1. **Stand-Alone PV Systems**

   - PV systems not connected to the power grid
   - Technically includes applications such as:
     - satellites → specialty app
     - calculators and toys
     - cellphone rechargers for camping → low power, battery replacement apps
     - pumping water, emergency phones signs

   - Generally thought of as a replacement for grid power in homes or other buildings

   **Reasons:**
   1. home/building far from the grid
   2. replacement for other non-grid power sources like a diesel generator
   3. people who do not want to be connected to the grid: "off-the-grid" living

a. Example "off-the-grid" application

   - show [Fig. 5.1]

   Box (1) → PV array mounted facing toward the sun at an optimal angle
   - underground cables from PV array to building

   Box (2) → small windmill. Often, in stand-alone PV systems, other electricity producing systems are used with PV
   - such as: wind, diesel/gas powered, small hydro, etc.

   Ex: wind + PV: wind might blow at night when PV is unusable
Figure 5.1 Remote and independent: a stand-alone system for a farmhouse.
Box (3) → charge controller. Each electricity producing device has its own charge controller. The charge controller regulates the flow of charge into the battery bank.

Box (4) → rechargeable battery bank, typically 12V or 24V, but could be of higher voltage.

Box (5) → inverter. Note, this inverter does not have to synchronize itself to the grid and is therefore simpler.

Box (6) → fuse-or-breaker box.

Box (7) → electrical loads. Note, in stand-alone PV (or wind) systems, electricity is a precious commodity and normally not used for power hungry applications for which other technologies exist.

Ex: ① heating → thermal solar or wood/gas burning
    ② cooking → wood/gas stove
    ③ hot water → solar/gas
    ④ air conditioner → fans or underground forced air

Typical uses: ① lights
        ② refrigeration
        ③ consumer electronics
        ④ pumping water
        ⑤ air movement

Note: It is possible to bypass the inverter and run everything on 12V DC → typical for cars and small boats.
1. Historically (pre 1990) → Stand-Alone PV systems
   → PV modules were designed for charging 12V batteries
   → a Si PV module with 36 cells in series yields ~20V
     open-circuit and 17V at MPP in bright sunlight
     → sufficient for charging 12V batteries
   → Typical 12V lead-acid batteries approach 14.5V at full charge
   → The "extra voltage" from the PV system is used up by the blocking diode and charge controller, and to ensure sufficient operation in reduced sunlight or at elevated module temperature

Note: Grid connected systems favor higher PV module output voltages than battery charging systems
   → i.e. carefully select an appropriate PV module for a battery recharging application

2. Stand-Alone PV without battery storage or inverter
   → PV module supplies DC power directly to the load
   → Example: A PV array powering an irrigation or livestock watering pump
     → runs when there is sufficient sunlight and a kill switch (tank water level for example) is not tripped
→ Advantage of solar vs windmill powered pumps:
  - The windmill system has a lot more moving parts compared to PV → requires more maintenance.
→ Advantages of not having batteries in the system:
  1. Using batteries creates electrical loss, which reduces overall efficiency.
  2. Batteries (along with the required extra cables, charge controller and battery enclosure) increase system cost.
  3. Batteries require care and maintenance.
     - If they freeze, they can be damaged.
     - Overcharging or high temperature can reduce battery operating lifetime.
→ Key to this application is to store enough water during sunshine operation to last until the next opportunity to pump.
→ Show photos of PV agricultural applications.

3. Stand-Alone PV with battery storage but without an inverter.
→ PV → battery → DC load.
  a. Use PV to recharge consumer electronic devices that already have rechargeable batteries.
     - Ex: cell phone, flashlight, laptop, MP3 player.
→ Show photos.
Check Out This Great Deal..

ReVIVE Series Solar ReStore External Battery Pack with Universal USB Charging Port for Portable Smartphones / E-readers / MP3 Players and More USB Powered Devices

Buy new: $49.99 $27.99

http://cellphonesolarcharger.net/

4W PV Backpack: $199 – recharges your electronics

Solar powered "geek hat": PV powers small fan under the bill of the hat: $3.99

http://www.coated.com/solar-powered-cap/
b. Use PV to recharge battery operated vehicles, like
golf carts
  → show photo

c. For stand-alone emergency phones, railroad crossing
  signals

d. For garden lighting systems
  → Typical design: PV recharges NiCd battery(s) during
  day to "fully charged"
  → CdS photocell (high R in dark, lower R in sunlight)
  ~200kΩ
  ~10kΩ
  used to turn light on at night
  → light fully discharges NiCd battery by morning

e. Other agricultural applications
  → PV electric fence charger
Solar powered flood light

www.lowes.com

CdS photocell

http://www.ladyada.net/learn/sensors/cds.html
PV electric fence charger
http://farm4.staticflickr.com/3043/2701996483_aacf768b70_z.jpg
Solar Powered Dock Light


Solar Powered Road Lights