PATH

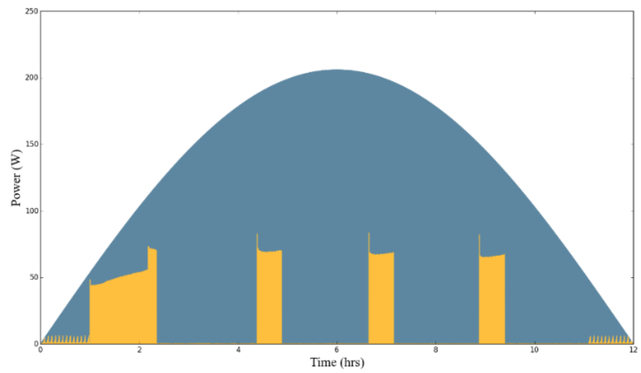
Advancing solar innovation to power health facility equipment

Energy harvest controls: A new, verified category of products

Enormous global effort and investment have gone into ensuring access to safe and effective vaccines, yet powering vaccine cold chain equipment in health facilities remains a challenge in low- and middle-income countries (LMICs), where many locations lack reliable grid electricity. However, solar energy is an increasingly effective and affordable means of powering equipment essential for storing, delivering, and supplying vaccines in places where grid electricity is unavailable or unreliable. In fact, there is unused, reliable power being generated at some facilities by solar panels powering only cold storage equipment like refrigerators and freezers. If harvested, this excess power could be safely diverted to address many additional health needs and health system issues in LMIC health facilities.

A number of solar direct drive (SDD) refrigerators and freezers are commercially available, designed to operate using intermittent solar power, and prequalified by the World Health Organization (WHO) Performance, Quality and Safety (PQS) team to support safe and effective immunization delivery. When SDD appliances are installed at health facilities with dedicated, appropriately sized solar panels, excess power is produced (Figure 1). But in the past, WHO has not recommended use or storage of that energy for any other purpose due to the potential risk of the cold chain appliance receiving inadequate power to protect the vaccines. Currently, there are no WHO PQS–approved products available that can prioritize limited available power delivery between multiple devices. Any product developed would need to ensure the primary function of the refrigerator or freezer to store vaccines at safe temperatures.

Figure 1. Solar energy available for harvest over an idealized day.



A simulated day of solar power generation. The total area under the blue curve is energy produced by an idealized photovoltaic array. The yellow area represents the energy used by a tested refrigerator; the blue area, potentially harvestable energy.

TECHNOLOGY SOLUTION

In collaboration with the Solar Electric Light Fund (SELF), PATH is exploring a new category of products to address this gap: energy harvest controls (EHCs) that ensure the fail-safe operation of primary SDD appliances while diverting excess power to other needs. An EHC would work with SDD appliances in two general formats. One would consist primarily of added logic and circuitry internally integrated into a refrigerator. The user would have access to electric power outlets on the exterior of the refrigerator where other devices could be plugged in. Alternatively, an external EHC might look simply like a power strip or charging station that allows excess power to be delivered to outlets on the EHC itself.

POTENTIAL USES AND CAPACITY

In addition to providing enough power for solar refrigerators and freezers, the list of potential uses for the excess solar power is long and could include equipment like lighting, computers, cell phones, cold chain equipment remote monitoring, microscopes, centrifuges, otolaryngoscopes, fetal monitors, and suction pumps.

While solar availability varies from location to location, on a sunny day, most users would be able to consistently power a standard SDD appliance using approximately 10% to 25% of the available solar energy. Based on laboratory testing with unoptimized, initial prototypes, it is estimated that EHCs could deliver more than 55% of the generated solar energy to other devices that would otherwise be wasted.

MOVING FROM PROTOTYPES TO PRODUCTS

Specification and verification protocol development. PATH tested multiple EHC prototypes in collaboration with SELF to gain working knowledge of the controls, explore possible failure modes, test protocols, verify functionality of the prototypes, and anticipate issues in design, testing, and verification of EHCs in general. Two general control systems were tested: one that can harvest energy only when the SDD appliance is not running, and one that can also harvest energy at times when the SDD appliance is running and there is more power than the SDD appliance needs. Initial testing of each EHC with three different SDD appliances confirmed that both work. Testing also showed that the timing and logic of the refrigeration cycles and the separate logic of the EHC can sometimes interfere with each other. Therefore, manufacturers are encouraged to develop solutions for their specific appliance to address operation, control logic interference, and optimize energy harvest.

Supporting international organizations to drive in-country availability. In support of WHO and PQS, PATH and SELF provided expert development support for specifications, standards, and testing protocols to ensure that any PQS-qualified[1] EHC design will prioritize the primary SDD appliance. Qualified EHCs must be resilient under harsh electrical and environmental conditions and fail-safe in instances of realistic outages or malfunctions.

PATH and SELF's work helped WHO PQS to create a new, verified category for EHCs so that manufacturers can prequalify, market, and sell high-quality devices while organizations like the United Nations Children's Fund and country ministries of health can procure them for use through established channels.

Field tests for verification. To confirm successful operation outside of the laboratory, SELF tested two EHC prototypes with multiple appliances and actual solar installations in a one-month initial pilot. The SDD appliances were opened and closed daily, as they might be in a true use-case. Throughout the trials, the EHCs directed power to the SDD appliance as needed. Thereafter, three EHCs were installed with solar panels and SDD refrigerators at trial sites in Colombia. The energy harvested provided rechargeable lighting at all three health facilities and cell phone recharging at the two off-grid sites. Lighting revitalized one of the facilities, motivated expanded services at another, and reduced reliance on a backup generator at the grid-powered, district-level facility. The EHC designs did not harvest all of the possible excess energy; all three sites would have consumed more power had it been available. Other valuable lessons learned were incorporated into the WHO PQS specifications, further assuring the safe application of energy harvesting.

ADVANCING SOLAR INNOVATION

PATH and SELF have openly published the EHC designs to support manufacturers in designing and improving on them.[2] This open publishing is also intended to prevent future patents from blocking development. Several companies have developed appliances with energy harvesting capabilities, but none have been PQS prequalified. This means that the equipment is not yet accessible to many countries that rely on the United Nations Children's Fund for equipment procurement.

PATH and SELF continue to support WHO specifications to ensure robust devices with proper safety mechanisms are brought to market. Multiple companies are considering submitting applicable solutions to PQS. Many health ministries and facilities have expressed strong interest in this means to power essential medical equipment. Our goal is to support development efforts and facility installations.

COLLABORATING FOR IMPACT

PATH is exploring possibilities for pushing forward with further developments toward positive health impact. We are interested in collaborations to help encourage broad introduction and use of this energy harvesting technology. We will also continue to provide technical assistance through information-sharing with manufacturers and field and laboratory testing to verify and quantify performance of devices. Developing low-powered medical devices that can take advantage of the power provided by EHCs would also be of great benefit to health clinics in areas without reliable mains electricity.

CONTACT

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1. The specification and verification protocol are posted on the WHO website at http://apps.who.int/immunization_standards/vaccine_quality/pqs_catalogue/catdocumentation.aspx?id_cat=36.

2. PATH, Solar Electric Light Fund. *How Energy Harvest Controls Can Increase the Benefits of Solar Direct–Drive Refrigerators*. Seattle: PATH; 2016. Available at http://www.path.org/publications/detail.php?i=2701.

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