Appendix I

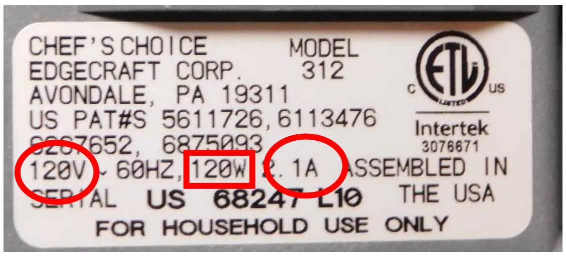
The Limits to Solar Emergency Power, by Scott Wetenkamp and Bob Buddemeier

## Background

This appendix is intended to provide information both for those who are not familiar with the subject, and for those who are familiar and wanrt more details about how the conclusions of the article were arrived at.

A watt (symbol: W) describes the rate of energy transfer.  In electricity it is the product of voltage (V) and current (I, measured in amperes).

Wattage describes the rate of electrical energy transfer required to do work, such as running an electric motor.  Electrical equipment typically has a label specifying the voltage and current at which it operates. See example below.




The energy consumed in operating a piece of equipment is the wattage time the operating time, which is usually expressed as watt-hours (Wh).  In cases where the equipment is constantly operating, the watt-hours are simply voltage x current x time.  However, some machines operate intermittently, like a refrigerator that turns on and off to maintain a constant temperature.  In that case the same voltage and amperage are required when the equipment operates, but the energy used depends on the actual running time and not the total time.  The term “duty cycle” is used to describe the fraction of time during which the appliance is operating.  In the case of a refrigerator that might be 25%, so the energy actually used would be voltage x amperage x 0.25 x total time.

## Solar Energy Collection

The average amount of solar energy that falls on the earth’s atmosphere is 340 watts per square meter.  The amount that actually reaches the ground depends on location, atmospheric conditions, time of year, and time of day.

The efficiency with which solar panels transform radiant energy to electrical energy is 20-25%.

Under ideal (clear sky) atmospheric conditions, the maximum input of solar energy (noon) is at the summer solstice and the minimum at the winter solstice. Input at other times of day can be calculated from the earth-sun geometry, and these inputs can be summed to calculate watt-hours per day of incoming energy.

The values in Table 2 were calculated in this way for the latitude of Medford and manufacturer's specifications for the Jackery panels.

**Applications**

This energy is transferred to the storage battery until the battery reaches its capacity (full charge) and can accept no more.  In the example system we use, the battery can hold 3000 Wh, or 3 kWh.  This energy can be discharged to run motors, generate heat, or power electronics until the battery is discharged.

Table 1 shows the time distributions of some describe/explain]

For the purposes of the article we used the calculated energy supply of the solar generating system and the requirements of a variety of equipment (see article Table 1) that might be used under emergency conditions of a power outage.

Starting from the basic data, we have used the following estimates:

Insolation at the equinoxes is the average of summer and winter values

Full cloud cover is equivalent to moderate AQI (e.g. smoke density) values and reduces the solar energy available to about 25% of the maximum.

Partly cloudy or mildly smoky conditions are assumed to result in a value of about 60% of the maximum.

In estimating demand, we have generally used wattage estimates that are within the upper portion of the average range for the equipment in question.