SOLAR II

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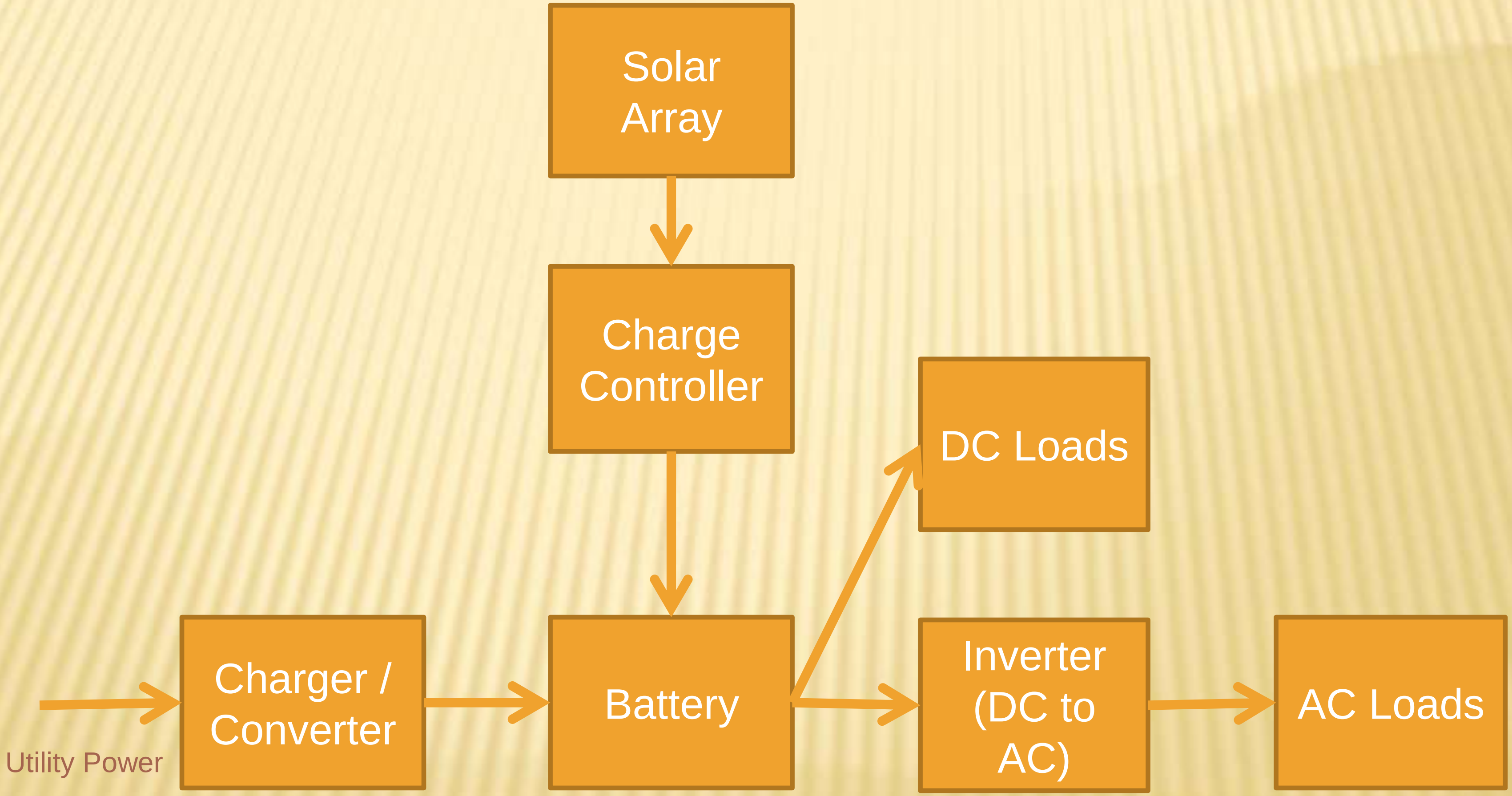
WHY BOTHER?

- No utility power available
- Reduce costs of utility power
- Reduce dependency on utility power
- Reduce environmental impact


SPORTSMOBILE
4x4

WHAT ARE THE COMPONENTS?



ESTIMATING POWER REQUIREMENTS

1. List items requiring power
2. Estimate power usage
3. Estimate hours of usage per day
4. Estimate total energy required per day

ESTIMATING POWER REQUIREMENTS

- Maximum power requirements per Apple manuals or labels:

Item	Power (Watts)
Apple //+ CPU	132 W (13 W w/ 48 KB and no peripherals)
Apple //e CPU	80 W (60 W typical)
Apple //c CPU	25 W
Apple //c+ CPU	36 W
Apple IIgs CPU	43 W
AppleColor Composite Monitor	75 W (50 W typical)
Monitor IIc (9”)	36 W
Apple Monochrome (12”)	45 W (20 W typical)
AppleColor RGB	90 W (65 W typical)

ESTIMATING POWER REQUIREMENTS

- Measured power draw for an Apple //c (ROM FF) with an Apple 9” monochrome monitor:

Item	Power
Power brick alone	2 W
9” monitor	20 W
CPU	12 W typical
CPU + monitor	31 W min / 40 W max

ESTIMATING POWER REQUIREMENTS

- Power measurements from a comp.sys.apple2 thread started on 4/11/2011:
  - Apple //e main board only (DC input): 4.2 W
  - Apple //c: 25 W (May be suspect. Same as maximum rating of brick.)
  - Apple 9” monitor: 60 W (May be suspect. Exceeds rating printed on monitor.)
  - Apple //e with monitor, DuoDisk, SSC, and System Saver: 87 W (startup), 72 W (boot), 66 W (idle)
  - Apple //e with DuoDisk, SSC, and System Saver: 34 W (startup), 29 W (boot), 24 W (idle)
  - System Saver //e: 7 W

ESTIMATING POWER REQUIREMENTS

Item	Power (Watts)	Usage (Hours per Day)	Energy (Watt-Hours per day)
Apple //c CPU	25 W	8 hours/day	200 Wh/day
Apple 9” Monitor	36 W	8 hours/day	288 Wh/day
		Total:	488 Wh/day


pico

SYSTEM DESIGN

1. Estimate solar radiation
2. Size solar array
3. Size battery bank

SOLAR ARRAY SIZING

On average how much energy will your solar array produce?

- *National Renewable Energy Laboratory (NREL) Renewable Resource Data Center* (http://www.nrel.gov/rredc/pvwatts/)
- *Solar Radiation Data Manual for Flat-Plate and Concentrating Collectors* (http://rredc.nrel.gov/solar/pubs/redbook/)

SOLAR ARRAY SIZING

$$P_{solar} = \frac{E_{required}}{T_{solar\ hours}} \times \frac{1}{\eta}$$

P_{solar}: $minimum\ power\ generation\ to\ break\ even$
$E_{required}$: $energy\ required$
$T_{solar\ hours}$: $equivalent\ solar\ hours\ per\ day$
η: $derating\ factor\ (conversion\ efficiency)$

SOLAR ARRAY SIZING

- System conversion efficiency varies and may be as low as 50% to 80%.
- Efficiency depends on:
  - Nameplate rating (-5% to +5%)
  - Charge controller losses (1% to 10%)
  - Inverter losses (8% to 30%)
  - Battery losses (2% to >25%)
  - AC and DC wiring losses (3% to 7%)
  - Angle of incidence (0% to 100%)
  - Temperature (12%)
  - Soiling (5% to 15%)
  - Shading
  - Age

SOLAR ARRAY SIZING

$$P_{solar} = \frac{488\ Watt \cdot hours/day}{4.3\ solar\ hours/day} \times \frac{1}{0.77}$$

$$= 147.4\ Watts \approx 150\ W$$

(minimum to break even each day)

BATTERY BANK SIZING

- What happens when solar power is insufficient or unavailable?
- How long must stored power last?

- Most batteries must not be discharged less than 50%.

BATTERY BANK SIZING

$$Bank\ size(Ah) = \frac{E_{required}}{V_{system}} \times T_{reserve} \times \frac{1}{0.50}$$

$$Bank\ size(Ah) = \frac{488\ Wh/d}{12.6\ Volts} \times 3\ days \times \frac{1}{0.50}$$
$$= 232\ Amp \cdot hours$$

CONSIDERATIONS

- Plan for the minimum and maximum solar radiation (e.g. bad weather, storms, clouds, etc.).
- Plan for temperature variations (both when matching controller to array and when estimating system performance).
- Consider consequences of insufficient power.
- Consider alternative power sources.

REDUCING POWER REQUIREMENTS

- Replace the CRT
- Remove unused cards or peripherals
- Skip the inverter (run off DC)