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GLOBAL CHALLENGES AND OPPORTUNITIES

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Sun-Powered Irrigation

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If poor farmers in Ghana, India, or China want to water small plots of vegetables to sell in the local market, they break their backs hauling water in buckets or sprinkling cans from a nearby stream. It takes six hours a day, every other day, for three months to water 400 m^2 (0.1 acre) of vegetables, which they hope to sell for $100 US. In India and Nepal, a treadle pump that costs less than $100 will irrigate as much as 0.2 ha (0.5 acre) with about six hours a day of work. A five-horsepower diesel pump can irrigate 1.0 ha (2.5 acres) of vegetables, but it costs $500, plus $450 a year for diesel fuel and another $150 a year for repairs, not counting the damage to the crop while the pump is waiting to be repaired.

What if the same farmers could use electric pumps, powered by solar photovoltaic panels, and drip irrigation to water 1 ha (2.5 acres) of vegetables? The fuel costs and operating costs would be pretty close to zero, but there's a big catch. Currently, a solar PV-powered drip irrigation system of that size would cost about $10,000! The small farmers in Asia and Africa could never afford to buy one.

A young bride in Nepal shows off her favorite wedding present, a treadle pump for irrigating the family's vegetable plot.

Who we are and what we do

We are a team of professionals dedicated to improving the income of the rural poor. We subscribe to zero-based design coupled with the relentless pursuit of affordability and a market-driven approach to accomplishing this. This development approach is outlined in a book that has just been released: *The Business Solution to Poverty* by Paul Polak and Mark Warwick. The basic premise of zero-based design is to begin from scratch and focus on searching out the most cost-effective solution for each component of the complete system.

Using the zero-based design approach, we decided that we could find a way to cut the retail cost of a solar-powered drip irrigation system to $4,000 for 1 ha (2.5 acres) of diversified off-season fruits, vegetables, and spices. That way, smallholder farmers could have food security for their families and clear at least $4,500, enough to make payments on a three-year loan or lease and put some real money in their pockets. By finding a way to achieve breakthrough affordability for PV-powered pumping and efficient irrigation, smallholder farmers all over the world could move out of poverty. At the same time, they could provide jobs for their neighbors in planting, weeding, harvesting, and marketing the crops they grow.

India, for example

Today, in India alone, 19 million diesel engines are being used to pump irrigation water from shallow wells, spewing millions of tons of carbon into the atmosphere. If market forces could replace a quarter of them with radically affordable solar PV-powered pump systems and drip or mini-sprinkle irrigation, we could transform smallholder farmer livelihoods and radically reduce rural carbon emissions.

Presently, we are in the process of developing cost-effective PV-based, low-pressure irrigation systems and establishing a commercial enterprise to promote their adoption by farmers in India and other Asian counties. Minimizing the energy requirements is essential for building a cost-effective PV-powered pumping system to irrigate crops. We are accomplishing this by applying a systems approach to optimize the energy and water flow components from the water supply to the irrigated crops. These components include the PV array, with or without mirror concentrators and tracking; the DC or

AC motor and pump mechanism; the well filter and screen, which are designed to reduce drawdown to optimize water output from the solar input; and low-pressure water conveyance and application systems to optimize crop production per unit of irrigation applied.

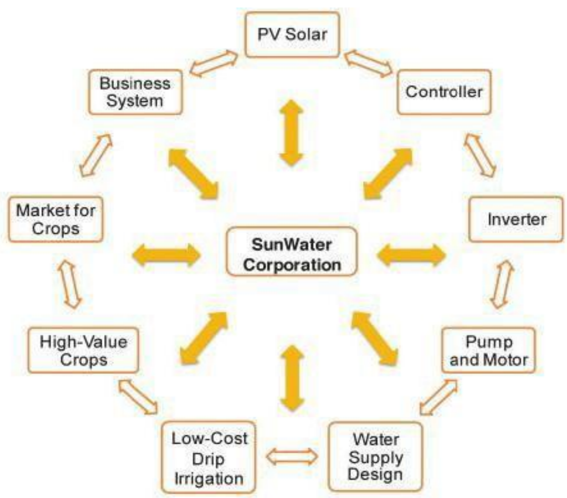
A mixed vegetable farm with summer squash and pole beans under drip irrigation.

What does this involve?

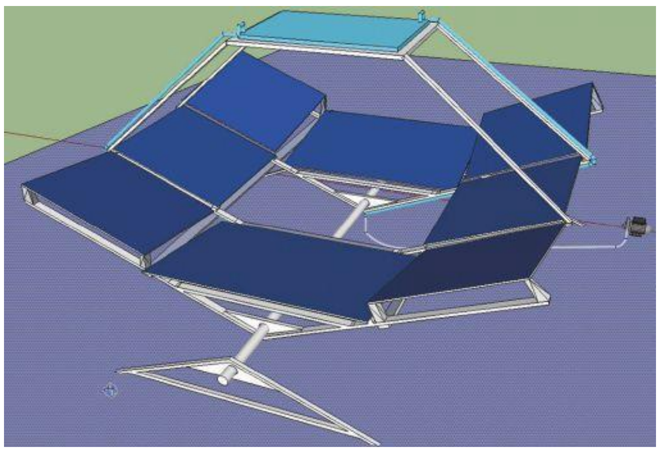
To pull it off, we need to work on solar power, pumping, water supply, irrigation, and livelihood-enhancing high-value crop production and marketing as a total system, with each component of the system influencing the design of every other component. The diagram below shows what this interactive system looks like.

While working with International Development Enterprises, an NGO located in Denver, Colo., we succeeded in reducing the market price of drip irrigation by employing very low operating pressures. This allows the use of recycled plastic tubing and simpler fittings and valves to break the irrigated area into subplots supplied by thin-walled lay-flat drip lines. We also employed wide flow path emitters, allowing the use of affordable filters to remove dirt from the water. With a water supply well at the field boundary, our 1 ha (2.5 acre) drip system will be designed to provide a net water application of up to 7 mm (0.28 in.) per day and requires an inlet pressure of only 39.2 kPa or 4.0 m of pressure head (5.7 psi) and an overall pump head requirement of only 9.0 m (29.5 ft) when combined with an assumed 5.0 m (16.4 ft) dynamic suction lift.

Despite the fact that the price of solar PV systems has dropped significantly over the past ten years, the capital cost of an installed PV system to pump irrigation water is still too high. But there are options for further lowering the capital cost. For example, a simple glass mirror is much cheaper than a solar panel. If we use mirrors to concentrate sunlight onto a solar panel, we can increase the generated power. Since we're pumping water, we can pump a small amount of water through a simple heat exchanger on the back of the PV panel to keep the panel from overheating.



The above diagram shows the solar-powered drip irrigation system and market development interactions.



Eight mirrors focused on a PV solar panel with water cooling.

How to make ends meet

To afford a PV-powered pumping system supplying a low-cost drip system, and make a reasonable livelihood at the same time, smallholder farmers need to irrigate in the dry season, when vegetable prices are two or three times as high as they are during the rainy season, when everybody can grow vegetables. Savvy farmers plant four or five high-value crops because it's impossible to predict what the market price for any one crop will be, and diversified cropping lowers both plant disease risks and market risks and increases the probability that at least one of the crops will generate a lucrative profit. Field tests in a variety of countries have demonstrated that typical farmers can earn a net income after expenses of $0.45 per square meter, or $4500 from 1 ha (2.5 acre) of diversified high-value cash crops, such as off-season vegetables in local urban markets. So it's just as important to help farmers optimize their income as it is to lower the cost of pumping and improve the efficiency of conveying and applying water from its source to the crop.

A local urban market in Nepal. ***Photo courtesy of IDE.***

The best way to reach scale is to release market forces, creating opportunities for every participant in the market to earn a reasonable profit. This includes the manufacturers of both the PV-powered pumping systems and the irrigation systems, the dealers who sell them, the technicians who install them, and the farmers who buy them to improve their livelihoods.

Taking the first step

The first barrier to profitability is the capital cost of $4,000 for the total system. Even though it can earn attractive returns on investment, the upfront cost is too high for most smallholder farmers. For this reason, an important player in the system needs to be a business that offers solar PV-powered pumping and irrigation systems on a lease basis or on credit, with the lease/credit business also earning an attractive profit.

To energize this project and ultimately the market, a holding company, called Paul Polak Enterprises, has been formed. This company is partnering with volunteer engineers from Ball Aerospace, called the Design Revelation Employee Resource Group, headed by Paul Storaci. Ball Aerospace is providing workshop facilities, and staff engineers and technicians are donating their time and talents as a contribution to this initiative. These guys are good: Ball Aerospace built the instruments on the Hubble Space Telescope. Now they are charged with building the proof-of-concept prototype of the low-cost solar PV-powered pumping system.

Meanwhile, two of this feature's co-authors—Jack Keller and Robert Yoder, world authorities on small-plot irrigation and development—are working on the design and beta testing of the total system, and the pilot commercial rollout in Gujarat, India. In India, we will be working with an Indian subsidiary of Paul Polak Enterprises that will play the local leadership role. From Gujarat, SunWater India will initiate a full-scale rollout of the affordable solar PV-powered pumping and irrigation system in India's eastern states, where the majority of India's 19 million diesel pumps are located. After we create a new market for solar PV-powered irrigation in India, our dream is to take it to other countries in Asia and throughout the world.

Each dream starts with a first step, and our first step was to raise $32,000 in an Indiegogo (crowd funding) campaign to fund the completion of the proof-of-concept prototype by the volunteer engineers at Ball Aerospace. That goal has been met. Stay tuned for the rest of the story.

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