

## February 2001

Colorado State University  
Evaluation of a 50-W Stand-Alone Photovoltaics System – Update  
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The system described earlier was now running for more than 170 days. Starting in the middle of August there was one major break in the data collection in September/October due to a power outage to the computer and our failure to reboot right away.

### 1. State of Charge over Time

An evaluation of the last 5 months is shown on page 4. For every day the minimum voltage was extracted (usually in the morning shortly before sunrise). These voltages were monotonically ordered for display.

After sunset the battery will always discharge until the next sunrise. Therefore the minimum State of Charge values for each day can never be 100%. The State of Charge is estimated using the following values:

**Table 1: State of Charge in terms of Voltage**

State of Charge (SoC)	Open Circuit Voltage $V_{OC}$ [V]	Voltage under load $V_{WL}$ [V]
100%	> 12.64 V	12.58 V
90%	12.56 V	12.50 V
75%	12.44 V	12.38 V
50%	12.26 V	12.2 V
25%	12.08 V	12.02 V
0%	< 11.90 V	11.84 V

Assuming that the voltage drop is inverse proportional to the battery size (double battery size, half the voltage drop), the same data was plotted for 110 Ah and 180 Ah batteries. For more than 85 days, the State of Charge never dropped below 75%, and for another 75 days, it stayed above 50%. Only on 13 days the State of Charge was below 50%. Considering the fact, that this data was taken in the winter months (September – February) and the tilt of the panel is not optimized for the winter, the battery seems to be fairly well sized. Using batteries 110 Ah or 180 Ah would maintain higher States of Charge. The 180 Ah battery would not have been below 75% at any time and the 110 Ah one never below 50% (see Table 2 and Figure 1).

**Table 2: Number of days with minimum State of Charge in different ranges**

State of Charge	55Ah (battery used)	110Ah (estimated)	180Ah (estimated)
90 % < SoC < 100%	7	54	125
75% < SoC < 90%	78	108	48
50% < SoC < 75%	75	11	0
25% < SoC < 50%	12	0	0
0% < SoC < 25%	1	0	0

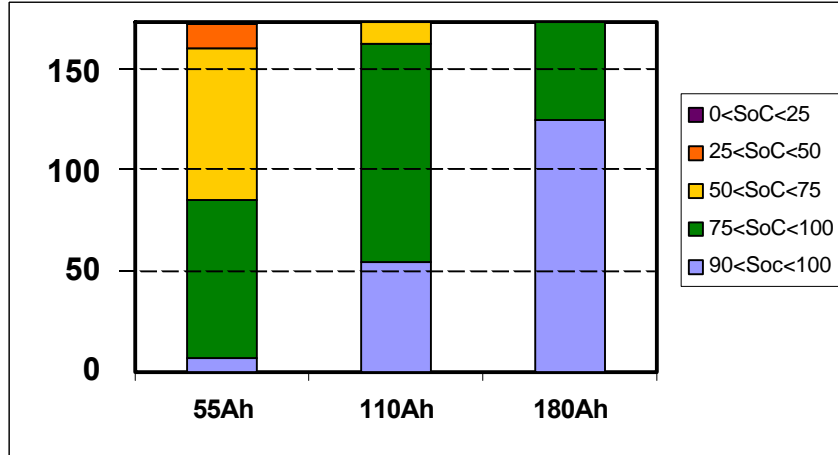


Figure 1: Number of Days for ranges of State of Charge

One battery-selection parameter is weight. Approximately 30 kg is the limit that one person can conveniently handle. Our 55 Ah battery was 16 kg. Advertised 86 and 225 Ah twelve-volt batteries are 30 and 75 kg respectively.

## 2. Average Charge and Average Voltage for Sept.-Febr.

Due to the temporarily shutdown in September/October the data was averaged accordingly to Table 3.

Table 3: Time of Data Acquisition

Aug./Sep.	8/19/2000 – 9/13/2000
Oct.	10/5/2000 – 10/31/2000
Nov.	11/1/2000 – 11/30/2000
Dec.	12/1/2000 – 12/31/2000
Jan.	1/1/2001 – 1/31/2001
Feb.	2/1/2001 – 2/26/2001

The average total charge per day available, the average net charge that was going to the battery, and the average minimum voltage are shown in Figure 2, Figure 3, and Figure 4.

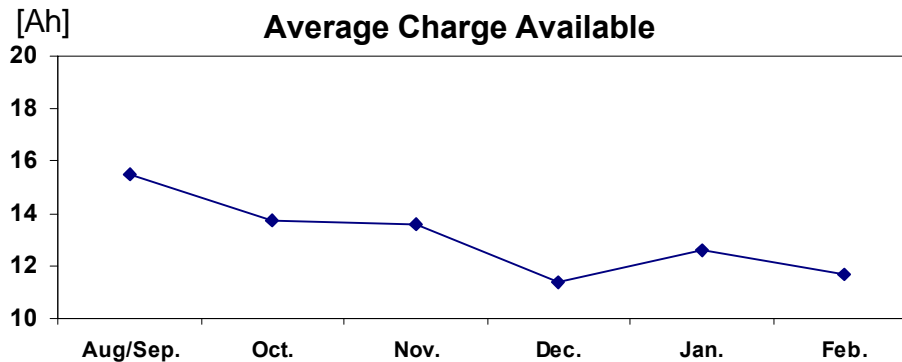


Figure 2: Average Available Charge

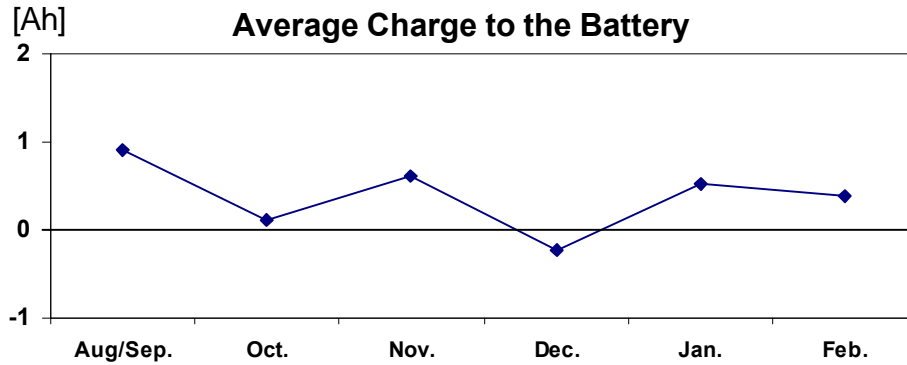


Figure 3: Average Charge to the Battery

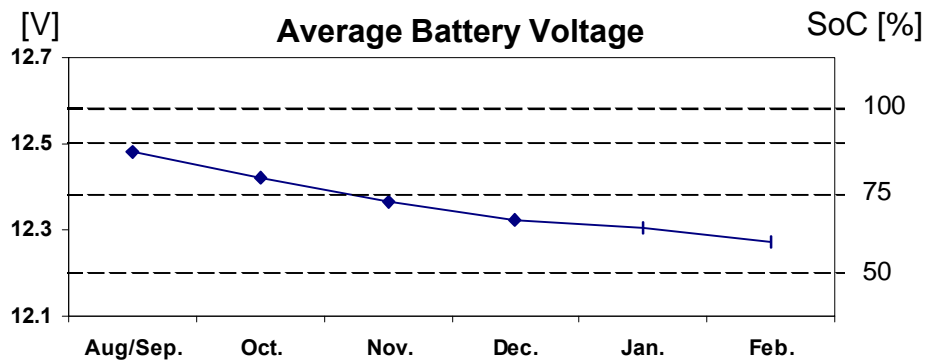


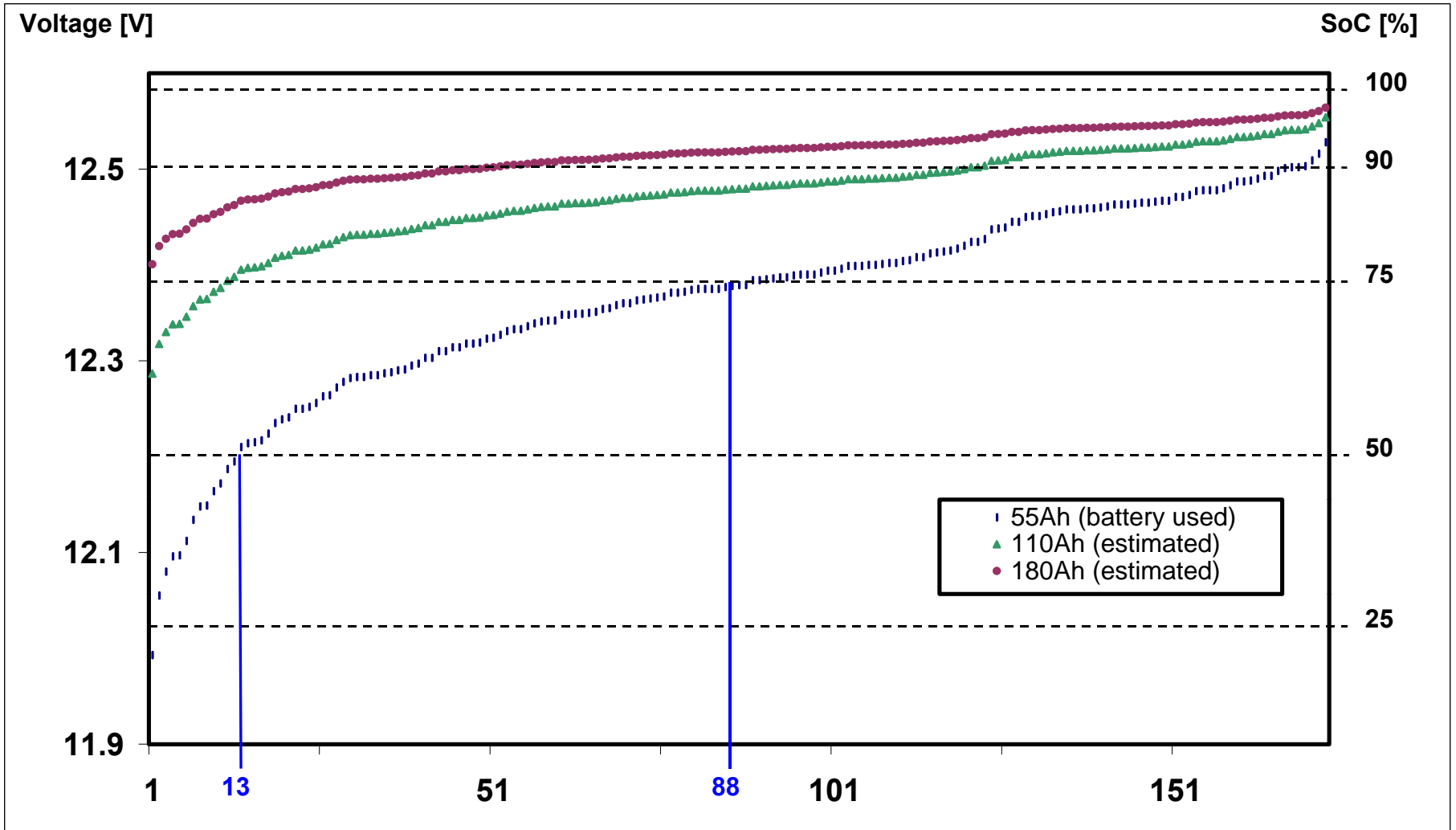
Figure 4: Average Minimum Battery Voltage

The average charge available was lowest in December. This correlates directly with the time the sunlight is available. The net charge going to the battery was slightly negative in December. It is very important to remember, that the battery is still indoors at a constant temperature of 25°C. Usually the battery would be outside and therefore the charging voltage would be increased due to the higher internal resistance of the battery. At a higher voltage, the current output of the solar panel will be less and this would lead to a lower amount of available charge.

### 3. Selected daily data plots

Page 5 shows the data for the 21<sup>st</sup> of December. This is the shortest day of the year in the northern hemisphere. A building nearby shaded the solar panel from the sun in the early morning, and the current increased abruptly when the sun rose above it. There were almost 17 Ah of charge available, compared to 20 Ah in mid summer. (The panel angle at 45° somewhat favored the winter solar angles).

On the 16<sup>th</sup> of January there were several inches of snowfall in Ft. Collins. The snow covered the solar panel for almost half the day on the 17<sup>th</sup> of January, but then abruptly slid off (see page 6). This occurred here in Ft. Collins at least twice. In areas with stronger snowfalls, effects of snow accumulation have to be considered in the layout of the system.



date: 12-21-0

**Charge**

available: 16.87 Ah  
used for charging battery: 1.78 Ah  
excess panel charge available: 4.8 Ah  
used for load: -10.27 Ah

**Battery voltage**

max: 13.80 V  
min: 12.36 V

at 12:00 AM: 12.53 V  
at 11:59 PM: 12.55 V  
change over the day: 0.02 V

**Current**

max: 2.92 A

**Solar panel temperature**

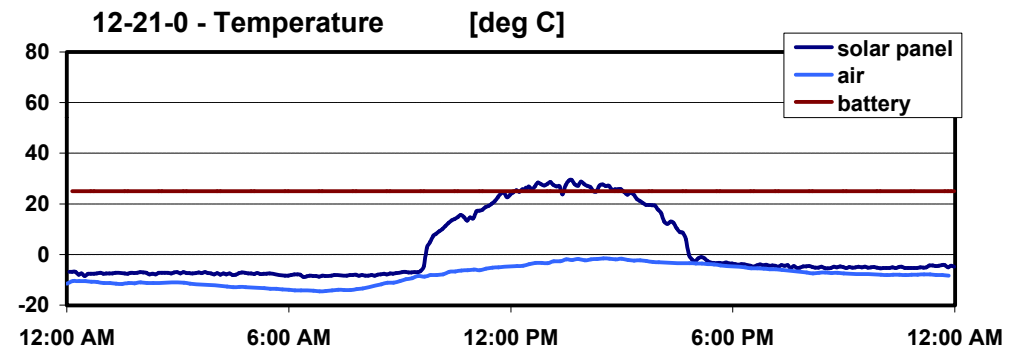
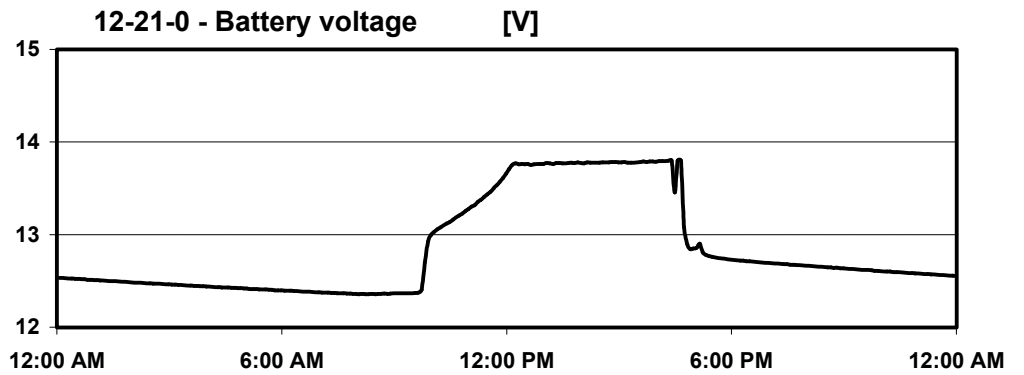
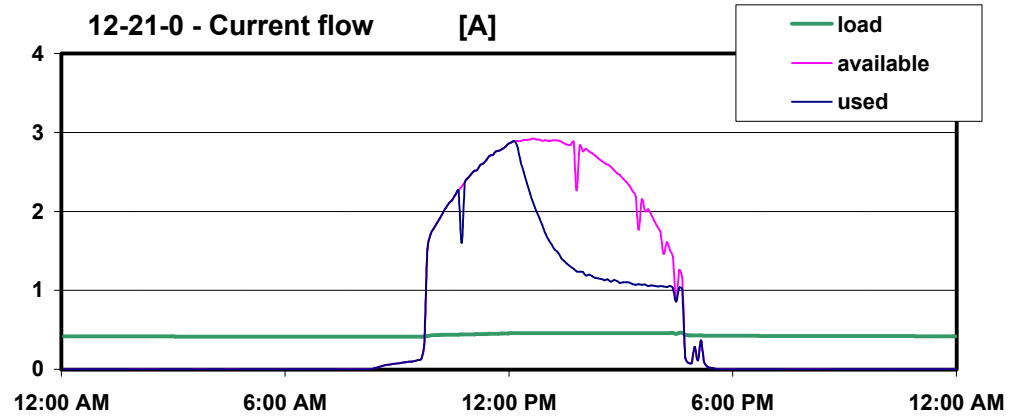
max: 29.4 deg C  
min: -8.8 deg C

**Air temperature**

max: -1.6 deg C  
min: -14.6 deg C

Battery: Interstate HD24-DP  
Load: 30 ohms

no. of points: 288



date: 1-17-1

**Charge**

available: 13.26 Ah  
used for charging battery: 3.18 Ah  
excess panel charge available: 0.0 Ah  
used for load: -10.07 Ah

**Battery voltage**

max: 13.38 V  
min: 12.26 V

at 12:00 AM: 12.30 V  
at 11:59 PM: 12.52 V  
change over the day: 0.22 V

**Current**

max: 3.15 A

**Solar panel temperature**

max: 30.3 deg C  
min: -6.4 deg C

**Air temperature**

max: -1.8 deg C  
min: -15.8 deg C

Battery: Interstate HD24-DP  
Load: 30 ohms

no. of points: 288

