Date: 15-Apr-06	Type: Monthly Report 8270 Appendix	Author: Ib I. Olsen
Subject: DCEC Residential Installation – March 2006		

Installation Summary:

This month the fuel cell only ran uninterrupted for the whole period powering either the battery storage unit or in parallel with the utility. Towards the end of the month we did a thorough measurement of the total installation including the house, plus we interviewed the house owner to understand the flicker problem. We brought the battery storage unit back online and it has been operating since.

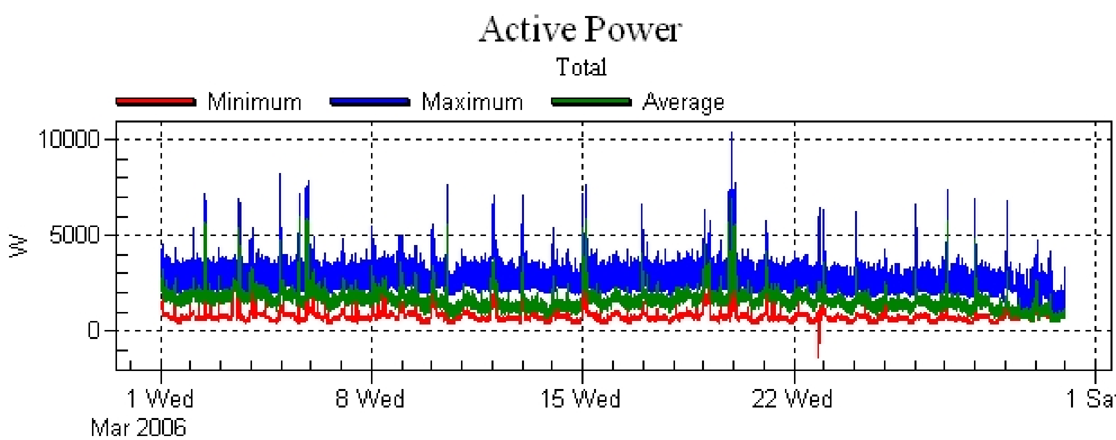

Figure 1: Total system load (Service Entrance). Even without the hot tub the load reached more than 10kW at times.

The light flicker problem turns out to be a very subjective problem, and comes back to the fact that some people can see flicker of a certain frequency, whereas other people cannot see it. In fact the original definition of 'Short Term Flicker' relates to the fraction of the population that can see the flicker, and a PU value of 1 means that 50% of the population can see the flicker. Lower numbers would mean fewer people can see the flicker. It was only after studying the data we get from the house and the site visit we clarified the problem (house owner and Chris Todd from Gaia could see the flicker, whereas Mark from DCEC could not).

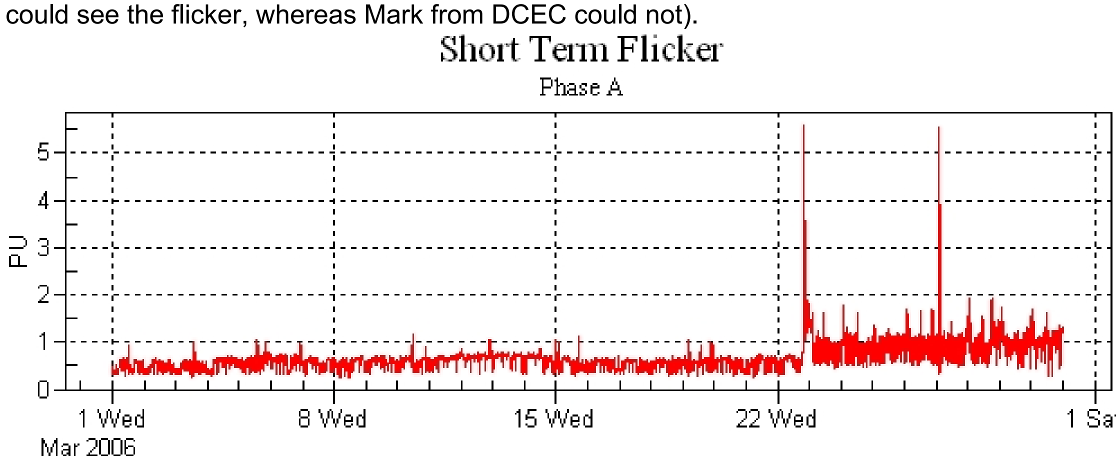

Figure 2: Short term flicker. A PU value above 1 corresponds to more than 50% of the population will notice flicker in an incandescent light bulb.

As it can be seen from Figure 2 the flicker went up significantly after the PowerTower was brought online again March 23rd. Based on IEEE standards P_{st} should be below 1.0 95% of the time, and it is clear that this is not the case for this site. Even with the energy storage unit bypassed the site experience considerable flicker, but with less variation.
We used an oscilloscope to map the AC sine wave at various places in the system. We are currently speculating that the increased flicker is due one of two scenarios: Either it is because the PowerTower oscillate between charge and discharge of the batteries, which changes the output voltage, or it could be due to a compounded effect of using two pseudo-sine wave inverter in series.

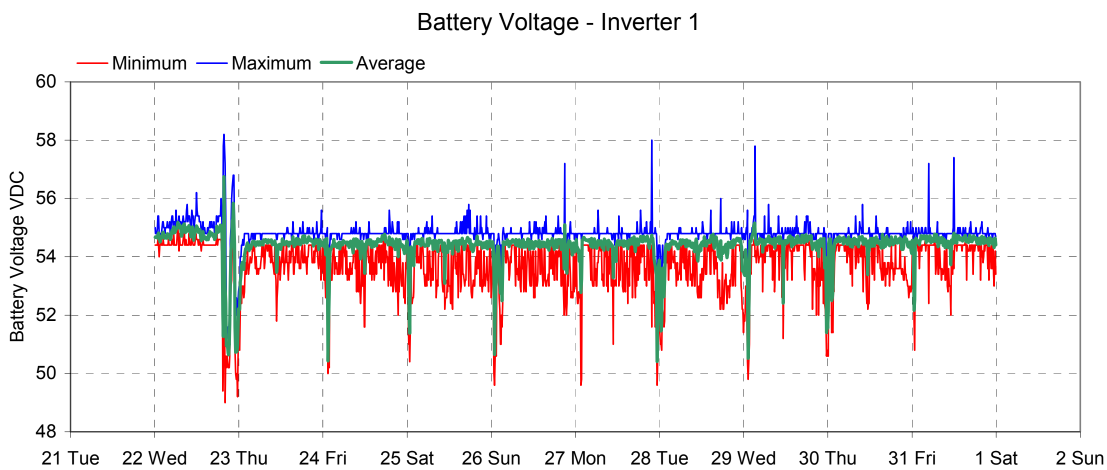

Figure 3: PowerTower battery voltage (Inverter Leg 1)

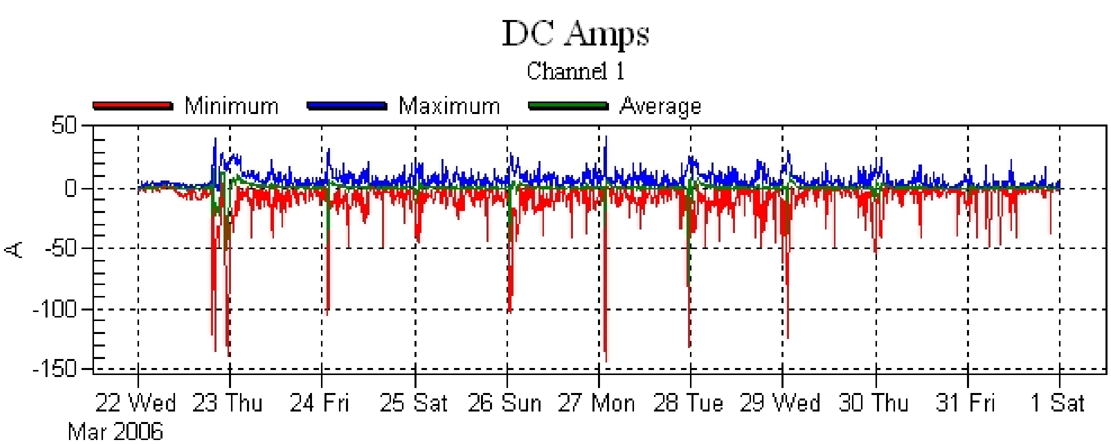

Figure 4: PowerTower battery current (Battery Monitor). Negative current equals discharge and positive equals charge.

As seen in the figures above, the battery voltage fluctuates a lot and the current shifted frequently between discharge and charge. This would indicate that the fuel cell output is relative well matched with the load and the batteries are hardly discharged during normal operation

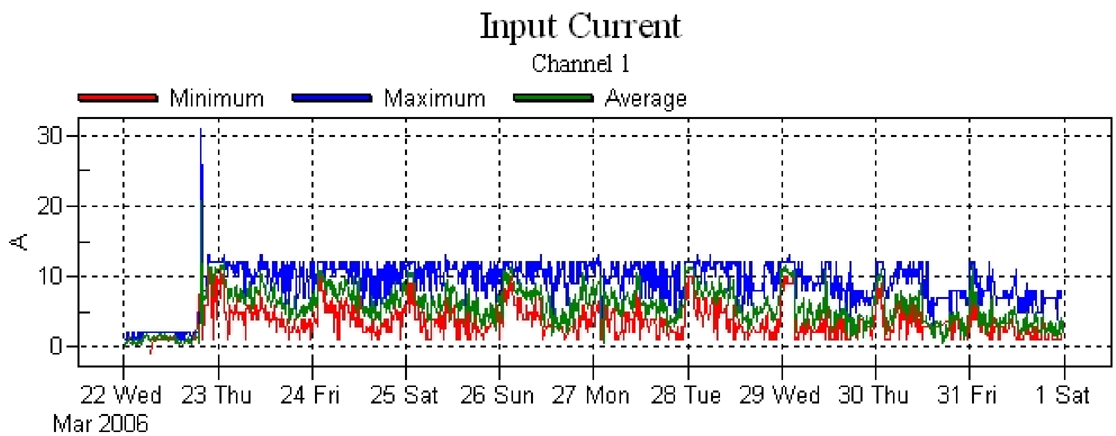

Figure 5: Inverter 1 input current (Inverter Leg 1)

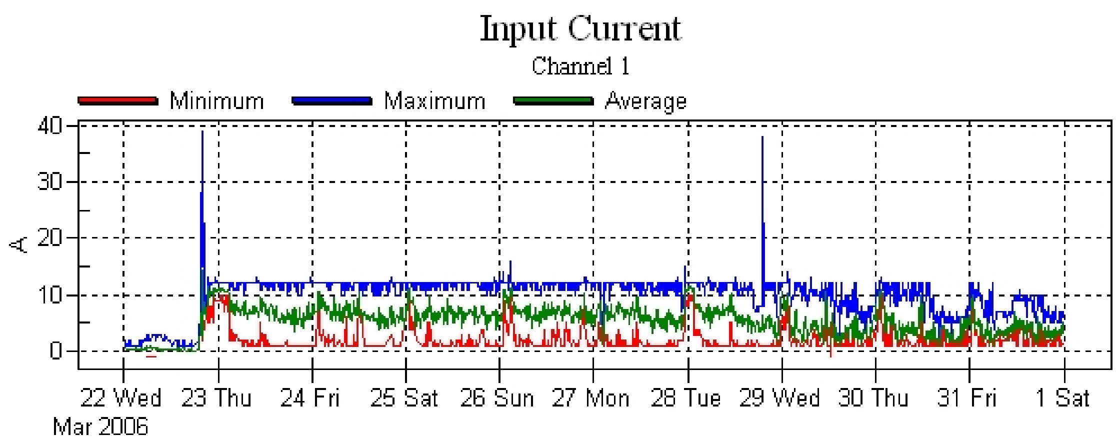

Figure 6: Inverter 2 input current (Inverter Leg 2)

One way to prove if the switching between charge and discharge is the main cause of the flickering would be to prevent the PowerTower from charging during day time or until a given battery voltage has been reached.

As to the compounding effect of two inverters we will see if this is the cause, when we switch from fuel cell to utility power later in the project.

Two other solutions would be to substitute the incandescence light bulbs with fluorescents, LED, or halogen lights, which are less sensitive to voltage fluctuations, or we could use the DC power directly from the fuel cell, which would bypass both the fuel cell inverter and the PowerTower charger.

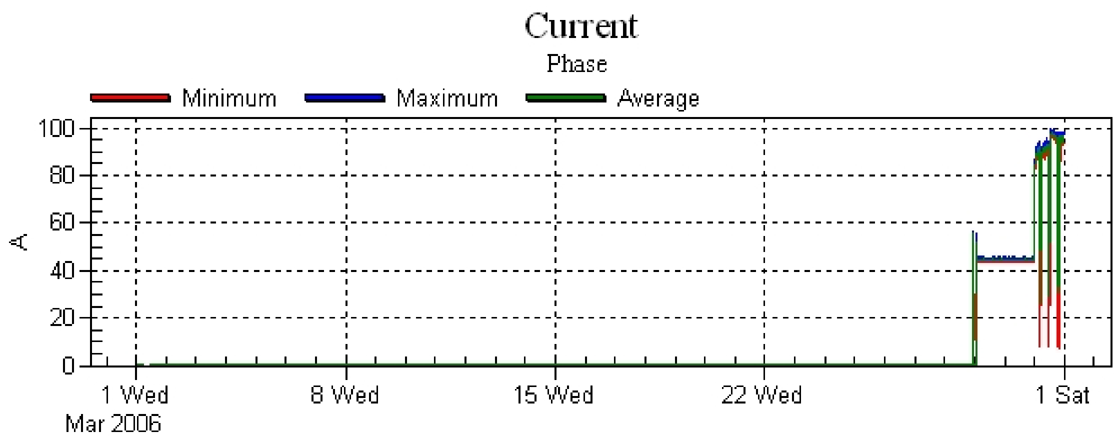

Figure 7: Fuel cell output (PlugPower Fuel Cell). March 1st the fuel cell went off-line and was only brought back on-line March 28th. The battery storage was brought online March 23rd, and it has been adjusting the fuel cell set point in order to match the house load / battery charging needs.

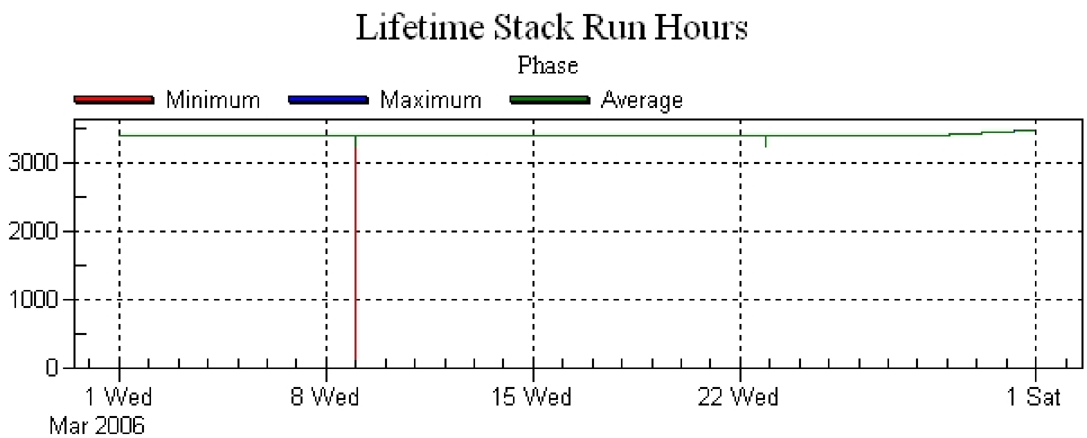

Figure 8: Accumulated run time of fuel cell stack (PlugPower Fuel Cell).

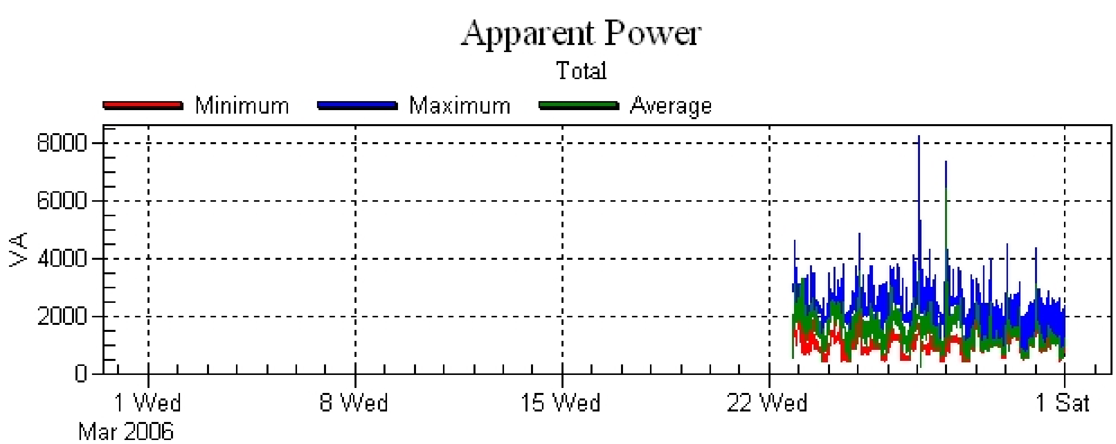

Figure 9: Battery storage power output for the month (PowerTower Output).

Figure 9 shows that the battery storage delivered up to 8 kW during its operation in March. A further analysis of the system during the time the battery storage was online, shows that it performed as expected.