OWEN Electric

A Touchstone Energy® Cooperative

RECEIVED

SEP 10 2015

PUBLIC SERVICE
COMMISSION

September 9, 2015

Mr. Jeffrey Derouen
Executive Director
Kentucky Public Service Commission
211 Sower Boulevard
P.O. Box 615
Frankfort, Kentucky 40602-0615

Re: Case No. 2015-00213

Dear Mr. Derouen:

Please find enclosed for filing with the Commission in the above-referenced case, and original and ten copies of the update to response 2 of Owen Electric Cooperative, Inc. ("Owen Electric") to the Commission Staff's Second Request for Information, dated August 20, 2015.

Very truly yours,

Ann F. Wood

Ann F. Wood
Senior Vice President of Corporate Services

Enclosures

CC: Hon. Jennifer Hans
Hon. Mike Kurtz

8205 Hwy 127 N • P.O. Box 400 • Owenton, Kentucky 40359-0400 • 800/372-7612 • Fax - 502/484-2661 • www.owenelectric.com

RECEIVED
SEP 10 2015
PUBLIC SERVICE COMMISSION

OWEN ELECTRIC COOPERATIVE, INC.

PSC CASE NO. 2015-00213

CERTIFICATE OF PUBLIC CONVENIENCE AND NECESSITY

RESPONSE TO INFORMATION REQUEST

COMMISSION STAFF'S SECOND REQUEST FOR INFORMATION TO OWEN ELECTRIC COOPERATIVE, INC. DATED 8/20/2015

REQUEST 2

RESPONSIBLE PARTY: Mark A. Stallons

Request 2: Refer to the response to Item 7 of Staff's First Request. Provide a copy of the system impact study upon its completion.

Response 2: The system impact study is provided on pages 2 through 16 of this updated response.

A Touchstone Energy Cooperative

Bromley Natural Gas Generator

System Impact Study

September 2015

Distribution System Solutions, Inc.

Walton, Kentucky

Table of Contents

Scope

IEEE 1547, *Standard for Interconnecting Distributed Resources with Electric Power Systems*, recommends a system impact study be performed for all distributed generation (DG) additions to a system if the DG is 15% of the connected line load. The purpose of an impact study is to determine if there will be any adverse effects to the system with the added DG, and if so what mitigation strategies are advised. The impact study will look at steady state conditions; short-circuit analysis, impacts to power quality, and system grounding. The study will also outline any impacts to existing protection schemes, and verify that all equipment interrupting ratings will not be exceeded by the addition of the DG.

Background Information

Owen Electric Cooperative (OEC) headquartered in Owenton, KY is an electric cooperative that presently serves around 59,000 members. The system consists of 28 delivery points distributing power at primary voltages of 12.5/7.2 kV and 25/14.4 kV over approximately 4,500 miles of line. East Kentucky Power Cooperative (EKP) provides all power and energy needs to OEC.

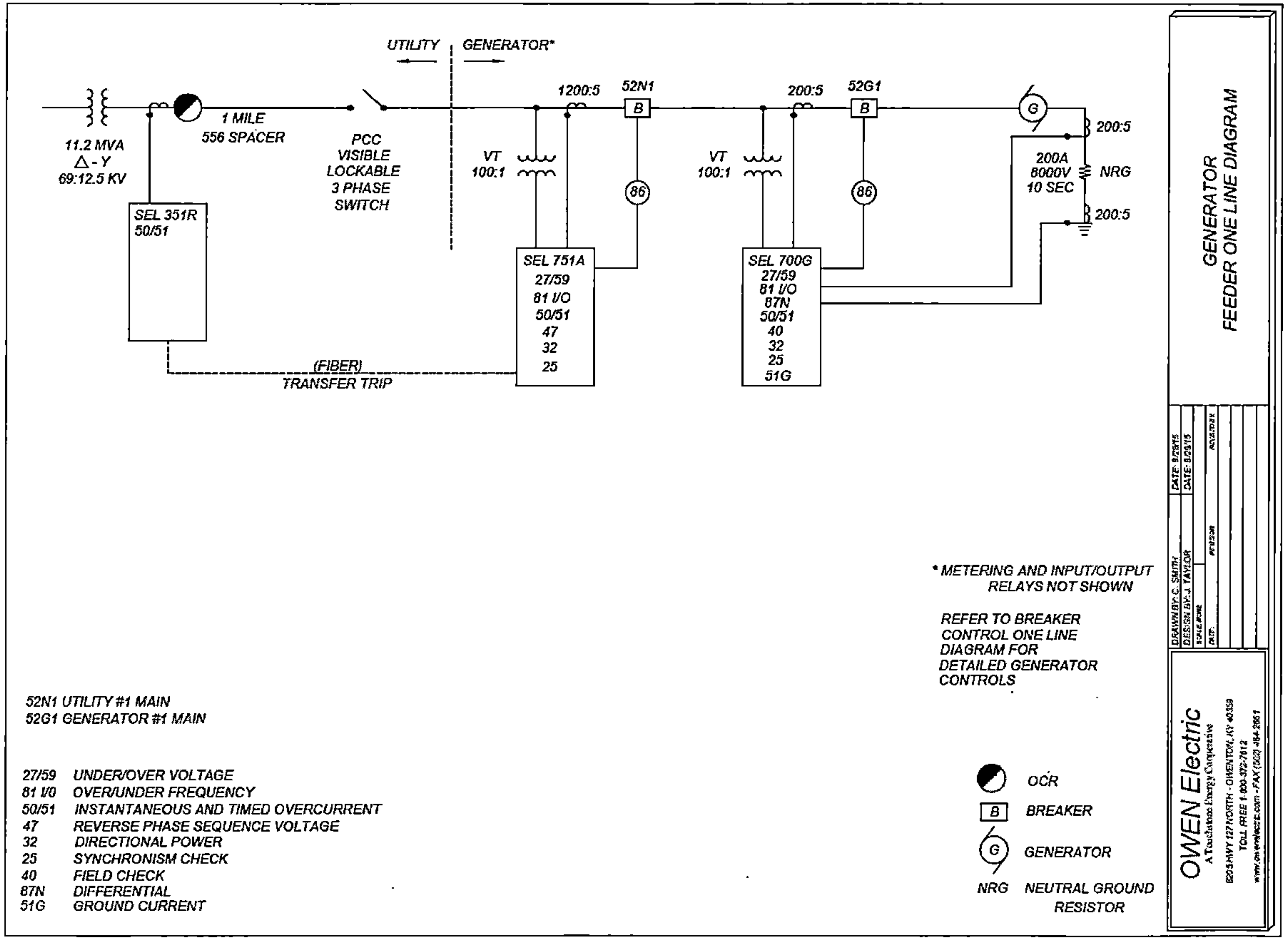
Under the terms of Amendment Three to the Wholesale Power Contract, member systems of EKP are allowed to purchase or produce power up to 15% of their total connected load by another source. OEC is proposing the addition of a 2MW natural gas-fueled, synchronous generator to provide power that will be used by their load base. The generator will be located at OEC headquarters which is approximately one mile from the Bromley substation. The generator will interconnect with the Bromley substation, which is owned and operated by EKP. The Bromley substation is bus regulated. OEC will own and operate the DG.

Generator Specifications

The three-phase 1,988kW synchronous generator consists of a continuous duty, Caterpillar engine model G3516H. It is a V16 cylinder, reciprocating engine fueled by natural gas. The generator excitation type is a permanent magnet.

The generator will tie to the Bromley substation by way of a dedicated one-mile feeder. (See feeder one-line diagram on the following page.) The generator will operate at 12.5/7.2kV and will synchronize to the system voltage and frequency. The generator controls will be configured in a load following mode; and will be linked into OEC's Supervisory Control and Data Acquisition system (SCADA). At no time will the generator produce more power than can be used by the native load on the Bromley substation. Therefore, there will be no net-metering.

Figure 1.1 Feeder One Line Diagram



PSC Request 2
Page 5 of 16
(Updated)

Steady State Analysis / Power Flow

An analysis was performed to determine the impact of the DG, on the system, at both peak summer and winter loads, as well as at minimum loading. The output of the generator will vary based on overall load on the Bromley substation. The OEC SCADA system will monitor the load on the substation transformer and adjust the output through the controls of the generator. The generator output will vary between 1,000kW and the full 1,988kW and will stay 10% below Bromley load. This 10% separation may be lowered to 5% as experience and historical data permit. The controls of the generator will be set for a fixed power factor.

Given the dedicated feed configuration to the DG, the steady state impact to the system is negligible under the minimum and maximum loading conditions that were studied. It is highly recommended that the generator be operated at close to unity power factor. In this configuration, there will be a voltage rise expected at the generator of about 0.5V. A negligible rise in voltage may be expected at the substation bus. Bromley substation often has a power factor at the substation near unity, and actually goes leading about 37% of the time. If the generator were to run with a lagging power factor whereby it is providing VARs to the system, then the Bromley substation will go more leading throughout the year. Once the unit is operational, the power factor of the generator could be altered to allow some additional VAR support in the summer with little voltage impact; but based upon the average existing summer power factor, this is not necessary. There is one existing three-phase, 600kVAR capacitor bank and a single, 100kVAR capacitor presently on the Bromley substation that are both fixed and online. Once the DG is operational, it is recommended that the power factor at the substation be monitored and consideration given to opening those capacitors for the non-summer months.

Since the generator will be running continuously for about 80% of the year, steady-state voltage fluctuation caused by the generator will be almost non-existent. Therefore no additional stress on the substation regulators through excessive step changes is expected. There are no feeder regulators, mainline regulators or switched capacitors that need to be considered in this evaluation.

When the DG is at full output, the steady-state load currents, on all line equipment and conductors, will be within the capacity ratings of all equipment.

A summary of the voltage effects from the DG is on the following page. Detailed results of the voltage drop analysis can be found in the Appendix.

Summary of Voltage Drop Results

Power Factor of Generator	Min Load	Peak Winter	Peak Summer
1.00	No rise at substation bus when generator running 0.3 Volts rise at generator No voltage drop at bus when DG kicks off	0.2V rise at substation bus when generator running 0.6V rise at generator 0.2V drop at bus when DG kicks off	0.2V rise at substation bus when generator running 0.5 rise at generator 0.2V drop at bus when DG kicks off
0.80 lagging*	0.2V drop at substation bus when generator running 0.5 Voltage rise at generator 0.8 Voltage drop at bus when DG kicks off	0.2V drop at substation bus when generator running 1V rise at generator 1.7V drop at bus when DG kicks off	0.3V drop at substation bus when generator running 1V rise at generator 1.6V drop at bus when generator kicks off
0.80 leading*	0.2V rise at substation bus when generator running 0 Voltage rise at generator 0.7V rise at bus when DG kicks off	0.5V rise at substation bus when generator is running 0V rise at generator 1.3V rise at bus when generator kicks off	0.5V rise at substation bus when generator is running 0V rise at generator 1.5V rise at bus when generator kicks off

*lagging power factor from a generator perspective supply VARS to the power system.
* leading power factor from a generator perspective absorb VARS from the power system

Power Quality

An analysis was performed to determine the impact on voltage if the DG was suddenly tripped offline. If the DG was taken offline before the substation regulators had time to respond due to the regulator time delay, a 0.2Volt drop would be anticipated if the generator is operating at unity power factor. A 0.2V drop will be virtually unnoticeable on incandescent lighting and residential motor loads. Since it will be a rather unlikely occurrence that the generator should suddenly be taken offline, and the voltage drop is minimal; flicker concerns due to the generator are nonexistent.

As for other power quality concerns, there are no anticipated adverse effects brought on by the DG. Since the DG will be on a dedicated feeder and the VAR output of the generator will be small, any large nearby motors on adjacent feeders would be unaffected. There will be no single phase fault interruption by either the generator breaker or the main feeder recloser, so ferroresonance conditions will not be an issue. Since there are no power electronics such as power convertors/invertors involved with a synchronous generator, harmonics will not be introduced to the system from the DG.

A direct transfer trip scheme will be designed between the generator breaker controls and the feeder recloser. Both sets of controls will be Schweitzer controls and will communicate over fiber. If any fault is detected on the feeder, the generator breaker will immediately open taking the generator offline. Additionally if there is a fault on the substation transformer high side and the transmission feed is interrupted, the DG will be taken offline so as not to feed back through the transmission. There are no switched capacitors or voltage regulators on the dedicated feeder to create transients on the system affecting the synchronous generator. There are no large motors on the feeder or in the adjacent area that would cause transient instability with the generator. There will be no load switching or islanding with the DG on the system during an outage. Synchronization relays will be employed to trip the generator breaker in the event that the DG loses synchronization which could potentially cause transient instability. The DG will not be brought back online following an outage event until the system has returned to normal operation. The generator control scheme will be designed so that the generator will be running at system frequency and voltage before it will be connected to the system so as not to cause any adverse effects to the system.

Short-circuit Analysis

A short-circuit analysis was performed to determine the additional fault current contribution from the DG. With the transfer trip scheme, any fault contribution from the generator to the system will be less than 2 seconds before the generator breaker opens disconnecting it from the system. Under a fault condition, the impact on the adjacent feeders as to increased fault current from the DG is negligible. The maximum increase to fault current from the DG on the substation bus is an additional 550A on a three phase fault and an additional 935A on a L-G fault. The maximum L-G fault current at the substation transformer secondary is 6,764A. The maximum anticipated fault current on the dedicated DG feeder will be 6,614A on a L-G fault at the feeder recloser before the generator is taken offline. The maximum fault currents projected with the DG contribution falls well below the fault interrupting ratings of all line equipment. Therefore, no additional modifications need to be made to existing line and feeder equipment. Generator reactances used for the analysis, as specified by the manufacturer, may be found in the Appendix. Detailed results of fault current analysis may also be found in the Appendix.

Protection Settings

Since the DG will be on a dedicated feeder, no existing mainline reclosers or overcurrent protective devices will be impacted by the addition of the DG. A system protection study to coordinate all relaying functions of the generator main switchgear, the utility breaker on the generator, and the feeder recloser will be conducted. A transfer trip configuration will be incorporated between the distribution feeder recloser and the DG protection system.

Grounding Review

A low-impedance grounding system consists of a connection from the generator's neutral terminal to ground - through a 40 Ω impedance (See Fig 1.1). The resistor limits ground fault current magnitudes to 200 A for a short duration. The selection of the magnitude of fault current is made to minimize damage at the point of fault and provide selective coordination of the protection system.

In addition to minimizing the damage at the point of fault, low-impedance grounded systems minimize shock hazards caused by stray currents, minimize thermal and mechanical stresses on equipment, and control transient overvoltages. The transient overvoltage is limited to 8,000 V for this unit. This is well within the rating of the 15 kV rated distribution system.

The grounding system for the subject generator is a standard installation from Caterpillar. All applicable safety codes will be followed for this project.

Appendix

Bromley Peak Summer Load Model

	Peak Summer	Peak Winter	Minimum Load
kW	5900	9500	1400
KVAR	1636	1240	-100
PF	96.4	99.2	-99.7

Gen pf = 1	Before Generator	Generator ON	Gen off VR locked	After VR adjusts
Sub kW	5872	3891	5872	No change
Sub kVAR	1649	1504	1649	
Sub pf	96.3	93.27	96.3	
VR Voltage	124.2/124.3/123.5	124.3/124.5/123.7	124.2/124.3/123.5	
Tap	0/0/-1	0/0/-1	0/0/-1	
Boost	0/0/-.75	0/0/-.75	0/0/-.75	
Gen kW	0	2000	0	
Gen kVAR	0	0	0	
Gen pf	0	100	0	
Gen V	0	124.9/125/124.2	0	
Gen I	0	-88A per phase	0	

Gen pf = .8	Before Generator	Generator ON	Gen off VR locked	After VR adjusts
Sub kW	5903	3914	5848	5872
Sub kVAR	1635	-9	1654	1649
Sub pf	96.37	100	96.23	96.3
VR Voltage	125.1/125.3/125.4	124.9/125/125.1	123.3/123.4/123.5	124.2/124.3/123.5
Tap	1/1/1	-1/-1/-1	-1/-1/-1	0/0/-1
Boost	0.75/0.75/0.75	-0.75/-0.75/-0.75	-0.75/-0.75/-0.75	0/0/-.75
Gen kW	0	1988	0	0
Gen kVAR	0	1491 supply	0	0
Gen pf	0	80	0	0
Gen V	0	125.9/126/126.2	0	0
Gen I	0	-110	0	0

Gen pf = -.8	Before Generator	Generator ON	Gen off VR locked	After VR adjusts
Sub kW	5872	3908	5927	5906
Sub kVAR	1649	3052	1631	1636
Sub pf	96.3	78.8	96.42	96.37
VR Voltage	124.2/124.3/123.5	124.7/124.8/124.0	126/126.2/125.4	125.1/125.3/125.4
Tap	0/0/-1	2/2/1	2/2/1	1/1/1
Boost	0/0/-.75	1.5/1.5/.75	1.5/1.5/0.75	0.75/0.75/0.75
Gen kW	0	1988	0	0
Gen kVAR	0	1491 absorbed	0	0
Gen pf	0	-80	0	0
Gen V	0	124.7/124.9/124.1	0	0
Gen I	0	-110A per ph	0	0

Bromley Peak Winter Load Model

	Peak Summer	Peak Winter	Minimum Load
kW	5900	9500	1400
KVAR	1636	1240	-100
PF	96.4	99.2	-99.7

Gen pf = 1	Before Generator	Generator ON	Gen off VR locked	After VR adjusts
Sub kW	9491	7516	9491	No change
Sub kVAR	1194	936	1194	
Sub pf	99.2	99.23	99.22	
VR Voltage	124.8/125/124.8	125/125.1/125	124.8/125/124.8	
Tap	0/0/0	0/0/0	0/0/0	
Boost	0/0/0	0/0/0	0/0/0	
Gen kW	0	2000	0	
Gen kVAR	0	0	0	
Gen pf	0	100	0	
Gen V	0	125.5/125.7/125.6	0	
Gen I	0	-88A per ph	0	

Gen pf = .8	Before Generator	Generator ON	Gen off VR locked	After VR adjusts
Sub kW	9491	7501	9371	9371
Sub kVAR	1194	-547	1208	108
Sub pf	99.2	-99.8	99.2	99.2
VR Voltage	124.8/125/124.8	124.6/124.7/124.6	122.9/123.1/123	123.9/124/123.9
Tap	0/0/0	-2/-2/-2	-2/-2/-2	-1/-1/-1
Boost	0/0/0	-1.5/-1.5/-1.5	-1.5/-1.5/-1.5	-.75/-.75/-.75
Gen kW	0	2000	0	0
Gen kVAR	0	1491 supply	0	0
Gen pf	0	80	0	0
Gen V	0	125.6/125.8/125.6	0	0
Gen I	0	-110A per ph	0	0

Gen pf = -.8	Before Generator	Generator ON	Gen off VR locked	After VR adjusts
Sub kW	9435	7492	9568	9501
Sub kVAR	1202	2482	1192	1197
Sub pf	99.2	94.93	99.23	99.22
VR Voltage	123.9/124/123.9	124.4/124.6/124.4	125.7/125.9/125.8	124.8/125/124.8
Tap	-1/-1/-1	1/1/1	1/1/1	0/0/0
Boost	-.75/-.75/-.75	.75/.75/.75	.75/.75/.75	0/0/0
Gen kW	0	1988	0	0
Gen kVAR	0	1491 absorbed	0	0
Gen pf	0	-80	0	0
Gen V	0	124.5/124.6/124.5	0	0
Gen I	0	-110A per phase	0	0

Bromley Minimum Load Model

	Peak Summer	Peak Winter	Minimum Load
kW	5900	9500	1400
KVAR	1636	1240	-100
PF	96.4	99.2	-99.7

Gen pf = 1	Before Generator	Generator ON	Gen off VR locked	After VR adjusts
Sub kW	1400	401	1400	No change
Sub kVAR	-106	-117	-106	
Sub pf	-99.7	-96	-99.7	
VR Voltage	124.0/125.3/125.1	124.0/125.3/12.2	124.0/125.3/125.1	
Tap	-2/-1/-1	-2/-1/-1	-2/-1/-1	
Boost	-1.5/-0.75/-0.75	-1.5/-0.75/-0.75	-1.5/-0.75/-0.75	
Gen kW	0	1000	0	
Gen kVAR	0	0	0	
Gen pf	0	100	0	
Gen V	0	124.4/125.6/125.4	0	
Gen I	0	-44A per phase	0	

Gen pf = .8	Before Generator	Generator ON	Gen off VR locked	After VR adjusts
Sub kW	1400	401	1392	1394
Sub kVAR	-106	-858	-98	-99
Sub pf	-99.7	-42	-99.8	-99.8
VR Voltage	124.0/125.3/125.1	123.9/125.1/125	123.1/124.4/124.2	124.0/124.4/124.2
Tap	-2/-1/-1	-3/-2/-2	-3/-2/-2	-2/-2/-2
Boost	-1.5/-0.75/-0.75	-2.25/-1.5/-1.5	-2.25/-1.5/-1.5	-1.5/-1.5/-1.5
Gen kW	0	1000	0	0
Gen kVAR	0	750 supply	0	0
Gen pf	0	80	0	0
Gen V	0	124.4/125.6/125.5	0	0
Gen I	0	-55A per ph	0	0

Gen pf = -.8	Before Generator	Generator ON	Gen off VR locked	After VR adjusts
Sub kW	1397	402	1404	1402
Sub kVAR	-102	640	-110	-108
Sub pf	-99.73	53.2	-99.7	-99.7
VR Voltage	125/124.4/124.2	125.2/124.6/124.4	125.9/125.3/125.1	125/125.3/125.1
Tap	-1/-2/-2	0/-1/-1	0/-1/-1	-1/-1/-1
Boost	-.75/-1.5/-1.5	0/-.75/-.75	0/-.75/-.75	-.75/-.75/-.75
Gen kW	0	1000	0	0
Gen kVAR	0	750 absorbed	0	0
Gen pf	0	-80	0	0
Gen V	0	125.2/124.6/124.5	0	0
Gen I	0	-55.5A per phase	0	0

GENERATOR DATA **JUNE 25, 2015**

For Help Desk Phone Numbers Click here

Selected Model

Engine: 3516	Generator Frame: 2770	Genset Rating (kW): 2000.0	Line Voltage: 12470
Fuel: Gas	Generator Arrangement: 3951752	Genset Rating (kVA): 2000.0	Phase Voltage: 7200
Frequency: 60	Excitation Type: Permanent Magnet	Pwr. Factor: 1.0	Rated Current: 92.6
Duty: CONTINUOUS	Connection: SERIES STAR	Application: EPG	Status: Current

Version: 41205 /41066 /41092 /6066

Spec Information

Generator Specification

Frame: 2770	Type: SR4BHV	No. of Bearings: 2
Winding Type: FORM WOUND		Flywheel: 21.0
Connection: SERIES STAR		Housing: 00
Phases: 3		No. of Leads: 6
Poles: 4		Wires per Lead: 1
Sync Speed: 1800		Generator Pitch: 0.667

Generator Efficiency

Per Unit Load	kW	Efficiency %
0.25	500.0	94.0
0.5	1000.0	96.5
0.75	1500.0	97.2
1.0	2000.0	97.4
1.1	2200.0	97.4

Reactances	Per Unit	Ohms
SUBTRANSIENT - DIRECT AXIS X''_d	0.1399	10.8768
SUBTRANSIENT - QUADRATURE AXIS X''_q	0.1740	13.5280
TRANSIENT - SATURATED X'_d	0.1836	14.2757
SYNCHRONOUS - DIRECT AXIS X_d	1.8973	147.5160
SYNCHRONOUS - QUADRATURE AXIS X_q	0.9819	76.3412
NEGATIVE SEQUENCE X_2	0.1565	12.1684
ZERO SEQUENCE X_0	0.0201	1.5635

Time Constants	Seconds
OPEN CIRCUIT TRANSIENT - DIRECT AXIS T'_{d0}	3.8250
SHORT CIRCUIT TRANSIENT - DIRECT AXIS T'_d	0.5670
OPEN CIRCUIT SUBSTRANSIENT - DIRECT AXIS T''_{d0}	0.0380
SHORT CIRCUIT SUBSTRANSIENT - DIRECT AXIS T''_d	0.0300
OPEN CIRCUIT SUBSTRANSIENT - QUADRATURE AXIS T''_{q0}	0.0190
SHORT CIRCUIT SUBSTRANSIENT - QUADRATURE AXIS T''_q	0.0040
EXCITER TIME CONSTANT T_e	0.1760
ARMATURE SHORT CIRCUIT T_a	0.0690

Short Circuit Ratio: 0.86 | Stator Resistance = 0.6389 Ohms | Field Resistance = 0.2144 Ohms

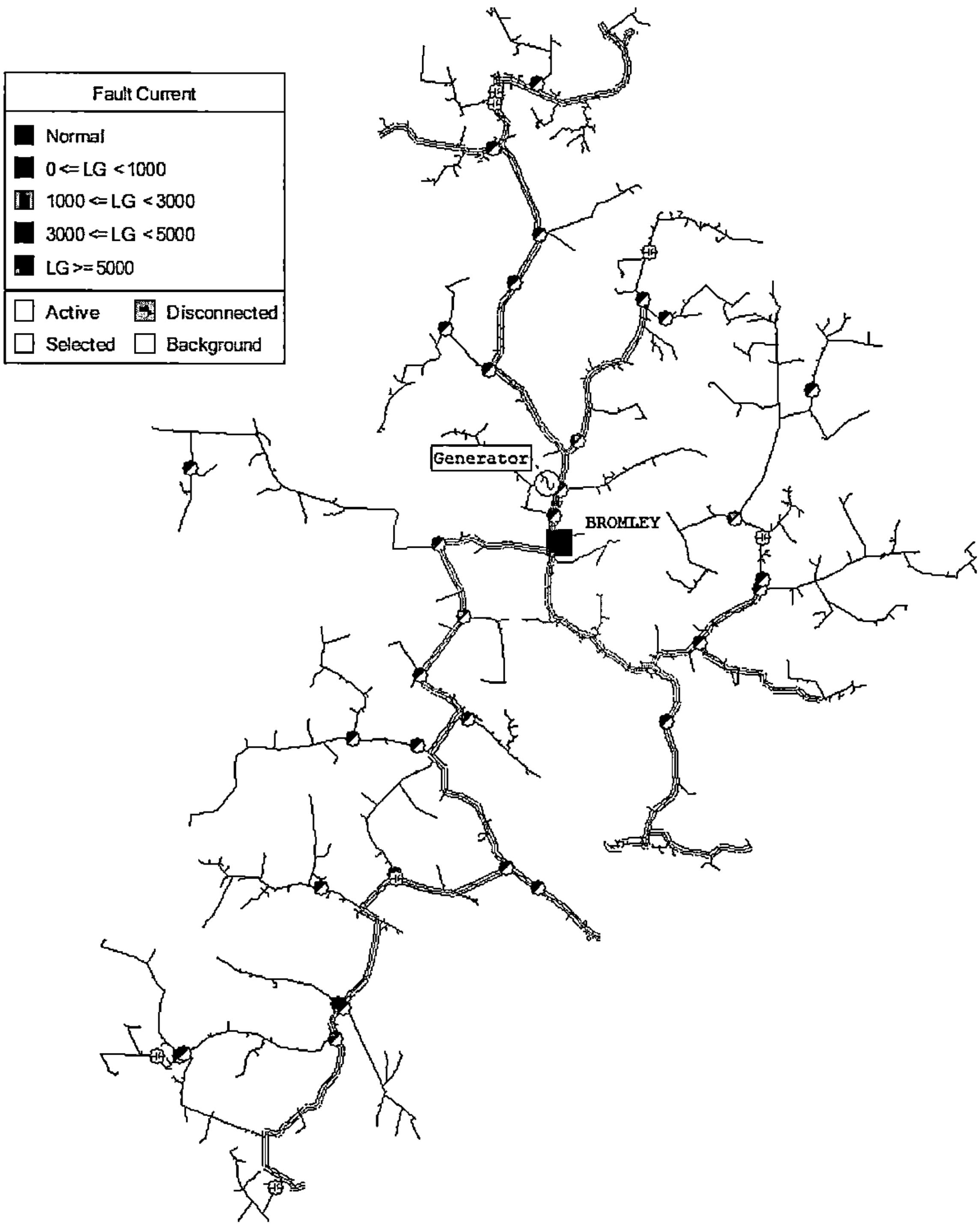
Voltage Regulation

Voltage level adustment: +/-	5.0%
Voltage regulation, steady state: +/-	0.5%
Voltage regulation with 3% speed change: +/-	0.5%
Waveform deviation line - line, no load: less than	2.0%
Telephone influence factor: less than	50

Generator Excitation

	No Load	Full Load, (rated) pf Series	Parallel
Excitation voltage:	20.82 Volts	54.24 Volts	Volts
Excitation current	2.21 Amps	4.74 Amps	Amps

Maximum Fault Currents based on Sub-Transient Reactance of Generator - Bromley territory



Maximum Fault Currents based on Sub-Transient Reactance of Generator - DG feeder