EFOY 1200 Fuel Cell Testing, February 15-March 9 2010, Skagway, AK
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The EFOY 1200 fuel cell powered the weather station in the KLGO maintenance yard for three weeks while I studied its fuel consumption and response to temperatures below freezing. The unit was stored in an uninsulated metal box, with two vents connected by pipe to the heat exhaust vents on the unit itself. Ten-gauge wire connected the unit to six 12-Volt batteries and the batteries to the weather station charger. The fuel cell operated in three modes: charging, standby, or antifreeze, depending on the battery voltage and fuel cell temperature.

By marking the level of fuel in the cartridge at the beginning and end of the experiment, I estimated that about three-quarters of a liter of methanol were consumed. At this rate of consumption, a fuel cell and ten liters of methanol could power a weather station for forty weeks. However, comparing the weather station's actual energy draw (from both data collection and satellite transmission) to the fuel cell's official production rate suggested that the unit was operating inefficiently even in the mild temperatures of the test period, and would consume much more fuel in a colder environment.

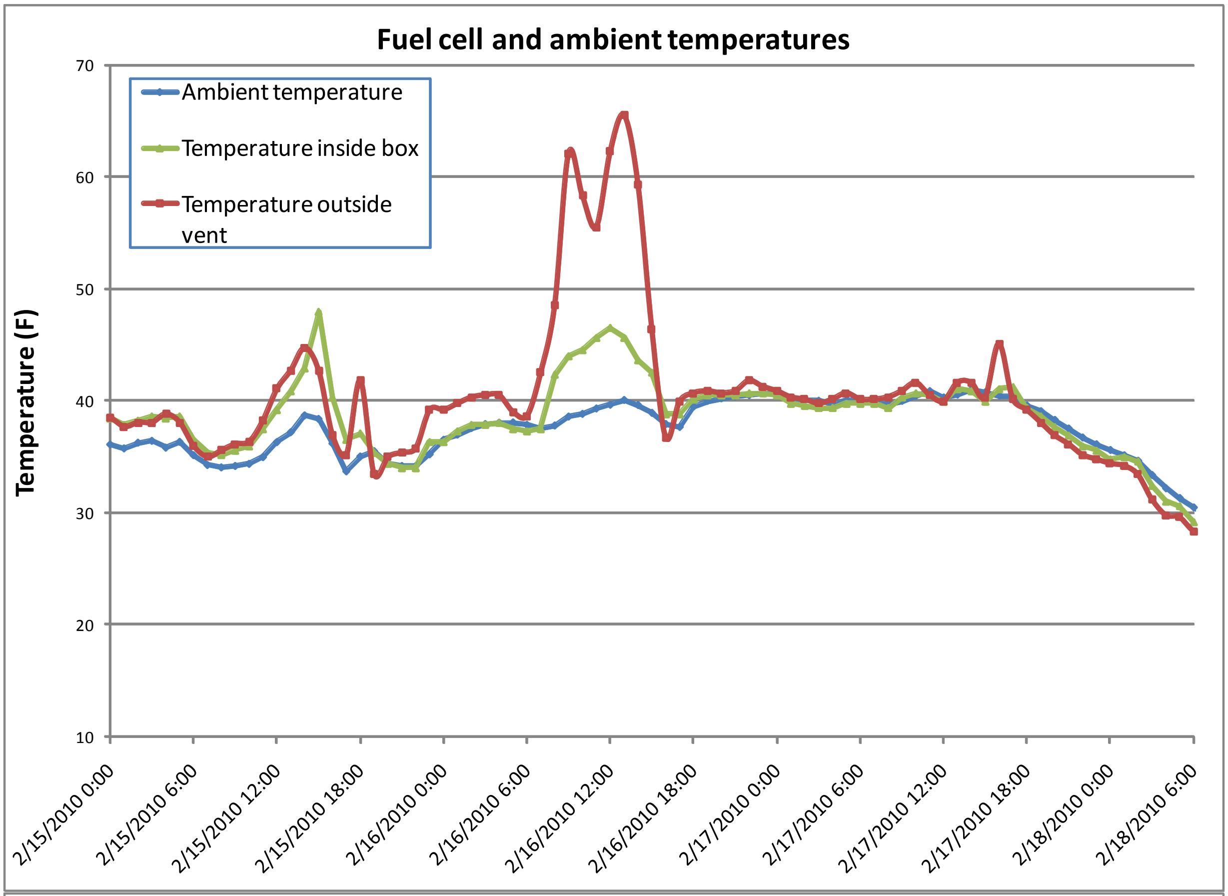
Table 1 below shows the energy produced and consumed over the test period. 723 Watt hours were produced by the fuel cell but not consumed by the weather station, and seem to have been used in antifreeze mode, which according to the manufacturer is activated when temperatures are below 3^{o} C (37.5^{o} F).

	Energy (Watt-hours)
Rated energy production for 1 L methanol	900
Rated energy production for .75 L methanol	833
Consumed by weather station	109
Lost to wire resistance	0.2
Unaccounted for. Antifreeze mode?	723

Table 1: Energy expended by the fuel cell over the test period

For one week within the test period I measured the temperature at the heat exhaust vent and inside the box with temp loggers (that sampled once an hour), and compared the results both to the average hourly ambient temperatures and the hourly minimum and maximum battery voltages. I hoped to determine when the unit was operating in antifreeze mode rather than charging the battery. The results are shown in Figure A, below. At the end of the week, I switched the sampling time on the temp loggers to once every thirty seconds, and show the results over 24 hours in Figure B. The source data and charts are in an Excel spreadsheet at T:/NRM/Weather Station/Fuel Cell Testing/fuelcell.xls

In both cases, the charts show that all the spikes in battery voltage have a corresponding increase in the temperatures at the heat vent and in the box. The temperature increases (relative to the ambient temperature) that don't have corresponding voltage increases represent the antifreeze mode. This is particularly clear on February 19th in Figure B, when the temperature at the heat vent rises abruptly to 70^{o}F after several hours of below-freezing ambient temperatures. (While the ambient temperatures also rose at the time of the spike, the maximum temperature recorded by the weather station for February 19th was 51^{o}F, well below the temperature at the heat vent.)



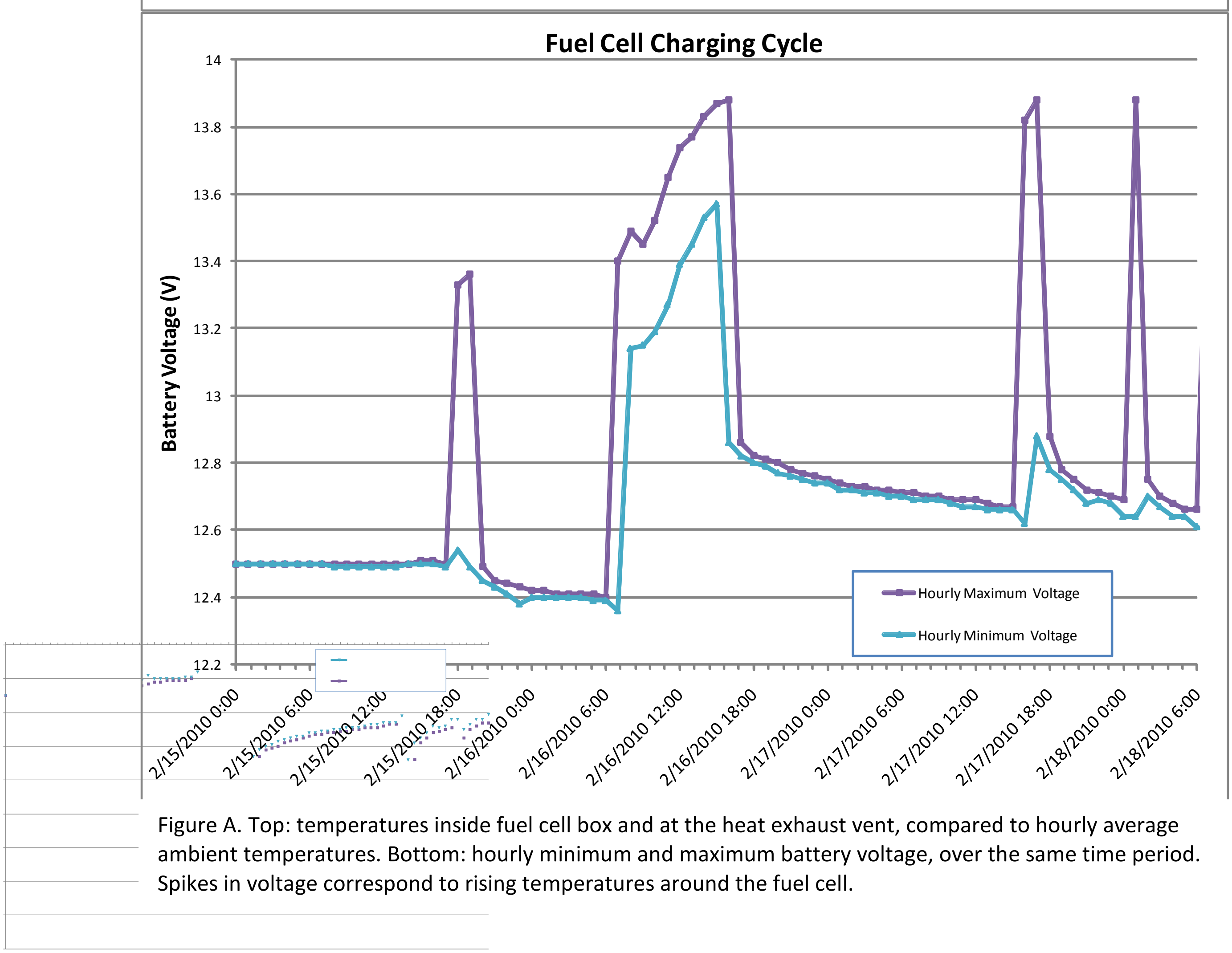


Figure A. Top: temperatures inside fuel cell box and at the heat exhaust vent, compared to hourly average ambient temperatures. Bottom: hourly minimum and maximum battery voltage, over the same time period. Spikes in voltage correspond to rising temperatures around the fuel cell.

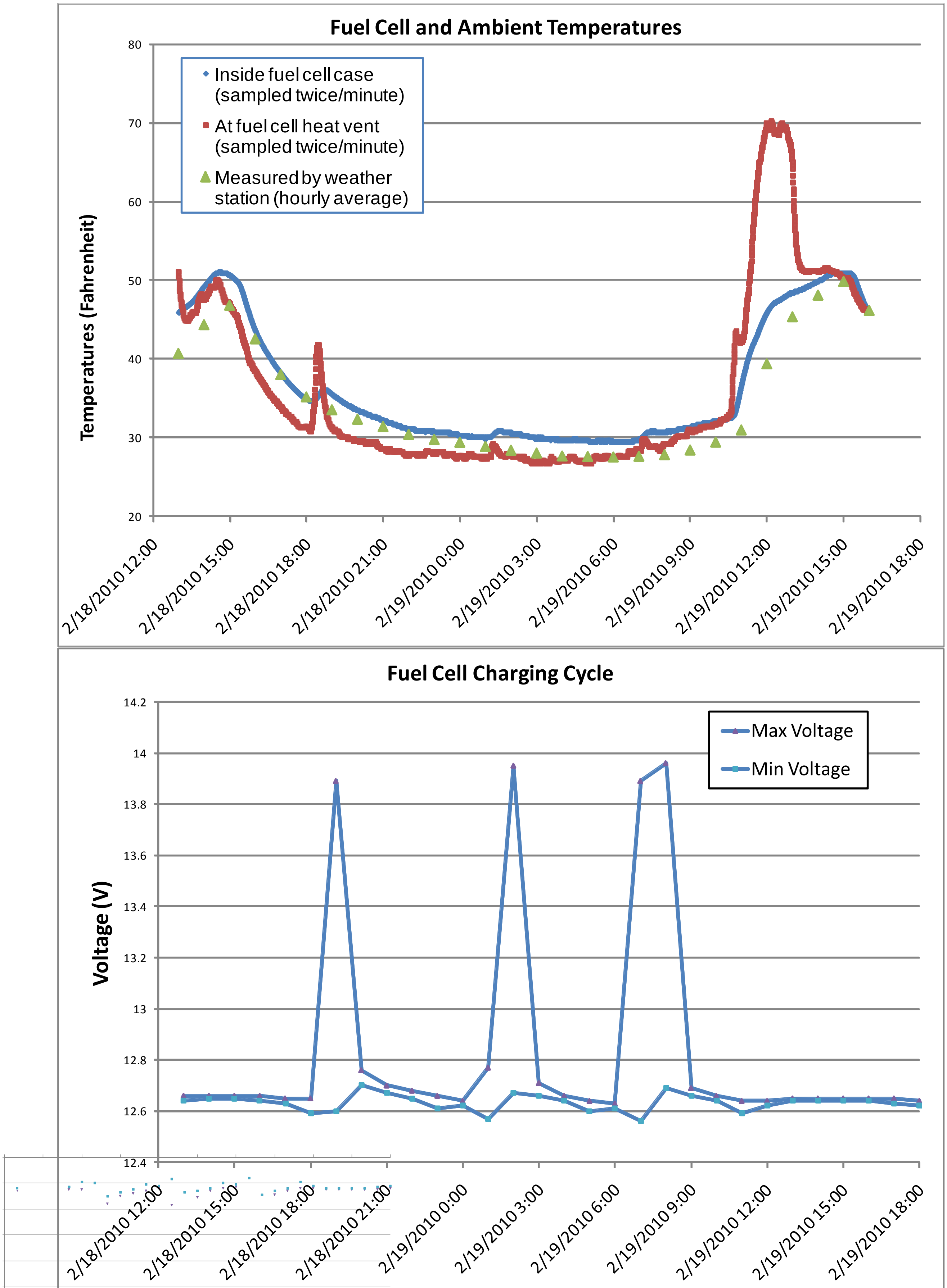


Figure B. Top: temperatures inside fuel cell box and at the heat exhaust vent sampled at a higher resolution over 24 hours. Bottom: hourly minimum and maximum battery voltage, over the same time period. The final temperature spike has no corresponding voltage increase, suggesting unit was in antifreeze mode.

The fuel cell remained at sub-freezing temperatures for several hours before activating the antifreeze mode, then it seemed to overcompensate, continuing for several hours after ambient temperatures increased. This may account for the high energy use of the antifreeze feature. A much more efficient warming solution would be to retain the heat from the battery-charging mode, reducing the number of times the fuel cell enters antifreeze mode at all. The EFOY manufacturer recommended the Canadian distributor Four Stones (http://www.fourstones.ca) who have developed an insulated box with partial recovery of the heat exhausted from battery charging. This box also decreases the minimum operating temperature from -20^{o}C (-4^{o}F) to -50^{o} C (-58^{o} F), similar to the temperature limit of the weather station itself, -55^{o}C (-67^{o}F). The Four Stones product was still in development during the test period, but specifications, price, and ordering information will be available in mid-April 2010.