The Solar Market Garden

The Solar Market Garden is a technology designed to help rural farmers generate income and to combat food and nutrition insecurity in the developing world. The Solar Market Garden combines solar (photovoltaic) water pumping and low-pressure drip irrigation, allowing farmers in remote, dry regions to grow high-value and nutritious crops year-round. This flier describes Solar Market Gardens installed in Kalalé, Benin, by the Solar Electric Light Fund (SELF) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) as part of the Kalalé Solar Electrification Project.

Solar-powered water pumps have long been used in remote regions for reliable water delivery. In rural areas, where the price of diesel for generators is frequently highest, and the supply most unreliable, solar-powered pumps are both clean and cost-effective. Drip irrigation is a proven efficient and labor-saving technology that delivers water directly to plant roots and facilitates simple and uniform fertilizer application. With drip irrigation, farmers can achieve higher yields over larger areas with less water and labor.

As shown in the cartoon above, the Solar Market garden consists of a solar-powered water pump that fills a ferro-cement reservoir. The reservoir, in turn, gravity-distributes water to a drip irrigation system. Solar Market Gardens can draw from both surface and groundwater sources, as described on the following pages. The Solar Market Garden is a direct-coupled system (no batteries); it is simple and safe to install and operate.

A Solar Market Garden costs approximately $20,000USD (not including the cost of a borehole if needed). When used to cultivate high-value crops, the payback time for this investment is 2-3 years. For more information about the Solar Market Garden, contact the Solar Electric Light Fund (SELF) at +1.202.234.7265 or info@self.org.

THE SOLAR MARKET GARDEN is based on the African Market Garden (AMG) concept developed by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), in Niamey, Niger. Please visit the ICRISAT AMG website: http://www.icrisat.org/wca/project6.htm

Top: Planting (panels in background)
Middle: Dry season lettuce harvest
Bottom: First market sales
Surface Water Systems

In the village of Bessassi, the two women’s groups use twin half-hectare Solar Market Gardens that draw irrigation water from a small year-round stream. Each SunCentric 7526 pump (24V nominal) is powered directly by a set of 6 SunTech Power 170S-24 Panels (35V/4.95A) wired in parallel. The pumps have a suction limit of 3m, and are thus situated at stream’s edge. A concrete pumphouse provides protection from normal seasonal rains, and the intake structures and pumps are designed to be easily removable in the rare event of high water. Voltage drop considerations limited placement of panels to 15m from the pumps. The panels are mounted at a fixed angle on 0.5m x 1m high reinforced concrete footers. Water is transported to the reservoirs (180m away) via 63mm PVC pipe (gasket connections for durability and repair simplicity) laid 0.5m deep under the garden area. To protect the pumps and prevent clogging of the drip irrigation lines, inline basket filters have been integrated into the intake structure in addition to the regular foot valve [see http://haywardindustrial.com]. The filters are cleaned at least once daily, as necessary. The entire intake structure at Bessassi was designed to be metal-free, as the area is home to crocodiles considered sacred by locals, who honor the reptiles by not placing metal in the stream.

Pump Specs and Performance:

[sources: http://www.conergy.com (left) and Bessassi field data (above)]
Groundwater Systems

In the village of Dunkassa, the women’s group uses a half-hectare Solar Market Garden that draws water from a borehole approximately 600 meters from the garden site. The Grundfos SQFlex 16SQF-10 (210V) submersible pump lies 25m deep and is powered by 12 SunTech Power 170S-24 Panels (35V/4.95A) wired as two parallel strings of 6 panels. A controller limits the pump input power to 1.4kW / 8.4A, and the pump is equipped with a water level sensor that automatically cuts power if the water level is too low. Voltage drop considerations limited placement of panels to 15m from the borehole, conveniently near the front porch of the village health clinic. Because the system is somewhat oversized, one set of panels may in the future also be used to provide power in the clinic. (The pumping capacity of this system is limited by the recharge rate of the borehole, which averages 40-50 L/minute.) The panels are mounted at a fixed angle on 0.5m x 1m high reinforced concrete footers. Water is transported to the reservoirs via 63mm PVC pipe (gasket connections for durability and repair simplicity) laid 0.5m deep along the side of the road between the clinic and the garden. A ‘T’ at the pump head can additionally divert water for drinking if needed.

Pump Specs:

Panel Specs (for both Surface and Groundwater Systems):

[source: http://www.conergy.com]
Reservoirs

For both surface and groundwater systems, water is pumped to a ferro-cement reservoir, which then gravity-distributes the water to a low-pressure drip irrigation system. These reservoirs are 4m tall and 4m in diameter, with 20cm thick walls. The entire reservoir sits 0.5m deep in the ground. Reservoirs are constructed using a segmented metal mold: the lower section is poured and cured, and then the mold is re-stacked on top of the lower section to pour the upper section. The floor is then poured and sealed. Each reservoir uses approximately 1.5T of cement, 180m of 10mm rebar, and 288m of 8mm rebar. Mixing and hauling all materials by hand, one reservoir can be constructed in 3-4 days.

In the Kalalé Solar Market Gardens, the underground piping from the pumps is simply extended up and over the edge of the reservoir for filling. The main outlet to the field is located 1.2m off the ground, and an overflow outlet lies 20cm from the top. Making the usable volume of water (the volume above the outlet) approximately 21m³. The reservoir also features a drain at ground level to facilitate monthly cleaning. Stainless steel outlet pipes and valves are cemented directly into the reservoir walls for structural integrity.

Drip Irrigation Systems

Both surface and groundwater systems utilize drip irrigation systems fabricated by NaanDan Jain Irrigation [see: http://www.naan.co.il, product line is NaanRON]. Each Solar Market Garden is approximately 0.5ha (60m wide x 80m long), with a slight downward slope away from the reservoir. The height of the water column above the outlet valve of the reservoir provides the pressure necessary to irrigate the entire garden uniformly.

Water leaving the reservoir passes through a large filter to help prevent clogging of the drippers (the filter is cleaned daily). The garden is divided into an upper field and a lower field, each fed by its own independently-valved, 63mm polyethylene central line connected to the filter. The two fields are watered in succession (upper, then lower, to maintain pressure). Both upper and lower fields are divided into 1.8m-wide beds on either side of the central 63mm line that are each fed by three 16mm polyethylene laterals. (Individual beds are separated by 20cm pathways.) The laterals have drippers every 30cm, with small labyrinth filters at each dripper to prevent clogging and maintain pressure. Lateral ends are clamped closed and central line ends are capped; both can be easily opened for flushing. Twice per year, laterals are removed and fully cleaned in an acidic solution.

Additional Notes

Bed Preparation: Garden beds are raised to facilitate runoff and allow for easy access to the entire bed length. Manure/compost (10,000kg per garden) and NPK (500kg per garden) are added to the garden beds before and after the rainy season. Fertigation: Fertilizer can be added directly to the reservoir for simple and uniform application across the garden. Currently each group uses 2-4kg of Urea per day.