2013 Substation Refurbishment and Modernization

June 2012

Prepared by:

John Pardy, P.Eng.
Table of Contents

1.0 Substation Refurbishment and Modernization Strategy .........................................................1

2.0 Substation Refurbishment and Modernization 2013 Projects...........................................1
   2.1 2013 Substation Projects .................................................................................................2
   2.2 Substation Monitoring and Operations .............................................................................15

Appendix A: Substation Refurbishment and Modernization Plan
   Five-Year Forecast 2013 to 2017
1.0 Substation Refurbishment and Modernization Strategy

Newfoundland Power (the “Company”) has 130 substations located throughout its operating territory. Distribution substations connect the low voltage distribution system to the high voltage transmission system. Transmission substations connect transmission lines of different voltages. Generation substations connect generating plants to the electrical system. Substations are critical to reliability; an unplanned substation outage will affect thousands of customers. The Company’s substation maintenance program and the Substation Refurbishment and Modernization project ensure the delivery of reliable least cost electricity to customers in a safe and environmentally responsible manner.

The Substation Refurbishment and Modernization project provides a structured approach for the overall refurbishment and modernization of substations and coordinates with major equipment maintenance and replacement activities. Where practical the substation plan is coordinated with the maintenance cycle for major substation equipment. This coordination minimizes customer service interruptions and ensures optimum use of resources.

When updating the substation strategic refurbishment and modernization plan substations are assessed with particular consideration given to the condition of the infrastructure and equipment, and the need to upgrade and modernize protection and control systems. This assessment is used to determine substation work.

Much of this work requires the power transformer to be removed from service; and, therefore, the timing of the work is restricted to the availability of the portable substation and the capacity of the portable substation to meet the load requirement. In many circumstances, this requires the work to be completed in the late spring and summer when the substation load is reduced.

The current five-year forecast for the Substation Refurbishment and Modernization Plan is shown in Appendix A.

2.0 Substation Refurbishment and Modernization 2013 Projects

The 2013 Substation Refurbishment and Modernization Project includes planned refurbishment and modernization projects of 5 substations and one portable substation. This work is estimated to cost a total of $4,020,000 which comprises approximately 90% of the total 2013 project costs. The remaining project cost of $432,000 is associated with Substation Monitoring and Operations upgrades to substation communication systems to accommodate increased data requirements and the addition of new metering at infeed points on the Island Interconnected System.

---

1 The Company’s Substation Refurbishment and Modernization Project is the result of the Substation Strategic Plan filed with the 2007 Capital Budget Application.

2 These infeed points are some of the locations where Newfoundland Power takes delivery of electricity from Newfoundland Hydro.
Table 1 identifies the 2013 Substation Refurbishment and Modernization Project expenditures for 2013.

<table>
<thead>
<tr>
<th>Project</th>
<th>Budget (000s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>St. Catherine’s Substation (SCT)</td>
<td>$561</td>
</tr>
<tr>
<td>Portable Substation 4 (P4)</td>
<td>$790</td>
</tr>
<tr>
<td>Stephenville Gas Turbine Substation (STV)</td>
<td>$732</td>
</tr>
<tr>
<td>Glenwood Substation (GLN)</td>
<td>$967</td>
</tr>
<tr>
<td>Twillingate Substation (TWG)</td>
<td>$770</td>
</tr>
<tr>
<td>Kenmount Substation (KEN)</td>
<td>$200</td>
</tr>
<tr>
<td>Substation Monitoring and Operations (SMU)</td>
<td>$432</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$4,452</strong></td>
</tr>
</tbody>
</table>

The following pages outline the capital work required for each substation.

2.1 **2013 Substation Projects ($4,020,000)**

**St. Catherine’s Substation ($561,000)**

St. Catherine’s Substation (SCT) was built in 2000 as a distribution substation. The substation contains one 66 kV to 25 kV distribution power transformer (T1) with a capacity of 5 MVA, and one 25kV to 12.5 kV step down power transformer (T2) with a capacity of 4 MVA.

The substation directly serves approximately 924 customers in the St Catherine’s area through one 25 kV feeder and one 12.5 kV feeder. In the substation there are two 66 kV transmission lines terminated in the high voltage bus, these being transmission lines 94L to Blaketown substation and 94L to Riverhead substation.

In 2013, the Company has transformer maintenance activities scheduled for both transformer T1 and T2 at St. Catherine’s substation. The Company will also undertake other substation refurbishment and modernization work at St. Catherine’s substation to take advantage of the installation of the portable substation, which is being installed to minimize the number and duration of customer outages.3

---

3 Wherever possible, the Company coordinates maintenance work on individual substations with capital substation refurbishment and modernization projects to minimize service interruptions to customers.
2.1 2013 Substation Refurbishment and Modernization

St. Catherine’s Substation Location

Maintenance records and on-site engineering assessments show that the 66 kV wood pole structures and bus and 25 kV wood pole structures and bus are in good condition.

A portable substation will be installed to bypass St. Catherine’s substation to refurbish the transformers and upgrade the transformer’s auxiliary protection.\(^4\) Maintenance is scheduled on both transformers. The oil in transformer T2 has PCB concentration tested at over 50 ppm so

\(^4\) Substation transformers are maintained on 10 year cycles. This will be the first transformer refurbishment since the substation was built in 2000.
while the transformer is de-energized the oil will be replaced to comply with current PCB regulations. Upgrades will be completed on both transformers including replacement of temperature gauges and gas detection relays. The silicon carbide lightning arrestors will be replaced with metal oxide arrestors.\(^5\)

Potential transformers and current transformers will be installed for metering of the transformer load and to provide current and voltage signals for protective relays. Engineering staff use transformer load metering data for system modeling and planning.

The two existing feeder reclosers are hydraulic type, and have 40 and 43 years in service. They will be replaced with new Nulec type reclosers and will be automated for control from the System Control Center.\(^6\) Varmint proofing will be installed on the 15 kV bus equipment.

The ground grid for the substation will be extended to improve safety for personnel inside the substation.

*Portable Substation P4 ($790,000)*

Portable substation P4 was purchased in 1992. It is used to respond to power transformer failures and for planned transformer maintenance and substation refurbishment and modernization work. P4 can provide backup for 70% of the 192 power transformers in service on Newfoundland Power’s system.

---

\(^5\) Report 2.1 Substation Strategic Plan included with the 2007 Capital Budget Application identified that until the early 1980’s silicon carbide lightning arrestors were standard. The Company has experienced many failures of silicon carbide lightning arrestors as they age due to water leaking into the arrestor through failed seals.

\(^6\) Monitoring and control of Nulec reclosers from the System Control Center will result in real time detection of trouble on the distribution feeder and provide for remote restoration of service. Also, the System Control Center will be able to remotely de-energize feeders in emergency situations thus enhancing employee and public safety.
Engineering for the refurbishment will be completed in 2012 with the actual refurbishment taking place in 2013. This is the first comprehensive refurbishment of this portable substation since its purchase in 1992. Refurbishment of portable substation P4 will ensure its continued availability for the next decade.

The trailer will undergo an overhaul addressing rust damage and applying a rust inhibiting coating to the chassis. A fall arrest system and work platforms will be installed in areas where employees have to work aloft. External lighting will be provided at locations around the trailer.

---

7 The engineering work in 2012 on Portable Substation P4 was included in the 2.1 Substation Refurbishment and Modernization project approved in Order No. P.U. 26 (2011).
The alarm annunciation panel has had several failures and will be replaced. The original protection relays will be replaced with microprocessor based protection relays. A digital metering system for power, voltage and current will be provided.

The wiring associated with the protection and control of the portable substation is original wiring showing signs of deterioration. Deteriorated wiring, termination and junction boxes will be replaced.

Online monitoring of transformer gas and oil analysis will be provided to protect the transformer. High voltage linkages connecting the power transformer to the switches are deteriorated and will be replaced. The batteries and charging system are at the end of life and will be replaced.

A SCADA remote terminal unit will be installed on the portable substation to provide remote monitoring and control capability of the unit.

Stephenville Gas Turbine Substation ($732,000)

The Stephenville Gas Turbine substation was built in 1976 as a transmission substation, and is located on a site containing assets for both Newfoundland Power and Newfoundland and Labrador Hydro (“Hydro”). The transmission portion of the substation contains a 66 kV bus and associated isolating devices for three transmission lines, 401L to Gallants, 405L to Harmon, and 407L to Stephenville Crossing. A fourth transmission line, 404L to Wheelers, is tapped off of 401L approximately 4.6 km away from the substation fence. The Stephenville Gas Turbine substation indirectly serves 5,569 customers in the greater Stephenville and Port aux Port Peninsula area through this transmission network.

---

8 Report 2.1 Substation Strategic Plan included with the 2007 Capital Budget Application identified that electro-mechanical relays contain moving parts and are prone to failure as they age, wear and accumulate dirt and dust. In the past 5 years the Company has experienced increasing numbers of electro-mechanical relay failures.
Maintenance records and on-site engineering assessments show that the substation steel structures, foundations, bus work, and insulators are all in good condition.

The switches on the structures are all in good condition, with the exception that the 401L-DB switch is deteriorated and as a result is difficult to operate. The switch is 1976 vintage and will be replaced due to its age and recent operating history.

The steel cable trench covers are corroded and will be replaced. In addition, all substation light fixtures will be replaced.

Currently, the Company uses a set of Hydro’s 66 kV potential transformers terminated on their bus to provide the voltage signal for protection of the 3 Newfoundland Power transmission lines that terminate in the station. During switching activity the 66 kV bus can be split into 2 isolated buses resulting in the loss of protection for the 3 transmission lines. To address this shortcoming a new set of 66 kV potential transformers will be installed on the Newfoundland Power side of the 66 kV bus, along with a single fuse-protected potential transformer on transmission line 407L for synchronization monitoring. With this upgrade, service to customers normally supplied via 407L can be maintained, from local generation, while completing transmission line maintenance and reconnected to the grid without an interruption in service.9

The relays for the transmission lines and bus protection are 1976 vintage electromechanical type and will be replaced with new microprocessor based relays.10 In addition, a complete

---

9 Transmission line 407L connects the Lookout Brook hydro plant to the Island Interconnected System at Stephenville Gas Turbine substation via St. George’s substation.
10 Report 2.1 Substation Strategic Plan included with the 2007 Capital Budget Application identified that electromechanical relays contain moving parts and are prone to failure as they age, wear and accumulate dirt and dust. In the past five years Newfoundland Power has experienced increasing numbers of electro-mechanical relay failures.
communications package will be installed, to facilitate both automated and remote control of the various protection elements within the substation. This will provide the capability of remote management of the relays to monitor power system operation and analyze disturbances without travelling to the site.

![Transmission Line Electromechanical Relays](image)

The ground grid for the substation will be extended to improve safety for personnel inside the substation.

*Glenwood Substation ($967,000)*

Glenwood substation was built in 1968. Today it is both a transmission and distribution substation. The transmission portion of the substation contains two 138 kV transmission line links; Hydro’s TL210 to Cobbs Pond and Stoney Brook. There is a single 8.3 MVA, 138 kV to 25 kV power transformer GLN-T1 terminated at a voltage regulation bank leading to a 25 kV bus infrastructure. The substation services 707 customers in the area of Glenwood through a single feeder GLN-01.

In 2013, the Company has transformer maintenance activities scheduled for T1 at Glenwood substation. The Company will also undertake other substation refurbishment and modernization work at Glenwood substation to take advantage of the installation of the portable substation, which is being installed to minimize the number and duration of customer outages.
Maintenance records and on-site engineering assessments show that the 138kV and 25 kV wooden structures, foundations, buses and insulators are all in good condition. Standard varmint protection and vegetation management practices will be implemented.

The portable substation will be installed and the power transformer GLN-T1 will be refurbished.\(^{11}\) The lightning arrestors on this transformer are silicon carbide and will be replaced with metal oxide arrestors.\(^ {12}\)

\(^{11}\) Substation transformers are maintained on 10 year cycles. The last transformer maintenance on GLN-T1 was in 1999.

\(^{12}\) Report 2.1 Substation Strategic Plan included with the 2007 Capital Budget Application identified that until the early 1980’s silicon carbide lightning arrestors were standard. The Company has experienced many failures of silicon carbide lightning arrestors as they age due to water leaking into the arrestor through failed seals.
The 27 year old 138 kV motorized air break switch and high speed ground switch for power transformer GLN-T1 will be replaced, to permit integration of the motor operator and the high speed ground switch with the transformer protection relay. The transformer protection relays will be replaced with microprocessor based relays and the transformer protection panel will be installed in a new small control building.\textsuperscript{13} Upgraded transformer protection will isolate the transformer from system disturbances more quickly than existing protection.\textsuperscript{14}

New 25 kV potential transformers will be installed on the 25 kV bus to facilitate metering and protection upgrades. In addition, the voltage regulator structure will be relocated to a location just outside the substation fence. The existing regulator location does not permit maintenance to be safely performed on the units without a service interruption due to space limitation on the substation low voltage structure. Relocation of the voltage regulators to a standard voltage regulator structure outside the substation will permit safe, unrestricted access.

A grounding study will be completed and the ground grid for the substation will be extended to improve safety for personnel inside the substation. An access gate on the main substation driveway will be installed and crushed stone added to the yard.

\textsuperscript{13} Report \textit{2.1 Substation Strategic Plan} included with the 2007 Capital Budget Application identified that electro-mechanical relays contain moving parts and are prone to failure as they age, wear and accumulate dirt and dust. In the past five years Newfoundland Power has experienced increasing numbers of electro-mechanical relay failures.

\textsuperscript{14} The potential for transformer damage is decreased with improved protection.
Twillingate Substation ($770,000)

Twillingate ("TWG") substation was built in 1976 as a distribution substation. Transmission line 140L from Summerford terminates at switch T1-A. Transformer TWG-T1 is a 13.3 MVA, 66 kV to 12.5 kV power transformer terminated at a 12.5 kV bus structure. The substation services 1,650 customers in the area of Twillingate through 3 feeders.

Maintenance records and on-site engineering assessments show that the 66kV and 12.5 kV wooden structures, foundations, buses and insulators are all in good condition. Standard varmint protection and vegetation management practices will be implemented.
The power transformer TWG-T1 is in good condition. However, the lightning arrestors on this transformer are silicon carbide and will be replaced with metal oxide arrestors.\(^\text{15}\)

![Power Transformer with Silicon Carbide Arrestors](image)

The 66 kV air-break switch used to isolate power transformer TWG-T1 is deteriorated and will be replaced with a motorized air-break switch to improve the transformer protection.

The 3 hydraulic reclosers will be replaced with Nulec reclosers and will be automated for monitoring and control from the System Control Center.\(^\text{16}\) The automation equipment, transformer protection and recloser controls will be installed in a new small control building. A 125 VDC battery bank and charger will be added. With feeder automation, the Twiltingate feeders will be added to the provincial under-frequency load shedding scheme.

---

\(^{15}\) Report 2.1 Substation Strategic Plan included with the 2007 Capital Budget Application identified that until the early 1980’s silicon carbide lightning arrestors were standard. The Company has experienced increasing failures of this type of arrestor as they age due to water leaking into the arrestor through failed seals.

\(^{16}\) Monitoring and control of Nulec reclosers from the System Control Center will result in real time detection of trouble on the distribution feeder and provide for remote restoration of service. Also, the System Control Center will be able to remotely de-energize feeders in emergency situations thus enhancing employee and public safety.
The 12.5 kV oil-filled metering tank is deteriorated and will be replaced with an oil free unit.

The ground grid for the substation will be extended to improve safety for personnel inside the substation.

Kenmount Substation ($200,000)

Kenmount Substation (KEN) was built in 1975 as a transmission and distribution substation. The substation contains two 66 kV to 25 kV distribution power transformers each with a capacity of 25 MVA. The substation serves approximately 7,184 customers in the Kenmount Road area and west end of the City of St. John’s through four 25 kV feeders. In the substation there are three 66 kV transmission lines terminated in the high voltage bus, these being transmission lines 54L to Hardwoods substation, 69L to Stamps Lane substation and 35L to Oxen Pond substation.

During significant rain events the access road to the substation has flooded. Access to the substation was disrupted during each flooding event. The photo below shows the substation access road during Hurricane Igor on September 21, 2010. Water also entered the substation and flooded the cable trenches and the control building. Access to the substation was disrupted for two days during Hurricane Igor.

Recent flood events include hurricane Gabrielle in 2001, a heavy rain storm in November 2009 and the most recent during Hurricane Igor in 2010.

Standing flood water in a substation poses a significant safety hazard to workers.

Completing work in Kenmount substation during flood conditions will reduce response time and result in longer customer outages if line trucks or other equipment are unable to access the substation.

---

17 Recent flood events include hurricane Gabrielle in 2001, a heavy rain storm in November 2009 and the most recent during Hurricane Igor in 2010.
18 Standing flood water in a substation poses a significant safety hazard to workers.
19 Completing work in Kenmount substation during flood conditions will reduce response time and result in longer customer outages if line trucks or other equipment are unable to access the substation.
Flood mapping provided by the City of St. John’s shows that the Kenmount Substation is located within a flood plain. With the amount of housing and commercial development ongoing in the area it is anticipated that flood events will be more severe in the future as runoff from these developments is adding to the stream flow on the south side of the substation. Due to the development in the area the design capacity of the access road culvert is no longer adequate for the change in flow during peak rain events. The existing access road to the substation has a 1,525 mm culvert with a cross sectional area of 1.82 m$^2$ to pass water. In comparison about 150 metres downstream on Ladysmith Drive the City of St. John’s has recently installed a 6100 mm × 2290 mm box culvert with a cross sectional area of 14 m$^2$. The box culvert installed by the City of St. John’s has a cross sectional area 7.7 times larger to pass flow from the same stream.

---

Runoff from a drainage area is a function of the ground surface. Undeveloped areas have a low runoff as the lack of development allows much of the water to infiltrate the soil. Fully developed areas have a higher runoff as these areas tend to have harder asphalt and concrete surfaces which allow less water to infiltrate the soil.
To address the flooding problems a new access road will be constructed on the west end of the substation with a larger culvert system to handle the design flood. In addition, a berm will be constructed along the west side of the substation and connected to the access road to provide improved flood protection to the substation.

2.2 Substation Monitoring and Operations ($432,000)

Over the past decade, there has been a substantial increase of computer-based equipment in electrical system control and operations. Periodic upgrades of this equipment are necessary to ensure continued effective electrical system control and operations.

In 2013, upgrades to the communications hubs that connect multiple devices in substations to the SCADA system are planned. Effective management of increased volumes of electrical system data requires the upgrading of the hubs. This requires both hardware and software upgrades.

---

21 The blue contour line identifies the 100 year floodplain, while the red contour line identifies a 15 metre buffer around the floodplain. Photograph provided by the City of St. John’s Planning Department.
In 2013, the required work will incorporate manufacturers’ upgrades to communications and other computer-based equipment located in Company substations. These upgrades typically increase functionality of the equipment and software and remedy known deficiencies.

Newfoundland Power receives electricity supply from multiple Hydro infeed locations at various substations throughout its service territory. Many of these infeed locations are monitored through meters connected to the Company’s SCADA system. This item involves installing meters and communications equipment at 13 Hydro infeed locations to collect these data points on the Company’s SCADA system. These additional data points will provide Newfoundland Power with a more accurate measurement of the total instantaneous system load.
Appendix A
Substation Refurbishment and Modernization Plan
Five-Year Forecast 2013 to 2017
## Substation Refurbishment and Modernization Plan
### Five-Year Forecast
#### 2013 to 2017
(000s)

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUB</td>
<td>Cost</td>
<td>SUB</td>
<td>Cost</td>
<td>SUB</td>
<td>Cost</td>
</tr>
<tr>
<td>STV</td>
<td>732</td>
<td>CAR</td>
<td>1,269</td>
<td>BRB</td>
<td>1,796</td>
</tr>
<tr>
<td>P4</td>
<td>790</td>
<td>ILC</td>
<td>227</td>
<td>BVS</td>
<td>1,090</td>
</tr>
<tr>
<td>SCT</td>
<td>561</td>
<td>MAS</td>
<td>676</td>
<td>RRD</td>
<td>1,084</td>
</tr>
<tr>
<td>GLN</td>
<td>967</td>
<td>SPR</td>
<td>589</td>
<td>SPO</td>
<td>1,417</td>
</tr>
<tr>
<td>TWG</td>
<td>770</td>
<td>STX</td>
<td>372</td>
<td>VIC</td>
<td>1,539</td>
</tr>
<tr>
<td>KEN</td>
<td>200</td>
<td>SMU</td>
<td>155</td>
<td>SMU</td>
<td>160</td>
</tr>
<tr>
<td>SMU</td>
<td>432</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>$4,452</strong></td>
<td><strong>$3,288</strong></td>
<td><strong>$7,086</strong></td>
<td><strong>$5,389</strong></td>
<td><strong>$7,426</strong></td>
</tr>
</tbody>
</table>

**Note:** SUB: Substation - Refer to the Electrical System handbook included with the 2006 Capital Budget Application for three letter substation designations. P1, P3 and P4 are the designations for the portable substations.