SOLAR POWERED BATTERY BACKED HEALTH CARE FREEZER FOR REMOTE REGIONS

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Abstract*:Solar direct-drive (SDD) instruments like freezers and refrigerators are widely used for storing vaccines and other medical products in places without reliable mains electricity. The capacity of the solar array powering an SDD appliance must be large enough to provide sufficient compressor runtime during periods of reduced solar irradiance. SDD appliance solar arrays therefore create useful quantities of excess electricity that are currently not utilized. An Arduino that prioritizes the power requirements of the appliance and diverts excess electricity to other purposes has the potential to power a wide range of electrical devices, including health facility lights, appliance data loggers, medical devices, and mobile phone chargers. This paper discusses results of laboratory testing of twoArduino prototypes employing different control logics using simulated and actual solar power, as well as results from field testing. In laboratory testing, the prototype Arduino demonstrated diversion of useful amounts of electricity to secondary loads without adversely affecting refrigerator performance in most cases. Some problematic interactions between the refrigerator compressor controller and Arduino were observed. Development of more low-powered medical devices that can take advantage of the limited power provided by Arduino would be of great benefit to health facilities in areas without reliable mains electricity. Prioritized control of loads on solar arrays may have applications beyond medical refrigeration appliances.*

Keyword:*Solar power,Arduino board,SDD*

INTRODUCTION:

For many years, refrigerators powered by gas or kerosene (known as absorption refrigerators) were considered the most appropriate option to store vaccine in areas without reliable electricity. However, various drawbacks with these devices have made keeping temperatures within the safe range for vaccines of +2°C to +8°C both difficult and expensive.

Keeping the temperature within the acceptable range of +2°C to +8°C for vaccines is difficult in absorption refrigerators.1 There is a high risk of exposing vaccine to freezing temperatures. ++Gas and kerosene refrigerators require frequent maintenance to keep them operating well. ++Operating gas and kerosene refrigerators contributes to local air pollution and an increase in global greenhouse gas emissions.

In the 1980s, battery-powered solar refrigerators were introduced as a solution to these problems. But the batteries they rely on required frequent maintenance, had a lifetime of just three to five years, and quality.

A new approach to solar refrigerator design has emerged, eliminating the need for expensive (and problematic) energy storage batteries used to power solar refrigerators. SDD technology uses solar energy to directly freeze water or other cold storage material and then uses the energy stored in the frozen bank to keep the refrigerator cold during the night and on cloudy days. These appliances include refrigerators, water-pack freezers and combined refrigerator water-pack freezers and are called solar direct-drive because they are wired directly to the solar array. This new technology has the potential to resolve many of the problems of off-grid vaccine refrigeration, enabling national immunization programmes to extend the cold chain into areas in the "last mile" that might otherwise be underserved.

Figure 1 illustrates the differences between solar battery-powered (left) and SDD (right) refrigerators.

Solar panels on the roof of Pelewa dispensary, Kenya. Photo: Catherine Silali.

Because batteries are usually the most vulnerable component, and the most expensive part that needs regular replacement, removing them has the potential to increase the long-term success of solar vaccine refrigeration. Also, depending on the future cost of electricity and other key inputs, SDD refrigerators can compete with other types of refrigerator in terms of total cost of ownership.3

This is illustrated in Figure 2, which provides an example of how the annualized total cost of ownership of vaccine refrigerators may be compared, factoring for both capital costs and operational costs.4 In this example, the mains-powered ice-lined refrigerator has the lowest annualized total cost of ownership, while the kerosene-fuelled absorption refrigerator has the highest annualized life-cost.

The SDD refrigerator would have the lowest total cost of ownership in areas with unreliable electricity and suitable solar irradiance, and where a solar service provider can be funded to provide the necessary support.

Grade A – User-independent freeze protection. The user does not need to perform any actions to protect vaccines from freezing temperatures. For example, such refrigerators do not require thermostat adjustments or storage in supplemental baskets or bins in order to protect vaccines from freezing. These refrigerators offer the greatest intrinsic protection to vaccines against the risk of freezing.
++**Grade B** – User-dependent freeze protection. The user must perform one action to protect vaccines from freezing temperatures.
++**Grade C** – User-dependent freeze protection. The user must perform more than one action to protect vaccines from freezing temperatures.
SDD technology offers a potential solution to these problems. However, until recently this technology had not been used in Tanzania, and it was unclear whether SDD refrigerators and freezers would function reliably across the country's diverse climate zones. To find out, in May 2014 the Tanzanian Immunization and Vaccine Department, the Clinton Health Access Initiative and UNICEF initiated a 12-month pilot project to evaluate three different SDD refrigerators in 17 health facilities across five climate-diverse regions of the country.

II. LITERATURE REVIEW

In early 2013, three WHO-prequalified SDD refrigerators, three SDD water-pack freezers, and one WHO-prequalified combined SDD refrigerator-freezer were deployed at four remote health posts in Colombia's northern mountains by the Wintukwa Institución de Salud del Pueblo Indigenous, with the support of the Solar Electric Light Fund.

WORKING

This Effective Vaccine Management (EVM) Standard Operating Procedure (SOP) tells you how to install new vaccine refrigerators and freezers and covers routine non-mechanical maintenance and responses to emergency maintenance.

The total cost of ownership tool for cold chain equipment is designed to help users understand the costs of purchasing and maintaining cold chain equipment over time. The tool allows country-specific customization for modelling capital and operating expenses of WHO-prequalified equipment via interactive worksheets.

To date, health facility nurses and technicians have expressed satisfaction with the performance of the new SDD refrigerators, citing their minimal repair and maintenance requirements after installation. No major breakdowns have been reported, while the total cost of ownership for SDD refrigerators installed in 2009 and 2013 has compared favourably to the gas and electric refrigerators used previously.

The installation of solar panels on health facility roofs caused various problems at multiple facilities.

Water was found to accumulate on some solar panels due to incorrect installation.

Solar panels were sometimes blown off roofs by heavy winds. Poor installation and not using the right tools and materials were identified as the causes of these failures.

Some solar panels were stolen from health facilities. Better training on installation techniques, utilizing secure screws, is required to prevent these losses.

Site assessment is critical for successful SDD installation

Ahead of a large-scale deployment of SDD refrigerators, facility-level site assessments are critical to plan for key variables such as solar array mounting options, shading, facility space for the refrigerator, and other design considerations. Without this, technicians may encounter issues on installation day which they are not equipped to address, leading to delayed or interrupted deployment.

Technicians must be empowered through resource availability

Planning activities must take into account the time, tools and resources that technicians require to properly install an SDD refrigerator. For example, during the pilot, technicians relied on district health offices to provide ladders and source key resources locally (i.e. poles, cement, additional fixtures and fasteners, etc.). Minimizing the need for such last-minute installation-related procurements – and planning for those that cannot be anticipated – will be critical for ensuring smooth deployments in the future.

There is an appetite for power beyond the cold chain

Medical officers and users expressed their desire for electricity availability for purposes beyond vaccine refrigeration, particularly lighting that could be used to extend service hours. Emerging "energy harvesting" technologies being developed by manufacturers and global partners could serve this need well, by utilizing excess energy from the SDD for other health purposes, such as lighting, cell-phone charging, etc.

RESULT

To support countries in improving their cold chains, Gavi, the Vaccine Alliance has established the Cold Chain Equipment Optimisation Platform. Through the Platform, Gavi has committed an initial US$50 million to jointly invest with countries to purchase and install new cold chain equipment, including SDD vaccine refrigerators. With so many new developments underway, it is critical to use a structured approach to select the right equipment. This guide aims to provide clear advice on new technologies, identify which devices comply with Platform requirements, and help make purchasing decisions. It is intended for use in health facilities and lower levels of the cold chain.

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