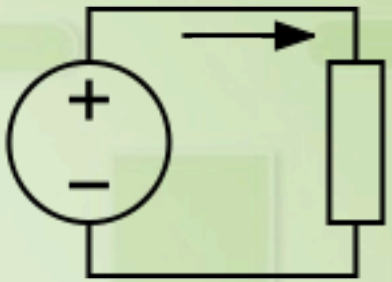
Power Systems

Power Topics

1. Review Electricity Basics
2. AC Power Conditioning and Efficiency
3. Power Elements and Devices
4. Solar Power Theory
5. Site Survey
6. Power Budgeting
7. System Design
8. Deployment

Review Electricity Basics

1. Circuits
2. Ohm's Law
3. Power
4. Safety



Circuits

- Electrical circuits always form a circle.
- Breaking the circuit will stop the current (that's what a switch does)

Current Source (Battery)

Load (Light bulb)

Wires (2)

Ohm's Law

All electrical equipment is based on this simple formula:

V=A*R (or A = V÷R or R=V÷A)

where V (Voltage) is the difference in potential electrical energy between two points in a circuit, R is the resistance between the points, and A is the current flowing through the circuit.

V (Voltage) is measured in "Volts", R (Resistance) in "Ohms", and A (Current) in "Amperes".

In an "open circuit" there is no current flowing, but there may still be potential energy present (measured in Volts).

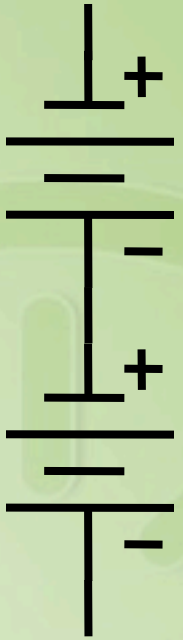
Ohm's Law

- Voltage is a measure of potential energy
- Amperage is a measure of the amount of current passing through a circuit.
- Resistance is a measurement of the ease or difficulty in transmitting current through a component of a circuit.
- Power is a measure of actual work.

P = V * A

Power = Voltage (potential) x Amperage (Current)

Series Connection



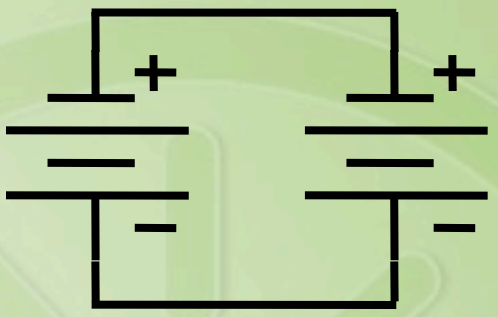
When 2 batteries are connected in series, the total voltage output is increased: V1 + V2
in this example, 4VDC total.

However, the current output remains the same.

Therefore, this resulting battery array gives 4VDC @ 3 Amps

Each cell = 2VDC
capacity = 3Amps

Parallel Connection



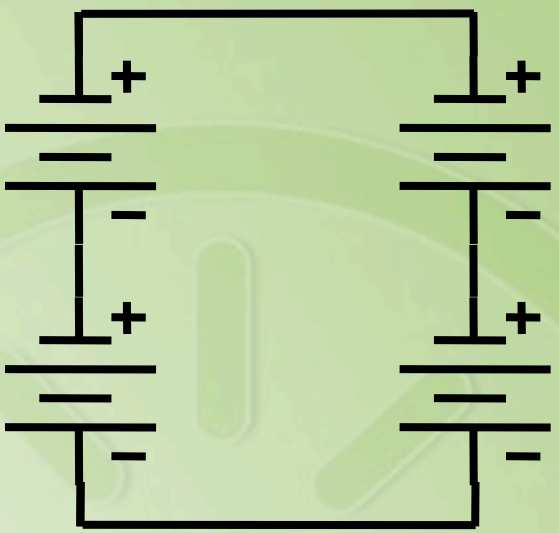
When 2 batteries are connected in parallel, the total voltage output is the same, 2VDC

However, the current output is increased: A1 + A2

Therefore, this resulting battery array gives 2VDC @ 6 Amps

Each cell = 2 VDC
capacity = 3 Amps

Series/Parallel Connection



Each cell = 2 VDC
capacity = 3 Amps

Each series pair of batteries will source 4V. Then the output of both series pairs is combined, so that the total current output is increased.

Therefore, this resulting battery array gives 4VDC @ 6 Amps

Safety

Lightning

Static

Short Circuit

Time to Play Power Bingo

- Object is to be the first to get 3 in a row.
- Announcer reads out definitions, while the bingo cards only have the words that match the definition
- Any direction wins - horizontal, vertical or diagonal
- Call out “POWER” when you have 3 in a row.
- The first person to call out “POWER” wins.

★Winners receive a sweet prize.

AC Power Conditioning & Efficiency

1. Typical local conditions
2. Efficiency
3. Power Conditioning, always use:
   - surge suppressor
   - wide input range voltage stabilizer
   - optional: UPS after stabilizer

Power Elements and Devices

1. panels
2. charge controllers
3. batteries
4. inverters
5. wiring
6. protection devices, circuit breakers
7. voltage stabilizers & UPS

Types of Batteries

Ventilated:

- Flooded (wet)

Sealed Lead-Acid:

- Standard Gel-Cell
- AGM (Absorptive Glass Mat) with higher

AGM batteries shown in parallel

Solar Power Theory

1. The Sun
   * insolation, hours per day
   * spectrum
   * angle
2. micro-Climates
3. Location
   * altitude
   * shading

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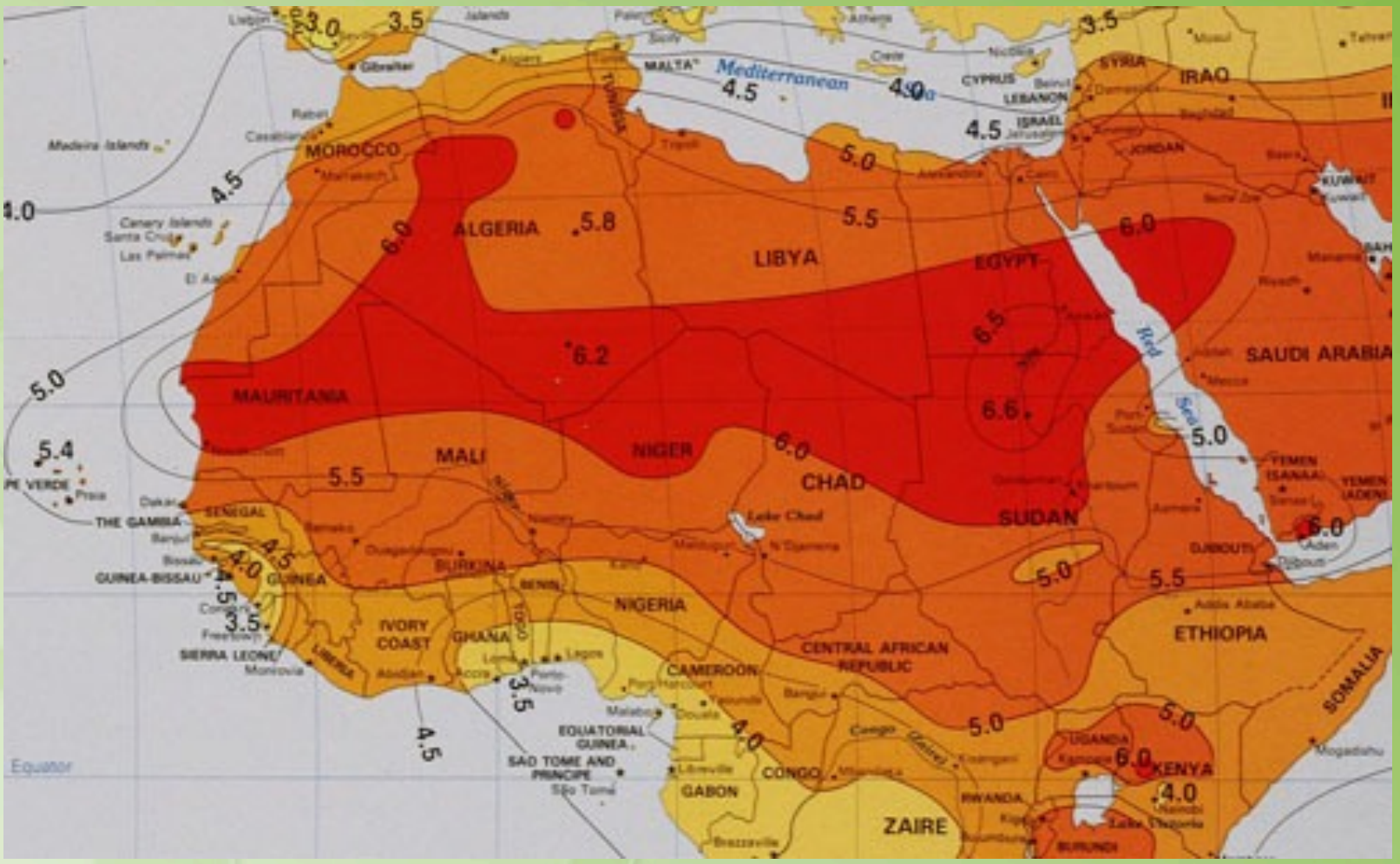
Solar Insolation Map



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Location, Location, Location

Each place is different, and has unique issues and problems. Much attention to fine detail is required for a successful design and installation.

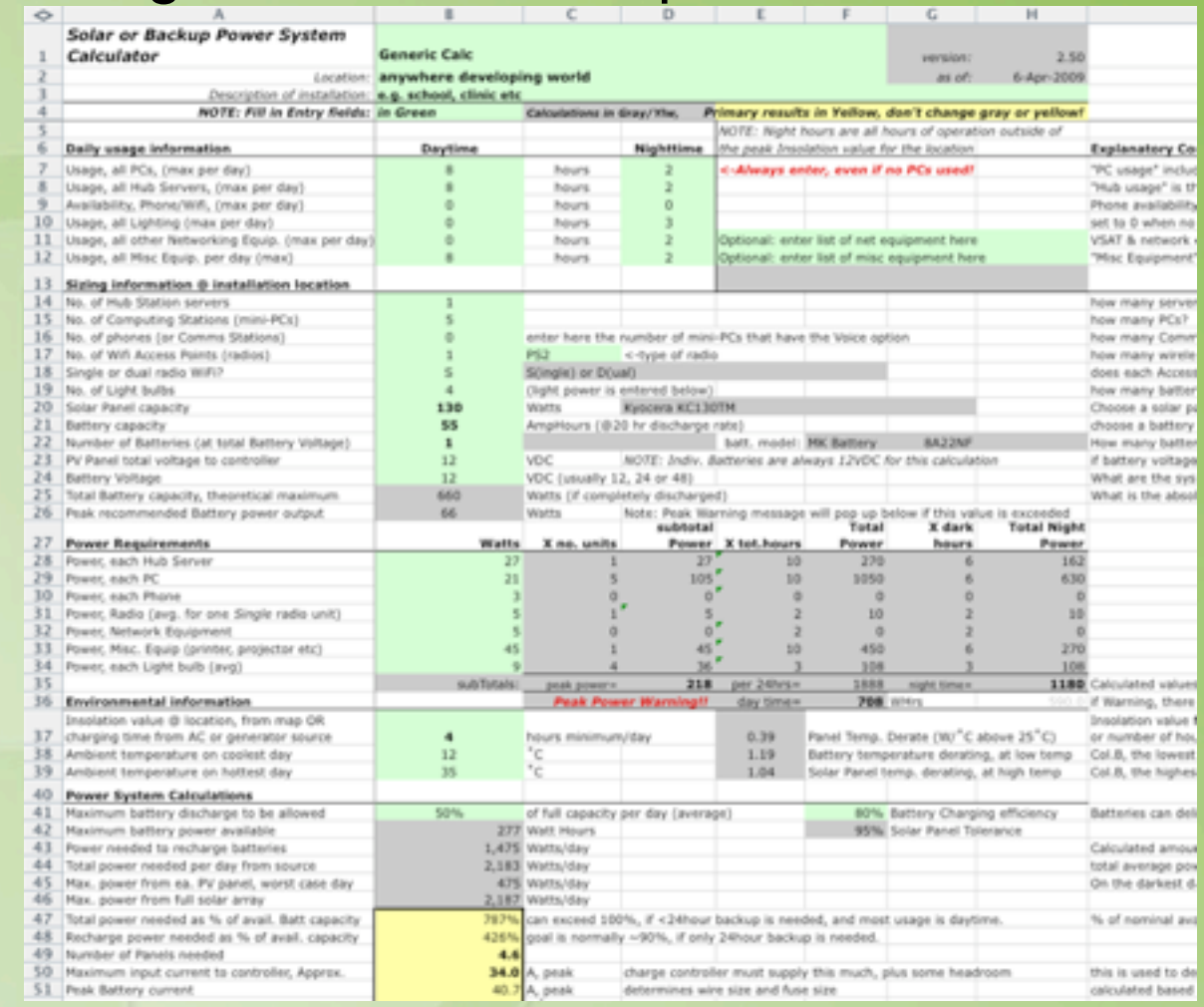
Komtoega, Burkina Faso IT classroom building

Site Survey Issues

1. Access to site?
2. Where will panels go?
3. Where will batteries and charger go?
4. How much wiring is needed? What size?
5. What type of loads? - equipment, lighting?
6. What is the security situation on site? Bars on windows and doors? Guard on site? Local people living close by?

Power Budgeting

1. Judgment based on type of installation and usage
2. Using the calculation spreadsheet



	A	B	C	D	E	F	G	H	
1	***Solar or Backup Power System Calculator***	**Generic Calc**					version:	2.50	
2	*Location:*	**anywhere developing world**					*as of:*	6-Apr-2009	
3	*Description of installation:*	**e.g. school, clinic etc**							
4	***NOTE: Fill in Entry fields:***	***in Green***	***Calculations in Gray/Yhe,***		***Primary results in Yellow, don't change gray or yellow!***				
5					*NOTE: Night hours are all hours of operation outside of*				
6	**Daily usage information**	**Daytime**		**Nighttime**	*the peak Insolation value for the location*				**Explanatory Co**
7	Usage, all PCs, (max per day)	8	hours	2	***<-Always enter, even if no PCs used!***				"PC usage" inclu
8	Usage, all Hub Servers, (max per day)	8	hours	2					"Hub usage" is t
9	Availability, Phone/Wifi, (max per day)	0	hours	0					Phone availabilit
10	Usage, all Lighting (max per day)	0	hours	3					set to 0 when no
11	Usage, all other Networking Equip. (max per day)	0	hours	2	Optional: enter list of net equipement here				VSAT & network
12	Usage, all Misc Equip. per day (max)	8	hours	2	Optional: enter list of misc equipment here				"Misc Equipment"
13	**Sizing information @ installation location**								
14	No. of Hub Station servers	1							how many serve
15	No. of Computing Stations (mini-PCs)	5							how many PCs?
16	No. of phones (or Comms Stations)	0	enter here the number of mini-PCs that have the Voice option						how many Comm
17	No. of Wifi Access Points (radios)	1	PS2	<-type of radio					how many wirele
18	Single or dual radio WiFi?	S	S(ingle) or D(ual)						does each Acces
19	No. of Light bulbs	4	(light power is entered below)						how many batter
20	Solar Panel capacity	**130**	Watts	Kyocera KC130TM					Choose a solar p
21	Battery capacity	**55**	AmpHours (@20 hr discharge rate)						choose a battery
22	Number of Batteries (at total Battery Voltage)	**1**			batt. model:	MK Battery	8A22NF		How many batte
23	PV Panel total voltage to controller	12	VDC	*NOTE: Indiv. Batteries are always 12VDC for this calculation*					if battery voltage
24	Battery Voltage	12	VDC (usually 12, 24 or 48)						What are the sys
25	Total Battery capacity, theoretical maximum	660	Watts (if completely discharged)						What is the abso
26	Peak recommended Battery power output	66	Watts	Note: Peak Warning message will pop up below if this value is exceeded					
27	**Power Requirements**	**Watts**	**X no. units**	**subtotal Power**	**X tot.hours**	**Total Power**	**X dark hours**	**Total Night Power**	
28	Power, each Hub Server	27	1	27	10	270	6	162	
29	Power, each PC	21	5	105	10	1050	6	630	
30	Power, each Phone	3	0	0	0	0	0	0	
31	Power, Radio (avg. for one *Single* radio unit)	5	1	5	2	10	2	10	
32	Power, Network Equipment	5	0	0	2	0	2	0	
33	Power, Misc. Equip (printer, projector etc)	45	1	45	10	450	6	270	
34	Power, each Light bulb (avg)	9	4	36	3	108	3	108	
35		subTotals:	peak power=	**218**	per 24hrs=	1888	night time=	**1188**	Calculated value
36	**Environmental information**		***Peak Power Warning!!***		day time=	**700**			if Warning, there
37	Insolation value @ location, from map OR charging time from AC or generator source	**4**	hours minimum/day		0.39	Panel Temp. Derate (W/°C above 25°C)			Insolation value or number of ho
38	Ambient temperature on coolest day	12	°C		1.19	Battery temperature derating, at low temp			Col.B, the lowest
39	Ambient temperature on hottest day	35	°C		1.04	Solar Panel temp. derating, at high temp			Col.B, the highes
40	**Power System Calculations**								
41	Maximum battery discharge to be allowed	50%	of full capacity per day (average)			80%	Battery Charging efficiency		Batteries can de
42	Maximum battery power available	277	Watt Hours			95%	Solar Panel Tolerance		
43	Power needed to recharge batteries	1,475	Watts/day						Calculated amou
44	Total power needed per day from source	2,183	Watts/day						total average po
45	Max. power from ea. PV panel, worst case day	475	Watts/day						On the darkest d
46	Max. power from full solar array	2,187	Watts/day						
47	Total power needed as % of avail. Batt capacity	787%	can exceed 100%, if <24hour backup is needed, and most usage is daytime.						% of nominal av
48	Recharge power needed as % of avail. capacity	426%	goal is normally ~90%, if only 24hour backup is needed.						
49	Number of Panels needed	**4.6**							
50	Maximum input current to controller, Approx.	**34.0**	A, peak	charge controller must supply this much, plus some headroom					this is used to de
51	Peak Battery current	40.7	A, peak	determines wire size and fuse size					calculated based

Preparing for Deployment

Importance of attitude

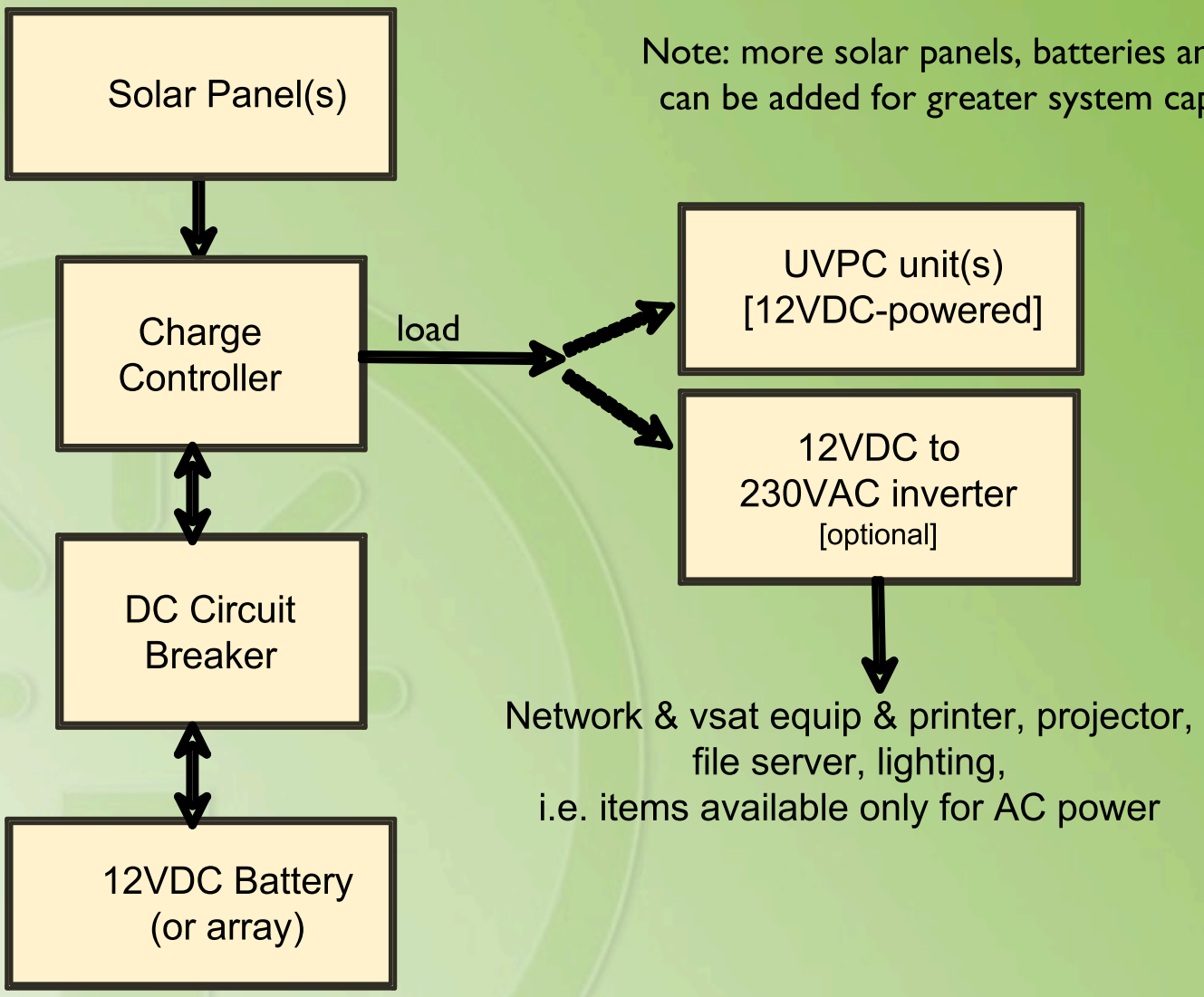
Be flexible and creative

Get the job done

“Time is Money”

So… PLAN AHEAD!

An Actual Solar Installation



Note: more solar panels, batteries and PCs can be added for greater system capacity

An Actual Solar Installation

Panels on school roof

CEG Komtoega, Burkina Faso

An Actual Solar Installation

CEG Komtoega, Burkina Faso

Installing a Solar System

Different Scenarios

Directly on a roof

With custom supports

Installing a Solar System

Lightning protection for solar, radio and network equipment.

Installing a Solar System

Wiring DC Hardware

Job well done!

Teachers using computer lab powered by the new solar system