Thursday, July 12, 2012

Hello Ken and Seth

The following summarizes the findings of our meeting. First I note some miscellaneous stuff, and provide the links you asked for.

Then, I summarize the components of the AC coupling system that were discussed.

And then, I include some descriptive notes. Actually, while writing up these detailed notes I ended up with something that looks like a work order and job description. It's not really meant to be that, since you or your engineering consultant may have better ideas. But I will be using it as a reference.

So, you may want to peruse it. OTOH, it is kind of long.

Note that I included a few small specs not mentioned in our meeting (see (6) – the subpanel/junction box)

Reminder: my goal is to implement an AC coupled solution that more or less follows the summary and notes discussed below, for a net price of $4300 – where "net price" means "an additional $4300 over current system cost". I would prefer to spend $3900, and would accept $4600 if necessary. Above that my willingness to accept drops dramatically.

Miscellany

a) Tilt. Kenergy will tilt the arrays as much as good engineering permits, using standard framing. Note that the 8 panels on the flat roof will be in 2 independent parallel rows (not in a 2 row plane). This allows the back (north ward) row to have a higher tilt.
   As noted in earlier discussions, PV panel placement will attempt to leave 2 feet between panel sides and roof edge.

b) Panels will be divided into 2 sets. Panels will be Helios 260T

   a. The larger set (17 or 19) will be grid-tied, and connected to main circuit breaker panel (CBP).
   b. The small set (8 or 6) will be part of an AC coupling solution.

c) FYI. Here are links to threads on NASW wherein I discuss "batteryization" issues (from newest to oldest)
   a. Sizing your backup: how to judge risk vs cost tradeoffs
   http://www.wind-sun.com/ForumVB/showthread.php?16431-Sizing-your-backup-how-to-judge-risk-vs-cost-tradeoffs

b) Cost effective grid-interactive choices: Outback vs Xantrex vs magnm vs ...
http://www.wind-sun.com/ForumVB/showthread.php?16394-Cost-effective-grid-interactive-choices-Outback-vs-Xantrex-vs-magnm-vs

c) Grid interactive: what benefits make it worthwhile?
http://www.wind-sun.com/ForumVB/showthread.php?16354-Grid-interactive-what-benefits-make-it-worthwhile

AC Coupling Specs

What follows is a summary of specs for the proposed AC coupling setup

1) 6 to 8 panels (260w /panel), 8 preferably
2) 200 AH (at 20 hours) AGM batteries, capable of sustaining c/2.5 surge and 65% DOD
3) A 4500W continuous, 6000W 30 second surge, 240V charger/inverter (OGI) capable of AC coupling,
4) Appropriately sized 240V grid-tie inverter (GTI) (or, possibly, microinverters)
5) A critical loads subpanel, and a simple 240V, 30 amp, transfer switch (GTI transfer switch)
6) If necessary, appropriate dump load controller for a 2000W dump load resistor

Minor specs:

- A breaker, or fault condition on the OGI, to prevent extremely large surges from damaging battery or inverter
- The critical loads subpanel switch could be a junction box, perhaps with breaker
- A 120V medium efficiency 30A battery charger (may not be needed)
- If required, a vented battery case (I could build this myself)
- Battery temperature sensor

Notes

Miscellaneous notes:

The set of 17 to 19 panels that will NOT be part of the AC coupling set will be grid-tied, and wired into the CBP. This may be done through a central inverter or through microinveters. If using a central inverter, they may also use DC optimizers,

I accept whatever decision Kenergy determines is best (in terms of efficiency or cost effectiveness).

Note that Ken's current thinking is to use an Aurora Power One 4.2, with DC optimizers. Ken is also considering checking whether Helios sells a version of the panel with a "DC optimizer" or a "microinverter" built (this may reduce installation costs)

AC coupling notes:

1) PV panels. For 200 AH battery, about 1.5kw of charge is appropriate. Thus, assuming about 300W of constant consumption (during outages), 2kw of PV input should be sufficient. This is about 8 panels. Hence, 8 panels is the preferred number of panels to be included in the AC coupling set. That means 17 panels for the non AC coupled set.
    - Though unlikely, sizing considerations may make it necessary to use only 6 panels.
    - This is acceptable, but **not** preferred.

2) Battery pack. In UPS mode, the battery bank may be called to deliver a surge of 4kw for less than 10 seconds. This will probably be rare (perhaps fewer than 5 times a year).
    - Some slight degradation of battery longevity, from such surges, is acceptable.
    - A substantial hit on stored power (say, 10% reduction in DOD from a 4kw 10 second surge) is acceptable.

    50% DOD is the typical maximum DOD target. However, given that discharges will be infrequent in this system, and the system is undersized for off-grid (outage) situations, deeper discharge is likely to be cost effective. Thus, allow DOD to 65% or so.
    - Up to a 40% reduction in lifespan, due to setting DOD to 65%, is acceptable. For example, from 1000 cycles (at 50% DOD) to 600 cycles (at 65% DOD).

    Note: using 65% DOD is akin to increasing the capacity to 260AH, and using 50% DOD.

    A vented case, with vent to the outside, may be needed for these batteries.
    If possible, I would build this myself.
    Also, a temperature sensor, and possibly a good quality battery monitor.

3) OGI. The OGI is the heart of the AC coupling solution. Thus, it must be rated for such a use. This means:

   a. Built in transfer switch. When no signal is detected from the grid, reverse flow (from PVs to GTI to OGI to CBP hence to grid) is blocked. Conversely, when the grid is healthy, reverse flow is allowed. However, in this proposal this capability for reverse flow (to the grid) will not be utilized (see 6 for details).

   b. At least 4500W continuous power, with at least 6000W of surge. 4000 W continuous, and 5200W 30 second surge, may be acceptable if necessary.

      i. This level of power is meant for use in normal (grid powered) situations. In these situations, all of the critical loads should be used naturally, which may lead to fairly large continuous demand (say, 4kw) and occasionally larger spikes in demand. In contrast, during off-grid situations the critical loads should be used with care: residents will need to be cognizant of power demands.
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      ii. The need for large surge capacity of the battery is due to the possible high loads on this subpanel (during normal times). Though unlikely, there may be a grid event (say, a 2 second outage) while the subpanel is serving a lot of loads (say, 4kw). In this event, the UPS functioning of the OGI will need to draw a lot of power.
         - There may be very rare cases where demand is extremely high (say, 6000W), and a grid event occurs. If this surge level is likely to damage the batteries or other equipment, some kind of fail safe (say, inverter fault or circuit breaker) should be used to protect the battery from damage.

   c. OGI must produce pure sine wave output, sufficiently close to grid output (see 4 below)

   d. The OGI output must be larger then the GTI output (i.e.; GTI output is no more than 80% of OGI output)

   e. Able to allow backflow from the subpanel (coming from the PV panels)

   f. Able to allow this backflow to charge the batteries, probably in an unregulated fashion (see 7 below)

Note: it might be possible to use a 120V OGI that meets the above requirements. However, use of a 120V OGI will require conversion of its output to 240V, or conversion of all other components to 120V (such as the GTI, GTI transfer switch, and critical loads subpanel). And it must provide the minimum outputs noted in (b),

4) GTI The 6-8 PV panels will be connected to a basic grid-tie inverter (GTI).

The GTI will be connected to a transfer switch (GTI transfer switch) which will connect to either:

a. The CBP. When switched to the CPB, the GTI is plain vanilla – it is providing power to household loads and/or the grid.

b. The critical loads subpanel. The OGI also will connect here [See (5) below for further details]. When connected to the critical loads subpanel, the GTI will frequency sync to the OGI (that is why the OGI must be able to provide high quality AC).

Notes;

- In the GTI to CBP setting, PV power to the critical loads follows a path of: PV -> GTI -> GTI transfer switch -> CBP -> OGI -> critical loads subpanel
- Published AC coupled solutions often have the GTI permanently connected to the critical loads subpanel, The proposed transfer switch specification is meant to minimize stress and complications from backfeeding the OGI all the time.

i. In the GTI->CBP setting, the OGI is a UPS; it maintains the battery and is ready to invert if the grid become unstable. No backfed power ever occurs. Battery charging is through the OGI's built in charger.
  - ❖ Since battery charging will be infrequent, a less efficient charger may be acceptable (i.e. use PWM and not MPPT). I suspect this option may not be available on any acceptable OGI

ii. In the GTI-> subpanel setting, the GTI is grid frequency synched to the OGI. When synched, the GTI will deliver any PV power to the subpanel loads. When more power is produced than subpanel loads can use, power from the PVs is backfed through the subpanel to the OGI.
  - ❖ Backfed power can be used to charge the batteries. However, this is an unregulated charge, so battery overcharge precautions are necessary

- One battery overcharge preventive measure is frequency desynching initiated by the OGI when the battery is fully charged. This is the Sunny Boy/Sunny Island solution. Other OGI's advertised as capable of AC coupling do this, but not as dependably. Hence, backups are needed (as described in 7)

- Microinverters: instead of a grid-tied central inverter, these 6-8 panels can use microinverters. Then, the transfer switch will switch the combined AC output from these microinverters.

  These two versions: micro inverters, and GTI, do the same thing: they supply PV generated AC when a proper AC signal can be syncedto. This proper AC signal is typically from the grid, but it can be from the OGI.

In most AC coupling descriptions a GTI is used. However, some report success using microinverters. It is possible that a micro inverter solution is cost effective. If so, and if a microinverter solution can be done code compliantly, use of micro inverters is acceptable.

5) Critical loads subpanel. The critical loads subpanel will connect to the OGI and the GTI.

   When switched here, the GTI is part of the AC coupled solution. The OGI is also connected to the critical loads subpanel. Thus, the GTI will "see" the OGI. And if the GTI can frequency sync to the OGI, it will be induced to provide PV power. That is why the OGI must be able to provide high quality AC.

   The critical load subpanel can either:

   a. Contain breakers serving the critical loads.

   b. Or, preferably, the critical loads subpanel can connect to the main-input of the currently installed generator transfer switch (GTS), which already contains breakers serving the critical loads.
      i. The generator-input of the GTS allows genset supplied power to the critical loads. When this generator=input is chosen, there will be NO connection from the genset the GTI or OGI. See below for further discussion

      ii. Under this option, this critical loads subpanel could be a simple junction box; possibly with a breaker between the line to the GTS switch and the junction of the GTI and OGI lines.

6) Dump load. When power is being backfed into the OGI from PV panels, it will charge the batteries. However, it will not go through the charge controller. Thus, it

will not a controlled charge. If allowed to continue it will overcharge the battery, causing damage. Thus, some way of preventing this overcharging is required.

- As noted above, an elegant way is to modify the frequency of the OGI, thus desyncing with the GTI (or microinverter) panels, which will cause them to stop sending power. This is the Sunny Island/ Sunny Boy solution.
- Other inverter's reportedly do the same, but their implementations may not be listed.

A dump controller provides a solution. It is connected to the batteries, and will shunt power to a dump resistor when the battery is becoming overcharged.

- Use of a dump controller is often required, if only as a backup should the OGI fail to succesfully signal the GTI to stop sending PV power.

Generator issues.

Use of a generator will probably be necessary, especially in longer outages (or if the weather is not sunny). There are a few generator options possible

1) As noted in 5b, if the GTS is utilized, the current genset (or any 240V genset) can be used to power the critical loads.

   However, the genset will not have any direct connection to the batteries. Battery charging is probably the best use of a genset, since it allows sustained draw from the genset for a short period of time.

   One workaround is to have an AC battery charger as one of the critical loads. This will charge the batteries. Since it will not be used frequently, a less efficient PWM charger may be cost effective

2) The OGI may have two AC inputs, or it may be easy to physically switch from grid to generator. While straightforward, this might be problematic.
   a. The OGI must have a "generator mode" that prevents backfeeding to the generator.,

   b. A typical geneset will not provide quality power. If the OGI simply transfers genset power to the critical loads subpanel (that is, the OGI does not attempt to clean the power), the GTI will not be able sync (so no PV power will be available).

   c. An inverter generator should solve this – but to avoid genset problems (a) above is crucial: the OGI must have a generator-input mode that prevents backfeeding of power out of its AC input.

3) If a 120 V generator (such as the Honda 2000EU) is used, the GTS will not be useable. Workarounds include:
    a. Using an auto-transformer to convert 120V genset output to 240V
    b. Connect the 120V genset to a battery charger. Basically, (1) above, but requiring a dedicated line from genset to charger (one could use a good extension cord, but a permanent connection from outside to a receptacle near the batteries would be better.

Solution 2 is the simplest, but is not worth a large expense. In fact, since there are strong odds of my swapping the current loud 240V genset for a 120V Honda, acquiring an AC battery charger might be advisable. That need not happen immediately.