs (fuel costs to run the tests), and an electricity value credit. The operating costs shown are the same for both the new and nearly new cases. For the kind of operation required, peak and emergency operation (typically <=60 Hrs/Yr, the diesel packages normally would require only an annual service and inspection by qualified service personnel. Most utilities would exercise the equipment once a month to verify proper operation.

The costs were assumed to include the ongoing maintenance costs (annual inspections, repairs, etc.), the operations costs (costs to run the unit on test), the fuelling costs (fuel costs to run the tests), and an electricity value credit. The assumptions used for fuel, operations, and electricity value are illustrated below. The electricity value is premised on receiving the same value per MWh as the existing units would if they were to recover their fuelling costs plus marginal operating and maintenance costs. The fuelling and electricity prices are intended as representative and based on running the units 150 hours per year, whereas actual hours could be as half of this.. The actual values (average run capacity, sent out heat rate (SOHR) and hence fuel and electricity depend on how the testing is actually done.

TABLE 3-19 NEW DIESEL GENSET – OMA COST ASSUMPTION

Assumptions

		Fuelling
#2 Oil Fuel Price (A)	$/MMBTU	$21.47
Unit Efficiency (B)	BTU/kWh	13,656
Average Running Capacity (C)	MW	4
Average Running Cost (D) = AxBxC/1000	$/Hr	$1,173
Electricity Value (E) = Value for existing GT	$/MWh	$343
Electricity Value (F) = E*C	$/Hr OP	$1,373

Operations	
2	Persons/Start (U)
4	Hrs/Start (V)
$70	$/PersonHr (W)
$560	$/Start (Z) = UxVxW

The resulting costs are:

TABLE 3-20 NEW DIESEL GENSET – OMA COSTS

New/Near New Diesel
1000's Cnd $ - 2011/Yr

	Maintenance	Operations	Fuelling	Sub-Total	Electricity Value	Total
2012	$15	$0	$0	$15	$0	$15
2013	$20	$40	$155	$215	($206)	$9
2014	$20	$40	$155	$215	($206)	$9
2015	$20	$40	$155	$215	($206)	$9
2016	$20	$40	$155	$215	($206)	$9
2017	$20	$40	$155	$215	($206)	$9
2018	$20	$40	$155	$215	($206)	$9
2019	$20	$40	$155	$215	($206)	$9
2020	$0	$40	$155	$195	($206)	($11)
TOTAL	$155	$323	$1,237	$1,714	($1,648)	$67

4 COMPARATIVE ANALYSIS OF OPTIONS

4.1 Economic Assumptions

4.1.1 Economic Parameters

The economic parameter values used for escalation rate (general, fuel, electricity rate), and discount rate (escalated and unescalated) are illustrated below, as well as the associated cumulative factors.

TABLE 4-1 ECONOMIC FACTORS

	Escalation		Discount Rate (Escalated $)		Real Discount Rate (UnEscalated $)		Fuel Escalation		Electricity Value Escalation	
Year	Escalation	Cumulative Escalation Factor	Discount Rate (Escalated $)	Discount Factor (Escalated $)	Discount Rate (UnEscalated $)	Discout Factor (Unescalated $)	Fuel Escalation Rate	Cumulative Fuel Escalation Factor	Electricity Value Escalation Rate	Cumulative Electricity Value Factor
	"A"	"B" = Previous B x (1+A)	"C"	"D" = Previous D x 1/(1+C)	"E" = "C"-"A"	"F" =Previous F x 1/(1+E)	"G"	"H" = Previous H x (1+G)	"I"	"J" = Previous J x (1+I)
2011	0.00%	1.000	10.00%	1.000	7.50%	1.000	0.00%	1.000	0.00%	1.000
2012	2.50%	1.025	10.00%	0.909	7.50%	0.930	3.00%	1.030	3.00%	1.030
2013	2.50%	1.051	10.00%	0.826	7.50%	0.865	3.00%	1.061	3.00%	1.061
2014	2.50%	1.077	10.00%	0.751	7.50%	0.805	3.00%	1.093	3.00%	1.093
2015	2.50%	1.104	10.00%	0.683	7.50%	0.749	3.00%	1.126	3.00%	1.126
2016	2.50%	1.131	10.00%	0.621	7.50%	0.697	3.00%	1.159	3.00%	1.159
2017	2.50%	1.160	10.00%	0.564	7.50%	0.648	3.00%	1.194	3.00%	1.194
2018	2.50%	1.189	10.00%	0.513	7.50%	0.603	3.00%	1.230	3.00%	1.230
2019	2.50%	1.218	10.00%	0.467	7.50%	0.561	3.00%	1.267	3.00%	1.267
2020	2.50%	1.249	10.00%	0.424	7.50%	0.522	3.00%	1.305	3.00%	1.305

4.1.2 Economic Values - Failure to Operate

The analysis assumed a relative difference in the relative probability of failure to perform as required (with Option 1 – the New 2 x 5 MW GTG as the base against which the others are compared). This is based on the reasons provided previously.

TABLE 4-2 ECONOMIC VALUES – FAILURE TO OPERATE ASSUMPTION

Failure To Operate		% Probability once over 2013-2020	Value of Hr Shutdown	# Hrs Per Shutdown	Probable $/Incident
		% (A)	MM$/Hr (B)	Hrs (C)	MM$ (D) = AxBxC
Option 0	Refurbished Unit	10%	$5	20	$10
Option1 & 1A	New/Used 2 x 5 MW GT	0%	$5	20	$0
Option 2 & 2A	New/Used 5x2 MW Diesel	4%	$5	20	$4

Notes:
Value/ Hr Shutdown = $5 MM (Impact to Newfoundland Economy)
Probability risk is relative to the new 2 x 5MW GT option
One occurrence assumed nominally in 2016
Probable $/incident increases proportional to (A), (B), or (C)

4.1.3 Economic Values –Terminal Values

Each of the options has a "terminal value" at the end of the 2020 period. The amount is a function of both the age and condition and market value of the units at that time, and/or of its internal value for redeployment for other uses within Hydro post 2020 (i.e. regional distribution line outage/maintenance support). Potential short term alternative uses prior to 2020 may also have value, but were not assessed. The terminal values assumed for the study are shown in Table 4-4.

TABLE 4-3 OPTION TERMINAL VALUES IN 2020

Option	Purchased Equipment Cost M$	System Terminal Value in 2020 M$	Comment
Option 0 - Refurbished Existing Unit	$3.0	$0	Terminal value covers cost for demolition
Option 1 - New 2 x 5 MW GT	$10.9	$7.0	Low use, essentially new condition.
Option 1A - Nearly New 2 x 5 MW GT	$9.2	$4.0	Lower percent recovery than new given prior use.
Option 2 - New 5 x 2 MW Diesel Genset	$8.6	$5.0	Lower market value – more available.
Option 2A - Nearly New 5 x 2 MW Diesel Genset	$7.5	$3.0	Lower percent recovery than new given prior use.

4.2 Capital Cost Comparison

Table 4-4 provides an overview of the total capital cost of the options.

Option 0, Existing GTG Unit

For Option 0, the existing GT Unit refurbishment, there are three relevant values.

- The base total ($4.462M) does not address the replacement of the unit's capacity during its extensive overhaul outage (12 to 22 weeks).
- The second case ("+ standby") is based on the assumption that a "replacement gas generator and power turbine" are leased and substituted for the current equipment during the overhaul outage. There is a strong likelihood that this is possible. It is assumed that other issues (gearbox oil leaks etc are fixed in relatively short time on site). It is unlikely that other major equipment such as a gearbox could be leased.
- The third option ("+ Rental Stby") assumes that two new 5 MW trailer mounted gas turbines are leased for the outage period and the necessary facilities to connect them installed. This is a very expensive option and auxiliary systems will have limited useful life. It is also likely to significantly extend the schedule. It is not seen as a viable option to pursuing Option 1 or 1A.

Options 1 and 2, New and Nearly New, Used Gas Turbine Generator and Diesel Generator Units

The difference in the New and Nearly New is mostly in the capital costs. It should be noted that there may be some additional costs required to retrofit nearly new units to meet the same or required standards as the new units that are designed to meet Holyrood requirements.

TABLE 4-4 CAPITAL COST COMPARISON OF OPTIONS

Capital Cost Comparison
Capital cost estimate $1,000 Can 2011

Option Number	0	1	1A	2	2A
Option	**Existing GT Refurb**	**New 2 x 5 MW GT**	**Used 2 x 5 MW GT**	**New 5 x 2 MW Diesel**	**Used 5 x 2 MW Diesel**
GT/Diesel Cost	$2,950	$10,865	$9,234	$8,553	$7,453
Civil Works	$224	$131	$131	$131	$131
Electrical Works	$541	$759	$759	$801	$801
BOP Systems	$330	$129	$129	$129	$129
Existing Unit Demolition & Removal	$0	$7	$7	$7	$7
Sub-Total - Directs and Indirects	$4,046	$11,891	$10,260	$9,620	$8,520
Project Engineering	$324	$625	$544	$513	$458
Project Management	$283	$832	$718	$673	$596
Total	$4,652	$13,348	$11,522	$10,807	$9,575

+ Standby = Total	$4,825
+ New Rental Stdby = Total	$9,421

4.3 Operating Cost Comparison

Operating costs were assumed to include the ongoing maintenance costs (annual inspections, repairs, etc.), the operations costs (costs to run the unit on test), the fuelling costs (fuel costs to run the tests), and an electricity value credit.

For Option 0, Existing GTG Unit

The operating costs are shown for both a refurbished case and a non-refurbished case. The assumptions used for fuel, operations, and electricity value are illustrated below. The electricity value is premised on recovering fuelling costs plus marginal operating costs.

TABLE 4-5 OMA ASSUMPTIONS – OPTION 0, EXISTING GTG

Assumptions

		Fuelling
#2 Oil Fuel Price (A)	$/MMBTU	$21.47
Unit Efficiency (B)	BTU/kWh	13,656
Average Running Capacity (C)	MW	4
Average Running Cost (D) = AxBxC/1000	$/Hr	$1,173
Electricity Value (E) = AxB/1000 + $50 Mtce	$/MWh	$343
Electricity Value (F) = E*C	$/Hr OP	$1,373

Operations	
2	Persons/Start (U)
4	Hrs/Start (V)
$70	$/PersonHr (W)
$560	$/Start (Z) = UxVxW

The non-refurbished case includes an assumption of an equipment failure with modest consequential damage in 2016.

TABLE 4-6 OMA COSTS – OPTION 0, EXISTING GTG

Existing Unit
1000's Cnd $ - 2011/Yr

	Maintenance		Operations		Fuelling		Sub-Total		Electricity Value		Total	
	With Rehab	Without Rehab	With Rehab	Without Rehab	With Rehab	Without Rehab	With Rehab	Without Rehab	With Rehab	Without Rehab	With Rehab	Without Rehab
2012	$15	$15	$0	$0	$0	$0	$15	$15	$0	$0	$15	$15
2013	$20	$15	$40	$0	$176	$0	$236	$15	($206)	$0	$30	$15
2014	$20	$15	$40	$0	$176	$0	$236	$15	($206)	$0	$30	$15
2015	$20	$15	$40	$0	$176	$0	$236	$15	($206)	$0	$30	$15
2016	$20	$1,500	$40	$1	$176	$88	$236	$1,589	($206)	($103)	$30	$1,486
2017	$20	$15	$40	$0	$176	$0	$236	$15	($206)	$0	$30	$15
2018	$20	$15	$40	$0	$176	$0	$236	$15	($206)	$0	$30	$15
2019	$20	$15	$40	$0	$176	$0	$236	$15	($206)	$0	$30	$15
2020	$0	$0	$40	$0	$176	$0	$216	$0	($206)	$0	$10	$0
TOTAL	$155	$1,605	$323	$1	$1,408	$88	$1,885	$1,694	($1,648)	($103)	$238	$1,591

For Option 1 and 1A – New and Nearly New 2 x 5MW GTG

The operating costs shown are the same for both the new and nearly new cases. The difference in the New and Nearly New is mostly in the capital costs. The vendor indicated that for the 6 month inspection the cost was to be 10,000 and for the yearly it was 18,000 and that these costs would be the same for both new and nearly new.

The assumptions used for fuel, operations, and electricity value are illustrated below. The electricity value is premised on recovering fuelling costs plus marginal operating costs.

TABLE 4-7 OMA ASSUMPTIONS – OPTION 1, NEW TRANSPORTABLE GTG

Assumptions

#2 Oil Fuel Price (A)	$/MMBTU	$21.47
Unit Efficiency (B)	BTU/kWh	12,000
Average Running Capacity (C)	MW	4
Average Running Cost (D) = AxBxC/1000	$/Hr	$1,031
Electricity Value (E) = Value for existing GT	$/MWh	$343.25
Electricity Value (F) = E*C	$/Hr OP	$1,373

2	Persons/Start (U)
4	Hrs/Start (V)
$70	$/PersonHr (W)
$560	$/Start (Z) = UxVxW

The resulting costs are:

TABLE 4-8 OMA COSTS – OPTION 1, NEW TRANSPORTABLE GTG

New/Near New GT
1000's Cnd $ - 2011/Yr

	Maintenance	Operations	Fuelling	Sub-Total	Electricity Value		Total
2012	$15	$0	$0	$15	$0		$15
2013	$20	$40	$155	$215	($206)		$9
2014	$20	$40	$155	$215	($206)		$9
2015	$20	$40	$155	$215	($206)		$9
2016	$20	$40	$155	$215	($206)		$9
2017	$20	$40	$155	$215	($206)		$9
2018	$20	$40	$155	$215	($206)		$9
2019	$20	$40	$155	$215	($206)		$9
2020	$0	$40	$155	$195	($206)		($11)
TOTAL	$155	$323	$1,237	$1,714	($1,648)		$67

For Option 2 and 2A – New and Nearly New 5 x 2MW Diesel Engine Generators

The operating costs shown are the same for both the new and nearly new cases. The difference in the New and Nearly New is mostly in the capital costs.

The assumptions used for fuel, operations, and electricity value are illustrated below. The electricity value is premised on recovering fuelling costs plus marginal operating costs.

TABLE 4-9 OMA ASSUMPTIONS – OPTION 2, NEW DIESEL GENSET

Assumptions

		Fuelling
#2 Oil Fuel Price (A)	$/MMBTU	$21.47
Unit Efficiency (B)	BTU/kWh	13,656
Average Running Capacity (C)	MW	4
Average Running Cost (D) = AxBxC/1000	$/Hr	$1,173
Electricity Value (E) = Value for existing GT	$/MWh	$343
Electricity Value (F) = E*C	$/Hr OP	$1,373

Operations	
2	Persons/Start (U)
4	Hrs/Start (V)
$70	$/PersonHr (W)
$560	$/Start (Z) = UxVxW

The resulting costs are:

TABLE 4-10 OMA COSTS – OPTION 2, NEW DIESEL GENSET

New/Near New Diesel
1000's Cnd $ - 2011/Yr

	Maintenance	Operations	Fuelling	Sub-Total	Electricity Value	Total
2012	$15	$0	$0	$15	$0	$15
2013	$20	$40	$155	$215	($206)	$9
2014	$20	$40	$155	$215	($206)	$9
2015	$20	$40	$155	$215	($206)	$9
2016	$20	$40	$155	$215	($206)	$9
2017	$20	$40	$155	$215	($206)	$9
2018	$20	$40	$155	$215	($206)	$9
2019	$20	$40	$155	$215	($206)	$9
2020	$0	$40	$155	$195	($206)	($11)
TOTAL	$155	$323	$1,237	$1,714	($1,648)	$67

4.4 Life Cycle Cost Comparison

Table 4-11 presents a summary of the life cycle cost comparison of the options in 1) un-escalated non-discounted (not present worthed), 2) un-escalated discounted (present worthed), 3) escalated non-discounted (not present worthed), and 4) escalated discounted (present worthed) costs.

The existing unit refurbishment option costs include the lower cost standby option, assuming that a replacement gas generator and power turbine are leased and installed while the existing units are sent out for refurbishment. This adds only about $200,000 to the base cost.

The existing unit refurbishment option costs assuming the standby option using a complete, installed 2 x 5 MW nearly new GT leased option would add an additional $4.6 M.

The options include a cost for differences in the likelihood of a failure occurring once during the period – an additional $10 million in 2016 for the existing GTG and $3 to 4 million for the 5 x 2 MW diesel options.

TABLE 4-11 LIFE CYCLE COST COMPARISON SUMMARY

		Refurbished Unit, Use of Spare Gas Generator & Power Turbine					
		Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
1	UNESCALATED	$14,825	$1,885	$1,408	$18,118	($1,648)	$16,470
2	UNESCALATED, DISCOUTED CASHFLOW	$11,454	$1,291	$959	$13,704	($1,122)	$12,582
3	ESCALATED CASHFLOW	$16,260	$2,159	$1,660	$20,079	($1,943)	$18,136
4	ESCALATED, DISCOUTED CASHFLOW	$11,521	$1,302	$992	$13,815	($1,161)	$12,654

		Option 1 New 2x5 MW GT					
		Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
1	UNESCALATED	$6,348	$1,714	$1,237	$9,300	($1,648)	$7,652
2	UNESCALATED, DISCOUTED CASHFLOW	$8,766	$1,175	$842	$10,783	($1,122)	$9,661
3	ESCALATED CASHFLOW	$4,940	$1,963	$1,459	$8,362	($1,943)	$6,419
4	ESCALATED, DISCOUTED CASHFLOW	$8,731	$1,185	$871	$10,787	($1,161)	$9,626

	Option 1A Used 2x5 MW GT					
	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
1	$7,522	$1,714	$1,237	$10,473	($1,648)	$8,826
2	$8,632	$1,175	$842	$10,649	($1,122)	$9,527
3	$6,815	$1,963	$1,459	$10,236	($1,943)	$8,294
4	$8,618	$1,185	$871	$10,674	($1,161)	$9,513

		Option 2 New 5x2MW Diesel					
		Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
1	UNESCALATED	$9,807	$323	$1,237	$11,366	($1,648)	$9,719
2	UNESCALATED, DISCOUTED CASHFLOW	$10,231	$220	$842	$11,293	($1,122)	$10,171
3	ESCALATED CASHFLOW	$9,358	$370	$1,459	$11,187	($1,943)	$9,244
4	ESCALATED, DISCOUTED CASHFLOW	$10,232	$222	$871	$11,325	($1,161)	$10,164

	Option 2A Used 5x2MW Diesel					
	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
1	$10,575	$323	$1,237	$12,134	($1,648)	$10,487
2	$10,128	$220	$842	$11,190	($1,122)	$10,068
3	$10,593	$370	$1,459	$12,422	($1,943)	$10,479
4	$10,143	$222	$871	$11,236	($1,161)	$10,075

The details of the un-escalated non-discounted (not present worthed) and unescalated discounted (present worthed) tables for the options, using the assumption in Section 4.1, are as follows:

TABLE 4-12 LIFE CYCLE COST COMPARISON (UNESCALATED, NOT-DISCOUNTED AND DISCOUNTED)

UNESCALATED, NOT DISCOUNTED CASHFLOW

Refurbished Unit, Use of Spare Gas Generator & Power Turbine

	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
2011		$0	$0	$0	$0	$0
2012	$4,825	$15	$0	$4,840	$0	$4,840
2013		$236	$176	$412	($206)	$206
2014		$236	$176	$412	($206)	$206
2015		$236	$176	$412	($206)	$206
2016	$10,000	$236	$176	$10,412	($206)	$10,206
2017		$236	$176	$412	($206)	$206
2018		$236	$176	$412	($206)	$206
2019		$236	$176	$412	($206)	$206
2020	$0	$216	$176	$392	($206)	$186
Total	$14,825	$1,885	$1,408	$18,118	($1,648)	$16,470

Option 1 New 2x5 MW GT

	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
2011		$0	$0	$0	$0	$0
2012	$13,348	$15	$0	$13,363	$0	$13,363
2013		$215	$155	$370	($206)	$164
2014		$215	$155	$370	($206)	$164
2015		$215	$155	$370	($206)	$164
2016	$0	$215	$155	$370	($206)	$164
2017		$215	$155	$370	($206)	$164
2018		$215	$155	$370	($206)	$164
2019		$215	$155	$370	($206)	$164
2020	($7,000)	$195	$155	($6,650)	($206)	($6,856)
Total	$6,348	$1,714	$1,237	$9,300	($1,648)	$7,652

Option 1A Used 2x5 MW GT

	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
2011		$0	$0	$0	$0	$0
2012	$11,522	$15	$0	$11,537	$0	$11,537
2013		$215	$155	$370	($206)	$164
2014		$215	$155	$370	($206)	$164
2015		$215	$155	$370	($206)	$164
2016	$0	$215	$155	$370	($206)	$164
2017		$215	$155	$370	($206)	$164
2018		$215	$155	$370	($206)	$164
2019		$215	$155	$370	($206)	$164
2020	($4,000)	$195	$155	($3,650)	($206)	($3,856)
Total	$7,522	$1,714	$1,237	$10,473	($1,648)	$8,826

Option 2 New 5 x 2 MW Diesel

	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
2011		$0	$0	$0	$0	$0
2012	$10,807	$0	$0	$10,807	$0	$10,807
2013		$40	$155	$195	($206)	($11)
2014		$40	$155	$195	($206)	($11)
2015		$40	$155	$195	($206)	($11)
2016	$4,000	$40	$155	$4,195	($206)	$3,989
2017		$40	$155	$195	($206)	($11)
2018		$40	$155	$195	($206)	($11)
2019		$40	$155	$195	($206)	($11)
2020	($5,000)	$40	$155	($4,805)	($206)	($5,011)
Total	$9,807	$323	$1,237	$11,366	($1,648)	$9,719

Option 2A used 5 x 2 MW Diesel

	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
2011		$0	$0	$0	$0	$0
2012	$9,575	$0	$0	$9,575	$0	$9,575
2013		$40	$155	$195	($206)	($11)
2014		$40	$155	$195	($206)	($11)
2015		$40	$155	$195	($206)	($11)
2016	$4,000	$40	$155	$4,195	($206)	$3,989
2017		$40	$155	$195	($206)	($11)
2018		$40	$155	$195	($206)	($11)
2019		$40	$155	$195	($206)	($11)
2020	($3,000)	$40	$155	($2,805)	($206)	($3,011)
Total	$10,575	$323	$1,237	$12,134	($1,648)	$10,487

UNESCALATED, DISCOUTED CASHFLOW

Refurbished Unit, Use of Spare Gas Generator & Power Turbine

	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
2011	$0	$0	$0	$0	$0	$0
2012	$4,489	$14	$0	$4,502	$0	$4,502
2013	$0	$204	$152	$357	($178)	$178
2014	$0	$190	$142	$332	($166)	$166
2015	$0	$177	$132	$309	($154)	$154
2016	$6,966	$165	$123	$7,253	($143)	$7,109
2017	$0	$153	$114	$267	($133)	$134
2018	$0	$142	$106	$248	($124)	$124
2019	$0	$132	$99	$231	($115)	$116
2020	$0	$113	$92	$205	($107)	$97
Total	$11,454	$1,291	$959	$13,704	($1,122)	$12,582

Option 1 New 2x5 MW GT

	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
2011	$0	$0	$0	$0	$0	$0
2012	$12,417	$14	$0	$12,431	$0	$12,431
2013	$0	$186	$134	$320	($178)	$142
2014	$0	$173	$124	$297	($166)	$132
2015	$0	$161	$116	$277	($154)	$123
2016	$0	$150	$108	$257	($143)	$114
2017	$0	$139	$100	$239	($133)	$106
2018	$0	$130	$93	$223	($124)	$99
2019	$0	$121	$87	$207	($115)	$92
2020	($3,651)	$102	$81	($3,469)	($107)	($3,576)
Total	$8,766	$1,175	$842	$10,783	($1,122)	$9,661

Option 1A Used 2x5 MW GT

	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
2011	$0	$0	$0	$0	$0	$0
2012	$10,718	$14	$0	$10,732	$0	$10,732
2013	$0	$186	$134	$320	($178)	$142
2014	$0	$173	$124	$297	($166)	$132
2015	$0	$161	$116	$277	($154)	$123
2016	$0	$150	$108	$257	($143)	$114
2017	$0	$139	$100	$239	($133)	$106
2018	$0	$130	$93	$223	($124)	$99
2019	$0	$121	$87	$207	($115)	$92
2020	($2,086)	$102	$81	($1,904)	($107)	($2,011)
Total	$8,632	$1,175	$842	$10,649	($1,122)	$9,527

Option 2 New 5 x 2 MW Diesel

	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
2011	$0	$0	$0	$0	$0	$0
2012	$10,053	$0	$0	$10,053	$0	$10,053
2013	$0	$35	$134	$169	($178)	($10)
2014	$0	$32	$124	$157	($166)	($9)
2015	$0	$30	$116	$146	($154)	($8)
2016	$2,786	$28	$108	$2,922	($143)	$2,779
2017	$0	$26	$100	$126	($133)	($7)
2018	$0	$24	$93	$117	($124)	($7)
2019	$0	$23	$87	$109	($115)	($6)
2020	($2,608)	$21	$81	($2,506)	($107)	($2,614)
Total	$10,231	$220	$842	$11,293	($1,122)	$10,171

Option 2A used 5 x 2 MW Diesel

	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
2011	$0	$0	$0	$0	$0	$0
2012	$8,907	$0	$0	$8,907	$0	$8,907
2013	$0	$35	$134	$169	($178)	($10)
2014	$0	$32	$124	$157	($166)	($9)
2015	$0	$30	$116	$146	($154)	($8)
2016	$2,786	$28	$108	$2,922	($143)	$2,779
2017	$0	$26	$100	$126	($133)	($7)
2018	$0	$24	$93	$117	($124)	($7)
2019	$0	$23	$87	$109	($115)	($6)
2020	($1,565)	$21	$81	($1,463)	($107)	($1,570)
Total	$10,128	$220	$842	$11,190	($1,122)	$10,068

Based on escalated cost assumptions in Section 4.1, the escalated non-discounted (not present worthed) and escalated discounted (present worthed) tables are as follows.

TABLE 4-13 LIFE CYCLE COST COMPARISON (ESCALATED, NOT DISCOUNTED AND DISCOUNTED, PRESENT VALUED)

ESCALATED, NOT DISCOUNTED CASHFLOW

Refurbished Unit, Use of Spare Gas Generator & Power Turbine

	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
2011	$0	$0	$0	$0	$0	$0
2012	$4,946	$15	$0	$4,961	$0	$4,961
2013	$0	$248	$187	$435	($218)	$216
2014	$0	$254	$192	$447	($225)	$222
2015	$0	$261	$198	$459	($232)	$227
2016	$11,314	$267	$204	$11,785	($239)	$11,547
2017	$0	$274	$210	$484	($246)	$238
2018	$0	$281	$216	$497	($253)	$244
2019	$0	$288	$223	$511	($261)	$250
2020	$0	$270	$230	$500	($269)	$231
Total	$16,260	$2,159	$1,660	$20,079	($1,943)	$18,136

Option 1 New 2x5 MW GT

	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
2011	$0	$0	$0	$0	$0	$0
2012	$13,682	$15	$0	$13,697	$0	$13,697
2013	$0	$226	$164	$390	($218)	$171
2014	$0	$231	$169	$400	($225)	$175
2015	$0	$237	$174	$411	($232)	$179
2016	$0	$243	$179	$422	($239)	$184
2017	$0	$249	$185	$434	($246)	$188
2018	$0	$255	$190	$446	($253)	$192
2019	$0	$262	$196	$458	($261)	$197
2020	($8,742)	$243	$202	($8,297)	($269)	($8,566)
Total	$4,940	$1,963	$1,459	$8,362	($1,943)	$6,419

Option 1A Used 2x5 MW GT

	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
2011	$0	$0	$0	$0	$0	$0
2012	$11,810	$15	$0	$11,826	$0	$11,826
2013	$0	$226	$164	$390	($218)	$171
2014	$0	$231	$169	$400	($225)	$175
2015	$0	$237	$174	$411	($232)	$179
2016	$0	$243	$179	$422	($239)	$184
2017	$0	$249	$185	$434	($246)	$188
2018	$0	$255	$190	$446	($253)	$192
2019	$0	$262	$196	$458	($261)	$197
2020	($4,995)	$243	$202	($4,550)	($269)	($4,819)
Total	$6,815	$1,963	$1,459	$10,236	($1,943)	$8,294

Option 2 New 5 x 2 MW Diesel

	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
2011	$0	$0	$0	$0	$0	$0
2012	$11,077	$0	$0	$11,077	$0	$11,077
2013	$0	$42	$164	$206	($218)	($12)
2014	$0	$43	$169	$212	($225)	($13)
2015	$0	$45	$174	$219	($232)	($13)
2016	$4,526	$46	$179	$4,750	($239)	$4,512
2017	$0	$47	$185	$231	($246)	($15)
2018	$0	$48	$190	$238	($253)	($15)
2019	$0	$49	$196	$245	($261)	($16)
2020	($6,244)	$50	$202	($5,992)	($269)	($6,261)
Total	$9,358	$370	$1,459	$11,187	($1,943)	$9,244

Option 2A used 5 x 2 MW Diesel

	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
2011	$0	$0	$0	$0	$0	$0
2012	$9,814	$0	$0	$9,814	$0	$9,814
2013	$0	$42	$164	$206	($218)	($12)
2014	$0	$43	$169	$212	($225)	($13)
2015	$0	$45	$174	$219	($232)	($13)
2016	$4,526	$46	$179	$4,750	($239)	$4,512
2017	$0	$47	$185	$231	($246)	($15)
2018	$0	$48	$190	$238	($253)	($15)
2019	$0	$49	$196	$245	($261)	($16)
2020	($3,747)	$50	$202	($3,494)	($269)	($3,763)
Total	$10,593	$370	$1,459	$12,422	($1,943)	$10,479

ESCALATED, DISCOUTED CASHFLOW

Refurbished Unit, Use of Spare Gas Generator & Power Turbine

	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
2011	$0	$0	$0	$0	$0	$0
2012	$4,496	$14	$0	$4,510	$0	$4,510
2013	$0	$205	$154	$359	($181)	$179
2014	$0	$191	$144	$336	($169)	$167
2015	$0	$178	$135	$313	($158)	$155
2016	$7,025	$166	$127	$7,318	($148)	$7,170
2017	$0	$155	$119	$273	($139)	$134
2018	$0	$144	$111	$255	($130)	$125
2019	$0	$134	$104	$238	($122)	$117
2020	$0	$115	$97	$212	($114)	$98
Total	$11,521	$1,302	$992	$13,815	($1,161)	$12,654

Option 1 New 2x5 MW GT

	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
2011	$0	$0	$0	$0	$0	$0
2012	$12,438	$14	$0	$12,452	$0	$12,452
2013	$0	$187	$136	$322	($181)	$142
2014	$0	$174	$127	$301	($169)	$132
2015	$0	$162	$119	$281	($158)	$123
2016	$0	$151	$111	$262	($148)	$114
2017	$0	$141	$104	$245	($139)	$106
2018	$0	$131	$98	$229	($130)	$99
2019	$0	$122	$91	$214	($122)	$92
2020	($3,707)	$103	$86	($3,519)	($114)	($3,633)
Total	$8,731	$1,185	$871	$10,787	($1,161)	$9,626

Option 1A Used 2x5 MW GT

	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
2011	$0	$0	$0	$0	$0	$0
2012	$10,737	$14	$0	$10,750	$0	$10,750
2013	$0	$187	$136	$322	($181)	$142
2014	$0	$174	$127	$301	($169)	$132
2015	$0	$162	$119	$281	($158)	$123
2016	$0	$151	$111	$262	($148)	$114
2017	$0	$141	$104	$245	($139)	$106
2018	$0	$131	$98	$229	($130)	$99
2019	$0	$122	$91	$214	($122)	$92
2020	($2,119)	$103	$86	($1,930)	($114)	($2,044)
Total	$8,618	$1,185	$871	$10,674	($1,161)	$9,513

Option 2 New 5 x 2 MW Diesel

	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
2011	$0	$0	$0	$0	$0	$0
2012	$10,070	$0	$0	$10,070	$0	$10,070
2013	$0	$35	$136	$171	($181)	($10)
2014	$0	$33	$127	$160	($169)	($10)
2015	$0	$30	$119	$149	($158)	($9)
2016	$2,810	$28	$111	$2,950	($148)	$2,801
2017	$0	$26	$104	$131	($139)	($8)
2018	$0	$25	$98	$122	($130)	($8)
2019	$0	$23	$91	$114	($122)	($7)
2020	($2,648)	$21	$86	($2,541)	($114)	($2,655)
Total	$10,232	$222	$871	$11,325	($1,161)	$10,164

Option 2A used 5 x 2 MW Diesel

	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
2011	$0	$0	$0	$0	$0	$0
2012	$8,922	$0	$0	$8,922	$0	$8,922
2013	$0	$35	$136	$171	($181)	($10)
2014	$0	$33	$127	$160	($169)	($10)
2015	$0	$30	$119	$149	($158)	($9)
2016	$2,810	$28	$111	$2,950	($148)	$2,801
2017	$0	$26	$104	$131	($139)	($8)
2018	$0	$25	$98	$122	($130)	($8)
2019	$0	$23	$91	$114	($122)	($7)
2020	($1,589)	$21	$86	($1,482)	($114)	($1,596)
Total	$10,143	$222	$871	$11,236	($1,161)	$10,075

5 CONCLUSIONS

5.1 Existing Gas Turbine Generator Unit

1. The existing GT generator should not be operated (started, operated, shutdown) except in an emergency situation, and in such an emergency its operation should be observe remotely to ensure personnel safety.
   - i) Fire from lube oil system gearbox seals remains a possible safety issue.
   - ii) Catastrophic failure of the power turbine disk is a possibility due to corrosion and high stress that may be present at blade roots and attachments
2. The existing GT generator requires extensive overhaul and repair work:
   - x) Power turbine disk may require replacement (9 month manufacturing lead time)
   - xi) One or more power turbine blades may require replacement or significant repair
   - xii) Gas generator blading requires cleaning and recoating
   - xiii) Inlet filter media requires replacement and inlet duct requires refurbishment (including cooling air duct to power turbine disk)
   - xiv) Exhaust stack requires replacement or extensive repairs
   - xv) Gearbox lube oil system requires modification and refurbishment
     - e. Seals require replacement/modification
     - f. Venting system modifications required to reduce lube oil pressure buildup
     - g. Lube oil pump system requires upgrade for start-ups.
     - h. Lube oil cooling fan is experiencing some leaks and snow and ice and water build-ups in its containment can cause start-issues
   - xvi) Gearbox bearings likely worn and need refurbishment or replacement and/or unit re-alignment
   - xvii) Unit generator requires significant testing and possibly rewind
   - xviii) Unit generator exciter needs refurbishment and likely replacement
3. GT electrical and controls system has elements that are not in compliance with current standards and/or are obsolete and hence necessitates replacement:
   - iii) Unit AVR
   - iv) Unit MCC's
4. The GT and generator enclosure rooms require modification to their fire detection and suppression systems to provide better coverage, as evidenced by the failure of the system to initially detect or suppress the gearbox lube oil fire in 2010.
5. GT fuel oil receiving, forwarding, and delivery system are in operable condition, but climatic conditions (icing, snow-buildup, water build-ups from rain, rusting from salty ambient air) result in significant periods where starts may fail or be significantly delayed. The GT generator building is in generally good condition, except for:
   - iv) Major leaks in and around the GT exhaust stack which are impacting the gas turbine power turbine volute and back end blades;
   - v) Minor leaks at generator ventilation stack; and
   - vi) Minor air leaks as a result of minor siding holes (corrosion) which require repair/ refurbishment
6. The electrical services room require expansion to allow for new electrical systems and current systems to be in compliance with current standards (i.e. space, separation distance for arc flash).

7. The earliest in-service dates for refurbishing the existing unit and returning it to service:
    a. Without back-up during the existing unit outage, but restricting the outage to lower risk, late spring to early fall periods is October 2013, with a roughly six month outage.
    b. With a nearly new 2 x 5 MW GT leased unit required during an existing unit outage is July 2013 with the existing unit on outage about five months.
    c. With shorter duration engineering and procurement times for BOP, fuel system and electrical systems, the in-service can theoretically be advance two to three months, but outage scheduling would likely mitigate this.

    Note: Using leased parts during outage, or procuring used parts and refurbishing them, has no significant positive impact.
8. The capital cost for refurbishing the existing unit is between $4.5 and $5 million, depending on the amount of additional work found during refurbishment. If leasing a replacement 2 x 5 MW unit is required to avoid any outage, then the total capital cost would be between $9.5 and $10.0 million, depending on the market price and availability of portable/mobile equipment. There is some opportunity to slightly reduce costs if used parts for the unit, and in particular the power turbine disk, are available.

5.2 New and Nearly-New 2 x 5 MW Portable/Transportable Gas Turbine Generator Units

1. The two 5 MW transportable gas turbine units option is consistent with the requirements for black start power, the need to start a 3 MW power block (one boiler feed pump motor), and simplicity of managing the number of black start units in parallel.
2. The space requirements for the two 5 MW transportable gas turbine units (2 trailers each plus a common electrical building) cannot be accommodated in the existing GT area.
3. Space and civil requirements support the use of the existing well graded area behind the old security building as the best location.
4. Two new 5 MW transportable gas turbine units could be readily purchased, with a manufacturing time of about 12 months.
5. Two nearly new, used 5 MW transportable GT units may be possible to acquire to a shorter time. Their availability and cost are functions of the market place. The units may also have to be adapted to suit Holyrood conditions (motor and start voltages, applicable codes, design fuel combustors, NOx levels).
6. Emissions, particularly NOx emissions, will have to be addressed:
    iv) NOx emissions are dependent on the nitrogen content of the diesel fuel oil used.
    v) NOx emissions will be lower than those of the current GTG units, but being oil fuelled units will be challenged to meet Canadian Council of Ministers of the Environment (CCME gas turbine NOx emission guidelines
    vi) Newfoundland & Labrador environmental regulations require Best Available Control Technology (BACT), although the regulations have provisions relaxing BACT requirements for both economic impacts as well as flexibility of approval by the Minister considering roles.
        c. The current designs do not have special technology (i.e. Selective Catalytic Reduction (SCR)). Their costs, the impacts of the technology on black start readiness and reliability, and the costs and impacts of ammonia use and storage for SCR use, make their consideration unreasonable for the roles contemplated.

d. A project going forth will have to seek approval for an exemption from the BACT requirement, and will likely have restrictions placed on the unit such as a limit on the number of operating hours per year.

7. Five MW units are likely the upper limit of useful unit size for redeployment in support of transmission and distribution line maintenance support either post 2020 or periods up to 2020.
8. The earliest in-service date for procuring and installing 2 x 5 MW new gas turbine generators is May 2013. The earliest in-service date for procuring and installing 2 x 5 MW nearly new/used gas turbine generators is March 2013.
9. The capital cost for procuring and installing 2 x 5 MW new gas turbine generators is $13.3 million. The capital cost for procuring and installing 2 x 5 MW nearly new/used gas turbine generators is $11.5 million.

5.3 New and Nearly-New 5 x 2 MW Portable/Transportable Diesel Engine Generator Units

1. The five 2 MW transportable diesel engine generator units option is potentially consistent with the requirements for black start power, but:
   i) The units may have significant difficulty responding to a block load start of 3 MW power block (one boiler feed pump motor), and
   ii) Islanded synchronous operation during start-up of five units may be difficult to maintain and affect overall system capacity available and overall system start-up reliability. It will also likely require a more complex control system.
2. The space requirements for the five 2 MW transportable diesel engine generator units (5 trailers plus two electrical trailers plus a common electrical building) cannot be accommodated in the existing GT area.
   i) Space and civil requirements suggested that use of the existing well graded area behind the old security building was the best location.
   ii) Spacing requirements are increased by separation requirements between units
3. Five new 2 MW transportable diesel engine generator units could be readily purchased, with a manufacturing time of about 12 months.
4. Five nearly new, used 2 MW transportable diesel engine generator units may be possible to acquire to a shorter time. Their availability and cost are functions of the marketplace and the units may have to be adapted to suit Holyrood conditions (motor and start voltages, applicable codes, design fuel combustors, NOx levels).
5. Emissions, particularly NOx emissions, will have to be addressed:
   i) NOx emissions are dependent on the nitrogen content of the diesel fuel oil used.
   ii) NOx emissions, particularly for some used engines, may not be lower than those of the existing GT unit. They will have higher emission levels than the GT options.
   iii) Applicable diesel engine generator emission regulations in the US and Canada are in flux, with significantly more stringent requirements likely for units coming into service in the 2012 through 2015 period. Emergency power non-mobile (i.e. not on road or off-road units) will face significant but less stringent levels, but will have their operation limited to emergency use only (in effect similar to the restriction imposed on the existing GT).
   iv) Newfoundland & Labrador environmental regulations require BACT, although the regulations have provisions relaxing BACT requirements for both economic impacts as well as flexibility of approval by the Minister considering roles.

  a. The current designs do not have special technology (i.e. Selective Catalytic Reduction (SCR)). Their costs, the impacts of the technology on black start readiness and reliability, and the costs and impacts of ammonia use and storage for SCR use, make their consideration unreasonable for the roles contemplated.
  b. A project going forth will have to seek approval for an exemption from the BACT requirement, and will likely have restrictions placed on its role and likely a limit on the number of operating hours per year.

6. Two MW units are good candidates for redeployment in support of transmission and distribution line maintenance support either post 2020 or in possible periods up to 2020. They are typical of larger unit sizes deployed for that purpose now.

7. The earliest in-service date for procuring and installing 5 x 2 MW new diesel gensets is May 2013. The earliest in-service date for procuring and installing 5 x 2 MW nearly new/used diesel gensets is March 2013.

8. The capital cost for procuring and installing 5 x 2 MW new diesel gensets is $10.8 million. The capital cost for procuring and installing 5 x 2 MW nearly new/used diesel gensets is $9.6 million.

5.4 Overall Economics

Using the Assessment Basis,

1. The base capital cost comparison of the options is as follows:

BASE CAPITAL COST COMPARISON OF OPTIONS

Capital Cost Comparison
Capital cost estimate $1.000 Can 2011

Option Number	**0**	**1**	**1A**	**2**	**2A**
Option	**Existing GT Refurb**	**New 2 x 5 MW GT**	**Used 2 x 5 MW GT**	**New 5 x 2 MW Diesel**	**Used 5 x 2 MW Diesel**
GT/Diesel Cost	$2.950	$10.865	$9.234	$8.553	$7.453
Civil Works	$224	$131	$131	$131	$131
Electrical Works	$541	$759	$759	$801	$801
BOP Systems	$330	$129	$129	$129	$129
Existing Unit Demolition & Removal	$0	$7	$7	$7	$7
Sub-Total - Directs and Indirects	$4.046	$11.891	$10.260	$9.620	$8.520
Project Engineering	$324	$625	$544	$513	$458
Project Management	$283	$832	$718	$673	$596
Total	$4.652	$13.348	$11.522	$10.807	$9.575

+ Standby = Total	$4.825
+ New Rental Stdby = Total	$9.421

2. The life cycle cost comparison of the options in:
   - un-escalated non-discounted (not present worthed),
   - un-escalated discounted (present worthed),
   - escalated non-discounted (not present worthed), and
   - escalated discounted (present worthed) costs is as follows.

The existing unit refurbishment option costs include the lower cost standby option assuming that a replacement gas generator and power turbine are leased and installed while the existing units are sent out for refurbishment. This adds only about $170,000 to the base cost. The existing unit refurbishment option costs assuming the standby option using a complete, installed 2 x 5 MW nearly new GT leased option would add an additional $4.7 M. The options include a cost for differences in the likelihood of a failure occurring once during the period – an additional $10 million in 2016 for the existing GT and $3 to 4 million in 2016 for the 5 x 2 MW diesel options.

		Refurbished Unit, Use of Spare Gas Generator & Power Turbine					
		Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
1	UNESCALATED	$14,825	$1,885	$1,408	$18,118	($1,648)	$16,470
2	UNESCALATED, DISCOUTED CASHFLOW	$11,454	$1,291	$959	$13,704	($1,122)	$12,582
3	ESCALATED CASHFLOW	$16,260	$2,159	$1,660	$20,079	($1,943)	$18,136
4	ESCALATED, DISCOUTED CASHFLOW	$11,521	$1,302	$992	$13,815	($1,161)	$12,654

		Option 1 New 2x5 MW GT					
		Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
1	UNESCALATED	$6,348	$1,714	$1,237	$9,300	($1,648)	$7,652
2	UNESCALATED, DISCOUTED CASHFLOW	$8,766	$1,175	$842	$10,783	($1,122)	$9,661
3	ESCALATED CASHFLOW	$4,940	$1,963	$1,459	$8,362	($1,943)	$6,419
4	ESCALATED, DISCOUTED CASHFLOW	$8,731	$1,185	$871	$10,787	($1,161)	$9,626

	Option 1A Used 2x5 MW GT					
	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
1	$7,522	$1,714	$1,237	$10,473	($1,648)	$8,826
2	$8,632	$1,175	$842	$10,649	($1,122)	$9,527
3	$6,815	$1,963	$1,459	$10,236	($1,943)	$8,294
4	$8,618	$1,185	$871	$10,674	($1,161)	$9,513

		Option 2 New 5x2MW Diesel					
		Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
1	UNESCALATED	$9,807	$323	$1,237	$11,366	($1,648)	$9,719
2	UNESCALATED, DISCOUTED CASHFLOW	$10,231	$220	$842	$11,293	($1,122)	$10,171
3	ESCALATED CASHFLOW	$9,358	$370	$1,459	$11,187	($1,943)	$9,244
4	ESCALATED, DISCOUTED CASHFLOW	$10,232	$222	$871	$11,325	($1,161)	$10,164

	Option 2A Used 5x2MW Diesel					
	Capital Cost	OMA	Fuel	Sub-Total	Elect Value	Total
1	$10,575	$323	$1,237	$12,134	($1,648)	$10,487
2	$10,128	$220	$842	$11,190	($1,122)	$10,068
3	$10,593	$370	$1,459	$12,422	($1,943)	$10,479
4	$10,143	$222	$871	$11,236	($1,161)	$10,075

6 RECOMMENDATIONS

1. The existing gas turbine generator should not be operated (started, operated, shut down), except in an emergency situation, and in such an emergency its operation should be observed remotely.
2. Using the Assessment Basis, the preferred option is Option 1, the 2 x 5 MW new GT installation.
3. Hydro should review the Assessment Basis and any impacts of changes in it as part of its internal decision-making process on the options.
4. Hydro should proceed with a preferred option as soon as practically possible, given that the likelihood of safely and successfully starting the existing GT unit in an emergency condition in its existing state is very poor and likely to decrease rapidly with time idle.
5. If Hydro internally chooses refurbishment of the existing GT generator as its preferred option, then the existing GT generator should undergo an extensive overhaul and repair program, including:

   i) Gas Turbine Unit

      a. Power turbine disk replacement (9 month manufacturing lead time);
      b. Power turbine damaged blades replacement (one or more) or significant repair;
      c. Gas generator blading cleaning and recoating;
      d. Inlet filter media replacement and inlet duct refurbishment (including cooling air duct to power turbine disk); and
      e. Exhaust stack replacement or extensive repairs

   ii) Gearbox lube oil system modification and refurbishment

      a. Seals replacement/modification;
      b. Venting system modifications to reduce lube oil pressure buildup;
      c. Lube oil pump system upgrade for start-ups; and
      d. Lube oil cooling fan replacement

   iii) Gearbox bearings refurbishment or replacement and/or unit re-alignment

   iv) GT Generator testing and refurbishment

      a. Unit generator electrical testing and possible rewind; and
      b. Unit generator exciter testing, and refurbishment/replacement as necessary

   v) GT electrical and controls system update to compliance with current standards and/or obsolescence replacement

      a. Unit AVR
      b. Unit MCC's

   vi) The GT and generator enclosure rooms' fire detection and suppression systems modifications to provide better coverage (as evidenced by the failure of the system to initially detect or suppress the gearbox lube oil fire in 2010).

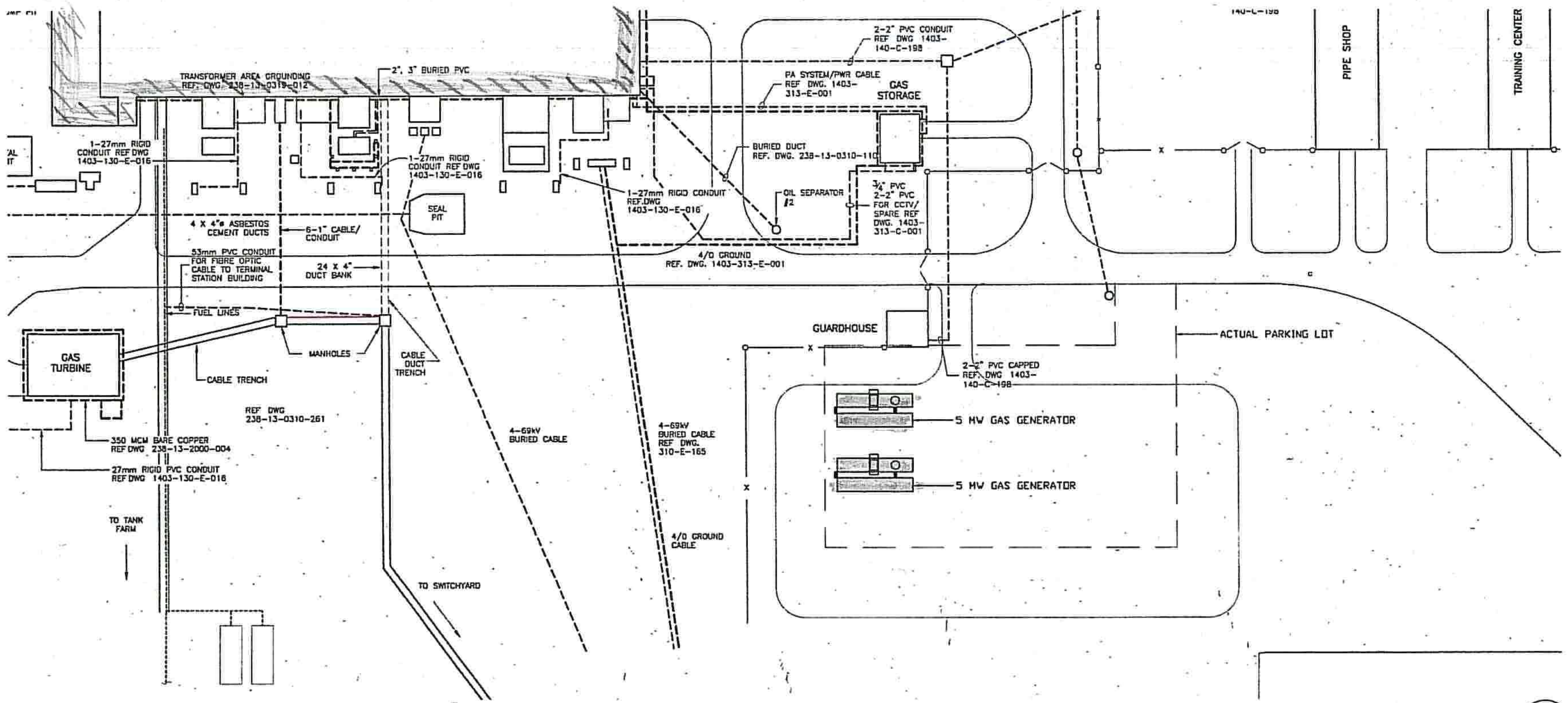
   vii) GT fuel oil receiving, forwarding, and delivery system replacement in an enclosed shed.

   viii) GT generator building repairs:

      a. Major leaks in and around the gas turbine exhaust stack
      b. Minor leaks at generator ventilation stack
      c. Minor air leaks as a result of minor siding holes (corrosion)

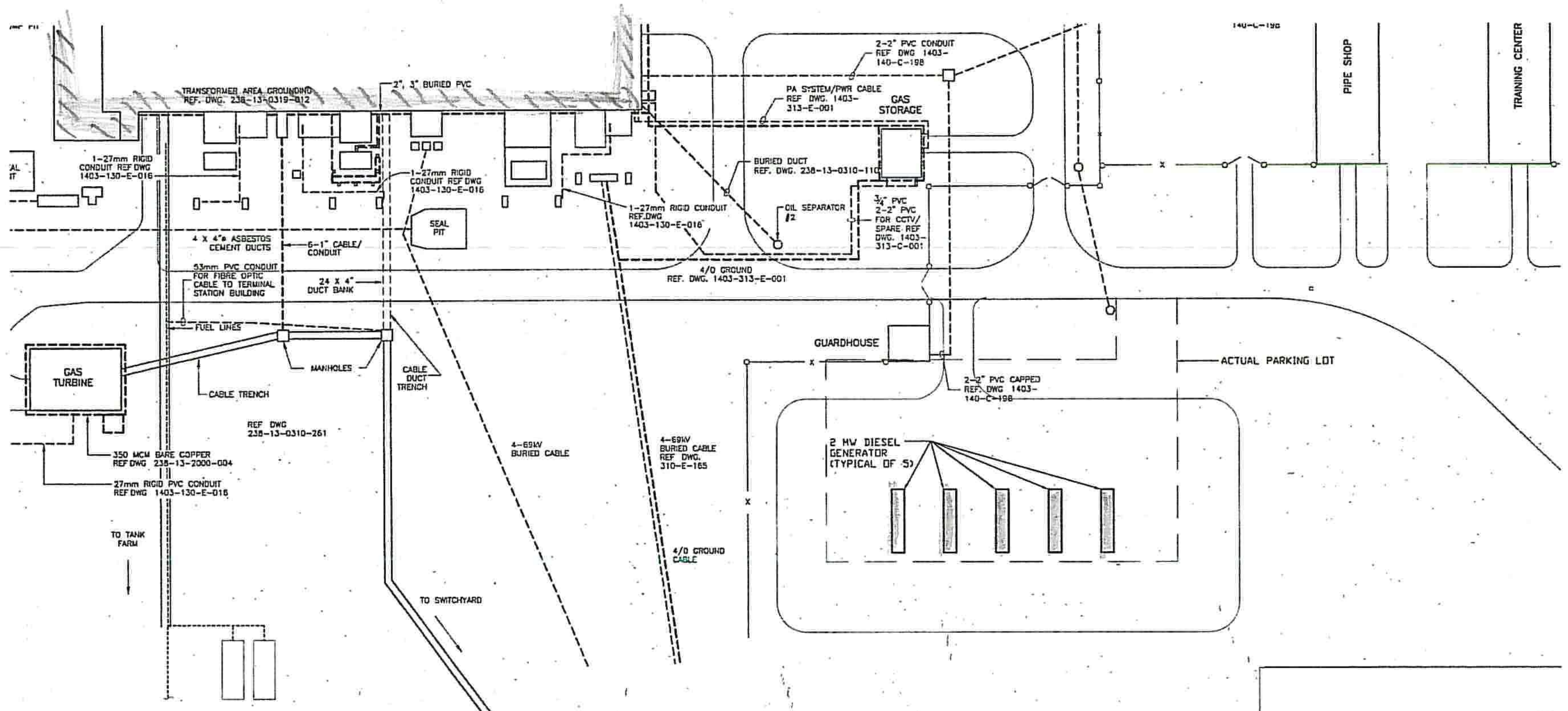
   ix) Expansion of the electrical services room to allow for new electrical systems and current systems to be in compliance with current standards (i.e. space, separation distance for arc flash)

APPENDIX 1
GENERAL ARRANGEMENT DRAWING



SITE PLAN WITH TWO 5 MW GAS GENERATOR
SCALE: 1:500 — 5 0 5 10 15 20 25 30 35m

1
SK-01 | SK-01



SITE PLAN WITH FIVE 2 MW DIESEL GENERATOR
SCALE: 1:500 — 5 0 5 10 15 20 25 30 35m

2
SK-01 | SK-01

NO.	DATE	REVISION/ISSUE	DRN	CHK	APPR
A	2011-06-29	ISSUED FOR INFORMATION	AB	DE	DE

STAMP/SEAL

amec

AMEC Americas Limited

CLIENT LOGO

PROJECT
NEWFOUNDLAND AND LABRADOR HYDRO
HOLYROOD GAS TURBINE CONDITION
HOLY ROOD, NEWFOUNDLAND

SUBJECT

DISCIPLINE: MECHANICAL	DATE: 2011-06-28
DESIGNED: DE	SCALE: AS SHOWN
DRAWN: AB	
CHECKED: SB	AMEC PROJECT No.: 168427
DRAWING NO.: SK-01	REVISION NO.: A

APPENDIX 2
SEQUENCE OF EVENTS REPORT

newfoundland labrador hydro
a nalcor energy company

Sequence of Events with Holyrood Gas Turbine Lube Oil Issues, 2010

- March 6, 2010: lube oil fire under gas turbine stack
- March 16, 2010: Alba Power contacted and quotation provided to come to site and perform repairs to gas turbine lube oil system
- March 30, 2010: Department of Occupational Health and Safety inspector imposes temporary stop work order on set due to Plant Operations concerns about safety of running the set
- April 6, 2010: Alba Power personnel arrive at Holyrood and begin repairs to lube oil system:
    - 4 leaks in the auxiliary lube oil piping around the AC, DC and shaft driven pumps were re-gasketed, no longer leaking
    - 8 other piping interfaces in the area of the leaks were re-gasketed as well, even though they were not leaking
    - A new set of seals were manufactured for the generator end of the power turbine gearbox. There is a further issue here, as the leak on this seal is increasing with more operating hours. A large temporary containment dish has been constructed and installed under this leaking seal, with an auxiliary hose running to a container next to the lube oil tank.
    - Three plates on the top of the power turbine casing were weeping lube oil. These were removed, cleaned and sealed. They are no longer leaking
    - An instrumentation line on the side of the power turbine casing was weeping lube oil. This line was removed, re-sealed and is no longer leaking
    - The auxiliary trip bolt mechanism on the top of the power turbine casing was weeping lube oil. This bolt is not being used for any tripping function so we removed it and blanked off the space. It is no longer leaking, and I will put the spare trip bolt mechanism in stores should it be required in the future.
- As repairs were being carried out, and for assessment by plant Occupational Health and Safety committee the unit was ran at full load on the following dates:

April 15:	2 hours
April 17:	3 hours
May 14:	1 hour
May 26:	2 hours
June 8	2 hours
July 15:	2 hours

Smoking continues at the top of the gas turbine gearbox, in vicinity of the stack. This indicates a further lube oil leak, doesn't seem accessible without removal of stack. Afore-mentioned power turbine gearbox end seal continues to leak. Temporary containment in place, further work required.

- July 20, 2010: Letter from plant Occupational Health and Safety committee recommending further repair/unit replacement

Assessment of alternate options for providing safe, reliable black start capabilities for Holyrood plant undertaken. Given condition of existing gas turbine decision was reached to have further condition assessment performed, and to seek alternate means of generation for black start capabilities for Holyrood plant for 2010-2011 operating season.

SWOP

Safe Workplace Observation Program

Observation No: 2010001421
Action

Action

Location Description:	Gas TurbineHRDEquipment		
Action Type:	● Remedial ○ Corrective ○ Preventive		
Action:	Coordinate investigation and repair for the source of the oil leak on the Gas Turbine that contributed to the fire incident on 7 March 2010		
Target Completion Date:	Aug 27th, 2010	**Person Responsible:**	Jeff Vincent/NLHydro
Line of Business Responsible:	Newfoundland & Labrador Hydro		
Division Responsible:	Regulated Operations		
Department Responsible:	Thermal Generation		
Section Responsible:	TG LT Asset Planning		
Safety Center Responsible:	LT Asset Planning (EA Thermal Generation)		
Work Order Required:	○ Yes ● No	**Planning Center:**	
Work Order:			
Action Status:	● Complete ○ Incomplete	**Actual Completion Date:**	09/07/2010
Comments:			

Status

Status: Complete
Assigned to: Jeff Vincent/NLHydro

Ron Ledrew on 3/30/2010 at 9:55:22 AM Assigned to: Jeff Vincent/NLHydro
Ron Ledrew on 3/30/2010 at 9:55:22 AM Action Status changed to: Incomplete
Ron Ledrew on 3/30/2010 at 9:55:22 AM Target Date changed to: 05/01/2010
Jeff Vincent on 5/3/2010 at 11:09:17 AM Target Date changed to: 05/31/2010
Repairs attempted but unsuccessful thus far. New brass seals to be in installed early May with subsequent test run thereafter. JV
Jeff Vincent on 6/8/2010 at 9:11:27 AM Target Date changed to: 06/11/2010
An attempt has been made to make repair and test run of Gas Turbine is ongoing during the week of June 7.
Jeff Vincent on 6/14/2010 at 9:08:09 AM Target Date changed to: 08/27/2010
OHSC are not happy with the running of the gas turbine - awaiting a letter from the committee with respect to their concerns. Repairs may be significant and will take some time to execute. JV
Jeff Vincent on 9/7/2010 at 11:42:18 AM Action Status changed to: Complete

Observation No: 2010001421

Observer Type:	Employee	**Observed By:**	Glen Kennedy/HO/NLHydro
Reported By Line of Business:	Newfoundland & Labrador Hydro	**Contractor Company:**	
Reported By Division:	Regulated Operations	**Reported By Department:**	Thermal Generation
Reported By Section:	TG Operations	**Reported By Safety Center**	Plant Operations (EA Thermal Ge
Date Observed:	03/07/2010 Sunday	**Time Observed:**	01:38:00 PM
Observation Location and Description:	The gas turbine @ Holyrood was operating at 10MW`s when a fire was noticed coming from exhaust section of the turbine.		
Aviation Related:	No	**Confidential:**	No
Immediate Action Taken:	Yes	**Immediate Action Taken Description:**	Unit was shut down and person or out with fire extingishers.
Reported To:	Ron Ledrew/NLHydro	**Date Reported:**	03/08/2010
FeedBack Required:	No	**Further Action Required:**	Yes

Observation Type Near Miss	**Safety Category**	
Observation Title: Fire on Gas Turbine	☐ Access Stairs & Walkways	☐ Legislative Requirements
	☐ Confined Space	☐ Off-Road Equipment
	☐ Contractor Related	☐ Off the Job Safety
	☐ Cranes & Lifting Equip	☒ Personal Injury/Illness
	☒ Defective Equipment	☐ PPE
	☐ Dropped/Falling Objects	☒ Production Loss
	☐ Electrical Contact	☒ Property/Equipment Damage
	☒ Emergency Response	☐ Surface Conditions
	☒ Equipment/Process Improvements	☐ Theft/Vandalism
	☐ Fall Arrest/Restraint	☐ Third Party Complaint
Aviation Category: NA	☐ Health Issues	☐ Tools - Power & Hand
	☐ Housekeeping	☐ Vehicle Involved
Severity Moderate	☒ Inspections	☐ Work Permit/Lockout Procedures
	☐ Job Planning	☐ Work Procedures/Practices
Probability Possible		
Risk To ☐ Environment ☒ People ☒ Property ☒ Equipment ☒ Production ☐ Public		**Environment Category**
Location Description:	Gas Turbine HRD Equipment	

Aviation event

Event	Characteristic	Narrative
Flight Phase:		
Flight Nature:		

Detailed Description

On Sunday March 7th 2010 at approx. 1030hr. E.C.C. called Shift Supervisor Glen Kennedy to notify the Holyrood Plant, they wanted the gas turbine on line at full load because they just lost transmission line TL201 to the Avalon and line TL217 was full of ice. Prior to switching unit on, the Shift Supervisor had one Emergency Response Technician and one Operator provide fire watch on the unit continiously while the unit was on-line. This precaution was implimented in light of previous small fires underneath the unit and to mitigate the risk of an advanced fire on the unit while operating for extended periods of time.
The gas turbine was started at approximately 11:30 and was running on 10 mw. At 12:30 the residual lube oil underneath the power turbine started to smoke. The ER Tech and Operator kept a close eye on this area and about 14:15, a fire occurred which quickly spread to the north side of the turbine. According to the ER Tech, there was a significant chance of losing control of the fire, so the Operator made the decision to perform an emergency stop on the turbine. After the turbine was shut down, The ER Tech got the fire under control and fully extinguished using full fire fighting PPE, self-contained breathing apparatus and five (5) CO2 extinguishers. Statements from both the Operator and ER Tech confimed that there were visible flames which occurred beneath the turbine and a significant amount of smoke was exiting the turbine near the over speed trips (up the ladder at the east side of the engine room).
The ER Coordinator and Shift Supervisor Glen Kennedy were called over to the Gas Turbine Building. During the next 30 mins, there were 6 minor flare ups some of which were put out with a dry chemical extinguisher. Over the next 2 hours while the generator was cooling down there was smoke exiting from the top of the engine and from the north side of the engine. No fire was detected after that.

Person in control

Name:	
Experience:	
JobTitle:	Lead Thermal Plant Opr.
Supervisor	

Aviation Failure

Factor	Characteristic	Narrative

Contributing Factors

Factor	Characteristic	Narrative

Existing Controls - What current existing procedures, processes, and/or policies are intended to prevent the incident, but didn't?	
Type	Narrative
Standards or Programs:	
Inspection or Functional Check:	
Required Maintenance Documenation:	
Supporting Documentation:	
Work Method:	
Other (eg. TBRA):	

Recommendation

Investigators	Date
Ron Ledrew/NLHydro	03/08/2010

Manager	Review Date
Terry LeDrew/HO/NLHydro	04/06/2010
as per description	

Accountable Manager	Review Date

Corporate Safety	Date
Sarah Churchill/NLHydro	04/21/2011

Employee:					
Injury Type:					
Workers Comp Form Required:	No				
Region Of Body Injured:					
Side Of Body:	N/A				
Source of Injury:					
Occup. Illness					
Away From Work:	No	Days Away:	0	Returned to work:	
Restricted Work:	No	Days Restricted:	0	Returned to normal duties:	
CEA Reportable	No				

Nalcor Energy Vehicle Involved	
Vehicle Accident:	No
Vehicle Number:	
Damage Estimate:	
Vehicle Accident Type:	
Third Party Involvement	
Third Party involved:	No
Vehicle Accident Form Completed:	No

Aircraft Involved:	
Aircraft Type:	
Registration Number:	
ELT equipped:	No
Engine Type:	
Aircraft Zone:	
Incident/ degradation/ Failure Description?	

Other Property/Equipment Damage	
What was Damaged	Estimate

Actions

Ta[illegible]sible					
2 of 3	Gerard Cochrane	04/09/2010	No	Corrective	Outline and communicate interm proced safety parameters/precautions to All Sh
3 of 3	Ron Ledrew	04/22/2010	No	Corrective	Identy specs for acquisition of foam/wat extinguishers for Gas Turbine building

Observation No: 2010001421

Observer Type:	Employee	**Observed By:**	Glen Kennedy/HO/NLHydro
Reported By Line of Business:	Newfoundland & Labrador Hydro	**Contractor Company:**	
Reported By Division:	Regulated Operations	**Reported By Department:**	Thermal Generation
Reported By Section:	TG Operations	**Reported By Safety Center**	Plant Operations (EA Thermal Ge
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Observation Location and Description:	The gas turbine @ Holyrood was operating at 10MW's when a fire was noticed coming from exhaust section of the turbine.		
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Immediate Action Taken:	Yes	**Immediate Action Taken Description:**	Unit was shut down and person or out with fire extinguishers.
Reported To:	Ron Ledrew/NLHydro	**Date Reported:**	03/08/2010
FeedBack Required:	No	**Further Action Required:**	Yes

Observation Type
Near Miss

Observation Title:
Fire on Gas Turbine

Aviation Category:
NA

Severity
Moderate

Probability
Possible

Safety Category

☐ Access Stairs & Walkways	☐ Legislative Requirements
☐ Confined Space	☐ Off-Road Equipment
☐ Contractor Related	☐ Off the Job Safety
☐ Cranes & Lifting Equip	☒ Personal Injury/Illness
☒ Defective Equipment	☐ PPE
☐ Dropped/Falling Objects	☒ Production Loss
☐ Electrical Contact	☒ Property/Equipment Damage
☒ Emergency Response	☐ Surface Conditions
☒ Equipment/Process Improvements	☐ Theft/Vandalism
☐ Fall Arrest/Restraint	☐ Third Party Complaint
☐ Health Issues	☐ Tools - Power & Hand
☐ Housekeeping	☐ Vehicle Involved
☒ Inspections	☐ Work Permit/Lockout Procedures
☐ Job Planning	☐ Work Procedures/Practices

Risk To
☐ Environment ☒ People ☒ Property
☒ Equipment ☒ Production ☐ Public

Environment Category

Location Description: Gas Turbine HRD Equipment

Aviation event		
Event	**Characteristic**	**Narrative**
Flight Phase:		
Flight Nature:		

Detailed Description

On Sunday March 7th 2010 at approx. 1030hr. E.C.C. called Shift Supervisor Glen Kennedy to notify the Holyrood Plant, they wanted the gas turbine on line at full load because they just lost transmission line TL201 to the Avalon and line TL217 was full of ice. Prior to switching unit on, the Shift Supervisor had one Emergency Response Technician and one Operator provide fire watch on the unit continiously while the unit was on-line. This precaution was implimented in light of previous small fires underneath the unit and to mitigate the risk of an advanced fire on the unit while operating for extended periods of time.
The gas turbine was started at approximately 11:30 and was running on 10 mw. At 12:30 the residual lube oil underneath the power turbine started to smoke. The ER Tech and Operator kept a close eye on this area and about 14:15, a fire occurred which quickly spread to the north side of the turbine. According to the ER Tech, there was a significant chance of losing control of the fire, so the Operator made the decision to perform an emergency stop on the turbine. After the turbine was shut down, The ER Tech got the fire under control and fully extinguished using full fire fighting PPE, self-contained breathing apparatus and five (5) CO2 extinguishers. Statements from both the Operator and ER Tech confimed that there were visible flames which occurred beneath the turbine and a significant amount of smoke was exiting the turbine near the over speed trips (up the ladder at the east side of the engine room).
The ER Coordinator and Shift Supervisor Glen Kennedy were called over to the Gas Turbine Building. During the next 30 mins, there were 6 minor flare ups some of which were put out with a dry chemical extinguisher. Over the next 2 hours while the generator was cooling down there was smoke exiting from the top of the engine and from the north side of the engine. No fire was detected after that.

Person in control	
Name:	
Experience:	
JobTitle:	Lead Thermal Plant Opr.
Supervisor	

Aviation Failure		
Factor	**Characteristic**	**Narrative**

Contributing Factors		
Factor	**Characteristic**	**Narrative**

Existing Controls - What current existing procedures, processes, and/or policies are intended to prevent the incident, but didn't?	
Type	Narrative
Standards or Programs:	
Inspection or Functional Check:	
Required Maintenance Documentation:	
Supporting Documentation:	
Work Method:	
Other (eg. TBRA):	

Recommendation

Investigators	Date
Ron Ledrew/NLHydro	03/08/2010

Manager	Review Date
Terry LeDrew/HO/NLHydro	04/06/2010
as per description	

Accountable Manager	Review Date

Corporate Safety	Date
Sarah Churchill/NLHydro	04/21/2011

Employee:					
Injury Type:					
Workers Comp Form Required:	No				
Region Of Body Injured:					
Side Of Body:	N/A				
Source of Injury:					
Occup. Illness					
Away From Work:	No	Days Away:	0	Returned to work:	
Restricted Work:	No	Days Restricted:	0	Returned to normal duties:	
CEA Reportable	No				

Nalcor Energy Vehicle Involved	
Vehicle Accident:	No
Vehicle Number:	
Damage Estimate:	
Vehicle Accident Type:	
Third Party Involvement	
Third Party Involved:	No
Vehicle Accident Form Completed:	No

Aircraft Involved:	
Aircraft Type:	
Registration Number:	
ELT equipped:	No
Engine Type:	
Aircraft Zone:	
Incident/ degradation/ Failure Description?	

Other Property/Equipment Damage	
What was Damaged	Estimate

Actions

	Responsible	Target	WO	Work Order	Type	Action
1 of 3	Jeff Vincent	08/27/2010	No		Remedial	Coordinate investigation and repair for t of the oil leak on the Gas Turbine that c
2 of 3	Gerard Cochrane	04/09/2010	No		Corrective	Outline and communicate interm procec safety parameters/precautions to All Sh
3 of 3	Ron Ledrew	04/22/2010	No		Corrective	Identy specs for acquisition of foam/wat extinguishers for Gas Turbine building

GT Fire Incident / 7 March 2010
Ron Ledrew to: Gerard Cochrane 03/07/2010 05:45 PM
Cc: Terry LeDrew, Jeff Vincent, Wayne Rice, Wade Kelloway, Michael Manuel, Glen Kennedy, Steve Connolly

Gerard,

The Gas Turbine was started today at 11:50 and ran for approx. 2 hours at 10 mw when a fire underneath the unit was discovered by ER Technician Steve Hunt and Operator Robert Stratton. I had called in the ER Tech at 11am to monitor the start-up of the unit upon discussion with the Shift Supervisor and yourself. Good decision on your part Gerard, because when he initially entered the room for a routine check, there was a significant fire underneath the unit. Steve initially had on full fire fighting PPE but had to leave to put on his SCBA in the next room, then re-enter to fully extinguish the fire using 4 CO2 and 1 Dry Chemical extinguishers. After the initial knock down of the fire, the unit was put immediately into emergency shut down by Stratton.

The GT continued to smoke for approx an hour and a half afterwards, with fire watch during the cooling down of the GT provided by Hunt. I spoke to Glen Kennedy and he called ECC to let them know the situation. I called in an additional ER Tech immediately after fire, to assist in the clean-up, replacement of extinguishers and to provide another fire watch if ECC determined whether they needed the GT back on-line over the supper period. Right now the ER Tech's are monitoring the GT building every 30 mins until 8pm, or if the unit goes back on, they will provide constant watch. If you require any further information immediately, contact Mike Murphy or Steve Hunt at #2754 or #2739.

Given the intensity of this fire and the resources necessary to establish fire control, I am suggesting this incident be communicated with an "Incident Announcement" I have asked Glen to submit the SWOP and I will require an email statement from Stratton, Hunt, Murphy and Kennedy on this incident, to assist completion of the AI. While it may be difficult to look on the bright side right now, having the right people with the right skills and composure in place when this occurred, may very well have prevented extensive damage to the GT and prolonged impact on operations.

Ron

newfoundland labrador hydro
a nalcor energy company

Ron LeDrew
Emergency Response Coordinator
Thermal Generation
Newfoundland and Labrador Hydro - a Nalcor Energy company
t. 709 229-2739 f. 709 229-7894
e. ronledrew@nlh.nl.ca
w. www.nlh.nl.ca

APPENDIX 3
COST REPORT BY WORK ORDER/ASSET

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
3838	90	G.T.STACK DOORS OPERATION CHK	Total	$167.03	7058	G.T.STACK DOORS OPERATION CHK.
		3M W/O				2002
5613	90	ELECTRONIC OVERSPEED TEST	Total	$111.00	7058	ELECTRONIC OVERSPEED TEST
						- elect + mech bolt on Pw. Turb. - Insp 2008?
5293	90	G.T.STACK DOORS OPERATION CHK	Total	$280.22	7058	G.T.STACK DOORS OPERATION CHK.
						~~2002~~ - Air Lk - Snow dos Sol | Mirr 2003 Air Dyn change over sol
5294	90	3- G.T.STACK DOORS	Total	$467.50	7058	3- G.T.STACK DOORS
						- Chk air cyl. 2003
0169	90	GAS TURBINE GENERATOR	Total	$264.00	7058	GAS TURBINE GENERATOR
						- Lube Oil Sample 2004
3279	90	G.T.STACK DOORS OPERATION CHK	Total	$81.00	7058	G.T.STACK DOORS OPERATION CHK.
						2005
7960	90	G.T.STACK DOORS OPERATION CHK	Total	$560.50	7058	G.T.STACK DOORS OPERATION CHK.
						- 2005
4956	90	GAS TURBINE LUBE OIL FILTER	Total	$1,057.13	7058	GAS TURBINE LUBE OIL FILTER
						- ΔP; not cleaned reg 2006
7744	90	FITTINGS ON GT GEARBOX	Total	$499.72	7058	FITTINGS ON GT GEARBOX
						- Leak ΔP check 2006
63	90	4- GT 2007 OUTAGE PREP WORK	Total	$956.73	7058	4- GT 2007 OUTAGE PREP WORK
						2007
7868	90	HRD GAS TURBINE GEARBOX LADDER	Total	$172.95	7058	HRD GAS TURBINE GEARBOX LADDE
						2007?
0298	90	GT REPLACE/CALIBRATE GAUGE	Total	$2,135.18	7058	GT REPLACE/CALIBRATE GAUGE
						ΔP gauge 2007
2920	90	GT GEARBOX DRAIN VALVE	Total	$292.00	7058	GT GEARBOX DRAIN VALVE
						- 2009.

Total Amout Of Work Orders **$7,044.96**

WORK ORDERS FROM 2000 FOR CONDITION ASSESSMENT CONSULTANT

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
765320	80	GAS TURB.GENER.OIL HEATER	Total	$90.88	7309	GAS TURB.GENER.OIL HEATER
						2009
814271	80	GAS TURB.GENER.OIL HEATER	Total	$587.44	7309	GAS TURB.GENER.OIL HEATER
						2009 ?

Total Amout Of Work Orders **$678.32**

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
84466	90	GAS TURBINE AIR COMPRESSOR	Total	$207.00	7311	GAS TURBINE AIR COMPRESSOR relief open; closed 2006
43204	90	GT tripped with 4MW	Total	$3,459.26	7311	GT tripped with 4MW - filter leak/low flow 2006
44721	90	GT FUEL OIL SUCTION STRAINERS	Total	$724.50	7311	GT FUEL OIL SUCTION STRAINERS - leaking 2006
56650	90	GAS TURBINE LUBE OIL LEVEL	Total	$640.17	7311	GAS TURBINE LUBE OIL LEVEL - 2006
57865	90	GAS TURBINE AIR COMPRESSOR	Total	$207.00	7311	GAS TURBINE AIR COMPRESSOR hot start 2007
57891	90	GAS TURBINE AIR COMPRESSOR	Total	$276.00	7311	GAS TURBINE AIR COMPRESSOR not start - relief vlv repl 2007
70815	90	GAS TURBINE AIR COMPRESSOR	Total	$317.22	7311	GAS TURBINE AIR COMPRESSOR - manual drn valve repl. 2007
36319	90	GAS TURBINE S/S XFMER	Total	$366.04	7311	GAS TURBINE S/S XFMER - painting 2007
0543	90	GT FO EAST DISCHARGE FILTER	Total	$632.29	7311	GT FO EAST DISCHARGE FILTER 2007
0799	90	GT VIBRATION CHECK	Total	$378.92	7311	GT VIBRATION CHECK - new monitor? 2007
1289	90	GAS TURBINE LIGHT OIL DISC.	Total	$155.89	7311	GAS TURBINE LIGHT OIL DISC. 2007
2096	90	GT DISC SPACE #7 INVALID	Total	$290.65	7311	GT DISC SPACE #7 INVALID 2007
3563	90	GT FO FLOW METER LEAK	Total	$150.86	7311	GT FO FLOW METER LEAK 2007
4370	90	GT VIBRATION CHECK	Total	$261.00	7311	GT VIBRATION CHECK 2007
5919	90	GT AC LUBE OIL PUMP	Total	$511.00	7311	GT AC LUBE OIL PUMP 2007
9314	90	GAS TURBINE-RADIATOR OIL LEAK	Total	$5,072.82	7311	GAS TURBINE-RADIATOR OIL LEAK 2008
544	90	GT AIR SYSTEM MODIFICATION	Total	$1,696.02	7311	GT AIR SYSTEM MODIFICATION 2008
326	80	GAS TURBINE COMPRESSOR	Total	$1,016.72	7311	GAS TURBINE COMPRESSOR 2010
			Total Amout Of Work Orders	$16,363.36		

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
170476	90	DETERMINE 'INCOMPLETE SEQUENCE	Total	$219.60	7310	DETERMINE 'INCOMPLETE SEQUEN 00
172497	90	GT INSTALL HINGED TABLE TO	Total	$99.00	7310	GT INSTALL HINGED TABLE TO 2005
313981	90	GAS TURBINE PLC TAPES RECORD	Total	$792.00	7310	GAS TURBINE PLC TAPES RECORD 206
382732	90	GAS TURBINE PLC TAPES RECORD	Total	$35.00	7310	GAS TURBINE PLC TAPES RECORD 2004
530274	90	RIBBON CABLES ON THE G.T.	Total	$34.50	7310	RIBBON CABLES ON THE G.T. 2006
589689	90	RAISE/LOWER CONTROLLER G/T	Total	$418.24	7310	RAISE/LOWER CONTROLLER G/T - spring on contrl 2007
632813	90	GAS TURBINE PLC TAPES RECORD	Total	$292.00	7310	GAS TURBINE PLC TAPES RECORD 2009
707427	90	FOXBORO GAS TURBINE	Total	$292.00	7310	FOXBORO GAS TURBINE PLC Replace 2009
			Total Amout Of Work Orders	$2,182.34		

Cost Report By Work Order/Asset

0/11/10

WO#	WO St	Work Order Description			Asset Number	Description of Asset
7298	90	GAS TURBINE-GEN.STATOR#4	Total	$126.31	7202	GAS TURBINE-GEN.STATOR#4 – New Card 2001
7374	90	GAS TURBINE-VIBRATION MONITOR	Total	$141.35	7202	GAS TURBINE-VIBRATION MONITOR – New bently 2001
3728	90	N.W. CORNER OF GT ENGINE	Total	$47.00	7202	N.W. CORNER OF GT ENGINE
5283	90	GAS TURBINE SUCTION STRAINER	Total	$1,159.01	7202	GAS TURBINE SUCTION STRAINER
5627	90	GAS TURBINE STRAINER	Total	$144.31	7202	GAS TURBINE STRAINER – Constant [illegible] 2002
2101	90	G.T. STACK DOORS MECH. CHECKS	Total	$142.50	7202	G.T. STACK DOORS MECH. CHECKS 2002
166	90	GAS TURBINE-WEST FUEL OIL PUMP	Total	$144.40	7202	GAS TURBINE-WEST FUEL OIL PUMP – coupling 2002
021	90	GAS TURBINE CONTROL RM BOARD	Total	$473.00	7202	GAS TURBINE CONTROL RM BOARD – replace card 2002
695	90	GAS TURBINE CONTROL RM BOARD	Total	$142.50	7202	GAS TURBINE CONTROL RM BOARD
[illegible]	90	GAS TURBINE OVERSPEED TEST	Total	$294.99	7202	GAS TURBINE OVERSPEED TEST
297	90	G.T. STACK DOORS MECH. CHECKS	Total	$242.79	7202	G.T. STACK DOORS MECH. CHECKS
468	90	G.T. STACK DOORS MECH. CHECKS	Total	$543.55	7202	G.T. STACK DOORS MECH. CHECKS 2002
768	90	GAS TURBINE-FUEL OIL TRIP VLV	Total	$142.50	7202	GAS TURBINE-FUEL OIL TRIP VLV – Free up Enclosure hinge 2002
224	90	GAS TURBINE - DYKES	Total	$55.60	7202	GAS TURBINE - DYKES – Cln Out → 2002
308	90	GAS TURBINE 02/06/28	Total	$228.00	7202	GAS TURBINE – Verify 2 Pw. Supply For Ctrl Trans 2002
758	90	CABLE TRAY COVER BY GAS TURB.	Total	$482.09	7202	CABLE TRAY COVER BY GAS TURB.
802	90	BEARING #2 CH.2 IS IN ALARM	Total	$1,433.14	7202	BEARING #2 CH.2 IS IN ALARM – Card repla 2002
29?	90	GT AVON INSPECTION	Total	$726.03	7202	GT AVON INSPECTION Sept 2002 * Not [illegible] = Intake air [illegible] - Trans [illegible]
133	90	GAS TURBINE	Total	$176.70	7202	GAS TURBINE – Oil 2002 East Filter [illegible]

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
2463 2467	91	PERF 13.8KV OIL CIRCUIT BKR	Total	$1,702.75	7202	PERF 13.8KV OIL CIRCUIT BKR
135081	90	DYKE DRAIN SYPHON IS MISSING	Total	$54.90	7202	DYKE DRAIN SYPHON IS MISSING
139563	90	ORDER/PLACE SIGNS ACCESS DOORS	Total	$199.42	7202	ORDER/PLACE SIGNS ACCESS DOOR
142505	90	GAS TURBINE LIGHT OIL SUCTION	Total	$219.60	7202	GAS TURBINE LIGHT OIL SUCTION
143135	90	GAS TURBINE/FLOOR SOUTH SIDE	Total	$152.71	7202	GAS TURBINE/FLOOR SOUTH SIDE
150425	90	GAS TURBINE EAST DISCHARGE	Total	$98.80	7202	GAS TURBINE EAST DISCHARGE
159239	90	CHECK/REPAIR GAS TURBINE MEGA	Total	$1,257.30	7202	CHECK/REPAIR GAS TURBINE MEGA
166127	90	GAS TURBINE FO DISCHARGE FILTE	Total	$650.84	7202	GAS TURBINE FO DISCHARGE FILTE
168568	90	GAS TURBINE, SNOW DOORS CLOSED	Total	$249.26	7202	GAS TURBINE, SNOW DOORS CLOSE
172304	90	GAS TURBINE GEN 80	Total	$244.77	7202	GAS TURBINE GEN 80
174393	90	GAS TURBINE CHECK DIGITAL READ	Total	$1,929.50	7202	GAS TURBINE CHECK DIGITAL READ
179056	90	GAS TURBINE	Total	$111.80	7202	GAS TURBINE
182923	91	GAS TURBINE/MODIFY CONTROL	Total	$2,930.52	7202	GAS TURBINE/MODIFY CONTROL
186350	90	GAS TURBINE 2 WEEKLY RUN UP	Total	$27.00	7202	GAS TURBINE 2 WEEKLY RUN UP
186516	90	GT ROSEMONT 4001/TEMP MONITOR	Total	$155.26	7202	GT ROSEMONT 4001/TEMP MONITOR
187978	90	GT TEMP MONITOR TRIP/GEN STAT	Total	$1,931.00	7202	GT TEMP MONITOR TRIP/GEN STAT
190208	90	MAKE NECESSARY REPAIRS TO SLID	Total	$439.60	7202	MAKE NECESSARY REPAIRS TO SLID
190409	90	GT TEMP ALARM CH 12	Total	$118.00	7202	GT TEMP ALARM CH 12
190754	90	MAKE NECESSARY REPAIRS TO SLID	Total	$348.75	7202	MAKE NECESSARY REPAIRS TO SLID

Cost Report By Work Order/Asset

/O#	WO St	Work Order Description			Asset Number	Description of Asset
7965	90	FIRE PANEL ALARM	Total	$276.97	7202	FIRE PANEL ALARM Grnd Fault in Energize 2002
)695	90	GAS TURBINE FUEL OIL FILTER	Total	$235.60	7202	GAS TURBINE FUEL OIL FILTER – Lk on top of flange 2002
7604	90	G.T. STACK DOORS MECH. CHECKS	Total	$85.50	7202	G.T. STACK DOORS MECH. CHECKS – Check 2002
7727	90	GAS TURBINE JET ENGINE LUBE	Total	$850.58	7202	GAS TURBINE JET ENGINE LUBE – Thr Tank 2002
7739	90	GAS TURBINE JET ENGINE LUBE	Total	$259.60	7202	GAS TURBINE JET ENGINE LUBE – Chn oil tank 2002
3455	90	G.T. STACK DOORS MECH. CHECKS	Total	$144.00	7202	G.T. STACK DOORS MECH. CHECKS
1291	90	WDPF PT# GT SS112 GAS TURBINE	Total	$189.00	7202	WDPF PT# GT SS112 GAS TURBINE – Freq US call 55-60 Hz
3920	90	GT HOT SECTION INSPECTION.	Total	$271.60	7202	GT HOT SECTION INSPECTION. Temp Cdn Turb Rp. 2003
3925	90	G.T. STACK DOORS MECH. CHECKS	Total	$117.80	7202	G.T. STACK DOORS MECH. CHECKS 2003 ✓
4291	90	BI-WEEKLY G.T. TEST RUN	Total	$85.50	7202	BI-WEEKLY G.T. TEST RUN Dec 5/02 Trip after 7 min No alarms Fuel Δ; Incomp Start
5418	90	GAS TURBINE WEST F.O. PUMP COI	Total	$43.80	7202	GAS TURBINE WEST F.O. PUMP COU – Repeat 2002
5491	90	INSTALL A PRESSURE XMITTER	Total	$504.00	7202	INSTALL A PRESSURE XMITTER – Trip – ? → Incd Fuel 2002
3633	90	REMOVE RECORDER & TRANSMITTER	Total	$189.00	7202	REMOVE RECORDER & TRANSMITTE – New Recorder 2003
2652	90	G.T. STACK (FLEX)	Total	$213.06	7202	G.T. STACK (FLEX) – 2006 Repair Flex
2920	90	FIRE DOOR RELEASE	Total	$70.00	7202	FIRE DOOR RELEASE – Repeat 2006 ?
4110	90	4-G.T. STACK	Total	$265.50	7202	4-G.T. STACK 2006 – Flex
5225	90	BATTERY SYSTEM FAULT ALARM	Total	$264.00	7202	BATTERY SYSTEM FAULT ALARM – 200 ?
5561	90	F.O. METER BLOCK VLV.	Total	$132.00	7202	F.O. METER BLOCK VLV.
5563	90	4- REPLACE FLUORESCENT TUBES	Total	$27.50	7202	4- REPLACE FLUORESCENT TUBES Misc 2003

02/11/05

02/11/05

? Repair ?

Repair – 20 min @ 9 MW → F.O. Press. 40 kPa lost

03/04/21

2002

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
191885	90	GT TEMP MONITOR CAME IN &	Total	$1,325.50	7202	GT TEMP MONITOR CAME IN & – replace card
203844	90	REPLACE FUEL OIL PRESS.GAUGE	Total	$185.42	7202	REPLACE FUEL OIL PRESS.GAUGE W ?
204729	90	GAS TURBINE,TEMP. MONIT.ALARM	Total	$1,218.50	7202	GAS TURBINE,TEMP. MONIT.ALARM – Not Running – Card 2001
206880	90	GAS TURBINE BLDG.NEEDS	Total	$135.00	7202	GAS TURBINE BLDG.NEEDS Cl[illegible] 2001
207081	90	GAS TURBINE WEST FUEL OIL	Total	$222.65	7202	GAS TURBINE WEST FUEL OIL Rep 2001
213121	90	GAS TURBINE SLIDING DOORS	Total	$216.00	7202	GAS TURBINE SLIDING DOORS Seal 2001
215372	90	GAS TURBINE 2 WEEKLY RUN UP	Total	$81.00	7202	GAS TURBINE 2 WEEKLY RUN UP
219360	90	GAS TURBINE-EXHAUST FAN	Total	$349.11	7202	GAS TURBINE-EXHAUST FAN O/C 2001
221712	90	GAS TURBINE-EXHAUST FAN	Total	$90.00	7202	GAS TURBINE-EXHAUST FAN O/C 2001
222990	90	GAS TURBINE-EXHAUST FAN	Total	$950.97	7202	GAS TURBINE-EXHAUST FAN O/C 2001
229697	90	INSTALL TOP LATCHING MECHANISM	Total	$320.61	7202	INSTALL TOP LATCHING MECHANIS – 2001
238640	90	GAS TURBINE FUEL OIL STRAINERS	Total	$506.32	7202	GAS TURBINE FUEL OIL STRAINERS – gland leak – 2001
238790	90	GAS TURBINE/WDPF	Total	$252.00	7202	GAS TURBINE/WDPF Readys 2001
239366	90	GT HOT SECTION INSPECTION.	Total	$297.08	7202	GT HOT SECTION INSPECTION.
239399	90	GAS TURBINE/WDPF	Total	$537.77	7202	GAS TURBINE/WDPF Δ Readys Tot 2001
240249	90	INSTALL MISSING BOLT	Total	$56.00	7202	INSTALL MISSING BOLT – hyd. oil pip 2001
242488	90	GAS TURBINE WEST LIGHT OIL	Total	$1,307.93	7202	GAS TURBINE WEST LIGHT OIL – West Pp Gasket – 2001
247039	90	GAS TURBINE FUEL FILTER DIF.	Total	$286.35	7202	GAS TURBINE FUEL FILTER DIF – ΔP 2001
247279	90	GAS TURBINE-GEN.STATOR#4	Total	$1,681.56	7202	GAS TURBINE-GEN.STATOR#4

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
2683	91	G.T. STACK DOORS MECH. CHECKS	Total	$385.00	7202	G.T. STACK DOORS MECH. CHECKS ✓ 2004
2733	90	GAS TURBINE BATTERY CHARGER	Total	$420.00	7202	GAS TURBINE BATTERY CHARGER PM ✓ Oct 04
2860	90	GT EAST FUEL MOTOR PUMP ANNUAL	Total	$283.80	7202	GT EAST FUEL MOTOR PUMP ANNUA – Mar 04
955	90	GT HOT SECTION INSPECTION.	Total	$143.80	7202	GT HOT SECTION INSPECTION – Aug 2004
392	91	4-G.T. STACK DOORS MECH. CHk	Total	$217.60	7202	4-G.T. STACK DOORS MECH. CHk
538	90	REQUEST FOR SANDING	Total	$145.00	7202	REQUEST FOR SANDING 2004
347	90	gas Turbine Fuel oil pumps	Total	$64.15	7202	gas Turbine Fuel oil pumps – not start – seized [illegible]
492	90	4- GAS TURBINE DYKES	Total	$174.00	7202	4- GAS TURBINE DYKES Ice 2004
343	90	3- GAS TURBINE DYKES	Total	$812.00	7202	3- GAS TURBINE DYKES – Ice 2004
2[illegible]	90	GAS TURBINE ALARM	Total	$2,707.00	7202	GAS TURBINE ALARM – [illegible] Card – Feb 2004
748	90	4- GAS TURBINE LUBE OIL COOLER	Total	$232.00	7202	4- GAS TURBINE LUBE OIL COOLER Dyke Frozen – 2004
811	90	4- GAS TURBINE DYKES	Total	$174.00	7202	4- GAS TURBINE DYKES Ice 2004
377	90	FIRE DOOR RELEASE	Total	$210.00	7202	FIRE DOOR RELEASE
372	90	EAST FUEL OIL FILTER LEAK	Total	$582.04	7202	EAST FUEL OIL FILTER LEAK 2004
531	90	GAS TURBINE LUBE OIL SAMPLE	Total	$140.00	7202	GAS TURBINE LUBE OIL SAMPLE ✓ 2004
030	90	GAS TURBINE	Total	$156.00	7202	GAS TURBINE – Speed ? – not found Ap 2004
141	90	BREAKER SSB-2	Total	$476.00	7202	BREAKER SSB-2 – Sec Disconnected [illegible] 2004
314	90	2 FLUORSESCENT LIGHTS	Total	$141.88	7202	2 FLUORSESCENT LIGHTS 2004
343	90	EMERGENCY LIGHTS IN SWITCHGEAR	Total	$245.00	7202	EMERGENCY LIGHTS IN SWITCHGEA – batt – 2004

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
336343	90	GAS TURBINE OVERSPEED TEST	Total	$462.24	7202	GAS TURBINE OVERSPEED TEST – Reg'l – Nov 2003
336701	90	CLEAN LUBE OIL FILTER	Total	$394.93	7202	CLEAN LUBE OIL FILTER [illegible] 2003 Oct.
336968	90	LUBE OIL DIFF. PRESS.	Total	$111.00	7202	LUBE OIL DIFF. PRESS. Reg Δ = 2003
337699	90	G.T. STACK DOORS MECH. CHECKS	Total	$271.60	7202	G.T. STACK DOORS MECH. CHECKS Reg ✓ 2003 May
338310	90	CAP "O" RING GASKET PROTRUDING	Total	$504.33	7202	CAP "O" RING GASKET PROTRUDING
338392	90	CAP "O" RING GASKET PROTRUDING 03/05/08	Total	$143.41	7202	CAP "O" RING GASKET PROTRUDING
339249	90	CLEAN LUBE OIL FILTER 03/05/14	Total	$9.16	7202	CLEAN LUBE OIL FILTER – Oct – 2003
339253	90	3 G.T. STACK DOORS MECH. Cks. 03/05/14	Total	$375.37	7202	3 G.T. STACK DOORS MECH. Cks.
340937	90	GAS TURBINE NOT STARTING	Total	$981.93	7202	GAS TURBINE NOT STARTING → wiring/logic May 2003
341635	90	LUBE OIL PRESS. INDICATION	Total	$1,147.59	7202	LUBE OIL PRESS. INDICATION – snubbers plugged 2003 Oct
341737	90	GAS TURBINE BAY AIR DRYER	Total	$151.80	7202	GAS TURBINE BAY AIR DRYER – replaced – not working [illegible] 2003
342531	90	F.O.PUMP WEST COUPLING Change – Repair	Total	$39.21	7202	F.O.PUMP WEST COUPLING 2003
343756	90	GAS TURBINE TRIPPED	Total	$487.30	7202	GAS TURBINE TRIPPED – Vib. – [illegible] June 2003
343838	90	GAS TURBINE TRIPPED 03/06/10	Total	$143.62	7202	GAS TURBINE TRIPPED
344720	90	G.T. SPEED PROBE → no auto sync. * Info p Start [illegible] → Cap speed modules → New logic → 10 MW x 30 min	Total	$1,696.64	7202	G.T. SPEED PROBE – Replace Speed Probe – Won't start June – 2003
345798	90	GAS TURBINE	Total	$110.00	7202	GAS TURBINE – Clr Floors Lube Oil 2003
346629	90	G.T. FUEL FILTERS	Total	$1,044.11	7202	G.T. FUEL FILTERS – Press Gauge 2003
346641	90	G.T. FUEL FILTERS 03/06/05	Total	$301.26	7202	G.T. FUEL FILTERS
348237	90	GAS TURBINE TRIPPED 03/07/03	Total	$481.00	7202	GAS TURBINE TRIPPED

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset	
2944	90	LIGHT OIL STRAINER GT	Total	$287.60	7202	LIGHT OIL STRAINER GT	2004
5217	90	4- GAS TURBINE CONTROL ROOM	Total	$116.00	7202	4- GAS TURBINE CONTROL ROOM	
7392	90	GAS TURBINE MONITOR STARTUP	Total	$300.20	7202	GAS TURBINE MONITOR STARTUP	2007 – Diesel #1 AVR; June 04
9397	90	GAS TURBINE RADIATOR	Total	$842.05	7202	GAS TURBINE RADIATOR	– Cln + Paint core; 2005 Sept
6595	90	GAS TURBINE FAILED TO START	Total	$13,892.57	7202	GAS TURBINE FAILED TO START	Start Motor Rep 2004
6660	90	GAS TURBINE FAILED TO START	Total	$143.80	7202	GAS TURBINE FAILED TO START	
6836	90	GAS TURBINE FAILED TO START	Total	$58.00	7202	GAS TURBINE FAILED TO START	04/08/10; 04/8/10; Start Motor
7713	90	GAS TURBINE EXHAUST GAS TEMP	Total	$78.00	7202	GAS TURBINE EXHAUST GAS TEMP.	Reset alarm/Trip 665/675°C.; Feb 05
2763	90	GAS TURBINE FUEL METER	Total	$2,606.49	7202	GAS TURBINE FUEL METER	Repl sen; Oct 04
3962	90	ALARM ON EMERGENCY LIGHTING	Total	$140.00	7202	ALARM ON EMERGENCY LIGHTING	– 2005
8317	90	GAS TURBINE, AVON SPEED (RPM)	Total	$1,288.83	7202	GAS TURBINE, AVON SPEED (RPM)	
8909	90	G.T. STACK DOORS MECH. CHECKS	Total	$319.75	7202	G.T. STACK DOORS MECH. CHECKS	✓ 2004 Oct
0844	90	SOLENOID VLV ON GT AIR DRYER	Total	$346.50	7202	SOLENOID VLV ON GT AIR DRYER	– repl; 2005
1829	90	GAS TURBINE	Total	$354.14	7202	GAS TURBINE	GG Speed ind.; No Start 2004
1830	90	GAS TURBINE	Total	$234.00	7202	GAS TURBINE	04\11 04; – N
2424	90	GAS TURBINE GEM 80 ALARM	Total	$105.00	7202	GAS TURBINE GEM 80 ALARM	GG Speed ind etc. – AC/DC and PPs Cont / GEM 80 cntrl bd; MCC shell ? Nov 04
4220	90	PROVIDE A MECHANIC	Total	$70.00	7202	PROVIDE A MECHANIC	– oil sample 2005
8335	90	4- GAS TURBINE DYKES	Total	$696.00	7202	4- GAS TURBINE DYKES	– [illegible] 2003
0441	90	FUEL FLOW METER GAS TURBINE	Total	$78.00	7202	FUEL FLOW METER GAS TURBINE	?; – 2005

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset	
348773	90	TAKE OIL SAMPLE	Total	$66.00	7202	TAKE OIL SAMPLE	2003
349131	90	FUEL OIL FILTERS	Total	$73.98	7202	FUEL OIL FILTERS	Vent 2007?
350487	90	G.T. STACK DOORS MECH. CHECKS	Total	$269.70	7202	G.T. STACK DOORS MECH. CHECKS	✓ Aug 2003
351061	90	GAS TURBINE TRIP	Total	$132.00	7202	GAS TURBINE TRIP	
351099	90	REPLACE FUEL SUCTION FILTER	Total	$303.60	7202	REPLACE FUEL SUCTION FILTER	2003
354630	90	GOVERNOR & TRIP	Total	$640.74	7202	GOVERNOR & TRIP	– ? GG+PT spare governors install? GEM 80 programme Ballard Ford; Aug 2003
355935	90	G.T. DOOR STEP	Total	$433.80	7202	G.T. DOOR STEP	– 2003
356654	90	GAS TURBINE - BATTERY ALARM	Total	$403.60	7202	GAS TURBINE - BATTERY ALARM	– [illegible] ✓
358628	90	CHANGE OVER HANDLE	Total	$274.49	7202	CHANGE OVER HANDLE	– 2003
366299	90	G.T. STACK DOORS MECH. CHECKS	Total	$403.60	7202	G.T. STACK DOORS MECH. CHEC	– 2003
367062	90	3- AIR INTAKE RUST,ETC.	Total	$236.00	7202	3- AIR INTAKE RUST,ETC.	Sept 2005; – Plenum Clng + rust on floor – Cement on duct
369579	90	GAS TURBINE FO. PUMPS E&W	Total	$205.60	7202	GAS TURBINE FO. PUMPS E&W	2003
369584	90	GAS TURBINE CONTAMINATED SOIL	Total	$113.96	7202	GAS TURBINE CONTAMINATED SOIL	– [illegible] fuel oil pump [illegible] 2003
369628	90	GAS TURBINE WEST FO PUMP	Total	$205.60	7202	GAS TURBINE WEST FO PUMP	2003; – [illegible] – tight [illegible] Nov 2003
375955	90	GAS TURBINE FREQ.ALARM	Total	$264.48	7202	GAS TURBINE FREQ.ALARM	Transducer Freq Dec 2003
375984	90	GAS TURBINE FREQ.ALARM	Total	$2,072.15	7202	GAS TURBINE FREQ.ALARM	
381440	90	E FUEL OIL PUMP PLUG LEAK	Total	$1,254.43	7202	E FUEL OIL PUMP PLUG LEAK	Plug Chg (Vent) Jan 2004
382210	90	GAS TURBINE TRIP	Total	$1,440.01	7202	GAS TURBINE TRIP	Lube Oil Lines – new [illegible]
382682	90	GAS TURBINE OVERSPEED TEST	Total	$210.00	7202	GAS TURBINE OVERSPEED TEST	Nov 2004

WO#	WO St	Work Order Description			Asset Number	Description of Asset	
2246	90	4- G.T. STACK DOORS MECH. CHE	Total	$442.50	7202	4- G.T. STACK DOORS MECH. CHE	06-04-24 ✓ 2006
23	90	INVESTIGATE G.T.TRIP @0902am	Total	$69.00	7202	INVESTIGATE G.T.TRIP @0902am	06-4-13 DONE ?
5172	90	G.T. LUBE OIL LEVEL TRIP	Total	$248.99	7202	G.T. LUBE OIL LEVEL TRIP	06/07/04 2006.
5383	90	GAS TURBINE, AVON SPEED (RPM)	Total	$16,853.05	7202	GAS TURBINE, AVON SPEED (RPM)	06/7/4
668	90	GAS TURBINE AIR COMPRESSOR	Total	$34.50	7202	GAS TURBINE AIR COMPRESSOR	06/6/12 2005
689	90	GAS TURBINE SUCTION STRAINER	Total	$138.00	7202	GAS TURBINE SUCTION STRAINER	06/06/13 2006
591	90	GAS TURBINE SUCTION STRAINER	Total	$167.56	7202	GAS TURBINE SUCTION STRAINER	6/6/06 13 OK 2006
345	90	GAS TURBINE GEAR BOX VENT	Total	$138.00	7202	GAS TURBINE GEAR BOX VENT	Check of press 13/6/13 OKV 2006
180	90	GAS TURBINE (POWER TURBINE)	Total	$3,485.25	7202	GAS TURBINE (POWER TURBINE)	06/6/29
21	90	GAS TURBINE OUTAGE WORK 2007	Total	$72,085.32	7202	GAS TURBINE OUTAGE WORK 2007	06/10/16
23	90	GAS TURBINE SPEED PROBES	Total	$467.96	7202	GAS TURBINE SPEED PROBES	after trip. 06/9/25 GT RC trip
33	90	GAS TURBINE BATTERY CHARGER	Total	$98.04	7202	GAS TURBINE BATTERY CHARGER	6/8/30 OK 2006
51	90	G.T. STACK DOORS MECH. CHECKS	Total	$345.00	7202	G.T. STACK DOORS MECH. CHECKS	6/10/25 2006
77	90	REMOVE COVER FROM GAS TURBINE	Total	$562.64	7202	REMOVE COVER FROM GAS TURBINE	6/10/12 OK 2006
26	90	GAS TURBINE DCS**TEST RUN**	Total	$163.65	7202	GAS TURBINE DCS**TEST RUN**	6/10/18
7	90	G.T. STACK DOORS MECH. CHECKS	Total	$684.69	7202	G.T. STACK DOORS MECH. CHECKS	6/10/25
8	90	GAS TURBINE FUEL OIL TOTALIZER	Total	$280.52	7202	GAS TURBINE FUEL OIL TOTALIZER	2006 OK 6/11/6
7	90	GAS TURBINE SPEED PROBES	Total	$452.78	7202	GAS TURBINE SPEED PROBES	Replaced 7/3/16 May 2007
5	90	GAS TURBINE AIR COMPRESSOR	Total	$1,248.65	7202	GAS TURBINE AIR COMPRESSOR	Didn't turn off 7/1/16

WO#	WO St	Work Order Description			Asset Number	Description of Asset	
454332	90	4- GT BATTERY ROOM DOOR KNOB	Total	$69.00	7202	4- GT BATTERY ROOM DOOR KNOB	2005
454334	90	3-COMPLETE GENERAL CLEAN UP	Total	$59.00	7202	3-COMPLETE GENERAL CLEAN UP	2006
455551	90	TEMP. ALARM ON CHANNEL #3	Total	$0.00	7202	TEMP. ALARM ON CHANNEL #3	Brg #3 - Reset OK. 2005
465498	90	Gas Turbine	Total	$1,150.59	7202	Gas Turbine	GEM 80 2005
465645	90	IRD VIBRATION MONITOR	Total	$128.37	7202	IRD VIBRATION MONITOR	Bentley 2005
468466	90	GAS TURBINE DISCH.W.FILTER	Total	$358.54	7202	GAS TURBINE DISCH.W.FILTER	2005
470503	90	G.T. STACK DOORS MECH. CHECKS	Total	$283.07	7202	G.T. STACK DOORS MECH. CHECKS	2005
476771	90	"TEMP MONITOR ALARM"	Total	$40.50	7202	"TEMP MONITOR ALARM"	Reset 2005
480166	90	GT HOT SECTION INSPECTION.	Total	$7,253.94	7202	GT HOT SECTION INSPECTION.	RR Bulletin - Re Exh Vd ... Sept 2005
480636	90	GT EAST FUEL MOTOR PUMP ANNUAL	Total	$86.25	7202	GT EAST FUEL MOTOR PUMP ANNUA	2005
480640	90	GT WEST FUEL OIL PUMP ANNUAL	Total	$86.25	7202	GT WEST FUEL OIL PUMP ANNUAL	PM 2005
484531	90	GAS TURBINE BATTERY CHARGER	Total	$103.50	7202	GAS TURBINE BATTERY CHARGER	2005
491849	90	TEMP. MONITOR PANEL	Total	$1,130.00	7202	TEMP. MONITOR PANEL	05
492475	90	G.T. AIR COMPRESSOR	Total	$2,151.91	7202	G.T. AIR COMPRESSOR	2005 Went start - Press ... 2005
496401	90	GAS TURBINE COMPRESSOR	Total	$1,011.00	7202	GAS TURBINE COMPRESSOR	Check Vlv 2006
502614	90	3- GAS TURBINE LIGHTING	Total	$118.00	7202	3- GAS TURBINE LIGHTING	2006
503285	90	GAS TURBINE OIL SAMPLE	Total	$69.00	7202	GAS TURBINE OIL SAMPLE	2006
503328	90	GAS TURBINE FUEL OIL FLOW	Total	$1,454.00	7202	GAS TURBINE FUEL OIL FLOW	Totalizer not ... 2005
504753	90	GAS TURBINE DYKE SYPHON	Total	$183.65	7202	GAS TURBINE DYKE SYPHON	Check vlv rep 2006

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset	
6287	90	GAS TURBINE PROVIDE ASSISTANCE	Total	$69.00	7202	GAS TURBINE PROVIDE ASSISTANCE	07/01/16
0137	90	GAS TURBINE AIR COMPRESSOR	Total	$2,011.25	7202	GAS TURBINE AIR COMPRESSOR	07/2/12 Press Switch
0496	90	GAS TURBINE COOLER DYKE	Total	$556.91	7202	GAS TURBINE COOLER DYKE	07/2/08 Snow
1526	90	GAS TURBINE E. FO MOTOR PM	Total	$146.00	7202	GAS TURBINE E. FO MOTOR PM	~~07/05/31~~ 07/5/14
1530	90	GT HOT SECTION INSPECTION.	Total	$5,467.87	7202	GT HOT SECTION INSPECTION.	07/05/31 - Belt
1532	90	GAS TURBINE W. FO MOTOR PM	Total	$146.00	7202	GAS TURBINE W. FO MOTOR PM	
1542	90	GAS TURBINE BATTERY CHARGER	Total	$292.00	7202	GAS TURBINE BATTERY CHARGER	Check - 7/5/14
1845	90	GAS TURBINE - FUEL OIL PUMP	Total	$1,819.11	7202	GAS TURBINE - FUEL OIL PUMP	Temp Hose 2007 7/3/05
2182	90	4- GAS TURBINE LIGHTING	Total	$1,101.47	7202	4- GAS TURBINE LIGHTING	7/2/12
3991	90	GAS TURBINE COMPRESSOR	Total	$312.97	7202	GAS TURBINE COMPRESSOR	7/2/19 Check VIV
2346	90	GAS TURBINE LIGHT OIL PLACARD	Total	$36.50	7202	GAS TURBINE LIGHT OIL PLACARD	7/6/12
4282	90	GAS TURBINE CAPABILITY CURVE	Total	$1,347.50	7202	GAS TURBINE CAPABILITY CURVE	09/12/16 2009.
6225	90	GT2007 OUTAGE PREP WORK	Total	$2,371.79	7202	GT2007 OUTAGE PREP WORK	07/6/19 Gearbox Com
6227	90	GT2007 OUTAGE PREP WORK	Total	$976.00	7202	GT2007 OUTAGE PREP WORK	07/5/17
9390	90	gas turbine generator exhaust	Total	$3,264.84	7202	gas turbine generator exhaust	07/06/13 - Cover fell of roof
3158	90	G.T. HIGH VOLTAGE LEADS	Total	$292.00	7202	G.T. HIGH VOLTAGE LEADS	07/08/19
8438	90	GAS TURBINE SPEED INDICATION	Total	$230.00	7202	GAS TURBINE SPEED INDICATION	09/11/30 Repair
8441	90	3-GAS TURBINE AREA CLEAN UP	Total	$1,149.80	7202	3-GAS TURBINE AREA CLEAN UP	07/09/25
0853	90	black start	Total	$497.52	7202	black start	07/08/05 Aug rcvd

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset	
507195	90	GAS TURBINE	Total	$276.00	7202	GAS TURBINE	Not Signed ? 2007
507303	90	BREAKER SSB2	Total	$87.88	7202	BREAKER SSB2	OK - Not Working -> Rep with SSD 4; 2006
507335	90	GAS TURBINE TEMPER.MONITOR	Total	$2,430.29	7202	GAS TURBINE TEMPER.MONITOR	2 Failed channels Rep; 2006
508555	90	GAS TURBINE FUEL OIL FLOW	Total	$1,931.04	7202	GAS TURBINE FUEL OIL FLOW	
508586	90	GAS TRUBINE FUEL OIL SYSTEM	Total	$421.02	7202	GAS TRUBINE FUEL OIL SYSTEM	2006
510850	90	4- REPLACE LIGHTS IN GAS TURB	Total	$59.00	7202	4- REPLACE LIGHTS IN GAS TURB	2006
511222	90	GROUND CLAMP - BROKEN OFF	Total	$22.00	7202	GROUND CLAMP - BROKEN OFF	2006
515295	90	EMERGENCY LIGHTS GAS TURBINE	Total	$297.62	7202	EMERGENCY LIGHTS GAS TURBINE	
515502	90	GAS TURBINE W. FO MOTOR PM	Total	$241.50	7202	GAS TURBINE W. FO MOTOR PM	2006
515503	90	G.T. STACK DOORS MECH. CHECKS	Total	$966.00	7202	G.T. STACK DOORS MECH. CHE	2006
515508	90	GAS TURBINE GENERATOR TEST	Total	$1,774.55	7202	GAS TURBINE GENERATOR TEST	PM 2006
515685	90	3- GAS TURBINE CONTAINMENT DY	Total	$280.25	7202	3- GAS TURBINE CONTAINMENT DY	Snow 2006
516062	90	GAS TURBINE	Total	$138.00	7202	GAS TURBINE	Low Air Press. 2006
517928	90	LOW LUBE OIL TRIP GAS TURBINE	Total	$276.00	7202	LOW LUBE OIL TRIP GAS TURBINE	2006
518890	90	GAS TURBINE TEMPER.MONITOR	Total	$12,444.18	7202	GAS TURBINE TEMPER.MONITOR	
519995	90	GT (T9) TRANSFORMER	Total	$98.04	7202	GT (T9) TRANSFORMER	- Deluge System Reset - N/A ??
520267	90	Gas turbine temp.monitot	Total	$162.00	7202	Gas turbine temp.monitot	- Alarm - Cards UPS Fail; Mar 06
521081	90	GAS TURBINE LUBE OIL TRIP	Total	$828.00	7202	GAS TURBINE LUBE OIL TRIP	Low Level 06
522058	90	GAS TURBINE COMPRESSOR	Total	$276.00	7202	GAS TURBINE COMPRESSOR	Fail Start Shut Down 2006

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
6963	90	GT FO COALESCERE (FILTER) LEAK – Seal	Total	$473.55	7202	GT FO COALESCERE (FILTER) LEAK 2007
69[illegible]	44	GT COMBUSTION CAN-INSPECTION – Fuel Ctrl Unit + Fuel Pump Exp.	Total	$164,853.92	7202	GT COMBUSTION CAN-INSPECTION 2005
2132	90	GT #4 BRG HIGH VIBRATION –	Total	$234.90	7202	GT #4 BRG HIGH VIBRATION 2009
7622	90	GAS TURBINE GEAR BOX LUBE OIL Low Alarm – Inaccurate	Total	$1,053.84	7202	GAS TURBINE GEAR BOX LUBE OIL
9366	90	GT COMBUSTION CAN - welder	Total	$6,876.25	7202	GT COMBUSTION CAN - welder 2005
9570	90	GT COMBUSTION CAN,	Total	$6,029.45	7202	GT COMBUSTION CAN, 2009
3703	90	REPLACE FUEL OIL METER – Rpl → 673641	Total	$65.66	7202	REPLACE FUEL OIL METER
3817	90	GT COMBUSTION CAN-INSPECTION	Total	$184.00	7202	GT COMBUSTION CAN-INSPECTION 2009
3931	90	GT COMBUSTION CAN-INSPECTION	Total	$1,100.28	7202	GT COMBUSTION CAN-INSPECTION 2009 ?
51[illegible]	90	GAS TURBINE AVON TRANSIT STAND – transport for [illegible]	Total	$1,243.00	7202	GAS TURBINE AVON TRANSIT STAND 2005
140	90	G.T. STACK DOORS MECH. CHECKS	Total	$784.00	7202	G.T. STACK DOORS MECH. CHECKS 2009
038	90	GAS TURBINE-REPLACE PLC-labour ✓2009 –2009 PLC labour	Total	$1,222.80	7202	GAS TURBINE-REPLACE PLC-labour
762	90	GT INTAKE AIR FITLERS LADDER – repair	Total	$772.15	7202	GT INTAKE AIR FITLERS LADDER 2010
042	90	GAS TURBINE FUEL OIL STRAINERS Cln	Total	$181.76	7202	GAS TURBINE FUEL OIL STRAINERS 2010 ??
435	80	SWOP#2009006173 GAS TURBINE	Total	$761.54	7202	SWOP#2009006173 GAS TURBINE
594	90	GT ENGINE ROOM AND TOP OF PT – Cln Up	Total	$310.98	7202	GT ENGINE ROOM AND TOP OF PT 2010 ?
328	90	GAS TURBINE ROOM - HIGH TEMP	Total	$2,055.46	7202	GAS TURBINE ROOM - HIGH TEMP Jan 2010
714	90	DISCONNECT ENERGEN FIRE SYSTEM	Total	$278.25	7202	DISCONNECT ENERGEN FIRE SYSTE
168	90	HOLYROOD GAS TURBINE	Total	$1,666.50	7202	HOLYROOD GAS TURBINE N_2 Gov

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
601965	90	GT BLEED VALVE DUCTING Repaired bleed v/v ducting	Total	$490.58	7202	GT BLEED VALVE DUCTING Sept 2009
604950	90	GAS TURBINE 2 WEEKLY RUN UP	Total	$124.00	7202	GAS TURBINE 2 WEEKLY RUN UP Not completed. ?
608345	90	G.T. STACK DOORS MECH. CHECKS 6-	Total	$292.00	7202	G.T. STACK DOORS MECH. CHECKS
608707	90	GAS TURBINE GEAR BOX Increase Vent Pipe	Total	$1,245.35	7202	GAS TURBINE GEAR BOX 20 ~~20~~ 7 ?
609033	90	GAS TURBINE DUPLEX FILTER Leak @ top.	Total	$10.64	7202	GAS TURBINE DUPLEX FILTER Oct 07
613422	90	4-G.T.STACK DOORS MECH.CHECKS	Total	$387.92	7202	4-G.T.STACK DOORS MECH.CHECKS
623656	90	G.T. STACK DOORS MECH. CHECKS ✓2007	Total	$146.00	7202	G.T. STACK DOORS MECH. CHECKS Oct 07
627899	90	GAS TURBINE INSTALL SWITCH	Total	$1,292.80	7202	GAS TURBINE INSTALL SWITCH Feb 2008
628839	90	GT CLEAN UP Lube oil @ gearbox	Total	$186.00	7202	GT CLEAN UP 2008 ?
629034	90	Gas turbine plc New PLC – snow door issues	Total	$12,684.69	7202	Gas turbine plc 2008
630741	90	4- GAS TURBINE INSTALL SWITCH Snow Doors	Total	$482.60	7202	4- GAS TURBINE INSTALL SWITCH 2008
630743	90	GAS TURBINE INSTALL SWITCH Snow Door Switch.	Total	$301.56	7202	GAS TURBINE INSTALL SWITCH 2008
630812	90	VIBRATION MONITOR	Total	$392.53	7202	VIBRATION MONITOR 2008
632798	90	GAS TURBINE OVERSPEED TEST (New GEM)	Total	$182.50 ✓	7202	GAS TURBINE OVERSPEED TEST 2008
632801	90	GT HOT SECTION INSPECTION.	Total	$8,675.27	7202	GT HOT SECTION INSPECTION. 2008
632805	90	G.T.ELECTRONIC OVERSPEED TEST	Total	$299.28 ✓	7202	G.T.ELECTRONIC OVERSPEED TEST 2008 ?
648125	90	GAS TURBINE N2 STORAGE	Total	$1,713.04	7202	GAS TURBINE N2 STORAGE 2008 ?
648129	90	3-REPLACE BULBS IN EXIT SIGNS	Total	$62.00	7202	3-REPLACE BULBS IN EXIT SIGNS 2008 ?
648978	90	BLACK START TEST	Total	$408.32	7202	BLACK START TEST – JUNE 08 ✓

Cost Report By Work Order/Asset

O#	WO St	Work Order Description			Asset Number	Description of Asset
299	90	G.T. STACK DOORS MECH. CHECKS	Total	$140.00	7202	G.T. STACK DOORS MECH. CHECKS 2009
557	90	CHECK GT ENG.ROOM FAN/LOUVERS	Total	$336.00	7202	CHECK GT ENG.ROOM FAN/LOUVERS 2010
383	90	CHECK GT ENG.ROOM FAN/LOUVERS	Total	$504.00	7202	CHECK GT ENG.ROOM FAN/LOUVERS 2009
943	80	GAS TURBINE EMERGENCY LIGHTING	Total	$1,095.67	7202	GAS TURBINE EMERGENCY LIGHTIN 2010
975	44	GAS TURBINE FUEL OIL CONTROL — Overhauled	Total	$18,060.02	7202	GAS TURBINE FUEL OIL CONTROL 2010?
65	80	4 GT INTAKE AIR FITLERS LADDER	Total	$758.31	7202	4 GT INTAKE AIR FITLERS LADDER
31	80	GAS TURBINE AVON TRANSIT STAND	Total	$144.44	7202	GAS TURBINE AVON TRANSIT STANC
74	80	GAS TURBINE VIBRATION EQUIP. PM (discontinued)	Total	$26.03	7202	GAS TURBINE VIBRATION EQUIP. 2010
08	80	LATCH BROKEN ON EAST DOOR	Total	$381.60	7202	LATCH BROKEN ON EAST DOOR 2010
49	80	BATTERY ROOM LIGHTING-SWOP- Misc	Total	$727.04	7202	BATTERY ROOM LIGHTING-SWOP- 2010
00	80	GAS TURBINE E. FO MOTOR PM	Total	$181.76	7202	GAS TURBINE E. FO MOTOR PM
05	80	GAS TURBINE W. FO MOTOR PM PM	Total	$181.76	7202	GAS TURBINE W. FO MOTOR PM 2010
08	80	GAS TURBINE BATTERY CHARGER PM	Total	$253.55	7202	GAS TURBINE BATTERY CHARGER 2010
09	80	G/TURBINE EXHAUST THERMOCOUPLE Misc	Total	$798.88	7202	G/TURBINE EXHAUST THERMOCOUP
24	80	GAS TURBINE BUILDING Clean Up	Total	$144.44	7202	GAS TURBINE BUILDING 2010
5	80	G.T. EAST ACCESS DOOR-SWOP- Misc	Total	$1,274.24	7202	G.T. EAST ACCESS DOOR-SWOP- 201?
2	80	GAS TURBINE GEAR BOX OIL LEAK	Total	$89,095.57	7202	GAS TURBINE GEAR BOX OIL LEAK
3	80	GAS TURBINE GEAR BOX OIL LEAK → run to find leak?	Total	$6,195.32	7202	GAS TURBINE GEAR BOX OIL LEAK 2009?
3	46	GAS TURBINE WEST END	Total	$288.88	7202	GAS TURBINE WEST END

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
654524	90	GAS TURBINE GEAR BOX exhaust above roof	Total	$678.01	7202	GAS TURBINE GEAR BOX 2008
654532	90	4 - GAS TURBINE GEAR BOX Same	Total	$434.00	7202	4 - GAS TURBINE GEAR BOX
658749	90	GAS TURBINE INTAKE PLENUM Fix Hudson west wall clean up plenum	Total	$292.00	7202	GAS TURBINE INTAKE PLENUM Je 08
658753	90	GAS TURBINE INTAKE PLENUM	Total	$1,835.00	7202	GAS TURBINE INTAKE PLENUM
658918	90	GAS TURBINE DUPLEX STRAINER Crossover [illegible] → Dec 08	Total	$3,304.19	7202	GAS TURBINE DUPLEX STRAINER
670836	90	GT WATERWASH/REPORT	Total	$655.98	7202	GT WATERWASH/REPORT Aug 08 Request
671129	90	GT WATERWASH/REPORT	Total	$1,213.04	7202	GT WATERWASH/REPORT "
671132	90	GAS TURBINE REPAIR Inlet Plenum + Vac	Total	$437.21	7202	GAS TURBINE REPAIR Aug 08.
671211	90	GAS TURBINE REPAIR 2008	Total	$300.00	7202	GAS TURBINE REPAIR "
671466	90	GAS TURBINE 2 WEEKLY RUN UP	Total	$125.28	7202	GAS TURBINE 2 WEEKLY RUN UP
673641	90	REPLACE FUEL OIL METER Replaced	Total	$2,318.56	7202	REPLACE FUEL OIL METER Sept 09
680816	90	GAS TURBINE-RADIATOR OIL LEAK 2008 Slight leak	Total	$3,850.21	7202	GAS TURBINE-RADIATOR OIL LEAK Dec 08
683849	90	OIL COOLER DYKE - GAS TURBINE Oil in Dyke	Total	$248.00	7202	OIL COOLER DYKE - GAS TURBINE
690280	90	G.T.DUPLEX STRN.INLET VLV Block VLV	Total	$365.90	7202	G.T.DUPLEX STRN.INLET VLV Sept 05
693347	90	ORDER A MAIL SLOT/BIN	Total	$146.00	7202	ORDER A MAIL SLOT/BIN 09
693544	90	GAS TURBINE E. FO MOTOR PM	Total	$109.50	7202	GAS TURBINE E. FO MOTOR PM Mar 09
693550	90	GAS TURBINE W. FO MOTOR PM	Total	$109.50	7202	GAS TURBINE W. FO MOTOR PM Mar 09
694640	90	GAS TURBINE TRIP	Total	$3,014.55	7202	GAS TURBINE TRIP
716564	90	GT FO COALESCERE (FILTER) LEAK	Total	$769.56	7202	GT FO COALESCERE (FILTER) LEAK May 09

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
774680	80	GAS TURBINE GEAR BOX OIL LEAK - Alba attempt to fix X	Total	$7,900.00	7202	GAS TURBINE GEAR BOX OIL LEAK 2010?
778593	80	GAS TURBINE ROOM - HIGH TEMP	Total	$144.44	7202	GAS TURBINE ROOM - HIGH TEMP
779638	80	HOLYROOD GAS TURBINE TC above engine	Total	$144.44	7202	HOLYROOD GAS TURBINE May 2010
779652	80	GT LUBE OIL RADIATOR DYKE	Total	$160.84	7202	GT LUBE OIL RADIATOR DYKE drain plug
782000 X	80	GAS TURBINE 230 V AVR SUPPLY Repair/Replace Contactor	Total	$1,438.24	7202	GAS TURBINE 230 V AVR SUPPLY 2011? X
787350	80	GAS TURBINE 2 WEEKLY RUN UP	Total	$123.00	7202	GAS TURBINE 2 WEEKLY RUN UP Not Req'd ??
			Total Amout Of Work Orders	$610,469.67		

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
336343	90	GAS TURBINE OVERSPEED TEST	Total	$462.24	7202	GAS TURBINE OVERSPEED TEST
336701	90	CLEAN LUBE OIL FILTER	Total	$394.93	7202	CLEAN LUBE OIL FILTER
336968	90	LUBE OIL DIFF. PRESS.	Total	$111.00	7202	LUBE OIL DIFF. PRESS.
337699	90	G.T. STACK DOORS MECH. CHECKS	Total	$271.60	7202	G.T. STACK DOORS MECH. CHECKS
338310	90	CAP "O" RING GASKET PROTRUDING	Total	$504.33	7202	CAP "O" RING GASKET PROTRUDING
338392	90	CAP "O" RING GASKET PROTRUDING 03/05/08	Total	$143.41	7202	CAP "O" RING GASKET PROTRUDING 2003
39249	90	CLEAN LUBE OIL FILTER 03/05/14	Total	$9.16	7202	CLEAN LUBE OIL FILTER 28- 2003
39253	90	3 G.T. STACK DOORS MECH. Cks. 03/05/14	Total	$375.37	7202	3 G.T. STACK DOORS MECH. Cks.
40937	90	GAS TURBINE NOT STARTING	Total	$981.93	7202	GAS TURBINE NOT STARTING
41635	90	LUBE OIL PRESS. INDICATION	Total	$1,147.59	7202	LUBE OIL PRESS. INDICATION
41737	90	GAS TURBINE BAY AIR DRYER	Total	$151.80	7202	GAS TURBINE BAY AIR DRYER
42531	90	F.O.PUMP WEST COUPLING	Total	$39.21	7202	F.O.PUMP WEST COUPLING
43756	90	GAS TURBINE TRIPPED	Total	$487.30	7202	GAS TURBINE TRIPPED
43838	90	GAS TURBINE TRIPPED 03/06/10	Total	$143.62	7202	GAS TURBINE TRIPPED
44720	90	G.T. SPEED PROBE	Total	$1,696.64	7202	G.T. SPEED PROBE
45798	90	GAS TURBINE	Total	$110.00	7202	GAS TURBINE
46629	90	G.T. FUEL FILTERS	Total	$1,044.11	7202	G.T. FUEL FILTERS
46641	90	G.T. FUEL FILTERS 03/06/05	Total	$301.26	7202	G.T. FUEL FILTERS 2003
48237	90	GAS TURBINE TRIPPED 03/07/02	Total	$481.00	7202	GAS TURBINE TRIPPED –2 trips; Speed Probe fixed –Ran 1 hr ok 2003

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
382683	91	G.T. STACK DOORS MECH. CHECKS	Total	$385.00	7202	G.T. STACK DOORS MECH. CHECKS 2003
382733	90	GAS TURBINE BATTERY CHARGER	Total	$420.00	7202	GAS TURBINE BATTERY CHARGER
382860	90	GT EAST FUEL MOTOR PUMP ANNUAL	Total	$283.80	7202	GT EAST FUEL MOTOR PUMP ANNU
382955	90	GT HOT SECTION INSPECTION.	Total	$143.80	7202	GT HOT SECTION INSPECTION.
384392	91	4-G.T. STACK DOORS MECH. CHk	Total	$217.60	7202	4-G.T. STACK DOORS MECH. CHk
385538	90	REQUEST FOR SANDING	Total	$145.00	7202	REQUEST FOR SANDING
388347	90	gas Turbine Fuel oil pumps	Total	$64.15	7202	gas Turbine Fuel oil pumps
388492	90	4- GAS TURBINE DYKES	Total	$174.00	7202	4- GAS TURBINE DYKES
389343	90	3- GAS TURBINE DYKES	Total	$812.00	7202	3- GAS TURBINE DYKES
390292	90	GAS TURBINE ALARM	Total	$2,707.00	7202	GAS TURBINE ALARM
390748	90	4- GAS TURBINE LUBE OIL COOLER	Total	$232.00	7202	4- GAS TURBINE LUBE OIL COOLER
392811	90	4- GAS TURBINE DYKES	Total	$174.00	7202	4- GAS TURBINE DYKES
394377	90	FIRE DOOR RELEASE	Total	$210.00	7202	FIRE DOOR RELEASE
395372	90	EAST FUEL OIL FILTER LEAK	Total	$582.04	7202	EAST FUEL OIL FILTER LEAK
397531	90	GAS TURBINE LUBE OIL SAMPLE	Total	$140.00	7202	GAS TURBINE LUBE OIL SAMPLE
398030	90	GAS TURBINE	Total	$156.00	7202	GAS TURBINE
398141	90	BREAKER SSB-2	Total	$476.00	7202	BREAKER SSB-2
400814	90	2 FLUORSESCENT LIGHTS	Total	$141.88	7202	2 FLUORSESCENT LIGHTS
402943	90	EMERGENCY LIGHTS IN SWITCHGEAR	Total	$245.00	7202	EMERGENCY LIGHTS IN SWITCHGEA

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
522246	90	4- G.T. STACK DOORS MECH. CHE	Total	$442.50	7202	4- G.T. STACK DOORS MECH. CHE
52[illegible]53	90	INVESTIGATE G.T.TRIP @0902am	Total	$69.00	7202	INVESTIGATE G.T.TRIP @0902am
525172	90	G.T. LUBE OIL LEVEL TRIP	Total	$248.99	7202	G.T. LUBE OIL LEVEL TRIP
526383	90	GAS TURBINE, AVON SPEED (RPM)	Total	$16,853.05	7202	GAS TURBINE, AVON SPEED (RPM)
530668	90	GAS TURBINE AIR COMPRESSOR	Total	$34.50	7202	GAS TURBINE AIR COMPRESSOR
530689	90	GAS TURBINE SUCTION STRAINER	Total	$138.00	7202	GAS TURBINE SUCTION STRAINER
530691	90	GAS TURBINE SUCTION STRAINER	Total	$167.56	7202	GAS TURBINE SUCTION STRAINER
30845	90	GAS TURBINE GEAR BOX VENT	Total	$138.00	7202	GAS TURBINE GEAR BOX VENT
35380	90	GAS TURBINE (POWER TURBINE)	Total	$3,485.25	7202	GAS TURBINE (POWER TURBINE)
37[illegible]	90	GAS TURBINE OUTAGE WORK 2007	Total	$72,085.32	7202	GAS TURBINE OUTAGE WORK 2007
43823	90	GAS TURBINE SPEED PROBES	Total	$467.96	7202	GAS TURBINE SPEED PROBES
44533	90	GAS TURBINE BATTERY CHARGER	Total	$98.04	7202	GAS TURBINE BATTERY CHARGER
49961	90	G.T. STACK DOORS MECH. CHECKS	Total	$345.00	7202	G.T. STACK DOORS MECH. CHECKS
52477	90	REMOVE COVER FROM GAS TURBINE	Total	$562.64	7202	REMOVE COVER FROM GAS TURBIN
52826	90	GAS TURBINE DCS**TEST RUN**	Total	$163.65	7202	GAS TURBINE DCS**TEST RUN**
53467	90	G.T. STACK DOORS MECH. CHECKS	Total	$684.69	7202	G.T. STACK DOORS MECH. CHECKS
55748	90	GAS TURBINE FUEL OIL TOTALIZER	Total	$280.52	7202	GAS TURBINE FUEL OIL TOTALIZER
61277	90	GAS TURBINE SPEED PROBES	Total	$452.78	7202	GAS TURBINE SPEED PROBES
3655	90	GAS TURBINE AIR COMPRESSOR	Total	$1,248.65	7202	GAS TURBINE AIR COMPRESSOR

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
454332	90	4- GT BATTERY ROOM DOOR KNOB	Total	$69.00	7202	4- GT BATTERY ROOM DOOR KNOB
454334	90	3-COMPLETE GENERAL CLEAN UP	Total	$59.00	7202	3-COMPLETE GENERAL CLEAN UP
455551	90	TEMP. ALARM ON CHANNEL #3	Total	$0.00	7202	TEMP. ALARM ON CHANNEL #3
465498	90	Gas Turbine	Total	$1,150.59	7202	Gas Turbine
465645	90	IRD VIBRATION MONITOR	Total	$128.37	7202	IRD VIBRATION MONITOR
468466	90	GAS TURBINE DISCH.W.FILTER	Total	$358.54	7202	GAS TURBINE DISCH.W.FILTER
470503	90	G.T. STACK DOORS MECH. CHECKS	Total	$283.07	7202	G.T. STACK DOORS MECH. CHECKS
476771	90	"TEMP MONITOR ALARM"	Total	$40.50	7202	"TEMP MONITOR ALARM"
480166	90	GT HOT SECTION INSPECTION.	Total	$7,253.94	7202	GT HOT SECTION INSPECTION.
480636	90	GT EAST FUEL MOTOR PUMP ANNUAL	Total	$86.25	7202	GT EAST FUEL MOTOR PUMP ANNUA
480640	90	GT WEST FUEL OIL PUMP ANNUAL	Total	$86.25	7202	GT WEST FUEL OIL PUMP ANNUAL
484531	90	GAS TURBINE BATTERY CHARGER	Total	$103.50	7202	GAS TURBINE BATTERY CHARGER
491849	90	TEMP. MONITOR PANEL	Total	$1,130.00	7202	TEMP. MONITOR PANEL
492475	90	G.T. AIR COMPRESSOR	Total	$2,151.91	7202	G.T. AIR COMPRESSOR
496401	90	GAS TURBINE COMPRESSOR	Total	$1,011.00	7202	GAS TURBINE COMPRESSOR
502614	90	3- GAS TURBINE LIGHTING	Total	$118.00	7202	3- GAS TURBINE LIGHTING
503285	90	GAS TURBINE OIL SAMPLE	Total	$69.00	7202	GAS TURBINE OIL SAMPLE
503328	90	GAS TURBINE FUEL OIL FLOW	Total	$1,454.00	7202	GAS TURBINE FUEL OIL FLOW
504753	90	GAS TURBINE DYKE SYPHON	Total	$183.65	7202	GAS TURBINE DYKE SYPHON

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
6963	90	GT FO COALESCERE (FILTER) LEAK	Total	$473.55	7202	GT FO COALESCERE (FILTER) LEAK
6988	44	GT COMBUSTION CAN-INSPECTION	Total	$164,853.92	7202	GT COMBUSTION CAN-INSPECTION
2132	90	GT #4 BRG HIGH VIBRATION	Total	$234.90	7202	GT #4 BRG HIGH VIBRATION
7622	90	GAS TURBINE GEAR BOX LUBE OIL	Total	$1,053.84	7202	GAS TURBINE GEAR BOX LUBE OIL
9366	90	GT COMBUSTION CAN - welder	Total	$6,876.25	7202	GT COMBUSTION CAN - welder
9570	90	GT COMBUSTION CAN,	Total	$6,029.45	7202	GT COMBUSTION CAN,
3703	90	REPLACE FUEL OIL METER	Total	$65.66	7202	REPLACE FUEL OIL METER
3817	90	GT COMBUSTION CAN-INSPECTION	Total	$184.00	7202	GT COMBUSTION CAN-INSPECTION
3931	90	GT COMBUSTION CAN-INSPECTION	Total	$1,100.28	7202	GT COMBUSTION CAN-INSPECTION
6100	90	GAS TURBINE AVON TRANSIT STAND	Total	$1,243.00	7202	GAS TURBINE AVON TRANSIT STAND
7140	90	G.T. STACK DOORS MECH. CHECKS	Total	$784.00	7202	G.T. STACK DOORS MECH. CHECKS
9038	90	GAS TURBINE-REPLACE PLC-labour	Total	$1,222.80	7202	GAS TURBINE-REPLACE PLC-labour
0762	90	GT INTAKE AIR FITLERS LADDER	Total	$772.15	7202	GT INTAKE AIR FITLERS LADDER
3042	90	GAS TURBINE FUEL OIL STRAINERS	Total	$181.76	7202	GAS TURBINE FUEL OIL STRAINERS
3435	80	SWOP#2009006173 GAS TURBINE	Total	$761.54	7202	SWOP#2009006173 GAS TURBINE
3594	90	GT ENGINE ROOM AND TOP OF PT	Total	$310.98	7202	GT ENGINE ROOM AND TOP OF PT
4328	90	GAS TURBINE ROOM - HIGH TEMP	Total	$2,055.46	7202	GAS TURBINE ROOM - HIGH TEMP
4714	90	DISCONNECT ENERGEN FIRE SYSTEM	Total	$278.25	7202	DISCONNECT ENERGEN FIRE SYSTE
5168	90	HOLYROOD GAS TURBINE	Total	$1,666.50	7202	HOLYROOD GAS TURBINE

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
601965	90	GT BLEED VALVE DUCTING	Total	$490.58	7202	GT BLEED VALVE DUCTING
604950	90	GAS TURBINE 2 WEEKLY RUN UP	Total	$124.00	7202	GAS TURBINE 2 WEEKLY RUN UP
608345	90	G.T. STACK DOORS MECH. CHECKS	Total	$292.00	7202	G.T. STACK DOORS MECH. CHECKS
608707	90	GAS TURBINE GEAR BOX	Total	$1,245.35	7202	GAS TURBINE GEAR BOX
609033	90	GAS TURBINE DUPLEX FILTER	Total	$10.64	7202	GAS TURBINE DUPLEX FILTER
613422	90	4-G.T.STACK DOORS MECH.CHECKS	Total	$387.92	7202	4-G.T.STACK DOORS MECH.CHECKS
623656	90	G.T. STACK DOORS MECH. CHECKS	Total	$146.00	7202	G.T. STACK DOORS MECH. CHECKS
627899	90	GAS TURBINE INSTALL SWITCH	Total	$1,292.80	7202	GAS TURBINE INSTALL SWITCH
628839	90	GT CLEAN UP	Total	$186.00	7202	GT CLEAN UP
629034	90	Gas turbine plc	Total	$12,684.69	7202	Gas turbine plc
630741	90	4- GAS TURBINE INSTALL SWITCH	Total	$482.60	7202	4- GAS TURBINE INSTALL SWIT
630743	90	GAS TURBINE INSTALL SWITCH	Total	$301.56	7202	GAS TURBINE INSTALL SWITCH
630812	90	VIBRATION MONITOR	Total	$392.53	7202	VIBRATION MONITOR
632798	90	GAS TURBINE OVERSPEED TEST	Total	$182.50	7202	GAS TURBINE OVERSPEED TEST
632801	90	GT HOT SECTION INSPECTION.	Total	$8,675.27	7202	GT HOT SECTION INSPECTION.
632805	90	G.T.ELECTRONIC OVERSPEED TEST	Total	$299.28	7202	G.T.ELECTRONIC OVERSPEED TEST
648125	90	GAS TURBINE N2 STORAGE	Total	$1,713.04	7202	GAS TURBINE N2 STORAGE
648129	90	3-REPLACE BULBS IN EXIT SIGNS	Total	$62.00	7202	3-REPLACE BULBS IN EXIT SIGNS
648978	90	BLACK START TEST	Total	$408.32	7202	BLACK START TEST

WO#	WO St	Work Order Description			Asset Number	Description of Asset
774680	80	GAS TURBINE GEAR BOX OIL LEAK	Total	$7,900.00	7202	GAS TURBINE GEAR BOX OIL LEAK
778593	80	GAS TURBINE ROOM - HIGH TEMP	Total	$144.44	7202	GAS TURBINE ROOM - HIGH TEMP
779638	80	HOLYROOD GAS TURBINE	Total	$144.44	7202	HOLYROOD GAS TURBINE
779652	80	GT LUBE OIL RADIATOR DYKE	Total	$160.84	7202	GT LUBE OIL RADIATOR DYKE
782000	80	GAS TURBINE 230 V AVR SUPPLY	Total	$1,438.24	7202	GAS TURBINE 230 V AVR SUPPLY
787350	80	GAS TURBINE 2 WEEKLY RUN UP	Total	$123.00	7202	GAS TURBINE 2 WEEKLY RUN UP
			Total Amout Of Work Orders		$610,469.67	

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
47298	90	GAS TURBINE-GEN.STATOR#4	Total	$126.31	7202	GAS TURBINE-GEN.STATOR#4 Card Issue 2001
47374	90	GAS TURBINE-VIBRATION MONITOR	Total	$141.35	7202	GAS TURBINE-VIBRATION MONITOR 2
48728	90	N.W. CORNER OF GT ENGINE	Total	$47.00	7202	N.W. CORNER OF GT ENGINE
55283	90	GAS TURBINE SUCTION STRAINER	Total	$1,159.01	7202	GAS TURBINE SUCTION STRAINER
55627	90	GAS TURBINE STRAINER	Total	$144.31	7202	GAS TURBINE STRAINER
62101	90	G.T. STACK DOORS MECH. CHECKS	Total	$142.50	7202	G.T. STACK DOORS MECH. CHECKS
64166	90	GAS TURBINE-WEST FUEL OIL PUMP	Total	$144.40	7202	GAS TURBINE-WEST FUEL OIL PUMP
65021	90	GAS TURBINE CONTROL RM BOARD	Total	$473.00	7202	GAS TURBINE CONTROL RM BOARD
65695	90	GAS TURBINE CONTROL RM BOARD	Total	$142.50	7202	GAS TURBINE CONTROL RM BOARD
73841	90	GAS TURBINE OVERSPEED TEST	Total	$294.99	7202	GAS TURBINE OVERSPEED TEST
76297	90	G.T. STACK DOORS MECH. CHECKS	Total	$242.79	7202	G.T. STACK DOORS MECH. CHECKS
79468	90	G.T. STACK DOORS MECH. CHECKS	Total	$543.55	7202	G.T. STACK DOORS MECH. CHECKS
31768	90	GAS TURBINE-FUEL OIL TRIP VLV	Total	$142.50	7202	GAS TURBINE-FUEL OIL TRIP VLV
34224	90	GAS TURBINE - DYKES	Total	$55.60	7202	GAS TURBINE - DYKES
36308	90	GAS TURBINE 02/06/28	Total	$228.00	7202	GAS TURBINE
36758	90	CABLE TRAY COVER BY GAS TURB.	Total	$482.09	7202	CABLE TRAY COVER BY GAS TURB.
36802	90	BEARING #2 CH.2 IS IN ALARM	Total	$1,433.14	7202	BEARING #2 CH.2 IS IN ALARM
33298	90	GT AVON INSPECTION	Total	$726.03	7202	GT AVON INSPECTION
5133	90	GAS TURBINE	Total	$176.70	7202	GAS TURBINE

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
2463	91	PERF 13.8KV OIL CIRCUIT BKR	Total	$1,702.75	7202	PERF 13.8KV OIL CIRCUIT BKR Ref TRF + CT – Megger test – 2004
135081	90	DYKE DRAIN SYPHON IS MISSING	Total	$54.90	7202	DYKE DRAIN SYPHON IS MISSING
139563	90	ORDER/PLACE SIGNS ACCESS DOORS	Total	$199.42	7202	ORDER/PLACE SIGNS ACCESS DOO
142505	90	GAS TURBINE LIGHT OIL SUCTION	Total	$219.60	7202	GAS TURBINE LIGHT OIL SUCTION
143135	90	GAS TURBINE/FLOOR SOUTH SIDE	Total	$152.71	7202	GAS TURBINE/FLOOR SOUTH SIDE – Roof Leak
150425	90	GAS TURBINE EAST DISCHARGE	Total	$98.80	7202	GAS TURBINE EAST DISCHARGE – 1
159239	90	CHECK/REPAIR GAS TURBINE MEGA	Total	$1,257.30	7202	CHECK/REPAIR GAS TURBINE MEGA 2000
166127	90	GAS TURBINE FO DISCHARGE FILTE	Total	$650.84	7202	GAS TURBINE FO DISCHARGE FILTE ?
168568	90	GAS TURBINE, SNOW DOORS CLOSE	Total	$249.26	7202	GAS TURBINE, SNOW DOORS CL – OK? Controller. 2000.
172304	90	GAS TURBINE GEN 80	Total	$244.77	7202	GAS TURBINE GEN 80 – Card issue
174393	90	GAS TURBINE CHECK DIGITAL READ	Total	$1,929.50	7202	GAS TURBINE CHECK DIGITAL READ New Card
179056	90	GAS TURBINE	Total	$111.80	7202	GAS TURBINE – Hot End Insp Asset ?
182923	91	GAS TURBINE/MODIFY CONTROL	Total	$2,930.52	7202	GAS TURBINE/MODIFY CONTROL
186350	90	GAS TURBINE 2 WEEKLY RUN UP	Total	$27.00	7202	GAS TURBINE 2 WEEKLY RUN UP
186516	90	GT ROSEMONT 4001/TEMP MONITOR	Total	$155.26	7202	GT ROSEMONT 4001/TEMP MONITOR 2000 Rec.
187978	90	GT TEMP MONITOR TRIP/GEN STAT	Total	$1,931.00	7202	GT TEMP MONITOR TRIP/GEN STAT Card Rep. 2000?
190208	90	MAKE NECESSARY REPAIRS TO SLID	Total	$439.60	7202	MAKE NECESSARY REPAIRS TO SLID
190409	90	GT TEMP ALARM CH 12	Total	$118.00	7202	GT TEMP ALARM CH 12 – 1
190754	90	MAKE NECESSARY REPAIRS TO SLID	Total	$348.75	7202	MAKE NECESSARY REPAIRS TO SLID

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
7298	90	GAS TURBINE-GEN.STATOR#4	Total	$126.31	7202	GAS TURBINE-GEN.STATOR#4
7374	90	GAS TURBINE-VIBRATION MONITOR	Total	$141.35	7202	GAS TURBINE-VIBRATION MONITOR
8728	90	N.W. CORNER OF GT ENGINE	Total	$47.00	7202	N.W. CORNER OF GT ENGINE
5283	90	GAS TURBINE SUCTION STRAINER	Total	$1,159.01	7202	GAS TURBINE SUCTION STRAINER
5627	90	GAS TURBINE STRAINER	Total	$144.31	7202	GAS TURBINE STRAINER
2101	90	G.T. STACK DOORS MECH. CHECKS	Total	$142.50	7202	G.T. STACK DOORS MECH. CHECKS
166	90	GAS TURBINE-WEST FUEL OIL PUMP	Total	$144.40	7202	GAS TURBINE-WEST FUEL OIL PUMP
021	90	GAS TURBINE CONTROL RM BOARD	Total	$473.00	7202	GAS TURBINE CONTROL RM BOARD
695	90	GAS TURBINE CONTROL RM BOARD	Total	$142.50	7202	GAS TURBINE CONTROL RM BOARD
18	90	GAS TURBINE OVERSPEED TEST	Total	$294.99	7202	GAS TURBINE OVERSPEED TEST
297	90	G.T. STACK DOORS MECH. CHECKS	Total	$242.79	7202	G.T. STACK DOORS MECH. CHECKS
468	90	G.T. STACK DOORS MECH. CHECKS	Total	$543.55	7202	G.T. STACK DOORS MECH. CHECKS
768	90	GAS TURBINE-FUEL OIL TRIP VLV	Total	$142.50	7202	GAS TURBINE-FUEL OIL TRIP VLV
224	90	GAS TURBINE - DYKES	Total	$55.60	7202	GAS TURBINE - DYKES
308	90	GAS TURBINE 02/06/28	Total	$228.00	7202	GAS TURBINE
758	90	CABLE TRAY COVER BY GAS TURB.	Total	$482.09	7202	CABLE TRAY COVER BY GAS TURB.
302	90	BEARING #2 CH.2 IS IN ALARM	Total	$1,433.14	7202	BEARING #2 CH.2 IS IN ALARM
298	90	GT AVON INSPECTION	Total	$726.03	7202	GT AVON INSPECTION
133	90	GAS TURBINE	Total	$176.70	7202	GAS TURBINE

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
2463	91	PERF 13.8KV OIL CIRCUIT BKR	Total	$1,702.75	7202	PERF 13.8KV OIL CIRCUIT BKR
135081	90	DYKE DRAIN SYPHON IS MISSING	Total	$54.90	7202	DYKE DRAIN SYPHON IS MISSING
139563	90	ORDER/PLACE SIGNS ACCESS DOORS	Total	$199.42	7202	ORDER/PLACE SIGNS ACCESS DOO
142505	90	GAS TURBINE LIGHT OIL SUCTION	Total	$219.60	7202	GAS TURBINE LIGHT OIL SUCTION
143135	90	GAS TURBINE/FLOOR SOUTH SIDE	Total	$152.71	7202	GAS TURBINE/FLOOR SOUTH SIDE
150425	90	GAS TURBINE EAST DISCHARGE	Total	$98.80	7202	GAS TURBINE EAST DISCHARGE
159239	90	CHECK/REPAIR GAS TURBINE MEGA	Total	$1,257.30	7202	CHECK/REPAIR GAS TURBINE MEGA
166127	90	GAS TURBINE FO DISCHARGE FILTE	Total	$650.84	7202	GAS TURBINE FO DISCHARGE FILTE
168568	90	GAS TURBINE, SNOW DOORS CLOSED	Total	$249.26	7202	GAS TURBINE, SNOW DOORS CLOSE
172304	90	GAS TURBINE GEN 80	Total	$244.77	7202	GAS TURBINE GEN 80
174393	90	GAS TURBINE CHECK DIGITAL READ	Total	$1,929.50	7202	GAS TURBINE CHECK DIGITAL REA
179056	90	GAS TURBINE	Total	$111.80	7202	GAS TURBINE
182923	91	GAS TURBINE/MODIFY CONTROL	Total	$2,930.52	7202	GAS TURBINE/MODIFY CONTROL
186350	90	GAS TURBINE 2 WEEKLY RUN UP	Total	$27.00	7202	GAS TURBINE 2 WEEKLY RUN UP
186516	90	GT ROSEMONT 4001/TEMP MONITOR	Total	$155.26	7202	GT ROSEMONT 4001/TEMP MONITOR
187978	90	GT TEMP MONITOR TRIP/GEN STAT	Total	$1,931.00	7202	GT TEMP MONITOR TRIP/GEN STAT
190208	90	MAKE NECESSARY REPAIRS TO SLID	Total	$439.60	7202	MAKE NECESSARY REPAIRS TO SLID
190409	90	GT TEMP ALARM CH 12	Total	$118.00	7202	GT TEMP ALARM CH 12
190754	90	MAKE NECESSARY REPAIRS TO SLID	Total	$348.75	7202	MAKE NECESSARY REPAIRS TO SLID

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
382683	91	G.T. STACK DOORS MECH. CHECKS	Total	$385.00	7202	G.T. STACK DOORS MECH. CHECKS
382733	90	GAS TURBINE BATTERY CHARGER	Total	$420.00	7202	GAS TURBINE BATTERY CHARGER
382860	90	GT EAST FUEL MOTOR PUMP ANNUA	Total	$283.80	7202	GT EAST FUEL MOTOR PUMP ANNUA
382955	90	GT HOT SECTION INSPECTION.	Total	$143.80	7202	GT HOT SECTION INSPECTION.
84392	91	4-G.T. STACK DOORS MECH. CHk	Total	$217.60	7202	4-G.T. STACK DOORS MECH. CHk
85538	90	REQUEST FOR SANDING	Total	$145.00	7202	REQUEST FOR SANDING
88347	90	gas Turbine Fuel oil pumps	Total	$64.15	7202	gas Turbine Fuel oil pumps
88492	90	4- GAS TURBINE DYKES	Total	$174.00	7202	4- GAS TURBINE DYKES
89343	90	3- GAS TURBINE DYKES	Total	$812.00	7202	3- GAS TURBINE DYKES
90292	90	GAS TURBINE ALARM	Total	$2,707.00	7202	GAS TURBINE ALARM
90748	90	4- GAS TURBINE LUBE OIL COOLER	Total	$232.00	7202	4- GAS TURBINE LUBE OIL COOLER
92811	90	4- GAS TURBINE DYKES	Total	$174.00	7202	4- GAS TURBINE DYKES
94377	90	FIRE DOOR RELEASE	Total	$210.00	7202	FIRE DOOR RELEASE
95372	90	EAST FUEL OIL FILTER LEAK	Total	$582.04	7202	EAST FUEL OIL FILTER LEAK
97531	90	GAS TURBINE LUBE OIL SAMPLE	Total	$140.00	7202	GAS TURBINE LUBE OIL SAMPLE
98030	90	GAS TURBINE	Total	$156.00	7202	GAS TURBINE
98141	90	BREAKER SSB-2	Total	$476.00	7202	BREAKER SSB-2
0814	90	2 FLUORSESCENT LIGHTS	Total	$141.88	7202	2 FLUORSESCENT LIGHTS
2943	90	EMERGENCY LIGHTS IN SWITCHGEAR	Total	$245.00	7202	EMERGENCY LIGHTS IN SWITCHGEA

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
336343	90	GAS TURBINE OVERSPEED TEST	Total	$462.24	7202	GAS TURBINE OVERSPEED TEST
336701	90	CLEAN LUBE OIL FILTER	Total	$394.93	7202	CLEAN LUBE OIL FILTER
336968	90	LUBE OIL DIFF. PRESS.	Total	$111.00	7202	LUBE OIL DIFF. PRESS.
337699	90	G.T. STACK DOORS MECH. CHECKS	Total	$271.60	7202	G.T. STACK DOORS MECH. CHECKS
338310	90	CAP "O" RING GASKET PROTRUDING	Total	$504.33	7202	CAP "O" RING GASKET PROTRUDING
338392	90	CAP "O" RING GASKET PROTRUDING	Total	$143.41	7202	CAP "O" RING GASKET PROTRUDING
339249	90	CLEAN LUBE OIL FILTER	Total	$9.16	7202	CLEAN LUBE OIL FILTER
339253	90	3 G.T. STACK DOORS MECH. Cks.	Total	$375.37	7202	3 G.T. STACK DOORS MECH. Cks.
340937	90	GAS TURBINE NOT STARTING	Total	$981.93	7202	GAS TURBINE NOT STARTING
341635	90	LUBE OIL PRESS. INDICATION	Total	$1,147.59	7202	LUBE OIL PRESS. INDICATION
341737	90	GAS TURBINE BAY AIR DRYER	Total	$151.80	7202	GAS TURBINE BAY AIR DRYER
342531	90	F.O.PUMP WEST COUPLING	Total	$39.21	7202	F.O.PUMP WEST COUPLING
343756	90	GAS TURBINE TRIPPED	Total	$487.30	7202	GAS TURBINE TRIPPED
343838	90	GAS TURBINE TRIPPED	Total	$143.62	7202	GAS TURBINE TRIPPED
344720	90	G.T. SPEED PROBE	Total	$1,696.64	7202	G.T. SPEED PROBE
345798	90	GAS TURBINE	Total	$110.00	7202	GAS TURBINE
346629	90	G.T. FUEL FILTERS	Total	$1,044.11	7202	G.T. FUEL FILTERS
346641	90	G.T. FUEL FILTERS	Total	$301.26	7202	G.T. FUEL FILTERS
348237	90	GAS TURBINE TRIPPED	Total	$481.00	7202	GAS TURBINE TRIPPED

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
02944	90	LIGHT OIL STRAINER GT	Total	$287.60	7202	LIGHT OIL STRAINER GT
05217	90	4- GAS TURBINE CONTROL ROOM	Total	$116.00	7202	4- GAS TURBINE CONTROL ROOM
07392	90	GAS TURBINE MONITOR STARTUP	Total	$300.20	7202	GAS TURBINE MONITOR STARTUP
09397	90	GAS TURBINE RADIATOR	Total	$842.05	7202	GAS TURBINE RADIATOR
16595	90	GAS TURBINE FAILED TO START	Total	$13,892.57	7202	GAS TURBINE FAILED TO START
16660	90	GAS TURBINE FAILED TO START	Total	$143.80	7202	GAS TURBINE FAILED TO START
16836	90	GAS TURBINE FAILED TO START 04/08/10 04/8/10	Total	$58.00	7202	GAS TURBINE FAILED TO START
17713	90	GAS TURBINE EXHAUST GAS TEMP	Total	$78.00	7202	GAS TURBINE EXHAUST GAS TEMP.
22763	90	GAS TURBINE FUEL METER	Total	$2,606.49	7202	GAS TURBINE FUEL METER
23[illegible]	90	ALARM ON EMERGENCY LIGHTING	Total	$140.00	7202	ALARM ON EMERGENCY LIGHTING
8317	90	GAS TURBINE, AVON SPEED (RPM)	Total	$1,288.83	7202	GAS TURBINE, AVON SPEED (RPM)
8909	90	G.T. STACK DOORS MECH. CHECKS	Total	$319.75	7202	G.T. STACK DOORS MECH. CHECKS
0844	90	SOLENOID VLV ON GT AIR DRYER	Total	$346.50	7202	SOLENOID VLV ON GT AIR DRYER
1829	90	GAS TURBINE	Total	$354.14	7202	GAS TURBINE
1830	90	GAS TURBINE 04/11/04	Total	$234.00	7202	GAS TURBINE
2424	90	GAS TURBINE GEM 80 ALARM	Total	$105.00	7202	GAS TURBINE GEM 80 ALARM
4220	90	PROVIDE A MECHANIC	Total	$70.00	7202	PROVIDE A MECHANIC
33[illegible]	90	4- GAS TURBINE DYKES	Total	$696.00	7202	4- GAS TURBINE DYKES
3441	90	FUEL FLOW METER GAS TURBINE	Total	$78.00	7202	FUEL FLOW METER GAS TURBINE

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
348773	90	TAKE OIL SAMPLE	Total	$66.00	7202	TAKE OIL SAMPLE
349131	90	FUEL OIL FILTERS	Total	$73.98	7202	FUEL OIL FILTERS
350487	90	G.T. STACK DOORS MECH. CHECKS	Total	$269.70	7202	G.T. STACK DOORS MECH. CHECKS
351061	90	GAS TURBINE TRIP	Total	$132.00	7202	GAS TURBINE TRIP
351099	90	REPLACE FUEL SUCTION FILTER	Total	$303.60	7202	REPLACE FUEL SUCTION FILTER
354630	90	GOVERNOR & TRIP	Total	$640.74	7202	GOVERNOR & TRIP
355935	90	G.T. DOOR STEP	Total	$433.80	7202	G.T. DOOR STEP
356654	90	GAS TURBINE - BATTERY ALARM	Total	$403.60	7202	GAS TURBINE - BATTERY ALARM
358628	90	CHANGE OVER HANDLE	Total	$274.49	7202	CHANGE OVER HANDLE
366299	90	G.T. STACK DOORS MECH. CHECKS	Total	$403.60	7202	G.T. STACK DOORS MECH. CHEC
367062	90	3- AIR INTAKE RUST,ETC.	Total	$236.00	7202	3- AIR INTAKE RUST,ETC.
369579	90	GAS TURBINE FO. PUMPS E&W	Total	$205.60	7202	GAS TURBINE FO. PUMPS E&W
369584	90	GAS TURBINE CONTAMINATED SOIL	Total	$113.96	7202	GAS TURBINE CONTAMINATED SOIL
369628	90	GAS TURBINE WEST FO PUMP	Total	$205.60	7202	GAS TURBINE WEST FO PUMP
375955	90	GAS TURBINE FREQ.ALARM	Total	$264.48	7202	GAS TURBINE FREQ.ALARM
375984	90	GAS TURBINE FREQ.ALARM	Total	$2,072.15	7202	GAS TURBINE FREQ.ALARM
381440	90	E FUEL OIL PUMP PLUG LEAK	Total	$1,254.43	7202	E FUEL OIL PUMP PLUG LEAK
382210	90	GAS TURBINE TRIP	Total	$1,440.01	7202	GAS TURBINE TRIP
382682	90	GAS TURBINE OVERSPEED TEST	Total	$210.00	7202	GAS TURBINE OVERSPEED TEST

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
22246	90	4- G.T. STACK DOORS MECH. CHE	Total	$442.50	7202	4- G.T. STACK DOORS MECH. CHE
22353	90	INVESTIGATE G.T.TRIP @0902am	Total	$69.00	7202	INVESTIGATE G.T.TRIP @0902am
25172	90	G.T. LUBE OIL LEVEL TRIP	Total	$248.99	7202	G.T. LUBE OIL LEVEL TRIP
26383	90	GAS TURBINE, AVON SPEED (RPM)	Total	$16,853.05	7202	GAS TURBINE, AVON SPEED (RPM)
30668	90	GAS TURBINE AIR COMPRESSOR	Total	$34.50	7202	GAS TURBINE AIR COMPRESSOR
30689	90	GAS TURBINE SUCTION STRAINER	Total	$138.00	7202	GAS TURBINE SUCTION STRAINER
30691	90	GAS TURBINE SUCTION STRAINER	Total	$167.56	7202	GAS TURBINE SUCTION STRAINER
30845	90	GAS TURBINE GEAR BOX VENT	Total	$138.00	7202	GAS TURBINE GEAR BOX VENT
35380	90	GAS TURBINE (POWER TURBINE)	Total	$3,485.25	7202	GAS TURBINE (POWER TURBINE)
37621	90	GAS TURBINE OUTAGE WORK 2007	Total	$72,085.32	7202	GAS TURBINE OUTAGE WORK 2007
43823	90	GAS TURBINE SPEED PROBES	Total	$467.96	7202	GAS TURBINE SPEED PROBES
44533	90	GAS TURBINE BATTERY CHARGER	Total	$98.04	7202	GAS TURBINE BATTERY CHARGER
49961	90	G.T. STACK DOORS MECH. CHECKS	Total	$345.00	7202	G.T. STACK DOORS MECH. CHECKS
52477	90	REMOVE COVER FROM GAS TURBINE	Total	$562.64	7202	REMOVE COVER FROM GAS TURBINE
52826	90	GAS TURBINE DCS**TEST RUN**	Total	$163.65	7202	GAS TURBINE DCS**TEST RUN**
53467	90	G.T. STACK DOORS MECH. CHECKS	Total	$684.69	7202	G.T. STACK DOORS MECH. CHECKS
55748	90	GAS TURBINE FUEL OIL TOTALIZER	Total	$280.52	7202	GAS TURBINE FUEL OIL TOTALIZER
51277	90	GAS TURBINE SPEED PROBES	Total	$452.78	7202	GAS TURBINE SPEED PROBES
53655	90	GAS TURBINE AIR COMPRESSOR	Total	$1,248.65	7202	GAS TURBINE AIR COMPRESSOR

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
454332	90	4- GT BATTERY ROOM DOOR KNOB	Total	$69.00	7202	4- GT BATTERY ROOM DOOR KNOB
454334	90	3-COMPLETE GENERAL CLEAN UP	Total	$59.00	7202	3-COMPLETE GENERAL CLEAN UP
455551	90	TEMP. ALARM ON CHANNEL #3	Total	$0.00	7202	TEMP. ALARM ON CHANNEL #3
465498	90	Gas Turbine	Total	$1,150.59	7202	Gas Turbine
465645	90	IRD VIBRATION MONITOR	Total	$128.37	7202	IRD VIBRATION MONITOR
468466	90	GAS TURBINE DISCH.W.FILTER	Total	$358.54	7202	GAS TURBINE DISCH.W.FILTER
470503	90	G.T. STACK DOORS MECH. CHECKS	Total	$283.07	7202	G.T. STACK DOORS MECH. CHECKS
476771	90	"TEMP MONITOR ALARM"	Total	$40.50	7202	"TEMP MONITOR ALARM"
480166	90	GT HOT SECTION INSPECTION.	Total	$7,253.94	7202	GT HOT SECTION INSPECTION.
480636	90	GT EAST FUEL MOTOR PUMP ANNUAL	Total	$86.25	7202	GT EAST FUEL MOTOR PUMP A
480640	90	GT WEST FUEL OIL PUMP ANNUAL	Total	$86.25	7202	GT WEST FUEL OIL PUMP ANNUA
484531	90	GAS TURBINE BATTERY CHARGER	Total	$103.50	7202	GAS TURBINE BATTERY CHARGER
491849	90	TEMP. MONITOR PANEL	Total	$1,130.00	7202	TEMP. MONITOR PANEL
492475	90	G.T. AIR COMPRESSOR	Total	$2,151.91	7202	G.T. AIR COMPRESSOR
496401	90	GAS TURBINE COMPRESSOR	Total	$1,011.00	7202	GAS TURBINE COMPRESSOR
502614	90	3- GAS TURBINE LIGHTING	Total	$118.00	7202	3- GAS TURBINE LIGHTING
503285	90	GAS TURBINE OIL SAMPLE	Total	$69.00	7202	GAS TURBINE OIL SAMPLE
503328	90	GAS TURBINE FUEL OIL FLOW	Total	$1,454.00	7202	GAS TURBINE FUEL OIL FLOW
504753	90	GAS TURBINE DYKE SYPHON	Total	$183.65	7202	GAS TURBINE DYKE SYPHON

Cost Report By Work Order/Asset

VO#	WO St	Work Order Description			Asset Number	Description of Asset
6963	90	GT FO COALESCERE (FILTER) LEAK	Total	$473.55	7202	GT FO COALESCERE (FILTER) LEAK
6988	44	GT COMBUSTION CAN-INSPECTION	Total	$164,853.92	7202	GT COMBUSTION CAN-INSPECTION
2132	90	GT #4 BRG HIGH VIBRATION	Total	$234.90	7202	GT #4 BRG HIGH VIBRATION
7622	90	GAS TURBINE GEAR BOX LUBE OIL	Total	$1,053.84	7202	GAS TURBINE GEAR BOX LUBE OIL
9366	90	GT COMBUSTION CAN - welder	Total	$6,876.25	7202	GT COMBUSTION CAN - welder
9570	90	GT COMBUSTION CAN,	Total	$6,029.45	7202	GT COMBUSTION CAN,
3703	90	REPLACE FUEL OIL METER	Total	$65.66	7202	REPLACE FUEL OIL METER
3817	90	GT COMBUSTION CAN-INSPECTION	Total	$184.00	7202	GT COMBUSTION CAN-INSPECTION
3931	90	GT COMBUSTION CAN-INSPECTION	Total	$1,100.28	7202	GT COMBUSTION CAN-INSPECTION
51[illegible]	90	GAS TURBINE AVON TRANSIT STAND	Total	$1,243.00	7202	GAS TURBINE AVON TRANSIT STANE
7140	90	G.T. STACK DOORS MECH. CHECKS	Total	$784.00	7202	G.T. STACK DOORS MECH. CHECKS
9038	90	GAS TURBINE-REPLACE PLC-labour	Total	$1,222.80	7202	GAS TURBINE-REPLACE PLC-labour
9762	90	GT INTAKE AIR FITLERS LADDER	Total	$772.15	7202	GT INTAKE AIR FITLERS LADDER
3042	90	GAS TURBINE FUEL OIL STRAINERS	Total	$181.76	7202	GAS TURBINE FUEL OIL STRAINERS
3435	80	SWOP#2009006173 GAS TURBINE	Total	$761.54	7202	SWOP#2009006173 GAS TURBINE
5594	90	GT ENGINE ROOM AND TOP OF PT	Total	$310.98	7202	GT ENGINE ROOM AND TOP OF PT
328	90	GAS TURBINE ROOM - HIGH TEMP	Total	$2,055.46	7202	GAS TURBINE ROOM - HIGH TEMP
714	90	DISCONNECT ENERGEN FIRE SYSTEM	Total	$278.25	7202	DISCONNECT ENERGEN FIRE SYSTE
168	90	HOLYROOD GAS TURBINE	Total	$1,666.50	7202	HOLYROOD GAS TURBINE

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
601965	90	GT BLEED VALVE DUCTING	Total	$490.58	7202	GT BLEED VALVE DUCTING
604950	90	GAS TURBINE 2 WEEKLY RUN UP	Total	$124.00	7202	GAS TURBINE 2 WEEKLY RUN UP
608345	90	G.T. STACK DOORS MECH. CHECKS	Total	$292.00	7202	G.T. STACK DOORS MECH. CHECKS
608707	90	GAS TURBINE GEAR BOX	Total	$1,245.35	7202	GAS TURBINE GEAR BOX
609033	90	GAS TURBINE DUPLEX FILTER	Total	$10.64	7202	GAS TURBINE DUPLEX FILTER
613422	90	4-G.T.STACK DOORS MECH.CHECKS	Total	$387.92	7202	4-G.T.STACK DOORS MECH.CHECKS
623656	90	G.T. STACK DOORS MECH. CHECKS	Total	$146.00	7202	G.T. STACK DOORS MECH. CHECKS
627899	90	GAS TURBINE INSTALL SWITCH	Total	$1,292.80	7202	GAS TURBINE INSTALL SWITCH
628839	90	GT CLEAN UP	Total	$186.00	7202	GT CLEAN UP
629034	90	Gas turbine plc	Total	$12,684.69	7202	Gas turbine plc
630741	90	4- GAS TURBINE INSTALL SWITCH	Total	$482.60	7202	4- GAS TURBINE INSTALL SWITCH
630743	90	GAS TURBINE INSTALL SWITCH	Total	$301.56	7202	GAS TURBINE INSTALL SWITCH
630812	90	VIBRATION MONITOR	Total	$392.53	7202	VIBRATION MONITOR
632798	90	GAS TURBINE OVERSPEED TEST	Total	$182.50	7202	GAS TURBINE OVERSPEED TEST
632801	90	GT HOT SECTION INSPECTION.	Total	$8,675.27	7202	GT HOT SECTION INSPECTION.
632805	90	G.T.ELECTRONIC OVERSPEED TEST	Total	$299.28	7202	G.T.ELECTRONIC OVERSPEED TEST
648125	90	GAS TURBINE N2 STORAGE	Total	$1,713.04	7202	GAS TURBINE N2 STORAGE
648129	90	3-REPLACE BULBS IN EXIT SIGNS	Total	$62.00	7202	3-REPLACE BULBS IN EXIT SIGNS
648978	90	BLACK START TEST	Total	$408.32	7202	BLACK START TEST

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
5299	90	G.T. STACK DOORS MECH. CHECKS	Total	$140.00	7202	G.T. STACK DOORS MECH. CHECKS
6557	90	CHECK GT ENG.ROOM FAN/LOUVERS	Total	$336.00	7202	CHECK GT ENG.ROOM FAN/LOUVERS
7383	90	CHECK GT ENG.ROOM FAN/LOUVERS	Total	$504.00	7202	CHECK GT ENG.ROOM FAN/LOUVERS
0943	80	GAS TURBINE EMERGENCY LIGHTING	Total	$1,095.67	7202	GAS TURBINE EMERGENCY LIGHTIN
1975	44	GAS TURBINE FUEL OIL CONTROL	Total	$18,060.02	7202	GAS TURBINE FUEL OIL CONTROL
5165	80	4 GT INTAKE AIR FITLERS LADDER	Total	$758.31	7202	4 GT INTAKE AIR FITLERS LADDER
5231	80	GAS TURBINE AVON TRANSIT STAND	Total	$144.44	7202	GAS TURBINE AVON TRANSIT STAND
5674	80	GAS TURBINE VIBRATION EQUIP.	Total	$26.03	7202	GAS TURBINE VIBRATION EQUIP.
3508	80	LATCH BROKEN ON EAST DOOR	Total	$381.60	7202	LATCH BROKEN ON EAST DOOR
3049	80	BATTERY ROOM LIGHTING-SWOP-	Total	$727.04	7202	BATTERY ROOM LIGHTING-SWOP-
5300	80	GAS TURBINE E. FO MOTOR PM	Total	$181.76	7202	GAS TURBINE E. FO MOTOR PM
5305	80	GAS TURBINE W. FO MOTOR PM	Total	$181.76	7202	GAS TURBINE W. FO MOTOR PM
5308	80	GAS TURBINE BATTERY CHARGER	Total	$253.55	7202	GAS TURBINE BATTERY CHARGER
5309	80	G/TURBINE EXHAUST THERMOCOUPLE	Total	$798.88	7202	G/TURBINE EXHAUST THERMOCOUP
5924	80	GAS TURBINE BUILDING	Total	$144.44	7202	GAS TURBINE BUILDING
5015	80	G.T. EAST ACCESS DOOR-SWOP-	Total	$1,274.24	7202	G.T. EAST ACCESS DOOR-SWOP-
2362	80	GAS TURBINE GEAR BOX OIL LEAK	Total	$89,095.57	7202	GAS TURBINE GEAR BOX OIL LEAK
5433	80	GAS TURBINE GEAR BOX OIL LEAK	Total	$6,195.32	7202	GAS TURBINE GEAR BOX OIL LEAK
243	46	GAS TURBINE WEST END	Total	$288.88	7202	GAS TURBINE WEST END

Cost Report By Work Order/Asset

WO#	WO St	Work Order Description			Asset Number	Description of Asset
654524	90	GAS TURBINE GEAR BOX	Total	$678.01	7202	GAS TURBINE GEAR BOX
654532	90	4 - GAS TURBINE GEAR BOX	Total	$434.00	7202	4 - GAS TURBINE GEAR BOX
658749	90	GAS TURBINE INTAKE PLENUM	Total	$292.00	7202	GAS TURBINE INTAKE PLENUM
658753	90	GAS TURBINE INTAKE PLENUM	Total	$1,835.00	7202	GAS TURBINE INTAKE PLENUM
658918	90	GAS TURBINE DUPLEX STRAINER	Total	$3,304.19	7202	GAS TURBINE DUPLEX STRAINER
670836	90	GT WATERWASH/REPORT	Total	$655.98	7202	GT WATERWASH/REPORT
671129	90	GT WATERWASH/REPORT	Total	$1,213.04	7202	GT WATERWASH/REPORT
671132	90	GAS TURBINE REPAIR	Total	$437.21	7202	GAS TURBINE REPAIR
671211	90	GAS TURBINE REPAIR	Total	$300.00	7202	GAS TURBINE REPAIR
671466	90	GAS TURBINE 2 WEEKLY RUN UP	Total	$125.28	7202	GAS TURBINE 2 WEEKLY RUN UP
673641	90	REPLACE FUEL OIL METER	Total	$2,318.56	7202	REPLACE FUEL OIL METER
680816	90	GAS TURBINE-RADIATOR OIL LEAK	Total	$3,850.21	7202	GAS TURBINE-RADIATOR OIL LEAK
683849	90	OIL COOLER DYKE - GAS TURBINE	Total	$248.00	7202	OIL COOLER DYKE - GAS TURBINE
690280	90	G.T.DUPLEX STRN.INLET VLV	Total	$365.90	7202	G.T.DUPLEX STRN.INLET VLV
693347	90	ORDER A MAIL SLOT/BIN	Total	$146.00	7202	ORDER A MAIL SLOT/BIN
693544	90	GAS TURBINE E. FO MOTOR PM	Total	$109.50	7202	GAS TURBINE E. FO MOTOR PM
693550	90	GAS TURBINE W. FO MOTOR PM	Total	$109.50	7202	GAS TURBINE W. FO MOTOR PM
694640	90	GAS TURBINE TRIP	Total	$3,014.55	7202	GAS TURBINE TRIP
716564	90	GT FO COALESCERE (FILTER) LEAK	Total	$769.56	7202	GT FO COALESCERE (FILTER) LEAK

APPENDIX 4
BUDGETARY INFORMATION - SOLAR TURBINES

Solar Turbines
A Caterpillar Company

TAURUS 60
Mobile Power Unit

Mobile Power - When and Where You Need It

The *Taurus*™ 60 Mobile Power Unit is the prime choice if you're looking to produce reliable, low-cost, on-site peaking power. Designed as an on-site generator system to optimize service for seasonal or cyclical loads, the *Taurus* 60 Mobile Generator System includes these key features:

Easy to Install and Relocate
- Highway Transportable
- Modular Design for Quick Set-Up and Connection
- No Concrete Foundation Required
- Compact Footprint to Minimize Space Requirements
- Ideal for Rental Fleets and Utility Equipment Pools

Environmentally Friendly
- Low Emissions State-of-the-Art *SoLoNOx*™ Dry Low NOx Combustion System
- No Visible Emissions
- Sound Attenuation Package for Quiet Operation
- Low Profile Design to Minimize Installed Height
- Easy to Permit

Flexible Solution
- Leasing and Rental Options Available
- 5-MW Size for Highly Flexible Capacity Addition and Operation
- Fuel Flexibility, Gas or Diesel with Dual Fuel Option

Complete Systems Solution
- Set-Up and Commissioning
- Site Preparation (If Needed)
- Ancillary Support Systems (If Needed)
- Wide Range of Product Support Programs

Operational Features
- Dispatchable to be On Line in Six Minutes (from cold start)
- Range of Control System Options for Remote Operation and SCADA Integration
- Utility Grade Switchgear and Protective Relay Module
- KVAR Control for Excellent Reactive Power Capability

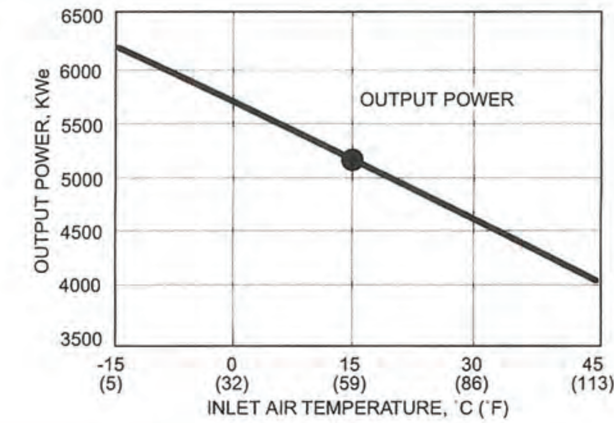
Solar Turbines
A Caterpillar Company

TAURUS 60
Mobile Power Unit

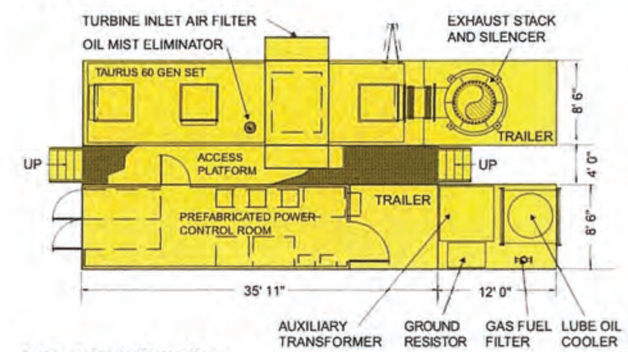
Nominal Generator Set Performance

At the core of the Mobile Power Unit is the 5.2 MW *Taurus* 60 industrial gas turbine, with a population of more than 900 units in the field. The Mobile Power Unit combines the features and benefits of the proven *Taurus* 60 industrial gas turbine with a mobile system that is easy to relocate and connect.

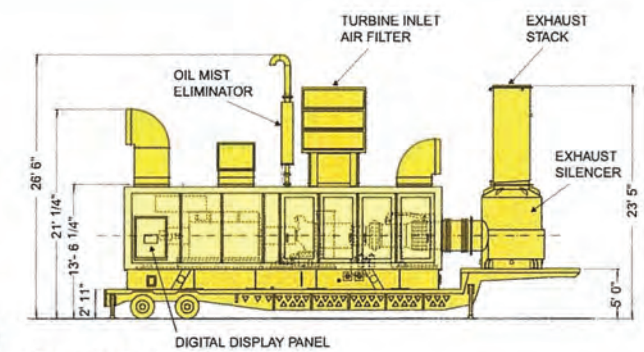
Output Power, kWe ISO: 15°C (59°F), sea level	5,200
Heat Rate, (Btu/kWe-hr)	11,263



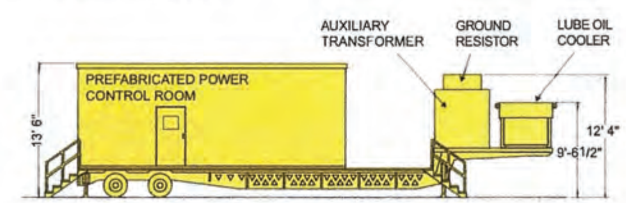
Typical Dimensions



Installation Plan View



Generator Set Module



Power Control Module

Sited Configuration of Taurus 60 Mobile Power Unit

Mobile Power - When and Where You Need It

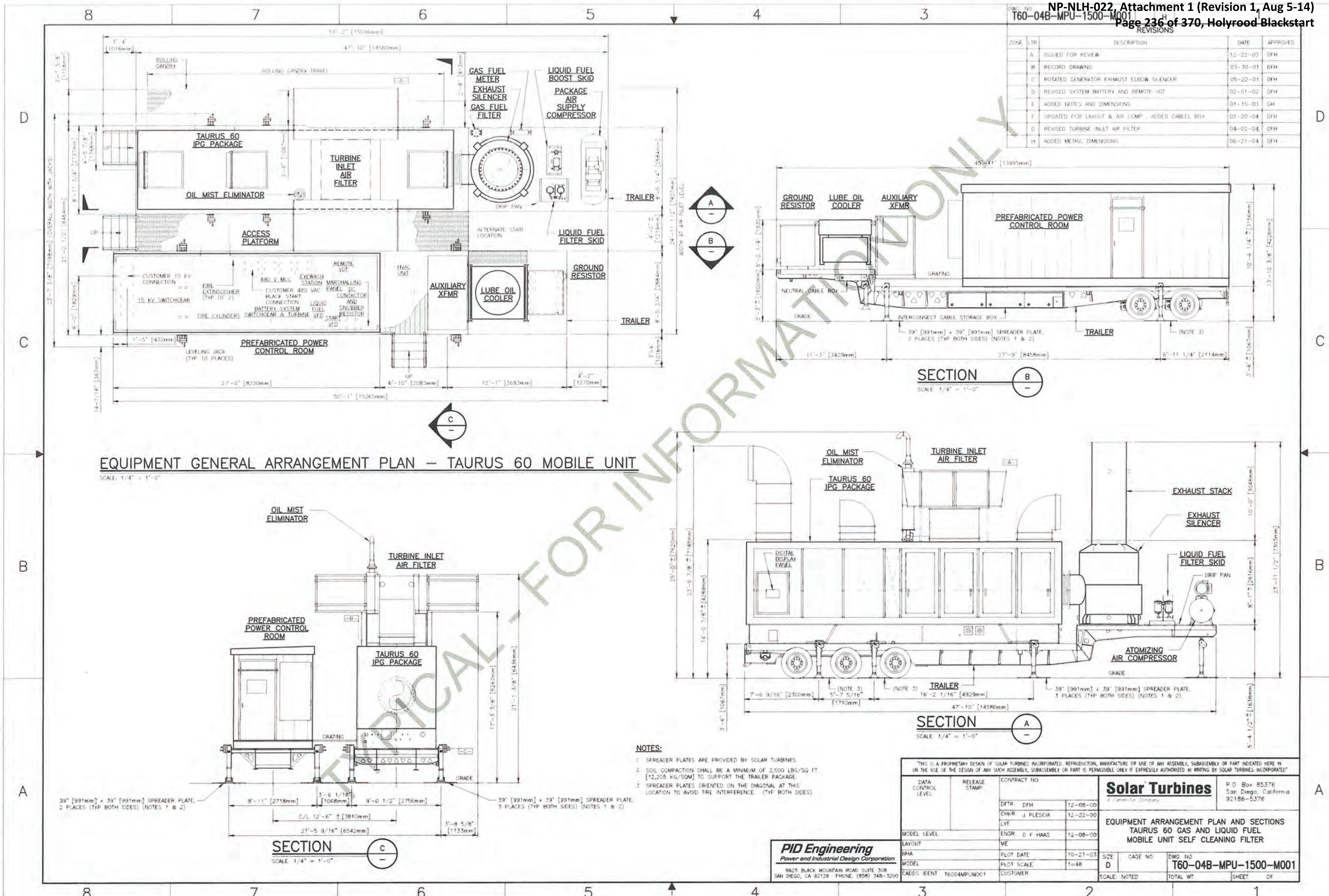
For information on price, delivery and how the *Taurus* 60 Mobile Power Unit can meet your needs for short-term capacity and reduce your exposure to market spikes, e-mail: powergen@solarturbines.com or call (619) 544-5352.

Solar Turbines Incorporated
P.O. Box 85376
San Diego, CA 92186-5376 U.S.A.

FOR MORE INFORMATION

Telephone: (+1) 619-544-5352
Telefax: (+1) 619-544-2444
Internet: www.solarturbines.com

ISO 9001
DNV
CERTIFICATED FIRM


DWG NO T60-04B-MPU-1500-M001
REVISIONS
ZONE LTR DESCRIPTION DATE APPROVED
A ISSUED FOR REVIEW 12-22-00 DFH
B RECORD DRAWING 03-30-01 DFH
C ROTATED GENERATOR EXHAUST ELBOW SILENCER 05-22-01 DFH
D REVISED SYSTEM BATTERY AND REMOTE VDT 02-01-02 DFH
E ADDED NOTES AND DIMENSIONS 01-15-03 GH
F UPDATED PCR LAYOUT & AIR COMP., ADDED CABLE BOX 02-20-04 DFH
G REVISED TURBINE INLET AIR FILTER 04-02-04 DFH
H ADDED METRIC DIMENSIONS 06-21-04 DFH
TAURUS 60 IPG PACKAGE
TURBINE INLET AIR FILTER
GAS FUEL METER
EXHAUST SILENCER
GAS FUEL FILTER
LIQUID FUEL BOOST SKID
PACKAGE AIR SUPPLY COMPRESSOR
OIL MIST ELIMINATOR
TRAILER
ACCESS PLATFORM
LIQUID FUEL FILTER SKID
GROUND RESISTOR
AUXILIARY XFMR
LUBE OIL COOLER
PREFABRICATED POWER CONTROL ROOM
15 KV SWITCHGEAR
EQUIPMENT GENERAL ARRANGEMENT PLAN – TAURUS 60 MOBILE UNIT
SCALE: 1/4" = 1'-0"
SECTION B
SCALE: 1/4" = 1'-0"
EXHAUST STACK
ATOMIZING AIR COMPRESSOR
SECTION A
SCALE: 1/4" = 1'-0"
SECTION C
SCALE: 1/4" = 1'-0"
TYPICAL – FOR INFORMATION ONLY
NOTES:
1. SPREADER PLATES ARE PROVIDED BY SOLAR TURBINES.
2. SOIL COMPACTION SHALL BE A MINIMUM OF 2,500 LBS/SQ FT [12,205 KG/SQM] TO SUPPORT THE TRAILER PACKAGE.
3. SPREADER PLATES ORIENTED ON THE DIAGONAL AT THIS LOCATION TO AVOID TIRE INTERFERENCE. (TYP BOTH SIDES)
PID Engineering
Power and Industrial Design Corporation
9625 BLACK MOUNTAIN ROAD SUITE 308 SAN DIEGO, CA 92126 PHONE: (858) 348-3200
Solar Turbines
A Caterpillar Company
P.O. Box 85376 San Diego, California 92186-5376
DFTR. DFH 12-08-00
CHKR. J PLESCIA 12-22-00
ENGR. D F HAAS 12-08-00
PLOT DATE 10-21-03
PLOT SCALE 1=48
EQUIPMENT ARRANGEMENT PLAN AND SECTIONS
TAURUS 60 GAS AND LIQUID FUEL
MOBILE UNIT SELF CLEANING FILTER
SIZE D
DWG NO T60-04B-MPU-1500-M001
SCALE: NOTED

Solar Turbines
A Caterpillar Company

TITAN 130 Mobile Power Unit

Mobile Power - When and Where You Need It

The *Titan*™ 130 Mobile Power Unit is the prime choice if you're looking to produce reliable, low-cost, onsite continuous duty or peaking power. Designed as a complete power system, the *Titan* 130 Mobile Power Unit includes these key features:

Easy to Install and Relocate

- Highway Transportable
- Modular Design for Quick Set-Up and Connection (Plug and Play)
- Dispatchable to be On-Line in Six Minutes (from Cold Start)
- No Concrete Foundation Required
- Compact Footprint to Minimize Space Requirements
- Ideal for Rental Fleets and Utility Equipment Pools
- North American Electrical Certification

Environmentally Friendly

- Low Emissions State-of-the-Art *SoLoNO$_X$*™ Dry Low NO_X Combustion System
- Sound Attenuation Package for Quiet Operation
- Low Profile Design to Minimize Installed Height
- Easy to Permit

Flexible Solution

- Purchase, Leasing and Rental Options Available
- 14.3 MW Size for Highly Flexible Capacity Addition and Operation
- Dual Fuel Capability (Natural Gas or Diesel)
- Rotational Turbine Exhaust Elbow for Cogen Applications

Complete Systems Solution

- Complete Power Control Room
- Set-Up and Commissioning
- Site Preparation (Sold as an Option)
- Wide Range of Product Support Options

Operational Features

- Utility Grade Switchgear and Protective Relay Module
- Low Voltage Motor Control Center
- Low Voltage Step-Down Transformer
- Range of Control System Options for Remote Operation and SCADA Integration
- KVAR Control for Excellent Reactive Power Capability

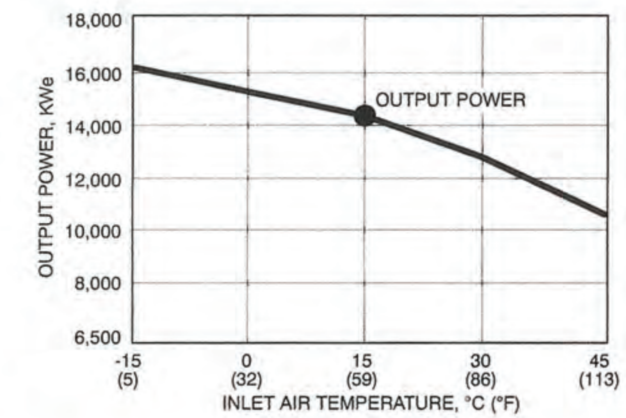
Solar Turbines
A Caterpillar Company

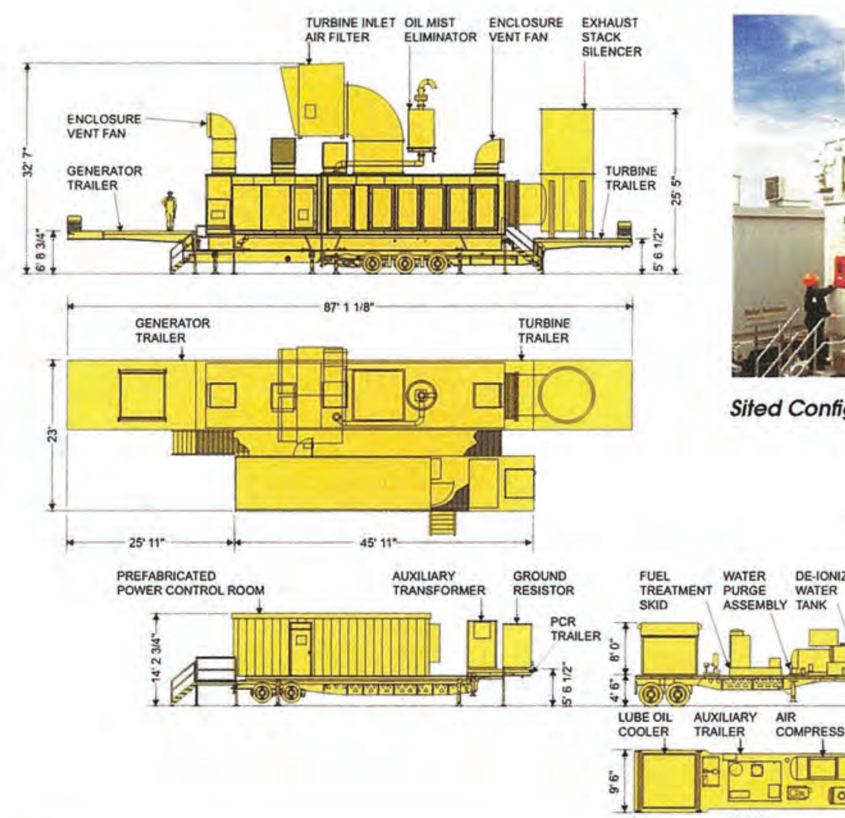
TITAN 130 Mobile Power Unit

Nominal Generator Set Performance

At the core of the Mobile Power Unit is the 14.3 MW *Titan* 130 industrial gas turbine, with a population of more than 106 units in the field. The Mobile Power Unit combines the features and benefits of the proven *Titan* 130 industrial gas turbine with a mobile system that is easy to relocate and connect.

Output Power, kWe ISO: 15°C (59°F), sea level	14,250
Heat Rate, Btu/kWe-hr	9,749





Sited Configuration of Mobile Power Unit

Solar Turbines Incorporated
P.O. Box 85376 MZ SP3-Q
San Diego, CA 92186-5376 U.S.A.

FOR MORE INFORMATION

Telephone: (+1) 619-544-5352
Telefax: (+1) 858-694-6715
E-mail: powergen@solarturbines.com
Internet: www.solarturbines.com

T-130 MPU Basic Set Up

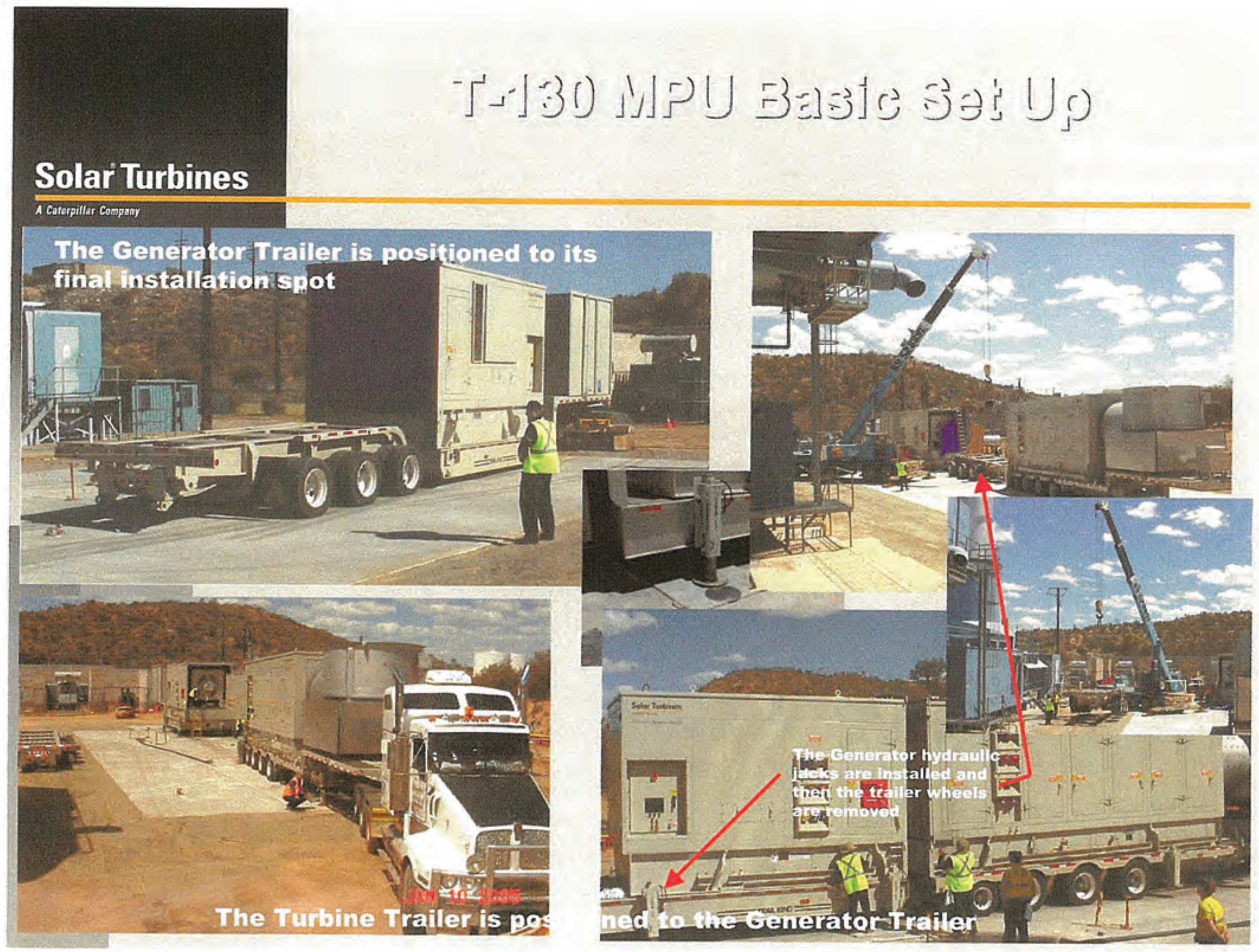
Solar Turbines
A Caterpillar Company

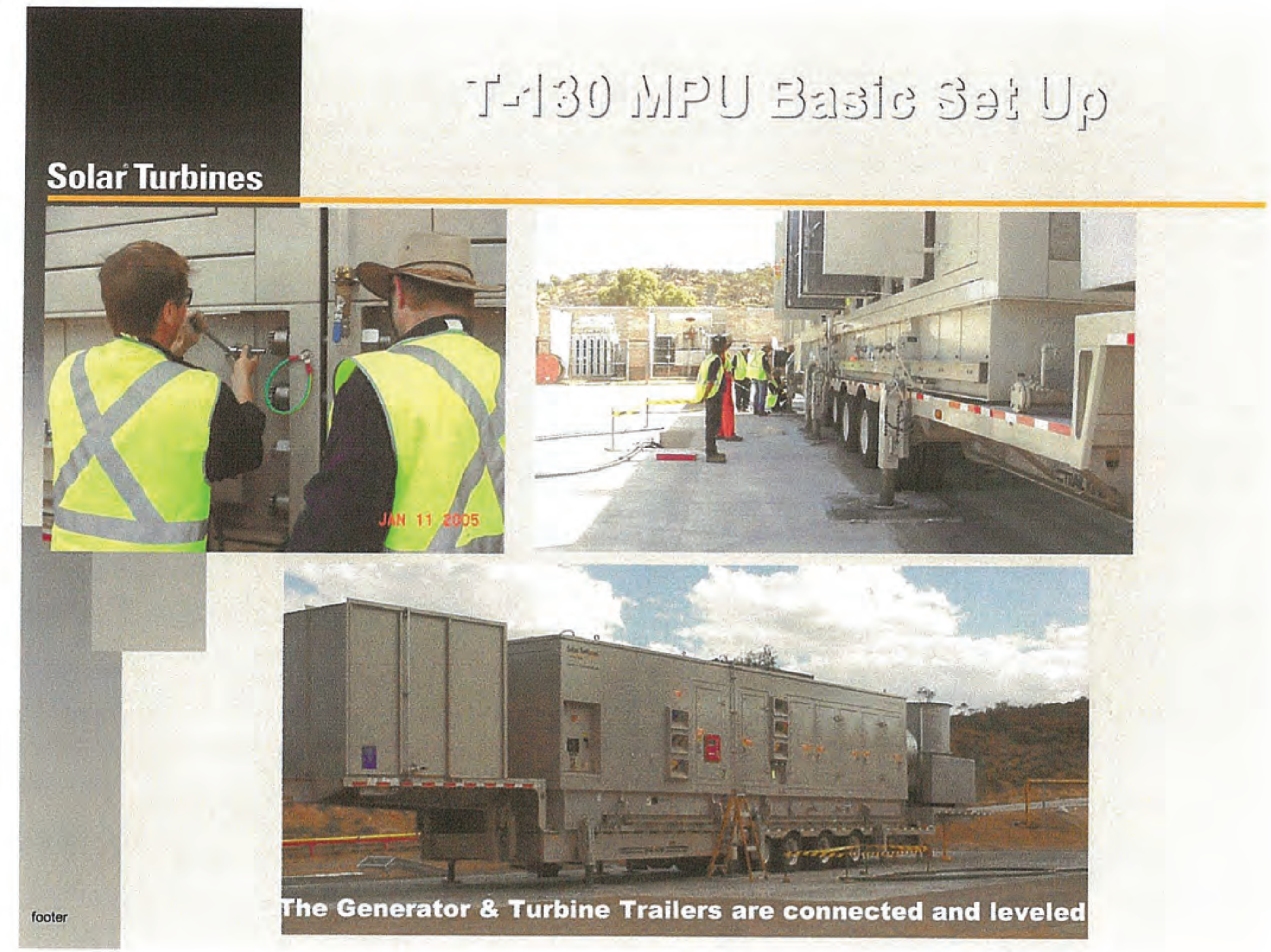
footer

T-130 MPU Basic Set Up

Solar Turbines
A Caterpillar Company

footer


T-130 MPU Basic Set Up
Solar Turbines
A Caterpillar Company
The Generator Trailer is positioned to its final installation spot
The Generator hydraulic jacks are installed and then the trailer wheels are removed
The Turbine Trailer is pos ned to the Generator Trailer

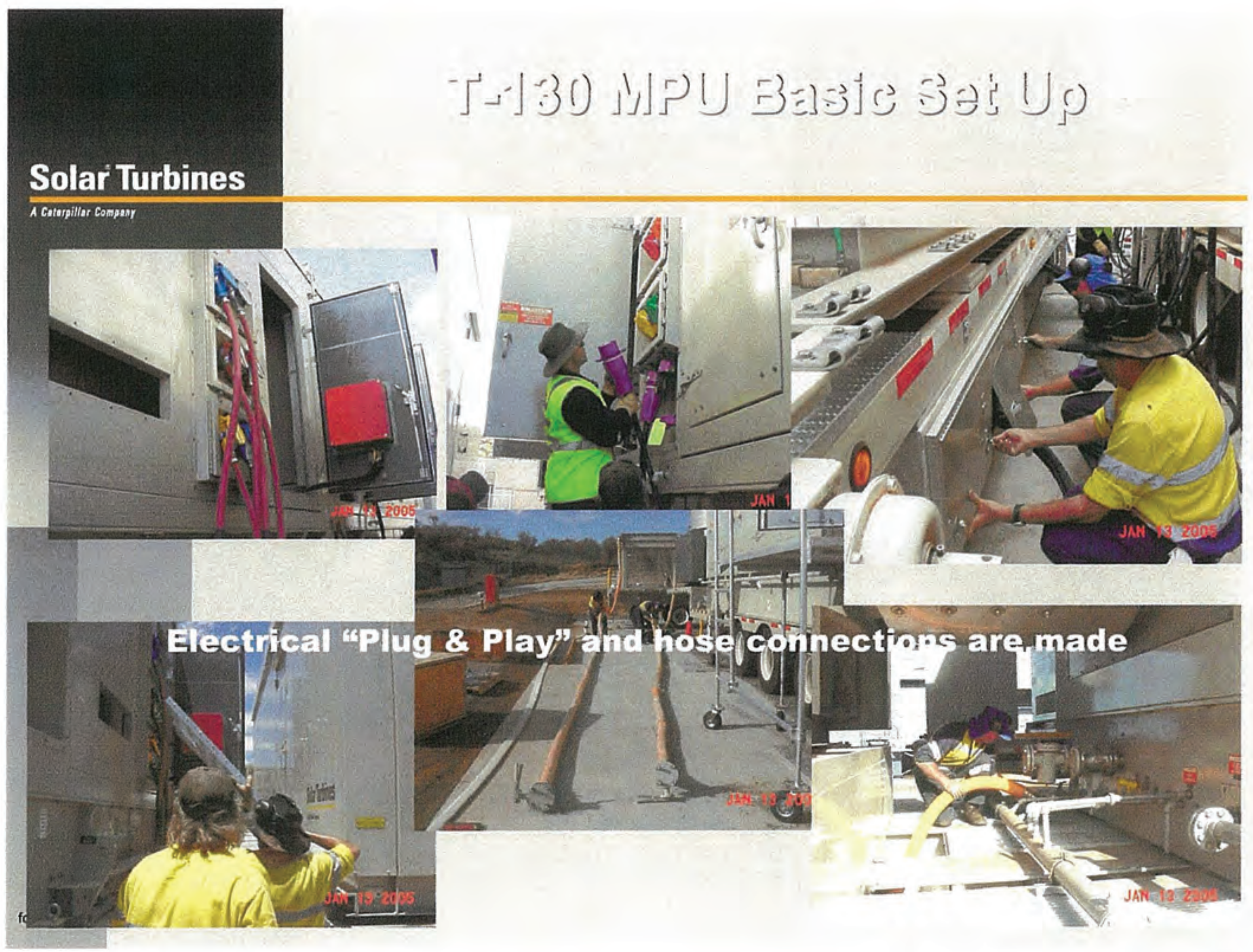

T-130 MPU Basic Set Up
Solar Turbines
JAN 11 2005
footer
The Generator & Turbine Trailers are connected and leveled


Solar Turbines
A Caterpillar Company
The Generator Trailer is positioned to its final installation spot
Gratings & Stairs are removed from the Storage Box on the Generator Trailer
Approximately 46' plus the Tractor
PowerWater
JAN 12 2005
footer

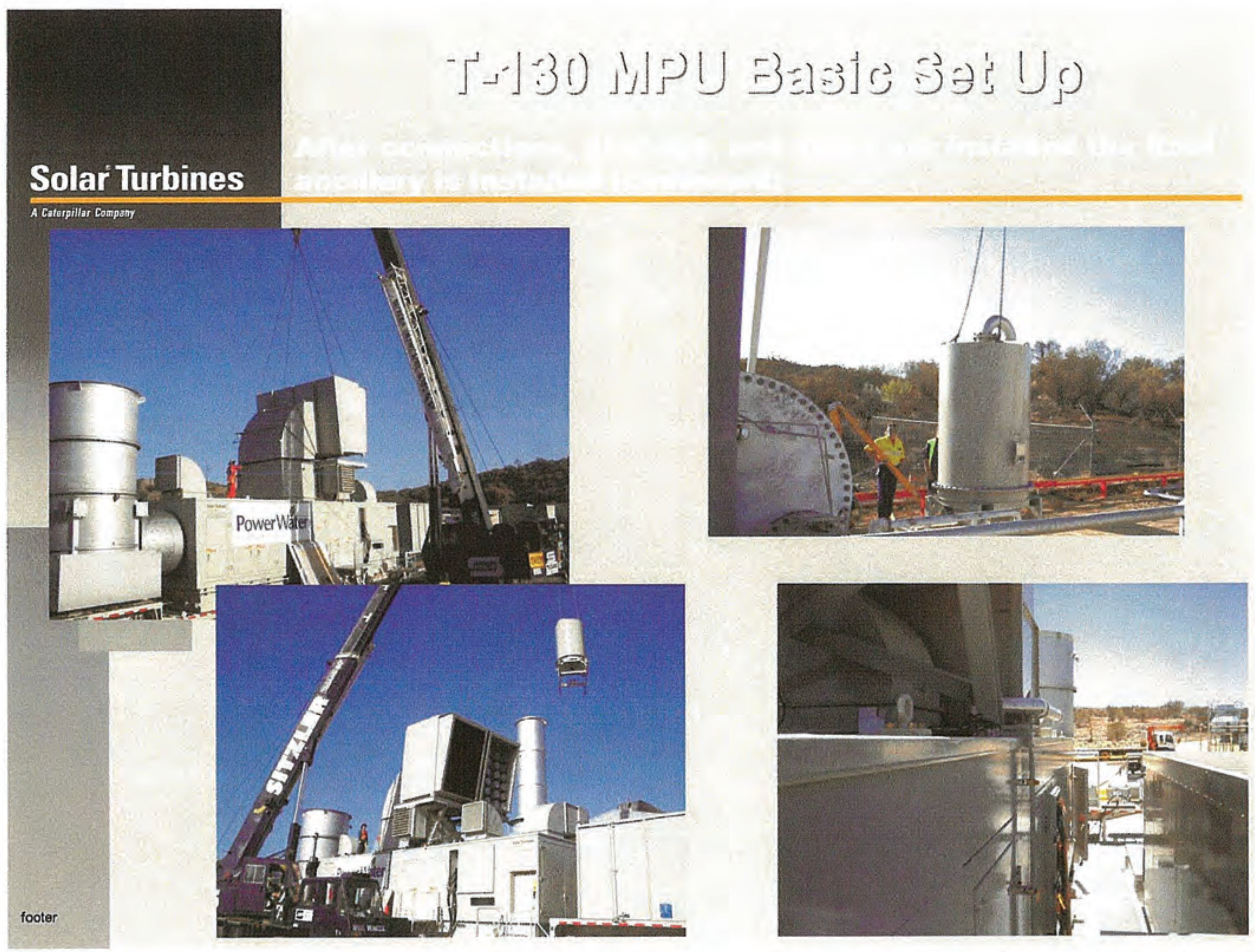

Solar Turbines
A Caterpillar Company
T-130 MPU Basic Set Up
Parallel the PCR Trailer to the required parallel dimensions to the T/G Trailers
footer

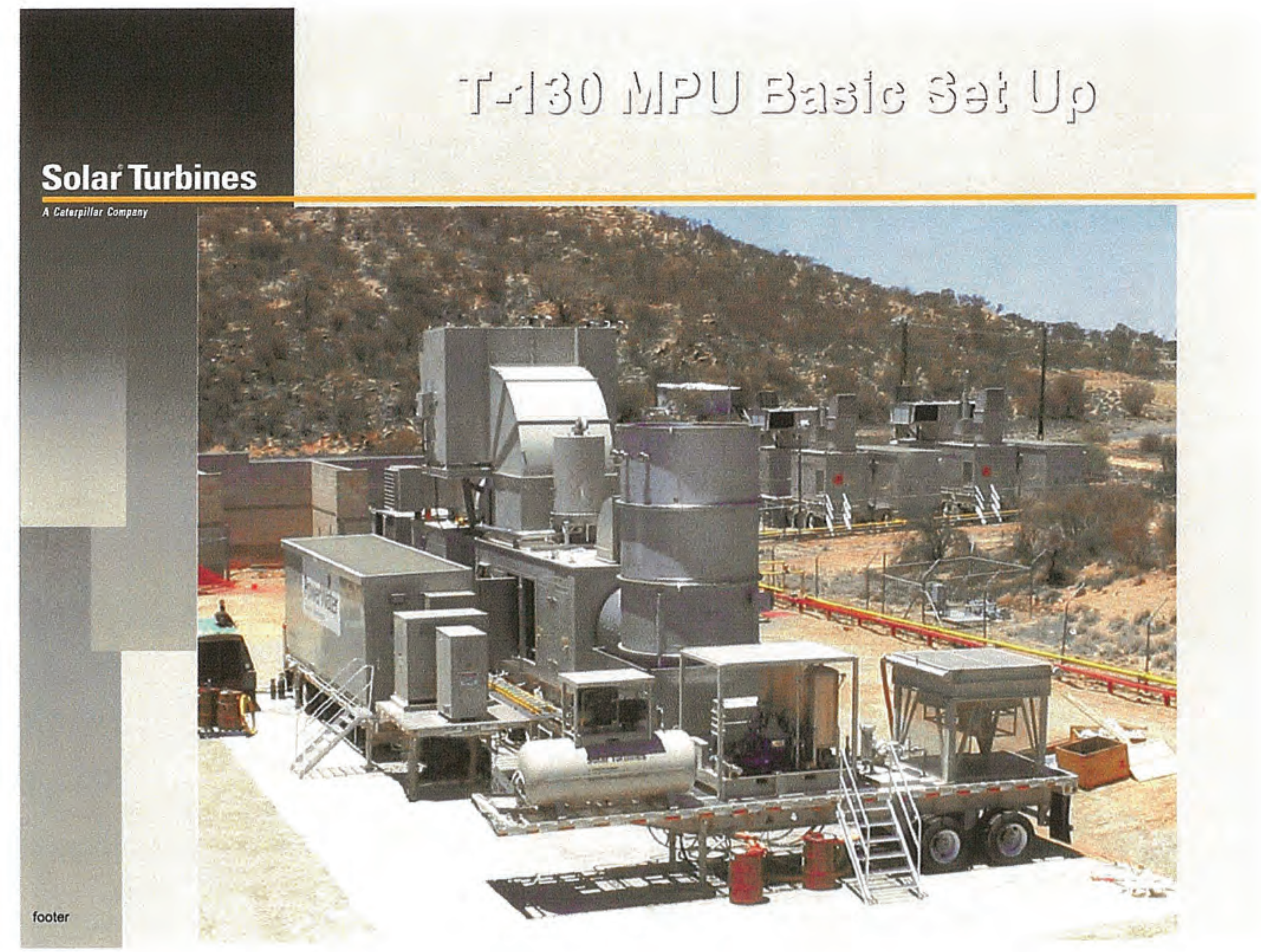

T-130 MPU Basic Set Up
Solar Turbines
A Caterpillar Company
The Auxiliary Trailer is brought to the Site
Approximately 35' plus the Tractor


T-130 MPU Basic Set Up
Solar Turbines
A Caterpillar Company
footer


T-130 MPU Basic Set Up
Solar Turbines
A Caterpillar Company
Electrical "Plug & Play" and hose connections are made
JAN 13 2006

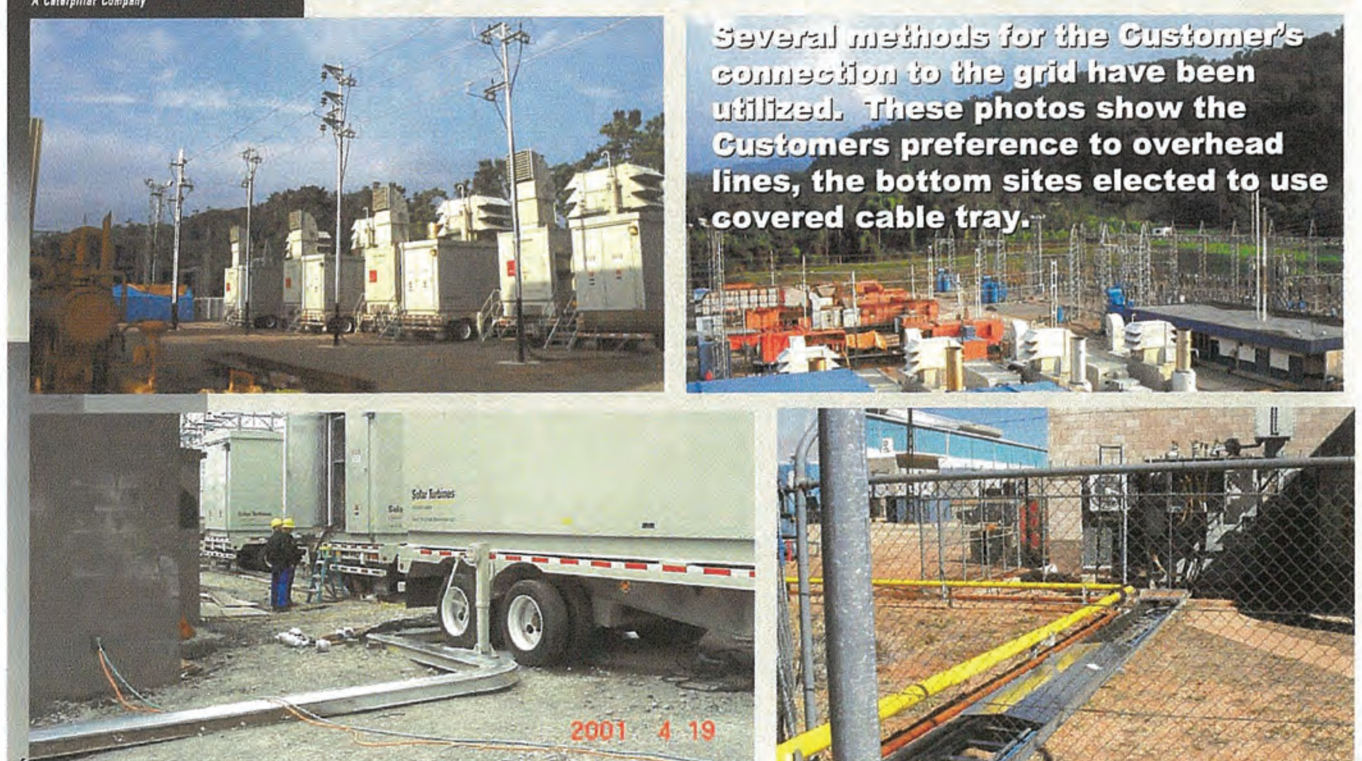

T-130 MPU Basic Set Up
Solar Turbines
A Caterpillar Company
PowerWater


T-130 MPU Basic Set Up
Solar Turbines
A Caterpillar Company
PowerWater
footer


T-130 MPU Basic Set Up
Solar Turbines
A Caterpillar Company
footer

Solar Turbines
A Caterpillar Company

T-130 MPU Basic Set Up



Solar Turbines Incorporated
Budgetary Quotation for Newfoundland Lab Hydro
Inquiry # TBD prepared on November 3, 2010
For more information contact:
Duane Wilson @ Solar Turbines, 630-842-8720, dewilson@solarturbines.com
(Prices shown below quoted in US Dollars $)
This quote is provided for budgetary purposes only and does not represent a firm quote.

Gas Turbine Equipment	
(1) Liquid Fuel TAURUS 60-7901S Mobile Power Unit Turbine Generator Set.................	$4,535,000
Commissioning Parts, Startup, and Site Testing..	$70,000
Electrical Equipment	
Power Control Room Included in MPU Package	
Mechanical Equipment	
Liquid Fuel Centrifuge...	included in MPU
Instrument Air Compressor and Liquid Fuel Centrifuge Included with MPU	
Miscellaneous	
Construction Estimate = $53,800 (construction is by others)	not included
Project Management & Engineering (Loose Ship Equipment Only)................	$0
Shipping..	$92,100
Development Costs...	$0
Special or Avoided Capital Items..	$0
6% Balance of Plant Contingency..	$5,500
Total for BOP Equipment (installation not included).................................	$97,600
Grand Total for Turbomachinery and Balance of Plant........................	**$4,702,600**
Estimation of cost per ISO rating kilowatt for selected equipment..................	$853

*Duties and taxes not included in estimate. Caterpillar Confidential: Green CEP Ver. 5.4

TAURUS 60-7901S Mobile Power Unit Generator Set Package Features

Engine:
Single shaft turbine, designed for industrial use
Axial compressor design
Annular type combustor
For start-up.

Basic Options:
Fully enclosed, generator set package requiring 460V, 3-phase, 60 Hz AC power
Rated Class I, Div II, Groups C,D per NEC
120V, 1-phase, 50/60 Hz internal lighting and heater power
Gas turbine engine in upward oriented air inlet, and axially oriented exhaust outlet
1800 rpm; 60 Hz Gearbox
Continuous Duty, Open Drip Proof generator rated for 13,800 VAC with Class F insulation, B rise

Included Package Features:
Direct AC start motor system
Duplex lube oil filter system
Allen-Bradley based Turbotronics IV control system including:
- Ethernet network interface
- Touch Screen display with Engine Performance map
- Software for heat recovery interface (without diverter valve control)
- Software for CO2 system "lock out" (maintenance access to enclosure)
- Backup Safety Shutdown System
- kW Control
- kVAR/Power Factor Control

Included Factory Testing/Customer Witness/Quality Control Documentation:
Standard package dynamic testing
Factory vibration testing
Factory emissions testing per Solar's ES 9-97
Observation on "Non-Interference" basis
Quality Control documentation (Level 1)

Field-installed Ancillary Equipment (excludes ducting):
Cross-flow type, self-cleaning engine air inlet filter (customer-supplied air), with bottom outlet
Engine air inlet silencer
Exhaust bellows (interface to waste heat recovery equipment)
"Elbow" type enclosure inlet/exhaust ventilation system with silencer

Included "Off-Skid" Components/Systems:
Remote desktop PC/monitor and Printer/Logger
Gas fuel flow meter (for Gas-only and Dual Fuel configurations)
AC motor-driven Liquid Fuel boost pump skid (for Liquid Fuel configurations)
3-micron duplex filter/coalescer with auto drain (for Liquid Fuel configurations)
CO_2 system cabinet
Air/Oil lube oil cooler
VRLA Batteries with 120V DC charging system (back-up post lube)
Portable engine cleaning cart

Miscellaneous
Short-term preservation for shipment
Four (4) paper copies of Solar's Instruction, Operation and Maintenance manuals
Four (4) CD-ROM copies of Solar's Instruction, Operation and Maintenance manuals
UV Light and Gas Sensor test kit
Internal equipment handling system

Caterpillar Confidential: Green CEP Ver. 5.4

Cogeneration Plant Estimated Performance Summary

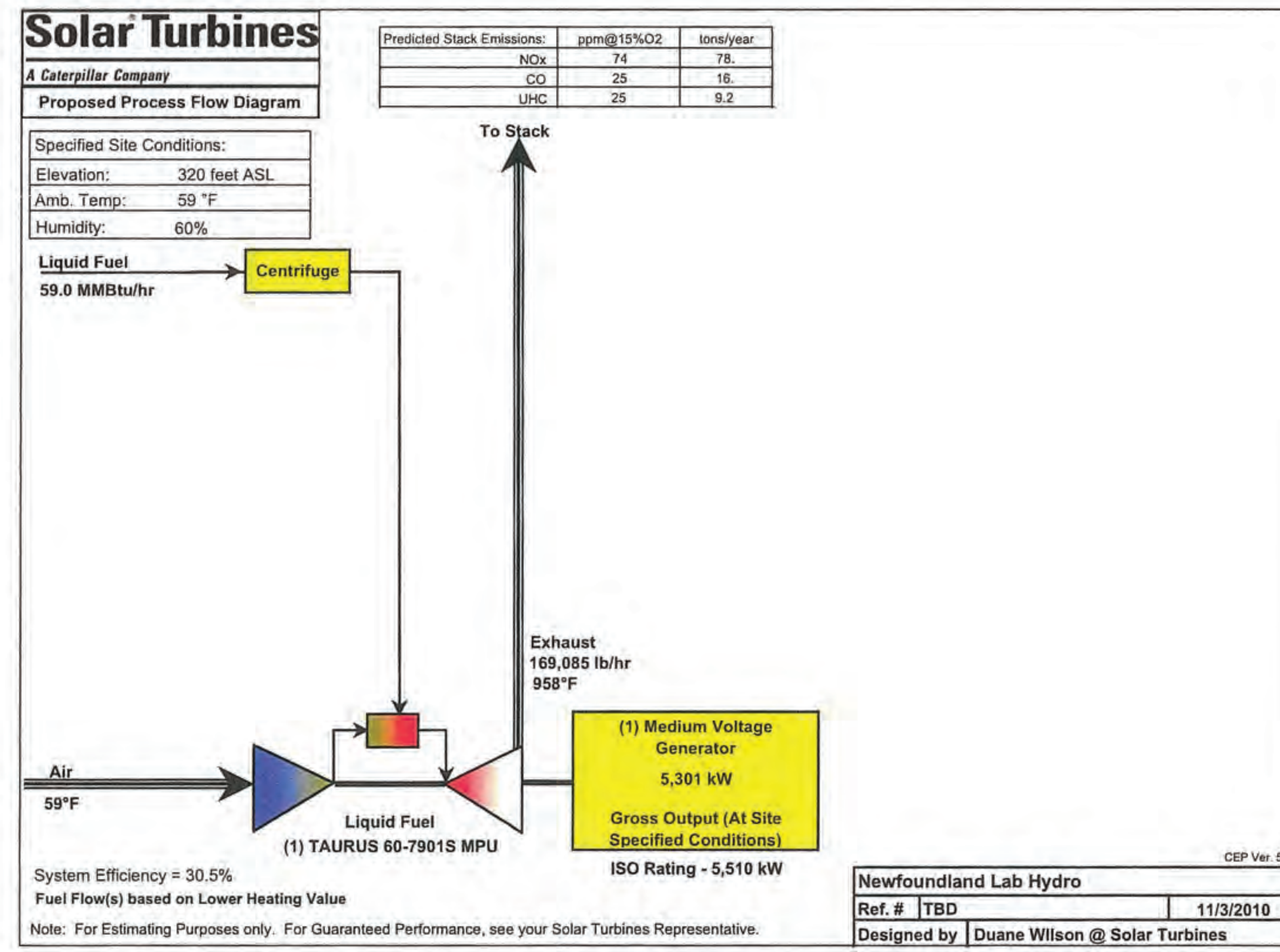
Newfoundland Lab Hydro
Solar Turbines Incorporated
November 3, 2010
Performance listed below is estimated, not guaranteed.

Gas Turbine:		
KW Gross Output @ ISO Conditions:	5,510	kW
Site Ambient Temperature for Performance Analysis:	59	°F
Site Elevation for Performance Analysis:	320	feet
Site Ambient Relative Humidity for Performance Analysis:	60	%
Turbine Inlet Pressure Loss:	4.0	"H2O
Turbine Outlet Pressure Loss:	4.0	"H2O
Turbine Fuel Consumption @ specified site conditions (LHV):	59.0	MMBtu/hr
KW Gross Output @ specified site conditions:	5,301	kW
Turbine Auxiliary Power Consumption:	15	kW
Total Auxiliary Power Consumption:	15	kW
Net Turbine Power Production:	5,286	kW
Black Start kW Requirement (Turbine Generator Set Only)	316	kW

Cycle Performance (lower heating value basis):		
Net Turbine Heat Rate:	11,170	Btu/kWHR
Gross Plant Heat Rate (Process steam or Tons converted to equivalent KW):	11,170	Btu/kWHR
Overall Cycle Thermal Efficiency (LHV):	30.5	%

Caterpillar Confidential: Green

CEP Ver. 5.4



Off Design Performance Worksheet

Newfoundland Lab Hydro

Prepared by Duane Wilson @ Solar Turbines on November 3, 2010

TAURUS 60-7901S

GSC STANDARD

Liquid

CHP Off Design

Duct Burner On/Off	Off	
# of Turbines in Service	1	
Boiler Steam Demand		lb/hr
Unfired Steam Flow	28,405	lb/hr
Firing Temperature	Off	°F
Duct Burner Fuel Flow	Off	MMBtu/hr

Site Elevation:	320	feet					
Barometric Pressure:	29.57	"Hg					
Inlet Duct Loss:	4.0	"H2O					
Exhaust Duct Loss:	4.0	"H2O					
Ambient Temperature (T1):	59	0	32	43	68	86	°F
Part Power (kWe), % Load, or 0 for Max:	→	0	0	0	0	0	kWe
Engine Inlet Air Temperature (T1):	59	0	32	43	68	86	°F
Nominal Output Power: (@terminals)	5,301	6,310	5,767	5,582	5,111	4,721	kWe
Fuel Flow (LHV):	59.0	67.6	62.9	61.4	57.5	54.8	MMBtu/hr
Inlet Air Flow:	165,873	180,340	173,229	170,564	162,373	155,742	lb/hr
Exhaust Gas Temperature (T7):	958	930	943	948	965	982	°F
Exhaust Gas Mass Flow:	169,085	184,018	176,652	173,903	165,504	158,724	lb/hr
Exhaust Gas Volumetric Flow:	38,127	41,346	39,733	39,140	37,383	36,041	SCFM
Nominal Thermal Efficiency: (@terminals)	30.6	31.9	31.3	31.0	30.3	29.4	%
Nominal Heat Rate: (@terminals)	11,137	10,712	10,908	10,993	11,260	11,607	Btu/kWHR
PCD Pressure:	159.5	174.4	167.1	164.3	155.9	149.1	psig
Exhaust Heat (from T7 to 325°F):	27.8	28.9	28.4	28.2	27.5	27.1	MMBtu/hr
% Argon, wet:	0.9	0.9	0.9	0.9	0.9	0.9	
% CO_2, wet:	3.9	4.1	4.0	4.0	3.9	3.9	
% H_2O, wet:	4.5	4.0	4.1	4.2	4.8	5.7	
% N_2, wet:	76.0	76.5	76.3	76.2	75.7	75.0	
% Oxygen, wet:	14.7	14.5	14.7	14.7	14.7	14.6	
			Net CHP System Efficiency =			29.3	% (LHV)

Estimated Power Island Emissions

Newfoundland Lab Hydro

Quoted using data available as of November 3, 2010

(1) Liquid Fuel TAURUS 60-7901S		Per Unit	Plant Total
Ambient Temperature	°F	59°F	
Fuel Type		Liquid	
Assumed Fuel Sulphur Content	lb/MMBTU (HHV)	0.21	
Gas Turbine Exhaust Flow	lb/hr	169,085	169,085
Duct Burner Fuel Flow	lb/hr	0	0
Stack Exhaust Flow	lb/hr	169,085	169,085
FG Temperature Leaving Gas Turbine	°F	958	
FG Temperature Leaving Duct Burner	°F	958	
FG Temperature At Stack	°F	958	
Heat Input to Gas Turbine	MMBtu/hr (LHV)	59.0	59.0
Heat Input from Duct Firing	MMBtu/hr (LHV)	0.0	0.0
Additive NOx from Duct Firing	lb/MMBTU (HHV)	0.125	
Additive CO from Duct Firing	lb/MMBTU (HHV)	0.100	
Additive UHC as CH4 from Duct Firing	lb/MMBTU (HHV)	0.055	
$PM_{10}/PM_{2.5}$ Particulates from Gas Turbine	lb/MMBTU (HHV)	0.061	
Additive PM-10 Particulates from Duct Firing	lb/MMBTU (HHV)	0.039	
Turbine Exhaust Gas Analysis			
H_2O	% vol	4.5%	
N_2	% vol	76.0%	
CO_2	% vol	3.9%	
O_2	% vol	14.7%	
SO_2	% vol	0.0%	
Argon	% vol	0.9%	
Gas Turbine Exhaust Emissions			
NOx	ppm @ 15% O2	74	74
	lb/hr	17.8	17.8
CO	ppm @ 15% O2	25	25
	lb/hr	3.7	3.7
UHC	ppm @ 15% O2	25	25
	lb/hr	2.1	2.1
$PM_{10}/PM_{2.5}$	lb/hr	2.4	2.4
SO_2	lb/hr	12.9	12.9

(1) Liquid Fuel TAURUS 60-7901S		Per Unit	Plant Total
Exhaust Emissions At Stack			
NOx	ppm @ 15% O2	74	74
	lb/MMBtu, HHV	0.284	
	lb/hr	17.8	17.8
	tons/year	78.0	78.0
CO	ppm @ 15% O2	25	25
	lb/MMBtu, HHV	0.058	
	lb/hr	3.7	3.7
	tons/year	16.0	16.0
UHC	ppm @ 15% O2	25	25
	lb/MMBtu, HHV	0.033	
	lb/hr	2.1	2.1
	tons/year	9.2	9.2
VOC	ppm @ 15% O2	25	25
	lb/MMBtu, HHV	0.033	
	lb/hr	2.1	2.1
	tons/year	9.2	9.2
$PM_{10}/PM_{2.5}$	lb/hr	2.4	2.4
	lb/MMBtu, HHV	0.039	
	tons/year	10.7	10.7
SO_2	lb/hr	12.91	12.9
	lb/MMBtu, HHV	0.20555	
	tons/year	56.5	56.5
SCR Ammonia Slip	ppm @ 15% O2	N/A	
SCR Reduction Efficiency	%	N/A	
CO Catalyst Reduction Efficiency	%	N/A	
UHC Catalyst Reduction Efficiency	%	N/A	
Greenhouse Gas Emissions	lbs of CO2/MMBtu (HHV)	162	

General Notes

SO2 emissions depend upon the fuel's sulfur content. The SO2 estimate is based upon the assumption of 100% conversion of fuel sulphur to SO2, using assumed values for various fuels that may not reflect actual fuel composition. Zero fuel bound nitrogen is assumed for gaseous fuels, less than 0.02% for liquid fuels. Actual emissions may be subject to site fuel characteristics. This document is for initial emissions estimates only. For air permit application emissions documentation, Solar can provide site-specific appropriate documentation.

Turbine Emissions Notes:

Values given above are for 8760 hours/year operation.

The table below gives the load ranges to which the turbine emissions listed above apply.

Pollutant	Load Range
NOx	65 to 100%
CO	65 to 100%
UHC	65 to 100%

Fuels must comply with Solar specification ES 9-98.

Values applicable for operation at ambient temperatures between 0 and 120°F. Caterpillar Confidential: Green

For more information contact: Duane WIlson @ Solar Turbines, 630-842-8720, dewilson@solarturbines.cor CEP Ver. 5.4

Solar Turbines
A Caterpillar Company

BUDGETARY LEASE ESTIMATE
FOR
Newfoundland Lab Hydro

Prepared by Duane WIlson @ Solar Turbines on November 3, 2010
(Amounts shown are in US Dollars)

Solar Turbines Inc is pleased to provide Newfoundland Lab Hydro with this budgetary lease proposal. Construction financing has been included in the development of this lease structure. It has been assumed that the design and construction cycle will be 12 months and that costs associated with the project will be evenly spread over the 12 months. Deviations from this assumption may affect the actual lease structure and payment.

1.0 LEASE PRICING

Equipment: (1) TAURUS 60-7901S Turbine Generator Set with the equipment and services specified in the attached quotation.

Lease Type: Tax Lease/Operating Lease

Rental: One Hundred and Twenty (120) payments of $54,460 each, payable in advance

1.1 LEASE TERMS

Lease Term: Ten (10) Years

Lessee: Newfoundland Lab Hydro

Lessor: Solar Turbines Incorporated (STI), Caterpillar Financial Service Corporation or its assignee. LESSOR's interest shall be freely assignable.

Lease Commencement: Lease Commencement will occur upon shipment of equipment from STI to Lessee.

Documentation: Lease Offering is our unbinding expression of interest and is subject to credit approval, tax and legal review, documentation and a fully executed commitment letter.

Net Lease: This is a net lease transaction in which LESSEE bears all expenses related to the transaction, such as operation, maintenance, fuel, taxes (property, sales, use, etc.), insurance, licensing, registration fees, permits, etc. Lessee will be responsible for

Equipment:	LESSEE will, at its expense, maintain, service, repair, and protect the Equipment so as to keep it in good operating condition, ordinary wear and tear excepted, and will cause the Equipment and its operation to comply with applicable law, the requirements
Extended Service Agreement:	Lessee will be required to sign an extended service agreement with Solar Turbines, Inc. or an equal service provider.
Commitment Fee:	To be determined.
Tax Lease Options At Lease End:	Per lease agreement, Lessee will have the option to purchase the Equipment for its Fair Market Value, continue the lease for a term and payment amount to be negotiated, or to return the Equipment to Solar in DeSoto, Texas, freight prepaid.
Tax Lease Notification:	LESSEE shall provide LESSOR with 90 days advance written notification of its intent, with respect to the End of Lease options, which shall be contingent upon satisfactory completion of all other terms and conditions of the Lease.

This budgetary estimate offer is subject to final credit approval, execution of lease documentation, and is valid through January 3, 2010.

APPENDIX 5
BUDGETARY INFORMATION - PETERSON POWER SYSTEMS

PETERSON Power Systems CAT

August 11, 2011

Dave Ennis, P.Eng.
Mechanical Engineer
AMEC
Power and Process
133 Crosbie Road St John's NL, A1A 3C1, Canada
Tel 709 724 1900 x 215
Fax 709 739 5458

Re: Rental of two Solar T60 Mobile Power Units.

Dear Mr. Ennis:

Thank you for inviting Peterson Power Systems to provide a budgetary proposal for your project in Holyrood Newfoundland. Peterson Power Systems is a solutions provider that can provide any level of service you may require from supply of mobile generation equipment and balance of plant to engineering, setup, commissioning, maintenance and operation. The proposal below is limited to the supply, setup, commissioning, and maintenance of the mobile rental turbine.

Project Overview:

Project Delivery Date to Site:	Unknown
Project duration:	12 Months
Project location:	Holyrood Newfoundland, Canada
Site Conditions;	Coastal climate
Project Load:	Unknown
Area Classification:	Turbine shall be in a non classified non hazardous area.
Number of turbines proposed	Two
Fuel:	Primary Fuel: Diesel Secondary Fuel: Natural Gas
Project elevation:	Sea Level
Minimum Rental Term:	12 months.
Design Ambient:	1.7° - 40°C (35° to 104° F)
Optional Ambient Capability:	-40 ° C (-40 ° F)
Turbine Voltage & frequency;	12.47 to 13.8 kV, 60 Hz.

A) **Net Rental Pricing in US dollars Taurus 60, 7300****

12 MONTH RENTAL TERM

Solar Mobile Power Units (Capacity) Charge	$114,000/turbine/month
Cold Weather Package (allows operation to – 40ºF)	$15,000/turbine/month
Turbine starts (31 per Month Allowed) Additional starts	$1,260/start/turbine
Fired hour charge for every hour of operation	$41/hour/turbine
Black Start Generator 300 kva (if required)	$Quote on request

** An example is given below of a rental rate calculation for one month.
700 hours of operation = $114,000 + (700 x 41) = $142,700

Included in the basic rental rate: Failures and Scheduled Maintenance (see paragraph E for complete details).

PETERSON Power Systems CAT

B) **Taurus 60 One Time Freight, Setup/Commissioning and Testing (BUDGETARY)**

Turbine Frt. from point of origin to jobsite	$27,000 - $37,000/turbine
Ocean Transit	Not Applicable
Turbine Mobilization & Consumables	$15,900/turbine
Turbine Supervision of Setup and Commissioning	$66,000/turbine
On site trainer operator (two – four wks minimum)	$12,700/week
Turbine Supervision of tear down at end of rental	$34,500 [t]/turbine
Ocean Transit	Not Applicable
Return Frt. to point of origin	$27,000 - $37,000/turbine

Peterson Rep. 15 days/turbine and Solar Rep. 11 days/turbine
Additional days will be charged at a rate of;
Peterson rep. $1,620/day.
Solar rep. $3,600/day.

[t] Labor rates are based on 12 hours per day 6 days per week. Rates do not include travel time, travel expense, per diem, or site specific Health Safety and Environmental (HSE) training required by the End User. Peterson reserves the right to change rates based on the actual jobsite location. We also reserve the right to decline to provide service in certain countries.

++The gas filter coalescer may be supplied by others but is subject to approval by Peterson.

C) Exclusions (excluded items quoted upon request)

1. Gas and/or Diesel fuel interconnect piping from customer fuel source, and shipped loose fuel treatment gas filter coalescer and handling equipment to the turbine. .
2. 13.8 kV cabling from Solar T60 Mobile Power Unit breaker 52G to Customer Breaker/tie in point.
3. Setup crew and equipment
   - Crane w/ operator to lift 14,000LBS. (7 metric tons) onto turbine roof.
   - All Terrain Fork-lift or Shooting Boom rated 6,000 lbs. (3 metric tons)
   - 4 – 6 laborers
   - 2 skilled mechanics
   - 1 high voltage electrician
   - 1 relay tech
4. Property damage, Boiler Machinery Insurance[1], and Liability Insurance.
5. Political risk insurance (required in some countries).

5a. Engineering of generator protective relay settings

6. Engineering of any of the above excluded items.
7. Emissions source testing (may or may not be required by local jurisdiction)
8. Regulatory approval (Operating Permits)
9. Operators and routine daily maintenance.
10. Replacement Fuel filter elements and fuel coalescer elements.

[1] Refer to paragraph K for a brief description of boiler machinery insurance.

D). Operation, Inspections, and Trouble Calls: Turbines are extremely reliable and can operate for months without incident. However, they do need to be inspected and monitored on a regular basis. The operations, inspections, and monitoring can be tailored to the customers individual needs.

If the customer elects to utilize their own operators they will need to be trained and approved by Peterson and adhere to our inspection and monitoring guidelines. Peterson will provide an experienced trainer operator who will stay on site for two to three weeks after the initial commissioning of the turbine. The trainer/operator will resolve any turbine "burn in" problems and provide both written and hands on training to the end users operators. Minimum operation and inspection guidelines are given below to assure the turbines are properly maintained.

Minimum Operation, Inspections, and Trouble Call Requirements

Frequency	Description	Responsible for Cost
Once.	Operation & Training of End Users Operators and/or dealer EPG Technicians. 8 hrs. /day five days per week for One to Two weeks immediately after commissioning of turbine.	The cost of Peterson's trainer operator is as shown in paragraph A. Training costs for END USER personnel is the responsibility of the end user.
Daily	Daily monitoring of turbine operating parameters by on site personnel. Requires about 15 to 30 minutes per shift.	Inspections performed by END USER's on Site personnel. END USER is responsible for the cost.
Weekly	Site inspections. Requires about 30 – 60 minutes.	Inspections performed by END USER's on Site personnel. END USER is responsible for the cost.
Quarterly	Site inspections by Peterson Technicians.	Peterson will pay all costs associated with Peterson personnel. Cost of END USER Personnel is by END USER.
Six Months	Site maintenance (requires 24 hour shutdown) is supervised by Peterson Personnel and requires support from End user site personnel.	Peterson will pay all costs associated with Peterson personnel. Cost of END USER Personnel is by END USER.
Annual	Site maintenance (requires 48 hour shutdown) is supervised by Peterson Personnel and requires support from End user site personnel.	Peterson will pay all costs associated with Peterson personnel. Cost of END USER Personnel is by END USER,
As needed	Trouble calls and failures, First response by END USER or local dealer. More complex problems will be handled by Peterson and/or Solar Turbines local field service office.	Peterson will pay all costs associated with Peterson or Solar personnel. Cost of END USER and dealer Personnel is by END USER. Replacement parts by Peterson.
As needed	Replacement of fuel filters, combustion and ventilation air inlet filtration.	End User

F. Availability:
Solar Taurus 60 Mobile Power Unit one to four weeks.

G. Rental Purchase Option: Lessee shall have the exclusive option, to purchase the equipment at a price equal to the prices set forth below, minus the sum of (i) 60% of the total monthly rental payments actually paid up through the twelfth month. Thereafter no rentals paid shall apply to the purchase price. The exercise price for the equipment shall be increased by an amount equal to the out-of-pocket cost of labor and materials to PETERSON for such turbine for cumulative nonscheduled service, repairs, upgrades, or failures that in the aggregate have exceeded $50,000 from the commercial operation date to the exercise of the purchase option for such turbine.

2 Used Solar T60 7300 SoLoNox Mobile Power Units with less then 5,000 hours $3,800,000 USD/Each

H. Terms:

The prices shown are net figures. All figures given are in U.S. dollars. Equipment quoted is subject to prior rental or sale.

Shipping point for turbines is San Leandro, California, USA.

As the importer of record, Lessee shall be liable and shall pay any import tariffs, customs, duties, port fees, value added or other taxes as a result of importation or exportation/return of any and all equipment or property under this rental agreement. The term equipment is meant to include the turbine, related appurtenances, spare parts, replacement parts, emergency repair parts, and special tooling shipped at any time during the contract term. If any government agency assesses Lessor or any of its affiliates for any of such import tariffs, customs, duties or other taxes, Lessee shall reimburse Lessor immediately upon presentation of assessment/notification.

Lessee shall pay local and state personal property taxes.

Turbine Rental billings begin 20 days after delivery to US Port or when the equipment arrives at the jobsite, whichever occurs first. Turbine Rental billings end when the equipment leaves the site. 20 days shall be allowed for return transit.

REQUEST A RENTAL CONTRACT FOR COMPLETE TERMS AND CONDITIONS.

I. Deleted

J. Technical Notes
1. A 250kW. Black Start Generator is required for turbine starting in the event auxiliary power is not available.

K. Boiler and Machinery Insurance.
Many persons are not familiar with Boiler Machinery Insurance and therefore do not understand why Peterson requires this form of insurance. Gas turbines are extremely reliable and operate for years without incident. However in the rare case where they fail catastrophically the cost of repairs can be very high. For example an engine overhaul due to a catastrophic failure can cost $1,000,000 to $1,300,000 for a 5 MW turbine.

Boiler and Machinery Insurance provides coverage against sudden and unexpected failures that cannot be predicted. For example if an internal piece of the turbine engine fails and is ingested by the turbine; boiler machinery insurance will cover the cost of the failure provided the failure was sudden and unexpected. This type of coverage clearly benefits Peterson as the failure was not due to any error or negligence by the end user. However, Boiler and Machinery Insurance also provides benefits the end user should they do something that causes and catastrophic failure. A good example is operator error that leads to a catastrophic failure.

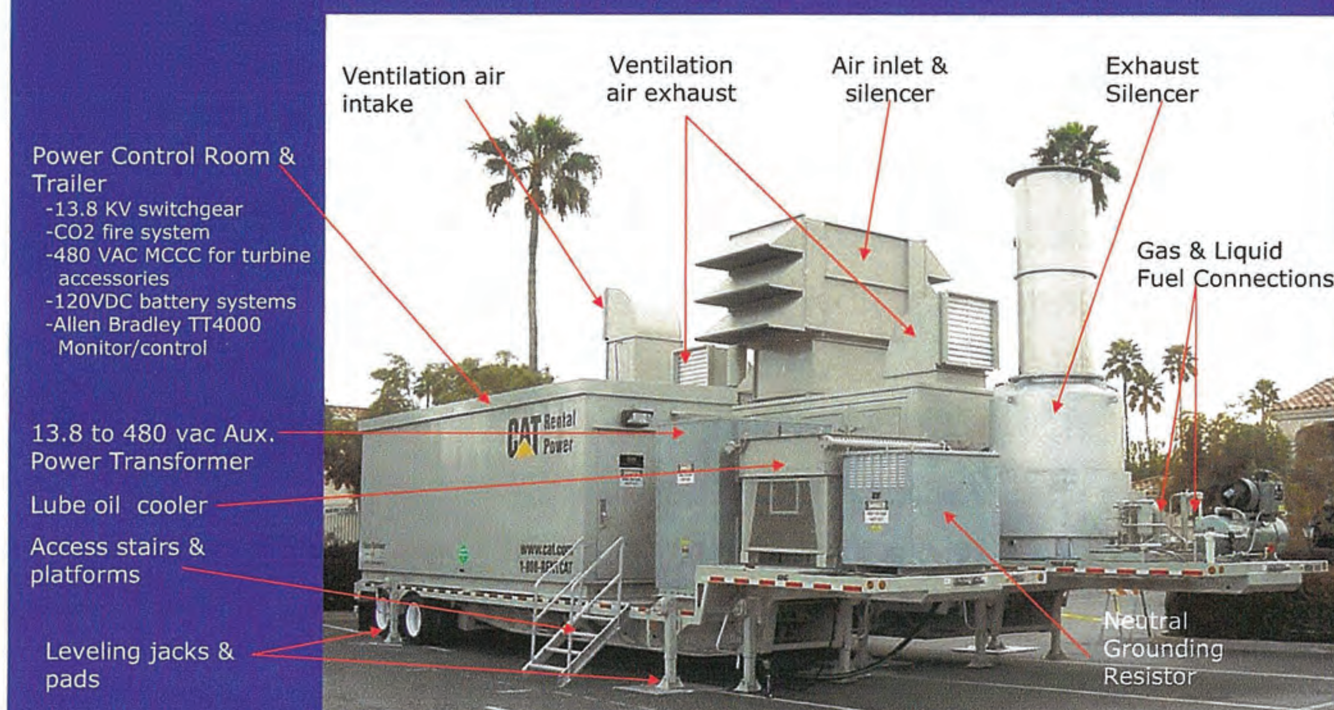
Thank you for this opportunity to quote your requirements. If you should have any questions or comments please feel free to call.

Sincerely,

Gene Hamilton
Peterson Power Systems, Inc.

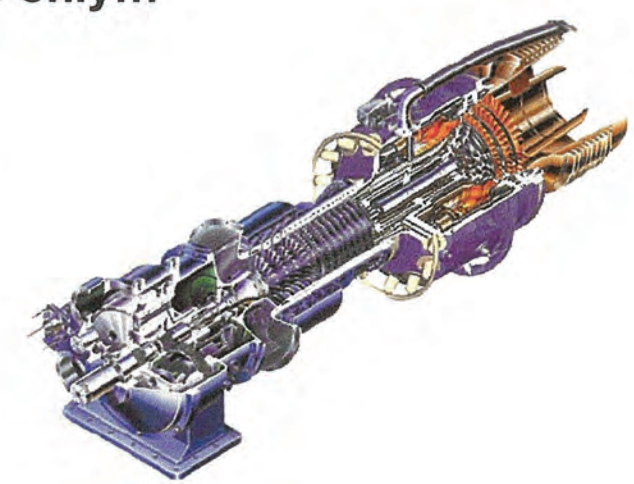
Phone: +1 -510-618-5546
Fax: +1 – 510-352-4885
Mobile: +1 - 530-518-1407

Self Contained Power Plant



Mobile Turbine Design

- Standard Solar Taurus 60 Power Gen. Package
- Rapid Setup & Commissioning
- Ease of transport…Land, Sea, & Air
- Totally self contained, Needs only…
  - Gas and/or Liquid Fuel
  - 13.8kV load connection
  - Black Start Requires 480VAC



Mobile Turbine Design

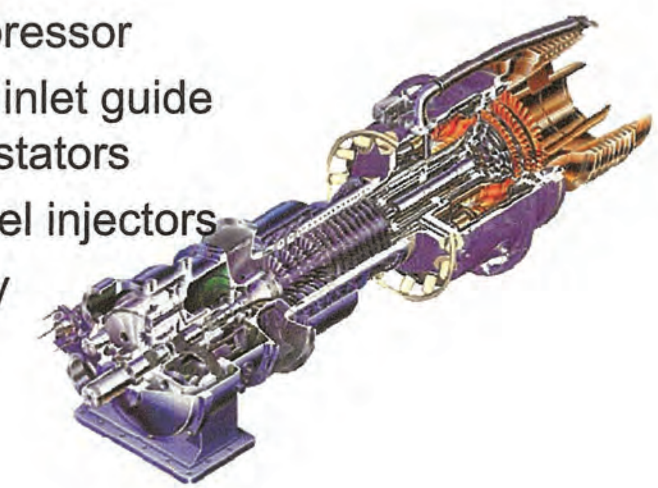
Standard Solar Taurus 60 Power Gen. Package

Parts
Service
Overhauls
Upgrades
Retrofits

Solar T60 – Engine

Standard Solar Taurus 60 Power Gen. Package

- Simple Cycle
- Single shaft axial flow engine
- Close Coupled to separate Gear Box
- Twelve-stage axial flow compressor
- Variable geometry control on inlet guide vanes and first three rows of stators
- Annular combustor with 12 fuel injectors
- Three-stage turbine assembly

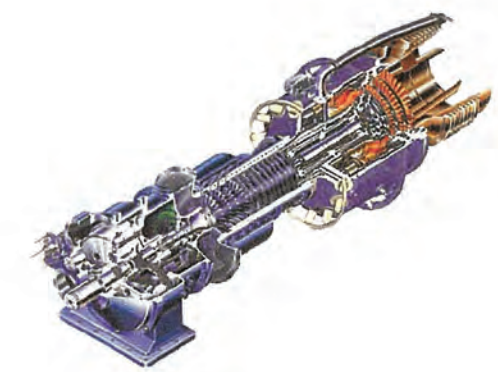


Solar T60 – Gear Box

- Coupled directly to the turbine engine
- Speed Reduction from 13,800RPM to 1800 RPM

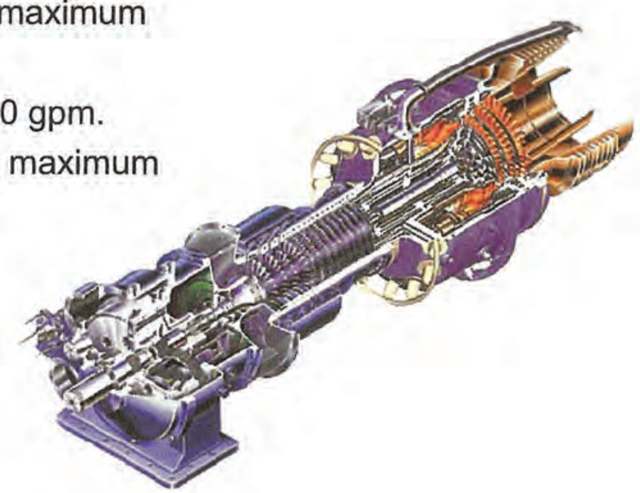
Solar T60 – Generator & Voltage Regulation

- **Ideal, Alstom, or Kato**
- Sleeve Bearings with pressure fed sumps
- Six-lead WYE connection
- Form wound stator windings
- Permanent magnet pilot exciter
- 12,470 – 13,800 Volt, 3 phase, 60 Hz.
- 11kV, 3 phase, 50 Hz.
- Insulation class F with
- **Voltage Regulator Characteristics**
- Solid state, Single-phase sensing
- 0.5% steady state voltage regulation
- Reactive load sharing to within 5% nameplate rating
- Crosscurrent compensation capability



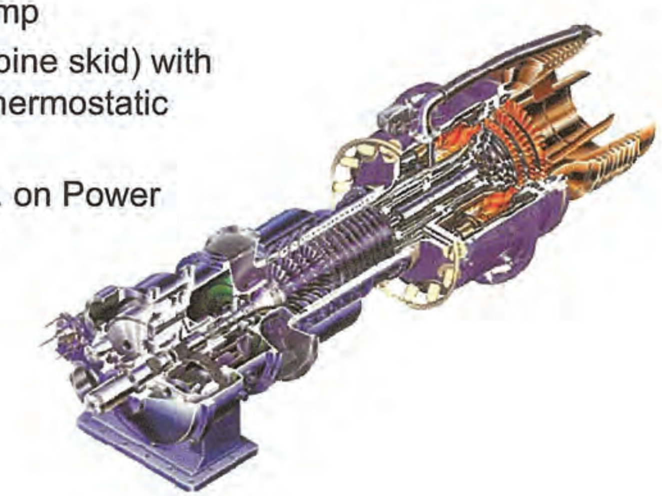
Solar T60 – Dual Fuel System

- Designed to operate on Natural Gas or Distillate Liquid Fuels
- NATURAL GAS
  - maximum flow demand rate of 1200 scfm
  - 250 psig minimum and 300 psig maximum
- Distillate Liquid Fuels
  - maximum flow demand rate of 8.0 gpm.
  - 20ft. Suction minimum to 25 psig maximum



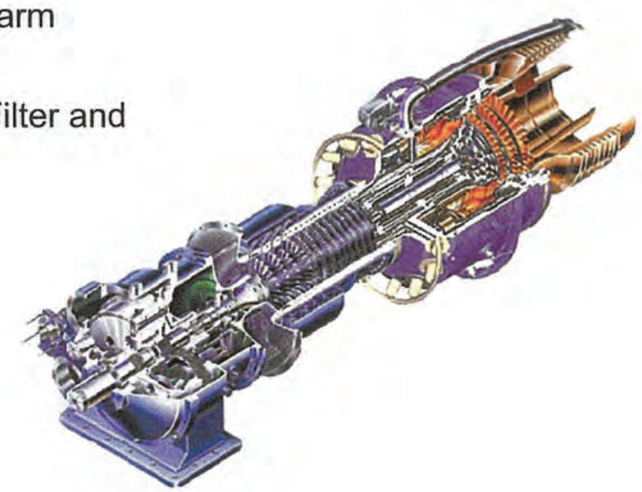
Solar T60 – Starter, Lube system

- Direct drive AC motor with VFD motor controller
- Lube system provides oil to the Taurus 60 gas turbine engine, gear box and generator.
  - Engine driven lube oil pump
  - Pre/Post Lube AC Motor Driven Pump
  - Pre/Post Lube DC Motor Drive Pump
  - Lube Oil Sump (integral part of turbine skid) with space heater, level controls, and thermostatic control valve.
  - Horizontal core lube oil cooler mtd. on Power Control Room



Solar T60 – Auxiliary Systems

- On Crank and On Line Water Wash
- WEATHERPROOF ACOUSTIC ENCLOSURE
  - Ventilation Silencers and Fans,
  - Lights
  - Fire Detection and Gas Monitoring System
  - High Temperature Detection and Alarm
  - CO2 Fire Suppression System.
- High Efficiency Combustion Air Barrier Filter and Silencer
- Trailer mounted exhaust silencer



Solar T60 – Allen Bradley PLC5 Control System

Solar Turbotronic Controller
Sequencing of Starting, Running & shutdown Package monitoring and protection
Local operator interface and monitoring.
Interface and monitoring in power control trailer via
Remote Video Display (TT4000) interface and monitoring.
Operational summary Alarms, shutdowns, Temperatures, pressures, vibration, Engine performance, Generator kW, voltage, p.f., hz., amps, current.
Relay backup in event of PLC failure
Flexibility to change logic or add features

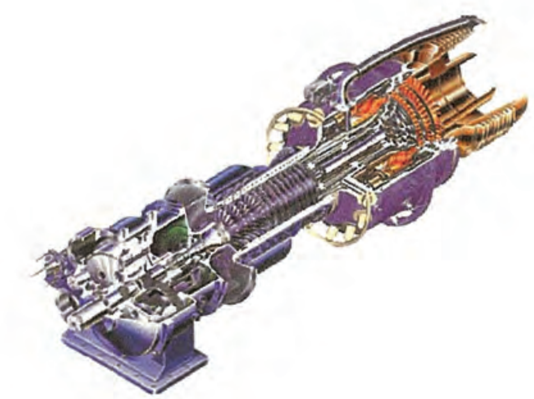
Solar T60 Performance (ISO Conditions)

	Natural Gas	*Natural Gas*	*Diesel #2*	*Diesel #2*
	English	*Metric*	*English*	*Metric*
Power Output	5,200 kWe	5,200 kWe	5,089 kWe	5,089 kWe
Heat Rate	11,263 Btu/kWe-hr	11,900 kJ/kWe-hr	11,376 Btu/kWe-hr	12,002 kJ/kWe-hr
Fuel Flow (LHV)	58.6 mmBTU/hr	61.8 mmkJ/hr	57.9 mmBTU/hr	61. mmkJ/hr
Emissions, NOX	48 PPMvd 25 PPMvd (1.1 lb.)/MW-hr)	48 PPMvd 25 PPMvd	96 PPMvd	96 PPMvd
CO	50 PPMvd	50 PPMvd	50 PPMvd	50 PPMvd
Gen. Voltage	12.47 or 13.8 KV	12.47 or 13.8 KV	12.47 or 13.8 KV	12.47 or 13.8 KV
Gen. Frequency	60 Hz.	60 Hz.	60 Hz.	60 Hz.
Voltage Steady State	0.5%	0.5%	0.5%	0.5%
Short Circuit	300% for 10 sec.	300% for 10 sec.	300% for 10 sec.	300% for 10 sec.

Solar T60 Performance

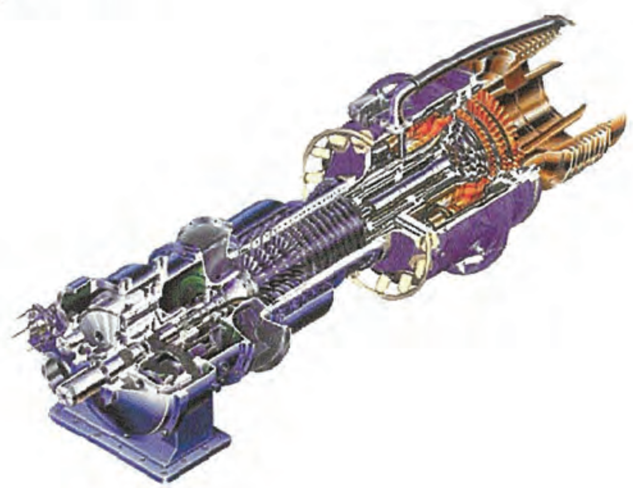
"Taurus™ 60, 7300 Industrial Gas Turbine

- **ISO Conditions (5,200MWe)**
  - 15° C (59° F) Sea Level,
    0 Inlet/Exhaust Losses
  - Varies with Air Temperature and Altitude
- **Taurus 60 at 152 M (500 ft.)**
  - 5367 kWe @ 4.4° C (40° F)
    4345 kWe @ 32° C (90° F)
- **Taurus 60 at 457M (1500 ft.)**
  - 5165 kWe @ 4.4° C (40° F)
  - 4182 kWe @ 32° C (90° F)



Mobile Turbine Design

- **Standard Solar Taurus 60 Power Gen. Package**
- **Ease of transport…Land, Sea, & Air**
- Totally self contained, Needs only…..
  - Gas and/or Liquid Fuel
  - 13.8kV load connection
  - Black Start Requires 480VAC



Ease of transport…Land, Sea, & Air

Ease of transport…Land, Sea, & Air

- Turbine Generator Trailer & 2-Axle Booster Unit
  - 18.9M (62 ft.)
  - Weight: 57MT (125,000 lbs.)
- Power Control Room Trailer
  - 14M (46 ft.)
  - Weight: 25MT (55,000 lbs.)
- Shipped Loose
  - Step deck or 12.2M (40 ft.) High Cube
  - 8.2MT (18,000 lbs.)
- Designed for All U.S. States and Canadian Provinces

Rapid Setup and Commissioning…8 wks.

Markham Ontario, 98 MW

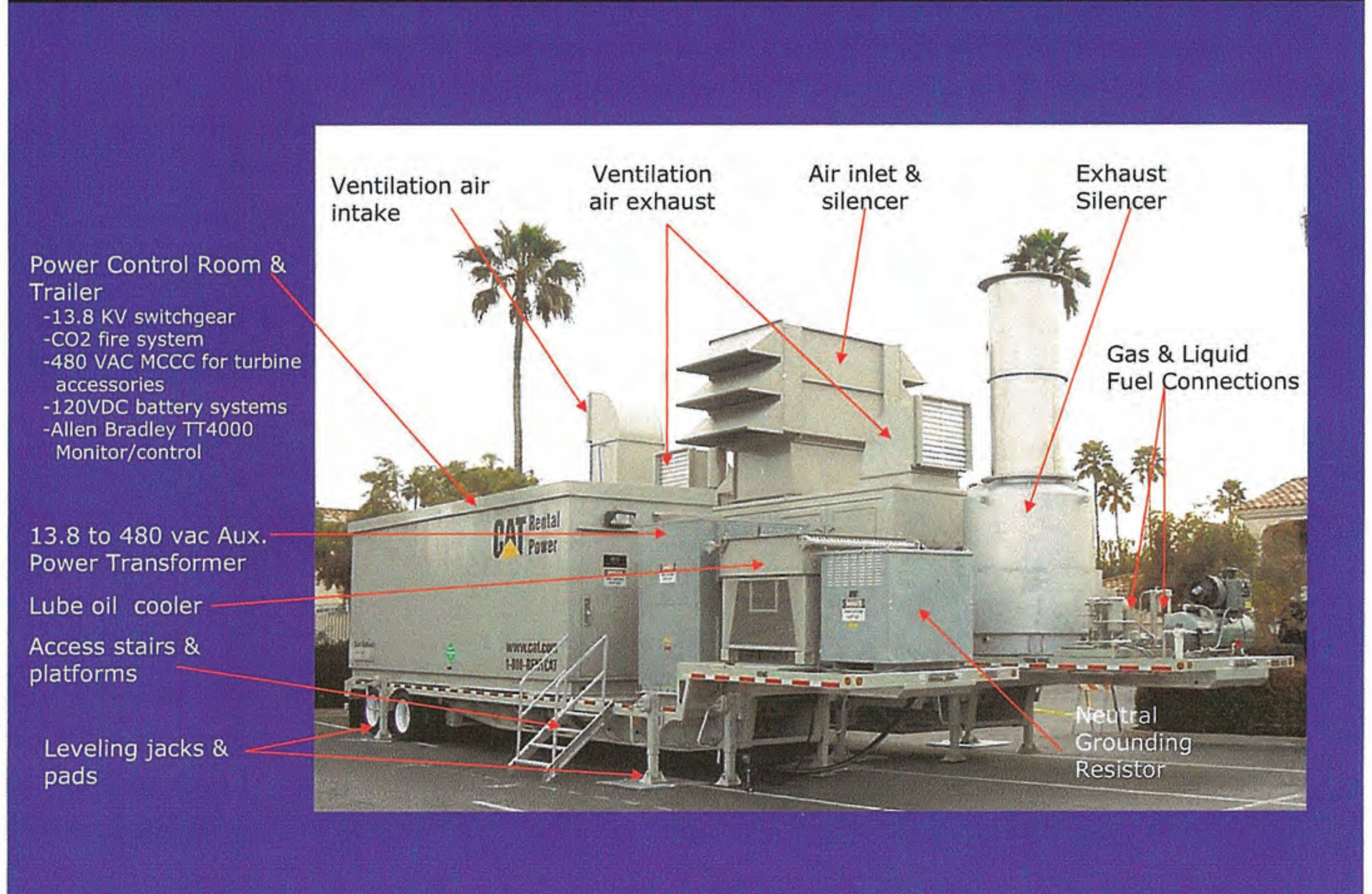
Rapid Setup and Commissioning…. 4 wks

Nassau, Bahamas, 20 MW Liquid Fuel

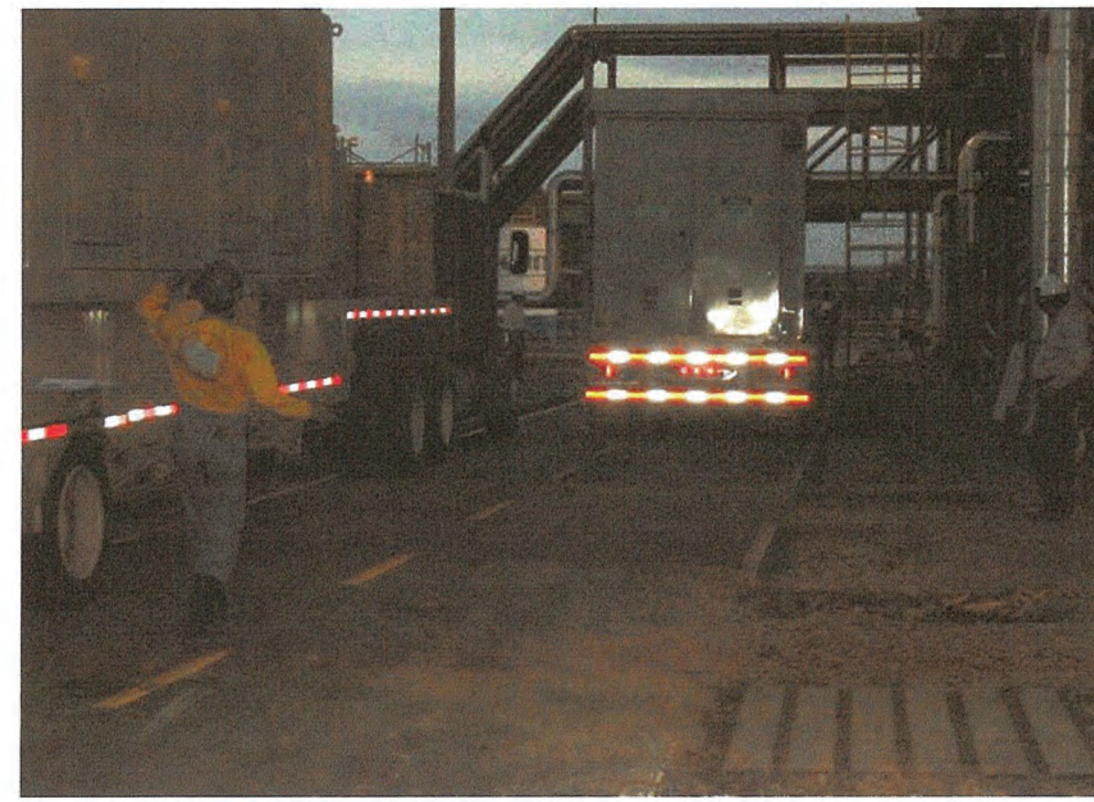
Rapid Setup and Commissioning…. 2 wks

Prudhoe Bay, Alaska USA; 15MW Natural Gas Fuel

Self Contained Power Plant



Ease of Placement



Heavy Turbine & Power Control room easily set in place

No Large Cranes Required

5,000 lbs. ….. Heaviest item lifted

Easy Siting Requirements

Level compacted surface 2,500 lbs. per square ft.

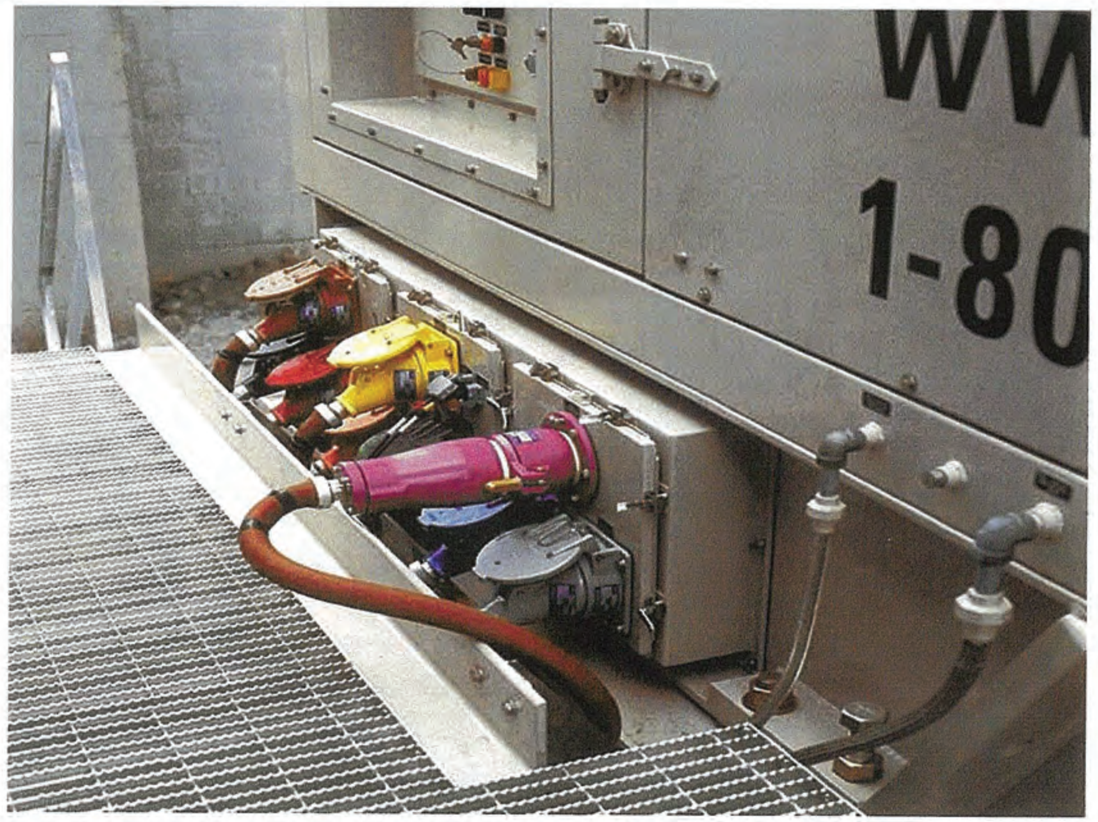
Easy Siting Requirements

- Low Profile
  - 7.3M (24 ft.) Stack Height
- Sound Attenuation Package
  - 85 dba @ 1 meter
  - CSA/NRTL

Rapid Installation

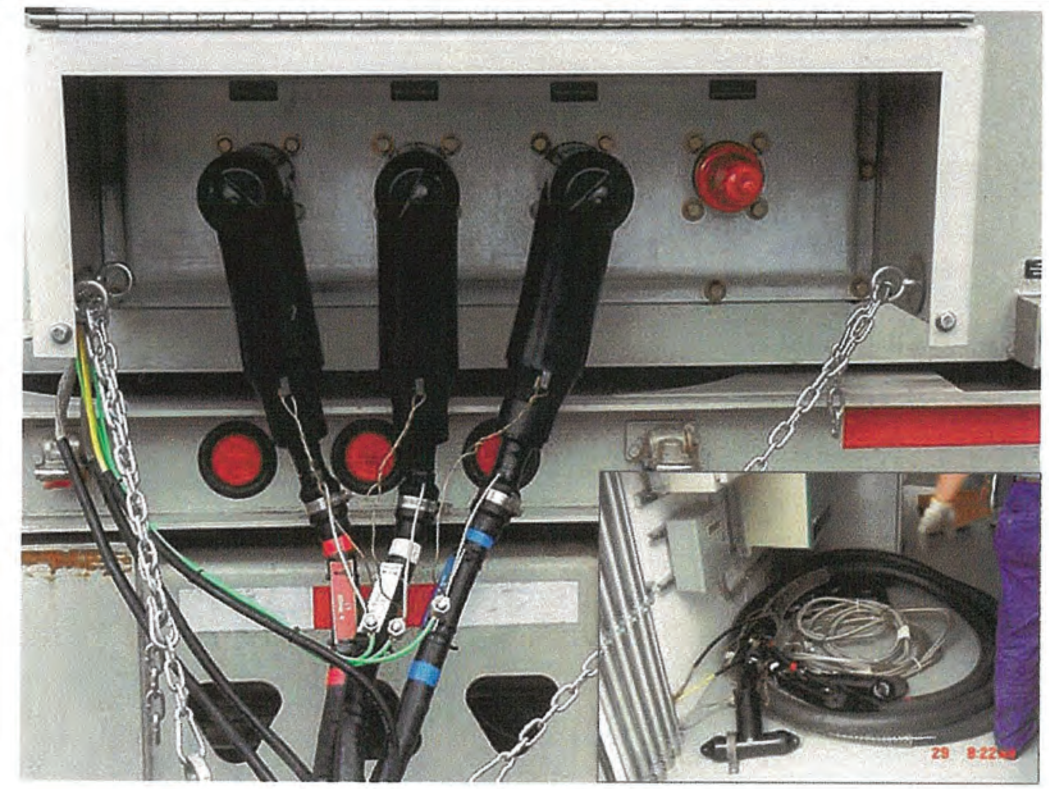
Oil Cooler Lines Factory Polished

Rapid Installation



Color Coded Quick Connectors

Rapid Installation



13.8KV Quick Connect Load Cable

Rapid Installation

CO2 Fire System

Ease of Use

Stairs & Platforms contribute to an easy installation

Set Up & Operational in 3 - 5 Days

Experienced Field Set Up Crew

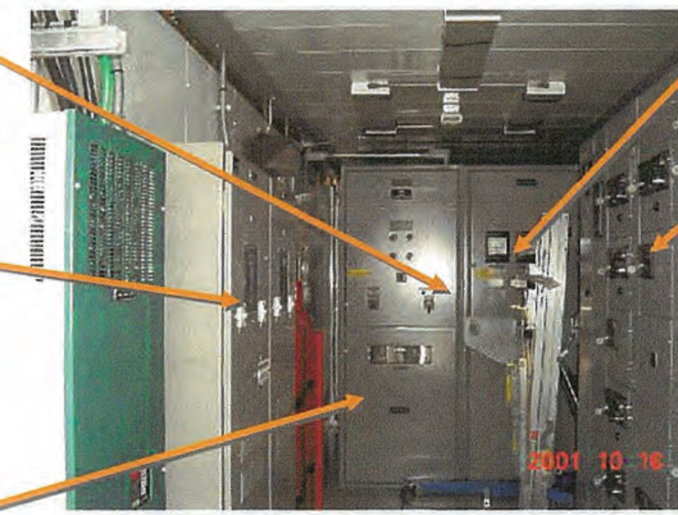
Solar T60 MPU Product Features

Power Control Room

Metal-Clad 15Kv Switchgear

Turbine & Switchgear Battery Systems

Beckwith Programmable Protective Relay Module



Basler Over Current Relays

400 or 480 Volt Motor Control Center

Generator Voltage: 11,000 or 13,800 Class F Insulation/ Class F Temperature Rise

Step-down transformer & Neutral Grounding Resistor

Solar T60 MPU Product Features

- **Turbotronic Controller, Allen Bradley PLC5(Turbine and Generator)**
  - **Auto Synch**
  - **Voltage Adjust**
  - **kW Control**
  - **KVAR/Power Factor Control**
- **TT4000Remote Control and Monitoring:**
  - **Remote Dial-up (Modem)**
  - **Historical Data**

Solar T60 MPU Installation Requirements

- Minimum Soil Loading
- (2,500 lb./ft2) 12.2MT/M2
  - Flat and Level Surface
- Gas Supply
  - (240-300 psig) 1725- 2068 KPAG Gas Supply
  - Distillate Liquid Fuels
    - maximum flow demand rate of 8.0 gpm.
    - 20ft. Suction minimum to 25 psig maximum
- 15kV load connections to PCR
  - Turbine AC and DC auxiliary loads powered Internally
- Grounding to Grid
- 480VAC, 400A Black Start

Solar T60 MPU Installation Requirements (cont')

- Small Drain Tank, 70 L (20 gal.)
- Crane with Lifting Capability of 2.5MT (5,500 lbs.)
- Installation and Commissioning
  - 3 Man Crew to Install
  - Standard Hand Tools
  - 5-7 Days to Commission
- Input Signal From Utility Tie Breaker
  - Island Mode Operation

Solar T60 MPU Operations and Service

Maintenance and Operation

- Rental Rate Covers all Maintenance, inspections and Failure Repair.
- Routine Daily Maintenance by End User or Peterson Operators (if provided)
- Typical Overhaul Interval is 30,000 Hours
- Overhaul by Exchange of Entire Turbine
- Limited Field Maintenance, 2 Inspections/Year

Options: Winterization Package

Winterization Package

- Operation to -50 Deg. C
- Start to -50 Deb.
- Requires 150 AMP, 480Vac Aux. Power

Options: Self Cleaning Air Inlet Filtration

Donaldson Self Cleaning Air Inlet Filtration

- Allows for operation in both desert and arctic environments.

XQ5200 MOBILE TURBINE

RENTAL POWER - WHEN AND WHERE YOU NEED IT

The XQ5200 is the answer to your need for short term generating capacity that is both economical and environmentally friendly. Designed as an on-site generating system where low emissions, fast setup and reliable operation are critical, the XQ5200 is based on the proven Solar® 5.2 MW Taurus™ 60 gas turbine generator set and includes these key features:

EASY TO INSTALL AND RELOCATE
- Highway Transportable
- Modular Design for Quick Setup and Connection
- No Concrete Foundation Required
- Compact Footprint to Minimize Space
- CSA Certified

ENVIRONMENTALLY FRIENDLY
- Low Emissions, Utilizing SoLoNOx™ Combustion System
- No Visible Emissions
- Sound Attenuation Package for Quiet Operation
- Low Profile Design to Minimize Installed Height
- Easy to Permit

FLEXIBLE SOLUTION
- Short and Long Term Rental Options Available
- 5.2 MW Output, 12.47 or 13.8 Kilovolts, 60 Hertz
- Fuel Flexibility, Natural Gas or Diesel

COMPLETE SYSTEMS SOLUTION
- Setup and Commissioning
- Maintenance Included in Rental
- Operators Available
- Site Preparation
- Transformers

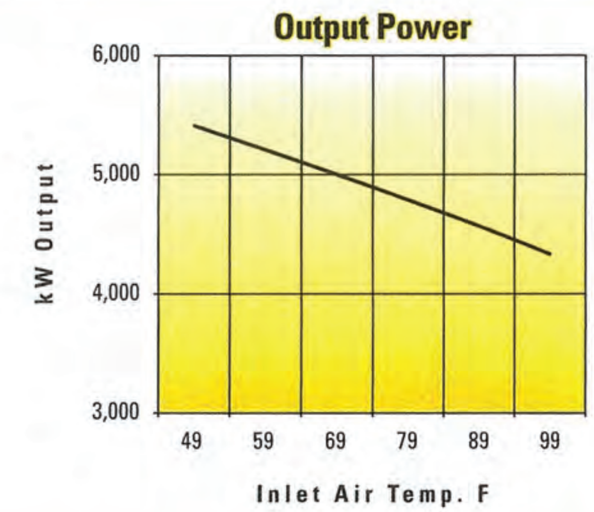
OPERATIONAL FEATURES
- Dispatchable to be On Line in Six Minutes (from cold start)
- Range of Control System Options for Remote Operation
- Utility Grade Switchgear with Programmable Protective Relay Module
- KVAR Control for Excellent Reactive Power Capability

PETERSON POWER SYSTEMS CAT

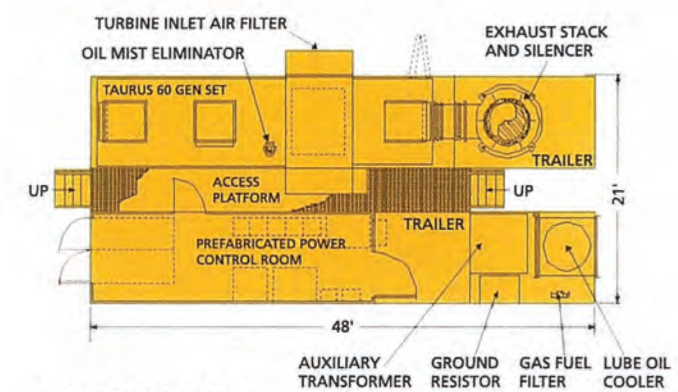
NOMINAL GENERATOR SET PERFORMANCE

At the core of the XQ5200 is Solar's 5.2 MW Taurus™ 60 industrial gas turbine, with a population of more than 1,000 units in the field. The XQ5200 combines the features and benefits of the proven Taurus™ 60 industrial gas turbine with a mobile system that is easy to relocate and connect.

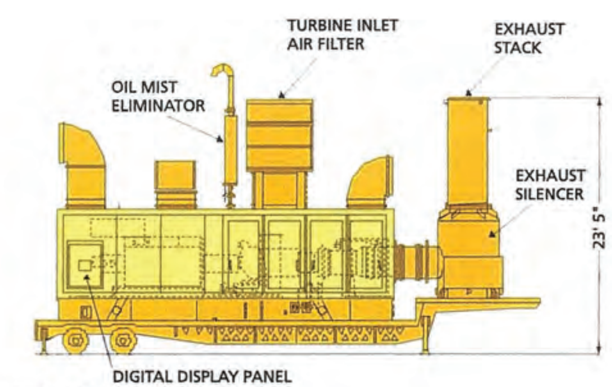
Output Power, kW	
ISO: 15° C (59° F), sea level	*5,200*
Heat Rate, (Btu/kW-hr)	*11,263*



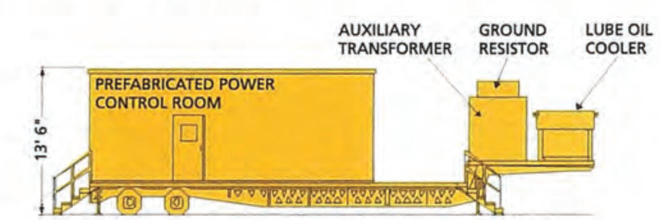
TYPICAL DIMENSIONS



Installation Plan View



Generator Set Module



Power Control Module

PETERSON POWER SYSTEMS
2828 Teagarden Street
San Leandro, CA 94577
United States of America

FOR MORE INFORMATION
Phone: (510) 963-6446
Fax: (510) 352-2064
Website: www.petersonpower.com

Peterson Power Systems

PETERSON CAT

Gene Hamilton

Past Successes

PETERSON CAT

- Rental
  - Equilon Refinery—Anacortes 20MW
  - BP—Cusiana, Colombia 5MW
  - OEFC—Markham, Ontario 98MW
  - City of Tallahassee, Florida 60MW
  - Bahamas Electric Corporation 20MW
  - BP– Milne Point, Alaska 15MW
  - SG Resources—Leakesville, Mississippi 10MW
  - Iroquis Bio Energy—Indiana 5MW
  - ICE—San Jose, Costa Rica 60MW
  - Alliant Energy—Cedar Rapids, Iowa 15MW
  - Spectra Energy—Chetwynd, BC 5MW
  - Shell– Gabon, Africa 5MW
  - BP Noel—Dawson Creek Canada 5MW
  - Power and Water, Australia 5MW
- Sale
  - CABGOC Cabinda—Angola, Africa 10MW
  - PTTEP—Thailand 10MW
  - Bruce Power – Canada 5MW
  - Energy International 75MW

Equilon Refinery—Anacortes, Washington 20MW

PETERSON CAT

BP– Cusiana, Colombia 5MW

PETERSON CAT

OEFC—Markham, Ontario 98MW

PETERSON CAT

City of Tallahassee, Florida 60MW

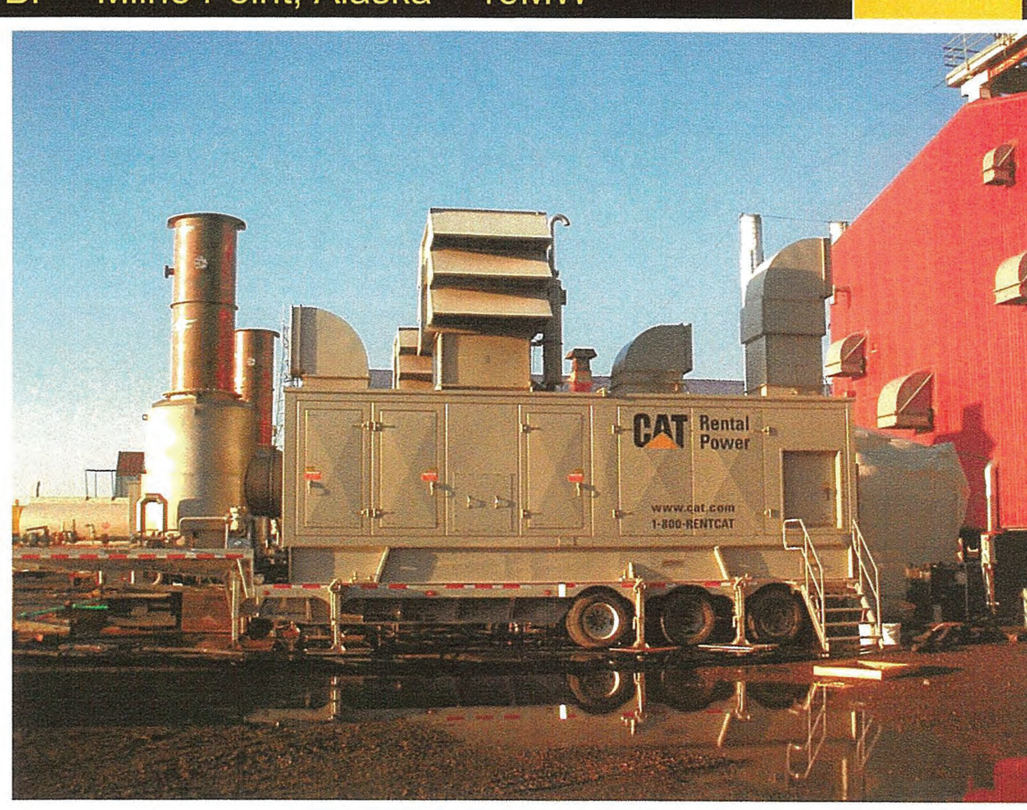
PETERSON CAT

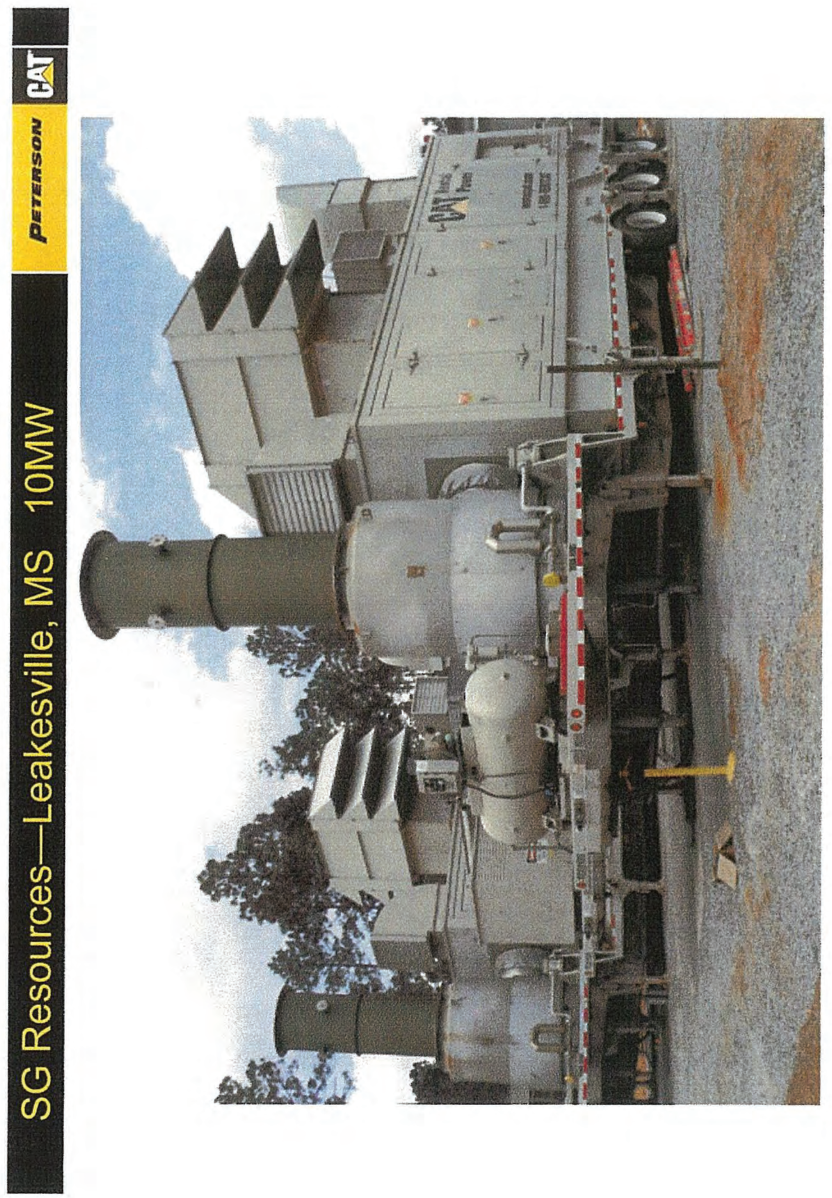
Bahamas Electric Corporation, Nassau 20MW Liquid Fuel

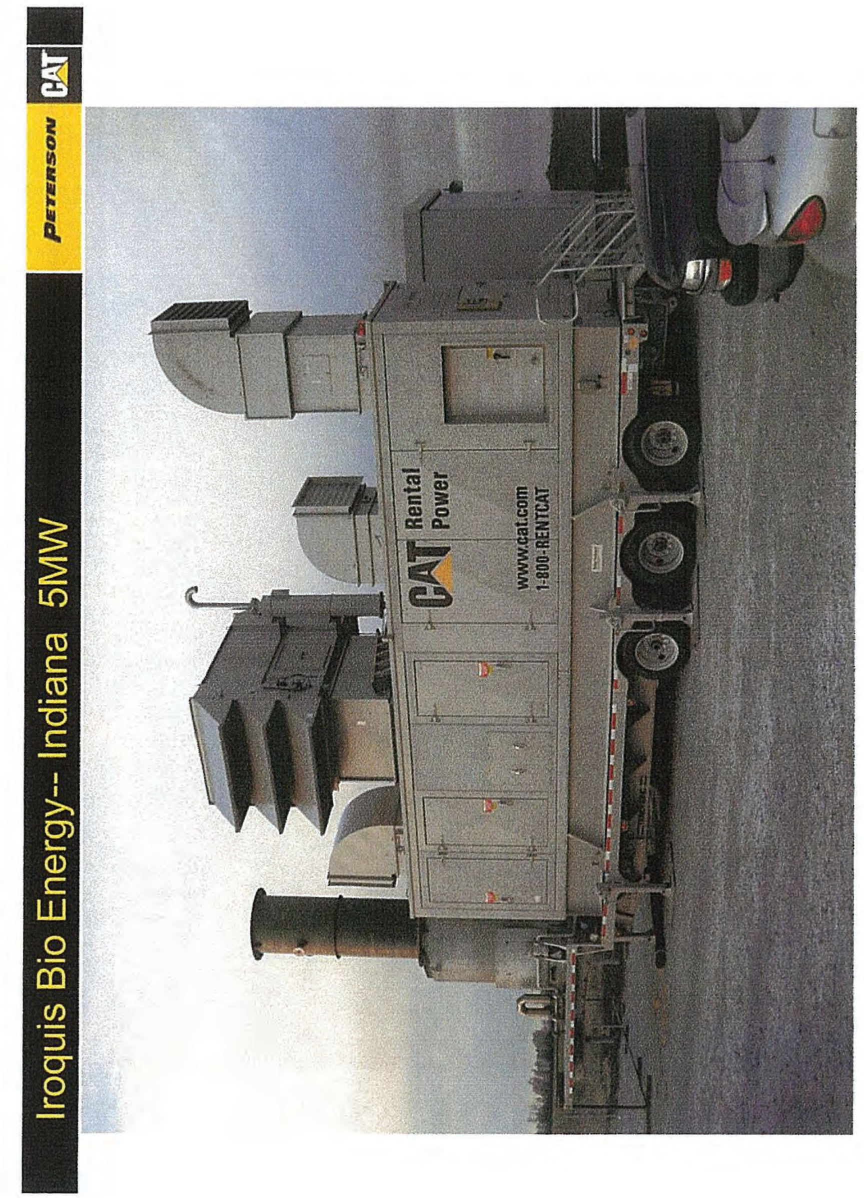
PETERSON CAT

BP—Milne Point, Alaska 15MW

PETERSON CAT

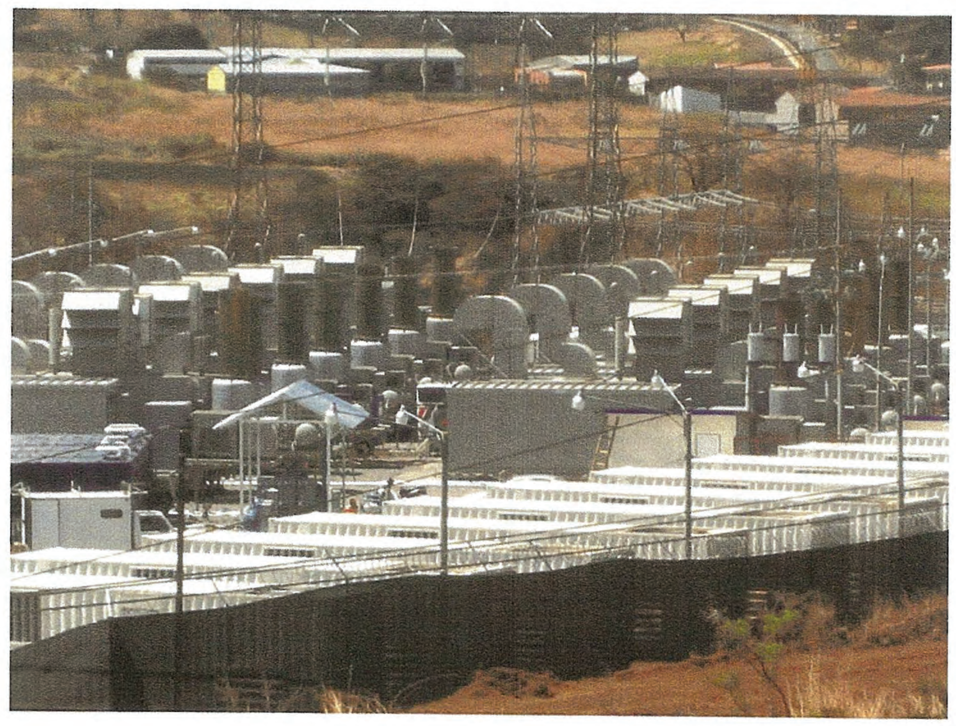



SG Resources—Leakesville, MS 10MW
PETERSON
CAT


Iroquis Bio Energy-- Indiana 5MW
PETERSON
CAT
CAT Rental Power
www.cat.com
1-800-RENTCAT

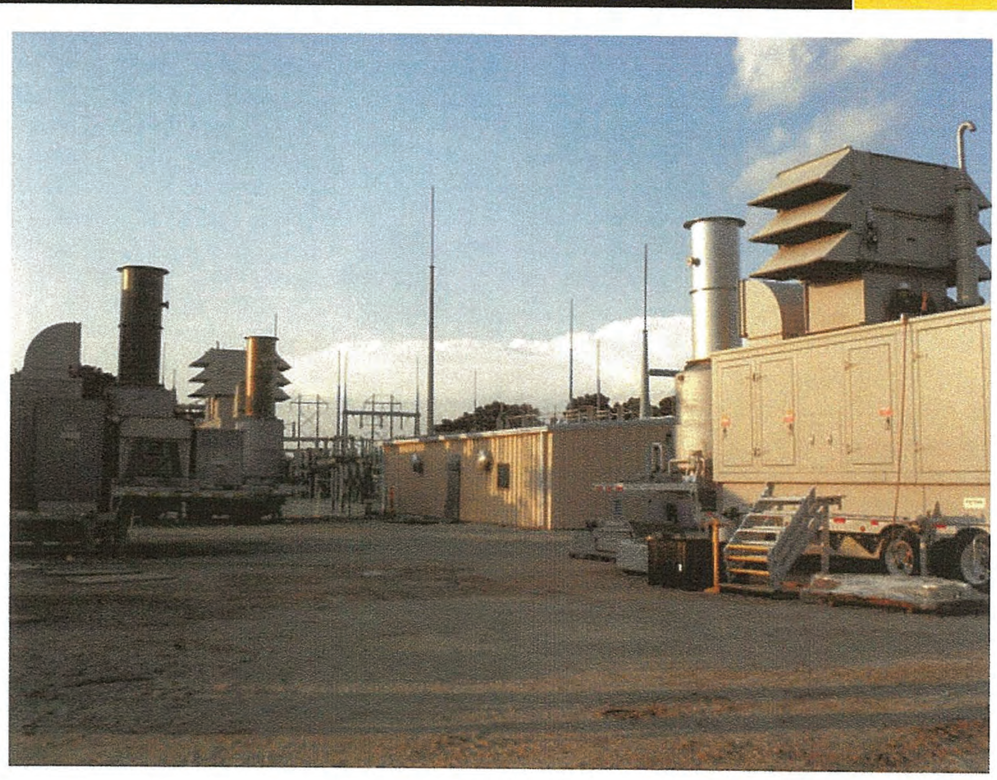
ICE—San Jose, Costa Rica 60MW Liquid Fuel

PETERSON CAT



Alliant Energy—Cedar Rapids, Iowa 15MW

PETERSON CAT

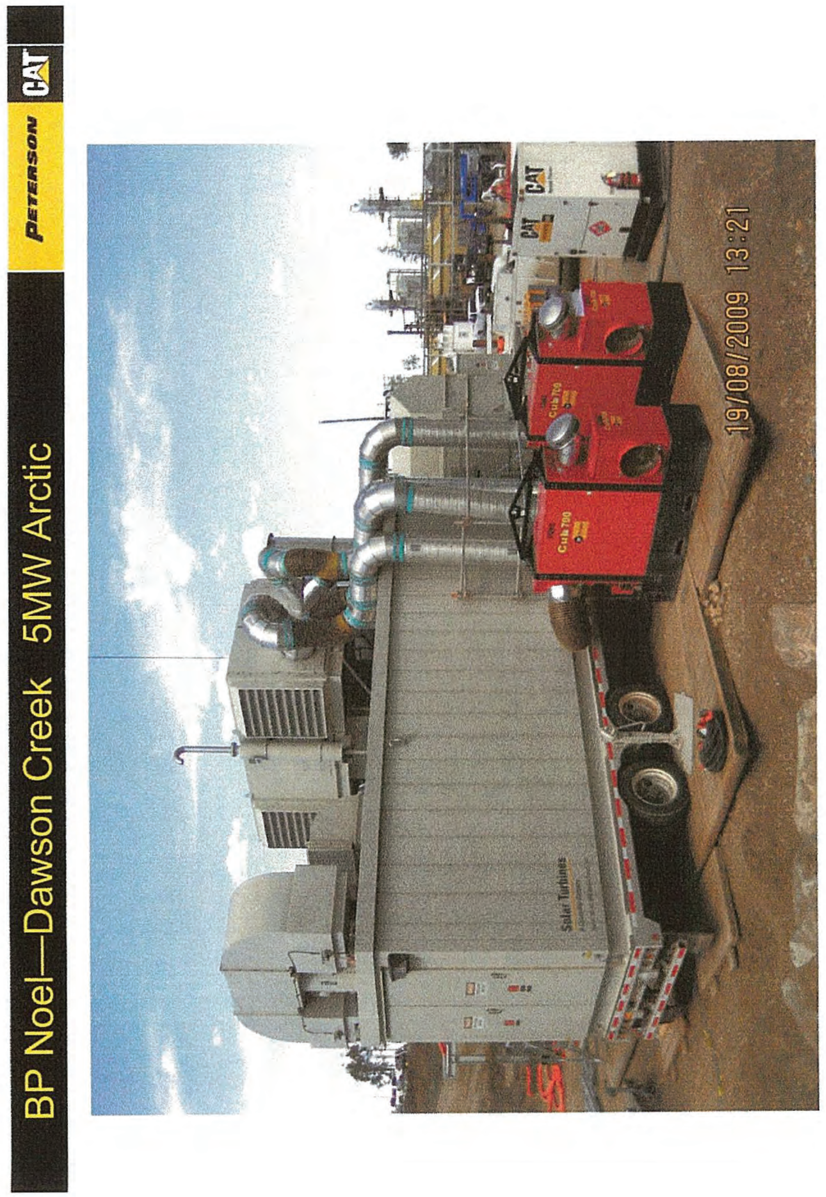


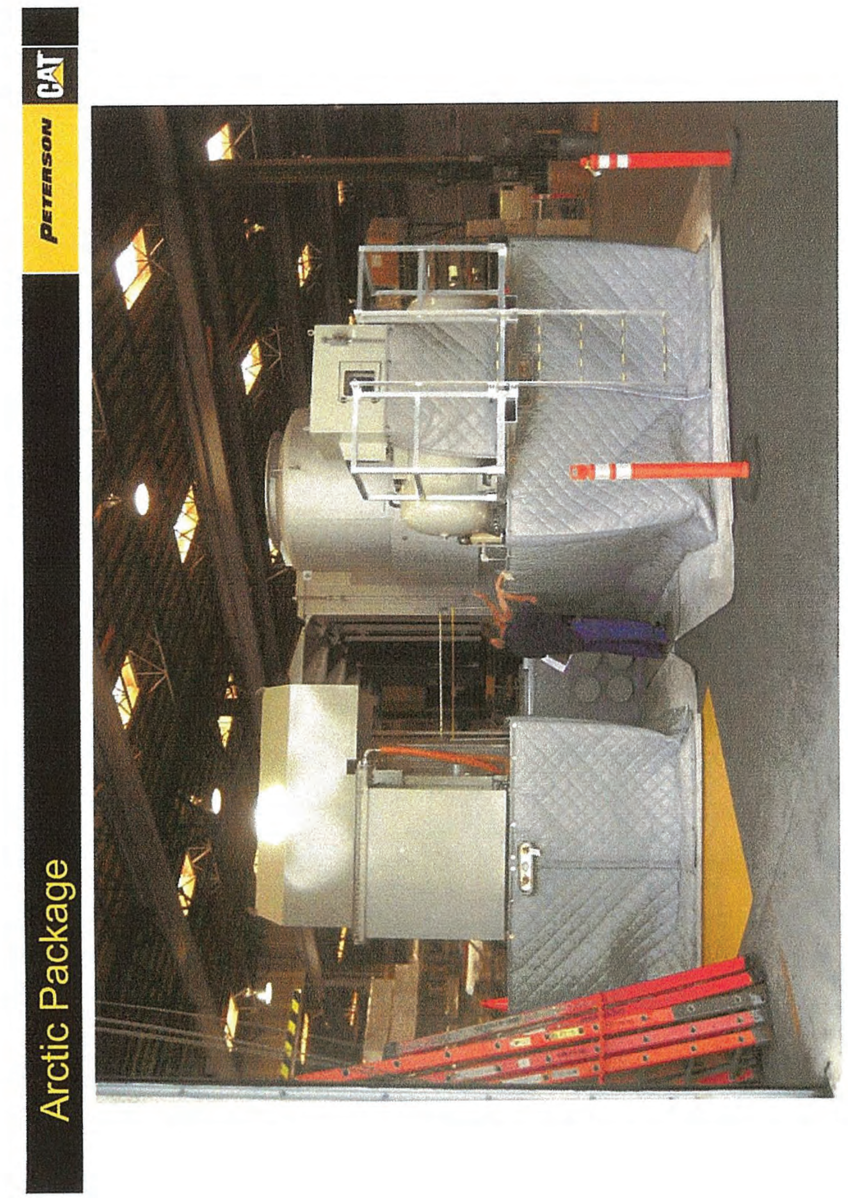
Spectra Energy—Chetwynd, BC 5MW

PETERSON CAT

Shell—Gabon, Africa 5MW

PETERSON CAT


PETERSON
CAT
BP Noel—Dawson Creek 5MW Arctic
19/08/2009 13:21
Solar Turbines


PETERSON
CAT
Arctic Package

CABCOG--Angola, Africa 10MW

PTTEP—Thailand 10MW

APPENDIX 6
BUDGETARY INFORMATION - ROLLS ROYCE

Seckington, Blair R

From: Ennis, David
Sent: Friday, July 01, 2011 7:30 AM
To: Seckington, Blair R; Rupert Merer; Bennett, Scott; Jones, David J (St. John's)
Subject: FW: 501 Mobile GenSets for NLH Holyrood Station
Attachments: Pictures of Mobile Package.ppt; P0079 501-KB7 GAS TURBINE 5200 MOBILE GEN SET.PDF; KB7s - Mobile Genset Perf.pdf

FYI

From: Hollis, Peter (RR Energy Systems) [mailto:peter.hollis@rolls-royce.com]
Sent: Thursday, June 30, 2011 6:57 PM
To: Ennis, David
Subject: 501 Mobile GenSets for NLH Holyrood Station

Dave,

Regarding your inquiry into portable generators for black start application at NLH's Holyrood Generating Station, I have attached information on the 501-KB7 mobile GenSet, including sample performance data and GA drawings. Nominal output of the KB7 is 5.2MW (ISO). The 501-KB5 with an ISO rating of 3.9MW can also be provided if lower output is preferred.

Budget price for the attached configuration is $4.1 – 4.3 Million; delivery is approx 1 year ARO.

As I mentioned on the phone, this equipment is packaged under Rolls-Royce license by OnPower, Inc. of Lebanon, Ohio. Should you decide to pursue this option, I will put you in direct contact with OnPower. Since it would appear this equipment will fit your requirements, please provide any additional information you have available so we can help you develop an optimized solution.

We have sold over 50 similar units to date.

I look forward to helping you develop a successful project with Rolls-Royce gas turbines.

Regards,

Peter Hollis
Rolls-Royce Energy
740-263-1479

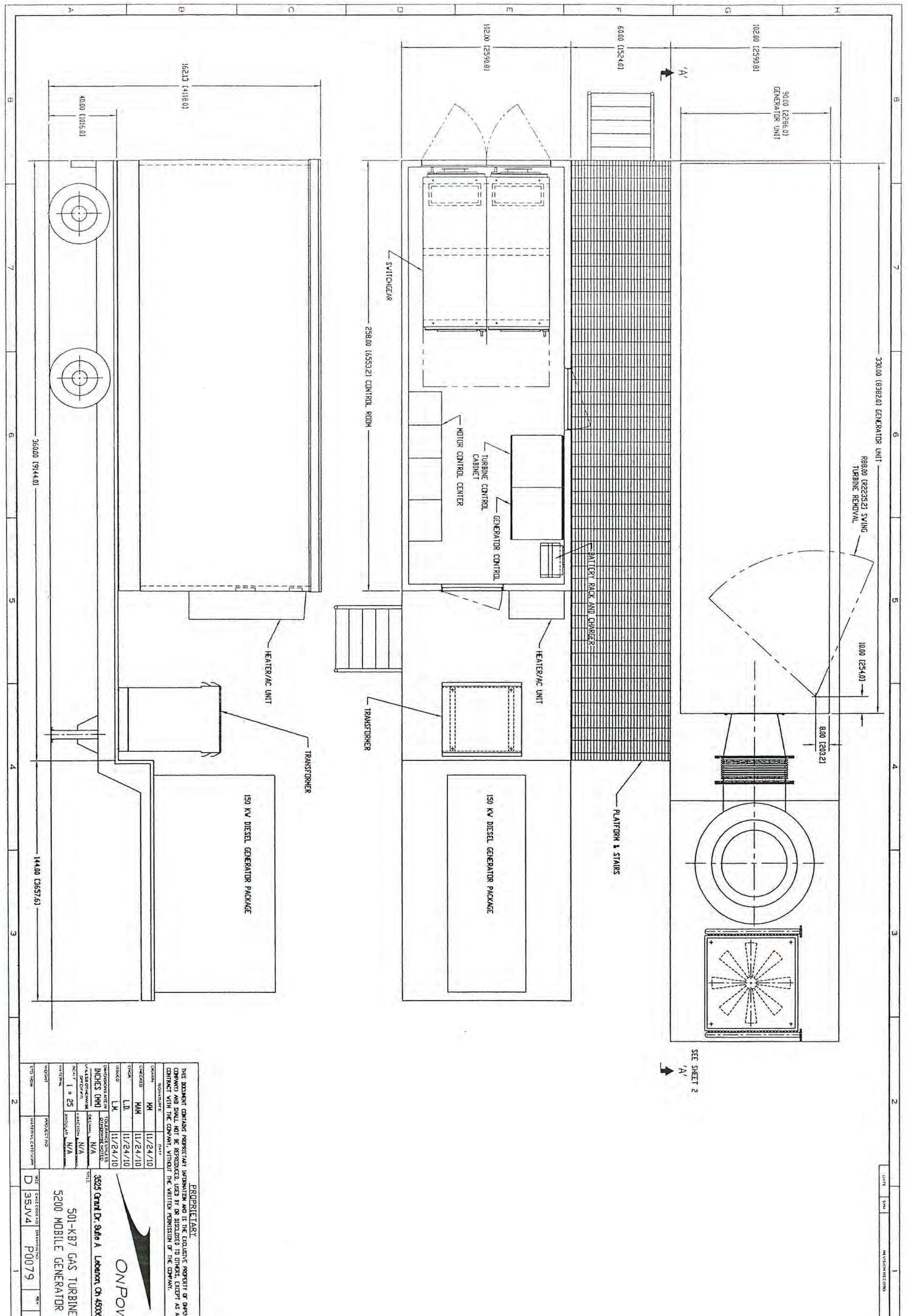
Rolls-Royce Corporation Industrial Engine Performance Estimate (EDR 19252G)

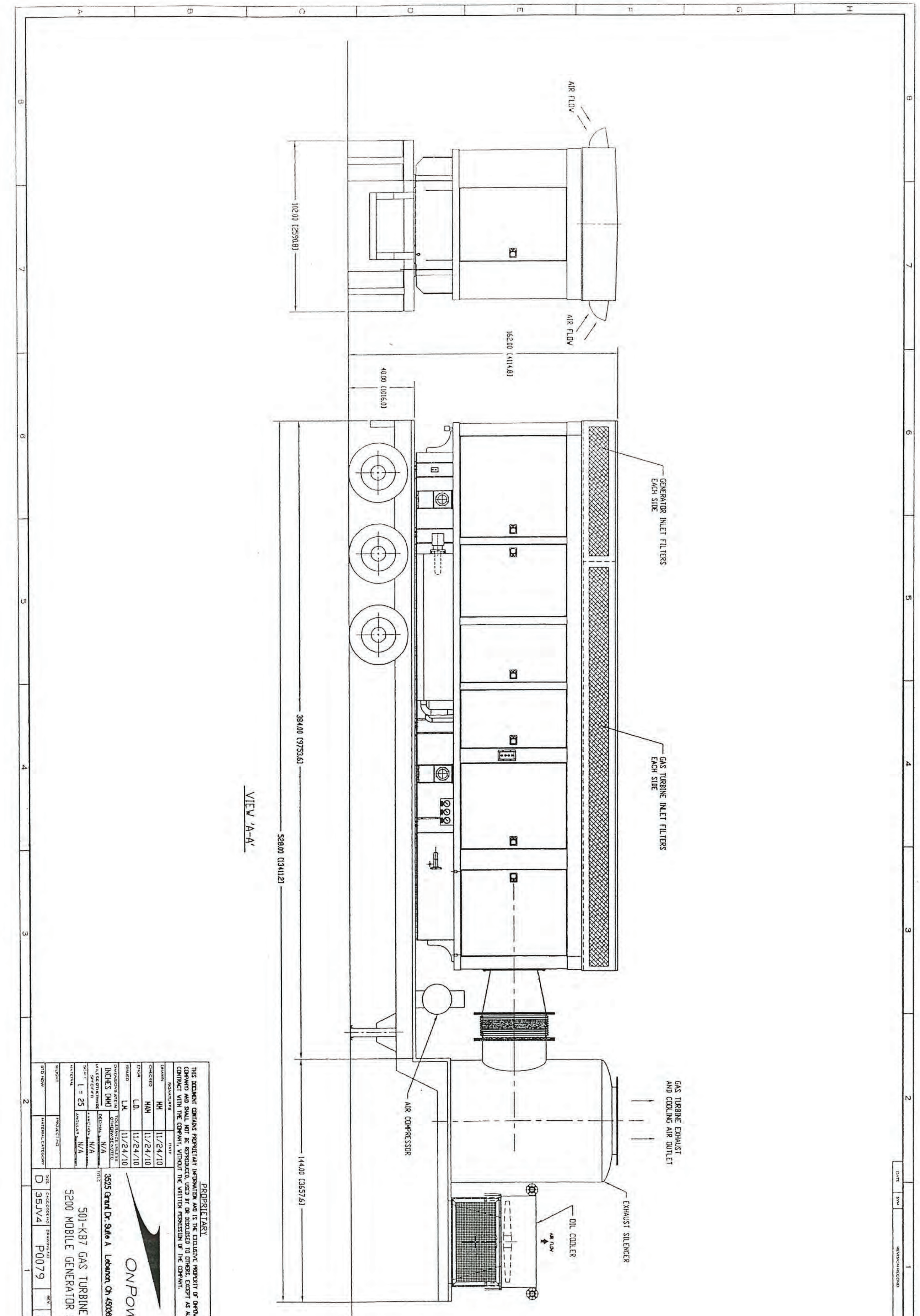
Date: Jun 11, 2011

Project: Mobile Genset

Engine Model: 501-KB7s

Parameter\Data Pt. No.	1	2	3	4	5	6	7	8	9	10	11	12
Altitude (feet)	400	400	400	400	400	400	400	400	400	400	400	400
Ambient Press. (psia)	14.485	14.485	14.485	14.485	14.485	14.485	14.485	14.485	14.485	14.485	14.485	14.485
Ambient Temp. (°F)	10	20	30	40	50	60	70	80	90	100	110	120
Ambient Relative Humidity	60	60	60	60	60	60	60	60	60	60	60	60
Inlet Loss ("H2O)	5	5	5	5	5	5	5	5	5	5	5	5
Exhaust Loss ("H2O)	6	6	6	6	6	6	6	6	6	6	6	6
Inlet Pressure (CIP, psia)	14.304	14.304	14.304	14.304	14.304	14.304	14.304	14.304	14.304	14.304	14.304	14.304
Inlet Temperature (CIT, °F)	10	20	30	40	50	60	70	80	90	100	110	120
Inlet Relative Humidity	60	60	60	60	60	60	60	60	60	60	60	60
Inlet Specific Humidity	0.000784	0.001282	0.002057	0.003147	0.004624	0.006685	0.009522	0.013382	0.018583	0.025533	0.034768	0.046994
Inlet Flow (lb/sec)	49.235	48.475	47.692	46.791	45.686	44.539	43.357	41.93	40.351	38.743	36.906	34.734
Bleed Flow (lb/sec)	0	0	0	0	0	0	0	0	0	0	0	0
Bleed Flow (% of Inlet)	0	0	0	0	0	0	0	0	0	0	0	0
Bleed Temperature (°F)	680	693	708	721	733	746	759	771	782	790	794	795
Bleed Pressure (psia)	222.268	218.911	215.705	211.801	206.963	202.131	197.203	191.256	184.558	177.433	169.219	159.388
CDT (°F)	680	693	708	721	733	746	759	771	782	790	794	795
CDP static (psia)	216.54	213.2	210.02	206.16	201.4	196.65	191.81	185.99	179.44	172.48	164.46	154.88
Combustion System	LE 3.1/3.2	LE 3.1/3.2	LE 3.1/3.2	LE 3.1/3.2	LE 3.1/3.2	LE 3.1/3.2	LE 3.1/3.2	LE 3.1/3.2	LE 3.1/3.2	LE 3.1/3.2	LE 3.1/3.2	LE 3.1/3.2
Noz Water/Fuel (lb/lb)	0	0	0	0	0	0	0	0	0	0	0	0
Noz Water Flow (lb/sec)	0	0	0	0	0	0	0	0	0	0	0	0
Noz Steam/Fuel (lb/lb)	0	0	0	0	0	0	0	0	0	0	0	0
Noz Stm Flow (lb/sec)	0	0	0	0	0	0	0	0	0	0	0	0
Noz Stm Temp. (°F)	—	—	—	—	—	—	—	—	—	—	—	—
Control Temp. (°F)	1935	1935	1935	1935	1935	1935	1935	1935	1935	1935	1935	1935
Fuel Flow (MMBTU/hr)	62.4096	60.8616	59.4999	57.9295	56.1352	54.5467	52.994	51.2931	49.3918	47.2263	44.8294	42.0446
Fuel Flow (lb/hr)	3391.82	3307.7	3233.69	3148.34	3050.83	2964.5	2880.11	2787.67	2684.33	2566.65	2436.38	2285.03
Output Shaft Speed (rpm)	14600	14600	14600	14600	14600	14600	14600	14600	14600	14600	14600	14600
Shaft Power (hp)	8366.5	8087.5	7813.4	7511.9	7156.8	6831.5	6503.6	6133.4	5721.3	5283.8	4802.5	4250.3
% of Full Load	100	100	100	100	100	100	100	100	100	100	100	100
SFC [lb/(hp*hr)]	0.4054	0.409	0.4139	0.4191	0.4263	0.4339	0.4428	0.4545	0.4692	0.4858	0.5073	0.5376
HeatRate[Shaft] BTU/(shp*hr)	7459	7525	7615	7712	7844	7985	8148	8363	8633	8938	9335	9892
Gear Box Losses	0.985	0.985	0.985	0.985	0.985	0.985	0.985	0.985	0.985	0.985	0.985	0.985
Generator Losses	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965
Generator Output (kWe)	5930.2	5732.5	5538.2	5324.5	5072.8	4842.2	4609.8	4347.4	4055.3	3745.2	3404.1	3012.7
HeatRate[Elec.]BTU/(kWe*hr)	10524	10617	10744	10880	11066	11265	11496	11798	12180	12610	13169	13956
Exhaust Flow (lb/sec)	49.957	49.176	48.375	47.455	46.328	45.162	43.962	42.516	40.915	39.282	37.416	35.213
Exhaust Temp. (f/a, °F)	901	905	913	920	928	940	952	968	985	998	1011	1026
Exhaust P-static (psia)	14.701	14.701	14.701	14.701	14.701	14.701	14.701	14.701	14.701	14.701	14.701	14.701
Fuel	Ref Liq	Ref Liq	Ref Liq	Ref Liq	Ref Liq	Ref Liq	Ref Liq	Ref Liq	Ref Liq	Ref Liq	Ref Liq	Ref Liq
Fuel LHV (BTU/lb)	18400	18400	18400	18400	18400	18400	18400	18400	18400	18400	18400	18400
H/C (wt ratio)	0.16786	0.16786	0.16786	0.16786	0.16786	0.16786	0.16786	0.16786	0.16786	0.16786	0.16786	0.16786
Synthetic Molecule												
Mols Carbon	1	1	1	1	1	1	1	1	1	1	1	1
Mols Hydrogen	1.9466	1.9466	1.9466	1.9466	1.9466	1.9466	1.9466	1.9466	1.9466	1.9466	1.9466	1.9466
Mols Oxygen	0	0	0	0	0	0	0	0	0	0	0	0
Mols Nitrogen	0	0	0	0	0	0	0	0	0	0	0	0
Mols Sulfur	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013
Fuel Specific Gravity	0	0	0	0	0	0	0	0	0	0	0	0
CO_2	3.9232	3.8839	3.8553	3.82	3.7831	3.7589	3.7351	3.7157	3.6881	3.6342	3.5717	3.4953
H_2O	3.9125	3.953	4.0474	4.1845	4.3801	4.6776	5.0931	5.6647	6.4224	7.3993	8.6728	10.3092
O_2	14.7331	14.779	14.7989	14.819	14.8291	14.8002	14.746	14.6529	14.532	14.4016	14.221	13.9833
N_2	76.5081	76.4615	76.377	76.2565	76.0898	75.8483	75.5149	75.0612	74.4592	73.6761	72.658	71.3514
Ar	0.9181	0.9175	0.9165	0.9151	0.9131	0.9102	0.9062	0.9007	0.8935	0.8841	0.8719	0.8562
SO_2 (ppm)	50.6018	50.0909	49.7196	49.2611	48.7827	48.4689	48.1612	47.9114	47.5565	46.8601	46.052	45.0658


SWITCHGEAR
MOTOR CONTROL CENTER
TURBINE CONTROL CABINET
GENERATOR CONTROL
BATTERY RACK AND CHARGER
HEATER/AC UNIT
TRANSFORMER
PLATFORM & STAIRS
150 KV DIESEL GENERATOR PACKAGE
SEE SHEET 2
PROPRIETARY
501-KB7 GAS TURBINE
5200 MOBILE GENERATOR SE
P0079


AIR FLOW
VIEW 'A-A'
GENERATOR INLET FILTERS EACH SIDE
GAS TURBINE INLET FILTERS EACH SIDE
GAS TURBINE EXHAUST AND COOLING AIR OUTLET
AIR COMPRESSOR
EXHAUST SILENCER
OIL COOLER
PROPRIETARY
501-KB7 GAS TURBINE
5200 MOBILE GENERATOR SE
P0079

Seckington, Blair R

From:	Ennis, David
Sent:	Monday, July 18, 2011 6:36 AM
To:	Seckington, Blair R; Jones, David J (St. John's); Duplessis, Andrew
Cc:	Bennett, Scott
Subject:	FW: RR501 Mobile Genset
Attachments:	OPI Overview 2010.pdf

FYI

From: Larry Davis [mailto:Larry.Davis@onpowerinc.com]
Sent: Saturday, July 16, 2011 1:29 PM
To: Ennis, David
Cc: 'Hollis, Peter (RR Energy Systems)'
Subject: RR501 Mobile Genset

David,

The unit can run on No. 2 diesel without any problem. The package will be designed to operate at your low ambient temperature. We would likely use an electric heater or two to maintain reasonable interior temperature when system is not operating. We have also re-circulated generator cooling air when running to maintain interior temperature. We currently have 4 units being refurbished for sale which we may be able to convert to a mobile configuration. The price would be approximately $ 1 M less than a new package. A new mobile set would sell for around $ 4 M.

I will have our engineering group put a drawing together to see how this would look and send to you for review so we can discuss the possibility.

Operation – 60 Hrs/Yr: The package normally would require only an annual service and inspection by our service personnel. Most utilities would exercise the equipment once a month to verify proper operation.

Most of this information will be included in our formal proposal. (Attached is a profile on our company)

Larry D. Davis

OnPower, Inc.
3525 Grant Drive
Lebanon, OH. 45036
P 513-228-2100
F 513-228-0111
C 513-885-9922
E Larry.Davis@onpowerinc.com

ONPOWER

ONPOWER, INC.
3525 Grant Drive
Lebanon, Ohio 45036
T 513.228.2100
F 513.228.0111

COMPANY OVERVIEW

OnPower, Inc. is composed of highly experienced equipment packing specialists. The company specializes in rotating equipment, controls and support systems for power generation and marine propulsion. OnPower, established in June 2001 by Larry D. Davis, former president of U.S. Turbine Corporation, a firm well known for providing top quality power generation equipment and services. Concentrating on electric power generation and marine propulsion packages since 2001, OnPower was selected in 2003 to design, engineer and package, in conjunction with Rolls-Royce Fuel Cell systems, a 1 MW – Solid Oxide Fuel Cell System. As a result this successful project and our significant gas turbine packaging experience, OnPower was appointed as sole distributor in the Americas for the Rolls-Royce 501-KB industrial gas turbines.

OnPower offers innovative industrial and marine engineering, design and manufacturing capability for industrial, oil & gas and marine power systems. Products are supported in the field with OPI trained service engineers having many years of rotating equipment experience.

OnPower staff composed of experienced mechanical, electrical and systems engineers, supported by designers and technical staff, using an integrated team business approach, produce innovative power product solutions. OnPower understands and designs to established engineering standards (API, ANSI, ASME, DNV etc.) but is not constrained to standard designs. OnPower's depth and breadth of experience combined with our project management skills allow us to offer unique innovative product design and the ability to focus on specific project needs for special purpose applications.

Product/Service Offerings

OnPower is a complete in-house electrical and mechanical systems provider. We provide diverse products and services to support multiple areas of power propulsion and electrical generation technology. The Company is ISO 9001:2008 certified furthering our commitment to providing quality products and services. When developing new products we enable clients to expand their product offerings and supplement their in-house engineering capabilities without additional staff, and tailor engineering solutions for each specific project using optimal resources and required skills.

O.E.M. Manufacture Agreements

- R. R. Corp. Authorized Distributor for Industrial 501-KB gas turbine.
- Air Products – Proprietary Liquid Air Energy Storage System

OnPower, Inc. has manufacture Non-Disclosure agreements with:

- R. R. Energy Systems, Inc. Approved Supplier no. 219623
- R. R. Fuel Cell Systems, Inc.
- R. R. Naval Marine, Inc.
- Pratt & Whitney & Vericor

Recent Projects

OnPower's recent gas turbine propulsion unit design and package projects include:

- Twelve mechanical gas turbine drive packages for the Norwegian Navy FPB
- Three mechanical gas turbine drive packages for a high-speed mega-yacht
- 1 MW SOFC for RRFCS
- RR 501-KB Dual fuel arctic duty generator package for Canadian utility
- RR 501-KB5 Off shore Platform generator package for a RR Engineered Solutions
- Closed loop recuperative Rankine cycle waste heat recovery power system utilizing 3000 psi CO_2 as the working fluid.

Personnel/Competencies

OnPower team members include engineering, design and technical professionals with extensive design-build, project management and field service experience. OnPower employs industry experts with more than twenty five years each of applied experience in structural engineering, mechanical & electrical systems design, controls engineering and support operations. Specific expertise has been achieved utilizing prime movers manufactured by Rolls-Royce Allison, Pratt & Whitney, General Electric and Allied Signal/Lycoming and speed reducing gearboxes manufactured by Renk, Allen Gears, Philadelphia Gear, Cincinnati Gear and Lufkin Gear. OnPower team members have also successfully completed several diesel engine gensets working with manufacturers like Cooper Superior, EMD and Detroit Diesel/MTU.

Product development includes component evaluations and system FMEA failure analysis. Design methods include PC work stations with Unigraphics 3-D modeling capability with AutoCAD® for design and manufacturing. Analysis capabilities are augmented by ANSYS, I-deas, ABAQUS, NASTRAN and Cosmos/M® Finite Element Analysis software. Fluent Software is used to conduct CFD analysis.

This combination of talent and analytical tools provides all of the essential elements needed to design and produce state of the art gas turbine driven systems for industrial and marine applications. **OnPower, Inc. is a complete power system provider.**

<u>Design & Manufacturing Facilities</u>

- Office and Engineering Space: 8,250 SF
- Fabrication and Assembly Space: 75,000 SF
- Material Handling:
  - Bridge Cranes - 32 tons; 4 tons; 3 tons
  - Coating Capabilities – 14' x 32' paint booth with drying capability
  - Truck docks and ramps (easy access to Interstate)
- Facility equipped with several welding processes and light machining
- Electrical and Controls clean room assembly area

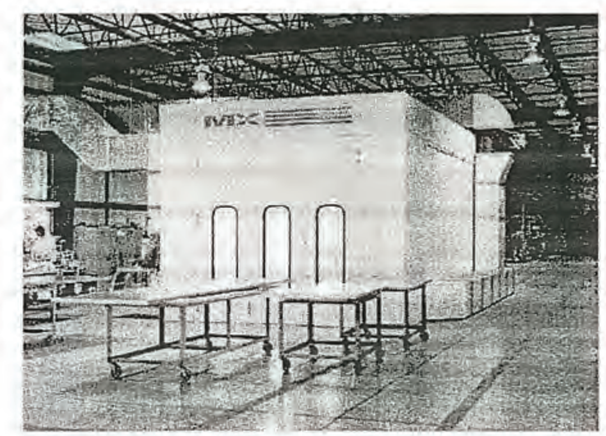
<u>Gas Turbine Equipment Testing Facility</u>

- Test Pad – Concrete slab 100' x 150'
- Natural Gas & Liquid Fuel Capability
- 10 MW Resistive Load Bank
- 5KV & 15 KV, 50/60Hz Switch gear
- 480V – 400 kW Auxiliary Diesel Genset

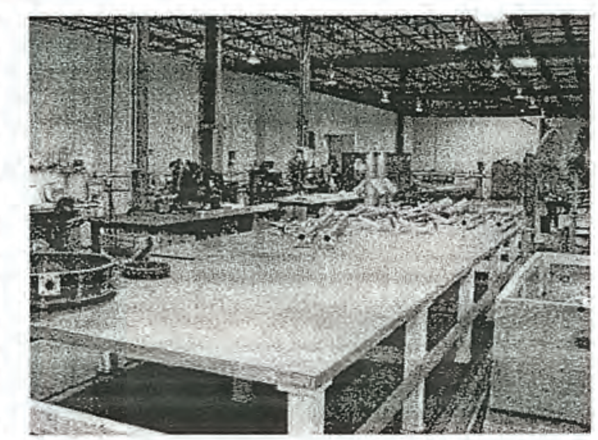
- Power Control Room – 12' x 20'
- Data Acquisition System with high speed transient capture capabilities

Experience List of Completed Designs & Manufactured Packages

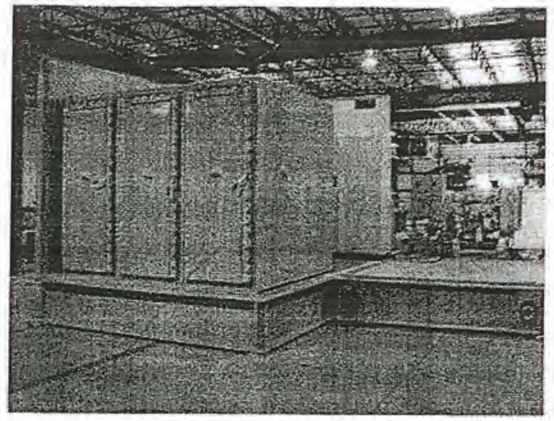
Package Description	No. of units
RR501KB Gas Turbine Generator Sets	187
RR501KH Gas Turbine Generator Sets	6
RR501KM Gas Turbine Generator Set	1
RR570KC Gas Turbine Mech. Drive Sets	6
RR571KB Gas Turbine Generator Sets	2
RR601KB Gas Turbine Generator Sets	3
GE LM1500 Gas Turbine Generator Sets	1
GE LM2500 Gas Turbine Mobile Generator Sets	2
GE LM2500 Gas Turbine Generator Sets	1
KHI M1A-01& M1A-13 Gas Turbine Generator Sets	13
MHI MF-111 Gas Turbine Generator Sets	5
EMD 8/12/16/20 Cyl. Gen Sets & Mech Dr.	43
Superior Gas Engines Gensets	31
P&W Dual ST18/ST40 Mech Drive	12
P&W ST40 Mech Drive	3
RRFCS – SOFC Genset	1
CO2 – Heat Engine	1
Total Packages	**318+**

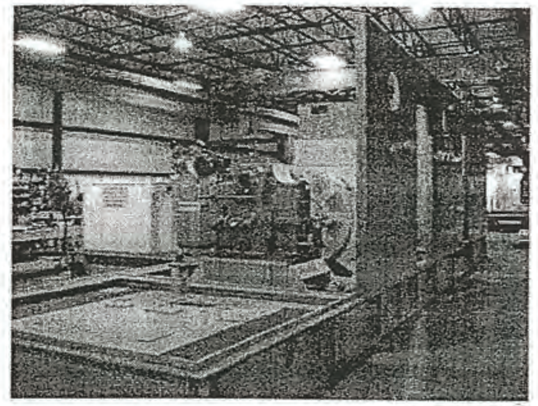


Paint Booth

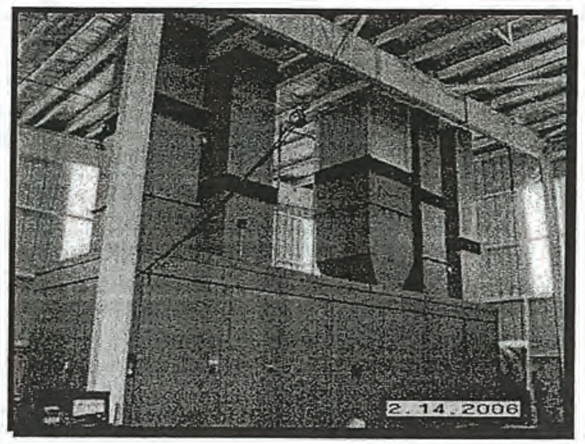


Weld Station

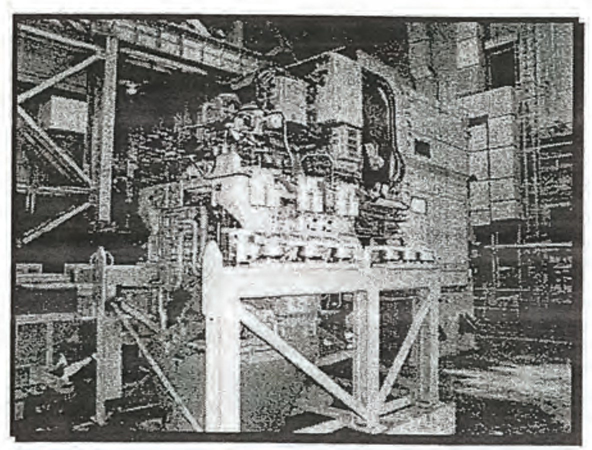




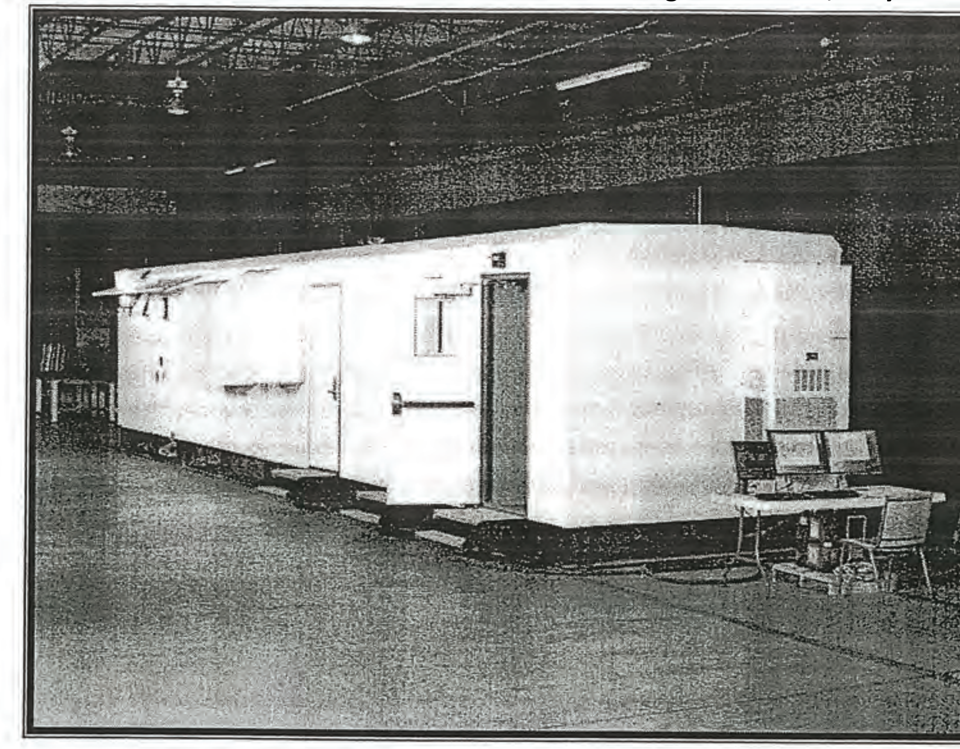
Dual Fuel RR501KB (Arctic Duty) Generator Package



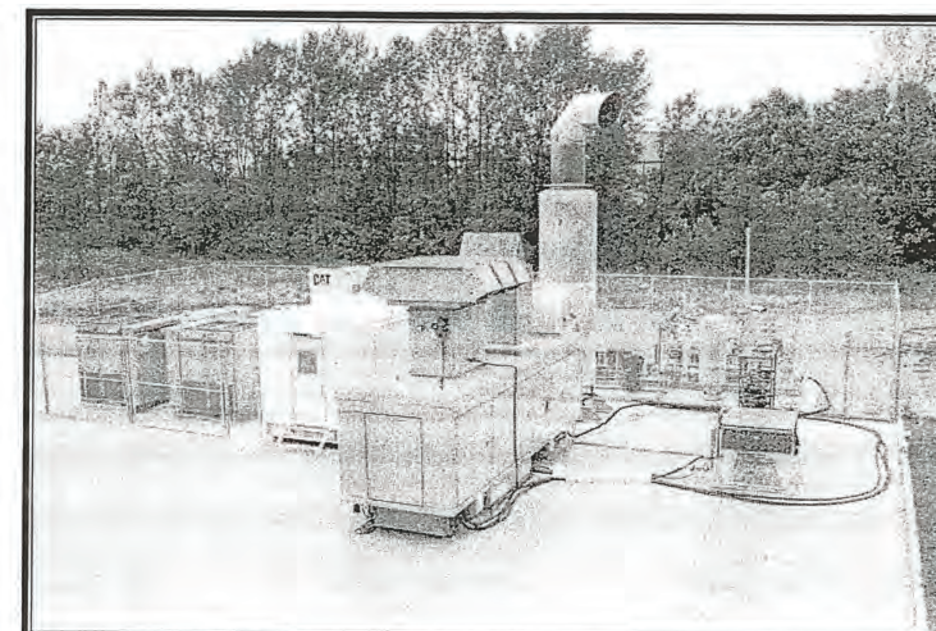
Steam Injected RR501KH7 Generator Packages



RNON Skjold Class Fast Patrol Boat – 12 Units
(Twin turbine drive w/Renk Reduction Gear)



Solid Oxide Fuel Cell - 1 MW Package



ONPOWER TEST FACILITY
(RR 501 KB5 PLATFORM PACKAGE ON TEST)

APPENDIX 7
EXISTING UNIT REFURBISHMENT CAPITAL COST DETAILS

Appendix 7

ExISTING UNIT REFURBISHMENT CAPITAL COST DETAILS

Base Existing GT Unit Refurbishment

Capital Cost

Existing Gas Turbine Generator and Major Auxiliaries.

Capital cost estimate $,000 Can 2011

	Gas Turbine Generator & Auxiliaries	Material	Labour	Total	Range
	Gas Generator (Avon)	$500	$0	$500	$400-$700
	Power Turbine	$534	$402	$936	$900-$1,100
	Disassemble/reassemble	$0	$75	$75	
	New Disk	$331	$0	$331	
	Moving blades	$93	$0	$93	
	Rotor rehabilitation	$0	$282	$282	
	Inlet structure repairs	$10	$5	$15	
	Diaphragm section	$30	$10	$40	
	Bearings	$50	$20	$70	
	Exhaust volute	$20	$10	$30	
	Gearbox	$125	$39	$164	$125-$200
	Bearings	$80	$34	$114	
	Gearbox venting	$20	$5	$25	
	Contingency; 2nd opinion	$25	$0	$25	
	Generator and aux	$950	$0	$950	$150-$1,200
	Generator	$900	$0	$900	
	Exciter	$50	$0	$50	
	Inlet filter	$120	$30	$150	$100-$1200
	Exhaust stack	$40	$10	$50	$30-$75
	Commission unit		$50	$50	$30-$75
	Sub-Total	$2,269	$531	$2,800	$2,400-$3,500
	Contingency (excl Avon)	$125	$25	$150	$100-$250
	SUB-TOTAL -GTG & Auxiliaries	$2,394	$556	$2,950	$2,500 - $3,750

	Site Civil & Structural Works - Rental Unit	Material	Labour	Total	Range
	Geotech Investigation - bearing capacity of soil	$0	$4	$4	$3-$10
	Pre-engineered shelter for elec. equipment	$40	$5	$45	$37-$55
	Concrete cable trench	$60	$10	$70	$60-$85
	Repair sections of roofing and siding that are corroded	$3	$2	$5	$3-$8
	Building extension shelter - for elec. equipment expansion	$30	$10	$40	$30-$50
	Building extension shelter - turbine fuel line mechanical equipment	$30	$10	$40	$30-$50
	Sub-Total	$163	$41	$204	$175-$250
10%	**Contingency**	$16	$4	$20	$20-$25
	TOTAL Civil Works	$179	$45	$224	$195-$275

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Base Existing GT Unit Refurbishment (Contd)

Capital Cost

Existing Gas Turbine Generator and Major Auxiliaries.

Capital cost estimate $,000 Can 2011

	Electrical Systems	Material	Labour	Total	Range
	Installation new 800A, 13.8 kV, 3ph, 60Hz Generator Main Breake	$126.86	$12.80	$139.66	
	Removal of Existing Main Breaker		$1.60	$1.60	
	Installation of Cable Tray	$3.50	$1.25	$4.75	
	Installation of New Junction Box	$1.00	$0.48	$1.48	
	Removal of Existing Power Cables from Existing Breaker to Generator and T9 Transformer		$1.60	$1.60	
	Installation of New Power Cables from New Breaker to Generator (2 x 500kcmil) and T9 Transformer (2x500kcmil)	$50.00	$10.00	$60.00	
	Connection of Existing and Used CT, PT and Control Cables in New JB, and run the new CT, PT and Control Cables from new JB to new 13.8 kV Main Breaker (4 x 4c10, 1 x 4c12, 1 x 12c12).	$0.60	$1.60	$2.20	
	Installation of New 13.8kV Fusible Switch			$0.00	
	Removal of Existing 13.8 kV Fusible Switch		$1.60	$1.60	
	Install 3c2AWG, Teeck, 15kV, Cable from 112kVA Transformer to new 13.8kV Fusible Switch	$0.75	$0.30	$1.05	
	Remove Existing MCC		$8.00	$8.00	
	Install New MCC	$30.00	$8.00	$38.00	
	Install Cable Tray	$1.60	$0.90	$2.50	
	Install New Incoming and Feeder Cables for 600V Circuits			$0.00	
	3C12, Teck, 1000V, (Seven Circuits)	$1.26	$0.53	$1.79	
	3c10, Teck, 1000V, (One Circuit)	$0.24	$0.12	$0.36	
	3c6, Teck, 1000V, (Five Circuits)	$1.03	$0.35	$1.38	
	3c2, Teck, 1000V, (One Circuit)	$1.04	$0.20	$1.24	
	Install New 230V, 3ph, Auxiliary Distribution Panel	$0.65	$0.35	$1.00	
	Relocate 30kVA, 3ph, 550:230V Transformer and Connect to MCC and New 230V, 3ph, Auxiliary Distribution Panel		$3.00	$3.00	
	3c12, Teck, 1000V (One Circuit)	$0.18	$0.08	$0.26	
	3c10, Teck, 1000V, (Two Circuits)	$0.12	$0.06	$0.18	
	Install new 110VDC,. NEMA 1 Breaker, new NEMA1 Splitter, new DC Starters, and Existing 100A DC Distribution Panel	$31.00	$6.40	$37.40	
	Install New Feeders from Splitter to DC Starters and DC Distribution Panel			$0.00	
	3c12, Teck, 1000V (One Circuit)	$0.18	$0.08	$0.26	
	3c10, Teck, 1000V, (One Circuit)	$0.21	$0.12	$0.33	
	3c2, Teck 1000V (One Circuit)	$0.41	$0.14	$0.55	
	Remove Existing AVR/Start Rectifier		$1.60	$1.60	
	Install New AVR/Start Rectifier	$145.00	$20.00	$165.00	
	Miscellaneous Hardware, Tray and 4/0 Grounding	$7.50	$7.50	$15.00	
	Sub-Total	$403	$89	$492	$450-$600
10%	**Contingency**	$40	$9	$49	$45-$60
	TOTAL Electrical Works	$443	$98	$541	$500-$650

Base Existing GT Unit Refurbishment (Contd)

Capital Cost
Existing Gas Turbine Generator and Major Auxiliaries.

Capital cost estimate $,000 Can 2011

BOP Systems		Material	Labour	Total	Range
	Fuel enclosure (See Civil/Structural)				
	Fuel piping	$60	$15	$75	$60-$90
	Stack removal	$0	$75	$75	$25-$35
	Inergen system	$7	$3	$10	$7-$15
	Lube oil cooler	$130	$10	$140	$75-$175
	Sub-Total	**$197**	**$103**	**$300**	**$150-$320**
10%	**Contingency**	**$20**	**$10**	**$30**	
	TOTAL BOP	**$217**	**$113**	**$330**	**$180-$350**

TOTAL DIRECTS		Material	Labour	Total	Range
	Sub-Total	**$3,032**	**$764**	**$3,796**	**$3,200-$4670**
	Contingency	**$201**	**$48**	**$250**	
TOTAL DIRECTS		**$3,234**	**$812**	**$4,046**	**$3,500-$5,000**

Project Engineering Costs Mechanical		Material	Labour	Total	Range
	Project Engineering Costs		$324	$324	
	Project Management Costs		$283	$283	
	TOTAL Project Engineering & Management	**$0**	**$607**	**$607**	**$550-$700**

Total Without Transition Replacement	Material	Labour	Total	Range
	$3,234	**$1,419**	**$4,652**	**$4,000-$5,700**

Standby Option – Installing Leased Gas generator and Power Turbine Parts To Reduce Unit Outage

Capital Cost
Existing Gas Turbine Generator and Major Auxiliaries.

Capital cost estimate $,000 Can 2011

Total Without Transition Replacement	Material	Labour	Total	Range
	$3,234	**$1,419**	**$4,652**	**$4,000-$5,700**

Standby Unit Costs - Leased Parts (Substituting Gas Generator & PT During Refurb)		Material	Labour	Total	Range
	Gas Generator Rental and Use	$42	$10	$52	
	Power Turbine Rental & Use	$42	$11	$53	
	Gas Generator Delivery	$10	$10	$20	
	Power Turbine Delivery	$10	$10	$20	
	Sub-Total	**$103**	**$41**	**$144**	**$125-$200**
20%	**Contingency**	**$21**	**$8**	**$29**	
	TOTAL GTG Lease Parts	**$124**	**$49**	**$173**	**$150-$225**

Total Including Lease Parts	Material	Labour	Total	Range
	$3,357	**$1,468**	**$4,825**	**$4,150-$5,900**

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Standby Option – Installing Leased Gas generator and Power Turbine Parts To Reduce Unit Outage

Standby Option –Leased Nearly new 2 x 5 MW GT To Reduce Unit Outage

Capital Cost
Existing Gas Turbine Generator and Major Auxiliaries.

Capital cost estimate $,000 Can 2011

Total Without Transition Replacement	Material	Labour	Total	Range
	$3,234	**$1,419**	**$4,652**	**$4,000-$5,700**

New GT Replacement During Outage		Material	Labour	Total	Range
	GT Lease - 2 x 5 MW				
	Rental ($/mo/GT=$105k for 2 GT and 10 months)	$2,100	$0	$2,100	
	Hourly operation charge (Assume $41/hr/GT x 1/mo x 2 Hrs)	$2	$0	$2	
	Delivery to Site (k$/GT)	$70		$70	
	Removal from site (k$/GT)	$70		$70	
	Mobilization (k$/GT)	$30		$30	
	Setup/Commissioning (k$/GT)		$220	$220	
	Breakdown/Demob (k$/GT)	$100		$100	
	Sub-Total	**$2,372**	**$220**	**$2,592**	
	Tax 10-15%	$237	$22	$259	
	Sub-Total	**$2,609**	**$242**	**$2,851**	**$2,500-$3,300**
10%	Contingency	$261	$24	$285	$250-$350
	TOTAL GT Lease	**$2,870**	**$266**	**$3,136**	**$2,750-$3,650**

Site Civil & Structural Works - Rental Unit		Material	Labour	Total	Range
	Geotech Investigation - bearing capacity of soil	$0	$4	$4	$3-$10
	Pre-engineered shelter for elec. equipment	$40	$5	$45	$37-$55
	Concrete cable trench	$60	$10	$70	$60-$85
	Sub-Total	**$100**	**$19**	**$119**	**$100-$150**
10%	**Contingency**	**$10**	**$2**	**$12**	**$10-$15**
	TOTAL Civil Works - rental Unit	**$110**	**$21**	**$131**	**$110-$165**

Electrical Systems - Rental Unit		Material	Labour	Total	Range
	3c500 kemil, Teck 15kV cable	$112.8	$10.0	$123	
	13.8kV isolating switchgear (3+1 fused switch)	$95.0	$10.0	$105	
	P&C/DCS interface	$55.0	$10.0	$65	
	10 x 3c12AWG, Teck, 1000V cable	$1.0	$2.3	$3	
	2 x 25c16AWG, Teck, 1000V cable	$8.5	$3.2	$12	
	4 x 4c12AWG, Teck, 1000V cable	$3.3	$6.3	$10	
	1 x 12C12AWG, Teck, 1000V cable	$2.2	$1.6	$4	
	3c2AWG, Teck, 15kV cable	$0.9	$0.3	$1	
	2 x 3c1/0, Teck, 1000V cable	$4.5	$1.1	$6	
	112kVA, 13.8kV:575V, 3ph, 60Hz transformer	$30.0	$3.0	$33	
	200A, 600V, 3ph, 60Hz automatic transfer switch	$5.3	$1.5	$7	
	200A, 600V, 3ph, 60Hz manual transfer switch	$2.0	$1.0	$3	
	MCC, 600A, 600V, 3ph, 3W	$30.0	$5.0	$35	
	30kVA, 575:120/280V, 3ph, 60Hz transformer	$1.0	$0.5	$2	
	129VDC distribution panel, motor starters and disconnects	$35.0	$6.5	$42	
	100A, 120/208V, 3ph, 60Hz distribution panel c/w breakers	$1.4	$0.4	$2	
	600V, battery charger, 129VDC output	$16.0	$3.2	$19	
	129VDC battery bank	$39.0	$7.5	$47	
	All interconnecting cabling	$16.0	$12.0	$28	
	Miscellaneous 4/0 ground wire, conducts trays and hardware	$16.0	$9.0	$25	
	Reconfiguration of DCS screens, conducts and existing system	$0.0	$25.0	$25	
	25kVA, 13.8kV, 3ph, 60Hz, zig-zag grounding transformer	$31.0	$2.0	$33	
	Commissioning	**$0.0**	**$63.0**	$63	
	Sub-Total	**$506**	**$184**	**$690**	**$650-$800**
10%	Contingency	$51	$18	$69	$65-$80
	TOTAL Electrical Works - Rental Unit	**$557**	**$203**	**$759**	**$725-$880**

Standby Option –Leased Nearly new 2 x 5 MW GT To Reduce Unit Outage (Contd)

Capital Cost
Existing Gas Turbine Generator and Major Auxiliaries.

Capital cost estimate $,000 Can 2011

BOP Systems - Rental Units		Material	Labour	Total	Range
	3" supply and return fuel line	$55	$22	$110	
	Sub-Total	$55	$22	$110	$100-$125
10%	Contingency	$6	$2	$11	$10-$13
	TOTAL BOP Rental Units - Rental Unit	$61	$24	$121	$110-$138

TOTAL DIRECTS - Rental Units		Material	Labour	Total	Range
	Sub-Total	$3,270	$467	$3,770	$3,500-$4,000
	Contingency	$327	$47	$377	$250-$500
TOTAL DIRECTS - Rental Units		$3,597	$514	$4,147	$3,750-$4,500

Project Engineering & Management Costs - Rental Units		Material	Labour	Total	Range
	Project Engineering Costs		$332	$332	
	Project Management Costs		$290	$290	
	TOTAL Project Engineering & Management - Rental	$0	$622	$622	$500-$750

	Material	Labour	Total	Range
Sub-Total Rental Units	$3,597	$1,136	$4,769	$4,250-$5,550

	Material	Labour	Total	Range
Total Including Rental Unit	$6,830	$2,555	$9,421	$8,400-$11,500

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APPENDIX 8
DRAWINGS FROM HYDRO

The following drawings will be provided to CONSULTANT for information during the PROJECT:

Holyrood Generating Station - Stage 1 238 - 13 - 3000 – 003 Gas Turbine Unit Relaying and Metering 3 Line A.C. Schematic
Holyrood Generating Station 238 - 13 - 3000 – 007 Gas Turbine Unit - Cabinet No. 4 Control & Protection, Turbine &Generator Wiring Diagram (5 of 5)
Holyrood Generating Station 238 - 13 - 3000 – 007 Gas Turbine - Cabinet No. 3 Termination Assembly Layout and Wiring Diagram (Sheet 4A of 5)
Holyrood Generating Station 238 - 13 - 3000 – 007 Gas Turbine Unit - Cabinet No. 3 Control & Protection, Turbine &Generator (4 of 5)
Holyrood Generating Station 238 - 13 - 3000 – 007 Gas Turbine - Cabinet No. 2 Termination Assembly Layout and Wiring Diagram (Sheet 3A of 5)
Holyrood Generating Station 238 - 13 - 3000 – 007 Gas Turbine Unit - Cabinet No. 2 Control & Protection, Turbine & Generator Wiring Diagram (3 of 5)
Holyrood Generating Station 238 - 13 - 3000 – 007 Gas Turbine - Cabinet No. 1 Termination Assembly Layout and Wiring Diagram (Sheet 2A of 5)
Holyrood Generating Station 238 - 13 3000 – 007 Panel, Control & Protection, Turbine and Generator Cabinet No. 1 Wiring Diagram (Sheet 2 of 5)
Holyrood Generating Station 238 - 13 - 3000 – 007 Gas Turbine - Cabinet No. 5 DCS Layout and Wiring Diagram (Sheet 7)
Holyrood Generating Station 238 - 13 - 3000 – 008 Gas Turbine Unit Interconnections, Site Wiring Diagram (Sheet 1 of 3)
Holyrood Generating Station 238- 13 - 3000 – 010 Gas Turbine Unit Control & Protection Schematic Diagram (Sheet 1 of 6)
Holyrood Generating Station 238- 13- 3000-010 Gas Turbine Unit Control & Protection Schematic Diagram (Sheet 2 of 6)
Holyrood Generating Station 238 - 13 - 3000 – 010 Gas Turbine Unit Control & Protection Schematic Diagram (Sheet 3 of 6)
Holyrood Generating Station 238- 13- 3000-010 Gas Turbine Unit Control & Protection Schematic Diagram (Sheet 4 of 6)
Holyrood Generating Station 238 - 13- 3000-010 Gas Turbine Unit Control & Protection Schematic Diagram (Sheet 5 of 6)
Holyrood Generating Station 238 - 13 - 3000 – 010 Gas Turbine Unit Control & Protection Schematic Diagram (Sheet 6 of 6)
Holyrood Gas Turbine 238- 13- 2000- 016 Phasing Diagram
Holyrood Generating Station 238 - 13 - 2000 – 015 Gas Turbine Station Services Panel No. 2 Wiring Diagram
Holyrood Gas Turbine 238 - 13 - 2000 – 014 Exciter & A.V.R. Control Schematic Diagram
Holyrood Gas Turbine 238- 13-2000-013 Avon Start System Connection Diagram
Holyrood Generating Station - Gas Turbine 238 - 13- 2000- 012 575 Volt Motor Control 3 Phase AC. Schematic
Holyrood Generating Station - Gas Turbine 238 - 13- 2000-011 230 V, *30,* AC & 1 1OV DC Auxiliaries Control Schematic
Holyrood Generating Station - Gas Turbine 238 - 13 - 2000 – 010 575 V, *30,* Station Service Supplies and Auto Transfer Switch Control Schematic
NL and Labrador HYDRO 238 - 13- 2000- 017 Wiring Schedule (Sheets 1-28)
Holyrood Generating Station 238 - 13- 0310 -204 Station Service Units 1 & 2, Gas Turbine 4160V Breakers Auxiliary Relay Schematic (Control)
Holyrood Generating Station 238 - 08 - 2000 – 006 Gas Turbine Building Mechanical Equipment
Holyrood Thermal Plant 238 - 08 - 2000 – 007 Gas Turbine Building Modifications to Generator Cooling Air Exhaust Dampers
Holyrood Generating Station 238 - 08 - 2000 – 008 Gas Turbine Avon Vent Ducting

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Holyrood Gas Turbine 238 - 08 - 2000 – 009 Compressed Air System Single Line Diagram
Holyrood Generating Station 238 - 13 - 3000 – 009 Gas Turbine Unit Junction Box, Assembly Arrangement of Air Piping 238 - 13- 6010- 015 For A.P.I. Gas Turbine (Sheet 1 of 3)
Holyrood Generating Station 238 - 13 - 3000 – 002 Gas Turbine Unit Panel, Control and Protection, Turbine & Generator
Holyrood Generating Station 238 - 13 3000 – 004 Gas Turbine Unit Junction Box, Pressure Switch, Assembly
Holyrood Generating Station 238 - 13 - 3000 – 005 Gas Turbine Unit Junction Box, Assembly
Holyrood Generating Station 238 - 13 - 3000 – 006 Gas Turbine Unit Junction Box, Assembly
Gas Turbine Generator Transformer Outline 238 - 13 - 6030 - 007R2 Halon 1301 Fire Extinguishing System Layout, 238 - 13- 3003- 001 Turbine & Generator Rooms
Holyrood Generating Station Fire Alarm/Halon Release 238 - 13 - 3003 – 002 Electrical Layout
Holyrood Generating Station Fire Alarm/Halon Release 238 - 13 - 3003 – 003 Control Panel Wiring Diagram
Holyrood Generating Station Holyrood Generating Station 238 - 13- 3000- 001 Gas Turbine Unit Interconnections, Site, Control System
Holyrood Thermal Plant 238 - 08 - 2000 – 001 Gas Turbine Building Outline of Exhaust Gas Stack
Holyrood Thermal Plant 238 - 08 - 2000 – 003 Gas Turbine Stack Support Steel (Original)
Holyrood Thermal Plant 238 - 08 - 2000 – 004 Gas Turbine Building Mechanical Equipment Mounting Details
Holyrood Generating Plant 238 - 04 - 2000 – 001 Proposed Building - Gas Turbine Floor Plan - (Electrical Equipment)
Holyrood Thermal Plant 238 - 08 - 2000 – 002 Gas Turbine Building Volute Exhaust Flange
Holyrood Generating Plant 238 - 04 - 2000 – 002 Proposed Building - Gas Turbine Elevations
Holyrood Thermal Plant 238 - 04 - 2000 – 003 Gas Turbine Building Roof Plan and Elevations
Holyrood Thermal Plant 238 - 04 - 2000 – 005 Gas Turbine Building Structural Steel Framing Plan
Holyrood Thermal Plant 238 - 04 - 2000 – 004 Gas Turbine Building Foundation Plan & Details
Holyrood Thermal Plant 238 - 04 - 2000 – 007 Gas Turbine Building Floor Plan and Section
Holyrood Thermal Plant 238 - 04 - 2000 – 008 Gas Turbine Building Miscellaneous Details
Holyrood Generating Station 238- 13- 0310-019 Gas Turbine Fuel Totalizer
Stack Cap (Snow Doors) 238 - 08 - 3001 – 001 Expansion Joint Fabric (Type C) Rectangular 238 - 08 - 3001 - 002
Holyrood Gas Turbine 238 - 13 - 2000 – 003 Single Line Diagram
Holyrood Thermal Plant 238 - 13 - 2000 – 004 Gas Turbine Building Grounding Layout
Holyrood Thermal Plant 238 - 13- 2000 – 005 Gas Turbine Building Conduit Layout & Details
Holyrood Gas Turbine 238 - 13 - 2000 – 001 Metering and Protection Single Line Diagram
Holyrood Gas Turbine 238 - 13 - 2000 – 006 Rehabilitation Project Schedule
Holyrood Thermal Plant 238 - 13 - 2000 – 007 Gas Turbine Building Lighting and Heating Layout
Holyrood Generating Station 238 - 13 - 2000 – 008 575 V, *30,* 230,1 iSV, 10 & 110 V D.C. Dist. PNL.'s 575V, 3 Phase Light Oil Transfer Pump
Holyrood Generating Station - Gas Turbine 238 - 13 - 2000 – 009 A.C. and D.C. Station Service Supplies Single Line
Holyrood Gas Turbine 238 - 13 - 6010 – 047 A.P.I. Governing & Control System Arrangement of Air Piping for A.P.I. Gas Turbine 238- 13- 6010-015 (Sheet 2 of 3)
Arrangement of Air Piping for A.P.I. Gas Turbine 238- 13-6010-015 (Sheet 3 of 3)

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APPENDIX 9
BRADEN MANUFACTURING SITE SERVICE REPORT

BRADEN MANUFACTURING, LLC

BRADEN MANUFACTURING SITE SERVICE REPORT

SP/I No:	37626	Date:	08 FEB 2011
Unit Description:	Rolls Royce Avon GT	Customer Reference:	Site Visit
Original SO No:	----	Turbine Serial No:	----
Customer:	Newfound Labrador Hydro - Nalcor	Site Contact:	Robert Shandera
Site Location:	Conception Bay, NL	Phone Number:	709.737.1301
Site Name	Holyrood Thermal Generating Station	Email Address:	RobertShandera@nlh.nl.ca
SSR No.	37626-exhaust		

Together with Robert Shandera and Bill Grace of Braden Manufacturing was invited to the Holyrood GT site near Conception Bay, Newfoundland on February 8, 2011. The purpose was to inspect the condition of the exhaust stack and to make recommendations if any for repairs or replacement of any components on Holyrood GT.

Bill Grace of Braden was introduced to Brian Drover at the site. After the introduction and brief discussion on the history of the unit, the team was taken to GT by an operator.

GENERAL ACTIVITIES

Inspection of both the Exhaust Stack of Holyrood GT

- Visual Inspection of the exhaust stack from the roof of the turbine building
- Visual Inspection of the interior of the turbine building of the exhaust plenum, expansion joint and transition.

FINDINGS

A. Condition of the Exhaust Stack

1. The exterior condition of the exhaust stack shows significant carbon steel crystallization, peeling of the carbon. CS casing is typically good for temperatures up to 750F (400C) There was no fatigue or cracking of any of the visual welds or any failure of welds (inspection was performed from roof on top of the turbine building). The top of the exhaust stack has a "snow-hood" which opens during operation to allow the exhaust gases to vent atmosphere. On the "south" side of the stack shows "bulging" of the stack, see photo 3.

Figure 1 – side wall of exhaust stack, evidence of no or minimum amount of internal insulation.

Figure 2 – near top of the exhaust stack with carbon steel deterioration.

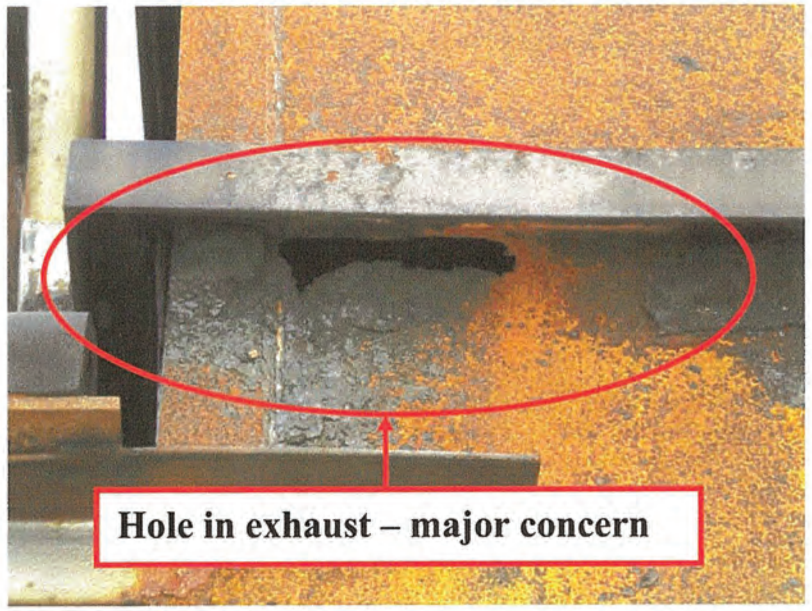

Figure 3 – Slight bulge in sidewall.

B. EXHAUST TRANSITION & EXPANSION JOINT

1. The transition duct with external insulation protects the casing plate, so no visual inspection was performed on the casing due to this insulation, (see photo 4).
2. The expansion joint belt (see photo 5) is in good condition with flange material is good.

Figure 4 Transition area of with external insulation above the exhaust plenum.

Figure 5 Expansion joint belt in good condition.

Figure 6 Holyrood GT – Black Start Unit at Holyrood Thermal Power Station

RECOMMENDATION

Customer may want to consider the following.

1. If the owners plan for the turbine – generator is long-term for generation and black-start duration, then the solution is stack replacement with the major OEM recommendation of the internal floating liner exhaust system. (see SP-37626 proposal)
2. Cosmetic coating of the exhaust stack with high temperature primer and high temperature final coatings. International Protective Coatings is recommended.

a) Scrape or sandblast the "loose" flakes of the carbon steel to get to a clean surface.
b) Zinc Primer; Inter-zinc 22.
c) High Temp Alumn – Intertherm 50 (no heat cure required).

APPENDIX 10
GREENRAY TURBINE SERVICE REPORT

GREENRAY

TURBINE SERVICE REPORT

TITLE	API – POWER TURBINE AND GEARBOX ASSESSMENT
REPORT BY	E. CARD
DATE	18th FEBRUARY 2011
REPORT NUMBER	60124
SERVICE REPRESENTATIVES	E. CARD
POSITION	SENIOR SERVICE ENGINEER
SERVICE ORDER NUMBER	GLL 9321
PERIODS OF VISIT	06.02.2011 / 14.02.2011
CUSTOMER	NEWFOUNDLAND / LABRADOR HYDRO
SITE	HOLYROOD – CANADA
ENGINE TYPE	API
CUSTOMER DESIGNATION	GAS TURBINE
POWER TURBINE SERIAL NO.	G305
OPERATING HOURS / STARTS	11,000 APPROX / 1557

GREENRAY

Report

The author and Mr Jeff Evans departed the UK am on 07/02/2011, arriving in Canada pm 07/02/2011 and commencing with the scope of works at N.L.H Holyrood the following morning.

Object

An Assessment of the A.P.I Power Turbine & Gearbox

Prior to starting work on the unit, Greenray Personnel had discussions with site staff in regard to any past and current problems they were experiencing with the unit and were informed that they were mainly:-

A, Lube oil leakage through the gearbox top half casing, adjacent to the volute.
B, Lube oil leakage through the gearbox low speed gear wheel lube oil retaining gland adjacent to the gearbox/alternator couplings.
C, The lube oil delivery engine drive pump was not maintaining sufficient main rail pressure, which was causing the AC lube oil pump to be activated. To overcome the problem, site staff had set the AC pump in a continual operating condition.

During the discussions regarding the lube oil leakage, Greenray were informed that on occasion there was a tendency for the Lube oil to "pool" under the Power Turbine Volte and when the unit was put into operation, this sometimes caught fire.

Please note:- The original machine design was for use as a **'black start'** facility but was put into service approximately once a week for test/availability purposes.

Due to the potential fire risk, the machine operation has been reverted for use only on an emergency basis. In this mode i.e. no testing, the author would recommend that the lube oil system should be put into operation approximately once a week for 30 minutes.

Work Undertaken

1/ Power Turbine inspection.

The power turbine inlet ducting and blading i.e. rotor and nozzle were inspected using a boroscope. N.L.H did not wish the Avon gas generator to be removed. This action proved to be slightly problematic, and limited the inspection, as on this type of unit the transition duct between the Avon and the inlet duct has very limited retraction back into the inlet duct. This results in only a 125mm gap between the end of the transition duct and the Avon exhaust cone lip, preventing access into the duct for clear visual inspection.

Prior to undertaking the boroscope, an attempt was made to remove the inlet cone boroscope plugs, which would also have given improved access to the rotor and disc. These plugs proved to be very tight (probably seized) and therefore not wishing to damage the plugs or the inlet duct threads, which may have resulted in time consuming repair work, this action was terminated.

The boroscope inspection revealed: - See photographic evidence in Appendix 1.

(i) There are several circumferential cracks on the inlet duct inner cone, approximately 6" upstream from the nozzle. These cracks had been noted, and marked, in a previous inspection (by others circa 2006). Those which had been repaired/marked during that inspection period did not appear to have propagated further, however hours run since the inspection were not confirmed. See Photos 1 & 2.

(ii)
(iii) There appears to be some weld repairs on the cone spokes inner downstream edges which may be starting to fail. Further checks need to be carried out on these welds to ensure security of the cone spokes is maintained. See Photo 3 & 4.

(iv) The nozzle blade track is corroded, especially in the 4-8 o'clock position. See Photo 5 & 6. The corrosion appears to be heavy in places and if untreated may cause failure of the Nozzle segment and shroud.

(v) The blade tips seem irregular, as if the feather has rubbed the nozzle or eroded. All blades have a similar profile which indicates contact with another item, however there appears to be no evidence of a blade tip rub. See Photo 7 & 8.

(vi) There is general corrosion (mostly light) on the blading. See Photo 9.

(vii) The rotor disc fir tree posts (for blades) are heavily corroded in the areas that are visible suggesting the remainder of the rotor disc is in a similar condition. These areas are subject to extreme stresses when the unit is in operation, and should be maintained in optimum condition. Failure of the fir tree root will have a catastrophic effect on the other components within the Power Turbine. See photo 10 & 11. Note on Photo 11 the corrosion appears to be propagating under the rotor blade shoulder. This may induce additional stresses on the blades, reducing operational life and increasing the potential for premature failure.

(viii) The diffuser/volutes appear to be generally corroded. Whilst corrosion will have no major effect on the operation of the machine, concern should be raised over the condition of the welding within the volute. See Photo 12.

2/ Gearbox Inspection:-

The alternator side top half cover was removed which revealed:-

A, The gear wheels and other internals were in pristine condition apart from normal gear contact marks. Photo 13 & 14

B, The low speed gear wheel to rotor stub dowels were in a normal condition i.e. not moved. Photo 15.

C, The engine driven pump drive system was in good condition with the exception that one flexible drive shaft membrane was slightly distorted. It is not expected that this would cause problems during operation of the machine, however prudence would recommend replacement at the next major service. Photo 16.

D, A static visual check of the leaking low speed gear wheel lube oil gland appeared to show that the outer wiper was touching the top of the shaft and probably may have some clearance on the bottom, when the opposite is normal. Site engineers advise that previous remedial work has been carried out

on this gland, i.e. new wipers were fitted with more drainage holes, and though initially it appeared successful the lube oil leakage reappeared. Photo 17. Damage of this nature would indicate that the driven machine is out of alignment with the gearbox output shaft. Checks need to be made on this alignment to ensure correct operation.

E, An attempt was made to determine the exact location of the oil leak on the gearbox between the housing and the exhaust volute. Whilst it can be confirmed that a leak has occurred, specific location could not be determined as the machine could not be operated. It is suspected that the gearbox casing half joint seal has failed.

Conclusion

Due to time/job constraints, only a minimal assessment was possible, which has raised several questions over the condition of the machine, and potential risk during further operation. The corrosion seen on the disc although it may be surface corrosion only, certainly appears to be fairly heavy. Should the corrosion not be addressed, there is a high potential for blade movement during machine operation. This movement will induce high stresses within the blade root, and may result in catastrophic failure of the machine.

It is the recommendation of Greenray that a more in depth assessment (which would require more dismantling of the unit) be undertaken. This would enable:-

(i) Removal of the inlet duct for further inspection and repair.

(ii) More visual access to the corroded rotor disc and nozzle for assessment of condition

(iii) More visual access to the volute for assessment of condition and potential repair (subject to as found condition)

(iv) Measurement of tip clearances and assessment of wear on rotor blade tips, including areas of potential wear/contact on the nozzle/shroud

(v) Removal of the engine driven pump for inspection.

(vi) Removal of the necessary lube oil pipe work to check the non return valves and pressure relief valve for correct operation.

(vii) Check the gearbox casing half joint for signs of lube oil leakage and detailed repair process. It is suspected that the gearbox casing will need to be split for repair to be carried out, however this can only be confirmed once the actual source of the leak is found.

(viii) Remove the leaking lube oil gland on the gearbox for a more extensive inspection and checks on orientation of the wipers.
Please note: - The author has had discussions with the Greenray Technical Department regarding the leaking lube oil gland, who will try to access information (drawings etc) regarding the gearbox, with a view to give advice on how to try to overcome the problem.
Clearances on the gland could not be measured by the site engineers during the limited scope of the inspection, however visually they do not appear to be within original tolerances. These detail a lower clearance of 0.002" and an upper clearance of 0.009". With these clearances, no damage would be noted on the upper wiper face.

(ix) Full alignment checks to be carried out, with re-alignment of the driven machine being undertaken if required.

The author and Mr Jeff Evans departed Canada pm on 13/02/2011 arriving on the UK am 14/02/2011

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Further discussion and review of the photographic evidence at the De-briefing meeting within the Greenray office concluded that, in its current condition the machine can and will operate when required.
It is clear by the corrosion noted within the machine, that liquid has pooled at the bottom of the Power Turbine, whether this is rain or snow ingress cannot be determined.
It is the opinion of Greenray that a major inspection of the machine be carried out to determine the full extent of any internal damage and corrosion, with a potential for replacing the rotor and nozzle and weld repairs on the inlet cone and Volute.
Further regular maintenance needs to be carried out after this inspection/component replacement to ensure the unit will continue to operate for the operable life of the Power Station, currently advised as 2028.

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Appendix 1

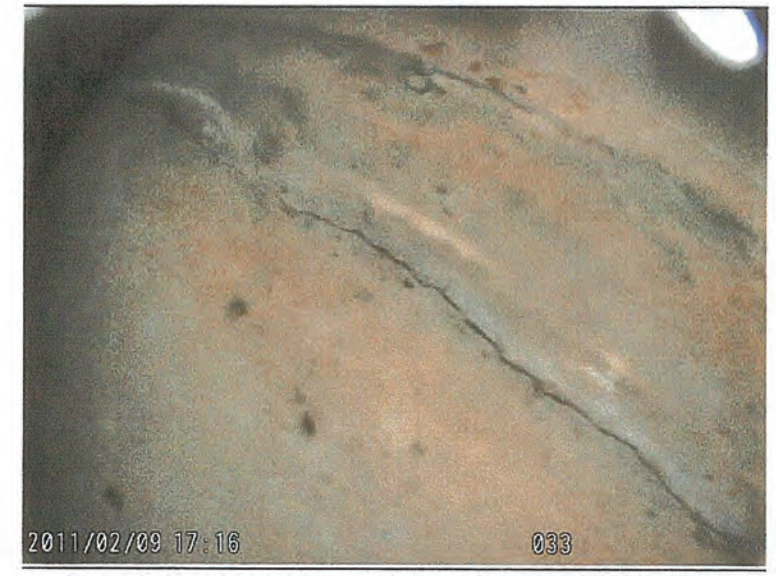

Photo 1. Showing crack around circumference of the PT cone.

Photo 2. Showing crack around circumference of the PT cone.

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Photo 3. showing weld repair on cone spoke inner edge.

Photo 4. showing weld repair on cone spoke inner edge.

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Photo 5. Showing corrosion of the nozzle blade track and on Rotor blade.

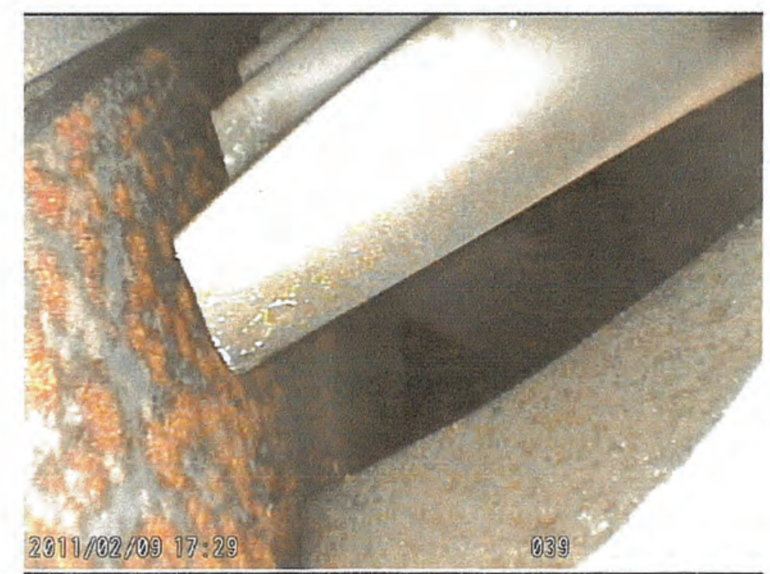

Photo 6. Showing corrosion of the nozzle blade track and on Rotor blade.

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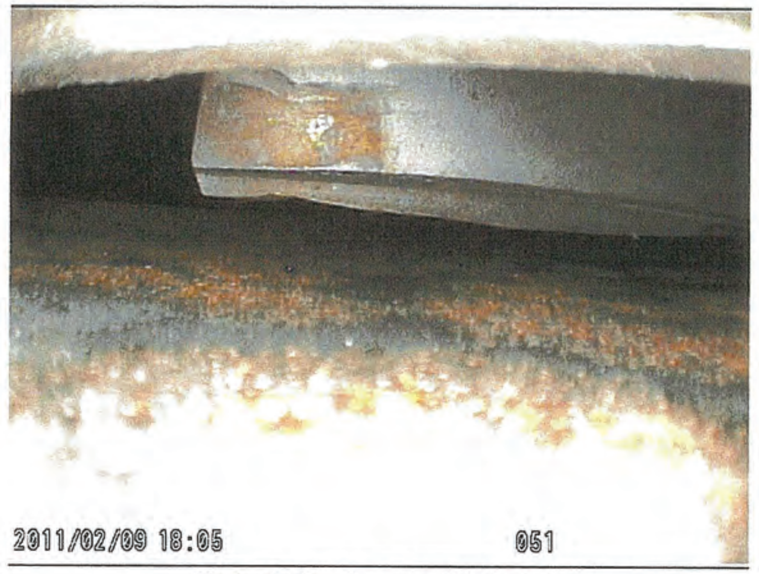


Photo 7. Showing worn blade tips.

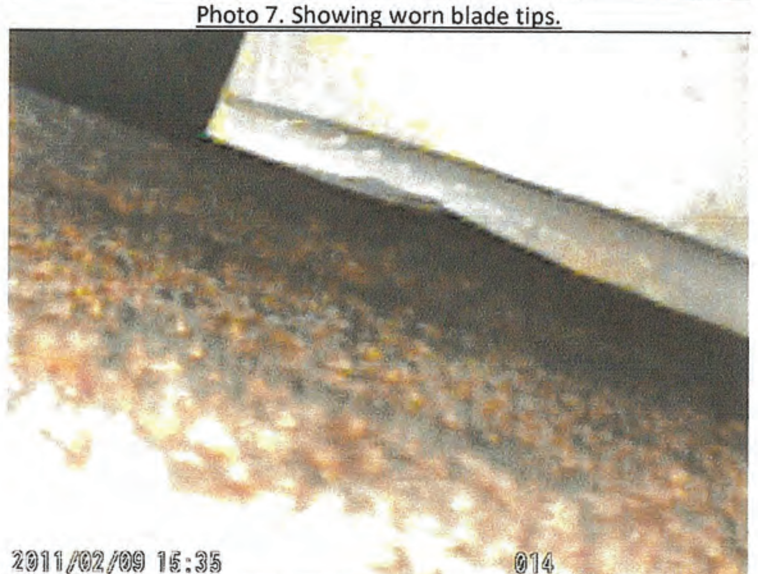


Photo 8. Showing worn blade tips. Note similar profile to Photo 7.

Photo 9. Showing corrosion on blades.

Photo 10. Showing fir tree root corrosion

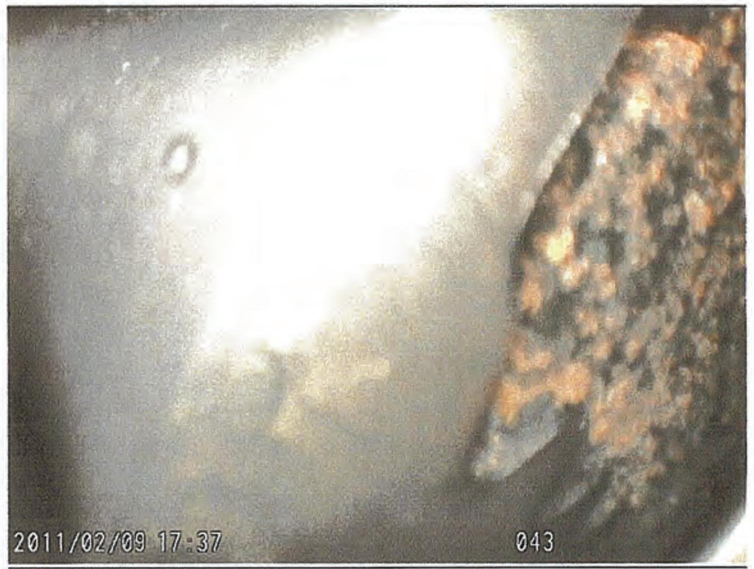
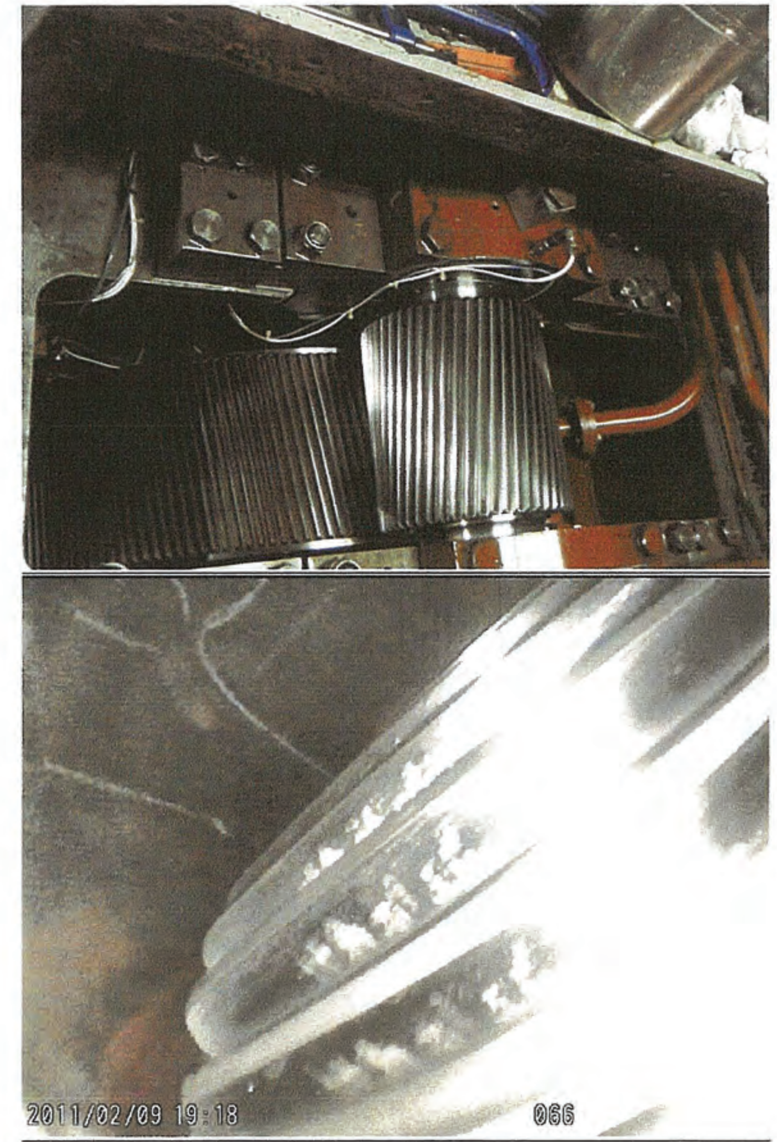


Photo 11. Showing fir tree root corrosion. Note propogation of corrosion under the blade shoulder.

Photo 12. Corrosion of volute.



Photos 13 & 14 showing gearwheel condition.

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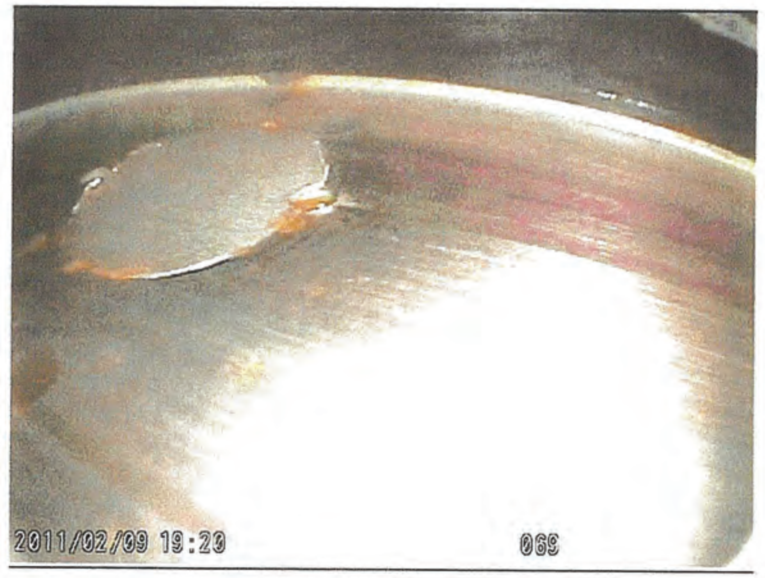

Photo 15. Showing gearwheel dowel pin.

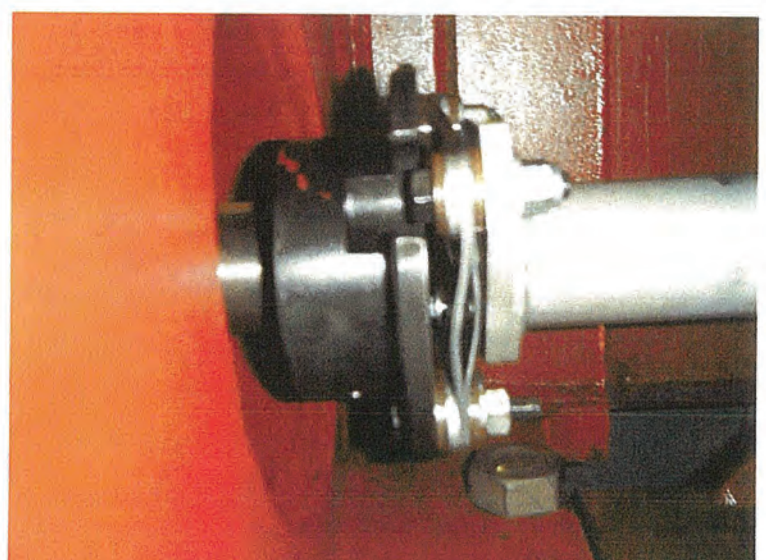

Photo 16 showing distortion on oil pump coupling.

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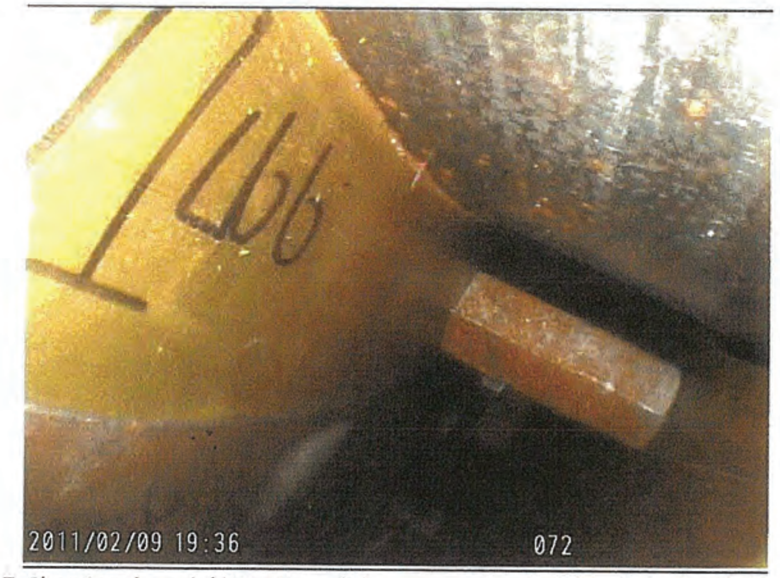

Photo 17. Showing the rub/distortion of the upper wiper on the shaft gland after contact with the main shaft. (photo taken upside down).

Report Compiled by:

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Service Supervisor

Approved by:

Mr R. Lingard
Service Manager

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APPENDIX 11
SIEMENS HRD CONDITION ASSESSMENT AND BUDGET PRICING

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HRD Condition Assessment and Budget Pricing

for

NL Hydro Holyrood Generating Station

PREPARED BY:

SIEMENS

February 2011

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Resistance To Ground Test

The resistance-to-ground test is also known in industry as a megger test due to the popularity of the instrument for performing the test manufactured by megger.

The purpose of the resistance-to-ground test is to determine whether or not there's a ground fault in a stator winding. This test is easy to conduct in the field as the only required tool is a meg-ohmmeter.

Important Notes:

- Ensure there is a good ground for the test lead to attach to.
- Take the resistance-to-ground reading at 1 min. Readings taken after this time will change as the insulation begins to polarize.
- Note the unit of measure when recording the test result (Mega, Giga, Tera).
- When performing multiple tests, IEEE states that between tests, the winding should be grounded for 4 times the length of the test to discharge the windings. (Ex: A resistance-to-ground test is done and held for 1 minute. Before performing any other tests, the motor leads should be grounded to the frame for 4 minutes).

Polarization Index of Machine Windings

Knowing the polarization Index of a motor or generator can be useful in appraising the fitness of the machine for service. The index is calculated from measurements of the winding insulation resistance.

Before measuring the insulation resistance, remove all external connections to the machine and completely discharge the windings to the grounded machine frame.

Proceed by applying either 500 or 1000 volts dc between the winding and ground using a direct-indicating, power-driven megohmmeter. For machines rated 500 volts and over, the higher value is used. The voltage is applied for 10 minutes and kept constant for the duration of the test.

The polarization index is calculated as the ratio of the 10-minute to the 1-minute value of the insulation resistance, measured consecutively.

$$\text{Polarization Index} = \frac{\text{Ins. Resistance after 10 minutes}}{\text{Ins. Resistance after 1 minute}}$$

The recommended minimum value of polarization index for ac and dc motors and generators is 2.0. Machines having windings with a lower index are less likely to be suited for operation. The desired result for a PI Test is a ratio between 2 and 5; readings less than 2 usually indicate that the winding is damp and dirty and a ratio over 5 indicates that the winding is dry and brittle.

The polarization index is useful in evaluating windings for:

- Build-up of dirt or moisture.
- Gradual deterioration of the insulation (by comparing results of tests made earlier on the same machine).
- Fitness for overpotential tests.
- Suitability for operation.

There are exceptions to the Polarization Index test for some new coil and insulation systems that are now being utilized in the industry therefore we recommend a trained technician perform the test so the proper diagnosis be given for your equipment. The procedure for determining the polarization index is covered in detail by IEEE Standard No. 43.

Phase-to-phase Resistance

Phase-to-phase resistance is the measured DC resistance between phases of the stator in an AC motor and between polarities of the armature and field coils in a DC motor.

In AC induction motors, use the phase-to-phase resistance values and resistive imbalances for trending, troubleshooting and quality control. In DC motors, use trending and relative comparison to determine the condition of the phases in the motor and power circuits. This includes comparing readings taken from identical motors operating in similar conditions and comparing current readings against past readings for the same motor.

An increasing resistive imbalance or a changing resistance over time can indicate one or more of the following:

- High resistance connections
- Coil-to-coil, phase-to-phase, or turn-to-turn current leakage paths
- Corroded terminals or connections
- Loose cable terminals or bus bar connections
- Open windings
- Poor crimps or bad soldier joints
- Loose, dirty, or corroded fuse clips or manual disconnect switches
- Undersized conductors (misassemble or improperly engineered)

Why is this important?

The length, size, width, composition, condition, type and temperature of the conductors and connectors determine circuit resistance. When two different conductors are connected, dirt, corrosion or an improper connection increases the circuit resistance. Also, inadequate connections cause heating of the conductor, which increases resistance even more. This could be caused if only a few strands of a conductor or portions of a soldered joint are improperly connected to a terminal or if undersized connectors are used.

In a three-phase motor circuit, the resistance in the conductor paths should be as close to equal as possible. A "resistive imbalance" occurs when the phase have unequal resistance. This produces uneven current flow and excessive heat.

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Condition Assessment Findings

NL Hydro
Hydro Place
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Equipment Name: **AC Lube Oil Motor**

Visual inspection:

Prior to conducting any electrical tests on this unit a visual inspection was performed.

- Externally the motor appears to be in good shape with all covers installed and conduit connectors in good physical condition.
- Internally the inspection was very limited due to accessibility. Therefore a full determination of condition cannot be made.
- Due to time limit and permitting issues, this motor was not run up for vibration analysis test.

Test Results:

- Insulation Resistance to ground @ 1 minute = 4600 MΩ
- Polarization Index Test = $\frac{\text{10 minute reading}}{\text{1 minute reading}} = \frac{5300\ \text{M}\Omega}{4600\ \text{M}\Omega}$ = 1.15 Damp and dirty.
- Phase to phase resistance:
  - Ø A to Ø B = 584.9 mΩ
  - Ø A to Ø C = 584.0 mΩ
  - Ø B to Ø C = 584.4 mΩ

Recommended Action:

- Overhaul unit to steam clean windings.
- Perform a stator VPI to recover insulation integrity and improve PI factor.
- Measure and record all mechanical fits and change bearings.
- Perform no-load run test and capture vibration trend data for future reference.
- Unit is installed in an area with a high delta in temperature (cold during idle, hot during operation). Anti condensation heater installation is recommended to prevent moisture build-up.

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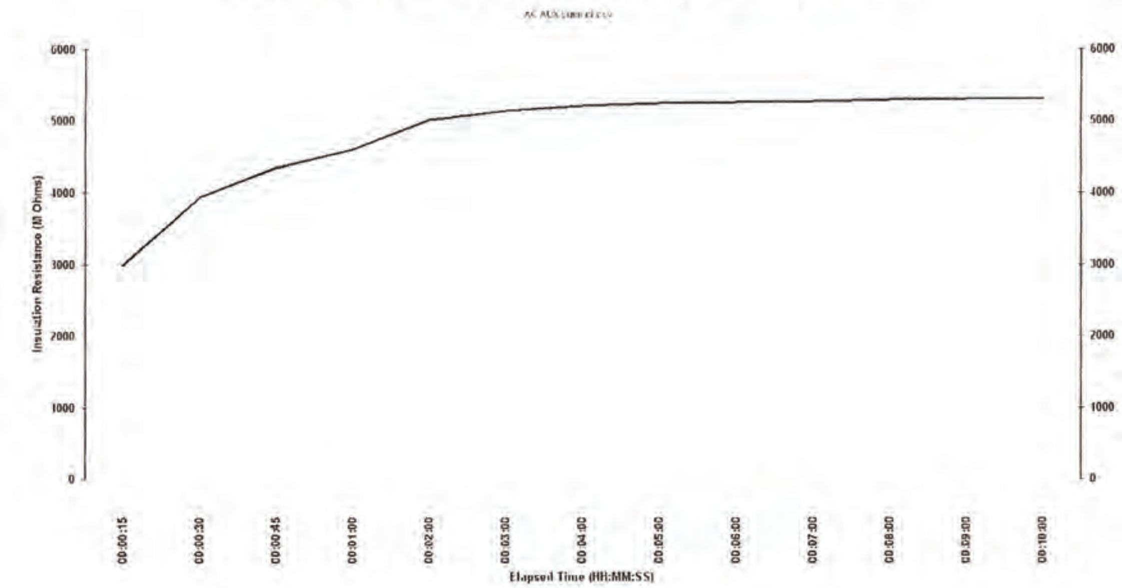
Condition Assessment Findings

Polarization Index Test Graphical Results



Budget Pricing with Scope of Work and Notes:

- Receive unit at our O'Leary Ave. facility.
- Dismantle and overhaul unit to steam clean windings.
- Perform a stator VPI to recover insulation integrity and improve PI factor.
- Dynamically balance rotor.
- Measure and record all mechanical fits and change bearings.
- Perform no-load run test and capture vibration trend data for future reference.

- **Budget Price for this service is .... $ 2,300.00 TNIP Budget Only**

Notes:
- This is a budgetary price only and is non-binding.
- Firm pricing is available if requested or tendered.
- Installation of anti-condensation heaters and all required mechanical work would be additional and extra.

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Condition Assessment Findings

Equipment Name: **DC backup lube oil pump motor**

Visual inspection:

Prior to conducting any electrical tests on this unit a visual inspection was performed.

- Externally the motor appears to be in good shape with all screens and covers installed and conduit connectors in good physical condition.
- Internally the inspection was limited due to accessibility. Therefore a full determination of condition cannot be made. However, it was noted that the armature coils appeared to be dry with some signs of overheating at the armature riser section.
- Due to time limit and permitting issues, this motor was not run up for vibration analysis test.

Test Results:

- Insulation Resistance to ground @ 1 minute = 185 MΩ
- Polarization Index Test = $\frac{\text{10 minute reading}}{\text{1 minute reading}} = \frac{172\ \text{M}\Omega}{185\ \text{M}\Omega}$ = 0.93 Damp and dirty.
- Overall DC Circuit Resistance = 27.62 Ω

Recommended Action:

- Overhaul unit to steam clean stator and armature windings.
- Perform a stator and armature VPI to recover insulation integrity and improve PI factor.
- Recondition brush rigging and check spring tension.
- Check all mechanical fits and change bearings.
- Refurbish commutator, undercut and bevel copper bar segments for smooth operation.
- Install new brushes and seat on refurbished commutator.
- Perform no-load run test and capture vibration trend data for future reference.
- Unit is installed in an area with a high delta in temperature (cold during idle, hot during operation). Anti condensation heater installation is recommended to prevent moisture build-up.

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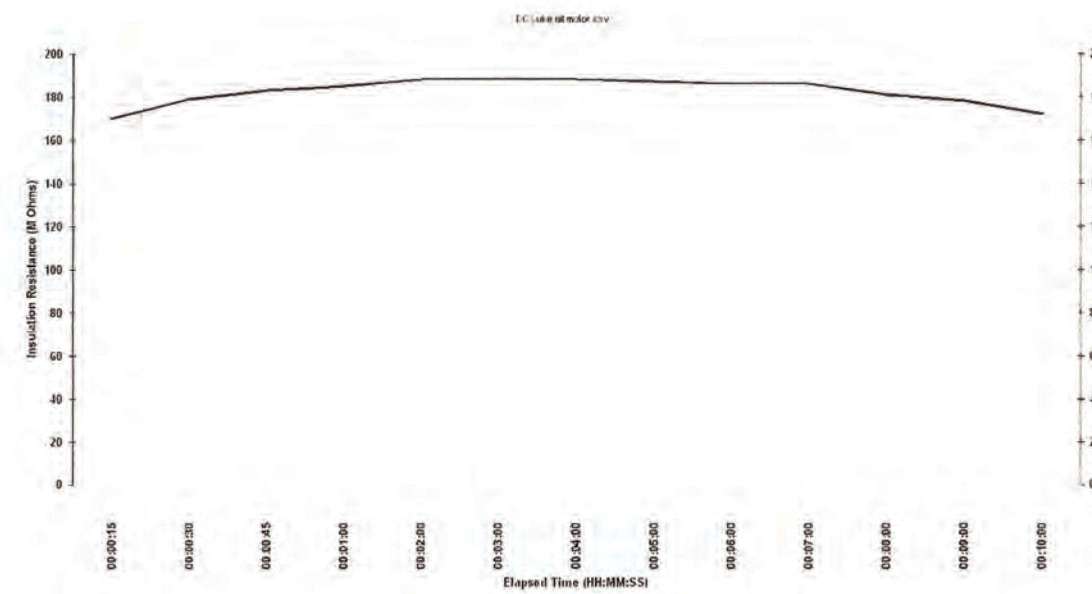
Condition Assessment Findings

Polarization Index Test Graphical Results



Budget Pricing with Scope of Work and Notes:

- Receive unit at our O'Leary Ave. facility.
- Dismantle and overhaul unit to steam clean stator and armature windings.
- Perform a stator and armature VPI to recover insulation integrity and improve PI factor.
- Dynamically balance armature.
- Recondition brush rigging and check spring tension.
- Check all mechanical fits and change bearings.
- Refurbish commutator, undercut and bevel copper bar segments for smooth operation.
- Perform no-load run test and capture vibration trend data for future reference.

- **Budget Price for this service is .... $ 3,500.00 TNIP Budget Only**

Notes:

- This is a budgetary price only and is non-binding.
- Firm pricing is available if requested or tendered.
- Supply and installation of brushes would be considered extra.
- Installation of anti-condensation heaters and all required mechanical work would be additional and extra.

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Condition Assessment Findings

Equipment Name: AC Lube Oil Cooler Fan

Visual inspection:

Prior to conducting any electrical tests on this unit a visual inspection was performed.

- Externally this fan unit is rusty on the outside, the stator frame and rotor shaft extension show signs of environmental corrosion but is mostly superficial.
- Disregarding the overall appearance, the motor appears to be in good shape with all screens and covers installed and conduit connectors in good physical condition. A screen was removed to gain access to the unit as shown in the picture above.
- Internally the inspection was limited due to accessibility. Therefore a full determination of condition cannot be made.

Test Results:

- Insulation Resistance to ground @ 1 minute = 5520 MΩ
- Polarization Index Test = $\frac{\text{10 minute reading}}{\text{1 minute reading}} = \frac{7550\ \text{M}\Omega}{5520\ \text{M}\Omega} = 1.37$ Damp and dirty.
- Phase to phase resistance:
  - Ø A to Ø B = 404.5 mΩ
  - Ø A to Ø C = 403.7 mΩ
  - Ø B to Ø C = 406.4 mΩ
- Vibration analysis:
  - The vibration analysis test indicated dry anti-friction bearings on both ends of the motor; adding grease into the bearings was suggested after the assessment testing and prior to the screen being installed.
  - Small amount of couple imbalance indicated at NDE of motor due to large fan at the DE of the motor.

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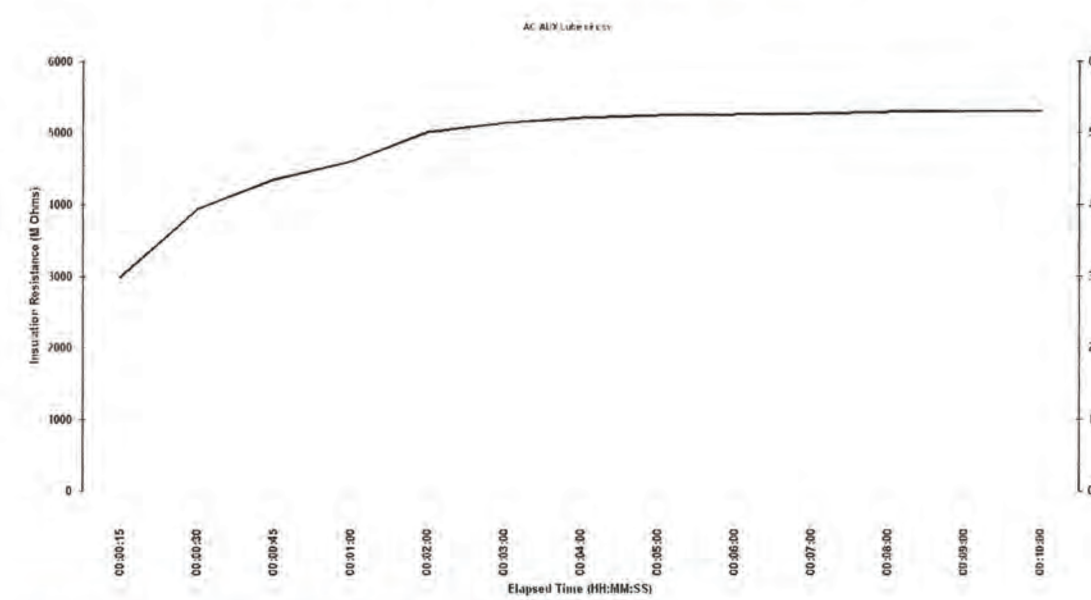
Condition Assessment Findings

Recommended Action:

- Overhaul unit to steam clean stator.
- Perform a stator dip & bake to recover insulation integrity and improve PI factor.
- Recondition fan unit and motor frame.
- Paint fan unit and motor with epoxy paint to prevent corrosion.
- Check all mechanical fits and change bearings.
- Perform no-load run test and capture vibration trend data for future reference.
- Anti condensation heater installation is recommended to prevent moisture build-up.

Polarization Index Test Graphical Results



Budget Pricing with Scope of Work and Notes:

- Receive unit at our O'Leary Ave. facility.
- Overhaul unit to steam clean stator.
- Perform a stator dip & bake to recover insulation integrity and improve PI factor.
- Recondition fan unit and motor frame.
- Paint fan unit and motor with epoxy paint to prevent corrosion.
- Check all mechanical fits and change bearings.
- Perform no-load run test and capture vibration trend data for future reference.

- **Budget Price for this service is .... $ 3,050.00 TNIP Budget Only**

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Condition Assessment Findings

Notes:

- This is a budgetary price only and is non-binding.
- Firm pricing is available if requested or tendered.
- Installation of anti-condensation heaters and all required mechanical work would be additional and extra.
- Sandblasting and painting of fan housing would be considered extra and completed by a 3rd party contractor.

Equipment Name: **East Fuel Oil Motor**

Both fuel oil pump (East and West) are in this enclosure

Visual inspection:

Prior to conducting any electrical tests on this unit a visual inspection was performed.

- Externally the motor appears to be in fair shape with some surface corrosion.
- All covers installed and conduit connectors in good physical condition.
- Internally the inspection was very limited due to accessibility. Therefore a full determination of condition cannot be made.
- This motor should not be confused with the 25 HP pump unit (25 HP pump unit is for pumping fuel to the storage tank not to supply fuel to turbine).
- Due to time limit and permitting issues, this motor was not run up for vibration analysis test.

SIEMENS

Condition Assessment Findings

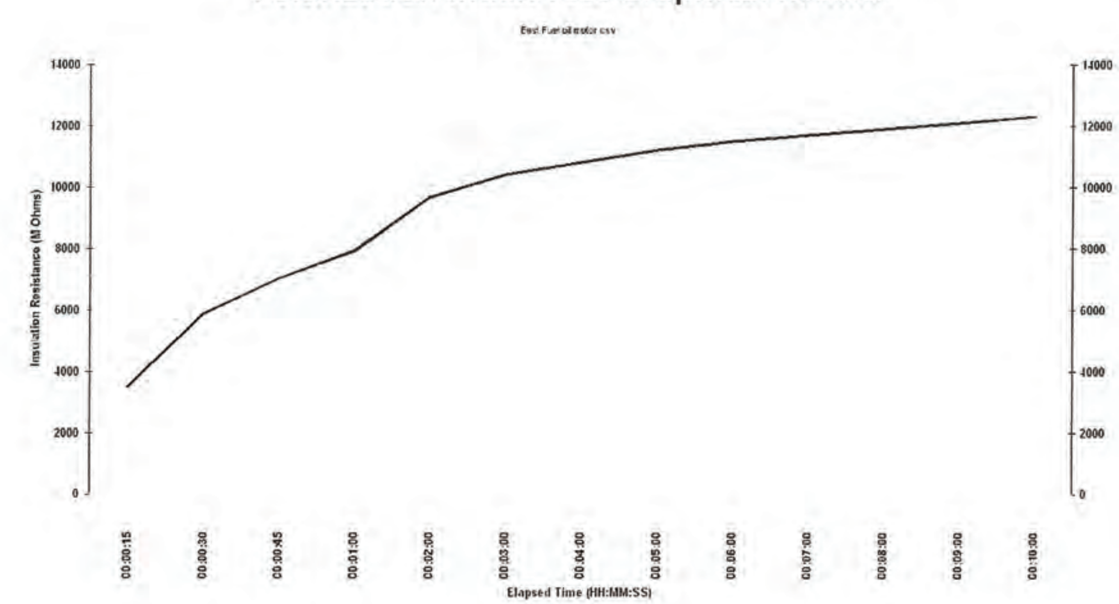
Test Results:

- Insulation Resistance to ground @ 1 minute = 7920 MΩ
- Polarization Index Test = $\frac{\text{10 minute reading}}{\text{1 minute reading}} = \frac{12300\ \text{M}\Omega}{7920\ \text{M}\Omega}$ = 1.56 Damp and dirty.
- Phase to phase resistance:
    - Ø A to Ø B = 9.952 Ω
    - Ø A to Ø C = 9.938 Ω
    - Ø B to Ø C = 9.956 Ω

Recommended Action:

- Overhaul unit to steam clean windings.
- Perform a stator dip & bake to recover insulation integrity and improve PI factor.
- Measure and record all mechanical fits and change bearings.
- Perform no-load run test and capture vibration trend data for future reference.
- Unit is installed in an area with a high delta in temperature (cold during idle, hot during operation). Anti condensation heater installation is recommended to prevent moisture build-up.

Polarization Index Test Graphical Results



Condition Assessment Findings

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Equipment Name: West Fuel Oil Motor

Both fuel oil pump (East and West) are in this enclosure

Visual inspection:

Prior to conducting any electrical tests on this unit a visual inspection was performed.

- Hatch on enclosure was not in place and unit is covered in snow. Snow was removed to perform visual and tests.
- Externally the motor appears to be in fair shape with some surface corrosion.
- All covers installed and conduit connectors in good physical condition.
- Internally the inspection was very limited due to accessibility. Therefore a full determination of condition cannot be made.
- Due to time limit and permitting issues, this motor was not run up for vibration analysis test.

Test Results:

- Insulation Resistance to ground @ 1 minute = 1250 MΩ
- Polarization Index Test = $\frac{\text{10 minute reading}}{\text{1 minute reading}} = \frac{1190\ M\Omega}{1250\ M\Omega}$ = 0.95 Damp and dirty.
- Insulation Resistance and PI Factor could be skewed due to motor being covered in snow, temperature will affect the conductors.
- Phase to phase resistance:
    - Ø A to Ø B = 9.952 Ω
    - Ø A to Ø C = 9.938 Ω
    - Ø B to Ø C = 9.956 Ω

Condition Assessment Findings

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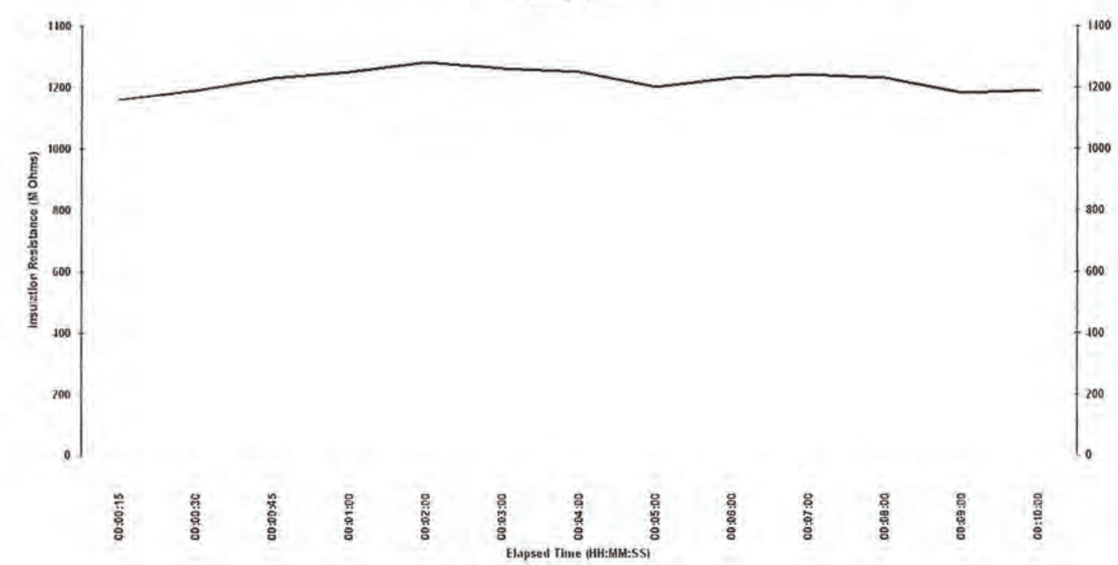
Recommended Action:

- Overhaul unit to steam clean windings.
- Perform a stator dip & bake to recover insulation integrity and improve PI factor.
- Measure and record all mechanical fits and change bearings.
- Perform no-load run test and capture vibration trend data for future reference.
- Unit is installed in an area with a high delta in temperature (cold during idle, hot during operation). Anti condensation heater installation is recommended to prevent moisture build-up.

Polarization Index Test Graphical Results



Budget Pricing with Scope of Work and Notes:

- Receive units at our O'Leary Ave. facility.
- Dismantle and overhaul unit to steam clean windings.
- Perform a stator Dip & Bake to recover insulation integrity and improve PI factor.
- Dynamically balance rotor.
- Recertify for explosion proof application.
- Measure and record all mechanical fits and change bearings.
- Perform no-load run test and capture vibration trend data for future reference.

- **Budget Price for this service is .... $ 1,875.00 TNIP each Budget Only**

Condition Assessment Findings

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Notes:

- This is a budgetary price only and is non-binding.
- Firm pricing is available if requested or tendered.
- Installation of anti-condensation heaters and all required mechanical work would be additional and extra.

Condition Assessment Findings

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Equipment Name: 73.5 KW Brushless AC Exciter

Figure 1 - Exciter with cover open.

Figure 2 - Name Plate of Exciter

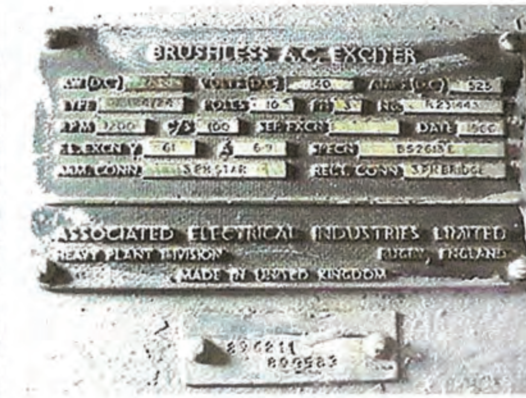


Figure 3 – Rectifier with main rotor leads

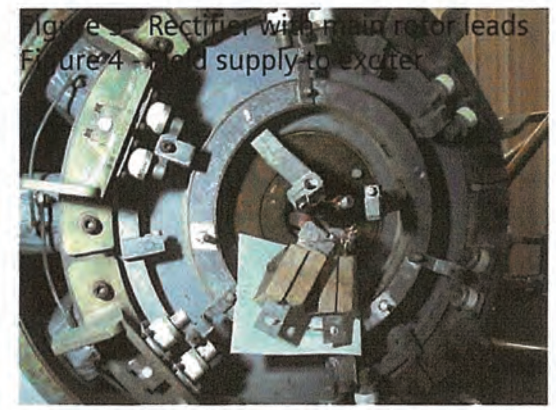
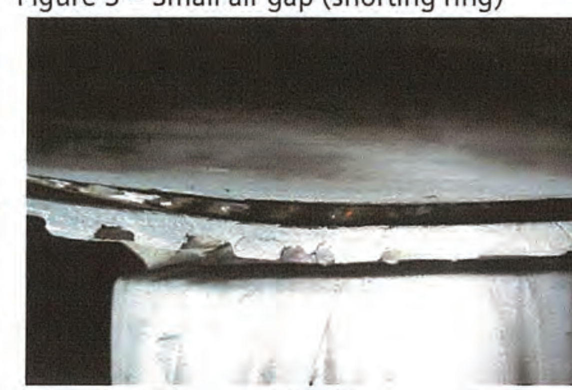


Figure 4 – Field supply to exciter

Figure 6 – View 2 air gap.

Figure 5 – Small air gap (shorting ring)



Condition Assessment Findings

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Figure 7 - Rust at the end of rotor iron

Figure 8 - Rusty exciter rotor shaft

Visual inspection:

Prior to conducting any electrical tests on this unit a visual inspection was performed.

- All fasteners are in good condition and solid.
- All electrical connections are in good condition.
- The air gap between the rotor and stator of exciter are very even in both directions (within 4%) which indicate the wear on the main bearing is very minimal from the original.
- The rectifier is in good condition in both physically and electrically.
- The exciter field stator appears to be dry which coincides with the PI reading.
- There is evidence of condensation in the unit due to the surface rust and corrosion of the rotor iron and shaft, figures 7 & 8 above.

Test Results:

Exciter Rotor:

- Insulation Resistance to ground @ 1 minute = 2060 MΩ
- Polarization Index Test = $\frac{\text{10 minute reading}}{\text{1 minute reading}} = \frac{4400\ \text{M}\Omega}{2060\ \text{M}\Omega}$ = 2.14 fair condition
- Phase to phase resistance:
    - Ø A to Ø B = 4.168 mΩ
    - Ø A to Ø C = 4.187 mΩ
    - Ø B to Ø C = 4.169 mΩ

Condition Assessment Findings

Exciter Stator:

- Insulation Resistance to ground @ 1 minute = 534 MΩ

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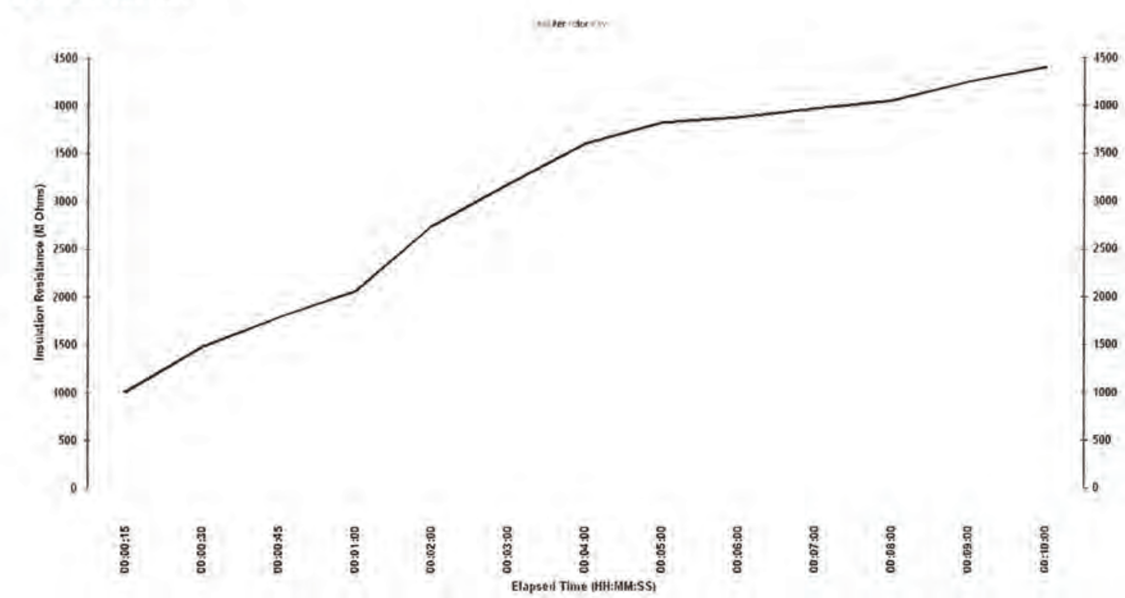
- Polarization Index Test = $\frac{\text{10 minute reading}}{\text{1 minute reading}} = \frac{513\ \text{M}\Omega}{534\ \text{M}\Omega}$ = 0.96 damp and dirty
- Overall DC Circuit Resistance = 4.50 Ω

Recommended Action:

- Overhaul unit to steam clean windings.
- Perform a VPI on stator to recover insulation integrity on stator and improve PI factor.
- Rotor should have VPI treatment to maintain the PI factor and increase the reliability.
- While overhauling unit a recondition rotor iron and shaft to remove rust should be performed. Once complete and rust removed a coating from the VPI and epoxy paint should be applied to prevent future corrosion.
- Measure and record all mechanical fits.
- Unit is installed in an area with a high delta in temperature (cold during idle, hot during operation). Anti condensation heater installation is recommended to prevent moisture build-up.

Polarization Index Test Graphical Results

Exciter Rotor:



Condition Assessment Findings

Exciter Stator:

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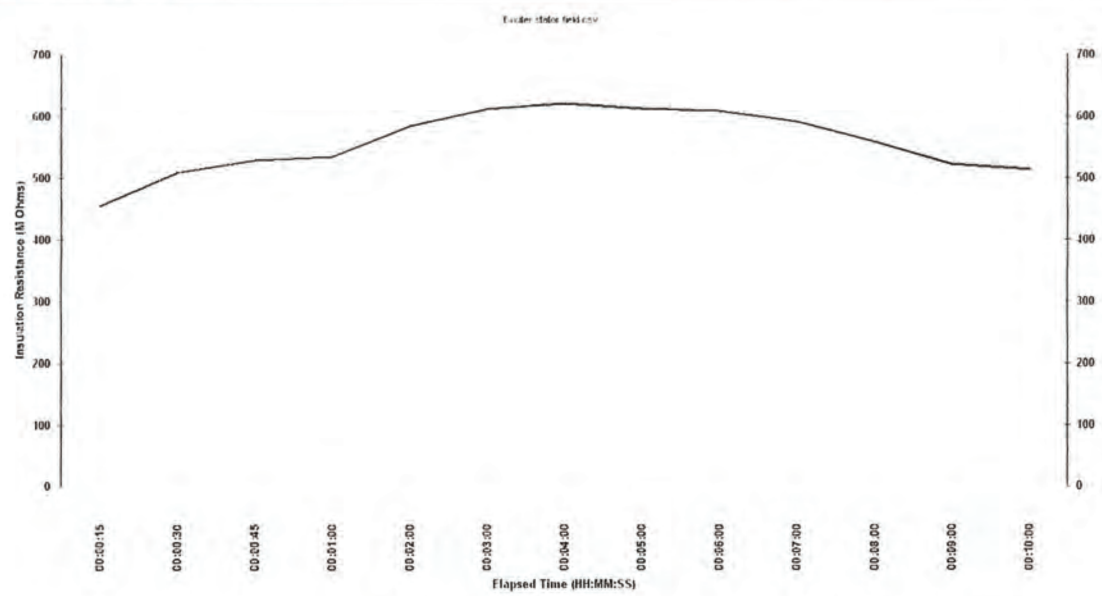

Budget Pricing with Scope of Work and Notes:

- Receive unit at our O'Leary Ave facility.
- Perform a VPI on stator to recover insulation integrity on stator and improve PI factor.
- Rotor should have VPI treatment to maintain the PI factor and increase the reliability.
- While overhauling unit a recondition rotor iron and shaft to remove rust should be performed. Once complete and rust removed a coating from the VPI and epoxy paint should be applied to prevent future corrosion.
- Dynamically balance rotor.
- Measure and record all mechanical fits.
- Reassemble and prepare for shipping.

- **Budget Price for this service is .... $ 6,875.00 TNIP Budget Only**

Notes:

- This is a budgetary price only and is non-binding.
- Firm pricing is available if requested or tendered.
- Installation of anti-condensation heaters and all required mechanical work would be additional and extra.

Condition Assessment Findings

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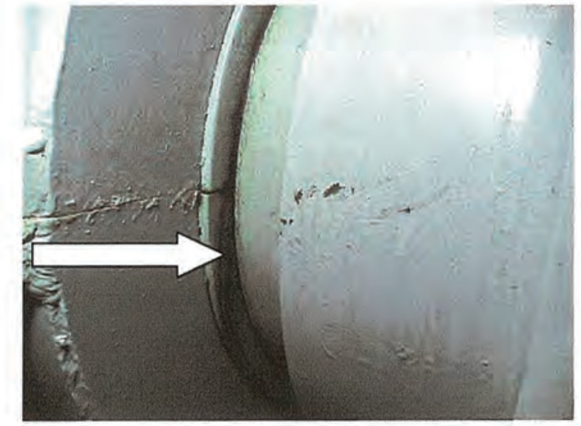
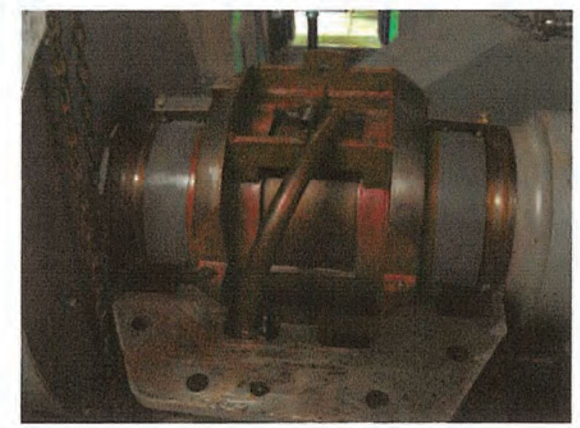
Equipment Name: **Main Babbitt Bearing**



Some leakage at labyrinth seal

Leakage on bearing foundation



Bearing with top half cover removed

Outboard labyrinth seal and shaft seal (grooves wear marks)

Condition Assessment Findings

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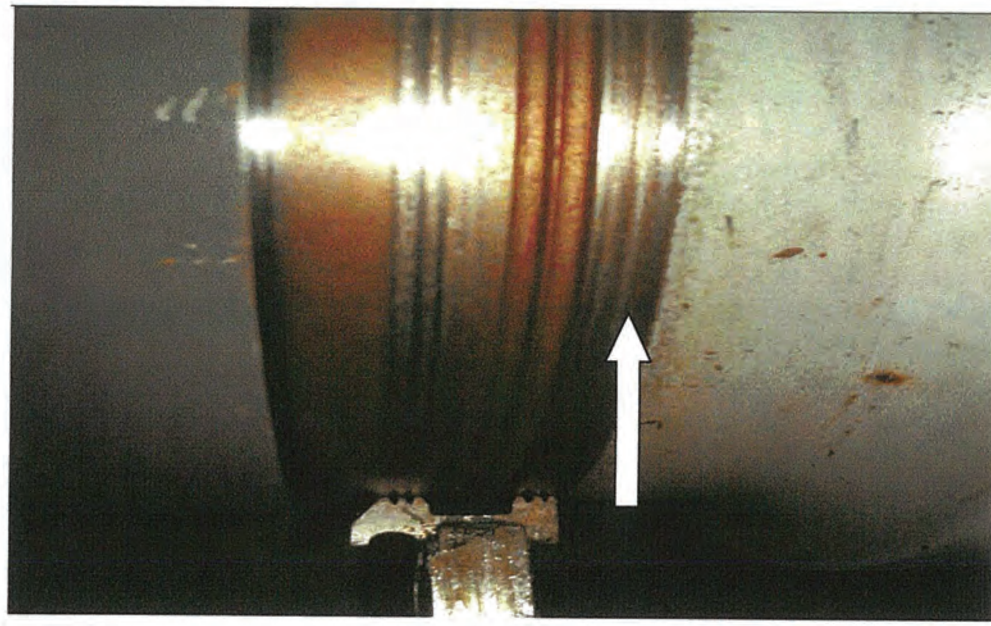
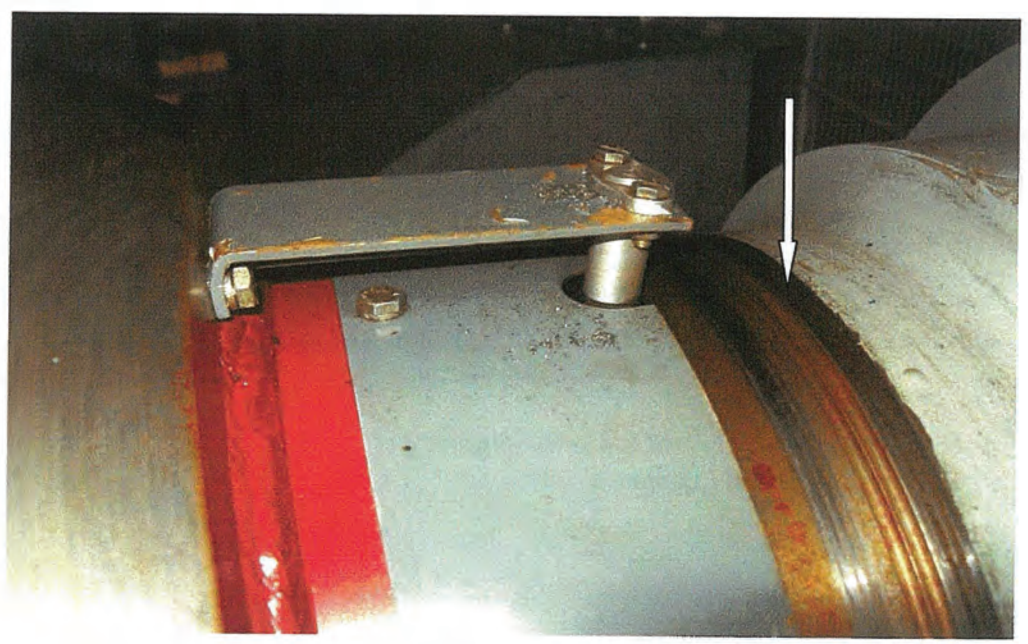


Inboard labyrinth seal and shaft seal (grooves wear marks) paint removal indicates thermal expansion



Inboard oil wiper setup and shaft seal condition (grooves wear marks)
Same thing applied on the outboard end but in reverse direction

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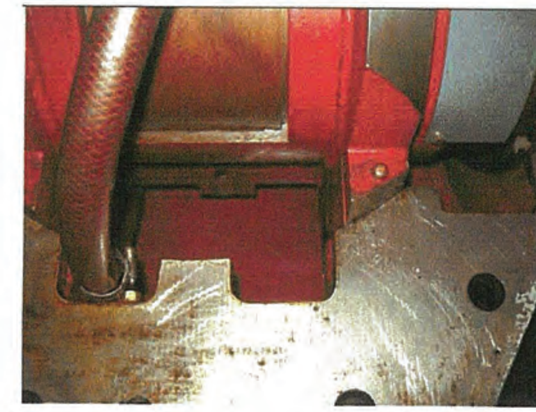

Self align bearing shell setup

Inboard and outboard oil wiper comparison

Babbitt liner of bottom half bearing

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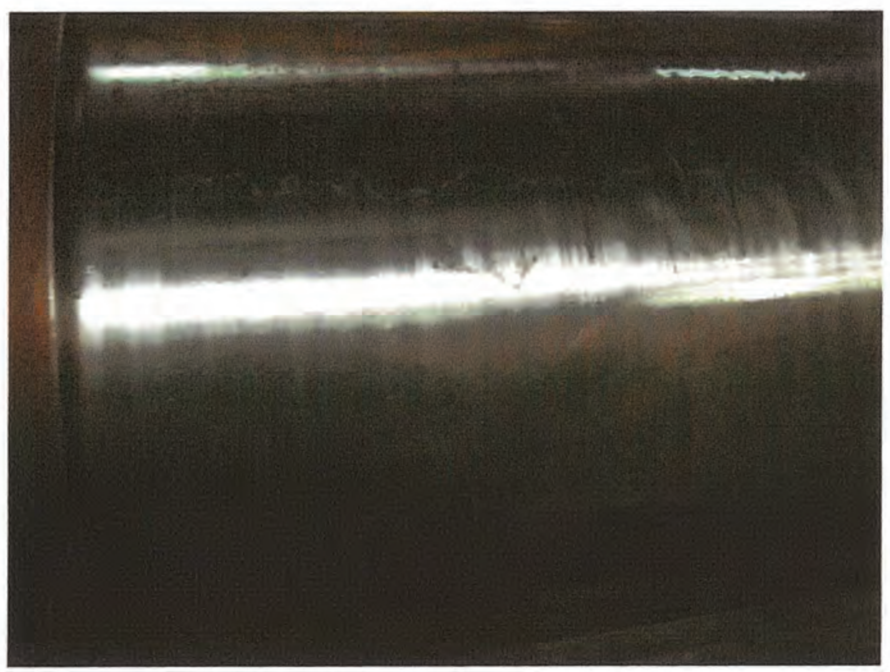
Close up of Babbitt liner bottom half bearing



Shaft journal condition (marking of sitting idle for long period of time)

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Visual inspection:

A visual inspection was performed on this bearing while apart.

- All fasteners are in good condition and solid.
- This bearing is still in good physical shape despite some oil leakage through the labyrinth seals.
- The air gap between the rotor and stator of exciter are very even in both directions (within 4%) which indicate the wear on the main bearing is very minimal from the original.
- There is wear and grooving on the shaft seals at both ends of the bearing.
- Oil leakage was apparent from the residue left on the bearing housing and foundation under the bearing.

Recommended Action:

- Bearing shells should be removed and sent for recondition and polishing of Babbitt areas and faces.
- Several sets of bearing measurements should be conducted with the bearing clamped together (inboard side, middle and outboard side).
- Labyrinth seals should be adjusted to prevent further grooving and the shaft should be polished to remove present grooves.
- Inboard oil wiper should be replaced, near end of life.
- When installed in the housing a fit test should be performed to verify bearing contact with shaft.
- For future preservation the rotor should be turned on a monthly basis to prevent shaft marking and maintain an oil film in the bearing.

Budget Pricing and Notes:

- **Budget Price for this service is .... $ 2000.00 TNIP Budget Only**

Notes:
- This is a budgetary price only and is non-binding.
- Firm pricing is available if requested or tendered.

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Equipment Name: 14.5 MW Generator

Roof top exhaust/ventilation is showing signs of corrosion and moisture ingress.

View #2 of the roof top exhaust/ventilation.

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Roof top exhaust/ventilation paint flaking and corrosion.

Rust flakes present on top stator core from exhaust/ventilation.

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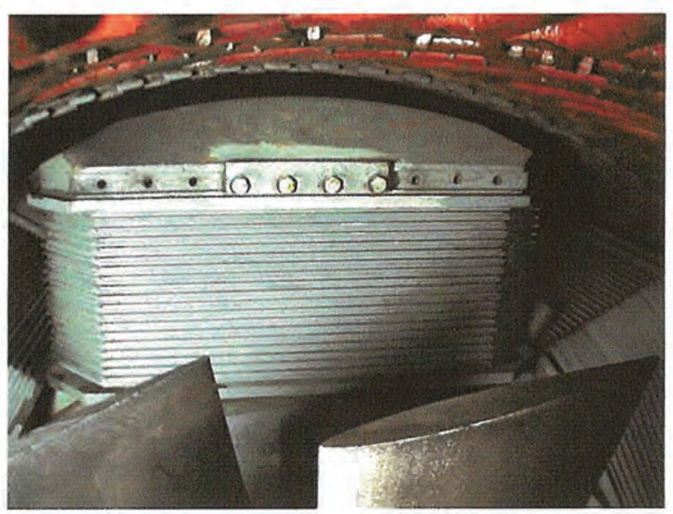
Rust flakes present in bottom of stator enclosure.



Air gap between rotor and stator; rotor poles are in good physical condition.

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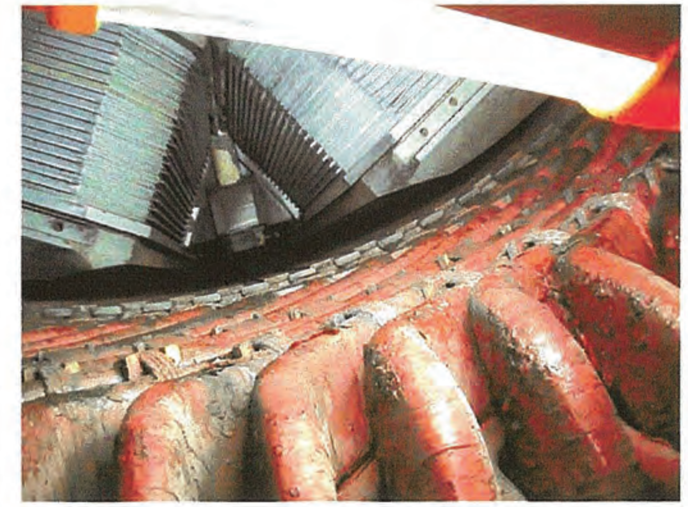
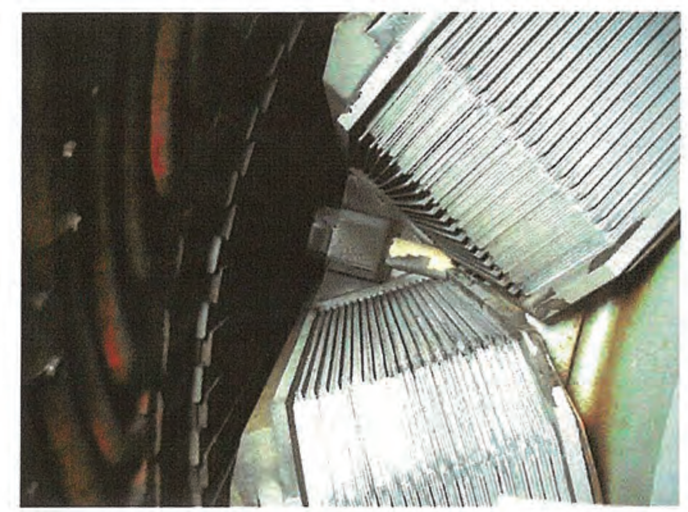


Connections between poles appear in good condition.



Pole clamps between poles appear to be in good condition

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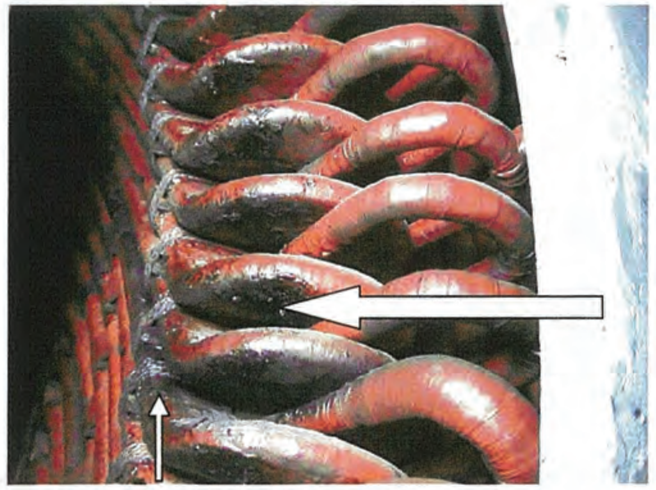

Over heating has occurred in the past: discoloration and resin melted at knuckles.

Discoloration heating pattern on some coils.

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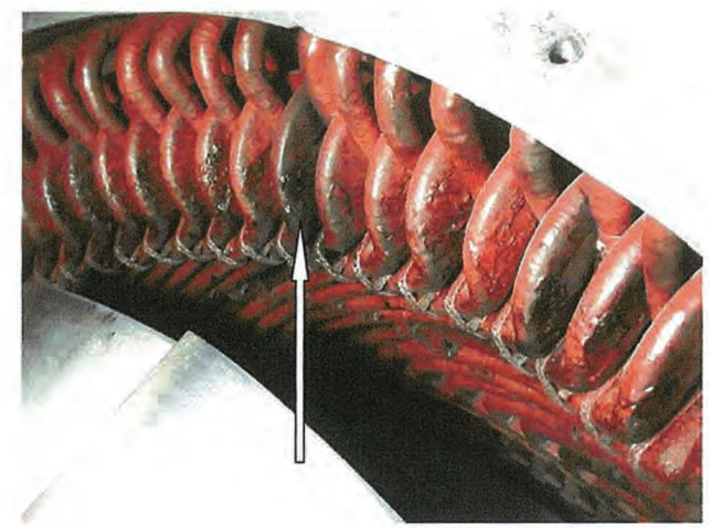
Resin present on knuckles is an indication of overheating.



Discoloration heating pattern on single coil.

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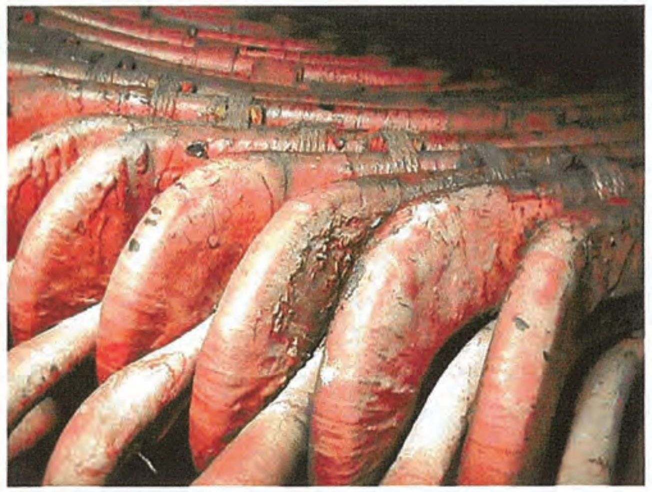

Dry brittle insulation

Dry brittle flaking insulation on coils

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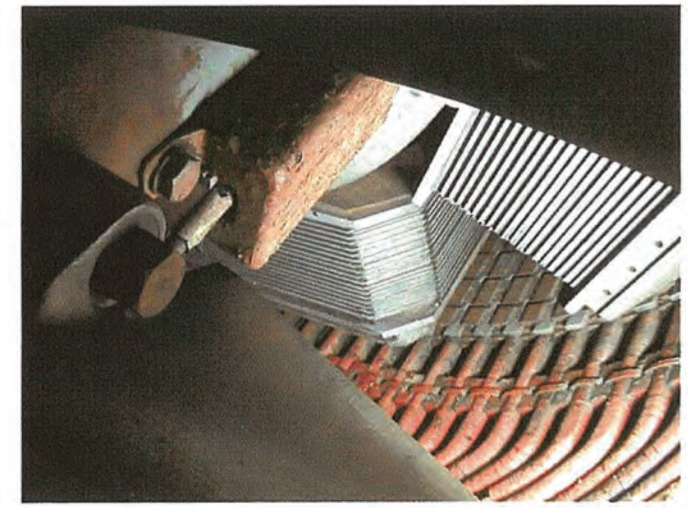

View of wedges and iron.

Rub mark on fan blade edge showing previous contact with fan cover.

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Wear marks on fan cover showing previous blade contact

Star Point had to be disconnected from transformer for true reading.
With this point connected insulation resistance to ground reading is 2000 Ω.

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Visual inspection:

Prior to conducting any electrical tests on this unit a visual inspection was performed.

- Roof top exhaust/ventilation is corroded and rusted.
- Rust flaking from exhaust/ventilation is present on top of stator core and in bottom of generator enclosure.
- Rotor appears to be in good condition, connections and pole clamps appear to be solid and do not show signs of movement.
- Stator iron and wedging appear to be in good condition.
- Stator coils show signs of over heating and heating discoloration pattern is present in coil system.
- Stator insulation system appears to be degraded, dry and flaking throughout the unit.
- Fan blades have contact wear pattern on edge of blades. This coincides with the wear pattern on the fan cover.

Test Results:

Generator Rotor:

- Insulation Resistance to ground @ 1 minute = 2.67 MΩ
- Polarization Index Test = $\frac{\text{10 minute reading}}{\text{1 minute reading}} = \frac{2.95\ \text{M}\Omega}{2.67\ \text{M}\Omega}$ = 1.1 damp and dirty
- Overall DC Rotor Circuit Resistance = 439 mΩ

Generator Stator:

- Insulation Resistance to ground @ 1 minute = 1030 MΩ
- Polarization Index Test = $\frac{\text{10 minute reading}}{\text{1 minute reading}} = \frac{1990\ \text{M}\Omega}{1030\ \text{M}\Omega}$ = 1.93 damp and dirty
- Phase to phase resistance:
  - Ø A to Ø B = 50.0 mΩ
  - Ø A to Ø C = 68.87 mΩ
  - Ø B to Ø C = 72.51 mΩ

Condition Assessment Findings

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Recommended Action:

- The exhaust/ventilation unit should be removed, reconditioned or replaced and a corrosion resistant coating applied to prevent future corrosion issues.
- The fan blade assembly and fan cover should be reconditioned and adjusted to prevent future contact and wear.
- The rotor winding insulation resistance to ground is not in the desired range (only 2.95 MΩ @500 volts).
- Drop test rotor poles when disassembled to verify balanced resistance of poles.
- Remove rotor and transport to work shop facility for overhaul and steam clean windings to improve test readings.
- Once readings have been improved the rotor should be sealed with a resin treatment to maintain the insulation system integrity.
- With star point of stator disconnected, the insulation resistance to ground of the stator winding is fair; however, the resistance between each phase is unbalanced (30% unbalance). Possible cause of undesirable readings could be Turn to Turn shorts in coil system or grounded coils cut out of coil system (discoloration in some coils are good indication).
- Stator should be stripped, blasted with a low abrasive to remove scale on top of core, a core loss or Elcid test should be performed to verify iron integrity and rewound on-site with high integrity coil system approved for high voltage generator applications.
- Rotor should be rotated once per month to prevent rotor sag condition.
- Unit is installed in an area with a high delta in temperature (cold during idle, hot during operation). Anti condensation heater installation is recommended to prevent moisture build-up.
- If unit is rewound and put back into service a run up of the unit should be performed after repair to measure the voltage output under load. At the same time, other tests should be conducted such as temperature of the new winding and a baseline vibration test conducted under motor view parameters and temperature rise of the bearing recorded.

Note: When reviewing this report our Technical Sales Representative is available to answer any questions you may have, provide information, clarification, explain test results and all findings. Please feel free to contact our office at your convenience to schedule a meeting time.

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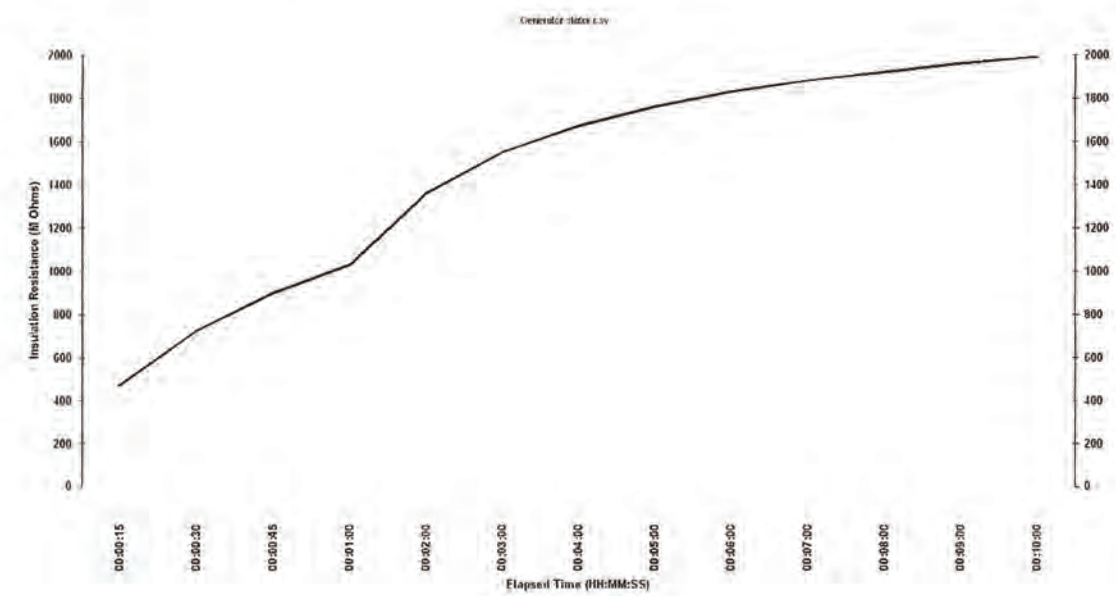
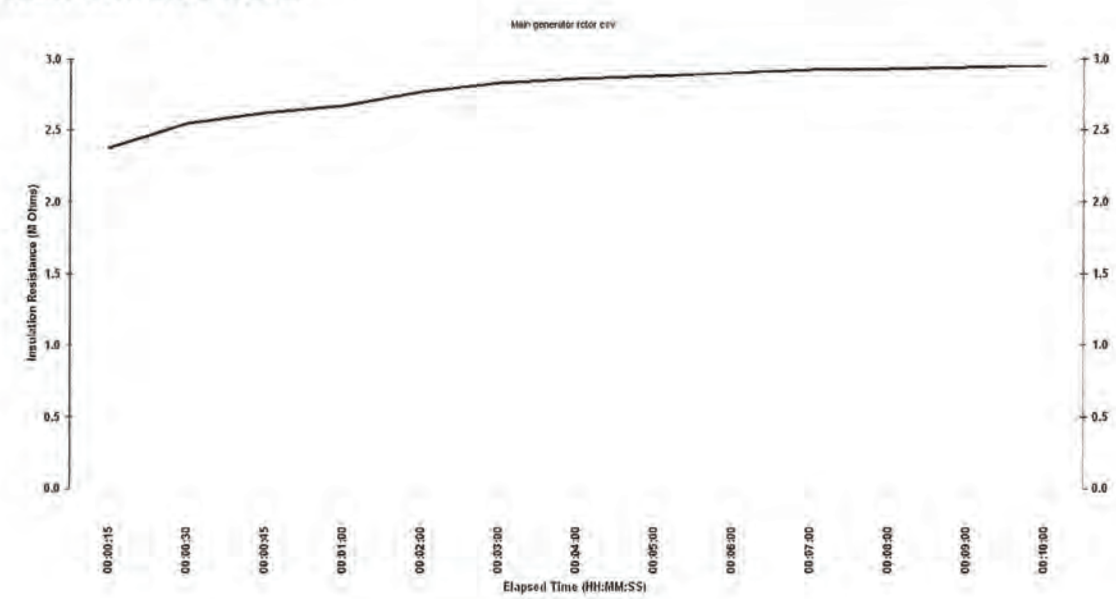
Polarization Index Test Graphical Results

Main Generator Stator:



Main Generator Rotor:



Budget Pricing with Scope of Work and Notes:

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- Dismantle generator on-site.
- Remove rotor and stator and transport to our O'Leary Ave shop facility.
- Drop test rotor poles when disassembled to verify balanced resistance of poles.
- Overhaul and steam clean windings to improve test readings.
- Once readings have been improved the rotor should be sealed with a resin treatment to maintain the insulation system integrity.
- Strip stator and take accurate winding data, blast core with a low abrasive to remove scale on top of core, a core loss or Elcid test should be performed to verify iron integrity and rewound with high integrity coil system approved for high voltage generator applications.
- Return unit to site and assemble.
- Once rewound and put back into service a run up of the unit should be performed after repair to measure the voltage output under load. At the same time, other tests should be conducted such as temperature of the new winding and a baseline vibration test conducted under motor view parameters and temperature rise of the bearing recorded.

- **Budget Price for this service is .... $ 750,000.00 TNIP each Budget Only**

Notes:

- This is a budgetary price only and is non-binding.
- Siemens will dismantle unit and remove from site for rewind.
- Exhaust/ventilation housing to be replaced by 3rd party contractor and would be considered extra.
- Firm pricing is available if requested or tendered.
- Installation of anti-condensation heaters and all required mechanical work would be additional and extra.

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HRD Condition Assessment and Budget Pricing

for

NL Hydro
Holyrood Generating Station

PREPARED BY:

SIEMENS

February 2011

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Resistance To Ground Test

The resistance-to-ground test is also known in industry as a megger test due to the popularity of the instrument for performing the test manufactured by megger.

The purpose of the resistance-to-ground test is to determine whether or not there's a ground fault in a stator winding. This test is easy to conduct in the field as the only required tool is a meg-ohmmeter.

Important Notes:

- Ensure there is a good ground for the test lead to attach to.
- Take the resistance-to-ground reading at 1 min. Readings taken after this time will change as the insulation begins to polarize.
- Note the unit of measure when recording the test result (Mega, Giga, Tera).
- When performing multiple tests, IEEE states that between tests, the winding should be grounded for 4 times the length of the test to discharge the windings. (Ex: A resistance-to-ground test is done and held for 1 minute. Before performing any other tests, the motor leads should be grounded to the frame for 4 minutes).

Polarization Index of Machine Windings

Knowing the polarization Index of a motor or generator can be useful in appraising the fitness of the machine for service. The index is calculated from measurements of the winding insulation resistance.

Before measuring the insulation resistance, remove all external connections to the machine and completely discharge the windings to the grounded machine frame.

Proceed by applying either 500 or 1000 volts dc between the winding and ground using a direct-indicating, power-driven megohmmeter. For machines rated 500 volts and over, the higher value is used. The voltage is applied for 10 minutes and kept constant for the duration of the test.

The polarization index is calculated as the ratio of the 10-minute to the 1-minute value of the insulation resistance, measured consecutively.

$$\text{Polarization Index} = \frac{\text{Ins. Resistance after 10 minutes}}{\text{Ins. Resistance after 1 minute}}$$

The recommended minimum value of polarization index for ac and dc motors and generators is 2.0. Machines having windings with a lower index are less likely to be suited for operation. The desired result for a PI Test is a ratio between 2 and 5; readings less than 2 usually indicate that the winding is damp and dirty and a ratio over 5 indicates that the winding is dry and brittle.

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The polarization index is useful in evaluating windings for:

- Build-up of dirt or moisture.
- Gradual deterioration of the insulation (by comparing results of tests made earlier on the same machine).
- Fitness for overpotential tests.
- Suitability for operation.

There are exceptions to the Polarization Index test for some new coil and insulation systems that are now being utilized in the industry therefore we recommend a trained technician perform the test so the proper diagnosis be given for your equipment. The procedure for determining the polarization index is covered in detail by IEEE Standard No. 43.

Phase-to-phase Resistance

Phase-to-phase resistance is the measured DC resistance between phases of the stator in an AC motor and between polarities of the armature and field coils in a DC motor.

In AC induction motors, use the phase-to-phase resistance values and resistive imbalances for trending, troubleshooting and quality control. In DC motors, use trending and relative comparison to determine the condition of the phases in the motor and power circuits. This includes comparing readings taken from identical motors operating in similar conditions and comparing current readings against past readings for the same motor.

An increasing resistive imbalance or a changing resistance over time can indicate one or more of the following:

- High resistance connections
- Coil-to-coil, phase-to-phase, or turn-to-turn current leakage paths
- Corroded terminals or connections
- Loose cable terminals or bus bar connections
- Open windings
- Poor crimps or bad soldier joints
- Loose, dirty, or corroded fuse clips or manual disconnect switches
- Undersized conductors (misassemble or improperly engineered)

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Description of Tests

Why is this important?

The length, size, width, composition, condition, type and temperature of the conductors and connectors determine circuit resistance. When two different conductors are connected, dirt, corrosion or an improper connection increases the circuit resistance. Also, inadequate connections cause heating of the conductor, which increases resistance even more. This could be caused if only a few strands of a conductor or portions of a soldered joint are improperly connected to a terminal or if undersized connectors are used.

In a three-phase motor circuit, the resistance in the conductor paths should be as close to equal as possible. A "resistive imbalance" occurs when the phase have unequal resistance. This produces uneven current flow and excessive heat.

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Condition Assessment Findings

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Equipment Name: **AC Lube Oil Motor**

Visual inspection:

Prior to conducting any electrical tests on this unit a visual inspection was performed.

- Externally the motor appears to be in good shape with all covers installed and conduit connectors in good physical condition.
- Internally the inspection was very limited due to accessibility. Therefore a full determination of condition cannot be made.
- Due to time limit and permitting issues, this motor was not run up for vibration analysis test.

Test Results:

- Insulation Resistance to ground @ 1 minute = 4600 MΩ
- Polarization Index Test = $\frac{\text{10 minute reading}}{\text{1 minute reading}} = \frac{5300\ \text{M}\Omega}{4600\ \text{M}\Omega}$ = 1.15 Damp and dirty.
- Phase to phase resistance:
  - Ø A to Ø B = 584.9 mΩ
  - Ø A to Ø C = 584.0 mΩ
  - Ø B to Ø C = 584.4 mΩ

Recommended Action:

- Overhaul unit to steam clean windings.
- Perform a stator VPI to recover insulation integrity and improve PI factor.
- Measure and record all mechanical fits and change bearings.
- Perform no-load run test and capture vibration trend data for future reference.
- Unit is installed in an area with a high delta in temperature (cold during idle, hot during operation). Anti condensation heater installation is recommended to prevent moisture build-up.

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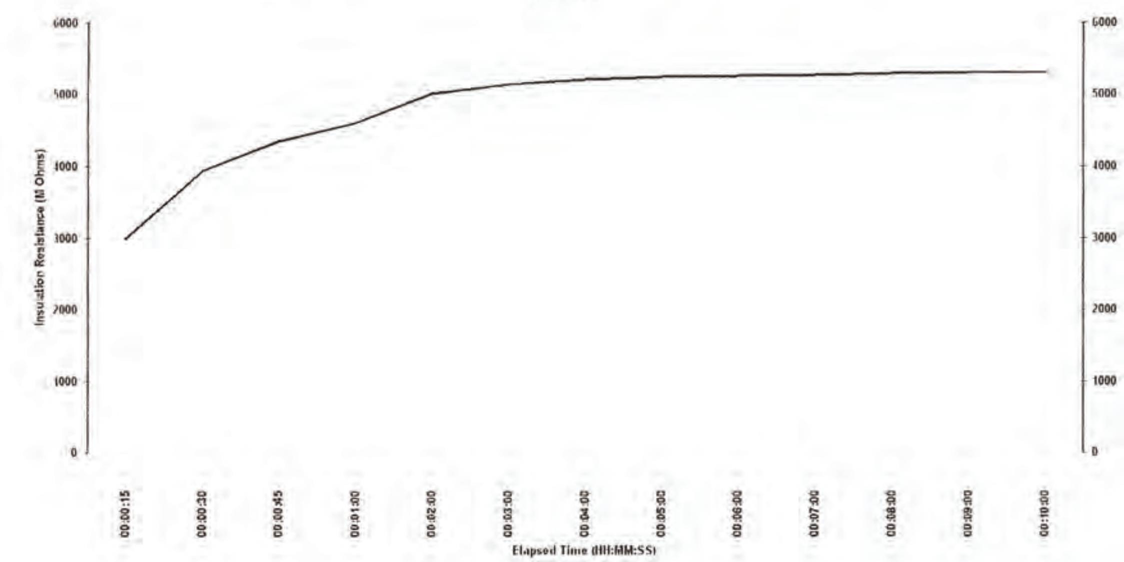
Condition Assessment Findings

Polarization Index Test Graphical Results



Budget Pricing with Scope of Work and Notes:

- Receive unit at our O'Leary Ave. facility.
- Dismantle and overhaul unit to steam clean windings.
- Perform a stator VPI to recover insulation integrity and improve PI factor.
- Dynamically balance rotor.
- Measure and record all mechanical fits and change bearings.
- Perform no-load run test and capture vibration trend data for future reference.

- **Budget Price for this service is .... $ 2,300.00 TNIP Budget Only**

Notes:
- This is a budgetary price only and is non-binding.
- Firm pricing is available if requested or tendered.
- Installation of anti-condensation heaters and all required mechanical work would be additional and extra.

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Condition Assessment Findings

Equipment Name: **DC backup lube oil pump motor**

Visual inspection:

Prior to conducting any electrical tests on this unit a visual inspection was performed.

- Externally the motor appears to be in good shape with all screens and covers installed and conduit connectors in good physical condition.
- Internally the inspection was limited due to accessibility. Therefore a full determination of condition cannot be made. However, it was noted that the armature coils appeared to be dry with some signs of overheating at the armature riser section.
- Due to time limit and permitting issues, this motor was not run up for vibration analysis test.

Test Results:

- Insulation Resistance to ground @ 1 minute = 185 MΩ
- Polarization Index Test = $\frac{\text{10 minute reading}}{\text{1 minute reading}} = \frac{172\ \text{M}\Omega}{185\ \text{M}\Omega}$ = 0.93 Damp and dirty.
- Overall DC Circuit Resistance = 27.62 Ω

Recommended Action:

- Overhaul unit to steam clean stator and armature windings.
- Perform a stator and armature VPI to recover insulation integrity and improve PI factor.
- Recondition brush rigging and check spring tension.
- Check all mechanical fits and change bearings.
- Refurbish commutator, undercut and bevel copper bar segments for smooth operation.
- Install new brushes and seat on refurbished commutator.
- Perform no-load run test and capture vibration trend data for future reference.
- Unit is installed in an area with a high delta in temperature (cold during idle, hot during operation). Anti condensation heater installation is recommended to prevent moisture build-up.

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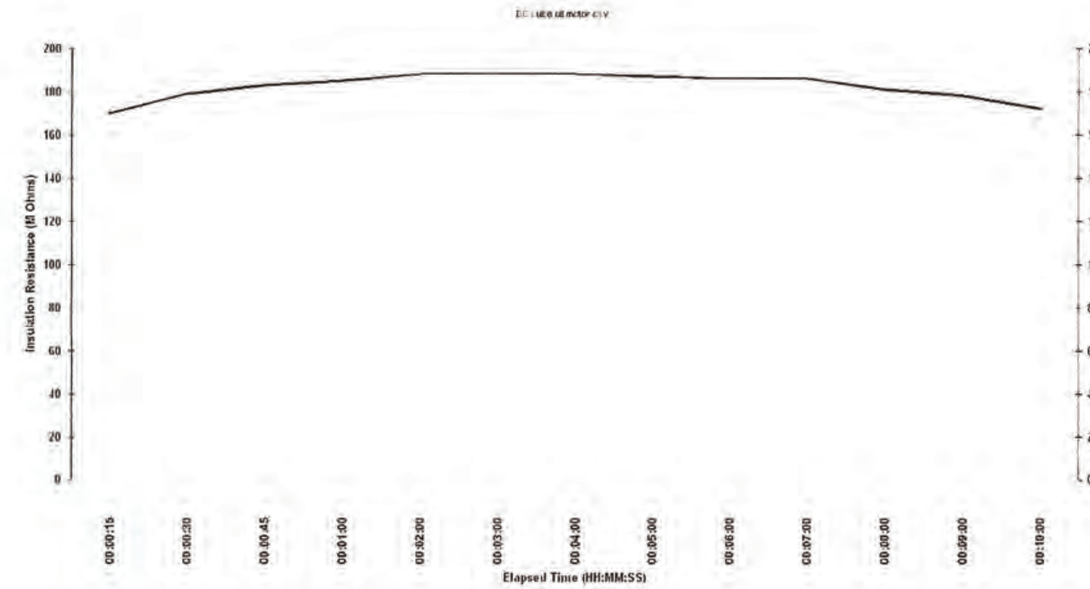
Condition Assessment Findings

Polarization Index Test Graphical Results



Budget Pricing with Scope of Work and Notes:

- Receive unit at our O'Leary Ave. facility.
- Dismantle and overhaul unit to steam clean stator and armature windings.
- Perform a stator and armature VPI to recover insulation integrity and improve PI factor.
- Dynamically balance armature.
- Recondition brush rigging and check spring tension.
- Check all mechanical fits and change bearings.
- Refurbish commutator, undercut and bevel copper bar segments for smooth operation.
- Perform no-load run test and capture vibration trend data for future reference.

- **Budget Price for this service is .... $ 3,500.00 TNIP Budget Only**

Notes:

- This is a budgetary price only and is non-binding.
- Firm pricing is available if requested or tendered.
- Supply and installation of brushes would be considered extra.
- Installation of anti-condensation heaters and all required mechanical work would be additional and extra.

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Equipment Name: AC Lube Oil Cooler Fan

Visual inspection:

Prior to conducting any electrical tests on this unit a visual inspection was performed.

- Externally this fan unit is rusty on the outside, the stator frame and rotor shaft extension show signs of environmental corrosion but is mostly superficial.
- Disregarding the overall appearance, the motor appears to be in good shape with all screens and covers installed and conduit connectors in good physical condition. A screen was removed to gain access to the unit as shown in the picture above.
- Internally the inspection was limited due to accessibility. Therefore a full determination of condition cannot be made.

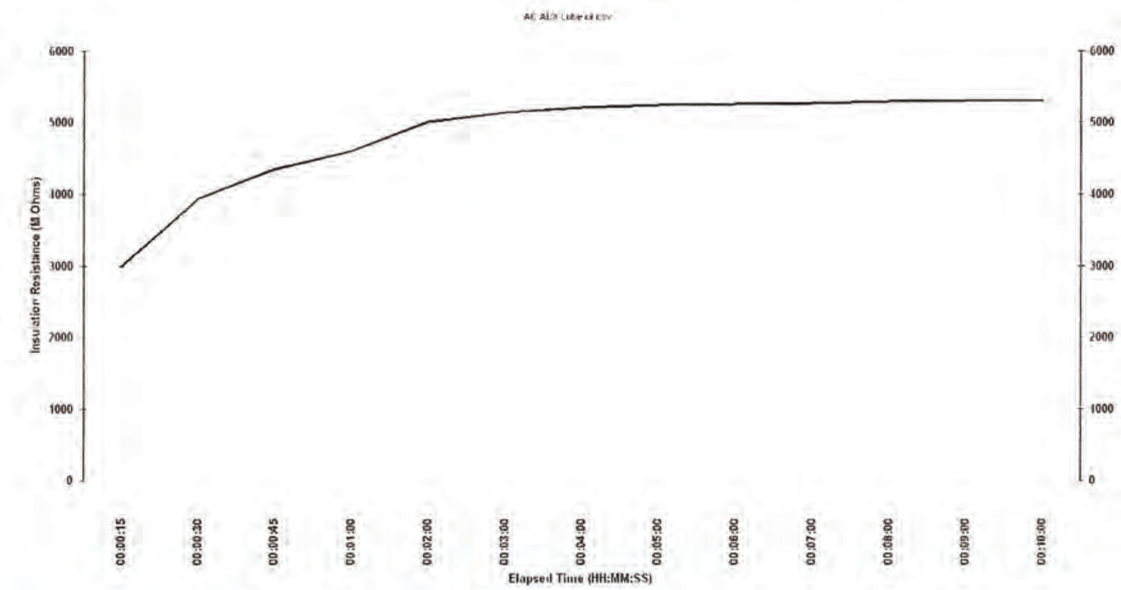
Test Results:

- Insulation Resistance to ground @ 1 minute = 5520 MΩ
- Polarization Index Test = $\frac{\text{10 minute reading}}{\text{1 minute reading}} = \frac{7550\ M\Omega}{5520\ M\Omega} = 1.37$ Damp and dirty.
- Phase to phase resistance:
  - Ø A to Ø B = 404.5 mΩ
  - Ø A to Ø C = 403.7 mΩ
  - Ø B to Ø C = 406.4 mΩ
- Vibration analysis:
  - The vibration analysis test indicated dry anti-friction bearings on both ends of the motor; adding grease into the bearings was suggested after the assessment testing and prior to the screen being installed.
  - Small amount of couple imbalance indicated at NDE of motor due to large fan at the DE of the motor.

Recommended Action:

- Overhaul unit to steam clean stator.
- Perform a stator dip & bake to recover insulation integrity and improve PI factor.
- Recondition fan unit and motor frame.
- Paint fan unit and motor with epoxy paint to prevent corrosion.
- Check all mechanical fits and change bearings.
- Perform no-load run test and capture vibration trend data for future reference.
- Anti condensation heater installation is recommended to prevent moisture build-up.

Polarization Index Test Graphical Results



Budget Pricing with Scope of Work and Notes:

- Receive unit at our O'Leary Ave. facility.
- Overhaul unit to steam clean stator.
- Perform a stator dip & bake to recover insulation integrity and improve PI factor.
- Recondition fan unit and motor frame.
- Paint fan unit and motor with epoxy paint to prevent corrosion.
- Check all mechanical fits and change bearings.
- Perform no-load run test and capture vibration trend data for future reference.

- **Budget Price for this service is .... $ 3,050.00 TNIP Budget Only**

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Condition Assessment Findings

Notes:
- This is a budgetary price only and is non-binding.
- Firm pricing is available if requested or tendered.
- Installation of anti-condensation heaters and all required mechanical work would be additional and extra.
- Sandblasting and painting of fan housing would be considered extra and completed by a 3rd party contractor.

Equipment Name: **East Fuel Oil Motor**

Both fuel oil pump (East and West) are in this enclosure

Visual inspection:

Prior to conducting any electrical tests on this unit a visual inspection was performed.
- Externally the motor appears to be in fair shape with some surface corrosion.
- All covers installed and conduit connectors in good physical condition.
- Internally the inspection was very limited due to accessibility. Therefore a full determination of condition cannot be made.
- This motor should not be confused with the 25 HP pump unit (25 HP pump unit is for pumping fuel to the storage tank not to supply fuel to turbine).
- Due to time limit and permitting issues, this motor was not run up for vibration analysis test.

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Condition Assessment Findings

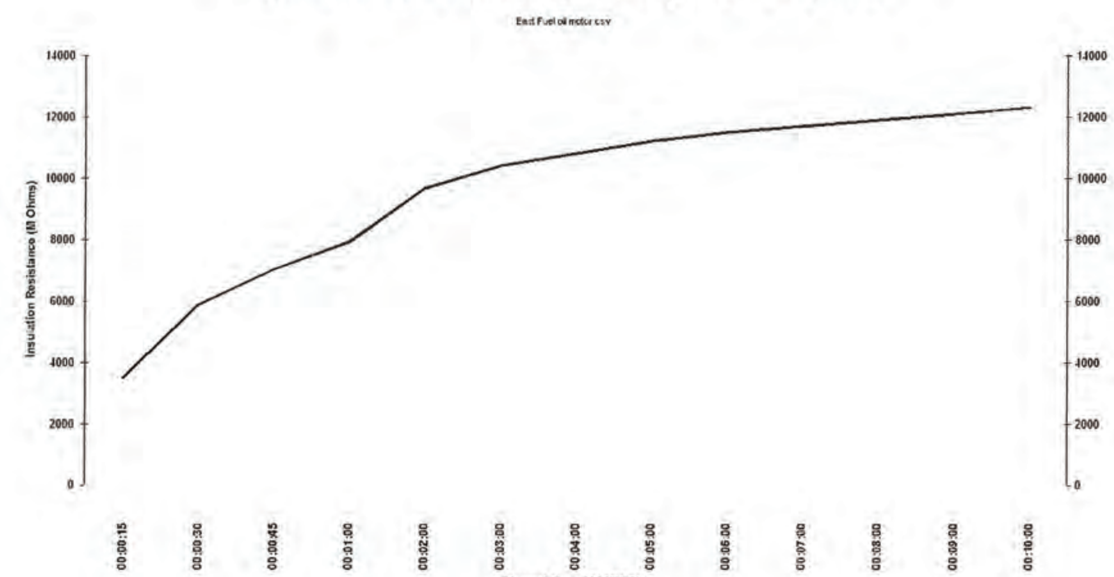
Test Results:

- Insulation Resistance to ground @ 1 minute = 7920 MΩ
- Polarization Index Test = $\frac{\text{10 minute reading}}{\text{1 minute reading}} = \frac{12300\ M\Omega}{7920\ M\Omega}$ = 1.56 Damp and dirty.
- Phase to phase resistance:
  - Ø A to Ø B = 9.952 Ω
  - Ø A to Ø C = 9.938 Ω
  - Ø B to Ø C = 9.956 Ω

Recommended Action:

- Overhaul unit to steam clean windings.
- Perform a stator dip & bake to recover insulation integrity and improve PI factor.
- Measure and record all mechanical fits and change bearings.
- Perform no-load run test and capture vibration trend data for future reference.
- Unit is installed in an area with a high delta in temperature (cold during idle, hot during operation). Anti condensation heater installation is recommended to prevent moisture build-up.

Polarization Index Test Graphical Results



Condition Assessment Findings

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Equipment Name: West Fuel Oil Motor

Both fuel oil pump (East and West) are in this enclosure

Visual inspection:

Prior to conducting any electrical tests on this unit a visual inspection was performed.

- Hatch on enclosure was not in place and unit is covered in snow. Snow was removed to perform visual and tests.
- Externally the motor appears to be in fair shape with some surface corrosion.
- All covers installed and conduit connectors in good physical condition.
- Internally the inspection was very limited due to accessibility. Therefore a full determination of condition cannot be made.
- Due to time limit and permitting issues, this motor was not run up for vibration analysis test.

Test Results:

- Insulation Resistance to ground @ 1 minute = 1250 MΩ
- Polarization Index Test = $\frac{\text{10 minute reading}}{\text{1 minute reading}} = \frac{1190\ \text{M}\Omega}{1250\ \text{M}\Omega}$ = 0.95 Damp and dirty.
- Insulation Resistance and PI Factor could be skewed due to motor being covered in snow, temperature will affect the conductors.
- Phase to phase resistance:
    - Ø A to Ø B = 9.952 Ω
    - Ø A to Ø C = 9.938 Ω
    - Ø B to Ø C = 9.956 Ω

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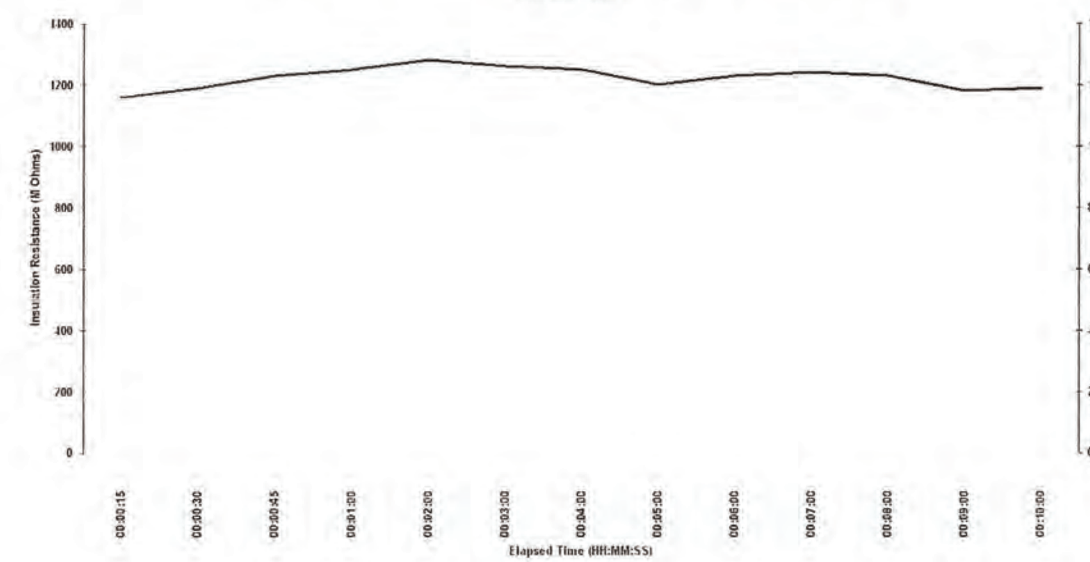
Recommended Action:

- Overhaul unit to steam clean windings.
- Perform a stator dip & bake to recover insulation integrity and improve PI factor.
- Measure and record all mechanical fits and change bearings.
- Perform no-load run test and capture vibration trend data for future reference.
- Unit is installed in an area with a high delta in temperature (cold during idle, hot during operation). Anti condensation heater installation is recommended to prevent moisture build-up.

Polarization Index Test Graphical Results



Budget Pricing with Scope of Work and Notes:

- Receive units at our O'Leary Ave. facility.
- Dismantle and overhaul unit to steam clean windings.
- Perform a stator Dip & Bake to recover insulation integrity and improve PI factor.
- Dynamically balance rotor.
- Recertify for explosion proof application.
- Measure and record all mechanical fits and change bearings.
- Perform no-load run test and capture vibration trend data for future reference.

- **Budget Price for this service is .... $ 1,875.00 TNIP each Budget Only**

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Notes:

- This is a budgetary price only and is non-binding.
- Firm pricing is available if requested or tendered.
- Installation of anti-condensation heaters and all required mechanical work would be additional and extra.

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Equipment Name: 73.5 KW Brushless AC Exciter

Figure 1 - Exciter with cover open.

Figure 2 - Name Plate of Exciter

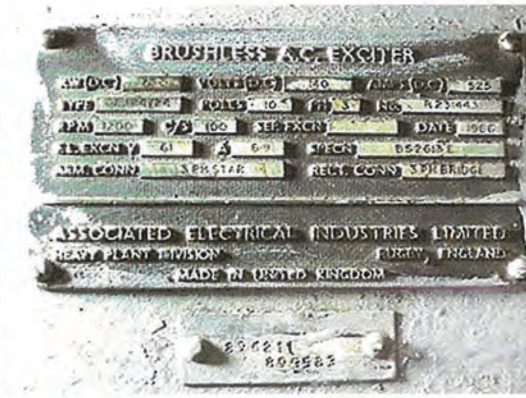


Figure 3 – Rectifier with main rotor leads

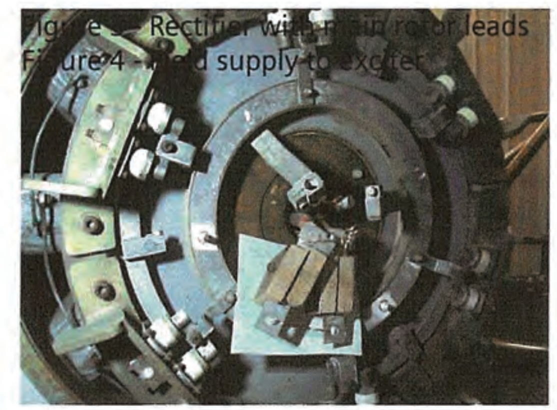
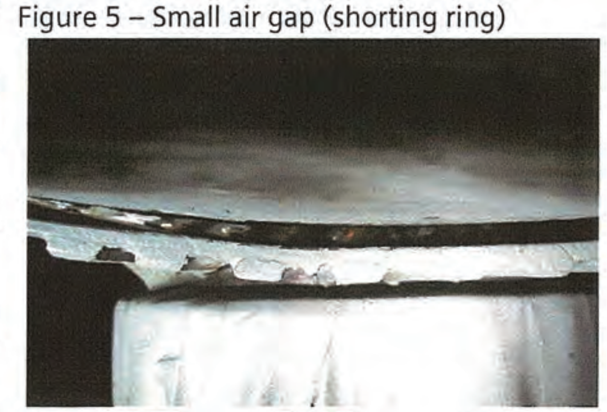


Figure 4 - Field supply to exciter

Figure 6 – View 2 air gap.

Figure 5 – Small air gap (shorting ring)



Condition Assessment Findings

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Figure 7 - Rust at the end of rotor iron

Figure 8 - Rusty exciter rotor shaft

Visual inspection:

Prior to conducting any electrical tests on this unit a visual inspection was performed.

- All fasteners are in good condition and solid.
- All electrical connections are in good condition.
- The air gap between the rotor and stator of exciter are very even in both directions (within 4%) which indicate the wear on the main bearing is very minimal from the original.
- The rectifier is in good condition in both physically and electrically.
- The exciter field stator appears to be dry which coincides with the PI reading.
- There is evidence of condensation in the unit due to the surface rust and corrosion of the rotor iron and shaft, figures 7 & 8 above.

Test Results:

Exciter Rotor:

- Insulation Resistance to ground @ 1 minute = 2060 MΩ
- Polarization Index Test = $\frac{\text{10 minute reading}}{\text{1 minute reading}} = \frac{4400\ \text{M}\Omega}{2060\ \text{M}\Omega}$ = 2.14 fair condition
- Phase to phase resistance:
  - Ø A to Ø B = 4.168 mΩ
  - Ø A to Ø C = 4.187 mΩ
  - Ø B to Ø C = 4.169 mΩ

Condition Assessment Findings

Exciter Stator:

- Insulation Resistance to ground @ 1 minute = 534 MΩ

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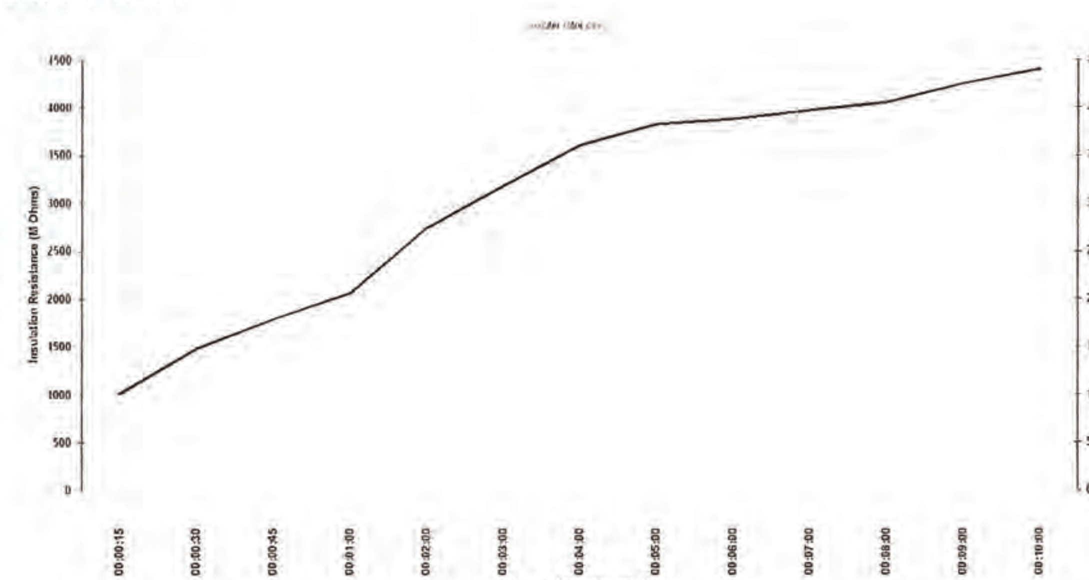
- Polarization Index Test = $\frac{\text{10 minute reading}}{\text{1 minute reading}} = \frac{513\ \text{M}\Omega}{534\ \text{M}\Omega}$ = 0.96 damp and dirty
- Overall DC Circuit Resistance = 4.50 Ω

Recommended Action:

- Overhaul unit to steam clean windings.
- Perform a VPI on stator to recover insulation integrity on stator and improve PI factor.
- Rotor should have VPI treatment to maintain the PI factor and increase the reliability.
- While overhauling unit a recondition rotor iron and shaft to remove rust should be performed. Once complete and rust removed a coating from the VPI and epoxy paint should be applied to prevent future corrosion.
- Measure and record all mechanical fits.
- Unit is installed in an area with a high delta in temperature (cold during idle, hot during operation). Anti condensation heater installation is recommended to prevent moisture build-up.

Polarization Index Test Graphical Results

Exciter Rotor:



Condition Assessment Findings

Exciter Stator:

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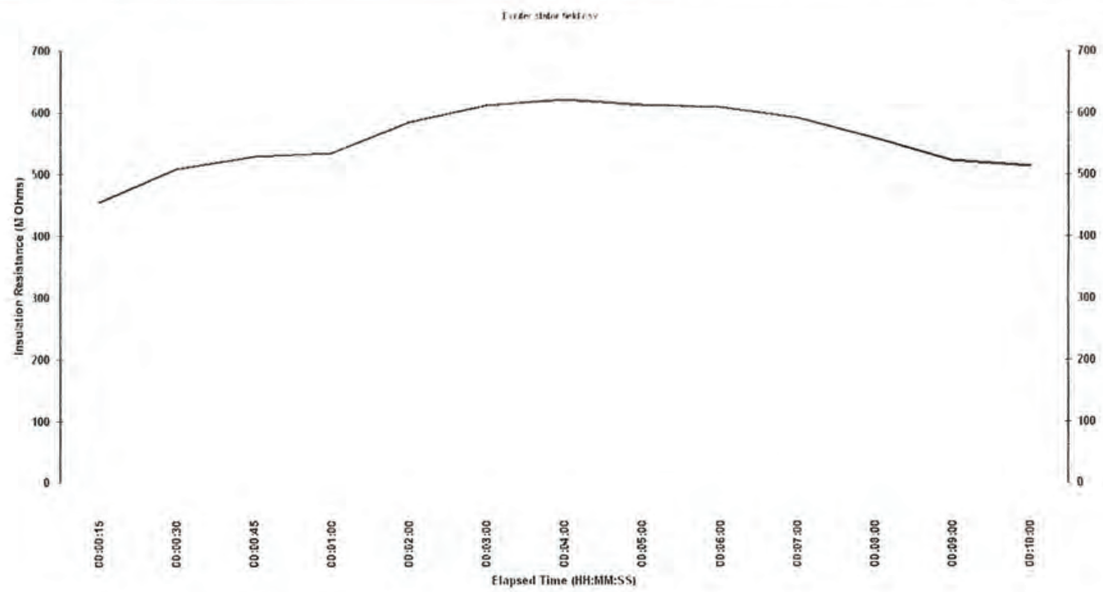

Budget Pricing with Scope of Work and Notes:

- Receive unit at our O'Leary Ave facility.
- Perform a VPI on stator to recover insulation integrity on stator and improve PI factor.
- Rotor should have VPI treatment to maintain the PI factor and increase the reliability.
- While overhauling unit a recondition rotor iron and shaft to remove rust should be performed. Once complete and rust removed a coating from the VPI and epoxy paint should be applied to prevent future corrosion.
- Dynamically balance rotor.
- Measure and record all mechanical fits.
- Reassemble and prepare for shipping.

- **Budget Price for this service is .... $ 6,875.00 TNIP Budget Only**

Notes:
- This is a budgetary price only and is non-binding.
- Firm pricing is available if requested or tendered.
- Installation of anti-condensation heaters and all required mechanical work would be additional and extra.

Condition Assessment Findings

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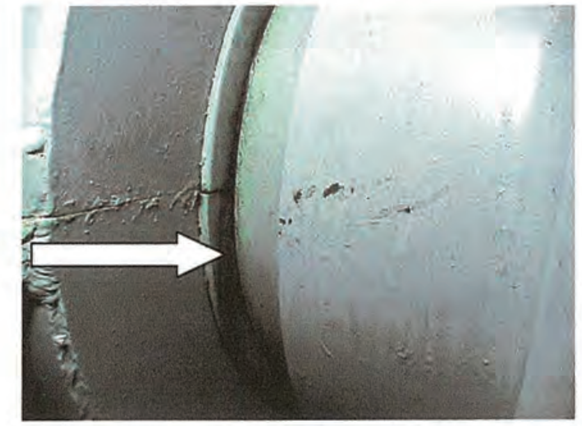
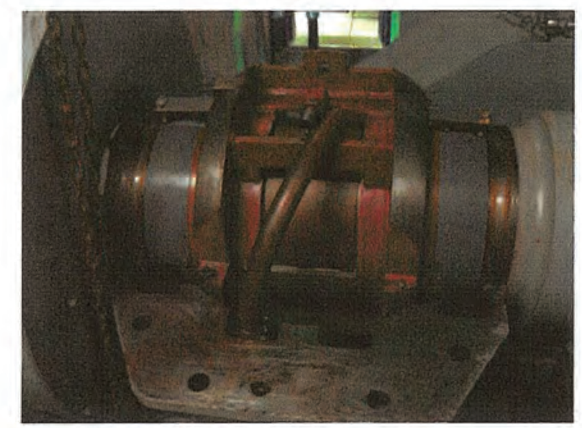
Equipment Name: Main Babbitt Bearing

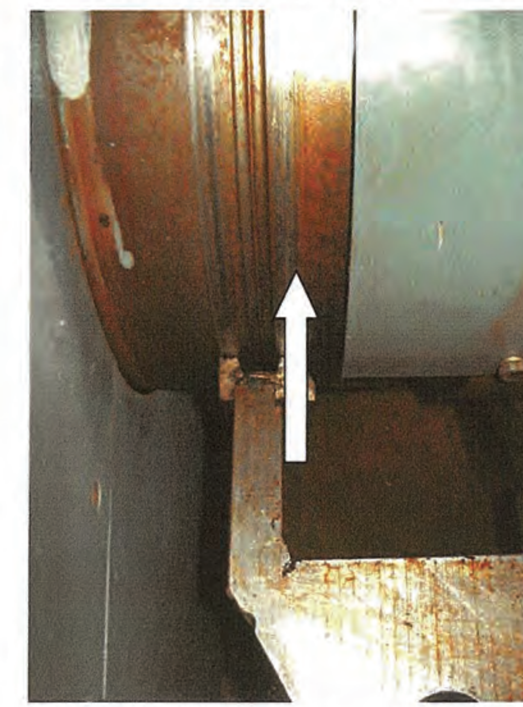


Some leakage at labyrinth seal

Leakage on bearing foundation



Bearing with top half cover removed



Outboard labyrinth seal and shaft seal (grooves wear marks)

Condition Assessment Findings

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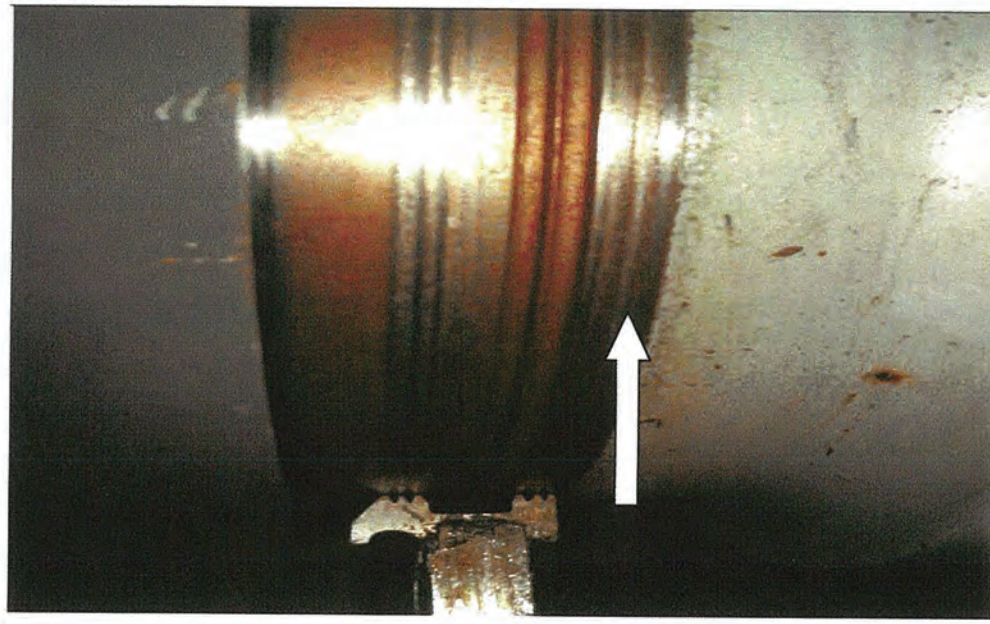
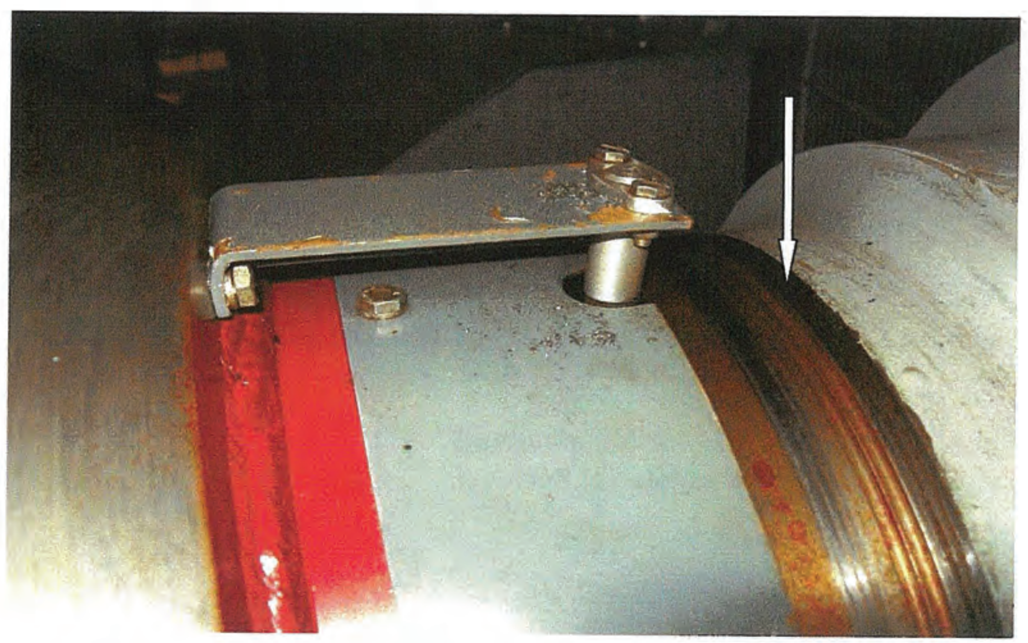


Inboard labyrinth seal and shaft seal (grooves wear marks) paint removal indicates thermal expansion



Inboard oil wiper setup and shaft seal condition (grooves wear marks)
Same thing applied on the outboard end but in reverse direction

Condition Assessment Findings

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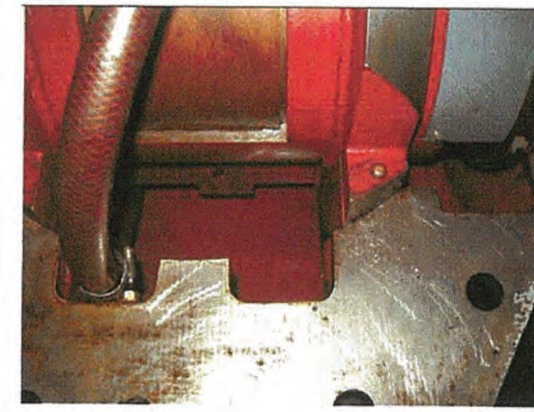
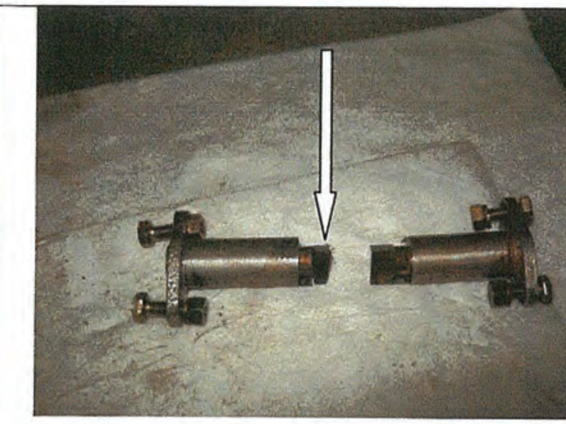


Self align bearing shell setup



Inboard and outboard oil wiper comparison

Babbitt liner of bottom half bearing

Condition Assessment Findings

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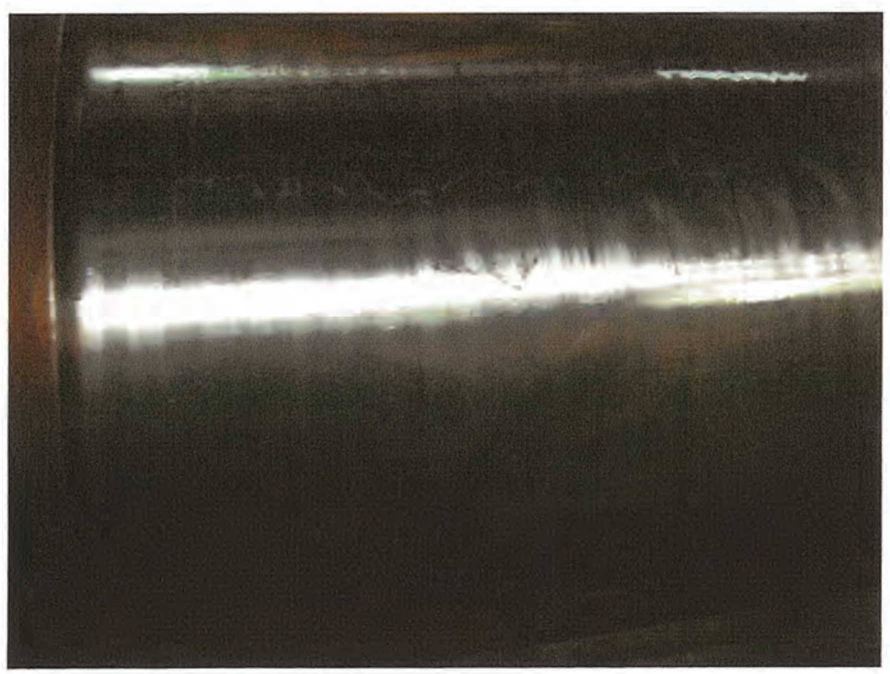
Close up of Babbitt liner bottom half bearing



Shaft journal condition (marking of sitting idle for long period of time)

Condition Assessment Findings

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Visual inspection:

A visual inspection was performed on this bearing while apart.

- All fasteners are in good condition and solid.
- This bearing is still in good physical shape despite some oil leakage through the labyrinth seals.
- The air gap between the rotor and stator of exciter are very even in both directions (within 4%) which indicate the wear on the main bearing is very minimal from the original.
- There is wear and grooving on the shaft seals at both ends of the bearing.
- Oil leakage was apparent from the residue left on the bearing housing and foundation under the bearing.

Recommended Action:

- Bearing shells should be removed and sent for recondition and polishing of Babbitt areas and faces.
- Several sets of bearing measurements should be conducted with the bearing clamped together (inboard side, middle and outboard side).
- Labyrinth seals should be adjusted to prevent further grooving and the shaft should be polished to remove present grooves.
- Inboard oil wiper should be replaced, near end of life.
- When installed in the housing a fit test should be performed to verify bearing contact with shaft.
- For future preservation the rotor should be turned on a monthly basis to prevent shaft marking and maintain an oil film in the bearing.

Budget Pricing and Notes:

- **Budget Price for this service is .... $ 2000.00 TNIP Budget Only**

Notes:

- This is a budgetary price only and is non-binding.
- Firm pricing is available if requested or tendered.

Condition Assessment Findings

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Equipment Name: 14.5 MW Generator

Roof top exhaust/ventilation is showing signs of corrosion and moisture ingress.

View #2 of the roof top exhaust/ventilation.

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Roof top exhaust/ventilation paint flaking and corrosion.

Rust flakes present on top stator core from exhaust/ventilation.

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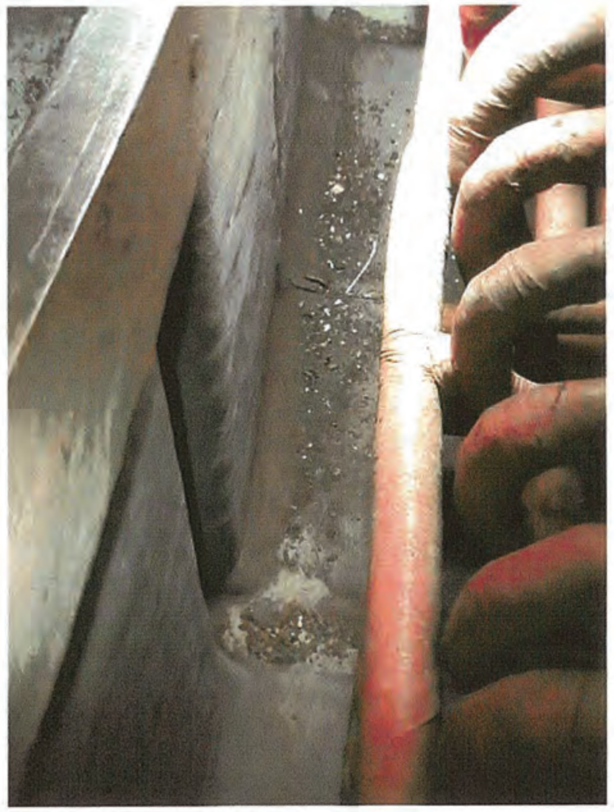
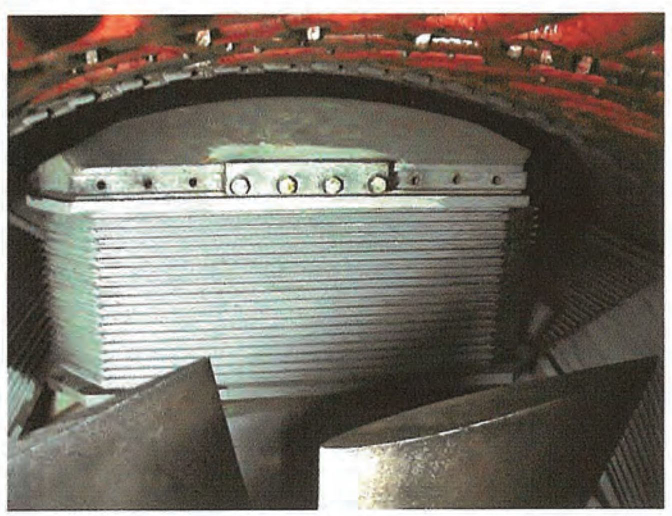


Rust flakes present in bottom of stator enclosure.



Air gap between rotor and stator; rotor poles are in good physical condition.

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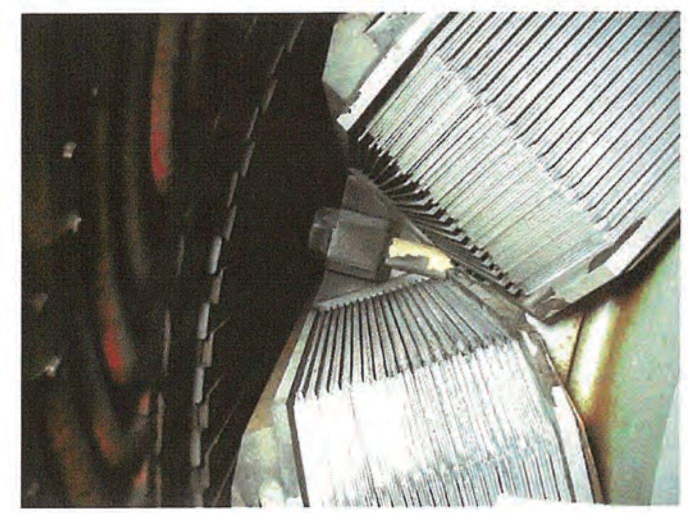
Connections between poles appear in good condition.



Pole clamps between poles appear to be in good condition

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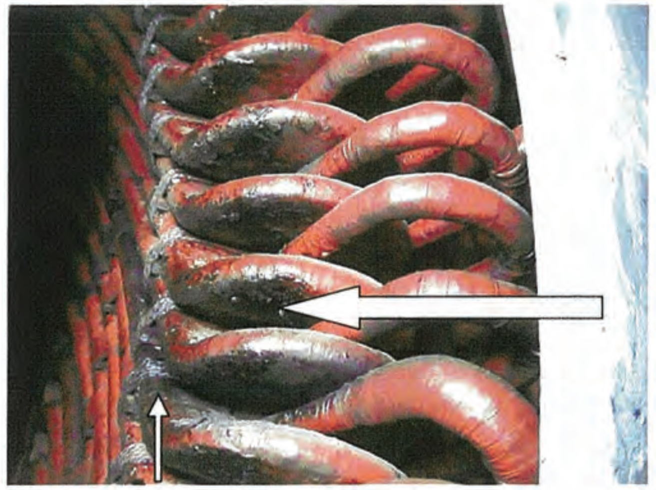

Over heating has occurred in the past: discoloration and resin melted at knuckles.

Discoloration heating pattern on some coils.

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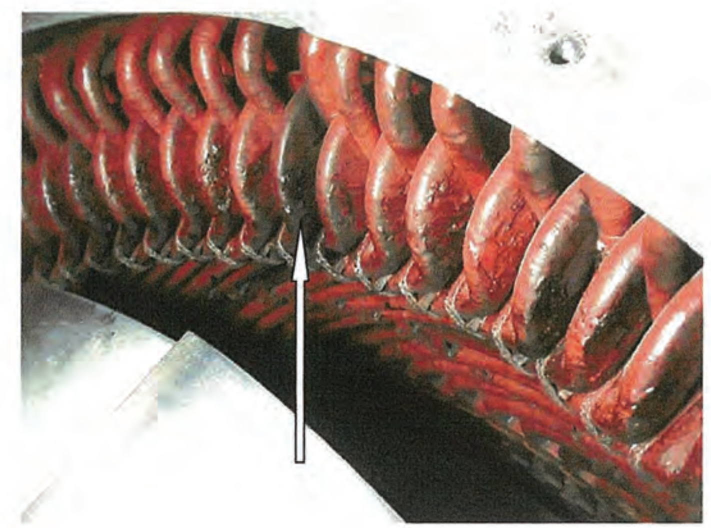
Resin present on knuckles is an indication of overheating.



Discoloration heating pattern on single coil.

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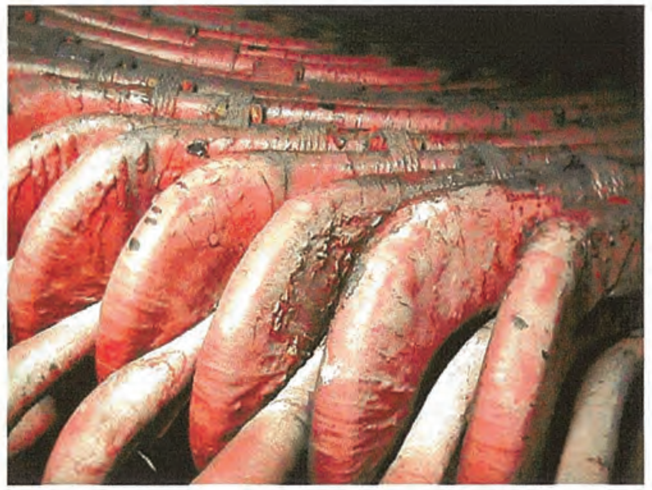

Dry brittle insulation

Dry brittle flaking insulation on coils

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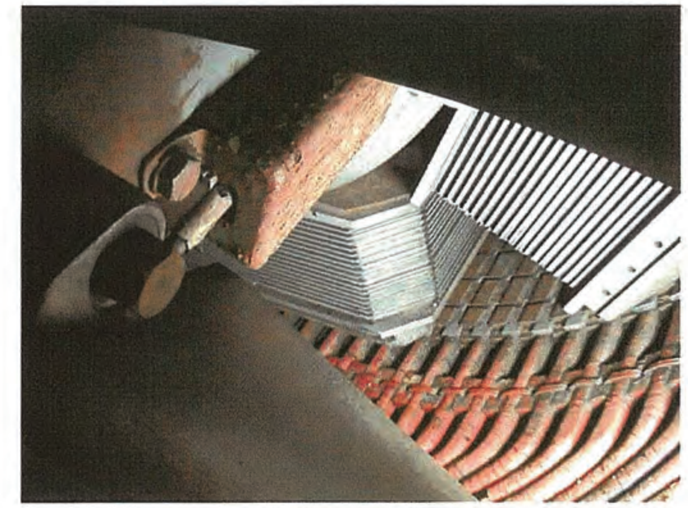

View of wedges and iron.

Rub mark on fan blade edge showing previous contact with fan cover.

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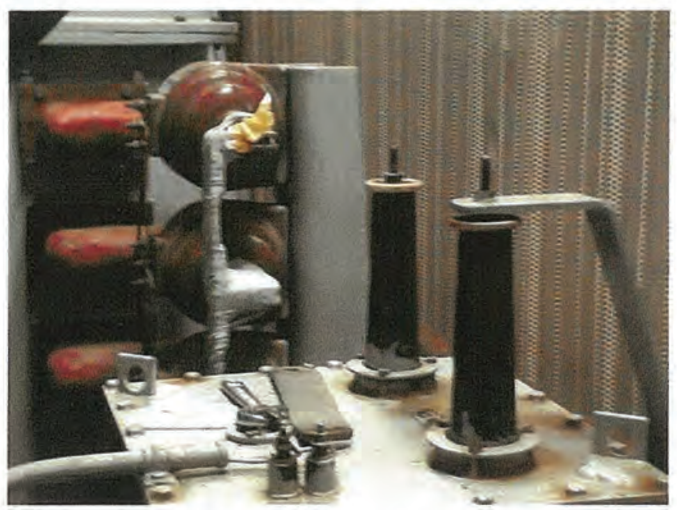
Wear marks on fan cover showing previous blade contact



**Star Point had to be disconnected from transformer for true reading.
With this point connected insulation resistance to ground reading is 2000 Ω.**

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Visual inspection:

Prior to conducting any electrical tests on this unit a visual inspection was performed.

- Roof top exhaust/ventilation is corroded and rusted.
- Rust flaking from exhaust/ventilation is present on top of stator core and in bottom of generator enclosure.
- Rotor appears to be in good condition, connections and pole clamps appear to be solid and do not show signs of movement.
- Stator iron and wedging appear to be in good condition.
- Stator coils show signs of over heating and heating discoloration pattern is present in coil system.
- Stator insulation system appears to be degraded, dry and flaking throughout the unit.
- Fan blades have contact wear pattern on edge of blades. This coincides with the wear pattern on the fan cover.

Test Results:

Generator Rotor:

- Insulation Resistance to ground @ 1 minute = 2.67 MΩ
- Polarization Index Test = $\frac{\text{10 minute reading}}{\text{1 minute reading}} = \frac{2.95\ M\Omega}{2.67\ M\Omega}$ = 1.1 damp and dirty
- Overall DC Rotor Circuit Resistance = 439 mΩ

Generator Stator:

- Insulation Resistance to ground @ 1 minute = 1030 MΩ
- Polarization Index Test = $\frac{\text{10 minute reading}}{\text{1 minute reading}} = \frac{1990\ M\Omega}{1030\ M\Omega}$ = 1.93 damp and dirty
- Phase to phase resistance:
  - Ø A to Ø B = 50.0 mΩ
  - Ø A to Ø C = 68.87 mΩ
  - Ø B to Ø C = 72.51 mΩ

Condition Assessment Findings

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Recommended Action:

- The exhaust/ventilation unit should be removed, reconditioned or replaced and a corrosion resistant coating applied to prevent future corrosion issues.
- The fan blade assembly and fan cover should be reconditioned and adjusted to prevent future contact and wear.
- The rotor winding insulation resistance to ground is not in the desired range (only 2.95 MΩ @500 volts).
- Drop test rotor poles when disassembled to verify balanced resistance of poles.
- Remove rotor and transport to work shop facility for overhaul and steam clean windings to improve test readings.
- Once readings have been improved the rotor should be sealed with a resin treatment to maintain the insulation system integrity.
- With star point of stator disconnected, the insulation resistance to ground of the stator winding is fair; however, the resistance between each phase is unbalanced (30% unbalance). Possible cause of undesirable readings could be Turn to Turn shorts in coil system or grounded coils cut out of coil system (discoloration in some coils are good indication).
- Stator should be stripped, blasted with a low abrasive to remove scale on top of core, a core loss or Elcid test should be performed to verify iron integrity and rewound on-site with high integrity coil system approved for high voltage generator applications.
- Rotor should be rotated once per month to prevent rotor sag condition.
- Unit is installed in an area with a high delta in temperature (cold during idle, hot during operation). Anti condensation heater installation is recommended to prevent moisture build-up.
- If unit is rewound and put back into service a run up of the unit should be performed after repair to measure the voltage output under load. At the same time, other tests should be conducted such as temperature of the new winding and a baseline vibration test conducted under motor view parameters and temperature rise of the bearing recorded.

Note: When reviewing this report our Technical Sales Representative is available to answer any questions you may have, provide information, clarification, explain test results and all findings. Please feel free to contact our office at your convenience to schedule a meeting time.

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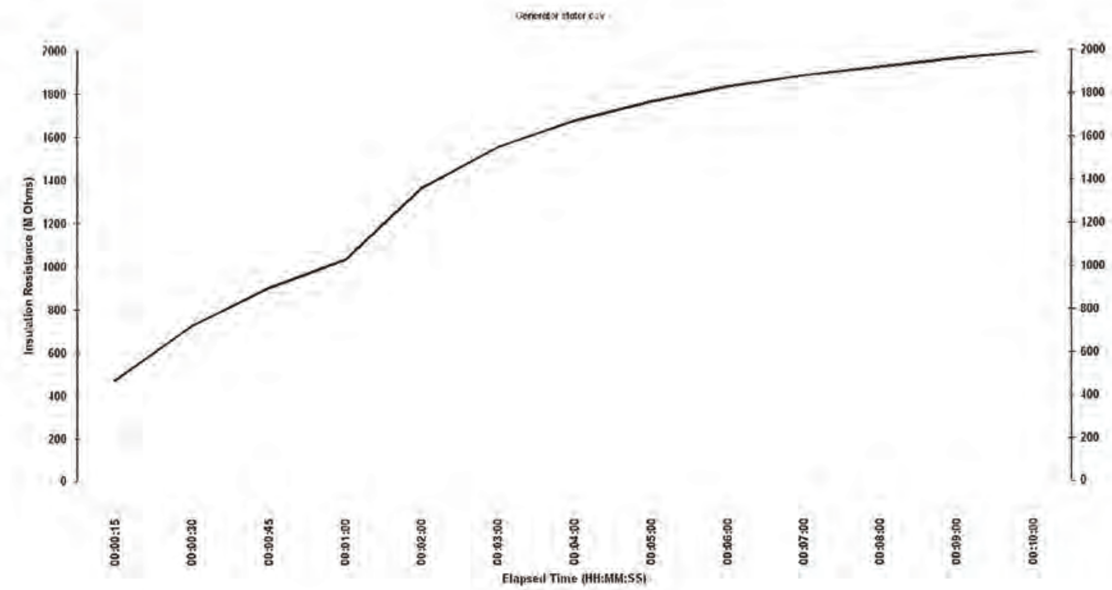
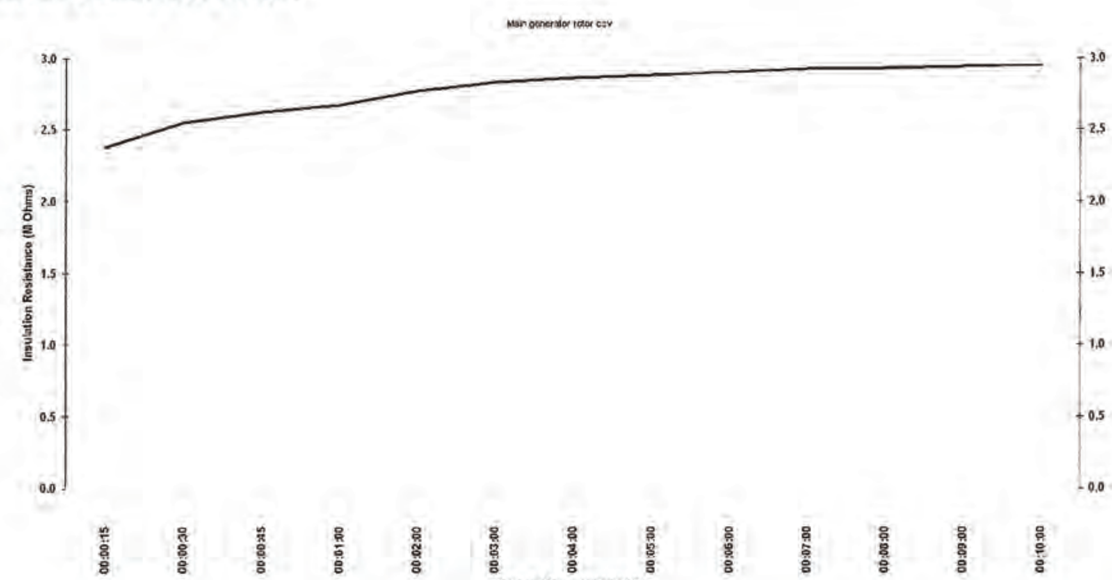
Polarization Index Test Graphical Results

Main Generator Stator:



Main Generator Rotor:



Budget Pricing with Scope of Work and Notes:

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- Dismantle generator on-site.
- Remove rotor and stator and transport to our O'Leary Ave shop facility.
- Drop test rotor poles when disassembled to verify balanced resistance of poles.
- Overhaul and steam clean windings to improve test readings.
- Once readings have been improved the rotor should be sealed with a resin treatment to maintain the insulation system integrity.
- Strip stator and take accurate winding data, blast core with a low abrasive to remove scale on top of core, a core loss or Elcid test should be performed to verify iron integrity and rewound with high integrity coil system approved for high voltage generator applications.
- Return unit to site and assemble.
- Once rewound and put back into service a run up of the unit should be performed after repair to measure the voltage output under load. At the same time, other tests should be conducted such as temperature of the new winding and a baseline vibration test conducted under motor view parameters and temperature rise of the bearing recorded.

- **Budget Price for this service is .... $ 750,000.00 TNIP each Budget Only**

Notes:
- This is a budgetary price only and is non-binding.
- Siemens will dismantle unit and remove from site for rewind.
- Exhaust/ventilation housing to be replaced by 3rd party contractor and would be considered extra.
- Firm pricing is available if requested or tendered.
- Installation of anti-condensation heaters and all required mechanical work would be additional and extra.

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APPENDIX 12
ROLLS WOOD GROUP FIELD SERVICE REPORT

Rolls Wood Group

Rolls Wood House
Wellheads Industrial Centre
Dyce, Aberdeen
Scotland AB21 7GA
Tel: (01224) 797000
Fax: (01224) 771552
E-mail: rwg@rwgroup.com
Website: www.rwgroup.com

Avon Field Service Representative's Report

Service Rep:	Ian Cross
Customer:	Newfoundland Labrador Hydro
Site:	Holyrood GT Site
Visit Date:	29 November 2010
Reason for Visit:	Condition survey and borescope
Personnel Contacted:	Robert Shandera
Job No:	

Date of Engine Installation:	N/K	Unit:	N/K
Engine Serial Number:	37029	Engine Mk:	1533 - 70L

TSI	TSR	TSO	TSN	GG Starts	Burner Type/ Mod Standard
N/K	N/K	N/K	N/K	N/K	Pintle

Lube Oil Type	Comp Wash Fluid	Power Turbine Type	Process
N/K	N/K	N/K	Power Generation

Report Summary

The visit was made to carry out a condition survey and borescope on Avon installed at the Newfoundland Labrador Hydro Thermal Generation Site, Holyrood.

Section 1.1 Flare

A 6" intake adapter was fitted. Light intake media deposits adhering to the flares inner faces.

Section 1.2 Front Bearing Housing

Found to be in good condition with medium loss of coating and corrosion noted on the support strut leading edges and inner air washed surfaces.

The inner and outer VIGV location bushes appeared in good condition.

All air washed surfaces were found to be reasonably clean.

Field Service Representative's Signature: ______________________

Project Engineer's Signature: ______________________

Section 1.3 Bleed Valves

Open, and visually in good condition.

Section 1.4 Compressor Casings and Stators

Stators appear to be in a good clean condition, with no defects noted.

The outer and inner surfaces of the casings were found in reasonably good condition, with areas of light to medium loss of coating and corrosion.

Generally in good condition First stage titanium, remainder Teflon coated, with only minor loss of coating to leading edges. No impact damage or defects noted.

Section 1.6 Compressor Outlet Casing

Was found to be in reasonably good condition.

Outlet guide vanes have minor to medium loss of coating and light corrosion to most surfaces.

No impact damage or defects noted.

Section 1.8 Wheelcase Assembly

Visually in good condition. There is evidence of minor oil leakage.

Section 1.12 Nozzle Box

The HP and LP nozzle guide vanes were viewed intact and were defect free.

The discharge nozzles and securing brackets were viewed intact and defect free.

Section 1.13 Rear Bearing Housing

No defects observed.

Section 1.15 Turbine Rotor Assembly

The HP, IP and LP turbine blades were all viewed intact and free from obvious defects.

Section 1.16 Flame Tubes and Air Casing

The borescope inspection was carried out utilising the 8 inspection ports positioned on the outer surface of the combustion chamber casing.

The flame tubes had single dish head sections and all exhibited carbon deposits to the head sections and streaks down the tube length. They were all in good condition. All Crook's washers viewed intact.

<u>Section 1.17 Exhaust Assembly</u>

Visually noted as being in good condition. Only minor surface corrosion seen.

<u>Section 1.18 Starter Fairing</u>

Found to be in good condition.

<u>Section 1.19 Inlet Guide Vane Ram</u>

Found to be in good condition.

<u>Section 1.20 Front Suspension</u>

Found to be in good condition.

<u>Section 1.22 Air Pipes and Fittings</u>

Visually noted as being in good condition.

<u>Section 1.23 Oil Pipes and Fittings</u>

All secure free from leaks and in good condition.

<u>Section 2.1 Fuel Burners</u>

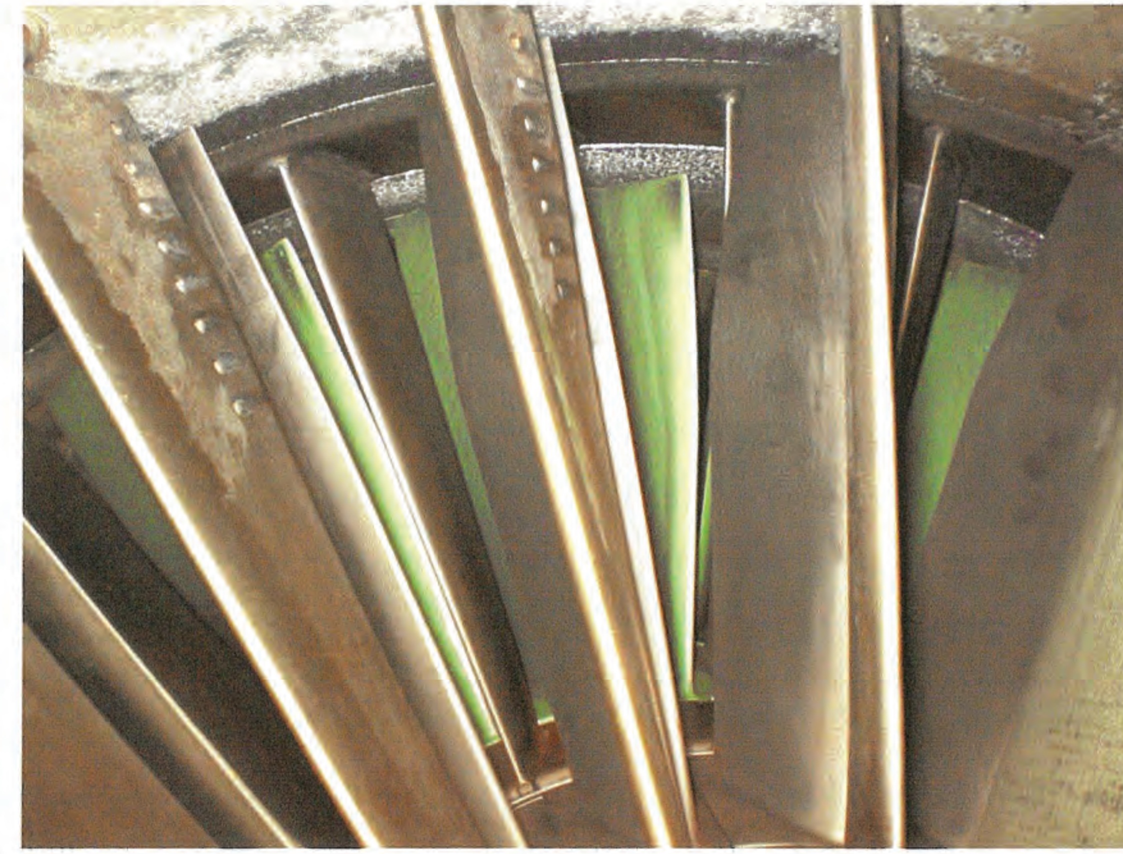
Exhibited carbon deposits on the pintle head sections.

<u>Miscellaneous Items</u>

The engine displayed a GTC identification plate. There was no log book available for viewing during the visit. Generally the engine appears to be in a reasonably good and serviceable condition.

The Avon is in full phase one configuration, retaining a full RTC fuel control unit, under throttle cable control. The IGV ram is a P2 controlled assembly.

The control room log recorded that Alba Power had visited the site during September 2009 and carried out rectification work to the combustion chambers, RTC and fuel pump.

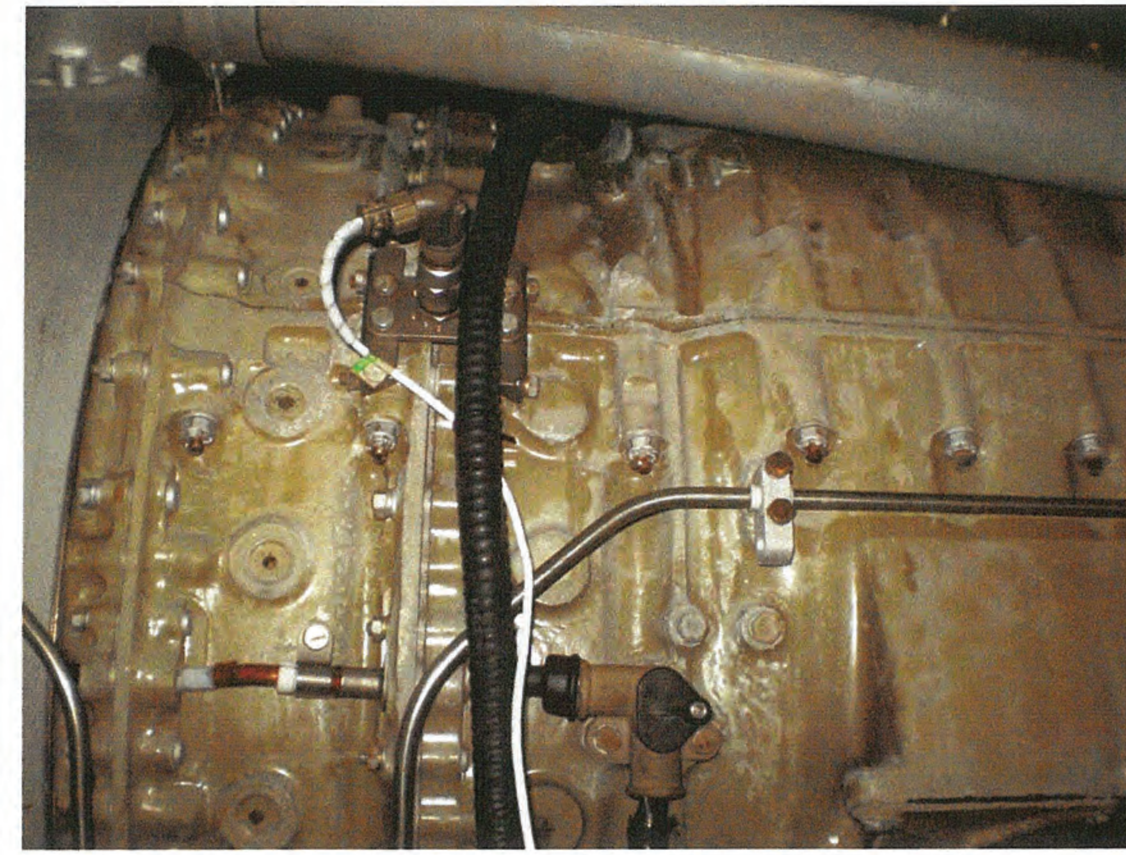


Light to medium corrosion noted to inner surface of the front bearing housing

Rolls Wood Group

Light to medium corrosion noted to inner surface of the front bearing housing

Rolls Wood Group



Light to medium loss of coating and corrosion to outer surfaces of the compressor casing

ALBA POWER

Package Overhaul Proposal

Quotation Number: CO TBA

Date: 15 July 2011

Client Reference: TBC

RoSPA 2011 GOLD Award

BROWZ keeping compliance in check

best business AWARDS

FPAL Verify Verified

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Introduction

Over the years Alba Power has enjoyed servicing the unit at Newfoundland Hydro, Holyrood.

The unit itself is in good mechanical order, with the usual signs of wear and corrossion, particularly with the unit being close to the sea.

Alba Power's proposal would be to return the unit to an Overhauled condition, suited to a minimum 10 years life at site with optimised availability and reliability. This would be achieved by;

- Intake repairs and coatings
- Exhaust structure review and panelling replacement
- Power Turbine lagging and panelling replacement
- Package interior clean, coating and upgrade
- Avon gas turbine repair / overhaul
- Power Turbine Overhaul
- Gearbox Overhaul
- Alternator inspection and repair
- Controls review
- Field wiring inspection / replacement and field instrument upgrade

Completing these works will ensure the client a reliability and availability in excess of 92%, and with routine maintenance suited to clients operations this could be increased.

Alba Power routinely completes this kind of works and is confident n the units mechanics, and with some attention over a 3-4 month period, this unit would be back to as good as new.

We hope to demonstrate some of the major elements and indicative pricing in the following document.

If you do have any questions or queries please do not hesitate to contact us, your contact for this proposal is as follows:

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E-mail Campbell.Archibald@albapower.co.uk

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Package Workscope

The package has suffered from age and salt corrosion over the years and most of these procedures would require strip, replacement and re-coating to give full weather proofing going forward. Alba Power are willing to manage these elements and utilise local contractors to save time and money.

Intake Casing

The main elements of the unit are in good condition, with the occassional leak leading to corrosion. Initially Alba Power would propose local repair and coating to weather proof the unit for long term use-age. Alba Power can also quote for replacement at an indicative £450,000.00.

Avon / Power Turbine Housing

Within the housing various walls and supports have suffered from weather ingress. these would be stripped while the Avon and Power Turbine are out for overhaul and reworked at site.

Alternator Housing

In general this package has faired well with slight tarnish. Contractors would be utilized to strip, clean and recoat the area to suit inspection and wiring replacement.

Vent pipes and fans / coolers

All vent pipes, fans and motors would be removed for service and repair. All pipes would be accessed for future use and repaired or replaced.

Oil System

All pipes, motors, filters and valves would be removed and inspected. Pipes, filters and housings would be subject to strip, clean, inspect and repair / coat with the valves and motors being despatched for overhaul and return.

Fuel System

All pipes, motors, filters and valves would be removed and inspected. Pipes, filters and housings would be subject to strip, clean, inspect and repair / coat with the valves and motors being despatched for overhaul and return. In addition Alba Power would suggest modifying some of the Fuel drain pipework to meet current standards.

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Workscope Avon

Alba Power has managed and supported the unit for many years, and although mechanically sound, the unit is suffering from material degradation and coating loss throughout. The main objective will be to recover and protect the clients material to save costs now,and going forward. With modern coating technologies and routine maintenance, this unit should achieve 10 years of operations.

The following is a breakdown of the planned workscope and indicative pricing schedule for the works;

The following details standard overhaul procedures for the Avon gas turbine. At all stages the client will be informed and consulted through reports and meetings to ensure quality and satisfactions.

Item	Description
1.	**Front Bearing Housing Standard Overhaul**
	-Strip, crack test, replacement journals, VIGV Journal rework, Seal rework, Front Bearing journal replacement (new) -VIGV inspection, crack test and rework of journals -Replacement Front Bearing outer race Potential additions
	-Replacement casing due to corrosion -Replacement VIGV due to wear -Replacement front bearing seals -Replacement VIGV nylon journals and bushes
2.	**Starter Motor** ***Standard Overhaul***
	-Strip, inspect, electrical checks, testing, coatings and rebuild Potential additions
	-Replacement in overhauled exchange condition
3.	**IGV Ram** ***Standard Overhaul***
	-Strip, inspect, replacement parts as required, casings overhauled and coated, unit rebuilt and tested Potential additions
	-Replacement in overhauled exchange condition

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4.	**VIGV Linkage Standard Overhaul**
	-Strip, crack test, replace seals and bushes, coat assembly, rebuild Potential additions
	-Replacement armatures due to wear
5.	**Compressor ½ casings (Including stages 10 – 15 located in COC) Standard Overhaul**
	-Strip and inspect, crack test all vanes, casings and fittings. Dimensionally check all vanes. Recoat all Vanes and casings as required (Stages 0-4 Teflon or alternative) Super polish where required. Casings to be coated in Ser W or alternative of required, Liners and fittings recoated with Alumigold. All fittings and fasteners replaced as standard. Potential additions
	-Replacement overhauled vanes due to chordial width failure of parent material. Liners and casings if cracked or out with limits.
6.	**Compressor Rotor Standard Overhaul**
	-Unit stripped and all components and journals dimensionally inspected. All items crack tested, Discs and shaft Magnetic Particle Inspected for cracks. All journals re-copper coated. Disc pinholes inspected for pitting. Discs, Shafts recoated. Blades recoated (advance coating technology available. Blades super polished. All pins replaced as required. All fasteners replaced as standard. Potential additions
	-Any parts failing inspection will be replaced with overhauled components from stock, including any discs, shafts, blades etc.

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7.	**Compressor outlet casing (including snouts) Standard Overhaul** -Units stripped and crack tested, all dowels, fasteners and fittings replaced as required. Weld repairs as required to COC. Snouts stripped and hard facing re-applied around combustion can location and dowel location areas. Casing recoated. Potential additions -Replacement COC and snouts from overhauled stock as required.
8.	**Internal Wheelcase** ***Standard Overhaul*** -Unit stripped and inspected. All bearings replaced including Centre Bearing. Seals reworked as required. Potential additions -Replacement casings, pinions and gears as required from overhauled stock.
9.	**Combustion Cans, Can Dowels and Trident Channels Standard Overhaul** -Units are stripped and disassembled to allow full inspection. All aspects crack tested. Replacements where necessary and material reworked. All units jigged for alignment and rebuild / welded. Hard facing replaced and Thermal barrier coating applied to the dishes. -Trident Channels and Can Dowels, Units crack tested and dimensionally checked. Units reworked and hard faced. Potential additions -Replacement from overhauled stock where required.
10.	**Combustion Casing Standard Overhaul** -Strip, crack test and recoat. Potential additions -Casing assembly from overhauled stock

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11.	**Nozzle Box assembly Standard Overhaul**
	-HP NGVS, Strip, crack test, rework through brazing if possible, recoat with Ser J -Rear Bearing housing, Strip and crack test, rework bearing location, Replace Rear bearing with New, re-work seal if required, recoat assembly. -Spider and seal assembly, Unit to be stripped, crack tested and inspected. All seals to be reworked or replaced as required, support assemblies to be recoated and all consumables to be changed for new. –Heat shields, Units to be stripped and crack tested, Trident channel locations to be reworked. Assemblies to be recoated. ***Potential additions***
	-HP NGV's, Rear bearing seal, Heat shields to be replaced with overhauled stock.
12.	**Turbine Rotor and Discs** ***Standard Overhaul***
	-Units to be stripped and Magnetic particle inspected. All fir tree roots to be inspected. All items to be recoated. Potential additions
	-Discs and shafts from overhauled stock
13.	**Turbine Blading HP, IP, LP Standard Overhaul**
	-Units to be stripped, crack tested and dimensionally inspected. Any units requiring rework such as welding and abutment faces reworked. All units recoated in Ser J. ***Potential additions***
	-All blading from overhauled stock.

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14.	**Turbine Nozzles HP, IP, LP Standard Overhaul**
	-Nozzles, All nozzles to be stripped, crack tested and dimensionally inspected. Any units requiring rework through welding, brazing etc. will be completed. All units recoated in Ser J. Potential additions
	-Any items requiring replaced from overhauled stock.
15.	**NGV Carrier Rings IP and LP Standard Overhaul**
	-Units stripped dimensionally inspected and crack tested, seals replaced where required and units recoated. Potential additions
	-If required replaced from overhauled stock.
16.	**Split Air Manifolds and Cooling Air Manifolds. Standard Overhaul**
	-Units stripped and inspected, location and fittings reworked as required, units recoated. ***Potential additions***
	-If required the units would be replaced from overhauled stock.
17.	**IP and LP Turbine Casings and shrouds Standard Overhaul**
	-Units will be stripped, crack tested and dimensionally inspected for bowing or distortion. All fasteners replaced. Potential additions
	-If units are distorted they will be replaced using overhauled stock.

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18.	**Exhaust Assembly Standard Overhaul**
	-Unit is stripped crack tested and dimensionally inspected. All bushings and heat shields as well as consumables are replaced. All fasteners are upgraded. Unit is rebuilt and jigged for inspection checks. Potential additions
	-Assembly replaced if damage beyond economical repair.
19.	**Thermocouple Harness Standard Overhaul**
	-The unit is stripped and inspected. After electrical testing all required parts are replaced. All tubing is recoated and the assembly rebuilt and tested. ***Potential additions***
	-Complete exchange if necessary.
20.	**Bleed Valves Standard Overhaul**
	-The units are stripped, inspected and dimensionally checked. All seals and fittings are replaced as well as Carbon pads. All casings and assemblies are recoated and the units re-assembled. The units are tested prior to fitment to the unit. Potential additions
	-If any of the housings are damaged, these will be issued from overhauled stock.
21.	**Fuel and Oil pipes Standard Overhaul**
	-All pipes and stripped and inspected. If required the fittings are replaced and all units flushed and pressure tested prior to release to the build workshop. Potential additions
	-Any damaged pipes will be replaced with overhauled stock.

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22.	**Fuel system** ***Standard Overhaul*** -Gas Burners, All units are stripped and inspected, replacement parts are issues where required and the units recoated prior to testing -IGV Ram, full overhaul - Bleed Valves, Full overhaul - Speed Pick up Full overhaul, or upgrade as required ***Potential additions*** -Any components found out with tolerance will be replaced with overhauled stock.
23.	**General Rules** - All consumables replaced as standard including nuts, bolts, washers, seals etc. - Any suspect part replaced and client informed - All replacement parts, repair procedures and coatings as approved by OEM

Image of Avon after overhaul

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Workscope Power Turbine / Gearbox

The Power Turbine and Gearbox have been relatively untouched since installation. To this end they have suffered typical cosmetic loss of material and coatings of the volute. Alba Power would propose to remove the Rotor and Nozzles and despatch for overhaul, while the remaining components including the gearbox would be overhauled locally. All bearings and seals would be reworked / replaced as available. (Following images of identical unit before and after overhaul at Alba Power)

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Workscope Alternator

Alba Power has experience of in situ overhaul of the EA1 Alternator, utilizing scaffolding we will inspect the rotor and stator as below;

GENERIC WORKSCOPE

1. Requirements From Platform / Others

- Electrical And Mechanical Isolation Of Alternator And All Auxiliaries
- Provision Of Load Bearing Scaffold For Rotor Removal
- Provision Of Riggers And Lifting Equipment For Removal Of Covers Etc.
- Provision Of Compressed Air Supply
- Provision Of Electrical Supply, 440V, 60Hz
- Safety Barriers And Signs
- Ventilation And Draining For Chemicals During Cleaning

2. Machine

- Review all logged or recorded data available; load, temperature, vibration etc. If any values give cause for concern a more detailed inspection may be required.
- Attend all safety inductions.
- Review and finalise Risk Assessment and Method Statement.
- Visually inspect foundations & check tightness of anchor bolts & dowels.
- Ensure all ventilation ducts and air passages on the generator & exciter, are clean & free from obstructions.
- Check tightness of all fastenings.
- Check integrity of all external wiring & earthing.
- Remove any loose rust or corrosion from the machines external surfaces.

3. Stator

- Remove all covers.
- Measure & record the main stator insulation resistance (Minimum reading at 1000V 10MΩ).
- Carry out polarization index check & record results.
- Measure & record main stator resistance.
- Inspect the winding connections, slot wedges, packers & bracing.
- Inspect the windings for cleanliness, discoloration, discharge, looseness, movement & wear.
- Chemically clean the windings, dry out and spray varnish.
- Measure & record the main stator insulation resistance after cleaning.
- Verify function of anti-condensation heaters & record the insulation resistance (minimum IR at 500V = 20MΩ).

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4. Terminal Boxes

- Check general condition & replace fixings as required.
- Check gasket condition & replace where required.
- Check tightening torque at all main & neutral connections.
- Check condition of insulation around the terminals.
- Check the pressure relief diaphragm.

5. Bearings

- Inspect bearing oil pipes, joints & flanges for leaks.
- Check tightness of all fastenings associated with the bearings.
- Verify function of all measuring equipment.
- Measure & record the bearing insulation resistance.
- Check & record the bearing clearances.
- Check condition of bearing top shell, bearing journal & oil rings.
- Check the shaft seals for leaks, wear or damage.
- Clean shaft seal drain holes.
- Check the seal shaft surface is free from corrosion & wearing.

6. Main Rotor

- Measure the main rotor field insulation resistance at 500V.
- Measure & record rotor resistance.
- Check rotor internal connections.
- Check main coils for cracks, movement & discolouration.
- Check coil support bolts, washers & insulation.
- Measure & record insulation resistance after cleaning.
- Check & record the rotor air gap.

7. Exciter & Rectifier

- Measure the exciter stator resistance & insulation resistance.
- Inspect the condition of the stator windings.
- Check the stator to rotor air gap.
- Visual inspect the exciter rotor windings.
- Measure the exciter rotor resistance & insulation resistance.
- Clean the rectifier assembly.
- Check all bolts & fastenings for tightness.
- Check the polarity & continuity of the diodes.

8. Cooling System

- We would recommend that both cooler heat exchangers be removed, refurbished & tested onshore.
- Visually inspect area around heat exchanger water boxes for leaks & excessive corrosion.
- Verify function of leak detector.

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Workscope Controls / Field wiring and transmitters

The client has recently completed an upgrade locally of the control system. Alba Power would propose a controls engineer to inspect and replace wiring and terminals during the overhaul process, in addition we would recommend changing all transmitters to allow maximum availability and reliability.

Workscope Exhaust stack

The Exhaust stack, support and snow hoods have suffered over the years with weather damage. This unit would be stripped and overhauled locally.

Basis of Investment

The following are based on Alba Power's experience and are indicative of our knowledge of the clients facilities. (Local input would be controlled through project management and 3 x quotes requested to control)

Item	Description	Cost $Can
1	Avon gas turbine overhaul	500,000.00
2	Power Turbine and Gearbox Overhaul	300,000.00
3	Alternator Inspection / Repair	87,000.00
4	Air Intake Repairs	30,000.00
5	Package Repairs	10,000.00
6	Field wiring and Transmitters	20,000.00
7	Oil and Fuel System	45,000.00
8	Exhaust stack	34,000.00
	Investment	1,026,000.00*

*Based on current knowledge and experience, subject to final inspection.

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2. Terms & Conditions

Attached is Alba Powers standard terms and conditions for the purposes of this budgetary quotation.

ALBA POWER LIMITED

STANDARD CONDITIONS FOR THE SALE OF GOODS AND SERVICES

1. INTRODUCTION

1.1 In these Terms and Conditions "The Company" means Alba Power Limited and the "Customer" means any person, firm or body offering to buy goods (the "Goods") and/or services (the "Services") from the Company. "Customer's Goods" means goods supplied by the Customer to the Company.

1.2 Unless otherwise agreed in writing by an authorised representative of the Company, these conditions constitute the only conditions upon which the Company is willing to supply Goods and/or Services.

1.3 These conditions shall prevail over any terms and/or conditions in the Customer's order or any other document or communication issued by the Customer or implied by trade usage, custom, practice or course of dealing except where specifically agreed in writing to by an authorised representative of the Company. Any purported provision to the contrary is hereby excluded or extinguished.

1.4 **THE CUSTOMER'S ATTENTION IS DRAWN PARTICULARLY TO CONDITIONS 6.1, 8.2, 8.3, 9 AND 10 WHICH EXCLUDE OR LIMIT THE COMPANY'S LIABILITY.**

2. QUOTATIONS AND ACCEPTANCE OF ORDER

2.1 Any order given by the Customer in respect of a quotation or estimate by the Company, shall not be binding on the Company until accepted in writing by it.

.2 The Company's price lists, estimates and quotations do not constitute offers made by the Company and, in any event, the Company may at its absolute discretion refuse to accept any order. The acceptance by the Company of each separate order shall constitute a separate contract between the Company and the Customer.

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.3 Quotations given by the Company shall be valid for 30 days only. The Company reserves the right to withdraw or revise the same without notice to the Customer.

.4 Any Customer's Goods required by the Company to fulfil an order for Goods and/or Services shall be delivered at the Customer's expense to an agreed facility of the Company together with all relevant up to date information pertaining thereto requested by the Company.

.5 If during the provision of Services it becomes apparent that additional work not initially agreed to be provided by the Company is necessary, the Company shall submit a quotation for such work. Acceptance of such quotation in writing by the Customer will constitute compliance with Condition 2.1. If the Customer does not require the additional work to be undertaken, the Company may invoice in respect of the Services completed and reassemble and package the Goods including any Customer's Goods for delivery to the Customer.

3. **PRICE**

3.1 Save where otherwise specified, all prices are net and subject, where applicable, to the addition of VAT at the applicable rate and, in the case of export sales to the Customer, any applicable customs, import and export and similar duties, and all prices are exclusive of carriage and insurance.

3.2 The Company shall have the right, subject to reasonable prior notice, to vary the prices quoted in the event of any increase in the cost of materials and/or labour and/or increase in customs, import or export duties.

3.3 If any variation or suspension of the work caused by the Customer's instructions or lack of instructions occurs the Company shall be entitled to adjust the price to reflect any additional costs incurred by the Company and to adjust delivery dates or schedules.

3.4 Where the Company provides Services, the Customer shall bear the cost of any testing of the Customer's Goods, components or equipment that is necessary.

3.5 The Company may invoice the Customer for any work reasonably carried out on the Customer's Goods necessary to prepare an estimate for supply of Goods and/or Services plus the cost of preserving the Customer's Goods while the Customer considers any quotation issued by the Company, in each instance regardless of whether the Customer subsequently places an order for any Goods and/or Services.

4. **PAYMENT**

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4.1 The Company shall be entitled to receive payment in full (without any right of set-off, deduction, counterclaim or withholding whatsoever) in the currency of the invoice on presentation to the Customer of an invoice for Goods supplied and/or Services completed on delivery to the customer of the Goods or the Customer's Goods concerned, or in the case of part delivery, on each delivery as if it were a separate order or contract. Unless otherwise agreed by the Company in writing, all payments shall be paid to the Company's account maintained with **Bank of Scotland** UK Sorting Code: **80-05-14**, Account No: **06015415** for sterling payments and Account No: **1989 5USD 01** for US Dollar payments. As a condition of supplying Goods and/or Services, or further Goods and/or Services, the Company may require a payment on account or in advance. Such payment in advance shall be treated as security for completion of the transaction to which it relates and may be retained by the Company if the Customer fails to pay the price in full or fails to take delivery otherwise than as a result of the Company's default. Time for payment of sums due to the Company shall be of the essence.

4.2 Irrespective of any other remedies available to the Company, the Company shall be entitled to receive interest on any sum owed by the Customer from the date that sum was due to be paid. Such interest shall accrue and be calculated on a daily basis both before and after any decree or judgment at the option of the Company the rate of 2% above the Bank of England Minimum Lending Rate or such maximum rate of interest permitted under law until the date on which it is actually paid and shall be compounded monthly.

5. **DELIVERY**

5.1 Any quoted delivery or completion date is the Company's best estimate and not a contractual commitment. The Company fulfils its obligation to deliver when it makes the Goods available to the Customer or the Customer's agent for collection at the Company's premises. At the request of the Customer and at the Customer's expense, the Company will arrange for the carriage of Goods to a location other than the Company's premises, but the Company shall have no liability for any loss or damage to the Goods while in transit nor for any act or omission (negligent or otherwise) of any third party in connection with such carriage. Where the Company performs the transportation it will, at its option, credit the cost of the relevant Goods and/or Services or repair or replace the Goods if there is any loss or damage during transportation resulting solely from the Company's negligence.

5.2 Risk in the Goods shall pass to the Customer upon delivery to the Customer at the Company's premises.

5.3 If the Customer fails to take delivery of any Goods within 7 days of the Company giving written notice that they are ready for collection, the Company shall be entitled, at its sole discretion, to

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store such Goods at the Customer's expense and/or to resell all or any part of such Goods without prejudice to any other right or remedy of the Company.

5.4 Where delivery of Goods to the Customer is to be by instalment, each instalment shall constitute a separate contract. Any defect or failure in delivery of one or more instalments shall not entitle the Customer to cancel any other instalment.

6. **CUSTOMER'S PROPERTY**

6.1 Any property, including without limitation the Customer's Goods, of the Customer placed in the Company's possession shall be held and handled entirely at the Customer's risk without any liability on the part of the Company for any loss or damage unless caused by an act or omission of the Company done with intent to cause damage or recklessly and with knowledge that damage would probably result; provided that, in the case of such act or omission of either an employee or agent of the Company, the Company shall be liable only if he or she was acting within the scope of his or her employment or agency (as the case may be).

6.2 The Customer authorises the Company to disassemble and inspect any of the Customer's Goods supplied to the Company for the purposes of providing to the Customer or issuing a quote for any Goods and Services. Risk in any Goods and/or Customer's Goods shall remain with the Company until delivery to the Customer under Condition 5. The Company shall comply, at the Customer's expense, with any instructions of the Customer accepted by the Company regarding the disposal of unserviceable Customer's Goods. In the absence of such instructions, and unless otherwise agreed, the Company shall not be liable in any manner whatsoever to return to the Customer or account for any of the Customer's Goods the Company reasonably deems to be unserviceable.

6.3 The Company shall be entitled to a general as well as a special or particular lien or right of retention on any of the Goods or the Customer's Goods (including, without limitation, any components or engine records) in the Company's possession for all amounts whatsoever and howsoever due from the Customer to the Company, even though possession of such Goods or Customer Goods may have been relinquished by the Company from time to time. Unless informed otherwise, the Company shall be entitled to assume that the Customer is entitled to subject such Goods or Customer Goods to the Company's lien or retention. The Company may seek to recover from the Customer all the costs and expenses of exercising its lien or right of retention including (without limitation) storage charges.

6.4 If any amount due from the Customer is outstanding for more than 30 days after written demand for payment being made by the Company, the Company may sell on such terms and at such price as it considers reasonable any of the Goods or Customer's Goods in its possession. The

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Customer shall give to the Company such assistance, including the delivery of any relevant documents, for the purpose of completing such sale. The Company shall apply the proceeds of sale firstly in payment of all costs and expenses incurred by the Company in connection with the sale, including (without limitation) storage, management time, legal and other professional costs and charges and secondly in total or partial satisfaction of such amount owed by the Customer. If any shortfall arises, the Customer shall pay such shortfall on demand. If a surplus arises, the Company shall pay such excess to the Customer. A certificate from the Company's Managing Director will be deemed to be conclusive between the Parties as to the disbursement of the proceeds of any sale.

7. **PASSING OF PROPERTY**

7.1 Title to the Goods supplied (whether on their own or with or as part of performance of Services and whether separate and identifiable or incorporated in or mixed with other goods) by the Company to the Customer shall remain with the Company until full payment has been received by the Company of any and all sums due and outstanding by the Customer to the Company at the time of delivery in terms of Condition 5 whereupon the Customer shall take the Goods with full title guarantee and if possession of any Goods has been given to the Customer before title has passed, the Customer shall hold such Goods as trustee for the Company and shall store them in such a way as to enable them to be identifiable as property of the Company and not encumber them in any way until full payment has been made.

7.2 While acting as trustee of any Goods on behalf of the Company, the Customer shall on demand immediately notify the Company of the whereabouts of the Goods and give the Company, its employees and agents free access to them.

7.3 If the Company gives the Customer written notice that the Company has reasonable grounds for believing that any of the events set out in Condition 11 below has occurred or is about to occur, or that the Customer is in breach of any of the terms of an agreement incorporating these Conditions or if the Company considers with reasonable cause that the Goods may be in jeopardy, the Customer's authority to possess the Goods of which it is trustee shall automatically end and all such Goods and any other property of the Company shall be immediately re-delivered to the Company or surrendered to the Company.

7.4 As trustor of the Goods, the Company, either acting itself or through any agent, shall be entitled to enter upon or into any land, buildings, vehicle, ship or aircraft where the Goods or part of them are situated or reasonably thought to be situated and may re-take possession of them at any time. If the Goods have been fitted to or fixed to an engine, ship, aircraft, generator or other equipment of the Customer, the Company shall have the right to take possession of such engine, ship, aircraft, generator or other equipment until the Goods have been detached. To the extent

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permitted in law, the Company's title in the Goods shall not be affected by any stipulation or rule of law that the Goods become part of an engine, ship, aircraft, generator or other equipment.

7.5 In the case of parts or components removed or replaced by the Company in the performance of Services, such parts or components shall become the property of the Company to the extent that they are replaced by the Company.

8. **WARRANTY**

.1 All Goods and Services are sold without any warranty whatsoever, save as specified in this Condition 8. The company will have no liability beyond the terms of the warranty set out in this Condition.

.2 8.2.1 The Company warrants that it will perform all Services with reasonable care and skill in accordance with all applicable laws and regulations and/or written instructions of the Customer accepted by the Company, provided always that the Company may make minor changes to Goods or Customer's Goods which do not affect price or safety.

8.2.2 Where materials, components, parts, assemblies or sub-assemblies are supplied and fitted by Company in the course of carrying out work for the Customer, Company warrants that such materials, components, parts and sub-assemblies are free from defects.

.3 8.3.1 If the Customer establishes to the Company's reasonable satisfaction within six months of, or during the first 3,000 hours of operation (whichever shall occur earlier) following, delivery that the Company has failed to comply with the warranty in Condition 8.2.1, the Company shall credit the Customer with the price paid by the Customer for the defective Services in question or, at its option, reperform the defective Services free of charge.

8.3.2 Should it be shown to the reasonable satisfaction of Company that a defect has become apparent in any Goods supplied or fitted by it, within the period set out in condition 8.3.1, Company shall undertake to repair or, at its option, refund the value of or replace, any such defective items free of charge at Company's Aberdeenshire Facility or such other location as may be agreed between the Parties. The Company will not be liable for the costs of transportation unless otherwise agreed in writing

8.3.3 Where betterment results from Company's remedial action, the Company will be permitted to invoice the Customer in respect of the value of such betterment at the Company's standard charges.

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8.3.4 The Company's liability for warranty claims will not exceed the invoice value of the original Services or Goods supplied or fitted by it.

.4 Warranty claims made pursuant to condition 8.3 will be subject to receipt by the Company (at the Customer's cost) of a full written report of claimed defects accompanied by any technical records (made up to date with all operating hours) and details of any work carried out on and storage of the Goods/Customer's Goods after delivery together with delivery to the Company of the Goods/ Customer's Goods to be remedied within 7 days of discovery of a claimed defect.

.5 The Company has no liability whatsoever under Conditions 8.2 or 8.3 if the Goods/Customer's Goods concerned have been subject to misuse or neglect or not been maintained and operated in accordance with any applicable manufacturer's manual or instructions applicable to such Goods or if the Goods/Customer's Goods have been removed, repaired or altered without the Company's prior approval.

.6 If a warranty claim is accepted by the Company and rectification work carried out, the applicable Company warranty period specified in Condition 8.3 may, at the Company's sole discretion, be extended by the period of time taken to carry out such work. If a warranty claim is rejected the Company may invoice the Customer for work carried out to investigate the claim.

.7 Insofar as it is reasonable to do so the Company will assign to the Customer the benefit of any assignable warranties which have been given to the Company by any manufacturer of Goods or sub-contractor of the Company. Upon reasonable request and at the Customer's sole expense, the Company shall give notice to any such other party of any such assignation, and shall give the Customer reasonable assistance, at the Customer's sole expense, in enforcing any rights of the Customer thus arising. The Company will use its reasonable endeavours (at the Customer's expense) to enforce and utilise any third party warranties that are not assignable but which remain valid and existing after the Goods are delivered to the Customer.

.8 The warranties in this Condition 8 are given in lieu of and replace, exclude and extinguish all and every condition, warranty or representation whatsoever whether express or implied by statute, common law, trade usage, custom and otherwise in respect of the quality or fitness for purpose, description of Goods, standard of Services/workmanship or otherwise. Additionally, the General Product Safety Regulations 1994 shall not apply to any Goods supplied for repair or reconditioning before use.

9. **LIMITATION OF LIABILITY AND INDEMNITY**

9.1 Nothing in these Conditions shall exclude or restrict any legal liability of the Company for death or personal injury resulting from the negligence of the Company, its employees or agents, sub-

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contractors and associate companies or restricts any of the Company's legal obligations arising under Section 12 of the Sale of Goods Act 1979 or under the Consumer Protection Act 1987 or in respect of fraud.

9.2 Save as provided in conditions 6.2 and 8, the Company shall have no liability to the Customer for any damages or losses (indirect or direct) or Consequential Loss resulting from defects in design, materials, or workmanship or statement of opinion or from any act or default of the Company (whether negligent or otherwise) unless caused intentionally or recklessly by the Company.

9.3 The Company's aggregate liability to the Customer whether for negligence, tort, delict, quasi-delict, under quasi-contract or breach of contract, misrepresentation or under warranty in terms of clause 8 or otherwise shall in no circumstances exceed the invoiced value of the Goods and/or Services which give rise to such liability in respect of any occurrence or series of occurrences.

9.4 The Customer will indemnify the Company, its employees, agents, sub-contractors and associated companies against all damages, losses, costs, claims or expenses (including reasonable legal fees) for any liability of such parties towards a third party arising out of or in connection with any Goods or Services supplied by the Company or Customer's Goods sold by the Company under Conditions 6.3 and 6.4.

9.5 Neither Party shall be liable for one to the other for Consequential Loss arising out of the performance, defective performance or non-performance of this contract. The Parties agree to exclude Consequential Loss to the maximum extent possible by law.

In these Conditions, the expression "Consequential Loss" shall mean indirect losses and/or loss of production loss of product, loss of use and loss of revenue, profit or anticipated profit.

10. <u>EXCUSABLE DELAY</u>

10.1 The Company shall not be liable for the loss, damage or otherwise as a direct or indirect result of the failure to perform or delay in performing any of its obligations or be in breach of an agreement with the Customer as a result of the occurrence of any circumstance or event beyond its control, including, without limitation, failure to receive or delay in receipt of the Customer's Goods, acts of God, fire, flood, storm, civil disturbance, explosion, power failure or reduction of power supplies, acts, orders or requirements of any governmental or regulatory body, lack or shortage of materials or parts, inability to procure or delay in procuring equipment and materials from its normal suppliers, mechanical breakdown or strike, lock-out or labour dispute, and the action or inaction of any government or other competent authority or the refusal of any licence, certificate or permission.

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10.2 If the Company cannot complete any Services or supply any Goods for any such reasons as is mentioned in Condition 10.1 for a period of 30 days, each party's obligations to the other will terminate on written notice of either party and the Company shall be paid in proportion to the amount of completed Goods and/or Services delivered and, once paid, shall deliver any Customer's Goods in its possession to the Customer.

10.3 The Company shall as soon as reasonably practicable give the Customer notice of any such event as is mentioned in Condition 10.1 which causes the Company to be unable to perform its obligations on time or at all. This Condition 10 shall not apply to the Customer's payment obligations.

11. <u>FINANCIAL CONDITION OF CUSTOMER</u>

11.1 If the events in (a) to (e) listed below occur, all sums outstanding to the Company shall become immediately due and payable and the Company may elect to proceed with the performance of contracts subsisting with the Customer or to treat such contracts as discharged. In the case of the latter, the Customer shall remain liable to indemnify the Company against all costs incurred by the Company in connection with such contracts until their discharge.

(a) The Customer breaches any of its obligations to the Company; or,

(b) the Customer wrongfully stops payment of any debt or is deemed to be unable to pay its debts (within the meaning of Section 123 of the Insolvency Act 1986 or its equivalent in any jurisdiction); or,

(c) a receiver, liquidator, trustee, encumbrancer of similar officer is appointed over the whole or any substantial part of the Customer's undertaking, property or assets or if a petition is presented for the appointment of an administrator of the Customer; or,

(d) the security of any of the Customer's secured obligations is enforced or any distress, execution, sequestration or other process is levied or enforced on or taken out against the Customer; or,

(e) the Customer enters into or offers to enter into any arrangements or composition for the benefit of its creditors; or,

(f) provisions equivalent to (c), (d) or (e) in any other system of law or jurisdiction apply to the Customer.

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11.2 If a contract for Services or Goods is terminated under Condition 11.1, the Customer shall pay the Company in proportion to the quantity of Services (and other ordered work) completed and/or Goods supplied or ready for delivery in terms of condition 5 at the time of termination together with the cost of all reassembly and packing work necessary to put the Customer's Goods (and other property) in a condition suitable for delivery to the Customer. In each instance the Company may retain the Customer's Goods pending payment of all of the Customer's invoices in full.

12. INTELLECTUAL PROPERTY

12.1 The Customer warrants that any design or instructions furnished by it shall not cause the Company to infringe any letters patent or other intellectual property right.

12.2 The sale of any Goods does not convey to the Customer any licence or right to use any of the Company's intellectual property which might form part of such Goods except to the extent that it is actually embodied in the Goods.

13. GENERAL

13.1 The Company shall be entitled to sub-contract performance of the whole or part of any agreement governed by these Conditions without prior notice to or the consent of the Customer.

13.2 If any part of any provision of these Conditions or any agreement governed by these Conditions shall be invalid or unenforceable, the remainder of such provision and all other provisions of these Conditions or any agreement governed by these Conditions shall remain valid and enforceable to the fullest extent permitted by law.

13.3 No amendment or variation of these Conditions or any agreement governed by these Conditions shall be effective unless it is made or confirmed in a written document signed by an authorised representative of the Company.

13.4 Any release, delay or waiver by the Company in favour of the Customer of any (or part of any) of its rights, power or privileges under these Conditions or any agreement governed by these Conditions shall only be binding if it is given in writing. Any binding release, delay or waiver shall:

13.4.1 be confined to the specific circumstances in which it is given;

13.4.2 not affect any other enforcement of the same right or the enforcement of any other right by or against any of the parties; and

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13.4.3 be revocable at any time in writing.

13.5 Excepting Condition 13.1, neither Party may assign, novate or sub-contract any of its rights or duties without the prior written consent of the other.

13.6 Headings are included for convenience only and shall not affect the interpretation or construction of these Conditions. In these Conditions, unless the context requires otherwise, references to a statute or statutory provision includes any consolidation, re-enactment, modification or replacement of the same and any subordinate legislation in force under the same from time to time; the masculine, feminine or neuter gender includes the other gender, references to the singular includes the plural (vice versa) and any reference to persons includes firms, corporations and unincorporated associations.

13.7 Insofar as it is possible to do so, the provisions of the United Nations Convention on Contracts for the International Sale of Goods are excluded from any contract for sale of goods between the Company and the Customer.

13.8 Conditions 3.5, 4, 5.2, 5.3, 5.4, 6, 7, 8, 9, 11, 12, 13.2, 13.6, 13.7, 13.8 and 14 shall continue to have effect notwithstanding the termination of any contract between the Company and the Customer which is subject to these Conditions.

14. LAW AND JURISDICTION

14.1 These Conditions and any agreement between the Company and the Customer to which these Conditions apply shall be governed by and construed in accordance with Scots law.

14.2 The parties agree that the Scottish Courts shall have non-exclusive jurisdiction to adjudicate in any dispute which arises out of or in relation to these Conditions.

DIESEL GENERATOR SET

CAT®

Image shown may not reflect actual package.

STANDBY
2000 ekW 2500 kVA
60 Hz 1800 rpm 13 800 Volts

Caterpillar is leading the power generation marketplace with Power Solutions engineered to deliver unmatched flexibility, expandability, reliability, and cost-effectiveness.

FEATURES

FUEL/EMISSIONS STRATEGY
- Low Fuel consumption

DESIGN CRITERIA
- The generator set accepts 100% rated load in one step per NFPA 110 and meets ISO 8528-5 transient response.

FULL RANGE OF ATTACHMENTS
- Wide range of bolt-on system expansion attachments, factory designed and tested
- Flexible packaging options for easy and cost effective installation

SINGLE-SOURCE SUPPLIER
- Fully prototype tested with certified torsional vibration analysis available

WORLDWIDE PRODUCT SUPPORT
- Cat dealers provide extensive post sale support including maintenance and repair agreements
- Cat dealers have over 1,800 dealer branch stores operating in 200 countries
- The Cat® S•O•S℠ program cost effectively detects internal engine component condition, even the presence of unwanted fluids and combustion by-products

CAT® 3516B TA DIESEL ENGINE
- Reliable, rugged, durable design
- Field-proven in thousands of applications worldwide
- Four-stroke-cycle diesel engine combines consistent performance and excellent fuel economy with minimum weight

CAT HV GENERATOR
- Matched to the performance and output characteristics of Cat engines
- Single point access to accessory connections
- UL 1446 Recognized Class F insulation

CAT EMCP 3 SERIES CONTROL PANELS
- Simple user friendly interface and navigation
- Scalable system to meet a wide range of customer needs
- Integrated Control System and Communications Gateway

STANDBY 2000 ekW 2500 kVA
60 Hz 1800 rpm 13 800 Volts

CAT®

FACTORY INSTALLED STANDARD & OPTIONAL EQUIPMENT

System	Standard	Optional
Air Inlet	• Single element canister type air cleaner • Service indicator	[ ] Dual element & heavy duty air cleaners [ ] Air inlet adapters & shut-off
Cooling	• Radiator with guard • Coolant drain line with valve • Fan and belt guards • Cat® Extended Life Coolant*	[ ] Radiator duct flange [ ] Jacket water heater
Exhaust	• Dry exhaust manifold • Flanged faced outlets	[ ] Mufflers and Silencers [ ] Stainless steel exhaust flex fittings [ ] Elbows, flanges, expanders & Y adapters
Fuel	• Secondary fuel filters • Fuel priming pump • Flexible fuel lines • Fuel cooler*	[ ] Water separator [ ] Duplex fuel filter
Generator	• Class F insulation • Cat digital voltage regulator (CDVR) with kVAR/PF control, 3-phase sensing • Winding temperature detectors • Anti-condensation space heaters	[ ] Oversized generators [ ] Cross current compensation transformer [ ] Bearing temperature detectors
Power Termination	• Bus bar (NEMA mechanical lug holes) • Right hand cable entry • Top or bottom cable entry	[ ] Left hand cable entry
Governor	• ADEM™ 3	[ ] Load share module
Control Panels	• EMCP 3.1 • User Interface panel (UIP) - wall mounted • AC & DC customer wiring area (right side) • Emergency stop pushbutton	[ ] EMCP 3.2 ... [ ] EMCP 3.3 [ ] Option for right or left mount UIP [ ] Local & remote annunciator modules [ ] Digital I/O Module [ ] Generator temperature monitoring & protection [ ] Remote monitoring software
Lube	• Lubricating oil and filter • Oil drain line with valves • Fumes disposal • Gear type lube oil pump	[ ] Oil level regulator [ ] Deep sump oil pan [ ] Electric & air prelube pumps [ ] Manual prelube with sump pump [ ] Duplex oil filter
Mounting	• Rails - Engine / generator / radiator mounting • Rubber anti-vibration mounts (shipped loose)	[ ] Isolator removal [ ] Spring-type vibration isolator (shipped loose) [ ] IBC Isolators