requirements that are notoriously more difficult to maintain. The COVID-19 vaccines from Moderna must be stored at between -25°C and -15°C. The Pfizer-BioNTech requires -70°C, but can be kept between -25°C and -15°C for up to two weeks.

Keeping vaccines seamlessly refrigerated is an especially daunting challenge where electricity is unavailable or unreliable. A 2013 review spanning 11 African countries found that just 28% of clinics and hospitals had reliable electricity, and 26% had no electricity access at all. Updated data on energy access in health facilities is scattered and sparse, but we are working on a new comprehensive review.

Unreliable power is extremely costly for vaccination efforts. Each year, nearly 50% of freeze-dried and 25% of liquid vaccines are wasted. This is in large part due to cold chain electricity disruptions.

Thus, to deliver COVID-19 vaccines at the required scale, the problem of energy access at health facilities must be confronted. But realistically, entire national grids can t be overhauled overnight to provide universal, uninterrupted power. So what can be done?

Solar as a solution

In many cases, the answer may be to go solar. Solar photovoltaic solutions, like other decentralised renewable energy systems, come in countless configurations. These typically include battery storage and can be used along with existing electricity sources like the national grid or a diesel generator.

This flexibility means that photovoltaic systems can be deployed rapidly and modularly to provide health facilities with power, often more reliably than the grid. Electricity is essential for vaccine cold chain and other services needed during a pandemic.

Health facilities in areas with limited electricity have long relied on gas-powered absorption type refrigerators. Solar-powered refrigerators are more reliable and efficient. Photovoltaic refrigerators with batteries store energy from solar panels for later use. In this way power is available even on cloudy days or at night, or (for grid-connected clinics) during a power outage.

Other photovoltaic refrigerators do not use batteries at all. Solar direct drive refrigerators use solar energy to directly freeze water into an ice wall. This keeps the storage container cold for days, even when solar energy isn t available.

Photo by Jason Blackeye on Unsplash

Solar direct drive refrigerators have had a profound impact in last-mile settings. These include rural parts of the Democratic Republic of Congo (DRC), where it s hard for health facilities to get fuel and batteries and they are far from the national grid. In 2020, Gavi, the vaccine alliance, supported a massive rollout of solar direct drive refrigerators. It led to a 50% increase in monthly immunisation sessions in the nine poorest provinces of the DRC just in the last year. These refrigerators have been instrumental in boosting the proportion of health facilities in the DRC with working cold chain equipment, from 16% in 2016 to nearly 80% today.

Subzero storage solutions

Most solar refrigerators are equipped to store vaccines only at standard temperatures (between 2°C and 8°C). Solar-powered solutions for subzero storage and transport are available, though not yet at wide scale. For example, the MOTE vaccine cooler, developed by Nigerian start-