Distribution Systems

On-line water main rehabilitation in Hong Kong

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Sun- and Wind-powered

Solar Cube Is a Self-contained Water Purification System

Depending on the water source, the Solar Cube™ can produce from 1,500 to 3,500 gal of potable water per day. While the machine is purifying water, its photovoltaic cells and wind generator can also produce enough excess power to operate emergency equipment.

By Richard Wood

The Solar Cube™, a portable and self-contained water purification system that uses solar and wind power, has been introduced in the United States by Spectra Watermakers Inc., a Northern California water treatment company. Grounded in Spectra’s reverse osmosis (RO) technology, the Solar Cube incorporates automatic backflush pretreatment, which makes this small, efficient water treatment unit ideal for providing disaster relief, supplying water to remote villages, or simply operating in an off-the-grid mode as a desalination and water purification unit.

This small plant comes in several configurations and can produce from 1,500 to 3,500 gal of potable water per day, depending on the water source. Its modular construction facilitates ease of handling, maintenance, and placement. The Solar Cube can also provide enough energy for emergency disaster officials to power refrigeration equipment for emergency medical supplies, keep a laptop online, or ensure that crisis communications equipment remains operational. In remote villages without infrastructure, it could be a source of clean potable water and electricity.

Solar Cube can save lives

“If New Orleans had had the Solar Cube when Hurricane Katrina struck, water for the troubled city would have been readily available,” said Bill Edinger, president of Spectra Watermakers Inc. “The Solar Cube’s pump could have been placed in the streets flooded with brackish water, and it would have filtered out up to 3,500 gpd per unit. This machine has the ability to save lives.”

After the major earthquake in Pakistan in 2005, the Solar Cube provided drinking water and electrical power to several villages in the country. During the past year, the Solar Cube has been introduced into remote areas of Asia and South America that have no access to clean drinking water or electricity.

The Solar Cube’s photovoltaic cells will generate up to 1,240 W at 24 V of direct current, and the machine’s wind generator will produce up to 1,000 W at 24 V of direct current. The water purification system requires about 900 W to operate, which leaves upwards of 1 kW in excess power to operate emergency equipment. The unit can also be plugged into the electric grid or a generator for its power.
Fortunately, choosing between quality and cost is no longer an issue.

As shown in Figure 1, the Solar Cube package is made up of three modules that slide into a framework. All of the casing and the components inside are made of marine-grade corrosion-resistant materials. One module houses the prefiltration system, which includes one 100-µm and two 25-µm self-cleaning filters, expansion tanks for the flushing cycle, and the backwashing and feedwater pump controls. A submersible borehole-type pump delivers source water to this module. The RO module houses Spectra’s energy-efficient Clark Pump, the RO membranes, a 5-µm filter, the feed and injection pumps, and a product water tank for the membrane backflush cycle. The face panel for the RO module includes displays for the injection speed rheostat and the meters indicating the system’s pressure, boost pressure, feed flow, product flow, and filter pressure differential. The third module houses a 200-Ah battery bank, an inverter/charger, and the controls for the solar panels and wind generator. The face panel of this module has receptacles for 24-V output and 110- or 220-V input and output, the master switch, and the switch for the submersible pump. The entire unit, excluding the wind generator, covers about a 5-ft square and weighs 3,000 lb.

The Solar Cube can process a broad spectrum of source water that ranges from surface water to contaminated and brackish groundwater to seawater. Its system is very efficient (watts per gallon), with a high, consistent recovery rate of around 30%. The feed pressure to the membrane system is manually controlled to optimize the output and water quality (and to compensate for variations in salinity and temperature). A Solar Cube, which ranges in cost from $38,000 to $80,000, can be set up and running in less than an hour and has an expected service life of about seven years.

For the Solar Cube product line, Spectra is collaborating with Trunz Metaltechnik AG in Arbon, Switzerland. Trunz is an ISO-certified metal fabrication and water treatment systems company known throughout Europe for its high-quality manufacturing processes. Trunz builds the stainless-steel modules and integrates its proprietary automatic backflushing prefiltration system with Spectra’s energy-efficient RO plant. Spectra markets the full range of water treatment products produced by Trunz.

Spectra has been manufacturing RO desalination systems for more than 10 years, primarily in the marine industry for onboard use in various types of vessels. Spectra’s systems are particu-
larly useful in smaller vessels—where case of use, dependability, and energy efficiency are paramount. Spectra’s patented high-efficiency, hydraulically powered Clark Pump (Figure 2) is a key factor in enabling the application of photovoltaics as the source of electrical power in the Solar Cube and similar products.

INNOVATIVE PUMP CONSUMES LITTLE ENERGY

The Clark Pump is an energy recovery and pressure amplification innovation. It is powered by a flow of relatively low-pressure water (at about 80–100 psi) from a separate, low-power-consuming electric pump—ultimately delivering the feedwater at a pressure of approximately 800 psi to the RO membrane.

As shown in Figure 2, the Clark Pump uses two opposing cylinders, with pistons that share a single rod that passes through a center block. A reversing valve (which is controlled by a pilot valve that is mechanically actuated by the pistons) allows the cylinders to alternate between driving and pressurizing. The driving cylinder has feed pressure pushing on the top of the piston, and the driving piston pushes the rod through the center block. The water under the driving piston (brine), which has gone through the membrane on the previous stroke, is discharged. A cylinder starts to pressurize when the rod is forced into it. As the rod pushes the driven piston, it circulates the water on top of the piston through the membrane and back to the reversing valve. The reversing valve directs it back into the same cylinder under the driven piston where the rod is entering. This creates a closed loop between the cylinder and membrane. The rod displaces water as it enters the cylinder, and, because the displaced water has no place to go, the pressure instantly rises until there is enough pressure for RO to occur in the membrane—allowing the displaced water to be forced out as product. Thus, an amount of fresh (displaced) water that is equal to the volume of the rod entering the cylinder is produced on every stroke as the piston circulates the water through the membrane. When the driven piston bottoms out on

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FIGURE 1 The modular system of the Solar Cube™

Wind generator can provide 1,000 W of 24-V direct current.

Solar panels can provide 1,240 W at 24-V of direct current.

Electrical module includes storage batteries, controllers, and an inverter/charger that provides emergency alternating current power.

From 1,500 to 3,500 gal of potable water—free of bacteria and viruses—can be produced each day.

Submersible feedwater pump delivers salt, brackish, or contaminated water to the Solar Cube.

Reverse osmosis module houses the pumps and membranes for water purification and desalination.

Prefilter module houses controls for the feed pump and the self-cleaning prefilters.

Source: Spectra Watermakers Inc.
the center block, it actuates a pilot valve, and the process is instantly reversed. It is somewhat like two devices combined into one. The two opposing cylinders that share a single rod to a piston having a surface area of 10 sq in. The total force acting on the piston is therefore 10 lb (1 psi × 10 sq in. = 10 lb). This piston with a 10-sq-in. face is also connected by a rod to another piston that has a surface area of 1 sq in. The pressure of 10 psi, acting on the 1-sq-in. area, can exert a pressure of 10 psi. The pressure is increased by the inverse of the ratio of the areas, and the volume of the fluid displaced is reduced by the inverse of the areas. In the Clark Pump, the 80 psi of pressure from the feed pump is converted into 800 psi by the (approximate) 10:1 ratio of the area of the piston face to that of the piston rod (which serves as the equivalent of a piston face with one tenth the area). In one version, a cylinder containing a piston with a 2¾-in. diameter is connected to a piston rod with a ¾-in. diameter, which in turn is connected to an identical piston in the adjoining cylinder. A valve system, actuated by the pistons as they reach the end of travel at the inward ends of their respective cylinders, controls the flow of water into and out of the cylinders. The 9.79:1 ratio of the area of the piston to that of the rod ultimately delivers feedwater at a pressure of 783 psi to the membrane. A series of check valves and pilot valves manages the fluid flow to create a reciprocating action, with the pressurized feedwater flowing alternately from one side of the pump to the other. The net result is that the Clark Pump’s energy consumption is very low.


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