American River College

System Sizing

Lesson Plan

- Electricity Basics – Any Questions?

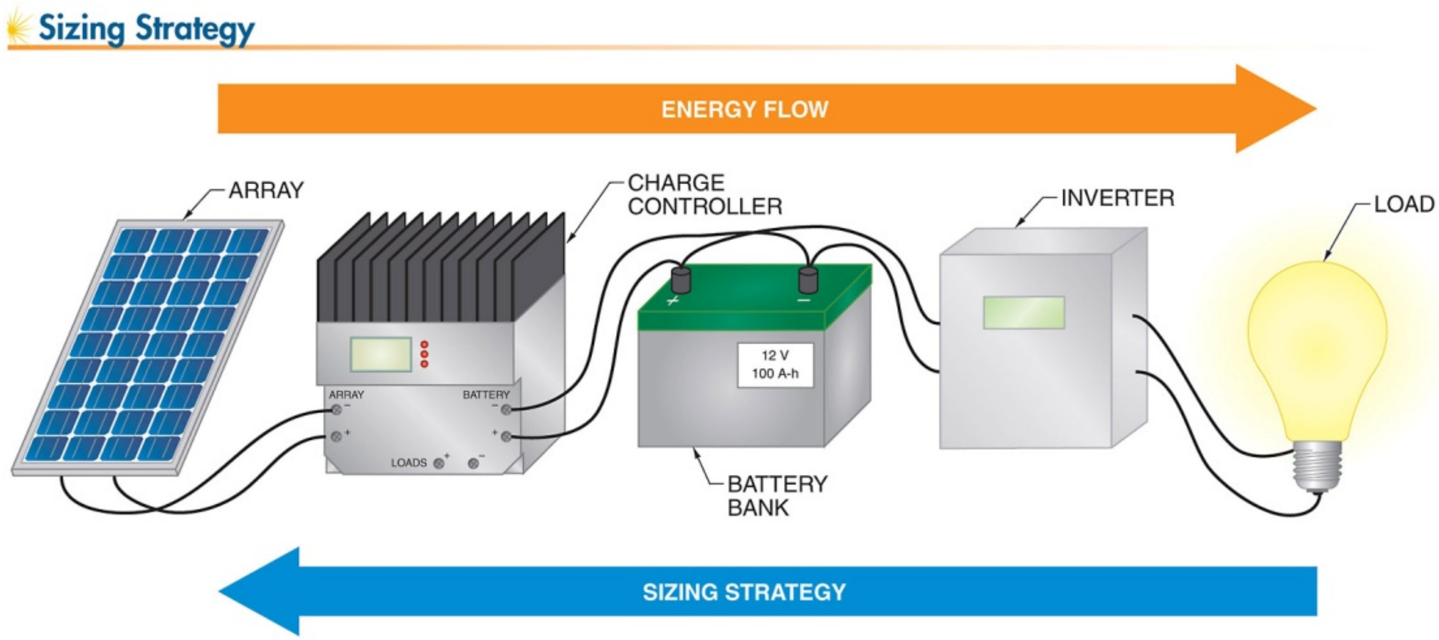
- NABCEP Learning Objectives:
  PV System Sizing Principles

NABCEP Learning Objectives

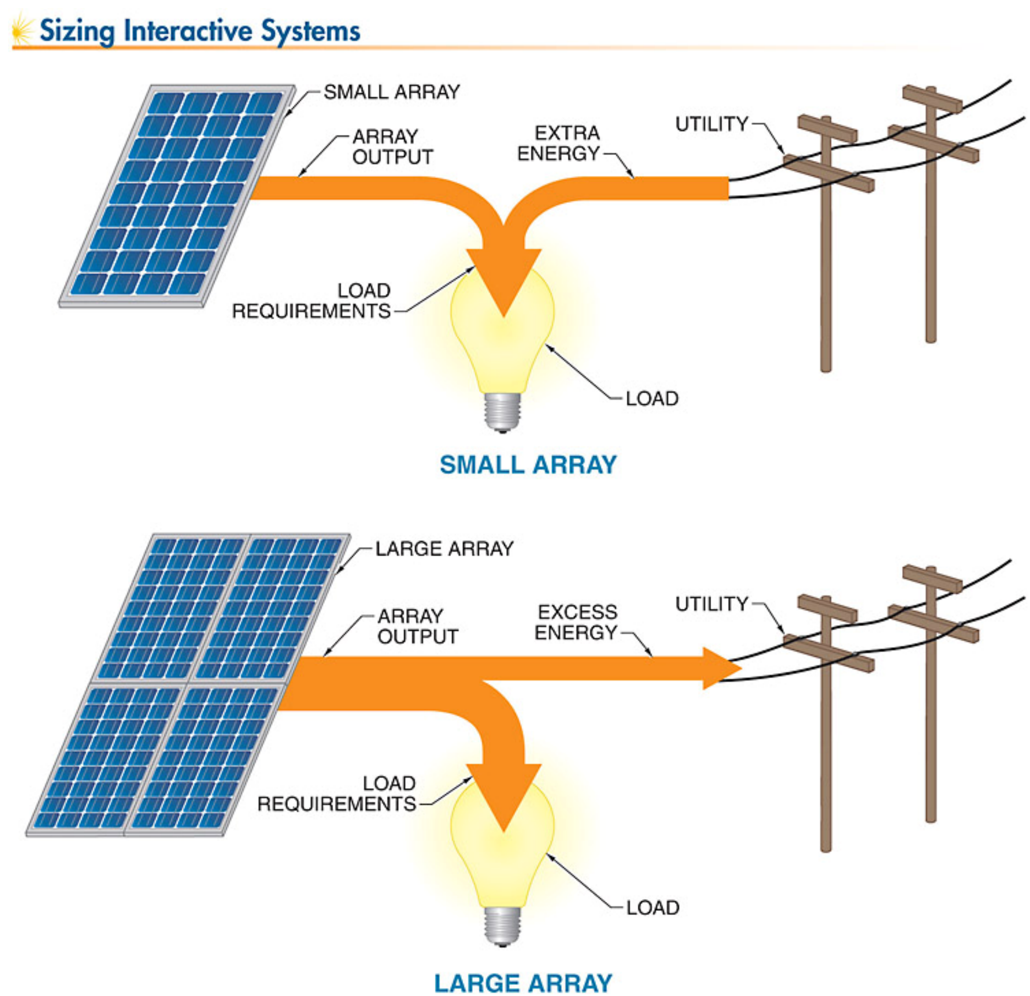
Category	Course Time By %	Exam Items	Level of Testing
1. PV Markets & Applications	5%	3	Comprehension
2. Safety Basics	5%	3	Comprehension Application
3. Electricity Basics	10%	6	Comprehension Problem Solving
4. Solar Energy Fundamentals	10%	6	Comprehension Application Problem Solving
5. PV Module Fundamentals	10%	6	Comprehension Application Problem Solving
6. System Components	15%	9	Comprehension Application Problem Solving
7. PV System Sizing Principles	10%	6	Application Problem Solving Design
8. PV System Electrical Design	15%	9	Application Problem Solving Design
9. PV System Mechanical Design	10%	6	Application Problem Solving Design
10. Performance Analysis, Maintenance and Troubleshooting	10%	6	Analysis Problem Solving
Totals	100%	60	

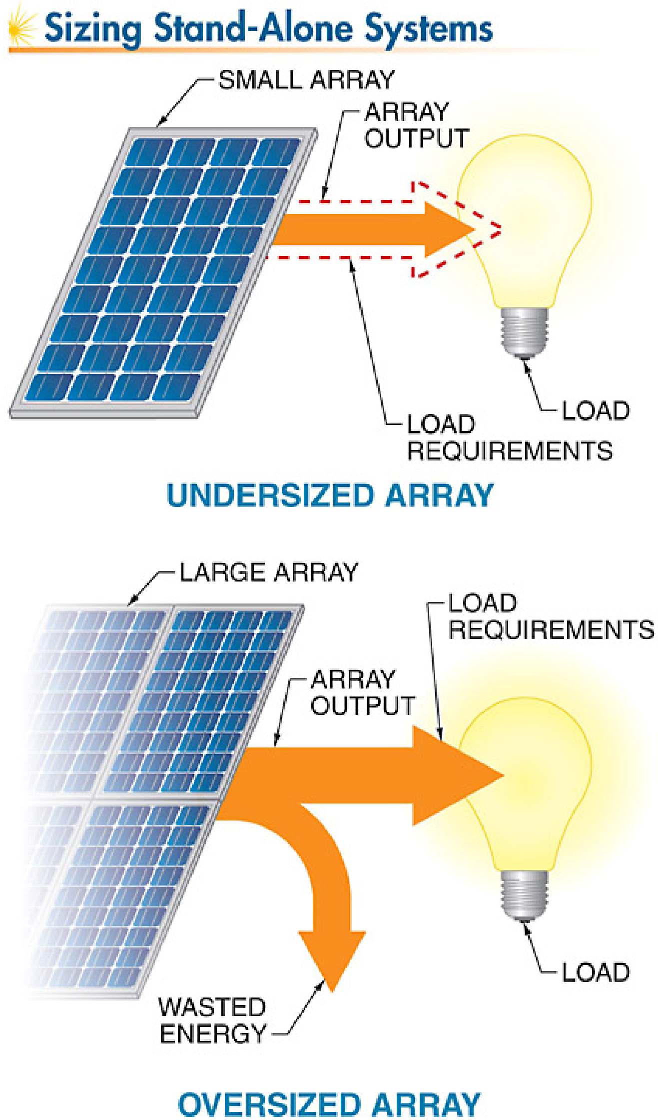
7.	**PV System Sizing Principles** *Suggested Percentage Time Allotment: 10%*	**Learning Priority**
7.1	Understand the basic principles, rationale and strategies for sizing stand-alone PV systems versus utility-interactive PV systems.	Important
7.2	Given the power usage and time of use for various electrical loads, determine the peak power demand and energy consumption over a given period of time.	Important
7.3	Beginning with PV module DC nameplate output, list the de-rating factors and other system losses, and their typical values, and calculate the resulting effect on AC power and energy production, using simplified calculations, and online software tools including PVWATTS.	Critical
7.4	For a specified PV module and inverter in a simple utility-interactive system, determine the maximum and minimum number of modules that may be used in source circuits and the total number of source circuits that may be used with a specified inverter, depending upon the expected range of operating temperatures, the inverter voltage windows for array maximum power point tracking and operation, using both simple calculations and inverter manufacturers' online string sizing software tools.	Critical
7.5	Given a stand-alone application with a defined electrical load and available solar energy resource, along with PV module specifications, size and configure the PV array, battery subsystem, and other equipment as required, to meet the electrical load during the critical design period.	Critical

- Sizing strategy starts at the load side and proceeds backward to the array.



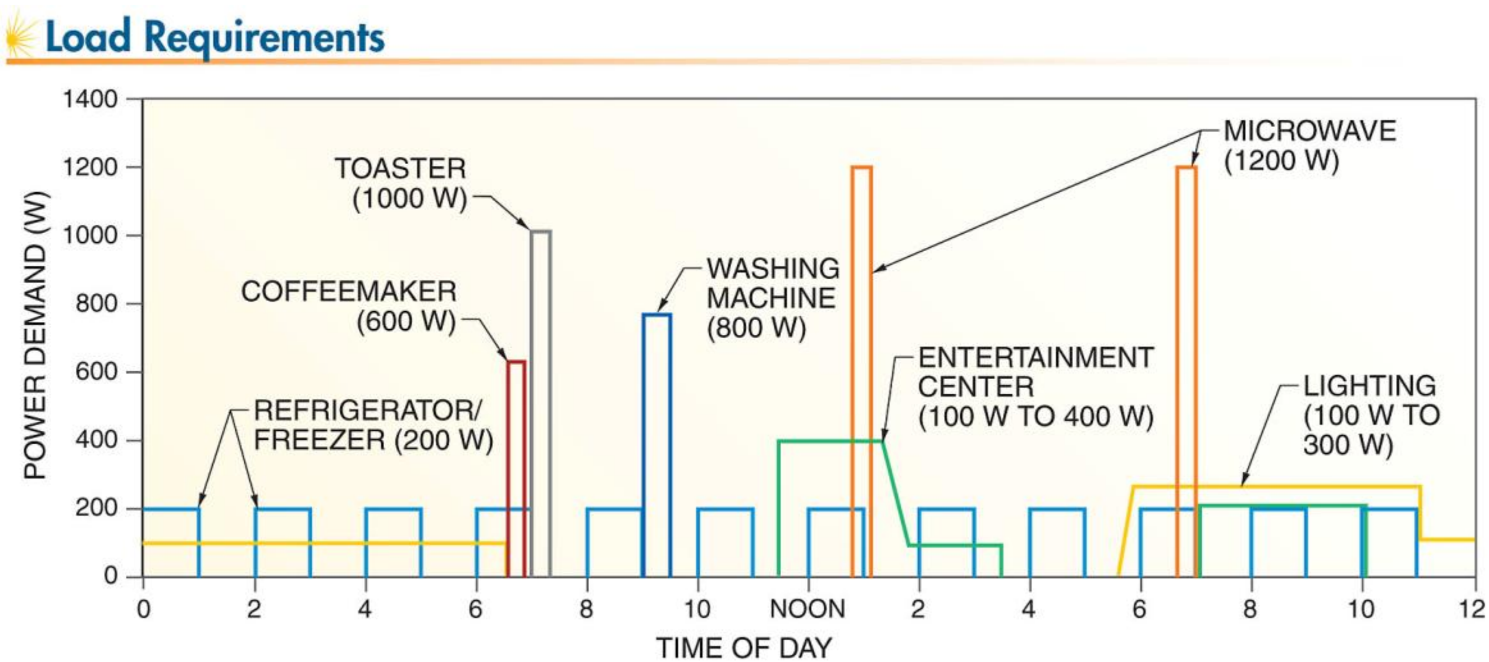
- Interactive-system sizing is very flexible because the utility can supply extra energy to the system loads and receive excess energy from the utility system.



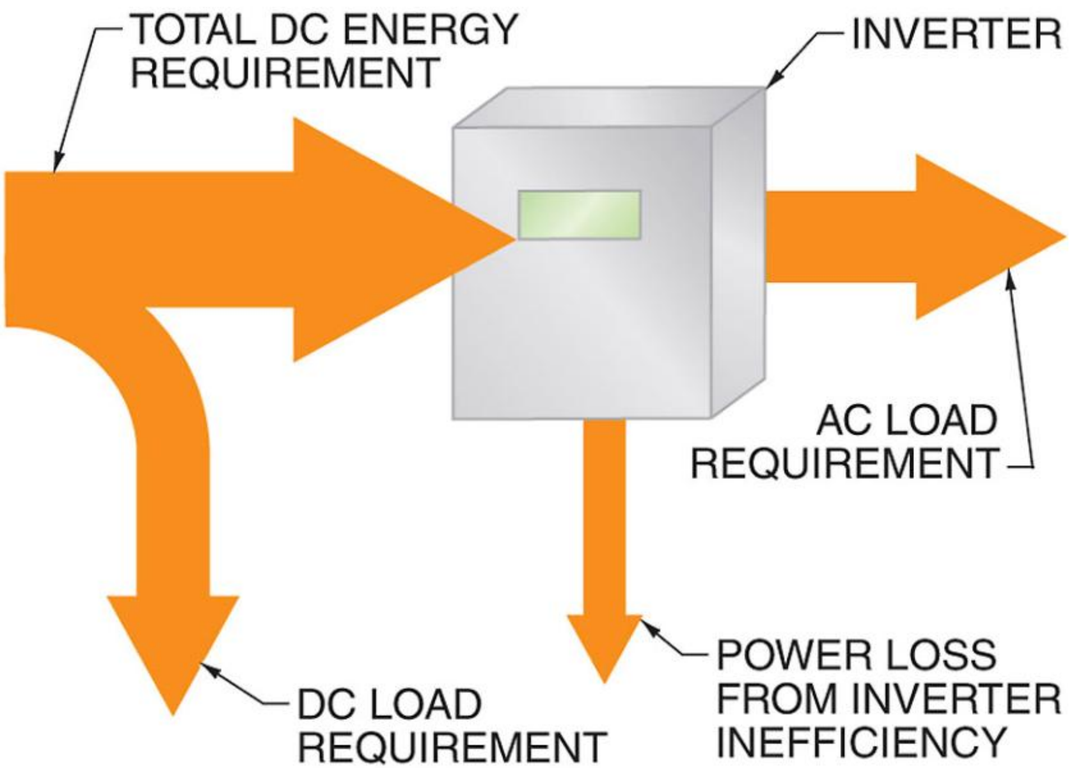


- Stand-alone systems must be carefully matched to load requirements to avoid reducing load availability or wasting excess energy.

- Load requirements include the power demand and electrical-energy consumption for all the expected loads in the system.



Total DC Energy Requirement



- The total DC-energy requirement is determined from the requirements for the DC loads (if any) plus the requirements for the AC loads, taking inverter efficiency into account.

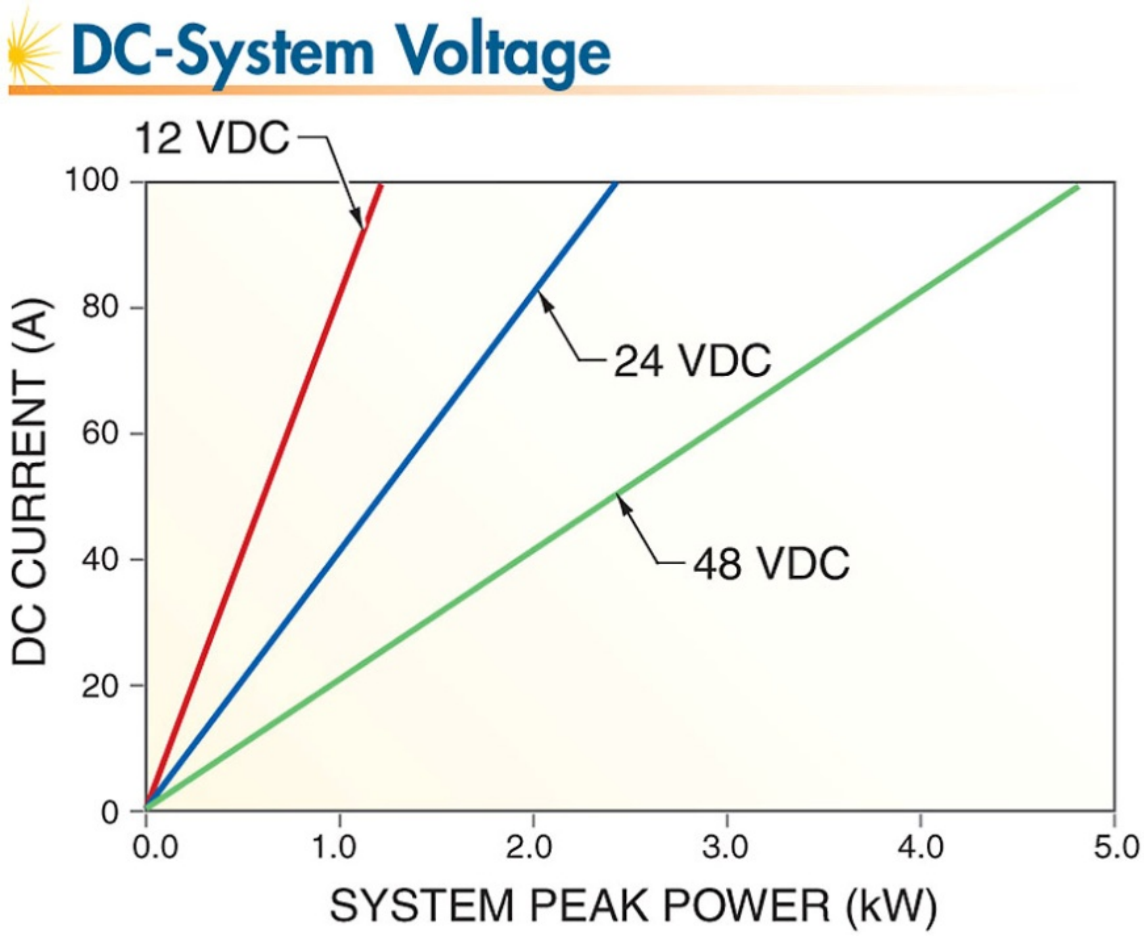
- A critical design analysis compares the load requirements and insolation for each month to determine the critical design month.

Critical Design Analysis

CRITICAL DESIGN ANALYSIS

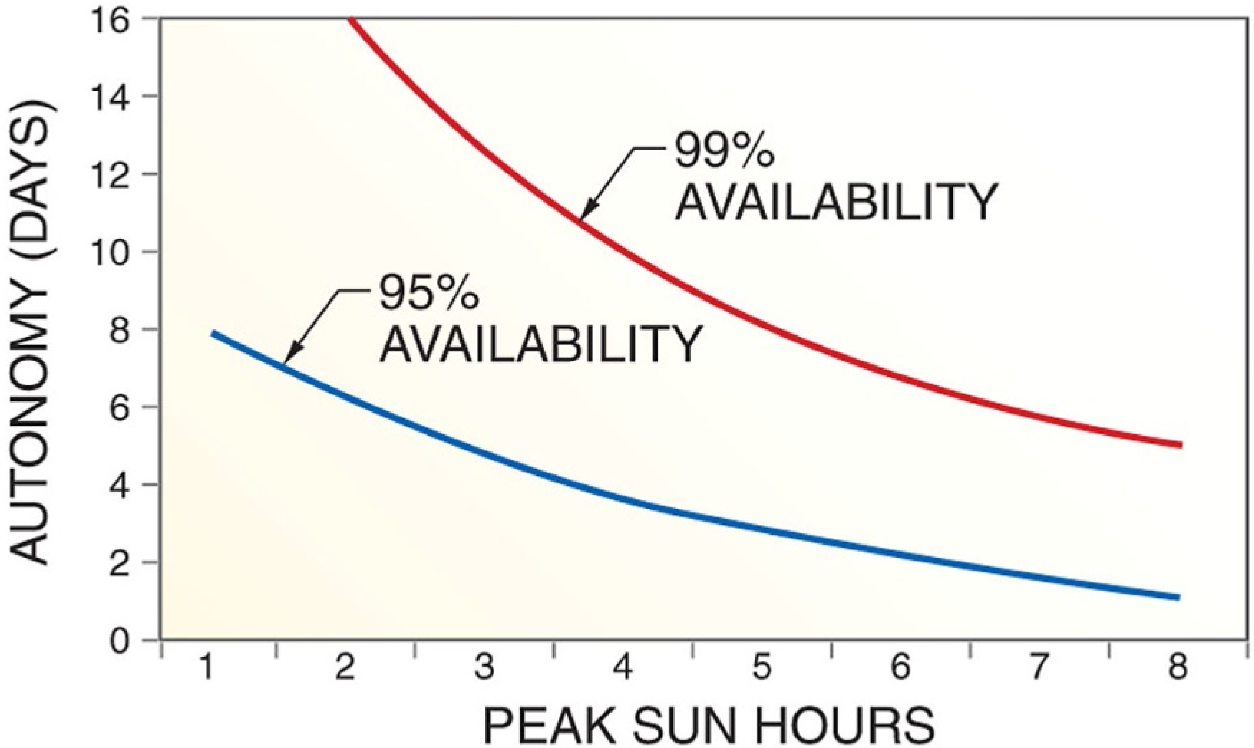
Month	Average Daily DC Energy Consumption (Wh/day)	Array Orientation 1		Array Orientation 2		Array Orientation 3	
		Insolation (PSH/day)	Design Ratio	Insolation (PSH/day)	Design Ratio	Insolation (PSH/day)	Design Ratio
January							
February							
March							
April							
May							
June							
July							
August							
September							
October							
November							
December							

Critical Design Month
Average Daily Energy Consumption Wh/day
Insolation PSH/day
Optimal Orientation



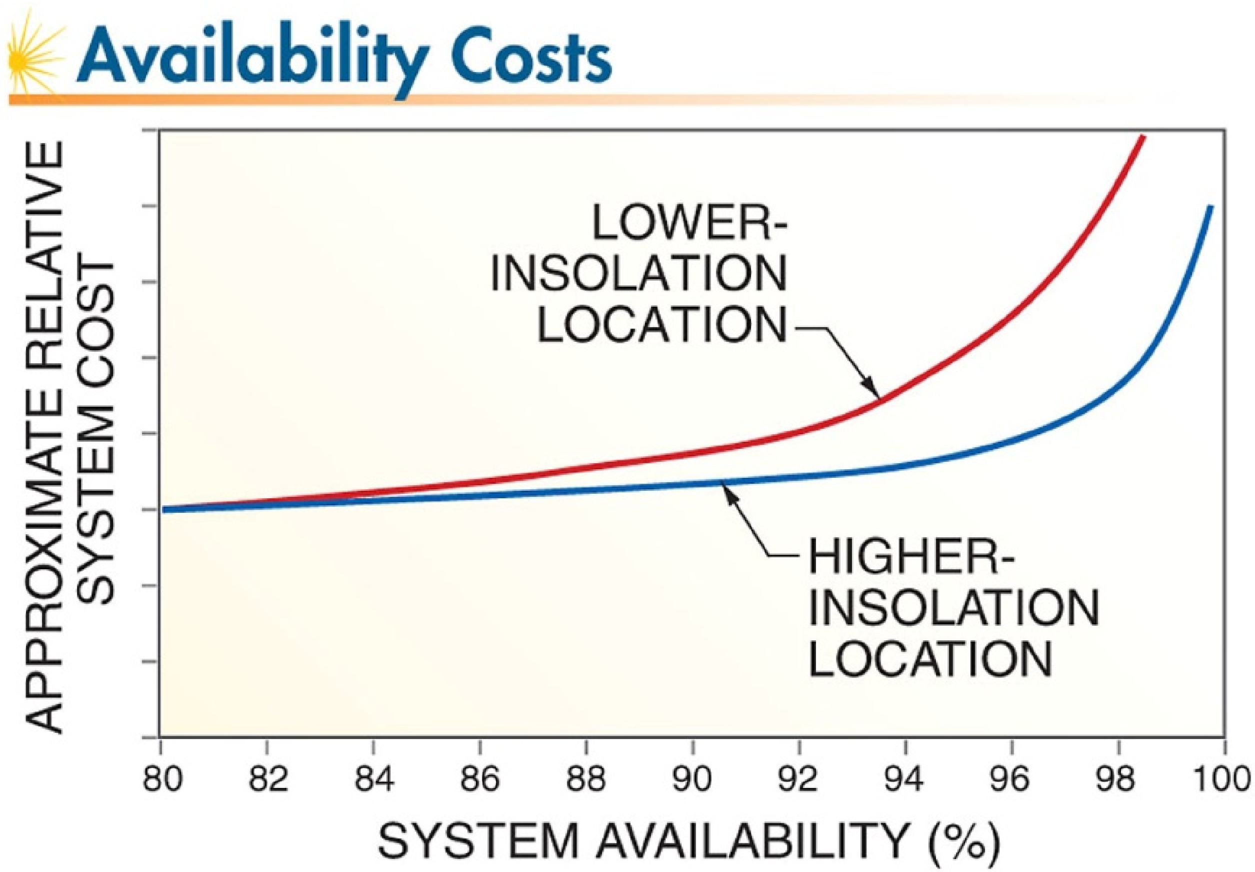
- DC-system voltage is chosen in proportion with the array size and to keep the operating current below 100 A.

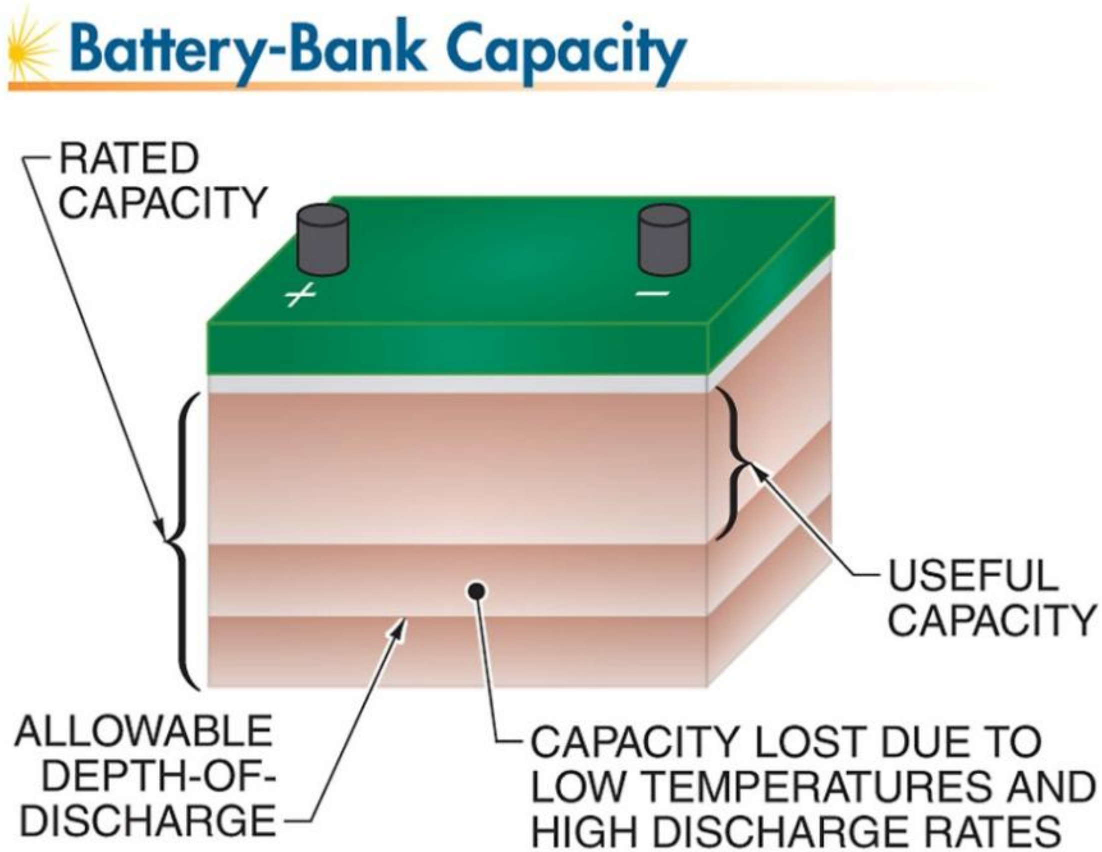
System Availability



- System availability is approximated from the local insolation and the autonomy period.

- Increasing system availability significantly increases the cost of the system.





- Due to the allowable depth-of-discharge, low temperatures, and high discharge rates, the amount of useful output in a battery bank is less than the rated capacity.

- The battery-bank sizing worksheet uses information from the load analysis to determine the required size of the battery bank.

Battery-Bank Sizing

BATTERY-BANK SIZING

Average Daily DC Energy Consumption for Critical Design Month		Wh/day
DC System Voltage		VDC
Autonomy		days
Required Battery-Bank Output		A-h
Allowable Depth-of-Discharge		
Weighted Operating Time		hrs
Discharge Rate		hrs
Minimum Expected Operating Temperature		°C
Temperature/Discharge Rate Derating Factor		
Battery-Bank Rated Capacity		A-h
Selected Battery Nominal Voltage		VDC
Selected Battery Rated Capacity		A-h
Number of Batteries in Series		
Number of Battery Strings in Parallel		
Total Number of Batteries		
Actual Battery-Bank Rated Capacity		A-h
Load Fraction		
Average Daily Depth-of-Discharge		