RV Campground Power Distribution (Ontario)

RV Campgrounds across North America suffer from a few common ailments

- **Low Voltage Conditions.**
- **Large Voltage Swings.**
- **Circuit Breaker trips in Hot weather.**
- **Not enough amperage available to drive all your goodies.**
- **Power at the hookup not as advertised by the Campground.**

The Bad News:

There is not much you can do to improve the situation. Moving to another campground is not really an option as it is probably just as bad.

The Good News:

This document will explain what is happening, and hopefully arm you with the knowledge and tools to protect yourself and your equipment.

RV Campground Power Distribution (Ontario)

Table of Contents

1) Purpose Of This Document

The purpose of this document is to provide information that pertains to the issues encountered by campers in some of Ontario's RV Campgrounds. This is information is aimed at the camper so that he can understand what is happening on his site and act accordingly. Campground Management should also benefit from this information and bear in mind the principles outlined here when expanding or renovating their power grid.

Note: Most of the attachments and technical information were gleaned from the internet with references to the site they came from.

2) Short History Lesson

Today's site hydro demand has skyrocketed since the early days when hydro was first installed into campgrounds Now we have A/C Units, Microwaves, Toasters, Toaster Ovens, Coffee Makers, Sewing Machines, TV's, VCR's DVD Players, Electric Fireplaces, Dishwashers. Most of these were still in the dream stage when the hydro circuits were installed in some of these RV Campgrounds, and as such the grid was not designed to handle this type of load.

The rules have changed regarding the design of circuits required to feed these sites. CSA came up with a set of rules they called the **Canadian Electrical Code in 1927 .** The new 2015 version will be the 23 **edition.** These rules were in the guise of a suggestion and had no teeth. The Ontario Electrical Safety Authority came into being in 1999 with a mandate from the Ontario Government. The OESA make the laws in Ontario regarding electrical matters and decreed that the rules as laid out in the Canadian Electrical Code would be the law of the land in Ontario and called them the **Ontario Electrical Safety Code**.

The Ontario Government also decreed that the Association of Professional Engineers of Ontario would have sole jurisdiction regarding Professional Engineering matters in Ontario, and only a member in good standing with the appropriate license could perform professional engineering duties. Along came the Association Of Certified Engineering Technician and Technologists(OACETT) and the rules changed again. Certified Engineering Technicians and Technologists were empowered to perform professional engineering duties under the auspices of a professional engineer.

The result of all this is that there is now a set of rules in place that outline what can or cannot be done with hydro electric circuits and who is allowed to design and implement these circuits.

Unfortunately these rules are often ignored for many possible reasons, In many cases the grid was in place long before the rules, however any modifications or changes must conform to the rules.

3) The Symptoms

1) Typical issues experienced by campers include.

1. Flickering of lights when the refrigerator starts
   - This is a result of Voltage Drop in the feeder cable when the motor starts up. A typical ac motor will draw 10 times it normal operating current when it starts, dropping the line voltage, causing the lights to flicker

.

2. Toaster oven and/or Coffee Maker take longer to cook.
   - These are straight resistive load devices and are not harmed by the lower voltage, however the Ohms Law formula comes into play here. V=IR (I=V/R). As the voltage drops, the current in the heater element drops. Heat is generated in the heater element as the current passes thru the resistive wire of the heater element.

3. Some appliances, especially newer ones with switching power supplies have unexplained shutdowns.
   - The switching power supplies in newer appliances have over voltage and under voltage protective shutdown circuitry. The shutdown trigger varies but 100V is common.

4. Cannot run multiple appliances at the same time (ie: A/C and Microwave) without tripping the main circuit breaker.
   - This is a Voltage Drop issue. These devices are Power dependent and the formula becomes P=IV (I=P/V). The Current in the circuit increases as the voltage goes down, and more current passes through the circuit breaker than would normally happen. A/C units draw more current after they start as the pressure generated by the compressor builds up and the compressor has to work harder. The circuit breaker is also affected by ambient temperature. See item 5.

5. Circuit breaker trips more often in hot weather.
   - Circuit breakers have two elements, One of which is a temperature sensitive bimetallic strip that heats up and trips the circuit. The ambient temperature at the circuit breaker affects the trip point. The hotter the breaker, the lower the current at which it will trip.

6. Air conditioner starts and runs a few minutes, stops but won't restart. Compressor just hums.
   - The compressor builds up pressure as it runs. When it stops and then restarts. It must start up against the pressure and draws much more current from the circuit. That current may not be available with long runs of undersized cable.

7. My refrigerator failed this year. It's only 5 years old.
    - Electric Motors are sensitive to low voltage and can be damaged below 106V

8. Voltage varies by as much as 22 Volts, based on park occupancy, and/or time of day.
    - Grid loading is involved here. The main park voltage during the week, may be as high as 127V. As people come into the park for the weekend and start loading the grid, which is not designed to handle the load, the voltage available to each site may drop as low as 106V. The voltage **SHOULD** not drop below 106V

9. Campers Protect Yourself – If you don't have one, buy a multimeter(Volt Meter) and monitor the voltage at your site. If you see the voltage drop below 106V turn off your A/C Unit and/or anything else that uses a motor.
    - **Canadian Tire sells a Line Monitor for just under $30.00. This device displays, the Voltage, and Frequency of the Line, and Current(Amps) and Watts for any device plugged into it.**
    - **Failure to follow this advise may be costly.**

4) The Issues and General Notes

1) Voltage Drop:

Voltage drop describes how the supplied energy of a voltage source is reduced as electric current moves through the passive elements (elements that do not supply voltage) of an electrical circuit. Voltage drops across internal resistances of the source, across conductors, across contacts, and across connectors are undesired; supplied energy is lost (dissipated).

For example, an electric space heater may have a resistance of ten ohms, and the wires which supply it may have a resistance of 0.2 ohms, about 2% of the total circuit resistance. This means that approximately 2% of the supplied voltage is lost in the wire itself. Excessive voltage drop may result in unsatisfactory operation of, and damage to, electrical and electronic equipment.

http://en.wikipedia.org/wiki/Voltage_drop

2) Campgrounds typically advertise 20A, 30A and 50A circuits, but due to the structure of the distribution system, cannot always provide this to the site, especially to systems that were put into place over 30 year ago. A few years back we were put on a meter. Prior to this we were not allowed to use A/C Units. This grid is now severely overloaded as more and more A/C units come on line during the hot weather.

3) Even today some park owners still use #10 wire regardless of the distance. I hope this document provides some insight into what is actually happening out there in the campground. I don't expect any dramatic changes as the expense of bringing everything up to code would be astronomically expensive. However I would hope that new circuits would take some of this data into account.

4) Voltage fluctuations measured on 4 July 2014 (Friday) At noon, the park was lightly inhabited. During the rest of the day campers were coming in for the weekend, and loading down the grid. The lowest voltage reading was at 17:50(5:50pm) dinner time. Ambient temperature was on the cool side around 25°C

Time	Voltage
11:53	*127.8*
15:20	*123.9*
15:45	*120.3*
17:50	*107.8*
18:45	*121.6*
19:50	*119.8*

5) The Rules per The Canadian Electrical Code(Very Similar to the American NEC)

1. Both the American National Electrical Code and the Canadian Electrical Code specify a maximum feeder voltage drop of 3% and a branch circuit voltage drop of 3 % with a combined voltage drop of 5%.
2. A circuit with a 30A circuit breaker should supply 80% of the circuit breaker rating= 24A to the site appliances with only a 5% voltage drop = 6V. IE: 120V, 24A should provide 114V at 24A to the site appliances.

3. A circuit with a 50A circuit breaker should supply 80% of the circuit breaker rating= 40A to the site appliances with only a 5% voltage drop = 6V. IE: 120V, 24a should provide 114V at 40A to the site Appliances.

4. A typical Site Circuit(30A) is comprised of
   - a Circuit Breaker located in a wood clad enclosure
   - #10 wire located underground
   - Wire is terminated on a 30A Socket mounted on a post at the site
   - #10 Cable above ground from the post into the trailer distribution panel.
   - #14 wire from a circuit breaker to the various receptacles and lights in the trailer

6) Specifying cable length and size for an underground circuit is an Engineering Design Function and requires a Professional Engineer or Certified Engineering Technologist. I suspect that this little requirement regularly gets ignored and the local electrician just goes about doing what has always done. See Attachment 13 on Professional Engineering

7) Most loads can be classified as either Resistive or Inductive.
   - Resistive loads like light bulbs, heaters, coffee makers, toasters etc. are not generally damaged by low voltage. Resistive loads tend to draw less current(Amps) as the voltage goes down. Ohms Law applies to Resistive circuits (V=IR, or I = V/R)
   - Inductive loads like AC Motors (Refrigerators, A/C Units, and device with a transformer) can be damaged when the voltage drops below 106V and tend to draw more current(Amps) as the voltage goes down. The formula applicable with Inductive Loads is P=IV or I=P/V or P=IZ, $P=E^2Z$ Where Z is the impedance of the load.

8) This report deals mainly with Voltage Drop in long runs of power cable. It has been my personal experience in Industrial Plants, that local electricians have no concept of voltage drop.

9) This issue of low voltage and voltage drop seems to be a common occurrence in campgrounds across the Province. See Attachment 10

10) The Acceptable voltage range according to Hydro One is as Follows (See Attachment 7)
1. Normal Limits 110 to 125
2. Exceptional Limits 106 to 110 & 125 to 127

11) #10 wire seems to be a common wire used to feed sites in my Park. The remainder of this report deals with the theoretical and observed effects for a circuit that has a 30A Circuit Breaker, and ~400ft of #10 Wire.
1. #10 is good for 40A, according to the CEC Table D3 on Attachment 6.
2. However Table D3 also indicates that it is only good for 40A to 3.9M at 1% VD
3. and 3.9*3=11.7M (38Ft) at 3%VD.
4. It works for 24A to 6.2M at 1% VD and 6.2M*3=18.6M(61Ft) at 3%.

Distance	Amps (5%) #10	Amps (10%) #10	Amps (5%) #8	Amp s (10%) #8	Amps (5%) #6	Amps (10%) #6	Amps (5%) #4	Amps (10%) #4
100Ft	25A	##	##	##	##	##	##	##
200Ft	12.5A	25A	19.23A	38.46	##	##	##	##
300Ft	8.33A	16.67A	12.82A	25.64A	20.41A	40.81	32.25	##
400Ft	**6.25A**	**12.5A**	**9.61A**	**19.23A**	**15.30**	**30.61A**	**24.19**	##

Amperage available at various cable selections
Indicates that the wire can handle more current than the circuit breaker allows.

12) I suspect that this 400ft run is an exception rather than a common occurrence, so here are the parameters for some other lengths for a 30A 120v circuit of #10 (CEC Table D3)
A) 100 Ft = 30.4 M , 30.4/3 = 10.1, Use 9.6 on Table =16A, Calculator = 15A
B) 200 Ft = 60.96M, 60.96/3 = 20.3, Use 19.4 on Table = 8A, Calculator =7.5A
C) 300 Ft = 91.44M, 91.44/3 = 30.5, Use 31 on Table = 5A, Calculator = 5A

Voltage Drop from the software calculator for these lengths for 24A is as follows
A) 5.76VD, 4.8% OK
B) 9.6VD, 9.6% Should Use #6
C) 17.3VD, 14.4% Should Use #4

Note: In all my years in factory electrical work, I have never seen an electrical inspector test for voltage drop.

5) Interpretations

A) The Branch Circuit is defined as the Circuit from the Trailer Circuit Breaker Panel to the end load ie: duplex receptacle
B) Feeder Circuit is the circuit from the line side of the circuit breaker in the main distribution panel, to the trailer circuit breaker panel.

6) Electrical Authority

1) Ontario Electrical Safety Authority – The legal entity that governs electrical construction in Ontario
2) Ontario Electrical Safety Code – The Law in Ontario
3) Canadian Electrical Code - A set of Rules on paper created by the Canadian Standards Association\ (CSA) and adopted into law by the Ontario Safety Authority
4) Hydro One
5) Association of Professional Engineers of Ontario (APEO) – The Legal Authority that governs Engineering Work in Ontario.
6) Association of Certified Engineering Technicians and Technologists (OACETT). Allowed to do engineering work under the auspices of a Professional Engineer.

7) ESA Electrical Safety Code

The Electrical Safety Authority is designated by Ontario Regulation 89/99 as the responsible authority for purposes of section 113 of the Electricity Act, 1998 and regulations made thereunder. The only such regulation is Ontario Regulation 164/99 as amended by Ontario Regulation 10/02. **This regulation adopts, by reference, the Canadian Electrical Code together with specific Ontario amendments and is referred to as the Ontario Electrical Safety Code (the OESC)**.

The **Ontario Electrical Safety Code** is primarily a technical document and it is prescriptive in approach. The OESC describes the standards for electrical installations in detail.

Risk associated with technical compliance can be decreased by taking appropriate measures to ensure that those who perform e**lectrical work are qualified, competent and appropriately certified or licensed.**

The Code is developed through the efforts of a number of committees representing electrical expertise and knowledge from across Canada and the U.S. The Ontario Electrical Safety Code is law in Ontario, and as such defines the legal requirements for safe electrical installations and products/equipment in Ontario. To ensure that the Code reflects changes in technologies, and responds to reports of electrical incidents, the Code is updated every three years. Changes to the Code are documented on an ongoing basis.

Ref: http://www.esasafe.com/about-esa/governance-and-regs/electrical-safety-code

8) Canadian Electrical Code - Rule 8 – 102 Summary

(see Attachment 5)

Rule 8-102 -1
1) Maximum voltage drop in a branch circuit is 3%
2) Maximum voltage drop in a feeder circuit is 3%
3) Maximum voltage drop in a combined feeder and branch circuit is 5%

Rule 8-102 -2
Load is unknown so the the voltage drop is calculated at 80% of the
Circuit Breaker Rating = 24A for a 30A breaker at 120V.

This means that he voltage can only drop by 6V at the load device, using the 5% rule.

CEC Table D3 for #10 Copper at 25Amps with 1% Voltage drop has maximum distance of 6.2 Meters. At 3% = 6.2*3=18.6 Meters and at 5% 6.2*5= 31 Meters. (101.7 ft)
(Ref:Attachment 6 - CEC Table D3)

To meet CEC Code requirements the Trailer Circuit breaker should be within 18.6 Meters (61 Feet) of the Circuit breaker in the Main Distribution Panel with #10 wire. 3% = 18.6M

9) Measurements

- The load used was an oil filled heater with three settings (Low, Medium, High)
- Measurements and resultant calculations are performed using the starting point no load voltage as the master with the understanding that the no load voltage fluctuates during the measurement cycle.
  Meter Readings with - Vellerman and Metex Multimeters

(Westwood Current Probe used on Metex Multimeter)

Stage	No Load Volts	Vellerman Multimeter Volts	Line Monitor Volts	Metex Multimeter Amps	Line Monitor Amps	VD Measured	VD Calc'd	VD %	Dst Calc to xfmr
Low	120	112.1	112.1	5.6	5.5	7.9	5	6.60	577.8
Medium	120	111.6	111.5	6.1	6.08	8.5	5.5	7.08	560.0
High	120	104.8	104.9	10.8	10.84	15.2	10.8	12.60	566.0

(Supposition) It is possible that the line feeding the transformer is not sufficient to handle the load imposed by the transformer and the voltage fluctuations on the input(voltage drop), affect the voltage coming out.

The variations of distance could indicate that the line feeding the transformer may not be sufficient, and there is a voltage fluctuation into the transformer affecting the output.(This is strictly supposition.)

The Load is a ceramic header (Thursday Morning with few people in the Park)
Using Chart Recorder

	Amps	Volts	VDrop	Vdrop %
No Load	0	124.96	0	0
Ramp	7.0	115.63	9.33	7.4%
Up to	8.75	113.77	11.19	8.9%
High	9.625	111.90	13.06	10.5%
	11.375	110.04	14.92	11.9%
	12.250	108.17	16.79	13.5%

Sample Software Calculation – Solve for Voltage Drop

V=104.8V, A=10.8A, VD= 120-104.8=15.2V

Software Calculator = VD = 10.36V,

Readings Taken at the Post (Length reduced from 400 Ft to 300 Ft for Calculator)

No Load Volts	Load Volts	Amps	VD Measured	VD Software Calculated	% VD
121.3	113.2	8.46	8.1	6	6.70%
121.3	118.3	2.68	3	2	2.50%

Readings for a New Toaster Oven – T-Fal (400 Ft)

No Load V	Load V	Amps	VD-Actual	VD-Actual%	VD-Calc
116V	105.8V	10.7A	10.2V	8.70%	10.27

VD-Calc is obtained by plugging Amps,Length into a software calculator.

10) Miscellaneous Appliance Readings/Tests

1) Test of Appliance Amperage

Device	Volts(Off)	Volts(On)	Amps	VDrop		Vdrop Calculated	Meters Calc'd
Coffee Maker	122.4	115.2	5.38	7.2		4.8	538
Toaster Oven	122.5	114.1	6.36	8.4		5.7	531
Microwave	121.1	106.8	9.46	14.3		8.5	608

11) Test of Low voltage on Microwave

1. Ambient temperature 30 Deg Celsius,
2. Time: 12:30 PM (Noon)
3. No Load Voltage = 110.6V
4. Loaded Voltage = 104.1V
5. Function: Defrost 4 pieces of whole wheat bread.
6. Required: 3 cycles of 30 Seconds at full power.
7. Should take 20 seconds at full power.

12) Circuit Parameters – Test Circuit

(1) Test Circuit with Reading taken at Site hydro Post

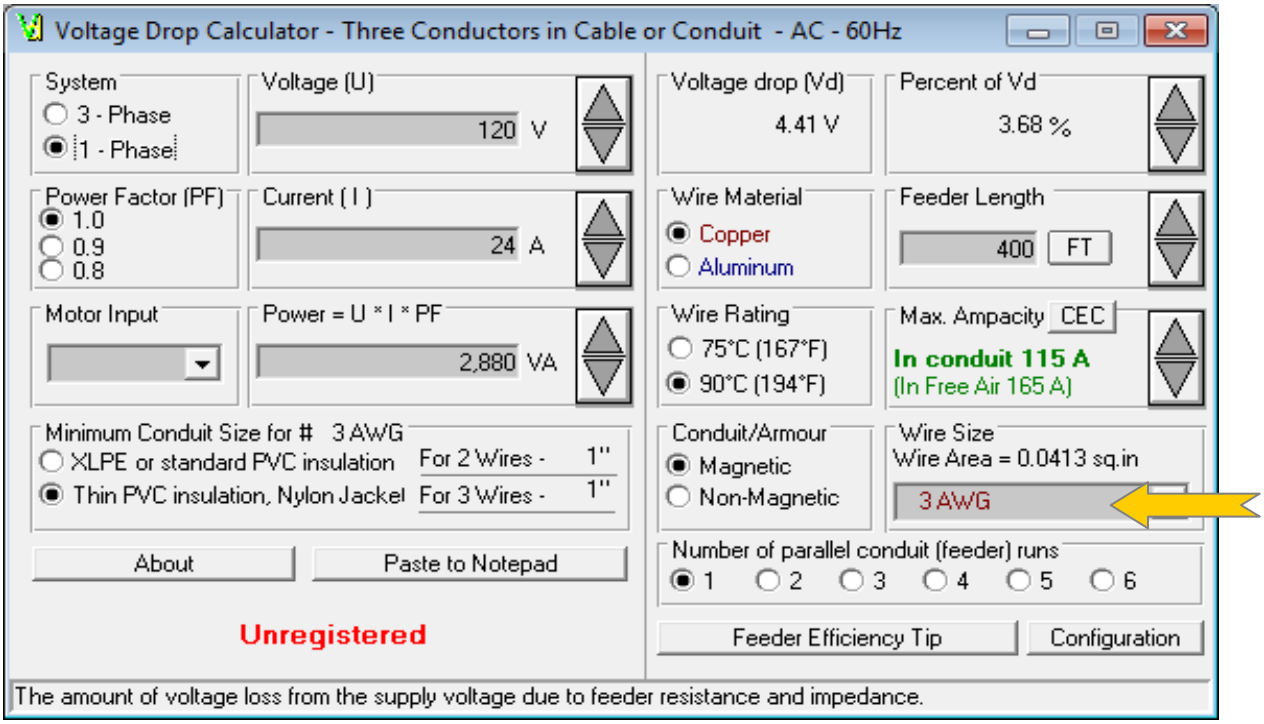
1. Our Theoretical Power Circuit is comprised of the following.
   C) Transformer to Main Panel Circuit Breaker = 25Ft Unknown Wire Size
   D) Main Distribution Panel (MDP) to Site Post = 320Ft of #10
   E) Post to Trailer Circuit Breaker Panel (TCBP) = 40Ft of #10
   F) TCBP to Device = 20Ft of #14
   G) For Software Calculations the joint Feeder and Branch Circuit are 400Ft of #10

Readings	Calculated
Voltage(No Load) = 121.3	*Voltage Drop = 8.1*
Voltage (Under Load) = 113.2	
Current(Amps) = 8.46	

Note: Item A is common to all sites and will add limited unpredictable results int the circuit test results.

13) Software Calculations

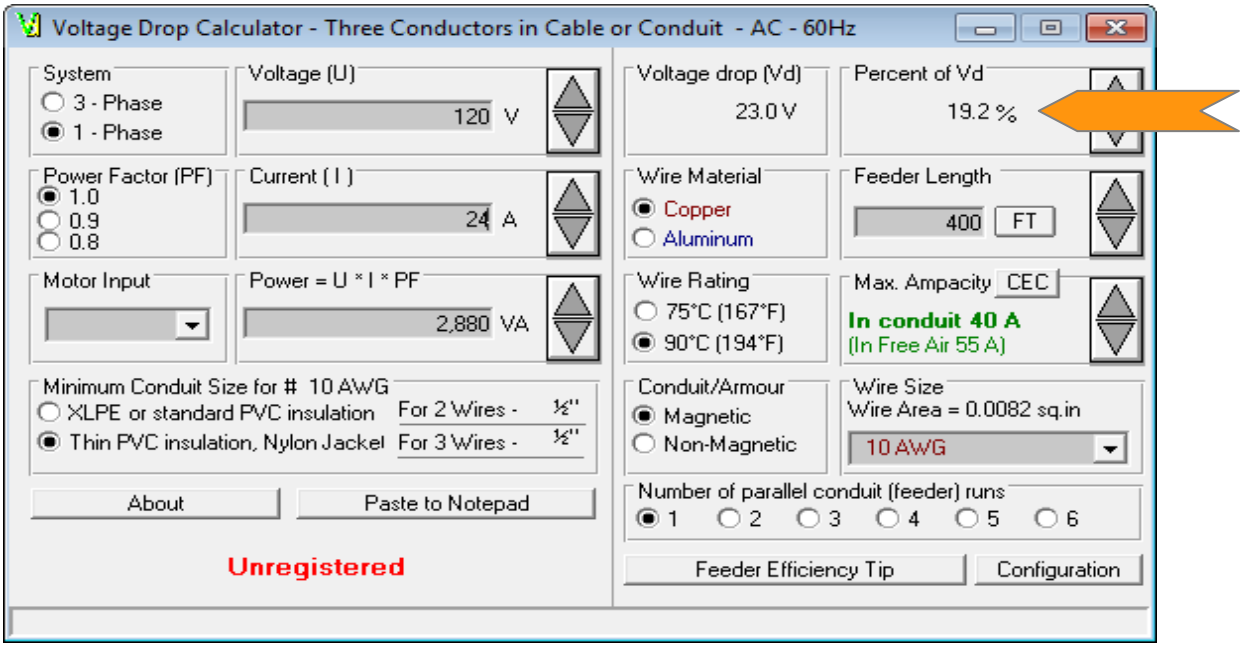
(1) Solve for Wire Size



Wire Size = #3 for 120V, 24A, 400 Feet

(2) Solve for Voltage Drop

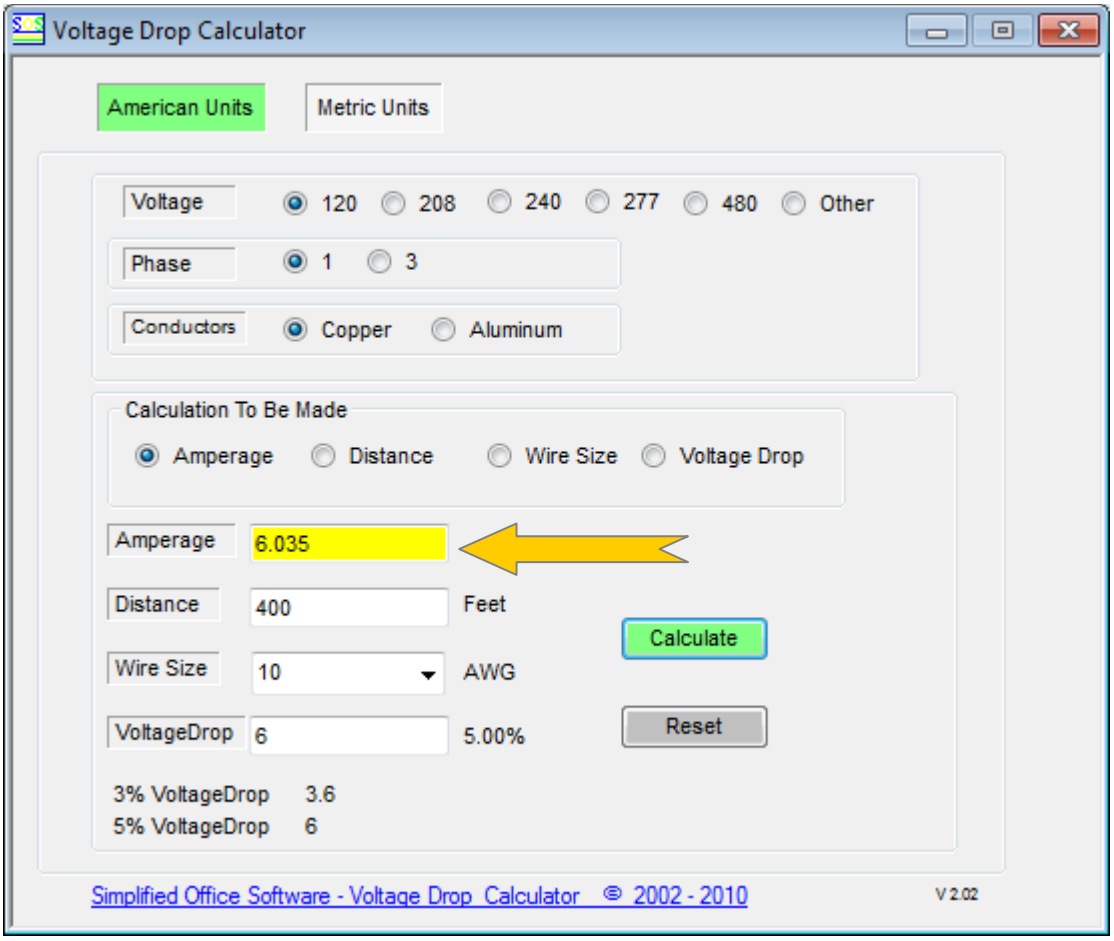
Software calculations are performed using nominal 120V



Voltage Drop = 19.2% for 120V 24A, 400Feet, #10Wire

This software package provides a Feeder Efficiency Tip as follows (Amperage used = 8A instead of the 24A shown above.)

(3) Solve for Available Current – Amps at 5% Voltage drop)



This Software Voltage Drop Calculator indicates a maximum Current of 6.035A at 5% V Drop. Over 400 ft. Of 310 Wire.

14) Limitations imposed on 50A circuits

1. A 50A circuit breaker with unknown load, uses the 80%. This means the voltage drop calculations are done assuming a 40A Load.
2. Feeder Circuit to the post uses the 3% rule, meaning the circuit must handle 40A with a voltage drop of only 3.6 Volts. 120V Feed can drop to 116.4
3. Looking at cable ampacity, 1% VD, CEC Table D3 Appendix
    1. #8 at 40A = 6.2M for 3% 6.2*3 = 18.6M (61 Ft)
    2. # 6 at 40A = 9.8M for 3% 9.8*3 = 29.4M (96.5 Ft)
    3. #4 at 40A = 15.6M for 3% = 15.6*3=46.8M (153.5 Ft)
    4. #3 at 40A = 19.2M for 3% = 19.2*3=57.6M (189 Ft)

Distance	Cable	Amps(5%)	Amps(10%)
100Ft	#8	38.46A	##
200Ft	#8	19.213	38.46
300Ft	#8	12.82	25.64
100Ft	#6	###	###
200Ft	#6	30.61	###
300Ft	#6	20.41	40.81
100Ft	#4	###	###
200Ft	#4	###	###
300Ft	#4	32.25	###

Amperage available at various cable sizes and distances at 120V
Indicates that the wire can carry more than current than the circuit breaker allows.

15) Test Equipment

1) Hioki 8804 Dual Channel Chart Recorder (Professional Grade)
    -Channel 1 Voltage with scaled to convert Peak to RMS(.707)
    -Channel 2 Amps with scaled to convert Peak to RMS(.707)
2) Tektronix A622 AC/DC Current Probe 10ma/Amp (Professional Grade|)
3) Metex Digital Multimeter -365CR with Serial Interface (Professional Grade)
4) Kill A Watt Line Monitor P4400 (Not Professional Grade)
5) Software – Voltage Drop Calculator by Simplified Office Software
6) Software – Voltage Drop Calculator by MC Group Inc – Engineering Software
7) Westword 31 AC Current Probe
8) Vellerman DVM850BL Multimeter

16) Equipment Calibration

None of the Equipment listed above can be traced to any official calibration standard However inter unit calibration checks were performed as follows.

1) Metex Meter = 122.1V	- Line Monitor = 122.1V	Err=0V
2) Metex Meter = 122.1V	- Chart Recorder = 118.4V	Err=3.1V
3) Line Monitor = 10.8A	-Chart Recorder = 10.9A	Err =0.1A

Calibration errors/differences are minor compared to the overall readings and trends.

17) Attachment 1 - Ambient Temperature Influence on Circuit Breakers

(1) E-T-A thermal and thermal-magnetic circuit breakers

To ensure optimum matching of circuit breaker performance to the system requirements, E-T-A thermal and thermal-magnetic circuit breakers are not normally compensated for fluctuations in ambient temperature. The circuit breaker is usually subjected to the same heat source as the system so will automatically track its protective requirements.

However, some applications require the circuit breaker to operate continuously in either high or low temperatures. The following table shows the correction factors that typically should be applied. The performance of magnetic circuit breakers and type 1410 is not affected significantly within this temperature range.

Ambient temperature	°C	-20	-10	0	23	40	50	60
Ambient temperature	°F	-4	14	32	73.4	104	122	140
Multiplication factor		0.76	0.84	0.92	1	1.08	1.16	1.24

Example: I_N = 10 A at +50 °C. By applying t factor of 1.16 the current value obtained is 11.6 A. A 12 A CBE rating is recommended.

Ref: **http://www.e-t-a.com/resources/technical_information/influence_of_temperature/**

A 30A circuit breaker in a panel in the hot sun, could theoretically reach temperatures in the 140+ °F range. A 30A breaker could trip out at 30/1.24=24A

(2) Close mounting of CBEs

When several devices are mounted together, an air gap between each is recommended. If this is not possible, each device should carry only 80 % of its rating.

Horizontal installation is preferable.

Plug-in Mounted E-T-A Devices:

The continuous rating capability of E-T-A sockets for plug-in circuit breakers is a function of the total number of circuit breakers fitted and the individual ratings of each. Please enquire with details of your application.

Ref: **http://www.e-t-a.com/resources/technical_information/influence_of_temperature/**

(3) AMBIENT RERATING CURVES – Square D Circuit Breakers

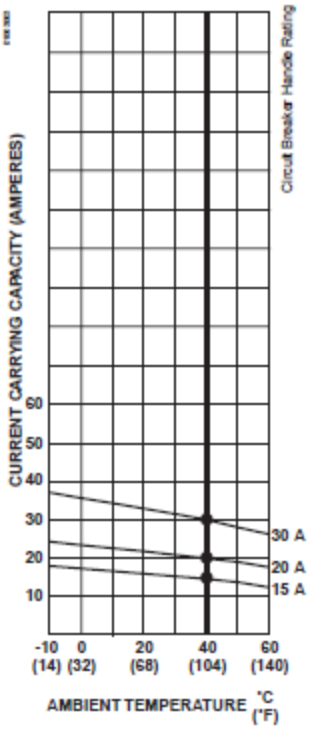


Figure 4: QOT Circuit Breakers

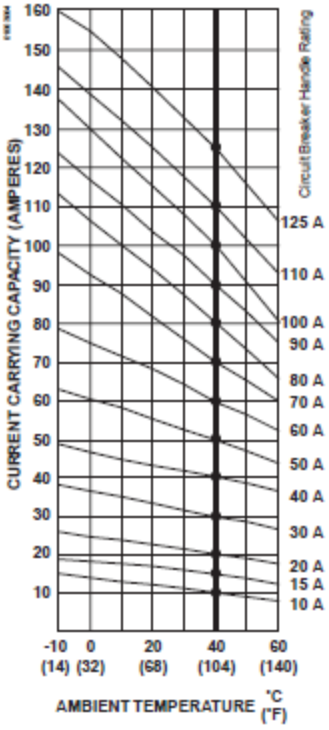


Figure 5: QO, QOB Circuit Breakers

Ref: http://static.schneider-electric.us/docs/Circuit%20Protection/Miniature%20Circuit%20Breakers/0100DB0101.pdf

18) Attachment 2 - Electric Motor Theory

Effects of low voltage. When you subject a motor to voltages below the nameplate rating, some of the motor's characteristics will change slightly and others will change dramatically. To drive a fixed mechanical load connected to the shaft, a motor must draw a fixed amount of power from the line. The amount of power the motor draws has a rough correlation to the voltage 2current (amps). Thus, when voltage gets low, the current must increase to provide the same amount of power. An increase in current is a danger to the motor only if that current exceeds the motor's nameplate current rating. When amps go above the nameplate rating, heat begins to build up in the motor. Without a timely correction, this heat will damage the motor. The more heat and the longer the exposure to it, the more damage to the motor.

For example, a 10% voltage decrease would cause a 10% amperage increase. This would not damage the motor, if the current stays below the nameplate value.

Ref:http://www.motorsanddrives.com/cowern/motorterms12.html

Ref: http://ecmweb.com/design/highs-and-lows-motor-voltage

19) Attachment 3 - Warranty void on inadequate power

An Interesting clause in my new refrigerator warranty.

Frigidaire 17cu Refrigerator with Top Freezer
Ref http://manuals.frigidaire.com/prodinfo_pdf/Anderson/FFHT1725P_1013_EN.pdf

Electrical Specifications
6.0 Amps @ 120 Volts:
Minimum Circuit Required (Amps): 15A
Power Supply Connection Location: Right Rear Bottom
Voltage Rating: 120V, 60Hz

This warranty does not cover the following:
13. Damages caused by: services performed by unauthorized service companies; use of parts other than genuine Electrolux parts or parts obtained from persons other than authorized service companies; or external causes such as abuse, misuse, **inadequate power supply,** accidents, fires, or acts of God.

20) Attachment 4 - Hydro One - Conditions of Service

Hydro One Networks Inc.

Distribution Customers, **Conditions of Service,** May 21, 2013

The Customer is responsible for ensuring that all Customer Equipment complies with all Applicable Laws, including, but not limited to, the Electrical Safety Code and is properly identified and connected for metering and operation purposes. Where applicable, Customer Equipment shall be subject to the reasonable acceptance of Hydro One and the approval of the Electrical Safety Authority. Hydro One's approval of any Customer Equipment is solely for the purposes of Hydro One's protection of the Distribution System. The Customer is solely responsible for protecting its own property.

The Customer shall inspect the Customer Equipment at regular intervals. Clearances must conform to the Electrical Safety Code. The Customer shall repair or replace, in a timely fashion, any Customer Equipment, including, but not limited to, poles and transformer pads, that may affect the safety, integrity or reliability of the Distribution System. If the Customer does not take such action within the time specified by Hydro One, Hydro One may disconnect the supply of power to the Customer. Hydro One's policies and procedures with respect to the disconnection process are further described in these Conditions of Service.

(1) J. Travel Trailer Parks (Intermittent/Seasonal Use)

The park authority/owner will provide, own, and maintain all distribution facilities, including transformers and individual metering as required, within the park boundary. Such facilities will be subject to the approval of the Electrical Safety Authority. All electricity supplied for park services will be combined and billed under one General Service account. If a Secondary Metered Service is not practical, a Primary Metered Service will be required at or near the park property limit.

(2) 1) Park distribution system owned by park owner:

(iv) park owners of privately-owned systems shall meet all the requirements of the Electrical Safety Authority,

Ref:
http://www.hydroone.com/MyHome/MyAccount/ConditionsofService/Documents/Hydro_One_Conditions_of_Service_2013_ENGLISH.pdf

21) Attachment 5 - Canadian Electrical Code – Rule 8-100,102,104

(1) 8-100 Current calculations

When calculating currents that will result from loads, expressed in watts or volt amperes, to be supplied by a low-voltage alternating-current system, the voltage divisors to be used shall be 120, 208, 240, 277, 347, 416, 480, or 600 as applicable.

(2) 8-102 Voltage drop

(1) Voltage drop in an installation shall
(a) be based upon the calculated demand load of the feeder or branch circuit;
(b) not exceed 5% from the supply side of the consumer's service (or equivalent) to the point of utilization; and
(c) not exceed 3% in a feeder or branch circuit.
(2) For the purposes of Subrule (1), the demand load on a branch circuit shall be the connected load, if known; otherwise it shall be 80% of the rating of the overload or overcurrent devices protecting the branch circuit, whichever is smaller.

(3) 8-104 Maximum circuit loading

(1) The ampere rating of a consumer's service, feeder, or branch circuit shall be the ampere rating of the overcurrent device protecting the circuit or the ampacity of the conductors, whichever is less.
(2) The calculated load in a circuit shall not exceed the ampere rating of the circuit.
(3) The calculated load in a consumer's service, feeder, or branch circuit shall be considered a continuous load unless it can be shown that in normal operation it will not persist for
(a) a total of more than 1 h in any two-hour period if the load does not exceed 225 A; or
(b) a total of more than 3 h in any six-hour period if the load exceeds 225 A.
(4) Where a fused switch or circuit breaker is marked for continuous operation at 100% of the ampere rating of its overcurrent devices, the continuous load as determined from the calculated load shall not exceed
(a) 100% of the rating of the circuit where the ampacity of the conductors is based on Column 2, 3, or 4 of Table 2 or 4; or
(b) 85% of the rating of the circuit where the ampacity of the conductors is based on Column 2, 3, or 4 of Table 1 or 3.
(5) Where a fused switch or circuit breaker is marked for continuous operation at 80% of the ampere rating of its overcurrent devices, the continuous load as determined from the calculated load shall not exceed
(a) 80% of the rating of the circuit where the ampacity of the conductors is based on Column 2, 3, or 4 of Table 2 or 4; or
(b) 70% of the rating of the circuit where the ampacity of the conductors is based on Column 2, 3, or 4 of Table 1 or 3.
(6) If other derating factors are applied to reduce the conductor ampacity, the conductor size shall be the greater of that so determined or that determined by Subrule (4) or (5).
(7) Notwithstanding the requirements of Rule 4-004(1)(d) and (2)(d), the ampacity of the underground conductors shall not exceed in any case those determined by Subrules (4)(b) and (5)(b) of this Rule.

Ref: Canadian Electrical Code 2012

22) Attachment 6 - CEC Table D3 – Cable Lengths

TABLE D3
(See Rule 8-102 and Appendix B, Rule 4-004)
DISTANCE TO CENTRE OF DISTRIBUTION FOR A 1 PER CENT DROP IN VOLTAGE ON NOMINAL 120 V, 2-CONDUCTOR COPPER CIRCUITS

Current Amps	Copper Conductor Size in AWG														
	18	16	14	12	10	8	6	4	3	2	1	1/0	2/0	3/0	4/0
	Distance in Metres to Centre of Distribution Measured along the Conductor Run, Calculated for Conductor Temperature of 60°C														
1.00	24.2	38.5	61.4												
1.25	19.4	30.8	49.1												
1.6	15.1	24.1	38.4	61.0											
2.0	12.1	19.3	30.7	48.8											
2.5	9.7	15.4	24.6	39.0	62.0										
3.2	7.6	12.0	19.2	30.5	48.5										
4.0	6.1	9.6	15.3	24.4	38.8	61.7									
5.0	4.8	7.7	12.3	19.5	31.0	49.3									
6.3	3.8	6.1	9.7	15.5	24.6	39.1	62.2								
8.0	3.0	4.8	7.7	12.2	19.4	30.8	49.0								
10.0	2.4	3.9	6.1	9.8	15.5	24.7	39.2	62.4							
12.5		3.1	4.9	7.8	12.4	19.7	31.4	49.9	62.9						
16		2.4	3.8	6.1	9.7	15.4	24.5	39.0	49.1	62.0					
20			3.1	4.9	7.8	12.3	19.6	31.2	39.3	49.6	62.5				
25				3.9	6.2	9.9	15.7	24.9	31.4	39.7	50.0	63.1			
32					4.8	7.7	12.2	19.6	24.6	31.0	39.1	49.3	62.1		
40					3.9	6.2	9.8	15.6	19.7	24.8	31.3	39.4	49.7	62.7	
50						4.9	7.8	12.5	15.7	19.8	25.0	31.5	39.8	50.1	63.2
63						3.9	6.2	9.9	12.5	15.7	19.8	25.0	31.6	39.8	50.2
80						3.1	4.9	7.8	9.8	12.4	15.6	19.7	24.8	31.3	39.5

Maximum Length of #10 Wire at 25A 1%VD = 6.2 Meters (5% = 6.2.*5 = 31 Meters) (101.7 Ft)

23) Attachment 7 - Hydro One Recommended Voltage Variation Limits

CSA Standard CAN3-C235-83 Table 3				
Nominal System Voltages	Recommended Voltage Variation Limits for Circuits ≤1000 volts, at the Service Entrance.			
	Extreme Operating Conditions	Normal Operating Conditions		Extreme Operating Conditions
Single Phase				
120/240	106/212	110/220	125/250	127/254
240	212	220	250	254
480	424	440	500	508
600	530	550	625	635
Three Phase 4 –Wire				
120/208Y	110/190	112/194	125/216	127/220
240/416Y	220/380	224/388	250/432	254/440
277/480Y	245/424	254/440	288/500	293/508
346/600Y	306/530	318/550	360/625	367/635
Three Phase 3 –Wire				
240	212	220	250	254
480	424	440	500	508
600	530	550	625	635

Service Entrance defined as the Trailer distribution panel.

Ref: http://www.biogasassociation.ca/bioExp/images/uploads/documents/NOP-032=Policy_on_Power_Quality.pdf

Normal Operating Voltage Range = 110 to 125 Volts,

Extreme Conditions Voltage Range = 106 to 109 Volts and 126 to 127 Volts

24) Attachment 8 - Effects of Low Voltage – Electric Motors

(1) Electric Motors (Refrigerator)

Effects of low voltage. When you subject a motor to voltages below the nameplate rating, some of the motor's characteristics will change slightly and others will change dramatically. To drive a fixed mechanical load connected to the shaft, a motor must draw a fixed amount of power from the line. The amount of power the motor draws has a rough correlation to the voltage to current (amps). Thus, when voltage gets low, the current must increase to provide the same amount of power. An increase in current is a danger to the motor only if that current exceeds the motor's nameplate current rating. When amps go above the nameplate rating, heat begins to build up in the motor. Without a timely correction, this heat will damage the motor. The more heat and the longer the exposure to it, the more damage to the motor.

Ref: http://ecmweb.com/design/highs-and-lows-motor-voltage

(2) Appliances

The answer is: it depends on the type of appliance, and occasionally the effort that the manufacturer put into protection against those conditions. Modern electronic devices such as PC's or TV's have switching regulators in them that compensate for variable supply voltage. Interestingly, if the supply voltage drops, those devices draw *more* current in order to automatically keep the device's power level constant, unlike non-regulated appliances like incandescent lamps. In extreme conditions, though, **these regulated devices also often have over and undervoltage lockouts to turn themselves off.**

Ref: http://www.newton.dep.anl.gov/askasci/eng99/eng99641.htm

25) Attachment 9 - Lower Than Normal Voltage – Appliance List

A far more common problem than high voltage. Many electrical appliances can be damaged when operated at 104 Volts AC or less.

	What will it do?
Electric Motors	**L**ow **V**oltage means higher amperage. That means more heat, slower running and early failure. **LV** also means that motors with a starting switch (see Air Conditioners below) like washing machines may not reach starter winding cutout speed and this will result in motor damage. Some motors, however, will just run slow and not be damaged. Do you want to risk yours to find out?
Air Conditioners	**LV** = Motors die early as above. Also, compressors (constant horse power loads) will be severely stressed and burn out.
Fluorescent Lamps	**LV** = Constant cycling of circuit board and ballast. That means premature failure.
TV/VCR/etc.	**LV** = Heat = premature failure of components. (And see Power Supplies below.)
Refrigerator	**LV** = Relays fail to operate properly; unit goes into search mode from 120VAC to LP to 12VDC constantly and thoroughly confuses circuit board that, in consequence, fails.
Furnace & Water Heater	**LV** = Slow fan, which = too much heat in furnace enclosure, which destroys circuit board. Water heaters with auto ignition have circuit board that may fail or not operate properly.
Microwave Oven	**LV** = Fan runs slow. Fan cools a magnetron (the cooking element). Hot magnetrons die if run too long in this condition.
Power Supplies	**LV** = Some power supplies will run too hot (switching power supplies); some just won't regulate properly (linear type). Either, if not running properly, are components of and may damage, computer equipment, TVs, VCRs and the like.

Ref: http://kriegerelectric.com/Cautions-RV.html

26) Attachment 10 - Internet Reviews of other Campgrounds in Ontario

(1) Riverside Park Motel and Campground

Very nice location about 15 minutes to the Falls located next to the Niagara River and bike path. Small spots, some seasonal campers, friendly staff. We did have a problem w/the power though on our site where our surge protector shut off frequently due to low voltage when trying to run A/C (less than 105v). Complained to CG staff, but insisted the problem was w/our camper. Luckily, the temps were not too hot and we were able to open the camper up and used the vents.
Ref:http://www.rvparkreviews.com/view_campground_review_details.php?cgid=4090&region=Ontario&city=Niagara-Falls&park=Riverside-Park-Motel-and-Campground

(2) Milton Heights Campground

No 50 amp sites available for our time period so we had to do with 30 amp, but then the power company cut down the voltage to the point that we thought our A/C might be damaged...got to 104.1 volts for an extended period of time. The day before we left the power got to a high of 110 volts.
Ref:http://www.rvparkreviews.com/view_campground_review_details.php?cgid=3364&region=Ontario&city=Milton&park=Milton-Heights-Campground

(3) Sherkston Shores

Electricity in the park was reasonably stable (we run A/C and are sensitive to low voltage) and the voltage didn't drop below 100V.
Ref:http://www.tripadvisor.ca/Hotel_Review-g1514526-d1384822-Reviews-or30-Sherkston_Shores-Sherkston_Ontario.html

(4) Wasaga Pines Family Campground, Wasaga Beach, Ontario

Negatives: Low line Voltage. lowest line voltage of any campground ever stayed in. If that was fixed would go back.

Its a good park except for the fact that the line voltage consistently was in the 105
Ref:http://www.staycanada.ca/19700-wasaga_pines_family_campground_wasaga_beach-details.html

27) Attachment 11 - Qualifications of the Author

Education: Diploma – Electrical Engineering Technology
Degree - BASc in Technology Management

Certification : Certified Engineering Technologist (Electrical Engineering)

Certified By : Ontario Association of Engineering Technicians and Technologists

Experience: 20+ years designing, procuring, and commissioning machine electrical systems, control systems and power distribution (up to 600V 3Ph 1600Amps)

MEMBER
OACETT

28) Attachment 12 - OACETT

(1) Who We Are

The Ontario Association of Certified Engineering Technicians and Technologists (OACETT) is a non-profit, self-governing, professional association of over 24,000 members.

OACETT is Ontario's independent certifying body for engineering and applied science technicians and technologists and confers the designations C.Tech. (Certified Technician) and C.E.T. (Certified Engineering Technologist). These designations are recognized across Canada by employers and other engineering professionals. The A.Sc.T. (Applied Science Technologist) designation is no longer conferred but is still used by some OACETT members.

OACETT promotes the interests of engineering and applied science technicians and technologists in industry, educational institutions, the public and government.

OACETT was incorporated in 1962 and legislated under the Statutes of Ontario by the OACETT Act of 1984. The Act established OACETT as a self-governing body with right to title for its members. Later, the provincial legislature passed the OACETT Act of 1998, a revised act that includes a description of work for technicians and technologists.

Engineering technicians and technologists are part of the engineering team that also consists of engineers, scientists and tradespeople. Each performs an integral part of engineering work.

OACETT is a founding member of Technology Professionals Canada.

(2) Duties of An Electrical Engineering Technologist

In general, electrical engineering technologists work independently or as part of a team with other technologists and engineers to:

- engineer and design power, lighting, control and communications systems in buildings and industrial plants
- engineer and design electrical generation, transmission and distribution systems
- write specifications for electrical installations and equipment
- oversee industrial networks and data communications
- manage electrical energy systems through load flow, power quality and energy management schemes
- prepare project cost estimates from electrical drawings
- manage electrical projects
- write and perform testing and commissioning procedures for electrical installations
- design, install and maintain electrical control systems and industrial automation systems
- test and maintain electrical equipment including switch gear, control circuits, transformers, motors, protective relays, variable speed drives and programmable logic controllers
- use computer software to design, test and control electrical equipment and installations including specialized functions such as distribution system design, fault calculations and relay settings, harmonic analysis and arc flash.

29) Attachment 13 - Professional Engineering

(1) Professional Engineers Act

“practice of professional engineering” means any act of planning, designing, composing, evaluating, advising, reporting, directing or supervising that requires the application of engineering principles and concerns the safeguarding of life, health, property, economic interests, the public welfare or the environment, or the managing of any such act; (“exercice de la profession d’ingénieur”)

No person shall engage in the practice of professional engineering or hold himself, herself or itself out as engaging in the practice of professional engineering unless the person is the holder of a licence, a temporary licence, a provisional licence or a limited licence. R.S.O. 1990, c. P.28, s. 12 (1); 2001, c. 9, Sched. B, s. 11 (16).

Ref: http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90p28_e.htm

(2) Ability to practice Engineering

In all provinces and territories, it is unlawful to practice Professional engineering and hold yourself as a Professional Engineer without a license to practice. However, some provinces provide exemptions allowing certified engineering technologists to practice under certain circumstances.

Ref: http://en.wikipedia.org/wiki/Certified_Engineering_Technologist

Ref: http://www.esasafe.com/assets/files/esaecra/pdf/Guide%20to%20the%20Duties%20and%20Responsibilities%20of%20Licensed%20Electrical%20Contractors%20and%20Master%20Electricians.pdf

30) Attachment 14 - Electrical Contractors/Master Electrician

(1) Electrical Contractors Must Be Licensed

Section 3 of Ontario Regulation 570/05 states that "**No person shall operate an electrical contracting business without an electrical contractor licence issued under this Regulation.**"

The Regulation defines an electrical contracting business as "**a business that is engaged in the carrying out of electrical work" and electrical work "means work within the scope of the Electrical Safety Code that consists of constructing, installing, protecting, maintaining, repairing, extending, altering, connecting or disconnecting any electrical installation or electrical equipment**". Ontario Regulation 570/05, Section 1

(2) Master Electrician - Scope of Practice

A master electrician designated by an electrical contractor is, within the scope of the designation, responsible,
(a) for the personal planning and direct supervision of electrical work carried out on behalf of the electrical contractor;
(b) for ensuring that the electrical work is carried out in accordance with applicable law, including the Electrical Safety Code and the laws relating to health and safety and consumer protection, on behalf of the electrical contractor; and
(c) for other matters of a similar nature

https://www.ceca.org/licensing/docs/JurisdictionalLicensingRequirements-ON.pdf

31) Campground Ratings and Reports

Dos your campground have low voltage, Too much voltage drop. Large swings in voltage at the site.

Send me a note with the details to inet@cogeco.ca

Rate your Campground as follows. (Note

Grade	Description	Comment
1	Voltage Stays at or above 118V at 80% of the circuit breaker Rating.	This meets code requirements
2	Voltage drops but stays at or above 115V	This is just outside the 3% rule
3	Voltage drops but stays at or above 112V	This is NOT acceptable according to the CEC adopted into law in Ontario
4	Voltage drops but stays at or above 106V	This is NOT acceptable according to the CEC adopted into law in Ontario
5	Voltage Drops below 106	This is NOT acceptable according to the CEC adopted into law in Ontario

(1) Camper Reports

Date	Campground	Location	Grade	Report By	Additional Comments
2014/07/12	Mine	Ontario	4	Author	