



ASPR

Safeguarding the Cold Chain with Solar Power

December 12, 2018





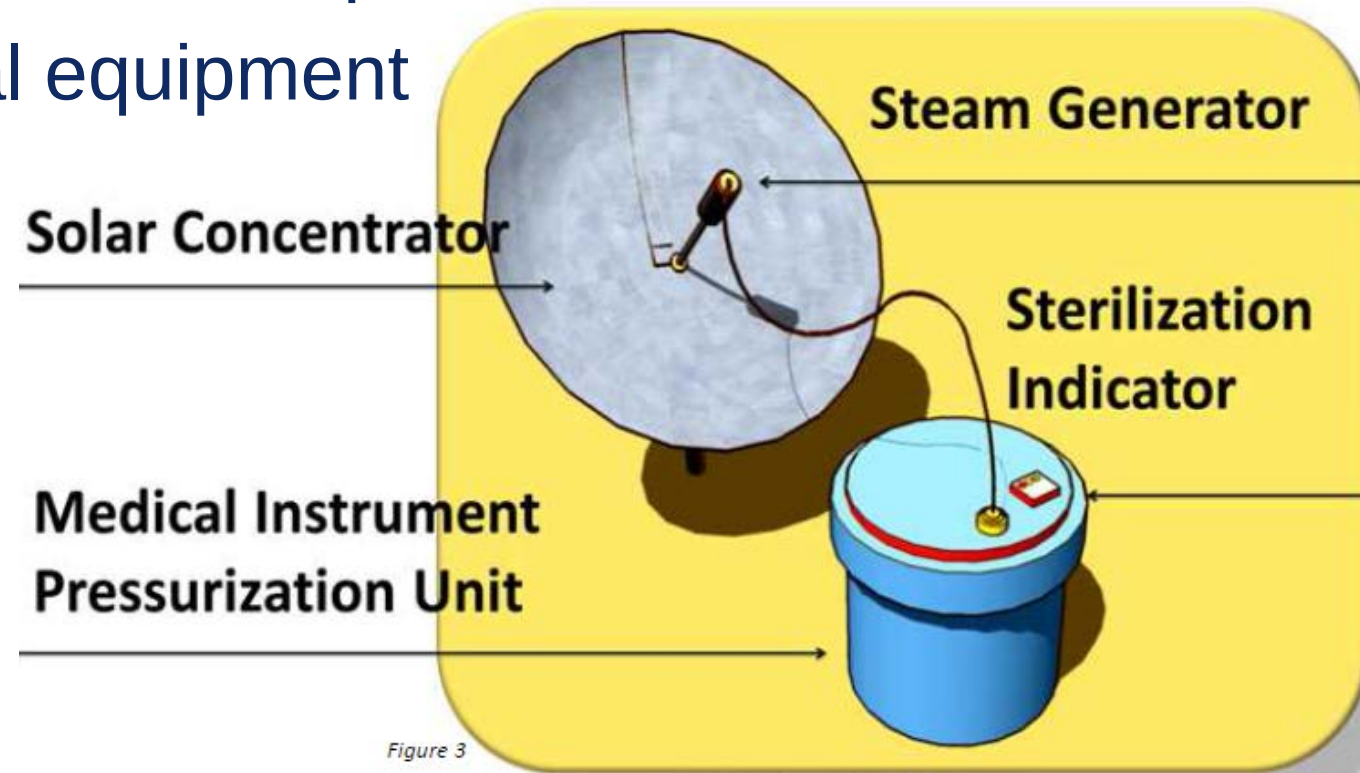
How Can Solar Power Fit Into Healthcare

- Modular, Electrically Isolated Systems¹⁻⁴
 - Vaccine Refrigerators
 - Communications Systems
 - Autoclaves
 - Emergency Lighting
- Incorporated into Existing Systems¹⁻³
 - Boilers
 - Air Conditioning
 - Laundries⁷
 - Supplementary power generators
 - Main power to small facilities



Solar Autoclaves: An Example Modular System

- Autoclave: a vessel capable of holding steam at high pressure insulated to maintain high internal temperature.
- Sterilizes medical and dental equipment
- Direct solar^{2,3}:
 - Low maintenance
 - No batteries
 - < \$500





Vaccine Refrigerators: What's at Stake

- Hospitals and clinics lost power and ran out of generator fuel following Hurricane Maria.
- As of March, 2018, 11% of permanent health centers had no or limited grid power⁵.
- 150,000 – 200,000 publicly-owned vaccine doses were lost after Hurricane Maria – not including privately owned businesses
- Vaccines and other important biologic drugs like therapeutic antibodies must remain cold (2-8°C) in storage, insulin for storage longer than 28 days at room temperature.
- Loss of power / cooling  Loss of vaccines



Ensuring Vaccines Stay Cold Until Time of Use

- **Cold Chain:** a supply chain that keeps cargo cool at all times, both during shipping and long-term storage⁶
 - Must maintain temperature from manufacture to patient
 - Storage in warehouses, pharmacies, and clinics
- Concerns in an Emergency^{4,6}: Power Efficiency, Ambient Conditions, Grid Power Access, Generators
 - Refrigerators reduce temperature ~40°C
- Refer to the CDC Vaccine Storage Toolkit¹⁰
 - <https://www.cdc.gov/vaccines/hcp/admin/storage/toolkit/storage-handling-toolkit.pdf>





The Cold Chain

- Cold Rooms
- Refrigerated Trucks
- Cold Boxes
- Refrigerators
- Freezers
- Carriers
- Ice Packs

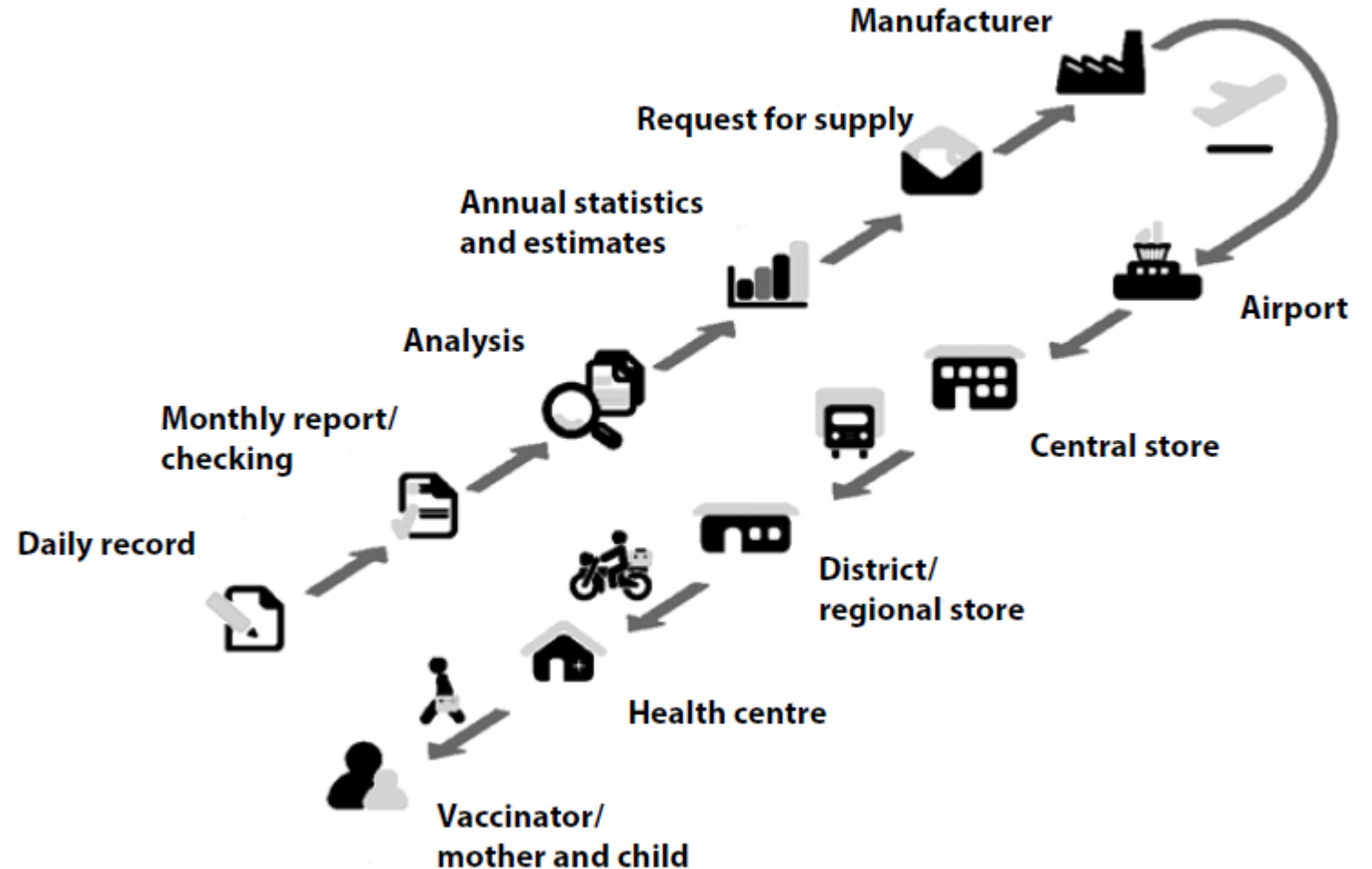


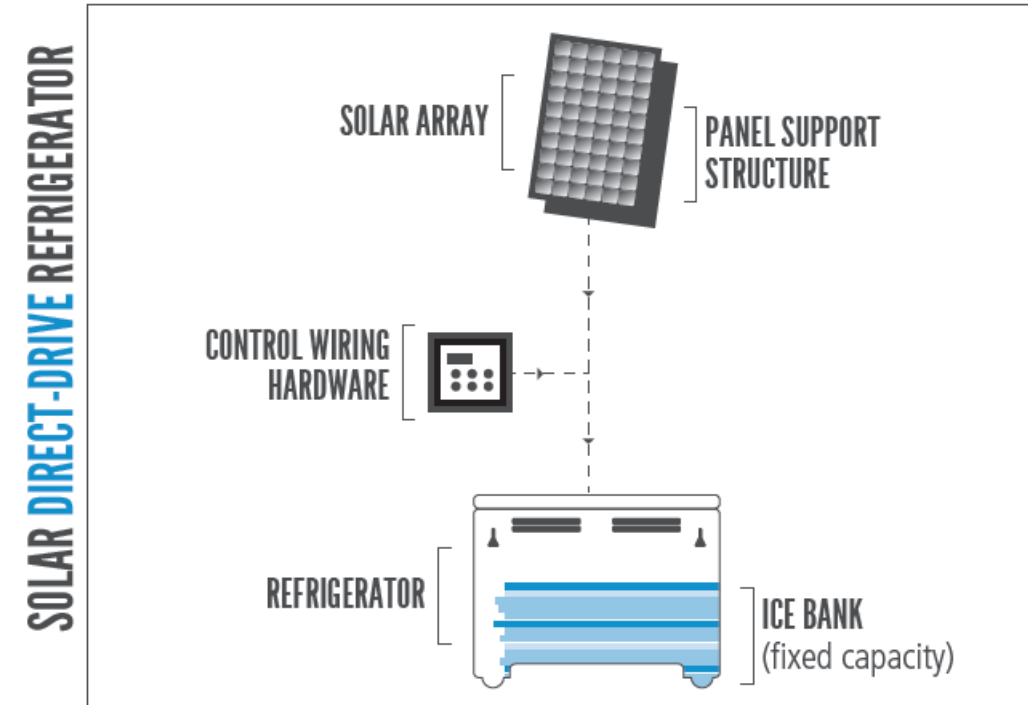
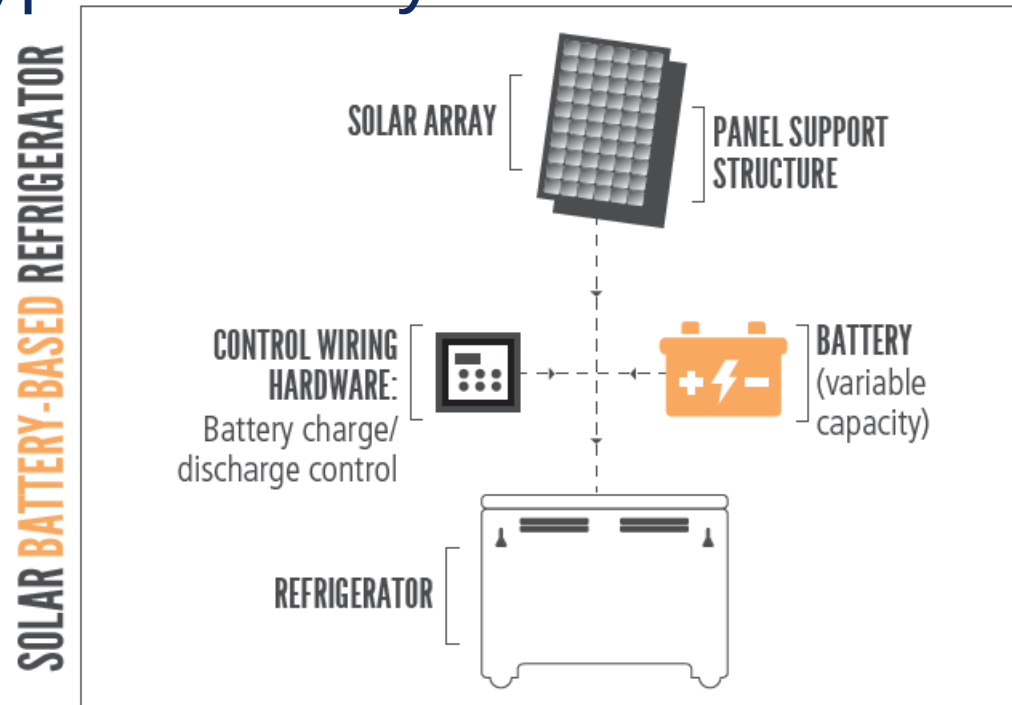
Figure from Ref. 5

Saving Lives. Protecting Americans.



Requirements of a Typical Solar Vaccine Refrigerator

- 1-4 kWh/day per 100 L volume, some less^{1,7}
- Holdover Time systems with over 80 hours available
- 2 Types: Battery and Direct-Drive⁷



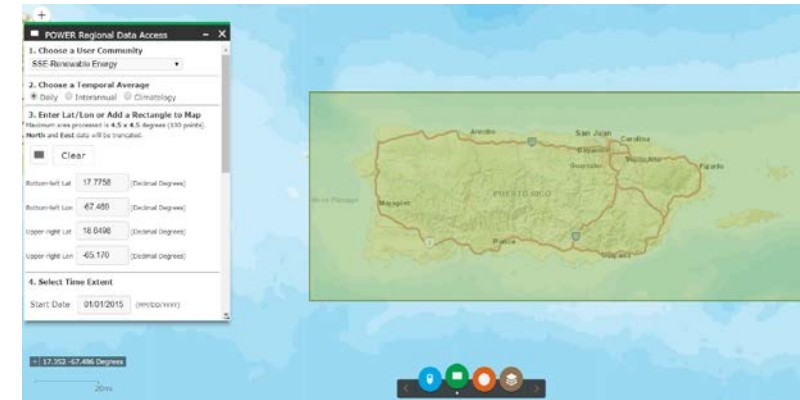


Site-Specific Concerns

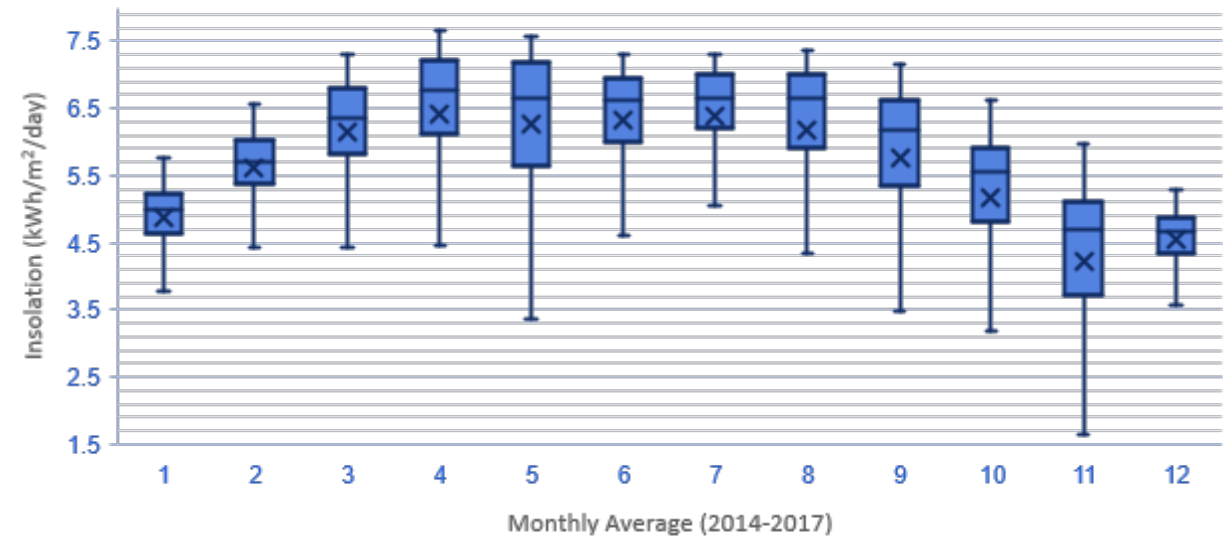
- Immediate Costs Hardware: Panels, batteries, inverters, wiring
 - Installation
 - Up-to-date refrigerators
- Long Term Costs
 - Replacement Plans and Funding
- Site Suitability
 - Roof or ground space for panels
 - Insolation: How much energy from the sun is available (examples on next slide)
 - Will high winds rip the panels off the roof? Can panels be removed, brought inside?
 - Will there be modifications to the building? Will the modifications allow moisture in?
 - Wiring complies with industry standards?
- Ambient Conditions
 - Refrigerators can only bring temperature down by 40°C
 - **Will the storage room go over 48°C in a disaster?**
 - ❑ Is there backup power to the HVAC system to prevent this?

Insolation Calculations: Puerto Rico

- Get Insolation Data from NASA POWER Data Access Viewer [Link: Ref 9](#)
 - Insolation at a point or over an area
- Use this data to determine average daily insolation by month.
- use the average value for the least-insolated month
- In this example, November is the least-insolated month at 4.6 kWh/m²/day



Average Daily Insolation by Month in Puerto Rico



Thank You!

References

1. Al-Akori, Adnan, “PV Systems for Rural Health Facilities in Developing Areas: A Completion of Lessons Learned” IEA Photovoltaic Power Systems Programme Report, November 2014
2. Dravid, M.N., et al. “The Use of Solar Energy for Powering a Portable Autoclave” *Journal of Hospital Infection*, March 2012
3. World Health Organization poster, “Distributed Surgical Instrument Sterilization Using Solar Powered Autoclaves in Low Resource Settings”
4. World Health Organization PQS Performance Specification “ Solar Power System for Compression-Cycle Vaccine Refrigerator or Combined Refrigerator and Water-Pack Freezer” July 2010
5. Kaiser Family Foundation, “Health Centers in Puerto Rico: Operational Status After Hurricane Maria” March 16, 2018
6. World Health Organization “Immunization in Practice Module 2: The Vaccine Cold Chain” October 2015
7. World Health Organization Evidence Brief, “Direct-Drive Solar Vaccine Refrigerators – a New Choice for Vaccine Storage” May 2013
8. Lima, Thiago et al. “Solar Water Heating for a Hospital Laundry: A Case Study” *Solar Energy* Volume 122, December 2015
9. NASA POWER Data Viewer, <https://power.larc.nasa.gov/data-access-viewer/>
10. CDC Vaccine Storage and Handling Toolkit, January 2018
<https://www.cdc.gov/vaccines/hcp/admin/storage/toolkit/storage-handling-toolkit.pdf>