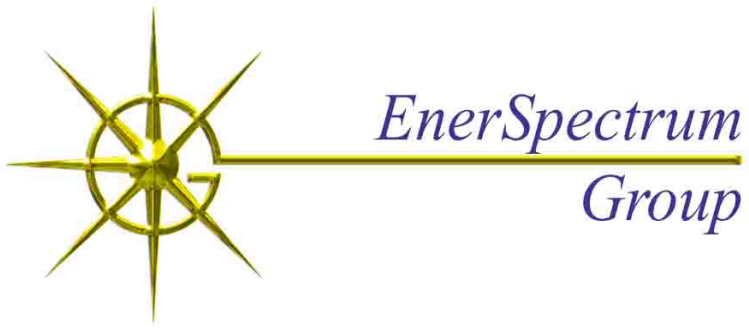


APPENDIX V



Lakefront Utilities Inc.

Conversion from 4160 V to 27,600 V

Distribution System Loss Assessment

Report 2

E1021

April 25, 2005

Prepared by:

Approved by:

*Original signed by
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Introduction

On January 21, 2005, EnerSpectrum Group delivered the report *Lakefront Utilities Inc., Conversion of F9 from 4,160 V to 27,600 V, Distribution System Loss Assessment*. The report provided an assessment of the effect on distribution losses of a feeder voltage conversion. The feeder, F9 from MS 2 in Cobourg, feeds a predominately residential neighbourhood in the central downtown area. The feeder is currently operated at 4,160V, supplied from a 5,000 kVA 44kV/4kV transformer at MS 2. Post-conversion, the feeder would operate at 27,600 V supplied from existing 27,600 facilities in the area.

This analysis was made in support of Lakefront Utilities Inc. line loss mitigation program which is part of their Conservation and Demand Management Plan.

Based on the positive results of the F9 voltage conversion assessment, EnerSpectrum Group was engaged to extend the study to the remaining 4,160 V feeders in Cobourg. The basis of the extended assessment was Lakefront Utilities' judgement that the F9 feeder was typical of the remaining feeders, and therefore, the F9 model results would be applicable to the remaining feeders.

This report documents the methodology used and result obtained from the extended assessment of the application of the F9 model to the remaining Cobourg 4,160 V feeders.

F9 Voltage Conversion Assessment

The assessment documented in the January 21 report determined that significant reduction in losses would occur through the conversion of Cobourg F9 from 4,160 V to 27,600 V. The report concluded:

As the charts and analysis illustrate, there are significant line loss savings which would result from voltage conversion to 27,600 V for feeder F9. The range of line loss reduction (3% - 5%) translates into 35 to 105 kW savings. This would impact the demand charges to Lakefront Utilities. Associated with this is the energy savings which amount to 700 – 2000 kWh per day. At an average value of 1,500 kWh per day this translates into 547,000 kWh per year. At the current artificially low price of 4.7 cents/kWh this represents a savings of \$25,700 each year.

The model provided results over the feeder load range of 1,500 to 3,000 kVA which is approximately 30 to 60% of the supply transformer loading. The losses associated with the range of peak loading are shown below in Figure 1, while the associated 24 hour energy loss is shown in Figure 2.

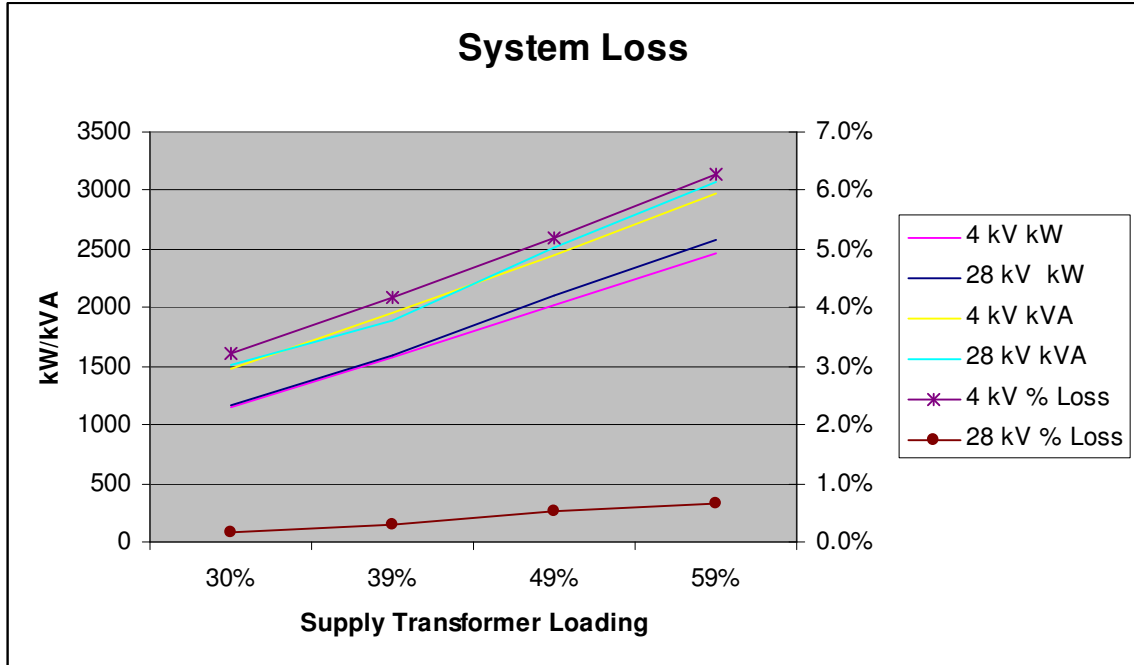


Figure 1
 Feeder F9 Peak Loss vs. Supply Transformer Loading

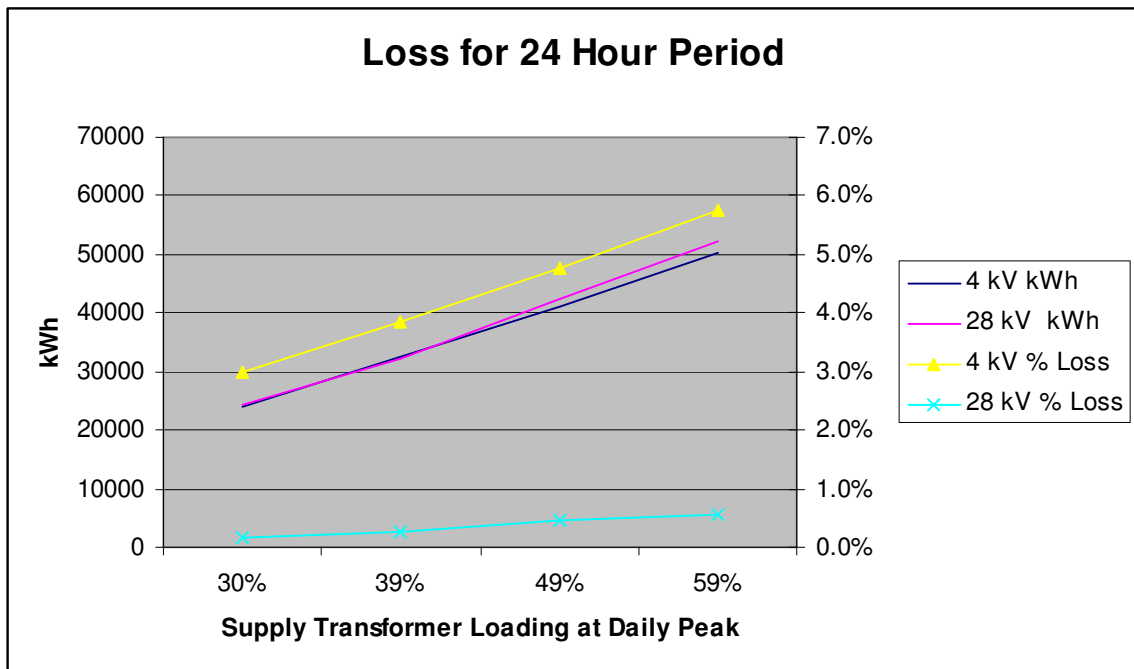


Figure 2
 Feeder F9 Energy Loss vs. Peak Transformer Loading

Cobourg 4,160 V Feeders

Information provided by Lakefront Utilities on the 4,160 V feeders is shown in Appendix 1. The seven feeders range in customer count from 83 to 645 with F9 having 360 customers. F9 customers are mainly residential with some commercial in the downtown business district. Three of the feeders were judged to be similar to F9 while two were judged to have a larger residential component and one to be largely three phase condominium loads.

Load current readings were provided for the three phases of each feeder. The readings, depending on the instrumentation used, were in one minute, five minute or 15 minute intervals. In all cases the readings were reduced to one reading per hour. The hourly load readings for each feeder are listed in Appendix 2.

The maximum average three phase current over the recorded time period for each feeder is shown in Table 1. Also shown is the calculated equivalent apparent power at a nominal 4,160 V.

Feeder	Date	Max Avg 3- Ph Current (Amps)	Apparent Power (kVA)
F4	07/04/2005	28	199
F5	06/04/2005	118	850
F9	21/12/2004	378	2724
F13	26/01/2005	279	2013
F14	27/01/2005	41	295
F15	03/03/2004	113	817
F19	24/03/2005	208	1501
F20	16/03/2005	230	1655

Table 1
 Feeder Peak Loading

F9 Model Applied to Other Feeders

The F9 model results in Figure 1 and 2 can be used as the basis for regression analysis to estimate the real power and real power losses associated with the feeder apparent power. The regression analysis output is shown in Appendix 3. Since the range of the F9 model is from 1500 kVA to 3000 kVA, only the feeders F13, F19 and F20 are within the F9 model range. F4, F5, F14 and F15 would produce invalid results if the F9 model were applied to their load levels.

The result of applying the regression analysis output to predict the real power and real power losses to the Cobourg feeders in the existing 4,160 V system are shown in Table 2.

Feeder	Date	Max Avg 3-Ph Current (Amps)	Apparent Power (kVA)	Load (kW)	Losses (kW)	% Losses
F9	21/12/2004	378	2724	2258	131	5.8%
F13	26/01/2005	279	2013	1626	75	4.6%
F19	24/03/2005	208	1501	1171	34	2.9%
F20	16/03/2005	230	1655	1308	46	3.5%

Table 2
 Losses at Feeder Peak Loading - 4,160 V

The predicted losses for the feeders when converted to 27,600 V are shown in Table 3.

Feeder	Date	Max Avg 3-Ph Current (Amps)	Apparent Power (kVA)	Load (kW)	Losses (kW)	% Losses
F9	21/12/2004	378	2724	2353	14	0.6%
F13	26/01/2005	279	2013	1672	7	0.4%
F19	24/03/2005	208	1501	1182	1	0.1%
F20	16/03/2005	230	1655	1329	3	0.2%

Table 3
 Losses at Feeder Peak Loading – 27,600 V

Tables 4 and 5 show the equivalent energy and associated losses for a 24 hour period related to the peak power in tables 2 and 3.

Feeder	Date	Max Avg 3-Ph Current (Amps)	Apparent Power (kVA)	Load (kWh)	Losses (kWh)	% Losses
F9	21/12/2004	378	2724	45990	2451	5.3%
F13	26/01/2005	279	2013	33414	1412	4.2%
F19	24/03/2005	208	1501	24364	665	2.7%
F20	16/03/2005	230	1655	27083	889	3.3%

Table 4
 Losses for 24 Hour Period - Feeder Peak Loading – 4,160 V

Feeder	Date	Max Avg 3-Ph Current (Amps)	Apparent Power (kVA)	Load (kWh)	Losses (kWh)	% Losses
F9	21/12/2004	378	2724	47589	247	0.5%
F13	26/01/2005	279	2013	34110	118	0.3%
F19	24/03/2005	208	1501	24410	25	0.1%
F20	16/03/2005	230	1655	27325	53	0.2%

Table 5
 Losses for 24 Hour Period - Feeder Peak Loading – 27,600 V

The savings to be gained from converting from 4,160 V to 27,600V can be arrived at by finding the difference in losses in the above table pairs. These savings are shown in Tables 6 and 7.

Feeder	Date	Max Avg 3-Ph Current (Amps)	Apparent Power (kVA)	4 kV Load (kW)	Losses Saved (kW)	% Losses
F9	21/12/2004	378	2724	2258	117	5.2%
F13	26/01/2005	279	2013	1626	68	4.2%
F19	24/03/2005	208	1501	1171	33	2.8%
F20	16/03/2005	230	1655	1308	43	3.3%

Table 6
 Losses Saved at Feeder Peak Loading

Feeder	Date	Max Avg 3-Ph Current (Amps)	Apparent Power (kVA)	4 kV Load (kWh)	Losses Saved (kWh)	% Losses
F9	21/12/2004	378	2724	45990	2205	4.8%
F13	26/01/2005	279	2013	33414	1295	3.9%
F19	24/03/2005	208	1501	24364	640	2.6%
F20	16/03/2005	230	1655	27083	836	3.1%

Table 7
 Losses Saved for 24 Hour Period

Annual Savings

Determining annual savings for each of the feeders based on the results of the above analysis is problematic given that only one point in time is analyzed. Although each feeder shows a significant loss reduction, an assessment of where each feeder's load fits in the annual load pattern would need to be performed to make an accurate determination of annual benefits. However, consistent with Report 1, using 75% of the above loss savings at the current residential rate of \$0.05/kWh provides the annual savings in Table 8.

Feeder	Losses Saved (kWh)	Savings @ \$0.05/kWh
F9	603,512	\$ 30,176
F13	354,377	\$ 17,719
F19	175,101	\$ 8,755
F20	228,968	\$ 11,448

Table 8
Annual Savings Based on 75% Average Loss Reduction and \$0.05/kWh

Other Benefits of Voltage Conversion

The energy loss savings outlined in the above analysis will provide savings to the customers of Lakefront Utilities Inc. through a reduction in the losses added to their energy bills. In addition, there are other benefits, both monetary and in service quality to be gained from converting from 4,160 V to 27,600 supply.

The additional benefits are:

- **An improvement in the feeder voltage profile.** In the 4,160 V feeders, the high line currents cause a voltage drop as the current flows through the line from the substation to the end customers. This requires that the voltage at the station be raised above nominal to ensure the end of line customers receive adequate voltage. The lower current in the converted line results in minimal voltage drop thereby providing all customers with voltages closer to nominal. This reduces the number of voltage complaints that require response. In addition, future investments to overcome voltage related problems associated with increased load can be avoided.

- **A reduction in demand charges.** The reduced load at peak times will result in lower demand charges to Lakefront Utilities thereby contributing to the reduction of the rates to their customers.
- **A reduction in capital assets.** The conversion of feeders to 27,600 V eliminates the need for the 44 kV to 4,160 V substations. This reduces maintenance expenses, depreciation and taxes. Properties released by the elimination of the 4,160 V substations can be sold.

Purchase of more efficient distribution transformers. The analysis and modeling of the voltage conversion of Feeder F9 did not include changes to the efficiency of the distribution transformers. All distribution transformers were modeled with the same loss characteristics for both the 4,160 V and 27,600 V scenarios. When purchasing transformers to implement the voltage conversion, Lakefront Utilities has the opportunity to purchase more efficient transformers. The reduction in system losses as a result of this action will be in addition to those identified in the studies.

Conclusion

Under Lakefront Utilities direction, the results of January 21, 2005 report *Conversion of F9 from 4,160 V to 27,600 V, Distribution System Loss Assessment* were used to successfully extrapolate losses and loss reductions for feeders F13, F19 and F20. Using the same assumptions as those used in the first report, estimates of dollar benefits associated with loss reductions were determined.

The load range for feeders F4, F5, F14 and F15 is below the range of loads in the F9 model. Therefore applying the F9 model to these feeders would produce invalid results. Feeders F13, F19 and F20 have measured loads that fall within the range of the F9 model. Based on the judgement of Lakefront Utilities that the feeders share similar characteristics with F9, the application of the F9 model to these feeders shows a significant loss reduction through voltage conversion.

Although each of the three feeders F13, F19 and F20, have loads at the low end of the F9 model range, the model produces energy loss savings from 600 kWh to 1300 kWh over the 24 hour periods studied. This is from 2.6% to 3.9% of the energy delivered.

Determining annual savings for each of the feeders based on the results of the above analysis is problematic given that only one point in time is analyzed. An assessment of where each feeder's load fits in the annual load pattern would need to be performed to make an accurate determination of annual benefits. However, using 50% of the above loss savings at the current residential rate of \$0.05/kWh provides the annual savings of \$25,000 for the three feeders.

Recommendations

Based on the result of this study, it is recommended that:

- A review be performed of the annual system load shape to assess the 75% factor used to derive the annual loss savings in Table 8.
- Feeders F4, F5, F14 and F15 not be modeled for voltage conversion alone. These feeders have load currents of one-half to one-quarter those in the F9 model with proportionately insufficient annual savings to justifying the effort involved.
- For those feeders that are not converted to 27,600 V or where conversion is delayed, other loss reduction techniques should be modeled on a selective basis, to pursue, for example, power factor correction for large customers, load balancing between phases, re-conductoring and a review of open points.
- The effects of customer demand management and demand response programs on distribution system losses should be identified modeled and documented.

Appendix 1 – 4,160 V System Information

From: Dale Dingwall [mailto:DDingwall@lusi.on.ca]
Sent: March 15, 2005 4:41 PM
To: Roger Ryan (E-mail)
Subject: Cobourg 4.16kV feeders

Have been having trouble with load study but here is some stats.

Feeder	phase	customer count	NOTES
F5		217	abut like feeder 9
F9		360	feeder we studied
F13		173	abut like feeder 9
F14		284	abut like feeder 9
F15		83	heavy on 3 phase for condos, small and light business
F19		627	heavy on residential and smaller commercial with few light medium like restaurants
F20		845	heavy on residential and smaller commercial like variety stores
total		2589	same as feeder 9

I am working on 1 day loads per feeder and phase

<<F13rwb0105.xls>> <<feeder a9RWB amps.xls>>

Dale Dingwall, C.E.T.,
Technical Services Supervisor,
Lakefront Utility Services Inc.,
207 Division St.,
Cobourg, ON
K9A 4L3
905-372-2193 p
905-372-2581 f

Appendix 2 – 4,160 V Feeder Loading

Feeder F4

Time	R	W	B	Hour	Max	kVA
					28	199
					Avg	
07/04/2005 8:05	21	22	33	8	25	
07/04/2005 9:05	28	27	27	9	27	
07/04/2005 10:05	20	21	28	10	23	
07/04/2005 11:05	22	24	26	11	24	
07/04/2005 12:05	25	27	29	12	27	
07/04/2005 13:05	23	24	28	13	25	
07/04/2005 14:05	25	29	29	14	28	
07/04/2005 15:05	24	25	28	15	26	
07/04/2005 16:05	23	22	26	16	24	
07/04/2005 17:05	21	23	25	17	23	
07/04/2005 18:05	19	20	24	18	21	
07/04/2005 19:05	20	22	28	19	23	
07/04/2005 20:05	19	22	25	20	22	
07/04/2005 21:05	20	21	23	21	21	
07/04/2005 22:05	18	20	22	22	20	
07/04/2005 23:05	15	19	16	23	17	
08/04/2005 0:05	16	17	18	0	17	
08/04/2005 1:05	17	19	23	1	20	
08/04/2005 2:05	16	15	18	2	16	
08/04/2005 3:05	16	16	17	3	16	
08/04/2005 4:05	16	16	19	4	17	
08/04/2005 5:05	15	16	20	5	17	
08/04/2005 6:05	18	19	24	6	20	
08/04/2005 7:05	18	20	24	7	21	

Feeder F5

Time	R	W	B	Hour	Max kVA	
					118	850
					Avg	
06/04/2005 8:15	63	181	105	8	116	
06/04/2005 9:15	62	179	105	9	115	
06/04/2005 10:15	67	178	109	10	118	
06/04/2005 11:15	62	169	103	11	111	
06/04/2005 12:15	61	162	104	12	109	
06/04/2005 13:15	58	164	95	13	106	
06/04/2005 14:15	61	149	96	14	102	
06/04/2005 15:15	57	154	100	15	104	
06/04/2005 16:15	62	153	96	16	104	
06/04/2005 17:15	66	180	97	17	114	
06/04/2005 18:15	58	165	93	18	105	
06/04/2005 19:15	54	156	82	19	97	
06/04/2005 20:15	64	175	98	20	112	
06/04/2005 21:15	69	184	97	21	117	
06/04/2005 22:15	65	176	96	22	112	
06/04/2005 23:15	61	157	92	23	103	
07/04/2005 0:15	60	145	84	0	96	
07/04/2005 1:15	53	137	75	1	88	
07/04/2005 2:15	54	125	71	2	83	
07/04/2005 3:15	54	122	69	3	82	
07/04/2005 4:15	54	131	71	4	85	
07/04/2005 5:15	54	142	77	5	91	
07/04/2005 6:15	57	139	76	6	91	
07/04/2005 7:15	61	164	94	7	106	

Feeder F9

Time	R	W	B	Hour	Avg	Max	kVA
						378	2724
21/12/2004 14:15	303	252	305	14	287		
21/12/2004 15:15	310	266	303	15	293		
21/12/2004 16:15	360	312	348	16	340		
21/12/2004 17:15	396	335	398	17	376		
21/12/2004 18:15	419	324	391	18	378		
21/12/2004 19:15	388	317	378	19	361		
21/12/2004 20:15	358	309	373	20	347		
21/12/2004 21:15	356	292	347	21	332		
21/12/2004 22:15	339	270	324	22	311		
21/12/2004 23:15	302	256	291	23	283		
22/12/2004 0:15	273	240	269	0	261		
22/12/2004 1:15	257	224	251	1	244		
22/12/2004 2:15	248	216	239	2	234		
22/12/2004 3:15	244	214	241	3	233		
22/12/2004 4:15	255	215	239	4	236		
22/12/2004 5:15	254	217	249	5	240		
22/12/2004 6:15	273	229	263	6	255		
22/12/2004 7:15	293	240	282	7	272		
22/12/2004 8:15	320	252	306	8	293		
22/12/2004 9:15	323	279	321	9	308		
22/12/2004 10:15	332	292	336	10	320		
22/12/2004 11:15	343	294	338	11	325		
22/12/2004 12:15	340	283	342	12	322		
22/12/2004 13:15	343	290	344	13	326		
22/12/2004 14:15	341	276	327	14	315		
22/12/2004 15:15	329	276	325	15	310		
22/12/2004 16:15	354	291	336	16	327		
22/12/2004 17:15	383	315	375	17	358		
22/12/2004 18:15	372	324	374	18	357		
22/12/2004 19:15	369	312	363	19	348		
22/12/2004 20:15	348	294	360	20	334		
22/12/2004 21:15	338	278	331	21	316		
22/12/2004 22:15	327	269	308	22	301		
22/12/2004 23:15	292	240	271	23	268		
23/12/2004 0:15	265	225	263	0	251		
23/12/2004 1:15	250	224	243	1	239		
23/12/2004 2:15	235	210	237	2	227		
23/12/2004 3:15	234	205	241	3	227		

Feeder Voltage Conversion Loss Assessment
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Lakefront Utilities Inc.

23/12/2004 4:15	240	211	236	4	229
23/12/2004 5:15	255	217	250	5	241
23/12/2004 6:15	280	228	254	6	254
23/12/2004 7:15	286	235	273	7	265
23/12/2004 8:15	306	262	313	8	294

Feeder F13

Time	R	W	B	Hour	Max kVA	
					279	2013
					Avg	
25/01/2005 11:12	245	339	228	11	271	
25/01/2005 12:12	259	325	218	12	267	
25/01/2005 13:12	259	332	225	13	272	
25/01/2005 14:12	251	298	227	14	259	
25/01/2005 15:12	247	314	218	15	260	
25/01/2005 16:12	253	321	208	16	261	
25/01/2005 17:12	259	326	215	17	267	
25/01/2005 18:12	250	311	219	18	260	
25/01/2005 19:12	238	302	219	19	253	
25/01/2005 20:12	238	282	228	20	249	
25/01/2005 21:12	224	265	213	21	234	
25/01/2005 22:12	209	254	205	22	223	
25/01/2005 23:12	195	246	181	23	207	
26/01/2005 0:12	190	236	160	0	195	
26/01/2005 1:12	173	237	161	1	190	
26/01/2005 2:12	173	228	166	2	189	
26/01/2005 3:12	176	223	166	3	188	
26/01/2005 4:12	183	223	159	4	188	
26/01/2005 5:12	174	232	165	5	190	
26/01/2005 6:12	181	246	174	6	200	
26/01/2005 7:12	218	282	206	7	235	
26/01/2005 8:12	228	302	217	8	249	
26/01/2005 9:12	263	335	240	9	279	
26/01/2005 10:12	257	330	243	10	277	

Feeder 14

Time	R	W	B	Hour	Max kVA	
					41	295
					Avg	
27/01/2005 7:43	21	39	39	7	33	
27/01/2005 8:43	25	41	49	8	38	
27/01/2005 9:43	26	47	50	9	41	
27/01/2005 10:43	22	46	48	10	39	
27/01/2005 11:43	20	50	44	11	38	
27/01/2005 12:43	21	47	45	12	38	
27/01/2005 13:43	22	45	44	13	37	
27/01/2005 14:43	24	43	39	14	35	
27/01/2005 15:43	24	45	42	15	37	
27/01/2005 16:43	24	49	44	16	39	
27/01/2005 17:43	21	42	47	17	37	
27/01/2005 18:43	24	44	44	18	37	
27/01/2005 19:43	22	39	36	19	32	
27/01/2005 20:43	21	39	40	20	33	
27/01/2005 21:43	23	38	39	21	33	
27/01/2005 22:43	21	36	34	22	30	
27/01/2005 23:43	21	32	38	23	30	
28/01/2005 0:43	16	28	34	0	26	
28/01/2005 1:43	19	35	34	1	29	
28/01/2005 2:43	19	32	34	2	28	
28/01/2005 3:43	19	30	39	3	29	
28/01/2005 4:43	18	27	30	4	25	
28/01/2005 5:43	19	31	33	5	28	
28/01/2005 6:43	18	34	37	6	30	
28/01/2005 7:43	20	34	40	7	31	

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Feeder F15

Date	R	W	B	Hour	Max kVA	
					113	817
					Avg	
3/3/04 10:15	71	90	146	10	102	
3/3/04 11:15	78	96	149	11	108	
3/3/04 12:15	83	99	158	12	113	
3/3/04 13:15	73	92	141	13	102	
3/3/04 14:15	73	91	143	14	102	
3/3/04 15:15	70	88	138	15	99	
3/3/04 16:15	74	88	144	16	102	
3/3/04 17:15	74	90	139	17	101	
3/3/04 18:15	80	83	138	18	100	
3/3/04 19:14	81	86	139	19	102	
3/3/04 20:14	76	83	131	20	97	
3/3/04 21:14	78	81	119	21	93	
03/03/2004 22:14	73	80	123	22	92	
03/03/2004 23:14	70	74	115	23	86	
04/03/2004 0:14	66	73	109	0	83	
04/03/2004 1:14	62	71	104	1	79	
04/03/2004 2:15	62	68	102	2	77	
04/03/2004 3:15	64	73	105	3	81	
04/03/2004 4:15	62	75	101	4	79	
04/03/2004 5:16	63	71	104	5	79	
04/03/2004 6:16	63	75	108	6	82	
04/03/2004 7:16	68	83	116	7	89	
04/03/2004 8:16	69	88	122	8	93	

Feeder F19

	Time	R	W	B	Hour	Avg	Max kVA	
							208	1501
24/03/2005 6:55	182	215	191	6	196			
24/03/2005 7:55	183	218	181	7	194			
24/03/2005 8:55	176	215	173	8	188			
24/03/2005 9:55	187	200	172	9	186			
24/03/2005 10:55	171	196	164	10	177			
24/03/2005 11:55	159	182	162	11	168			
24/03/2005 12:55	158	175	148	12	160			
24/03/2005 13:55	164	177	160	13	167			
24/03/2005 14:55	151	192	155	14	166			
24/03/2005 15:55	180	198	165	15	181			
24/03/2005 16:55	169	213	177	16	186			
24/03/2005 17:55	187	233	205	17	208			
24/03/2005 18:55	179	212	201	18	197			
24/03/2005 19:55	168	228	185	19	194			
24/03/2005 20:55	167	205	179	20	184			
24/03/2005 21:55	150	197	159	21	169			
24/03/2005 22:55	126	165	137	22	143			
24/03/2005 23:55	116	166	118	23	133			
25/03/2005 0:55	119	157	117	0	131			
25/03/2005 1:55	112	152	114	1	126			
25/03/2005 2:55	116	155	115	2	129			
25/03/2005 3:55	120	159	126	3	135			
25/03/2005 4:55	129	172	125	4	142			
25/03/2005 5:55	135	178	144	5	152			
25/03/2005 6:55	149	168	152	6	156			
25/03/2005 7:55	167	191	176	7	178			
25/03/2005 8:55	179	223	190	8	197			
25/03/2005 9:55	179	216	209	9	201			
25/03/2005 10:55	189	209	201	10	200			
25/03/2005 11:55	172	213	191	11	192			
25/03/2005 12:55	155	196	170	12	174			
25/03/2005 13:55	149	207	173	13	176			
25/03/2005 14:55	144	183	160	14	162			
25/03/2005 15:55	163	208	180	15	184			
25/03/2005 16:55	157	193	178	16	176			
25/03/2005 17:55	163	227	201	17	197			
25/03/2005 18:55	171	217	190	18	193			
25/03/2005 19:55	161	218	185	19	188			

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25/03/2005 20:55	148	208	166	20	174
25/03/2005 21:55	146	195	151	21	164
25/03/2005 22:55	129	176	131	22	145
25/03/2005 23:55	121	174	129	23	141
26/03/2005 0:55	112	154	114	0	127
26/03/2005 1:55	114	151	123	1	129
26/03/2005 2:55	116	169	117	2	134
26/03/2005 3:55	117	166	125	3	136
26/03/2005 4:55	126	176	131	4	144
26/03/2005 5:55	128	180	145	5	151
26/03/2005 6:55	142	183	171	6	165
26/03/2005 7:55	170	216	171	7	186
26/03/2005 8:55	160	210	178	8	183
26/03/2005 9:55	147	203	168	9	173
26/03/2005 10:55	137	209	184	10	177
26/03/2005 11:55	145	198	169	11	171
26/03/2005 12:55	142	188	156	12	162
26/03/2005 13:55	140	176	153	13	156
26/03/2005 14:55	135	192	146	14	158
26/03/2005 15:55	155	202	149	15	169
26/03/2005 16:55	159	202	176	16	179
26/03/2005 17:55	176	210	182	17	189
26/03/2005 18:55	179	230	176	18	195
26/03/2005 19:55	175	219	187	19	194
26/03/2005 20:55	162	205	176	20	181
26/03/2005 21:55	155	208	158	21	174
26/03/2005 22:55	137	175	147	22	153
26/03/2005 23:55	126	164	132	23	141
27/03/2005 0:55	130	165	116	0	137
27/03/2005 1:55	119	165	116	1	133
27/03/2005 2:55	125	156	116	2	132
27/03/2005 3:55	117	160	126	3	134
27/03/2005 4:55	126	171	132	4	143
27/03/2005 5:55	133	170	137	5	147
27/03/2005 6:55	138	175	154	6	156
27/03/2005 7:55	145	199	177	7	174
27/03/2005 8:55	158	207	171	8	179
27/03/2005 9:55	153	220	163	9	179
27/03/2005 10:55	149	205	186	10	180
27/03/2005 11:55	155	216	183	11	185
27/03/2005 12:55	146	196	171	12	171
27/03/2005 13:55	139	175	157	13	157

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27/03/2005 14:55	144	186	160	14	163
27/03/2005 15:55	149	210	171	15	177
27/03/2005 16:55	151	219	179	16	183
27/03/2005 17:55	154	212	183	17	183
27/03/2005 18:55	177	212	178	18	189
27/03/2005 19:55	152	199	173	19	175
27/03/2005 20:55	150	199	158	20	169
27/03/2005 21:55	130	173	135	21	146
27/03/2005 22:55	111	144	122	22	126
27/03/2005 23:55	106	134	116	23	119
28/03/2005 0:55	104	136	107	0	116
28/03/2005 1:55	101	145	108	1	118
28/03/2005 2:55	105	139	107	2	117
28/03/2005 3:55	105	141	111	3	119
28/03/2005 4:55	122	161	126	4	136
28/03/2005 5:55	139	169	137	5	148
28/03/2005 6:55	153	199	159	6	170
28/03/2005 7:55	160	207	179	7	182
28/03/2005 8:55	183	227	195	8	202
28/03/2005 9:55	174	233	202	9	203
28/03/2005 10:55	174	224	193	10	197
28/03/2005 11:55	167	222	198	11	196
28/03/2005 12:55	171	199	171	12	180
28/03/2005 13:55	176	210	182	13	189
28/03/2005 14:55	168	205	184	14	186
28/03/2005 15:55	179	227	204	15	203
28/03/2005 16:55	177	229	207	16	204
28/03/2005 17:55	179	225	193	17	199
28/03/2005 18:55	175	231	202	18	203
28/03/2005 19:55	173	213	183	19	190
28/03/2005 20:55	169	201	167	20	179
28/03/2005 21:55	131	178	142	21	150
28/03/2005 22:55	120	152	117	22	130
28/03/2005 23:55	112	137	114	23	121
29/03/2005 0:55	110	142	108	0	120
29/03/2005 1:55	107	130	105	1	114
29/03/2005 2:55	101	136	102	2	113
29/03/2005 3:55	106	144	112	3	121
29/03/2005 4:55	126	164	119	4	136
29/03/2005 5:55	142	177	137	5	152
29/03/2005 6:55	160	206	164	6	177

Feeder F20

Time	R	W	B	Hour	Max kVA	
					230	1655
					Avg	
16/03/2005 13:15	120	158	199	13	159	
16/03/2005 14:15	130	166	182	14	159	
16/03/2005 15:15	116	159	180	15	152	
16/03/2005 16:15	137	193	193	16	174	
16/03/2005 17:15	139	221	228	17	196	
16/03/2005 18:15	158	231	267	18	219	
16/03/2005 19:15	174	240	275	19	230	
16/03/2005 20:15	171	225	272	20	223	
16/03/2005 21:15	162	226	257	21	215	
16/03/2005 22:15	145	210	230	22	195	
16/03/2005 23:15	131	187	207	23	175	
17/03/2005 0:15	114	151	177	0	147	
17/03/2005 1:15	108	146	172	1	142	
17/03/2005 2:15	107	156	167	2	143	
17/03/2005 3:15	108	157	163	3	143	
17/03/2005 4:15	107	164	174	4	148	
17/03/2005 5:15	106	169	175	5	150	
17/03/2005 6:15	138	174	203	6	172	
17/03/2005 7:15	132	189	221	7	181	
17/03/2005 8:15	140	199	224	8	188	
17/03/2005 9:15	145	192	219	9	185	
17/03/2005 10:15	137	192	213	10	181	
17/03/2005 11:15	148	185	214	11	182	
17/03/2005 12:15	134	179	203	12	172	
17/03/2005 13:15	134	179	192	13	168	
17/03/2005 14:15	135	167	192	14	165	
17/03/2005 15:15	132	182	186	15	167	
17/03/2005 16:15	156	212	214	16	194	
17/03/2005 17:15	159	235	250	17	215	
17/03/2005 18:15	163	242	258	18	221	
17/03/2005 19:15	162	237	267	19	222	
17/03/2005 20:15	157	250	270	20	226	
17/03/2005 21:15	165	234	247	21	215	
17/03/2005 22:15	141	215	246	22	201	
17/03/2005 23:15	125	181	200	23	169	
18/03/2005 0:15	126	158	179	0	154	
18/03/2005 1:15	107	149	173	1	143	
18/03/2005 2:15	106	158	172	2	145	

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18/03/2005 3:15	120	151	166	3	146
18/03/2005 4:15	114	163	174	4	150
18/03/2005 5:15	125	161	181	5	156
18/03/2005 6:15	131	162	202	6	165
18/03/2005 7:15	134	169	209	7	171
18/03/2005 8:15	131	189	214	8	178
18/03/2005 9:15	145	189	200	9	178

Appendix 3 – F9 Model Regression Analysis

Regression Analysis

Format

m	b
SE	SEb
R^2	SEv
F	df
SSreg	SSresid

4 kV kW Load

0.888567902	-162.41299
0.011811129	26.937731
0.999646753	13.08185
5659.764909	2
968582.7304	342.2696

4 kV kW Losses

0.07952665	-85.198822
0.005499125	12.541896
0.990527635	6.0907582
209.1405022	2
7758.555329	74.194671

28 kV kW Load

0.957687082	-255.83579
0.009026677	20.587211
0.999822352	9.9978279
11256.19031	2
1125130.087	199.91312

28 kV kW Losses

0.010323875	-14.091068
0.000902915	2.0592844
0.984932389	1.0000564
130.7350397	2
130.7497746	2.0002254

4 kV 24 Hour Load kWh

17.69050569	-2191.8779
0.082122778	187.29804
0.999956902	90.958098
46403.76677	2
383915790.2	16546.751

**4 kV 24 Hour Losses
kWh**

1.46118261	-1528.545
0.099438136	226.7893
0.990822533	110.13636
215.9250545	2
2619174.715	24260.035

28 kV 24 Hour Load kWh

18.96049122	-4051.6588
0.451608397	1029.9867
0.998866654	500.19546
1762.686803	2
441016308	500391

**28 kV 24 Hour Losses
kWh**

0.18104633	-246.55614
0.018546331	42.298757
0.979443649	20.54167
95.29353083	2
40210.07955	843.92045