16 Oct 2013

Re: Overview of battery backup installation, 1909 Franwall

This document outlines the propose battery backup installation at 1909 Franwall Ave.

Two other documents are relevant:

1. dhProposalFigures_10oct2013.pdf : line drawing of current, and proposed, equipment. Also shows switch settings under different useage scenarios
2. houseElectricTable_11oct2013_proposed_ver2c: current circuit layout, and proposed layout

Goals

The goal is to install a 'most of house' battery backup system. The desired features of this system are:

1. Provide "UPS" quality backup for computers and other sensitive electronics, so as to deal with transient (several second) outages
2. Provide backup for critical loads during intermediate length (several hour) outages. This includes the above, and refrigerator, boiler, TVs, and lighting.
3. Provide power to an extended set of loads during extended (more than on day) outages. This includes microwave and toaster oven.
4. Permit use of gasoline generator during extended outages, both to recharge batteries and to provide power to the "extended" set of loads
5. The system will NOT be fully automated. During some conditions, manual intervention is required.
6. Cost control is important, so fully powering the house is not a goal. However, flexible design in conjunction with attentive but not complicated manual intervention, should provide for a robust set of options.

Equipment

Prior decisions based on the above goals means the following equipment is on site and installed

The first 3 items are on site and installed

1. A 60a/30a transfer switch that is installed, with 10 breakers (genTran)
2. A 8 breaker sub-panel hard wired to the genTran (genTranOverflow)
3. 6500w gasoline generator

The following equipment is on site but not installed

4. Four 245 AH 12v batteries, providing up to 11.6 kwh. Of course, actual capacity will be less, as fully draining the batteries should not happen.
5. A Magnum MS4448PAE off grid inverter (the "magnum"). This provides 4400VA continuous power. Surge capacities are (in "true watts"):
    - 5 seconds: 8500w
    - 30 seconds: 6000w

- 5 minutes: 5400w
- 30 minutes: 4800w

6. A bypass switch on the Magnum. When this is engaged, AC power will be sent directly to loads, rather than from the Magnum.
7. A 30a/30a transfer switch (the "magnumXfer")
8. A 30a/30a transfer switch with 4 breakers (the "subCritXfer")
9. A 1kw AC-to-DC charger

Loads

Major loads (such as the AC and stove) will not be part of the battery backup system.

The following is a rough and ready list of loads that may be "battery backed-up" (that will be on circuits that are connected to the Magnum, hence can receive battery power during outages)

- 8 computers at an average of 100w per computer (laptops less, servers more): 800w
- Large TV: 100w
- 15 overhead lights at 30w each (LCD): 450
- Refrigerator at 100w (start up 500w)
- Boiler at 200w (water pump)
- Other electronics (small TV, stereo, game system): 300w

Thus, a very busy house would consume around 2kw. This is well within the design spec of the Magnum.

However, this does not include heating loads, such as the microwave, toaster oven, space heaters, etc. At 1 to 1.5kw each, running several of these simultaneously might overload the the capacity of the Magnum, especially if they were run for a long time (say, cooking with microwave and toaster oven, with a space heater or two warming corners of the house for an hour or so).

One solution is to simply not support (on a battery backed-up circuit) the more common of these loads, in particular the microwave and toaster oven. However, that means that during long outages, you can't use these to easily cook! That is a sad inconvenience.

Hence, my proposal recognizes "extended" (or, "optional") critical loads. These are loads that will typically not be battery backed-up, hence not subject to the capacity constraints of the Magnum.

This is achieved by installing the transfer switch with several breakers (the subCritXfer).

- Critical circuits are connected to the genTran (and the genTranOverflow).
- The genTran receives AC power from the magnum
- Optional critical circuits are connected to the subCritXfer

The subCritXfer has two inputs

1. the main panel,
2. magnumXfer (hence, from the Magnum).

During normal times, “main panel” should be selected – so as to isolate large current draws (such as the microwave) from the Magnum. However, during longer outages the homeowner can switch the subCritXfer to the magnumXfer, and thereby power these convenient (though optional) loads.

Note that the underlying notion is that during outages, the homeowner will be much more cognizant of electrical usage. Thus, he will be aware of what other loads are running if/when he chooses to use one of the “optional” loads (such as the microwave). And, should the Magnum be overdrawn despite this awareness, and cause the Magnum to shutdown, resetting it will be an inconvenience that is part of the outage. Hence such a reset will be much more understandable and tolerable.

Reiterating, the identification and isolation of “optional critical loads” (onto the subCritXfer transfer switch enabled panel) allows for a robust compromise between minimizing the chance of overdrawing the Magnum during the 99% of the time when the grid is up, but simplifying powering convenient loads during longer outages.

Generator usage

During longer (multiple day) outages, the battery pack will be exhausted. Hence, incorporating a generator is useful. Ideally, this generator could both provide power to household loads (including the “optional” critical loads), and charge the batteries. The ability to charge batteries is actually a great convenience during extended outages, it means one can have power 24/7 while running the generator only a fraction of the time. This saves gasoline, reduces noise and pollution, and is easier to manage (less need to keep an eye on the generator, especially during night time hours).

The existing 6500w generator, in combination with the magnumXfer will provide most of this functionality. The magnumXfer's output will be the AC input of the Magnum.
The magnumXfer has two inputs

1. the main panel
2. the generator

Thus, one can select that the Magnum receive AC power from the grid (during normal times), or from a generator (during outages).

Unfortunately, the current 6500w generator (Generac) may not be able to charge batteries. This is because the Magnum monitors quality of power, and will not accept “dirty” AC power (that is of low quality) – hence will not have AC power available to charge batteries. The Generac's AC may be seen as dirty.

To overcome this, the 1kw AC-to-DC charger can be used. It will be plugged into a circuit that is a “critical load”. Typically, it will be unplugged during normal times (since the Magnum is a better DC charger than this standalone charger).

This may be seen as fatally flawed: during outages the AC-to-DC charger will pull power from the Magnum to charge batteries, but the Magnum is pulling power from the batteries. Which just means you run out of battery capacity quicker.

However, during these conditions the bypass switch will be engaged. Thus, the Magnum will be disconnected from the genTran (hence from all loads). AC power will flow directly from the generator (via the magnumXfer) to critical loads , which include this AC-to-DC charger.

Note that the battery discharge rate will be set relatively high: say, 70%. This will extend the length of outages where the generator will not be needed. The tradeoff is some reduction in battery life. Given that the batteries are likely to fail due to age than due to use, such a tradeoff is quite acceptable.

Disengaging

Since the Magnum might fail, and since there may be rare cases where critical circuits would be overloaded, there should be some way of bypassing the Magnum. Two are incorporated into this design

1. The bypass switch can be enabled. This is a 30a breaker, hence 7200w will be available to the critical loads (and the optional critical loads, if the subCritXfer is set to the Magnum).
2. The genTran transfer switch can be set to utility. At 60a, this provides 14.4kw, which should be ample (and is what the house has been using for over 2 years)
    - Note that the Magnum will provide power to the genTran via the 30a "generator" selection. Thus, one can think of the Magnum as being a generator, that is usually preferred to the utility.

This ability to bypass the Magnum is also useful should the Magnum overload, and turn off. Inexperienced residents can simply switch the bypass switch, or if really nervous select the utlility input on the genTran. At a later date, the Magnum could be reset and put back on line (note that it is not difficult to reset the Magnum, as a digital control panel is included).

Issues

The following lists some installation issues.

1. Location. I asked the inspector if the equipment could be place on the walls near the main baker panel. He noted "just be sure to get it permitted". Which either means he doesn't think it would be a code problem, or he doesn't want to think about it at all. For now, it seems that the equipment (batteries, magnum, magnumXfer, and subCritXfer) can be installed near the main breaker (and the inverters).
2. DC grounding. It appears that a separate grounding wire (GEC) is needed for the Magnum, which should be as large as the largest wire in the DC system. That would be the battery to Magnum wire, which is recommended to be 2/0. It also appears that this may be connected to an existing grounding rod (shared with the AC grounding)
    - Assuming the existing grounding rod is used, about 35 feet of 2/0 wire would be needed, as well as a hole in the wall.
    - I have about 30 feet of 4/0 wire! Perhaps that can be used, or traded for a sufficient length of 2/0 wire?
3. An exterior AC disconnect may be required? I suspect that if isn't code now, it will be soon. Hence, I advocate installing one – it will sit in the circuit that connects the Magnum to the 30a input on the genTran.
    - Can one of the two existing conduits, that take power from the Aurora's to the AC disconnect, be used? That would save a lot of trouble.