FACT SHEET

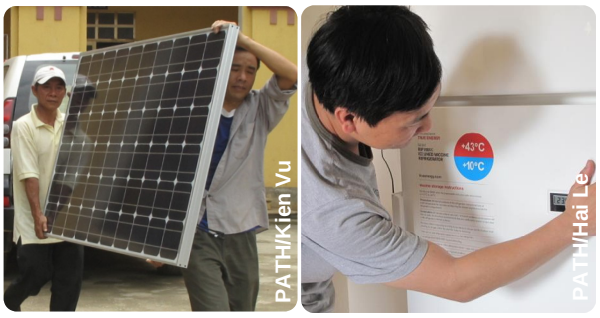
OPTIMIZE Immunization systems and technologies for tomorrow

PATH World Health Organization

Harnessing solar energy for health needs

Promising alternatives for storage and transport

Many health facilities in remote areas operate without grid electricity, have unreliable electricity, or find that using electricity is too costly. In these settings, solar energy is a promising solution for powering the storage and transportation needs of vaccines and heat-sensitive drugs at controlled temperatures. Project Optimize, a collaboration between the World Health Organization (WHO) and PATH, has been working with public and private partners on several solar technologies tailored to local electrical power conditions: unavailable or unreliable power, intermittent power, and reliable power.



A small solar array can power this direct-drive refrigerator.

Unreliable power conditions

When electricity is available less than four to eight hours on average per day, it is difficult to rely on electric refrigerators for vaccine storage. While kerosene- or gas-fueled absorption refrigerators are one option, they are challenging to maintain at proper temperatures, require significant maintenance, are not energy efficient, contribute to global warming, and are subject to fuel supply lines that can be interrupted or diverted for other uses.

An alternative option that has been in use for more than 30 years is solar-powered vaccine refrigerators. Until recently, the refrigerators available in this class were essentially first-generation design, using photovoltaic (solar) modules that recharge a high-quality, industrial battery system to store solar energy for use during night and poor solar weather conditions. While some solar refrigeration projects have been successful for more than ten years, many have suffered from battery system failures. If battery replacement is not anticipated or funding is unavailable, then the entire vaccine refrigeration system fails. Optimize has been encouraging companies to improve the reliability and life of solar-powered vaccine refrigeration.

Solar direct-drive vaccine refrigerators in Senegal and Vietnam

The next generation of solar refrigerators will solve the problems of the external battery by doing away with it all together, connecting solar panels directly to the compressor driving the refrigeration cycle. In 2010, the first solar direct-drive vaccine refrigerator was prequalified by WHO, meeting a new set of Performance, Quality and Safety (PQS) standards for solar direct-drive refrigerators. Instead of storing electrical energy in a battery, direct-drive refrigerators use cool storage (an “ice battery”) hidden in the refrigerator cabinet to maintain vaccine temperatures within the required range of 2°C to 8°C. At night or during cloudy, rainy weather, the well-insulated cool storage maintains acceptable temperatures for many days.

A field demonstration of 15 WHO PQS-prequalified solar direct-drive battery-free refrigerators is taking place at health posts in Senegal’s Podor and Pete Districts. Installed in December 2011, the refrigerators in Senegal are monitored continuously by temperature and alarm systems that send data via the Internet to a dashboard accessible to authorized district, regional, and central-level officers. All refrigerators are currently working properly. In Vietnam, a solar direct-drive battery-free refrigerator has been tested at health centers in Thanh Phu District in the south and Thanh Ba District in the north. Findings indicate that temperature control and performance is very good, even in northern Vietnam’s cloudy winter conditions. However, there are currently challenges with the refrigerator’s condensation management, which is creating unacceptable moisture conditions in the vaccine cabinet. Solutions for this problem are being researched.

Lifetime battery refrigerators in Vietnam

A “lifetime battery” is a battery that can outlast the 10- to 20-year lifetime of the refrigerator or the 20+ year lifetime of the solar module. New battery technologies (e.g., nickel-metal hydride and lithium) developed for the growing electric and

hybrid vehicle market appear promising in solar refrigeration applications. This innovation decreases battery maintenance and disposal burden for health centers while hopefully eliminating battery replacement entirely. Through a pilot project, Vietnam used lifetime batteries in refrigerators at two government health centers on Cat Ba and Cat Hai. The nickel-metal hydride batteries failed early in this project. The lithium batteries lasted throughout the one-year demonstration; however, longer-term battery life could not be measured. This PATH Health Innovations Portfolio project was principally funded by the Bill & Melinda Gates Foundation in collaboration with Hai Phong Medical University.

Intermittent power conditions

With intermittent power conditions, electricity shortages result in frequent interruptions and sudden reestablishments of power. In places where grid electricity is not reliable, diesel backup generators are needed to ensure an energy supply to refrigerators. However, generators are costly to operate, difficult to maintain and repair, and create air and noise pollution, and the fuel supply is subject to disruptions and may be diverted for other uses.

Hybrid solar and electric refrigeration in Senegal

Senegal benefits from excellent solar radiation conditions, but solar energy is not exploited generally because of the high initial equipment costs. Meanwhile, grid electrical power outages are common in the country. Fortunately, solar-powered systems costs are decreasing, making a solar and electric grid hybrid system an attractive alternative where diesel-fueled backup generators traditionally have been used.

The Senegalese Department of Preventive Medicine is working with project Optimize to explore ways to improve reliability, acceptability, and efficiency of solar energy in powering the cold chain at regional and peripheral levels. The team is installing a hybrid solar and grid electric power system at the Regional Supply Pharmacy in Saint-Louis. In addition, new ice-lined refrigerators have become WHO PQS prequalified, demonstrating more than ten days of sustained vaccine temperature control without any power, even in the country's hot climate. Grid power has been used for these super long-life ice-lined refrigerators without any backup for more than a year, and temperature records have not indicated excursions beyond the acceptable temperature range. Photovoltaic panels and a battery bank are being installed, which will enable solar electricity to power other critical loads such as freezers, lights, and computers.

Reliable power

Locations with reliable energy are often dependent on jet fuels, diesel vehicles, and electric refrigeration for vaccine distribution and storage. Some countries, like Tunisia, are using limited sea transport for vaccines shipped from Europe, an energy-saving solution because boats are more efficient and pollute less than air freight. However, there are several additional opportunities for energy efficiency in the transportation and storage of vaccines and heat-sensitive drugs, even in places with reliable power.

Toward net-zero energy in Tunisia

The Tunisian Ministry of Health is working with project Optimize to demonstrate the benefits of a "net-zero energy" supply chain. Over the course of a year, four health facilities have been equipped with enough photovoltaic panels to produce as much onsite solar energy as is consumed by onsite cold chain storage and transport. Rather than operating diesel-fueled vehicles, the team has introduced electric vehicles that are powered by solar energy collected onsite. Energy use reduction followed by renewable energy production can attain "net-zero energy" for local cold chain storage and transport.

In addition, energy-intensive equipment such as refrigerators, computers, and lights are being made more efficient through low- or no-cost management decisions. In some cases, the contents of two refrigerators can be consolidated into one, cutting energy use roughly in half. Older, less efficient refrigerators and desktop computers can be replaced with new, higher-efficiency refrigerators and laptops. Project teams in both Tunisia and Senegal have started using light emitting diode (LED) lights in place of traditional incandescent lights. This reduces energy without sacrificing lighting levels and ultimately cuts operating costs. Since LED lights run cool, their use reduces unwanted heat from less-efficient lights, decreasing the need for cooling energy. LED lights also last up to 25 times longer than incandescent lights and are mercury free, which minimizes pollution. Through measures like these, the anticipated benefits of the net-zero supply chain include reductions in electricity costs, fuel costs, maintenance, and environmental impact.

Project partners

- True Energy, Sundanzer, Sunfrost
- Senegal: Department of Preventive Medicine, Ministry of Health
- Vietnam: Hai Phong Medical University, National Institute of Hygiene and Epidemiology, Ministry of Health