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## BATTERY SIZING TIPS for STAND ALONE PV SYSTEMS

The following are Concorde's recommendations for sizing a battery system that should provide a reliable storage system for Stand Alone Alternate Energy Systems. Primary consideration is for Photovoltaic Systems but other alternate energy source systems would have similar requirements.

### LOAD CALCULATIONS:

#### **DC LOADS**

To calculate the *Total Number of DC Amp Hours per Day Required* to power the system:

DC Load Amps = kW ) DC System Voltage

Total Daily Load [Amp Hours] = (No. of Amps X No. of Hrs.) / Day of Operation

#### Example:

0.12 kW ) 48 VDC = 2.5 A.

Total Daily Load = (2.5 A. X 24 Hrs.) / Day of Operation = 60 AH/Day of Operation

For non-continuous DC Loads establish the duty cycle in time of operation per Day

(70% of day at xx Amps) + (30% of day at yy Amps) = Total AH Consumed/Day

#### Example:

(70% X 5 A. X 24 Hrs.)/Day + (30% X 10 A. X 24 Hrs.)/Day = 156 AH/Day

Total Daily Load = 84 AH + 72 AH = 156 AH/Day

## AC LOADS

When an inverter is used to power 120 or 240 VAC appliances, such as pumps, refrigerators, lighting, etc. the AC voltage must be converted to the Battery's DC voltage and the efficiency of the inverter must be considered.

If the inverter AC voltage is 120 VAC and the battery DC voltage is 24 VDC then the conversion factor is 5.0. For every AC amp drawn there will be 5 times as many DC amps. Also, the inverter's conversion efficiency from DC to AC is not 100%. There is an internal loss in the inverter which is normally about 10 to 15% [See inverter/charger manufacturer's efficiency specifications].

Example:

AC Load = 6 kWh/Day ) 120 VAC = 50 AH/Day @ 120 VAC

Convert to DC Battery Load. Inverter's Charger is 48 VDC. Therefore, the conversion factor is 2.5 to 1 and the efficiency is 90%.

DC Load =  
50 AH/Day X 2.5 [conversion factor] = 125 AH/Day ) 0.9 [efficiency] = 139 AH/Day battery load

*Note: When sizing the battery for non-continuous loads, or for larger loads for short periods of time per day, it may not be possible to use the 20, 24 or 120 hr. rate of discharge for the battery's capacity. When discharged at different rates, a battery's capacity will vary. The higher the rate of discharge the lower the capacity of the battery.*

## DAYS of AUTONOMY:

The sun does not shine with equal intensity every day, at night and during inclement weather. Cloud cover, rain, snow, etc, diminish the daily Insolation (*Insolation* measured is the amount of solar energy delivered to the earth's surface. Insolation is measured in kWatts/meter<sup>2</sup>). A storage factor must be employed to allow the photovoltaic battery system to operate reliably throughout these periods.

In addition, it is desired to obtain the best service life of the battery by limiting its average daily depth of discharge. This storage factor is commonly referred to as "Number of Days of Battery Autonomy". The number of days is established by evaluating the Peak Hours of Sun per Day [(kW/m<sup>2</sup>)/day] for the lowest Insolation month of the year; with the solar array oriented for maximum output during that month.

The minimum number of days that should be considered is 5 days of storage for even the

sunniest locations on earth. In these high sun locations there will be days when the sun is obscured and the desired battery's average daily depth of discharge is limited to 20%. Therefore, the recommended days of autonomy storage are listed on the following chart:

Recommended Days of Autonomy Storage	
kW/m <sup>2</sup> /day	Days of Storage
4.5+	5
3.5 to 4.5	6
2.7 to 3.5	7
2.0 to 2.7	8
<2.0	Up to 14*
*Special Considerations Required	

## OPERATING TEMPERATURES:

The temperature of the battery can be a major factor in sizing the system. Lead acid battery capacity is reduced in cold temperatures. Lead acid battery life is shortened in high temperatures.

It should be noted that the temperature of the battery itself and ambient temperature can be vastly different. While ambient temperatures can change very quickly, battery temperature change is much slower. This is due the mass of the battery. It takes time for the battery to absorb temperature and it takes time for the battery to relinquish temperature.

The battery's temperature is normally the average temperature for the past 24 hours plus or minus a few degrees. In many cases it can be difficult or impossible to heat or cool the battery and we must take temperature into consideration. A battery that is required to operate continuously at 0° F. (-18° C.) will provide about 60% of its capacity. This same battery operated continuously in a 95° F. (35° C.) environment can lose half its expected life.

The earth is a great heat sink which provides great insulation in high or low temperatures. By burying the battery in the ground we can increase its capacity in cold temperatures and increase the life of the battery in high temperatures. The battery with only 60% of its capacity at 0° F. [-18° C.] can be brought up to 85% to 90% capacity by burying it. With life cut in half at 95° F. [35° C.], burying the battery can bring it back to near normal life expectancy.

## ENGINEERING DESIGN FACTOR:

Many battery manufacturers will advise sizing the battery for cyclic applications to a maximum depth of discharge of 50%. That would mean doubling the size of the battery. Some batteries have trouble recovering from deep discharges. That would mean for the 60 AH/Day load with 5 days of autonomy or 300 AH that they would advise using a 600 AH battery.

The Concorde Sun~Xtender<sup>®</sup> does not have this limitation. We consider that the battery is

replaceable when it does not provide 80% of its original capacity. Therefore, we recommend that the same 300 AH requirement be divided by 0.80 to provide a reliable battery system. We would recommend using a 375 AH battery. That represents a significant savings.

### SUMMARY:

A properly designed PV system with adequate array, battery capacity and quality regulator can provide a power source many years of highly reliable energy.

The batteries we are referencing in this report are the Concorde Sun~Xtender<sup>®</sup> Series Sealed, Valve Regulated, Thick Plate, Absorbent Glass Mat [AGM] technology products designed specifically for Photovoltaic/Wind [Alternate Energy] applications.

Other batteries, AGM, Gel or Flooded designed for general purpose cycle or stand-by usage cannot be expected to perform to the same high level as our Sun~Xtender<sup>®</sup> Batteries.