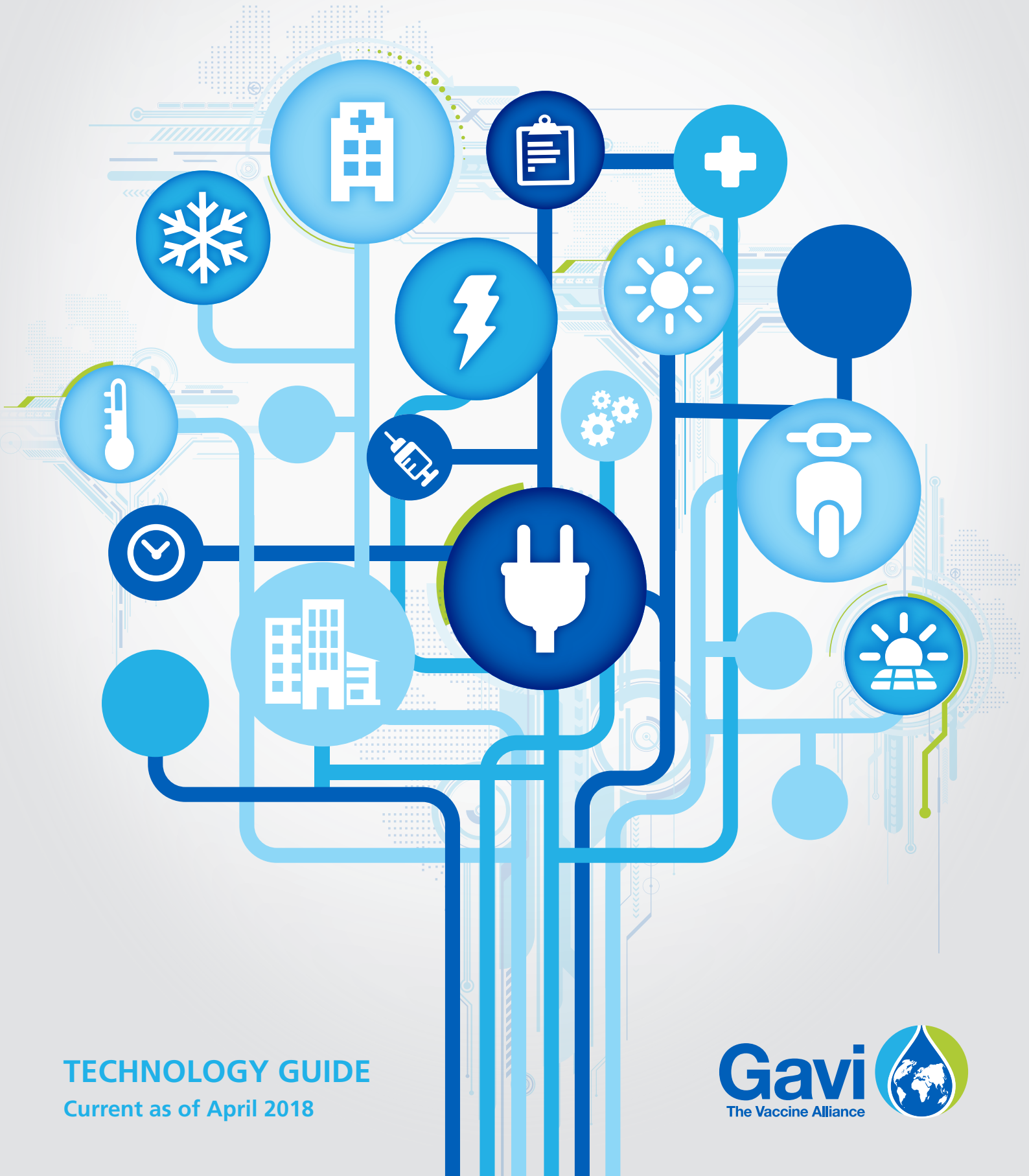
Cold chain equipment optimisation platform



TECHNOLOGY GUIDE

Current as of April 2018

Gavi
The Vaccine Alliance

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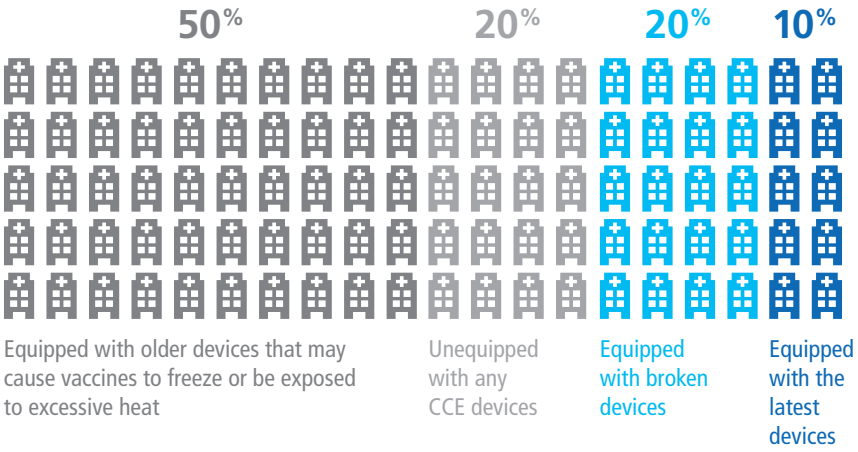
Cold chain equipment optimisation platform technology guide

This guide is current as of April 2018. As information and platform eligible equipment will be updated periodically, please reference http://www.gavi.org/support/apply/ to check for the latest version.

INTRODUCTION

Strong and efficient supply chains – equipped with reliable cold chain equipment (CCE) – are vital to helping countries increase immunisation coverage and equity, reaching children with life-saving vaccines and protecting them against deadly diseases.
To ensure that vaccines are widely available and remain cold, safe and effective throughout the entire supply chain, each country's immunisation programme needs access to high-performing and well-maintained cold chain equipment. Such cold chain equipment, when available at the required cold chain points-in-country, will increase vaccine availability, potency, and safety. This will help to improve immunisation coverage.

The challenge:
In a number of Gavi-eligible countries, up to 90% of health facilities are not equipped with adequate cold chain equipment.

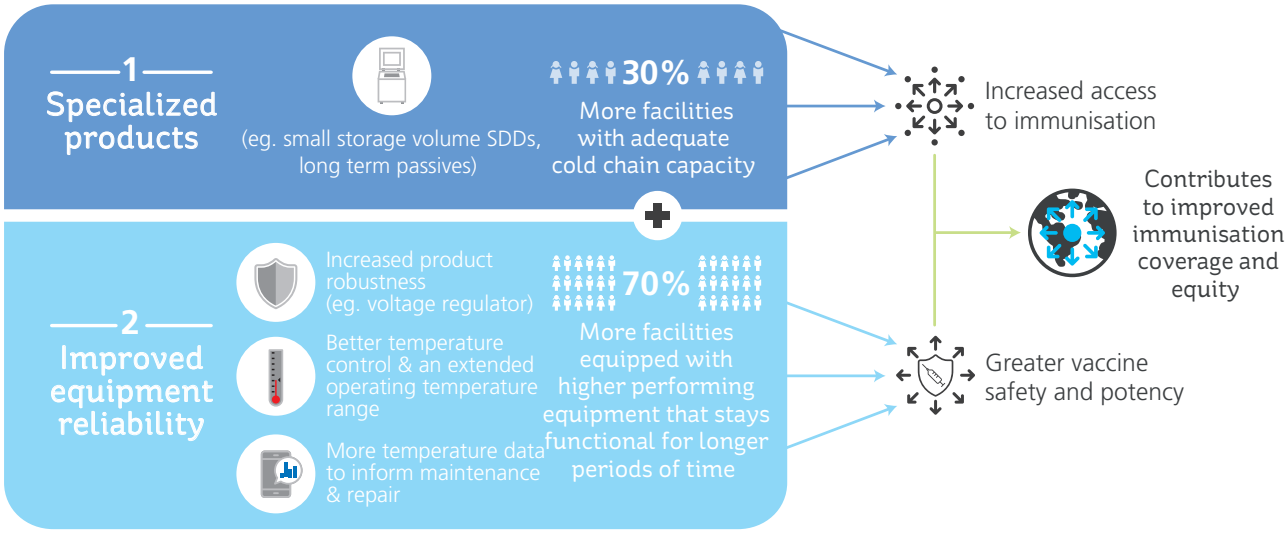


Some older technologies have high operating costs and/or poor temperature control that can lead to vaccine wastage if vaccines are exposed to very high or freezing temperatures. To support countries in improving their cold chains, Gavi, the Vaccine Alliance established the cold chain equipment optimisation platform in January 2016. Through the platform, Gavi has committed US $250 million for a five year period between 2017-2021 to jointly invest with countries to purchase and install equipment that meets specific technology requirements. For Ice-line Refrigerators (ILR) and Solar Direct Drive (SDD) products, the installation of equipment means that, for the first time, Gavi is requiring manufacturers to deliver the successful implementation of the service bundle for ILR & SDD, TMD and RTMD products procured through the CCEOP. By investing in new cold chain equipment, countries can ultimately save money over the average ten-year lifespan of the equipment. These technologies satisfy a higher standard of performance criteria beyond minimum WHO PQS requirements, and are also referred to as platform-eligible cold chain equipment.

Investing in new cold chain equipment is key to improving:

- Sustainable, equitable, immunisation coverage (by extending equipment availability into remote areas and better enabling outreach activities);
- Reliability, device up-time and overall device lifespan;
- Vaccine safety and effectiveness through better temperature control.

IMPROVED CCE CONTRIBUTES TO COVERAGE AND EQUITY OF VACCINES



As you begin thinking about the equipment currently in use in health facilities in your country, imagine the following possibilities:

- Fridges that are able to keep vaccines cool and safe even if the power is intermittent or out for multiple days;
- Remote facilities that keep vaccines cool and temperature stable using dependable solar-powered devices that do not need batteries;
- New device design features that make accidental freezing of vaccines in storage and transport very unlikely and contribute to reductions in closed vial wastage;
- Fridges and freezers that provide automatic alerts to health facility staff – and, in some cases, to the national maintenance centre – when they are not working properly. This helps ensure that the devices receive immediate attention so the vaccines can be protected.

These capabilities might sound futuristic, but the latest generation of cold chain equipment already achieves this level of performance. Suppliers are also developing equipment with even more advanced features, which will be available within the next two years.

About this guide

With so many new developments underway, it is critical to use a structured approach to select the right equipment. This guide aims to provide you with clear advice on new CCE technologies to help you make purchasing decisions. It is intended for use in health facilities and lower levels of the immunization supply chain.

In addition, it will help you identify which devices comply with platform requirements, and choose the cold chain solutions that match the needs of your country's health facilities.

If you have questions or if you would like more information, please contact cceplatform@gavi.org or visit www.gavi.org.

Overview of how to make purchasing decisions

This guide is designed to help you think through which equipment to purchase. Please use the following key steps to help you complete the decision-making process:

Categorise your health facilities based on CCE needs.

Learn how to divide the health facilities in your country into different groups.

Choose your device types.

For each facility group, learn how to determine what types of devices are appropriate.

Choose your device models.

For each type of device, see what models are currently available, what new models will be available in the next two years, found in the future device lists for each CCE product category, and weigh trade-offs.

Devices covered

This guide covers devices that are used at service delivery points (eg health facilities and hospitals) or small cold stores, and which meet or are expected to meet platform requirements. Larger scale storage (such as walk-in cold rooms and freezer rooms) are excluded. Specifically, you will find information about the following types of devices:

- **Ice-lined refrigerators (ILRs):** these vaccine refrigerators run on mains electricity or power from a generator. The latest models are designed with longer holdover times to keep vaccines cool during prolonged periods of power outage (often for more than two days). During normal conditions, many of these new ILR models require only eight hours of power per day to keep vaccines within the required temperature range. However, less than eight hours of power/day may reduce holdover time.
- **On-grid freezers (ILRs):** these vaccine freezers run on mains electricity or power from a generator. They are designed to have better temperature control and reliability than standard domestic freezers.
- **Solar direct drive (SDD) refrigerators and freezers:** these vaccine refrigerators and freezers run on solar power. In the latest generation, each one of these devices comes with a solar panel that is mounted on either a pole or on the roof of the health facility, and is connected to the device by a power cable. Unlike previous solar devices, they do not need batteries and, as a result, they require less maintenance.
- **Long-term passive devices:** these vaccine storage devices are designed to keep vaccines cold for long periods without any source of power. They do not require solar panels, batteries, electricity, gas or other fuels. They typically have limited vaccine storage capacities (of 10 l or less) and keep vaccines cool using a set of ice packs that must be refrozen every three to five weeks.
- **Cold boxes and vaccine carriers:** these insulated containers are used to transport vaccines between facilities or during field immunisation sessions. They use ice packs that must be refrozen after each use.
- **Temperature monitoring devices:** these devices are used to periodically measure and record temperature readings from cold chain equipment. They display current temperature readings and instances of unacceptable temperature excursions. 30-day temperature recorders (30-DTRs) log temperatures and alarms locally on the device. Data can be downloaded manually by the user. In addition to the 30-DTRs' capabilities, remote temperature monitoring devices (RTMDs) also have the ability to transmit SMS-based alarms (in case of excursions) and/or upload temperature data to logistics management information systems (LMIS).
- **Voltage stabilizers:** these devices are used to protect refrigerators and freezers powered by mains electricity from damage caused by fluctuations in the electricity supply. They protect the refrigerators and freezers from voltage and frequency levels that are either too low or too high for reliable functioning, as well as from lightning strikes. Some refrigerator and freezer manufacturers choose to integrate voltage stabilizers in the bodies of their devices, while others choose to use a standalone, external voltage

stabilizer with their devices. This guide only lists voltage stabilizer of the external type, since integrated stabilizers are a de facto option determined by the refrigerator or freezer manufacturer.

For details about cold chain devices that are not included here, please reference the World Health Organization (WHO) performance quality safety (PQS) catalogue.

This guide focuses on equipment selection for service delivery points (eg health facilities). Equipment selection for state or district stores involves additional considerations for vaccine transportation and is not addressed here.

Other available tools

While this guide is about choosing the right technology to meet your country's cold chain needs, additional tools are available to help you in other ways.

- **WHO performance quality safety (PQS) catalogue**: this catalogue provides detailed specifications on each WHO PQS-approved cold chain device, as well as WHO guidelines for device selection. PQS qualification means that a device has passed a set of performance, quality and safety tests set by WHO.
- **WHO vaccine volume calculator**: This tool determines the total supply chain storage volume needed for the set of vaccines included in a country's vaccination programme.
- **WHO Effective Vaccine Management (EVM) initiative website**: this website provides materials and tools to monitor and assess vaccine supply chains and help countries to improve supply chain performance. It includes background and training resources, EVM standard operating procedures, EVM assessment tools and user guides, and lessons learned from EVM country assessments. It also contains the Vaccine Management Handbook (below).
- **WHO EVM initiative vaccine management handbook**: this handbook provides technical advice on immunisation logistics, including the use of cold boxes, vaccine carriers and coolant packs for transport and outreach, and how to monitor temperatures in the supply chain.
- **PATH total cost of ownership (TCO) tool**: this tool calculates purchase, delivery, installation and operating costs for a variety of cold chain devices over their expected lifetimes. This tool was developed with input from numerous partners and experts and is hosted on the PATH website. This is the only tool in use today that has been approved by Gavi. There may be other tools in use but these are independent of Gavi or the CCEOP. It is essential that countries conduct the total cost of ownership analysis with the PATH TCO tool during planning and budgeting of their CCEOP applications. TCO varies by country due to country specific factors such as labour and energy costs. Therefore, this tool should be customized by using country-specific inputs to produce TCO estimates that correspond to their country context. For further details, please refer to P.17 in this Technology Guide.
- **UNICEF cold chain support package**: these documents provide commercial and technical guidance for you to use during procurement of cold chain equipment through the UNICEF Supply Division.
- **UNICEF supply catalogue**: in its "Cold Chain Equipment" section, this online catalogue contains many types of devices and includes technical specifications and pricing for each one.
- **TechNet-21**: TechNet-21 is a network of immunisation professionals from around the world. The goal of the network is to strengthen immunisation services by sharing experiences, coordinating activities, and helping to formulate optimal policies. The website provides a variety of useful tools, including a forum to discuss important topics and recent developments in immunisation and an area for members to review WHO PQS-prequalified cold chain equipment. The Technet-21 online library of immunisation resources includes journal articles, photographs, videos, useful links and tools.
- **"Introducing solar-powered vaccine refrigerator and freezer systems" guide**: this document, created by WHO and UNICEF, provides managers in national immunisation programmes with guidance on how to implement solar-powered vaccine refrigerator and freezer systems.

STEP 1: CATEGORISING YOUR HEALTH FACILITIES BASED ON COLD CHAIN EQUIPMENT NEEDS

Categorisation questions

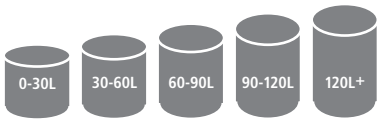
Before making any purchasing decisions, it is necessary to inventory your country's existing cold chain equipment. First, this process will help you sort out which facilities need cold chain equipment, and which do not. Second, this process will also help you assess which makes and models will complement your existing cold chain equipment. Standardising equipment across facilities results in benefits such as simpler training program design and common maintenance networks.

Choosing the correct cold chain solutions for your country's health facilities will require you to assess each facility's characteristics. For purchasing fixed storage devices (ie non-portable devices such as refrigerators, freezers and long-term passive devices), the following three questions will help you categorise your health facilities:

1. Does the facility have access to reliable electricity?

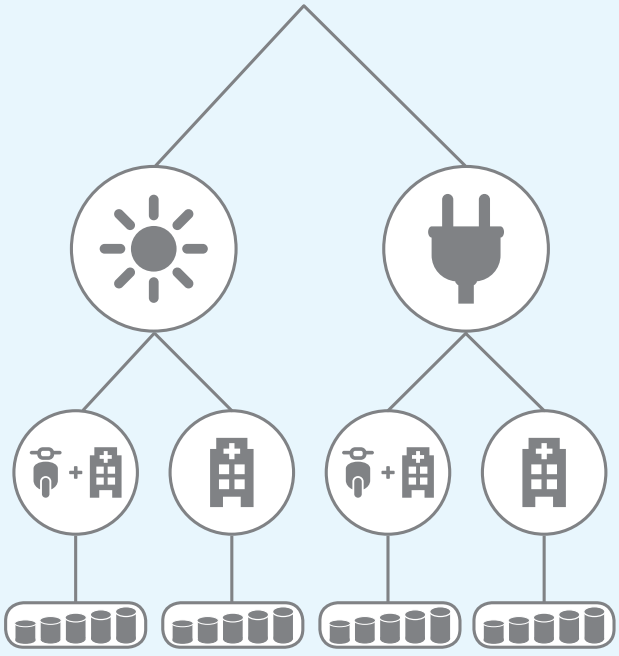
2. Does the facility need to either freeze or chill coolant packs to support outreach?

3. What is the current and near future* required vaccine storage capacity of the facility?



Accurately categorising your country's health facilities before purchasing any equipment will help you ensure that the diverse needs of facilities are met, and that you understand the total cost of ownership (TCO) and appropriately budget for CCE operating costs.
To note, TCO is a key consideration, but it should not be the sole decision making criterion for determining what CCE is most appropriate for your country.

Decision Tree Sample



* The term "near future" takes into consideration the average 10 year lifespan of the equipment. Therefore, the equipment should be able to accommodate any planned vaccine introductions or population increases.

1. DOES THE FACILITY HAVE ACCESS TO RELIABLE ELECTRICITY?

Begin by dividing your country's full set of health facilities in need of cold chain equipment into two segments based on access to electricity via mains or generator.

On-grid
On-grid facilities can access a minimum of eight hours of electricity per day from mains and/or generator power, and experience power outages of less than 48 hours.

Off-grid
Off-grid facilities access less than eight hours of electricity per day or experience recurring power outages that last more than 48 hours.

Purchasing implications

On-grid facilities should use electricity-powered devices – such as ice-lined refrigerators (ILRs) and on-grid freezers – since they have a lower total cost of ownership than solar or passive devices for the same amount of storage.

Between on-grid facilities, you might see variation in the degree and reliability of electricity access. Your choice of devices should correspond to the number of hours of electricity that a facility can access per day, and the length of electricity outages it experiences.

Number of hours of electricity per day: after a few days of near-continuous power to fully freeze its ice lining, a typical mains- or generator-powered ILR requires at least eight hours of electricity per day to keep its lining frozen and maintain a long holdover time. For facilities that can access more than eight hours of electricity per day, you can choose from a wide variety of ILRs. However, facilities with only four to eight hours of electricity per day will require specially-rated ILRs or may be better served by off-grid solutions. When considering individual models, it will be important to first check how many hours of electricity each model requires. Planning conservatively is key, as actual conditions where a device is used may be more demanding than those where it was tested, and in some locations, devices may need more hours of electricity per day than their supplier rating indicates.

Length of power outages: choose devices that have a holdover time longer than expected power outages. Current WHO performance quality safety (PQS) requirements require ILRs to have a minimum holdover time of 20 hours. If you expect that a given health facility will experience long power outages, you will need to select an ILR with an appropriately long holdover time.

Another consideration is the ability of on-grid facilities to reliably pay for power. For facilities where reliable payment is not possible, off-grid solutions might be more advisable.

Off-grid facilities should use devices that can generate their own power (such as solar direct drive –SDD– devices) or keep vaccines cold for long periods of time without power (such as long-term passive devices). These devices often cost much more to purchase than on-grid devices, and their operational costs tend to be higher than for those of ILR devices. For example, SDDs require more routine maintenance practices, such as regular cleaning of the panels, and long-term passive devices require regular ice pack replenishment. However, they also either greatly reduce or completely eliminate electricity costs.

2. DOES THE FACILITY NEED TO EITHER FREEZE OR CHILL COOLANT PACKS TO SUPPORT OUTREACH?

After you narrow down your device categories based on facilities' power access, you can further divide facilities by whether or not they need to produce coolant packs (ie freeze ice packs or chill water packs) for outreach.

Fixed-post immunisation facilities
These facilities rarely rely on outreach and conduct nearly all immunisations on site. As a result, they often do not need to freeze or chill coolant packs on site. For rare occasions when coolant packs are needed, they can be provided by the district store.

Fixed-post immunisation and outreach facilities
These facilities conduct immunisations on site and through multiple outreach sessions per month. They need appropriate on-site capacity to freeze or chill coolant packs for outreach activities.

The choice of coolant pack type depends on the type(s) of vaccines being provided and the temperature in the area where the device is used. WHO currently recommends using water-filled coolant packs. If freeze-free cold boxes or vaccine carriers are used, ice packs should not be conditioned before use. However, for non-freeze-free cold boxes or vaccine carriers, ice packs should be properly conditioned before use so vaccines do not freeze. For more information on choice, preparation and use of coolant packs for transport and outreach, please reference WHO vaccine management handbook, Module VMH-E7-02.1: "How to use passive containers and coolant packs for vaccine transport and outreach operations."

Purchasing implications

Fixed-post immunisation facilities do not need to produce coolant packs on site, as they conduct little to no outreach. You need only to consider refrigerators or long-term passive devices for storage. For the rare outreach sessions, coolant packs should be provided by the district store.

Fixed-post immunisation and outreach facilities conduct more than one outreach session per month. For these facilities, you can assess whether coolant packs need to be either frozen or chilled on site, or whether it might be more cost-effective and programmatically feasible to freeze or chill them off site in other reliable refrigerator or freezer spaces. You can compare the costs of nearby options in the local community or at the district store with the cost of purchasing a dual compartment fridge-freezer or additional fridge or freezer unit for the facility.

It is important to note that coolant packs should not be stored in the same compartment as vaccines. Facilities should use either a dual compartment device, or two separate devices – one for storing vaccines and one for storing coolant packs. The table below will help you factor the coolant type into your device choice.

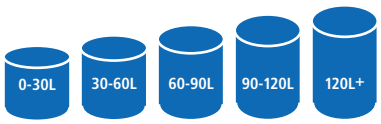
Coolant	Approach	Device for vaccine storage	Device for coolant production
Ice packs	Two devices	Fridge or long-term passive device	Freezer
	One dual compartment device	Dual compartment fridge-freezer	
Cool water packs	One device	Fridge	Fridge

Devices used to freeze or chill coolant packs should be selected based on the volume and number of packs needed, and their type according to the container used. These devices should be able to completely refreeze or re-chill the required number of packs in the time between sessions.

3. WHAT IS THE REQUIRED VACCINE STORAGE CAPACITY OF THE FACILITY?

The required storage capacity determines the right device size for a facility. The required vaccine storage capacity takes into account three factors:

- Volume of vaccines per fully immunised child (or per capita);
- Target population size;
- Vaccine supply frequency and reliability.



In assessing these factors, it is important to plan not only for current needs, but also for future needs over the lifetime of the device. Considerations could include:

- Expected population growth;
- Expected new vaccine introductions, including non-infant immunisations such as human papillomavirus (HPV) vaccines for women of childbearing age (and younger);
- Improved coverage targets;
- Supplemental immunisation activities, such as campaigns.

To calculate required vaccine storage capacity, you can use the WHO vaccine volume calculator and the WHO series of modules on immunisation training for Mid-level Managers.

Purchasing implications

If you are making purchases for multiple facilities, it will be useful to group devices into storage capacity bands, or size segments (0-30 l, 30-60 l, 60-90 l, 90-120 l and more than 120 l). This might enable you to receive volume discounts from bulk purchases.

On-grid facilities should consider ILRs, dual compartment ILR refrigerator-freezer and on-grid freezers that have the capacity to store the required number of vaccines and produce the required amount of coolant packs. Facilities with very large storage requirements (eg state or district stores) might also consider cold rooms and freezer rooms.

Off-grid facilities should consider SDD refrigerators, SDD dual compartment fridge-freezers or SDD freezers. Off-grid facilities requiring less than 5 to 10 l of storage – and that have the ability to receive regular pack ice replenishments – may also consider long-term passive devices.

Long-term passive device implications

Long-term passives are a new device category introduced within the last two years. Due to their limited storage capacity, they are mostly used by small, off-grid facilities. Because they cannot freeze or chill coolant packs, they are not suitable for facilities that perform high levels of outreach unless paired with a separate freezer. Long-term passive devices need a regular and predictable supply of large volumes of ice packs (potentially up to 30 kg for some future devices). Some also require special types of ice packs, which are larger than standard WHO-approved ice packs and shaped differently. Long-term passive devices have two major requirements:

1. A nearby delivery hub that can produce enough ice packs per month for each long-term passive device it supports. As each device's ice packs must be replenished every three to five weeks, this process often involves having a spare set of ice packs and using a freezer at the delivery hub. The number of devices that one delivery hub can support will vary. This number should be evaluated based on the existing or planned freezing capacity at the hub, as well as the ice demands of the device(s) being supported.

2. A delivery system capable of delivering a monthly shipment of enough ice packs (the ice must be transported in a box that can keep it frozen). Motorcycles may not be able to transport large shipments, which can limit ease of access to last-mile facilities. The distance and road conditions between the delivery hub and facility also need to be considered when evaluating the cost and sustainability of this delivery system.

If either one of these requirements is not met, there is a risk for vaccine wastage as well as for interruptions in interruptions in immunisation service at the facilities served by the delivery hub.

Given these restrictions, **a solar direct drive (SDD) device should be chosen over a long-term passive device unless a facility meets all of the following conditions:**

- An SDD device is inappropriate for a particular site or population (eg due to insufficient exposure to sunlight);
- On-grid, dependable freezing of ice packs is possible at a nearby supply point;
- Routine and cost effective delivery systems are capable of stable ice delivery;
- The required vaccine storage capacity is less than 10 l and storage needs are not likely to increase over the next several years.

Other considerations for device selection

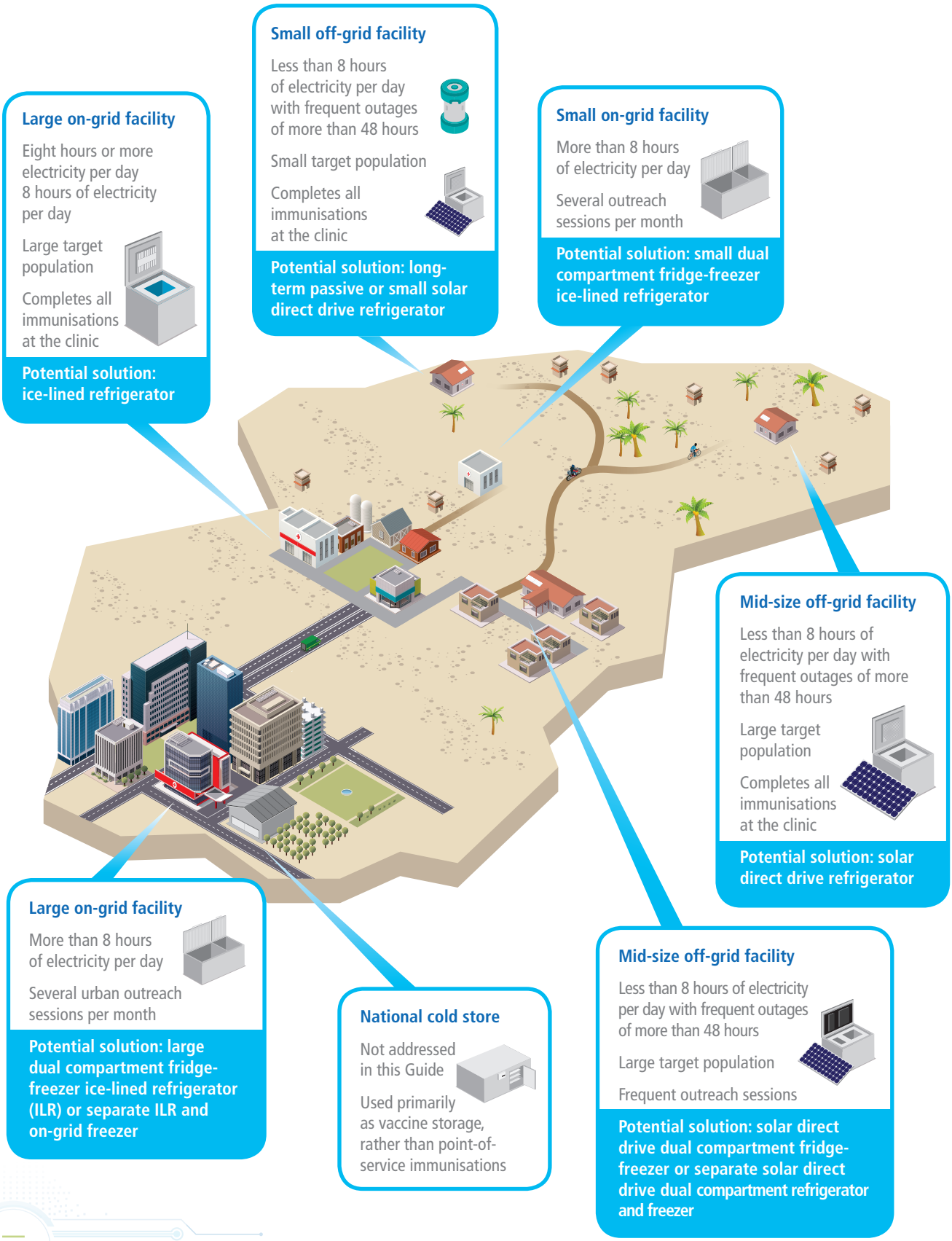
The answers to the three questions on page 6 are critical for identifying the correct cold chain devices for your health facilities, but there are a few other factors that should be considered before you make a purchase.

- **Ambient temperature range:** It will be important to select a device that is performance quality safety (PQS) tested to operate across the full range of temperatures in the area where the device is being used.
- **Ability to use solar devices:** Solar devices are not suitable for all facilities. Some facilities might be surrounded by buildings or trees that would block solar panels from receiving direct sunlight. Others may not have strong enough sunlight all year round. If you are considering purchasing solar devices, having a site evaluation conducted will help you determine whether a solar device will receive enough power. Solar panels can be mounted on either the roof of the facility, if strong enough and receives adequate sunlight during the day, or on a separate mounting pole. While a separate mounting pole may mean additional costs, it offers more flexibility for panel placement. When preparing an operational deployment plan, it is critical to note whether a pole or roof mount will be necessary at a given facility based on site evaluations. The number of pole and roof mount installations should be specified in the operational deployment plan so that appropriate resources can be mobilized for installation. To ensure long-term reliability and performance, consideration should be given to the availability of service providers to provide maintenance.

If you find that none of the options in this guide are appropriate for a particular facility, a WHO PQS representative can help you choose the right device. PQS representatives can be contacted via email at pqsinfo@who.int. They can provide support, advice and guidance to help you purchase the most suitable equipment for a given facility's field conditions.

Facility categorisation map

Once you have categorised your country's health facilities by CCE needs, the next section of this guide will assist you in choosing the appropriate device types, and then specific device models. Below, please find some hypothetical examples to help illustrate device selection. These examples are not representative of any specific country, but rather, are intended to help you start assessing the attributes of your facilities.



Worksheet

Categorising your country's health facilities will help you group those with similar traits together. This activity is designed to prepare you to use the next section to choose the right CCE devices and models. By filling out the worksheet below, you can divide your country's full landscape of health facilities into categories and count how many fit into each group.

How many health facilities are in need of new cold chain equipment?

_____

On-grid facilities

_____

Off-grid facilities

_____

Immunisation and outreach facilities

_____

Immunisation facilities

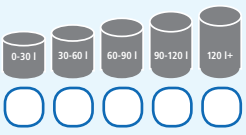
_____

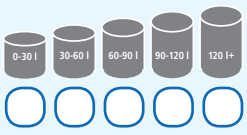
Immunisation and outreach facilities

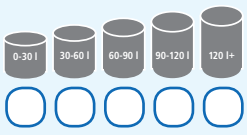
_____

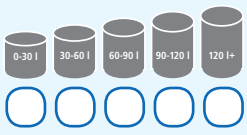
Immunisation facilities

_____









STEP 2: CHOOSING YOUR DEVICE TYPES, THEN YOUR DEVICE MODELS

Cold chain equipment optimisation platform (CCEOP) requirements

Through the cold chain equipment optimisation platform, Gavi has committed funds to co-invest with countries, both to equip facilities for the first time with cold chain equipment, and also, for facilities already equipped with aging or non-functional equipment, to upgrade with higher-performing equipment. They must also meet specific requirements for several technology features. This guide focuses on four of the most important features:

1. **User-independent ("Grade A") freeze protection.** WHO PQS defined three grades of freeze protection: A (user-independent), B (requiring one user intervention to prevent freezing), C (requiring more than one user intervention to prevent freezing). The CCEOP subsidises equipment that is Grade A only, ie, not requiring any user intervention to prevent freezing;
2. **Extended operating temperature range.** This requirement matches what is currently defined by WHO PQS: +10°C to +43°C for refrigerators, and long-term passive devices; +15°C to +43°C for freeze-free cold boxes and vaccine carriers;
3. **Temperature monitoring and logging.** The platform currently requires only Type 1 (the most basic) temperature monitoring devices to be provided with the refrigerator; Type 2 is expected to be required starting in 2019. However, the platform subsidises Types 1, 2, 3, and 4; and;
4. **Voltage stabilizing (for on-grid devices only).** This requirement matches what is currently defined by WHO PQS.

1. USER-INDEPENDENT FREEZE PROTECTION

This feature ensures that vaccines are not exposed to freezing temperatures.

User independent freeze protection		Meets platform requirement
Grade A	When the device is used within its rated ambient temperature range, the user does not need to perform any actions to protect vaccines from freezing temperatures. For example, the device would not require baskets to protect vaccines from freezing. However, baskets may still be used to sort vaccines in the device.	✓
Grade B	When the device is used within its rated ambient temperature range, the user must perform one action to protect vaccines from freezing temperatures.	✗
Grade C	When the device is used within its rated ambient temperature range, the user must perform more than one action to protect vaccines from freezing temperatures.	✗

WHO PQS is certifying devices for Grade A freeze protection. Grade A devices that have been certified by WHO PQS are indicated in the tables of currently-available products in this Guide, since these devices are platform-compliant. For additional details, please refer to the WHO PQS catalogue guidelines, the "target product profile mains-powered refrigerators WHO/PQS/E003/TPP04" for on-grid refrigerators, and the "target product profile SDD refrigerators WHO/PQS/E003/TPP01" for solar direct drive (SDD) refrigerators.

2. EXTENDED OPERATING TEMPERATURE RANGE

This feature keeps the equipment operating correctly even during large changes in ambient temperature.

Extended operating temperature range		Meets platform requirement
Moderate	The device operates at a steady 27 °C ambient temperature and over a 27 °C/10 °C day/night cycling temperature range.	✗
Temperate	The device operates at a steady 32 °C ambient temperature and over a 32 °C/15 °C day/night cycling temperature range.	✗
Hot	The device operates at a steady 43°C ambient temperature and over a 43 °C/25 °C day/night cycling temperature range.	✗
Extended	The device satisfies the requirements for hot zone operation above (43 °C), and can also operate at a continuous rated minimum ambient temperature of at most 10 °C.	✓

Note: for freeze-free cold boxes, the required extended operating temperature range is +15C to +43C, in accordance to PQS standards. For freeze-free vaccine carriers, the required extended operating temperature range is +10C to +43C, in accordance to PQS standards. For additional details on operating temperature ranges, please reference the WHO PQS catalogue, as well as the target product profiles for specific devices on the WHO PQS catalogue specifications web page.

3. TEMPERATURE MONITORING AND LOGGING

Once in the field, the refrigerator compartment must be equipped with a temperature recording device that supports the transfer of data to a logistics management information system (LMIS) for analysis. This device can be provided in two ways: 1) as a fully integrated part of the refrigerator or 2) as a separate, standalone device, but shipped along with the refrigerator.

Temperature monitoring and logging		Meets platform requirement
Type 1 Standalone logger	The device includes a country-selected and pre-qualified disposable 30-day temperature logger.	✓
Type 2 Integrated logger	The device includes a supplier-selected and fully-integrated 30-day temperature logger built into the refrigerator body.	✓
Type 3 Standalone Remote Temperature Monitoring Device	The device includes a country-selected and pre-qualified remote temperature monitoring device, which in addition to temperature monitoring and logging, can also send SMS alarm messages and potentially be integrated with an LMIS platform.	✓
Type 4 Integrated Remote Temperature Monitoring Device	The device includes a supplier-selected and fully-integrated remote temperature monitoring device, which in addition to temperature monitoring and logging, can also send SMS alarm messages and potentially be integrated with an LMIS platform.	✓

4. VOLTAGE STABILIZATION/STABILIZER (FOR ON-GRID DEVICES ONLY)

This feature protects equipment from electrical damage. All voltage stabilizers must meet WHO PQS certification requirements.

Voltage stabilizers are used between the electric power outlet and the refrigerator. Stabilizers are designed to protect AC-powered refrigerators from a range of power-related issues, including voltage or frequency fluctuation (eg when a generator is switching on or off) or voltage surges (due to power transmission issues in the grid). This protection from AC power issues can safeguard refrigerator's or freezer's electronic control unit (ECU), compressor, fuses, and other electronic components from damage, and can thereby increase the refrigerator's uptime in the cold chain. A built-in or stand-alone voltage stabilizer must always be used when connecting an on-grid refrigerator or freezer to mains power.

Voltage Stabilization/Stabilizer (for on-grid devices only)		Meets platform requirement
Standalone	A separate voltage stabilizer is bundled with the purchase of a refrigerator or freezer.	✓
Integrated	A voltage stabilizer is built into the refrigerator or freezer.	✓

After a power cut, some voltage stabilizers have a delay in restarting. This delay protects equipment from voltage fluctuations as the power grid re-stabilises. Depending on power quality, this delay can range from six minutes to more than 30 minutes. In choosing a device to purchase, these delays should be factored into the amount of power a device can access each day. Where equipment can be sufficiently protected, a shorter delay might be preferable to ensure access to enough power. As of September 2017, WHO PQS has published updated requirements for voltage stabilizers that are required for use with AC-powered fridges and freezers. Voltage stabilizer devices will be evaluated and pre-qualified against specifications and testing protocols found here: http://apps.who.int/immunization_standards/vaccine_quality/pqs_catalogue/catdocumentation.aspx?id_cat=36

Solar energy harvesting

Solar energy harvesting is not a requirement for platform compliance, but it is an innovative new feature offered on some current solar direct drive (SDD) devices – and that several other suppliers are considering incorporating into future models.

Frequently, the panels of an SDD device generate more power than is needed to run a refrigerator unit. Energy harvesting allows health facilities to use excess power from solar panels for other purposes. Depending on voltage specifications, health workers can use devices with energy harvesting to charge cell phones, laptops, radios and battery-powered lanterns, or power devices such as fans and lighting.

Solar energy harvesting is an especially promising capability, as it can evolve an SDD device from a cold chain solution to a potential power hub for other devices at an off-grid clinic.

As of May 2017, WHO PQS has updated requirements for devices offering energy harvesting. SDDs featuring energy harvesting technology will be evaluated using the specifications and testing protocols available on the http://apps.who.int/immunization_standards/vaccine_quality/pqs_catalogue/catdocumentation.aspx?id_cat=36.

Overview of future devices

The platform gives countries the opportunity to upgrade their cold chains with the best and most appropriate equipment available today. Looking ahead, more exciting cold chain technologies are expected to arrive on the market in the next one to two years. These devices and features are designed to address user needs and better protect vaccines.

This guide includes some new CCE devices that are still in the design and testing phases, or devices in the pipeline for future platform-eligibility. Information on these devices is included to help inform planning for procurement. However, please bear in mind several limitations below.

- Device specifications can change during the prototype and testing phases. Devices that are eventually PQS-approved may differ from what is indicated here.
- All information on future devices in this guide is self-reported by suppliers who were asked to describe their devices in development (for release in 2018 and beyond). The technical specifications and Platform-compliance of these devices have not been independently validated, nor have the devices been assessed by the WHO Department of Essential Medicines and Health Products Prequalification Team.
- Not all suppliers opted to provide details on their future products, so this list of future devices does not include every model that will arrive on the market in the next two years.

Information about these future devices will be updated and added with each new version of this Guide.

There are also emerging technologies and new device categories that are not mentioned in this guide because their development and commercialisation timelines are still uncertain.

If you have device-specific questions, you can reach out directly to the suppliers to receive the latest information.

Total Cost of Ownership (TCO)

The purpose of this tool is to understand the overall cost of purchasing, installing and maintaining CCE over the lifetime of the equipment. It is important for countries to calculate the Total Cost of Ownership (TCO) of their desired cold chain equipment during the CCEOP application stage.

The Total Cost of Ownership tool was developed by PATH and is the only tool currently in use that has been approved for use by Gavi and UNICEF. All TCO figures for Gavi CCEOP eligible products should be calculated using the PATH TCO Tool.

Previous versions of the Technology Guide offered only an indicative TCO for CCE equipment using Nigeria-specific inputs. Countries should calculate TCO for their own CCE equipment using local inputs.

The PATH TCO tool can be found here: http://www.path.org/publications/files/DT_ccce_tco_tool_061317.xlsm

The TCO calculations assume an effective life of 10 years for all devices. However, a device's actual life will vary based on equipment reliability, local conditions and its maintenance schedule. TCO is expressed through three measures:

- Purchase price, including the cost of the device, temperature monitoring device, and for ILRs a separate voltage stabilizer;
- Delivery and installation costs;
- Operational expense (Opex), which includes the cost of spare parts, energy, maintenance and repairs for an expected lifetime of ten years, as well as a replacement 30-day temperature logger if required to meet platform requirements. If the device utilizes an RTMD, the operating service and communications costs are considered as part of the Opex.

STEP 3: DEVICE SELECTION

In the previous section, the worksheet on page 13 helped you to divide your health facilities into categories based on electricity access, outreach activities and storage capacity requirements. In the pages that follow, you can identify the current and future devices that meet the needs of each group. You can also compare their features, and their compliance with Platform requirements (and their eligibility for joint investment from Gavi).

Of the three measures of the TCO methodology, the purchase price is singular and applies to all countries. However, delivery and installation costs, as well as Opex should be country-specific, calculated using local inputs, in order to provide a useful reference for comparison across all products. Appendix A lists the specific assumptions made when calculating such costs for Nigeria.

Device selection

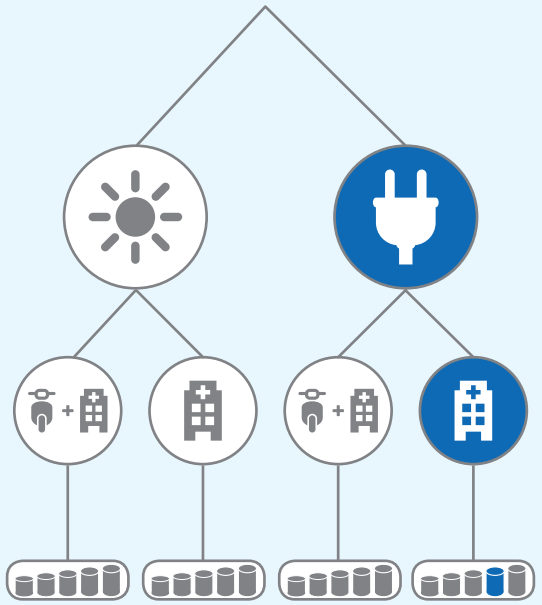
For each entry in the device tables, you will find a link to the model's corresponding page in the UNICEF SD catalogue. Please check the UNICEF SD Catalogue for accurate and up-to-date purchase prices for CCEOP-eligible equipment. If pricing information is not found in the UNICEF SD catalogue, please refer to the CCEOP application budget template as a second reference. Also, the device tables offer two volume ranges (price per unit for orders of 1-9 units and 200-499 units respectively), as all suppliers currently offer volume based discounts. Please refer to the UNICEF SD catalogue to view the full list (11 volume ranges) of volume based discounts.

For the information in the device tables, please note the following considerations.

- **Freeze protection:** WHO has recently published a testing protocol for Grade A freeze protection. The devices listed in the tables below have been verified by WHO to meet this protocol and therefore considered CCEOP-eligible.
- **Voltage Stabilizing:** WHO has recently published a testing protocol for adequate protection against voltage/frequency fluctuation. Although no device has as yet been verified by WHO to meet this protocol, the future products section shows devices that are expected to achieve PQS certification during the first half of 2018, informed by TPP 2019.
- **Device pricing:**
  - Where available, device pricing is taken from the UNICEF Supply Catalogue as a first point of reference. If not available in the SD catalogue, the prices are sourced from the latest WHO PQS catalogue. These price points are cross referenced against manufacturers' direct quotes.
  - All pricing is based on orders of 1-9 units, and 200-499 units, FCA INCOTERMS and plywood packaging.
  - The exchange rate is 1 Euro=1.18 USD. All pricing is in US Dollars (USD) using UN exchange rates as of December 2017.
  - Prices for each device include the cost of a temperature monitoring device and a voltage regulator (where applicable).
  - Prices do not include any additional fees incurred when ordering from the UNICEF supply catalogue.
  - Prices do not reflect the joint investment you may receive from Gavi if you purchase platform-compliant devices.
- **Service bundle costs:** the shipment costs from supplier factory to country port or health facility have been estimated as a percentage of purchase price. For more expensive devices, this estimate may overstate delivery cost. In-country transport costs are treated as a fixed amount for each device category.
- **Portable devices:** for cold boxes and vaccine carriers, this guide only shows purchase price, since delivery and operational costs will vary by country and device use.
- **Two-mode devices:** some single-compartment ice-lined refrigerators (ILRs) can be set to operate as either a fridge or a freezer. These devices are included in the table for current ILRs and have a footnote to indicate that they can also operate as freezers.

EXAMPLE 1

Sonia's decision tree



Sonia is a country-level decision maker who has to determine what device will be best for several large, on-grid facilities. These facilities conduct very little outreach and are not distribution points for vaccines or ice packs.

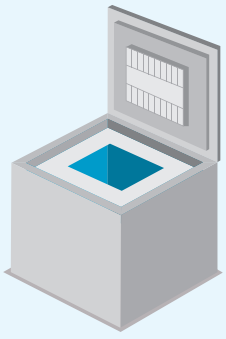
Decision process: although these semi-urban facilities consistently have access to more than eight hours of electricity per day, they have occasional power outages of up to 24 hours. A standard (non-ice-lined) refrigerator would be insufficient, but most ice-lined refrigerators can operate with eight hours of electricity per day.

Health workers primarily complete all immunisations at the facility. While they may do one outreach session per month, workers have access to a nearby store's refrigeration systems to obtain chilled water-packs. If needed, they can also collect frozen ice packs with their monthly vaccine pickup from the district store for little additional cost.

After grouping facilities according to their target population size (and accounting for population growth and new vaccine introductions), using WHO guidance on vaccine volume per fully immunised child and ensuring that vaccines can be reliably delivered on schedule, Sonia determines he needs devices with between 90 and 120 L in vaccine storage capacity.

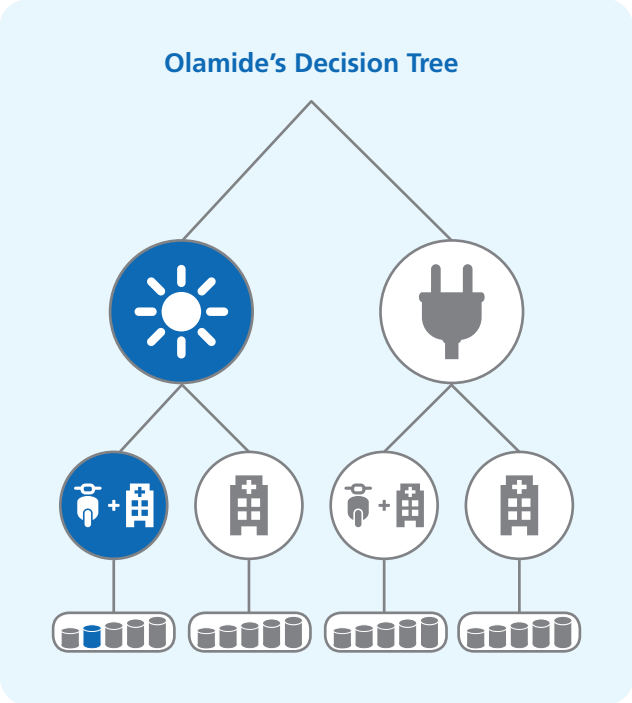
Final Selection: Sonia chooses a platform-compliant ice-lined refrigerator (ILR) with storage capacity between 90 and 120 L for each facility. The ILR is rated to operate with only eight hours of electricity per day. With a holdover in excess of 100 hours, it can easily withstand power outages of three to four days. The ILR also has a much lower total cost of ownership than similarly sized solar devices. Since platform-compliant devices have Grade A user-independent freeze protection, Sonia knows there is minimal chance of vaccine wastage due to freezing.

Additional considerations: Sonia must purchase and install high-quality voltage stabilizers with the ILRs to protect them from damage by power surges (if voltage stabilizers are not already integrated into the devices she chose). Sonia must also purchase and utilise suitable temperature monitoring devices (at least type 1 or type 2) in order to: a) immediately know, when looking at the device's display, whether vaccines have been exposed to unacceptable temperatures and b) track the performance of the refrigerator, and to call a technician for maintenance and repair, if required.



Device selection

EXAMPLE 2

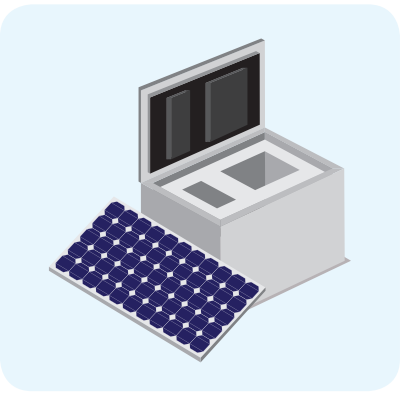


Olamide is a country-level decision maker who has to determine what devices are best for a group of mid-size, off-grid facilities that complete weekly outreach sessions.

Decision process: these facilities rarely have access to more than a few hours of electricity each week. When they can access electricity, it is inconsistent and unpredictable. Only a solar direct drive (SDD) or long-term passive device will keep vaccines at appropriate temperatures throughout these long periods without power.

Health workers at these facilities engage in weekly outreach activities in their communities. In most cases, there are no places nearby where workers can freeze ice packs (especially during Supplementary Immunisation Activities [SIAs]) or freeze icepacks, and ice deliveries are too expensive. These facilities require devices with a freezer compartment that can freeze ice packs.

Olamide determines that he needs devices with at least 30 L in vaccine storage capacity. This capacity would require four to six long-term passive devices per facility, but only one 30 L or larger SDD device. Given the need for freezer capability, the optimal solution would be either dual compartment SDD fridge-freezers or separate SDD refrigerators and SDD freezers.



Final Selection: Olamide decides to purchase a platform-compliant dual compartment SDD fridge-freezer for each facility. These devices can produce ice packs to support the facility's outreach sessions. Since they are solar powered, they are not affected by the lack of reliable electricity. Olamide also calculates that purchasing a dual compartment SDD fridge-freezer has a lower TCO than purchasing a separate SDD fridge and SDD freezer for each facility.

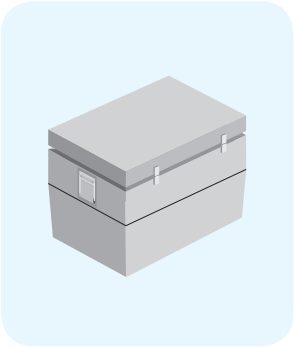
Additional considerations: to ensure solar compatibility, Olamide must have his sites evaluated for:

- Sufficient sun exposure for the SDD device to function correctly;
- A roof that can support solar panels and any special solar panel mounting equipment required;
- The length of cable required between solar panels and the device;
- Access to maintenance networks for repairs.

In addition, the freezer compartment of the SDD devices he purchases should be able to store the same size of ice packs (either 0.4 L or 0.6 L) that the vaccine carriers use for outreach.

Device selection

EXAMPLE 3



Michael is a country-level decision maker, who has to determine how to address freezing risk when transporting vaccines regionally.

Decision process: a recent temperature monitoring study found that a number of shipments leaving the regional stores exposed vaccines to dangerous freezing conditions. The main contributors were:

1. Use of old styrofoam containers with no insulation between the ice and vaccines;
2. Inconsistent ice pack conditioning practices by staff.

To prevent vaccine freezing, Michael initially considers switching to cool water packs as a lower-cost option. However, per the WHO guidance for mid-level delivery, cool water packs do not provide enough cold life for heat-sensitive vaccines on long delivery routes. For this reason, Michael decides to look at non-freeze cold boxes to ensure vaccine safety.

He needs to figure out the appropriate volume of the cold boxes, and how to account for different delivery routes. To collect this information, Michael surveys each regional store, and determines both the smallest and largest deliveries they make on a regular basis. On average, the smallest is 25 L and the largest is 50 L. To address differing route capacity requirements, he chooses two cold boxes so that the smaller and larger capacity routes can be served by one or two boxes respectively.

Final selection: Michael picks a capacity of 30 L for use in delivery from regional stores to districts, with each regional store to receive two 30 L boxes. However, there are currently no Grade A freeze protected cold boxes available in the market, and the CCE only subsidises Grade A cold boxes.

As a result, Michael considers whether to postpone procuring cold boxes until mid 2018 (when Grade A cold boxes are expected to be available) or to procure existing cold boxes. If Michael chooses the latter option, he knows he must procure the cold boxes with funding from other sources. He therefore decides to wait until mid 2018, select a Grade A cold box, and utilise CCE funding for the procurement.

How to choose between models

If you find more than one model that would meet the needs of a facility, the following factors can help you narrow down your decision:

Individual device characteristics:

- Compliance with platform requirements, which determines eligibility for platform funding and reflects a model's higher level of technological capability;
- Total Cost of Ownership, including purchase price of equipment, delivery, installation, training, commissioning, as well as life time operating costs (as calculated using the PAT TCO tool with your country-specific inputs);
- Holdover time for ILRs based on a facility's power reliability;
  - ***Devices with extended holdover time are preferable for facilities with less or unreliable electricity***
- Autonomy time for SDD devices based on regional climate factors;
  - ***Devices with extended autonomy time are preferable for facilities in regions with long periods of low sunlight***
- Freezer capacity for icepack production;
  - ***Devices with a freezer compartment are preferable for facilities that need ice packs for outreach or transport***
- Ease of use, including:
  - ***Readability of control panels and displays by a standing health worker;***
  - ***Use of internal storage racks, boxes or drawers to help organise vaccines and separate other medicines that are stored in the device.***

Support and standardisation considerations:

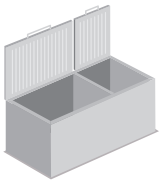
- Length and scope of the device's warranty. Please note that all warranties are not the same, and countries should refer to the manufacturer for more information on terms and conditions covered under each warranty;
- Access to professional in-country installation and maintenance support, including availability of spare parts;
- Quality of after-sales support from the supplier, including training for device users;
- Makes and models of your country's existing cold chain equipment, as standardisation across facilities will enable you to leverage benefits like common maintenance networks.

When choosing between vaccine carriers and cold boxes for transport or outreach, consider the following factors in your decision:

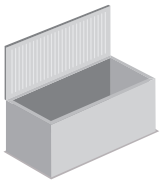
- Compliance with platform requirements, which determines eligibility for platform funding and reflects a model's higher level of technological capability;
- When developing applications for the platform, please indicate your preferred device based on the options in the freeze-free vaccine carrier section as well as the Future Products tables;
- Degree of cold life to keep vaccines at safe temperatures for an entire transport or outreach session (including travel to and from the outreach session);
- Storage capacity based on the volume of vaccines that must be transported at any one time for outreach or transport between facilities, and the number of transport or outreach activities that must be supported at any time;
- Size, type and number of coolant packs required, and their compatibility with other coolant packs used in the country.

On-grid devices

Ice-lined refrigerators (ILRs)



Dual compartment fridge-freezer ILRs



On-grid freezers

	Ice-lined refrigerators (ILRs)	Dual compartment fridge-freezer ILRs	On-grid freezers
Key features	This device has an internal lining of ice, ice packs or cold water-filled compartments Its internal compressor uses electricity to refreeze or re-cool its lining	This device is an ILR with a separate compartment to freeze ice packs	This device has a compression-driven system that uses electricity to create ice and freeze ice packs
Outreach capability	Does not support outreach by itself, unless verified safe to cool water packs in the vaccine compartment	Supports low/medium levels of outreach	Supports high levels of outreach*
Vaccine storage capacity	 **(27-240 L)**	 **(60 L)**	 **(n/a)**
Number of current Platform-compliant devices	18	1	8
Additional considerations	Most models require 8 hours of electricity per day to re-cool the lining Some new devices require only 4-6 hours to maintain safe storage temperature. However, more than 4-6 hours of power may be required to build longer holdover times for extended power outages This device should always be installed with a voltage regulator Some ILRs with a single compartment can be set to operate as either a fridge or a freezer	This device has an ice-making capability for outreach Most models require at least 8 hours of electricity per day to re-cool the lining Some new devices require only 4-6 hours to maintain safe storage temperature. However, more than 4-6 hours of power may be required to build longer holdover times for extended power outages This device should always be installed with a voltage regulator	This device has an ice-making capability for outreach Select models can be used to store freezable vaccines (eg oral polio vaccine) It cannot be used to store vaccines that require 2-8 °C storage It should always be installed with a voltage regulator

*Depending on freezer capacity when paired with a vaccine refrigerator.

Platform Compliance

The CCEOP invests only in products that meet full platform compliance. This Guide lists only fully compliant products, both for current and future devices. The criteria for full platform compliance are the following:

- Grade A freeze protection: WHO-verified
- Grade A freeze protection: supplier-reported[§]
- Extended operating temperature
- Temperature monitoring/ logging and type (1, 2, 3)
- Standalone voltage regulators
- Integrated voltage regulators
- ✓ Full platform compliance

CURRENT ICE-LINED REFRIGERATORS

The table below shows prices of platform-eligible products only. Service bundle costs are not included. Service bundle indicative costs for current ice-lined refrigerators is between USD 400 and USD 2000.

Supplier	Model	Vaccine storage capacity, L	Holdover (days)	Price per unit for orders of 1 to 9 units, USD	Price per unit for orders of 200-499 units, USD	Warranty (years)
Vaccine storage capacity, 120 L+						
B Medical	TCW 4000 AC	240	3.2	5,119	4,188	2 (standard)
Godrej (Sure Chill)	GVR 225AC	225	2.3	1,910	1,872	5
Haier	HBC 260	211	1.4	1,000	900	2 (standard)*
Dulas	VC 225 ILR	203.2	3.9	3,304	2,596	2 (standard)*
Vestfrost	VLS 400A Green Line	145	2.3	1,342	1,248	2 (standard)*
Zero (Sure Chill)	ZLF150AC	128	5.3	2,300	2,254	5
Vestfrost	VLS 350A Green Line	127	2.3	1,247	1,160	2 (standard)*
Haier	HBC 150	122	1.3	850	770	2 (standard)*
Vaccine storage capacity, 90-120 L						
Godrej (Sure Chill)	GVR100AC	99	12.5	2,355	2,308	5
Zero (Sure Chill)	ZLF100AC	99	4.7	1,950	1,912	5
Godrej (Sure Chill)	GVR 99 Lite	98.5	2.5	1,200	1,176	5
Vestfrost	VLS 300A Green Line	98	2.3	1,127	1,048	2 (standard)*
Vaccine storage capacity, 60-90 L						
Godrej (Sure Chill)	GVR 75 Lite	72.5	3.4	1,140	1,118	5
Haier	HBC 80	61	1.3	650	570	2 (standard)*
Vestfrost	VLS 200A Green Line	60	2.3	946	880	2 (standard)*
Vaccine storage capacity, 30-60 L						
Godrej (Sure Chill)	GVR 51 Lite	51	2.3	1,090	1,068	5
Aucma	CFD-50	50	5.0	1,400	1,300	2 (standard)
Godrej (Sure Chill)	GVR50AC	46.5	7.6	1,642	1,610	5
Vaccine storage capacity, 0-30 L						
Zero (Sure Chill)	ZLF30AC	27	3.2	1,250	1,226	5

* Please note that these products also come with the option for extended warranty

Note: **This table uses United Nations (UN) exchange rates as of December 2017.**

FUTURE ICE-LINED REFRIGERATORS

Stage	Supplier	Model	Vaccine storage capacity, L	Holdover (days) based on preliminary testing data or results	Integrated VS	Warranty
Prototype	Vestfrost	VLS500	265	3	N/A	N/A
Prototype	Zero (Sure Chill)	ZLF80AC	78	180	Integrated	2 (standard)*
Prototype	Aucma	YBC-120	60	24	Integrated	3
Testing	Zero (Sure Chill)	ZLF57AC	54	120	Integrated	2 (standard)*
Prototype	Godrej (Sure Chill)	GVR25AC	25	3	Integrated	2 (standard)*

Integrated VS is one of the future TPP criteria. However, this select TPP 2019 criterion is not defined as being mandatory by WHO PQS.

*Please note that these products also come with the option for extended warranty between 5-10 years.

CURRENT DUAL-COMPARTMENT ICE-LINED FRIDGE-FREEZERS

The table below shows prices of platform-eligible products only. Service bundle costs are not included. Service bundle indicative costs for current dual-compartment ice-lined refrigerators is between USD 400 and USD 2000

Supplier	Model	Vaccine storage capacity, L	Waterpack storage capacity, L	Waterpack freezing capacity (kg/24hr)	Holdover (days)	Price per unit for orders of 1 to 9 units, USD	Price per unit for orders of 200-499 units, USD	Warranty
Vaccine storage capacity, 30-60 l								
Vestfrost	VLS 064 RF	52.5	6 x 0.6	1.6	1.2	1,413	1,313	2 (standard)

Please note that this product also come with the option for extended warranty.

FUTURE DUAL-COMPARTMENT ICE-LINED FRIDGE-FREEZERS

Stage	Supplier	Model	Vaccine storage capacity, L	Waterpack storage capacity, L	Waterpack freezing capacity, (kg/24 hours)	Holdover (days)	Integrated VS	Warranty
Prototype	Zero (Sure Chill)	ZLF 170 AC	128	26 x 0.6	5.4	5.2	Integrated	2 (standard)*
Prototype	Zero (Sure Chill)	ZLF 120 AC	99	26 x 0.6	5.4	5.4	Integrated	2 (standard)*
Prototype	Godrej (Sure Chill)	GVR 60FF ILR	67.5	24 x 0.6	2.4	TBC	Integrated	2 (standard)*
Testing	Godrej (Sure Chill)	GVR55FFAC	55	24 x 0.6	N/A	72	Integrated	2 (standard)*
Testing	Zero (Sure Chill)	ZLF90FFAC	54	24 x 0.6	N/A	120	Integrated	2 (standard)*
Testing	Haier	HBCD-90	37.5	12 x 0.6	2.08	4.8	N/A	2 (standard)*

Integrated VS is one of the future TPP criteria. However, this select TPP 2019 criterion is not defined as being mandatory by WHO PQS.

*Please note that these products also come with the option for extended warranty between 5-10 years.

*Please note that these products also come with the option for extended warranty between 5-10 years.

Note: **This table uses United Nations (UN) exchange rates as of December 2017.**

CURRENT ON-GRID FREEZERS

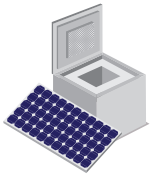
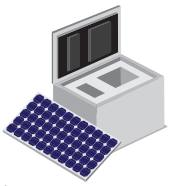
The table below shows prices of platform-eligible products only. Service bundle costs are not included. Service bundle indicative costs for current ice-lined freezers is between USD 400 and USD 2000

Supplier	Model	Gross Volume, L	Grade A Freeze Protection	Holdover (days)	Waterpack storage capacity, L	Waterpack freezing capacity, (kg/24 hours)	Price per unit for orders of 1 to 9 units, USD	Price per unit for orders of 200-499 units, USD	Warranty
Gross storage capacity, 90-120 L									
Vestfrost	MF 114	105	4	0.1	64 x 0.6	7.2	575	557	2 (standard)*
Gross storage capacity, 120 L+									
Aucma	DW-25W300	300	4	2.4	233 x 0.6	38.3	540	490	2 (standard)
B Medical	TFW 3000 AC	204	4	2.2	116 x 0.6	32	3,990	3,123	2 (standard)
Haier	HBD 286	298	4	0.2	310 x 0.6	16.8	560	532	2 (standard)*
Vestfrost	MF 314	281	4	0.2	256 x 0.6	7.2	758	735	2 (standard)*
Vestfrost	MF 214	171	4	0.1	160 x 0.6	7.2	657	637	2 (standard)*
Aucma	DW-25W147	147	4	0.3	124 x 0.6	14.5	450	400	2 (standard)
Haier	HBD 116	121	4	0.1	136 x 0.6	12	465	442	2 (standard)*

*Please note that these products also come with the option for extended warranty.

Note: **This table uses United Nations (UN) exchange rates as of December 2017.**

Off-grid devices

	 Solar direct drive (SDD) refrigerators	 Dual compartment fridge-freezer SDD devices	SDD freezers
Key features	This device is powered by solar panel It requires less maintenance than a solar battery refrigerator	This device is powered by solar panel It requires less maintenance than a solar battery fridge-freezer It has dual fridge and freezer compartments to support outreach	This device is powered by solar panel It requires less maintenance than a solar battery freezer
Outreach capability	Supports high/low levels of outreach when accompanied by an ice pack freezer or compartment for chilling water packs*	Supports low/medium levels of outreach	Supports medium levels of outreach using ice packs
Vaccine storage capacity	 **(15-170 L)**	 **(36-102 L)**	**No models currently recommended for vaccine storage, only ice pack freezing and storage.**
Number of current Platform-compliant devices	22	9	2
Additional considerations	This device requires installation by a trained technician A site evaluation is critical to determine whether solar technology is suitable for a health facility An alternate approach might be to use pole-mounted solar panels	This device requires installation by a trained technician A site evaluation is critical to determine whether solar technology is suitable for a health facility An alternate approach might be to use pole-mounted solar panels	This device requires installation by a trained technician A site evaluation is critical to determine whether solar technology is suitable for a health facility An alternate approach might be to use pole-mounted solar panels

*Depending on freezer capacity when paired with a vaccine refrigerator.

CURRENT SOLAR DIRECT DRIVE REFRIGERATORS

The table below shows prices of platform-eligible products only. Service bundle costs are not included. Service bundle indicative costs for current SDD refrigerators is between USD 650 and USD 2,550

Supplier	Model	Vaccine storage capacity, L	Autonomy (days)	Price per unit for orders of 1 to 9 units, USD	Price per unit for orders of 200-499 units, USD	Warranty
Vaccine storage capacity, 120 L+						
Vestfrost	VLS154 Green Line SDD	170	3.1	4,883	4,541	2 (standard)*
Dulas	VC200SDD	132	3.3	4,602	4,425	2 (standard)*
Zero (Sure Chill)	ZLF 150DC	128	4.5	5,330	5,224	10
Vaccine storage capacity, 90-120 L						
Dulas	VC110 SDD	110	3.3	4,366	4,130	2 (standard)*
Godrej (Sure Chill)	GVR100DC	99	7.3	4,750	4,656	10
Zero (Sure Chill)	ZLF100DC	99	7.1	4,847	4,751	10
Vestfrost	VLS094 Green Line SDD	92	3.0	3,893	3,620	2 (standard)*
Vaccine storage capacity, 60-90 L						
B Medical	TCW 3043	89	4.9	7,810	6,560	10
Dulas	VC88 SDD	88	3.3	4,366	4,130	2 (standard)*
Vaccine storage capacity, 30-60 L						
Haier	HTC 110 SDD	59	4.0	2,650	2,380	2 (standard)*
Vestfrost	VLS 054 Green Line SDD	55.5	3.0	3,492	3,247	2 (standard)*
SunDanzer	BFRV-55 SDD	54.5	3.5	3,165	3,015	2 (standard)*
Dulas	VC 50 SDD	52.5	3.1	3,245	2,950	2 (standard)
Godrej (Sure Chill)	GVR50DC	46.5	5.6	3,450	3,382	10
B Medical	TCW 40R SDD	36	3.4	6,476	5,337	10
Vaccine storage capacity, 0-30 L						
Zero (Sure Chill)	ZLF 30 DC	27	3.2	2,920	2,862	10
Vestfrost	VLS 024 SDD Green Line	25.5	3.4	3,150	2,930	2 (standard)*
Dulas	VC 30 SDD	25.5	3	3,009	2,714	2 (standard)*
Haier	HTC 40 SDD	22.5	4.9	2,400	2,166	2 (standard)*
B Medical	TCW 15R SDD	16	3.4	5,540	4,486	10
B Medical	Ultra 16 SDD	16	19.9	6,502	9,297	10
SunDanzer	BFRV-15 SDD	15	4.2	2,420	2,270	2 (standard)

*Please note that these products also come with the option for extended warranty.

Note: **This table uses United Nations (UN) exchange rates as of December 2017.**

Note: In order for the links in the tables to function, please go to **supply.unicef.org** before clicking the links.

FUTURE SOLAR DIRECT DRIVE REFRIGERATORS

Stage	Supplier	Model	Vaccine storage capacity, L	Autonomy (days)	Warranty
Prototype	Vestfrost	VLS 234 SDD	265	N/A	N/A
Prototype	Godrej (Sure Chill)	GVR225DC	225	2	2 (standard)*
Prototype	Zero (Sure Chill)	ZLF170FFDC	150	3	2 (standard)*
Prototype	Zero (Sure Chill)	ZLF120FFDC	99	3	2 (standard)*
Prototype	Godrej (Sure Chill)	GVR99LiteDC	99	2	2 (standard)*
Prototype	SunDanzer	BFRV 85 SDD	85	5.3	2 (standard)*
Prototype	Zero (Sure Chill)	ZLF80DC	78	12	2 (standard)*
Prototype	Godrej (Sure Chill)	GVR75LiteDC	75	2.5	2 (standard)*
Testing	Godrej (Sure Chill)	GVR55FFDC	55	2	2 (standard)*
Testing	Zero (Sure Chill)	ZLF57DC	54	3	2 (standard)*
Testing	Zero (Sure Chill)	ZLF90FFDC	54	3	2 (standard)*
Prototype	Godrej (Sure Chill)	GVR51LiteDC	51	3	2 (standard)*
Prototype	Aucma	CFD-50 SDD	50	5.6	2 (standard)
Prototype	Godrej (Sure Chill)	GVR 25 DC	25	2	2 (standard)*
Prototype	Aucma	YBC-10 SDD	10	5.6	2 (standard)

Integrated VS is one of the future TPP criteria. However, this select TPP 2019 criterion is not defined as being mandatory by WHO PQS.

*Please note that these products also come with the option for extended warranty between 5-10 years

CURRENT DUAL COMPARTMENT SOLAR DIRECT DRIVE REFRIGERATOR-FREEZERS

The table below shows prices of platform-eligible products only. Service bundle costs are not included. Service bundle indicative costs for current dual-compartment SDD refrigerators is between USD 650 and USD 2,550

Supplier	Model	Vaccine storage capacity, L	Waterpack storage capacity, L	Waterpack freezing capacity, (kg/24 hours)	Autonomy (days)	Price per unit for orders of 1 to 9 units, USD	Price per unit for orders of 200-499 units, USD	Warranty
Vaccine storage capacity, 90-120 L								
Dulas	VC150	102	20 x 0.6	2.04	3.2	6,490	6,254	2 (standard)*
Haier	HTCD-160	100	18 x 0.6	2.08	5.1	5,750	5,250	2 (standard)*
Vaccine storage capacity, 60-90 L								
B Medical	TCW 2043SDD	70	16 x 0.6	2.5	3.1	11,140	9,556	10
Vaccine storage capacity, 30-60 L								
Dulas	VC60SDD-1	57	13.8 kg	2.4	3.5	5,487	5,251	2 (standard)*
Vestfrost	VLS 056 RF SDD	36	30 x 0.6	1.8	3	5,676	5,278	2 (standard)*

*Please note that these products also come with the option for extended warranty between 5-10 years.

Note: **This table uses United Nations (UN) exchange rates as of December 2017.**

Supplier	Model	Vaccine storage capacity, L	Waterpack storage capacity, L	Waterpack freezing capacity, (kg/24 hours)	Autonomy (days)	Price per unit for orders of 1 to 9 units, USD	Price per unit for orders of 200-499 units, USD	Warranty
Haier	HTCD 90 SDD	37.5	20 x 0.6	2.08	4.8	3,950	3,610	2 (standard)*
B Medical	TCW 40SDD	36	8 x 0.6	1.8	3.4	6,799	5,650	10
Vaccine storage capacity, 0-30 L								
Vestfrost	VLS 026 RF SDD	20	30 x 0.6	1.8	3.1	5,339	4,965	2 (standard)*
B Medical	TCW 15 SDD	16	4 x 0.6	1.97	3.5	5,580	4,523	10

Note: Dulas purchase price information is based on Type 1 temperature monitoring equipment Additional costs will be associate with Type 4.

*Please note that this product also come with the option for extended warranty.

FUTURE DUAL COMPARTMENT SOLAR DIRECT DRIVE REFRIGERATOR-FREEZERS

Stage	Supplier	Model	Vaccine storage capacity, L	Waterpack storage capacity, L	Waterpack freezing capacity, kg/24 hours	Autonomy (days)	Warranty
Prototype	Zero	ZLF 170 DC	128	TBC x 0.6	5.4	5.0	2 (standard)*
Prototype	Zero	ZLF 120 DC	99	TBC x 0.6	5.4	5.0	2 (standard)*
Prototype	Vestfrost	VLS 096 RF SDD	92	45 x 0.6	2.2	5.0	2*
Prototype	Godrej	GVR 60FF SDD	67.5	24 x 0.6	2.4	N/A	2 (standard)*
Prototype	Aucma	SDD YBCD-55	30	N/A	N/A	5.0	3
Prototype	Aucma	YBC-10	10	N/A	N/A	5.0	3
Testing	Aucma	ARKTEK-SDD-YBC-10	10	TBC x 0.6	1.6	5.0	3

Integrated VS is one of the most talked about of the most talked about future TPP criterion. However, this select future TPP criterion is not defined as being mandatory by WHO PQS.

*Please note that these products also come with the option for extended warranty between 5-10 years

CURRENT SOLAR DIRECT DRIVE FREEZERS

The table below shows prices of platform-eligible products only. Service bundle costs are not included. Service bundle indicative costs for current SDD freezers is between USD 650 and USD 2,550

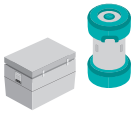
Supplier	Model	Vaccine storage capacity, L	Waterpack storage capacity, L	Waterpack freezing capacity, (kg/24 hours)	Autonomy (days)	Price per unit for orders of 1 to 9 units, USD	Price per unit for orders of 200-499 units, USD	Warranty
B Medical	TFW 40 SDD	0	11,2	2.16	5	6,088	4,997	10
Haier	HTD 40 SDD	0	16.8	2.4	5	2,250	1,890	2 (standard)*

FUTURE SOLAR DIRECT DRIVE FREEZERS

Stage	Supplier	Model	Waterpack storage capacity, L	Waterpack freezing capacity, kg/24 hours	Autonomy (days)	Warranty
Testing	Vestfrost	VFS 048 SDD	3 x 0.6	1.8	N/A	N/A

Note: **This table uses United Nations (UN) exchange rates as of December 2017.**

Off-grid passive devices



Long-term passive devices

Key features	This device has a cold life at 43 °C of more than 30 days It requires no active energy source (eg sunlight, batteries, electricity or fuel) It has low maintenance requirements It has no special installation requirements
Outreach capability	Could support outreach
Vaccine storage capacity	 **(7.9 L)**
Number of current Platform-compliant devices	1
Additional considerations	This device requires newly frozen ice packs monthly to maintain the appropriate storage temperature Current devices have a low storage capacity (less than 10 L)

CURRENT LONG-TERM PASSIVE DEVICES

Supplier	Model	Vaccine storage capacity, L	Ice Required, L	Cold life at 43 degrees (days)	Price per unit for orders of 1 to 9 units, USD	Warranty
Aucma	Arktek YBC-5	5.4	8	35	2,393	3

Note: The Arktek-YBC-5 requires conditioning of its ice packs before insertion, and is therefore not considered to have Grade A user independent freeze protection. Given the key features of the Arktek and its potential to satisfy specific supply chain needs, the platform will support its purchase on an exceptional basis.

The opex cost of an Arktek device will depend on the cold chain in your country.
An estimate can be calculated based on three components:

- The cost of any additional freezer equipment required at the district store;
- The cost of power use to freeze ice;
- The cost of labour and transport associated with picking up ice from the district store.

FUTURE LONG-TERM PASSIVE DEVICES

Stage	Supplier	Model	Vaccine storage capacity, L	Ice Required, L	Cold life at 43 °C (days)
Testing	Sure Chill	LTPD8	7.8	32.4	35

Portable devices

Freeze-free Vaccine carriers

Freeze-free Cold boxes

	Freeze-free Vaccine carriers	Freeze-free Cold boxes
Key features	This device is an insulated container used to transport and store vaccines for immunisation sessions	This device is a larger, portable, insulated container It is used for transportation between sites, storage during immunisation sessions and multi-day outreach activities, and campaigns
Outreach capability	Supports high levels of outreach	Supports high levels of outreach
Vaccine storage capacity	 **(1-4 L)**	 **(5-25 L)**
Number of current Platform-compliant devices	1	0
Number of future Platform-compliant devices	Vaccine carriers = 8	Cold boxes = 3
Additional considerations	Coolant pack standardisation should be considered if multiple carriers are used. Before purchasing, consider the maximum acceptable fully loaded weight, durability, shape/size and how long vaccines stay cold/ cool when used with ice packs.	Coolant pack standardization should be considered if multiple cold boxes are used. Before purchasing, consider the maximum acceptable fully loaded weight, durability, shape/size and how long vaccines stay cold/ cool when used with ice packs.

CURRENT FREEZE-FREE VACCINE CARRIERS

PQS Equipment Code	Supplier	Model	Vaccine Storage Capacity (liters)	Weight fully loaded (kg)	Cold life at +43°C (days)	Price per unit for orders of 1 to 9 units, USD	Price per unit for orders of >100 units, USD
E004/050	AOV International	AFVC-46	1.5	7.9	1.4	51	45

Future freeze-free Cold Boxes

A number of suppliers are on track to achieve PQS certification of platform-compliant cold boxes by 2018. These suppliers and products are shown in the table below, and are available for inclusion in Platform applications and budgeting templates. When developing applications for the Platform, please indicate your preferred device based on these future products. Please note funding from the Platform cannot be utilised to procure any non platform-compliant cold boxes that are not listed below. More freeze free cold box options with different storage capacities are expected in the coming few years.

FUTURE FREEZE-FREE COLD BOXES

Stage	Supplier	Model	Vaccine storage capacity, L	Weight fully loaded, kg	Cold life at 43 degrees (days)
Prototype	Vestfrost	VCB-A25	25	54	4
Prototype	Lifoam	TBD	20	35	3
Prototype	Haier	HRCB 24	20	40	5.4
Prototype	AOV INTERNATIONAL	TBD	15	50	4

Future freeze-free vaccine carriers

Currently, there is only one freeze-free vaccine carrier that is fully platform compliant. This product achieved WHO PQS status on 7 Dec., 2017. A number of suppliers are also on track to achieve PQS certification of platform-compliant vaccine freeze free carriers by early 2018. These suppliers and products are shown in the table below, and are available for inclusion in Platform applications and budgeting templates.

There are also emerging technologies that are not available for procurement until further notice. One example is the Portevap, which is included in the below table, but still in the development phase and hence not available for inclusion as part of platform applications and budgeting templates. The Portevap is a new technology of vaccine carrier currently in development by Global Good. The Portevap product (PE1000) is designed to be Grade A freeze protected, with lengthy cold life, and aimed at eliminating the need for ice packs in outreach. The Portevap is intended for use in outreach to hard-to-reach regions, in eradication campaigns, or in outreach from off-grid health facilities. The device contains a rechargeable thermal battery that can be charged through either mains power or solar power. Once fully charged, the thermal battery can maintain a constant 5 °C vaccine temperature for at least 5 days at a constant ambient temperature of 43 °C, according to testing by Global Good. The thermal battery can be turned on or off, thereby enabling its charge to be conserved for use only when required. The device is currently undergoing lab testing, design, and field testing, with a small field test in Nigeria confirming the device's lengthy cold life capabilities. In the upcoming months, additional work by Global Good will finalise the price of the product as well as plans for PQS qualification.

FUTURE FREEZE-FREE VACCINE CARRIERS

Stage	Supplier	Model	Vaccine storage capacity, L	Weight fully loaded, kg	Cold life at 43 degrees (days)
Prototype	Blowkings	BK-VC 2.0 (P)	2	7	1.2
Prototype	Global Good*	Portevap	2	8	5
Prototype	APEX	TBD	1.9	TBD	TBD
Prototype	Haier	HRVC 1.5	4.9	4.9	1.6
Testing	Blowkings	BK-VC1.7-FF	1.6	7.3	1.6
Prototype	Blowkings	BK-VC1.7-FF (SR)	1.6	5.5	1.1
Prototype	AOV INTERNATIONAL	TBD	1	5.80	0.8
Prototype	APEX	TBD	1	TBD	TBD

Temperature monitoring devices

Temperature monitoring devices (TMDs) are used to monitor the performance of CCE in maintaining the safe 2-8 °C range. Modern TMDs are designed to provide both a view of the current storage temperature, as well as a digital record of the temperatures – and high-risk events – over time.

In order to maintain vaccine quality, it is essential to monitor the temperature of vaccines throughout the supply chain. When done properly, this monitoring achieves the following goals:

- identifies malfunctioning cold chain equipment, reducing risk to vaccines;
- alerts health workers and supervisors to high-risk temperature exposures, so that corrective vaccine management and CCE maintenance actions can be taken. (eg testing/disposal of vaccines, repair of CCE)

Having an appropriate temperature monitoring device (TMD) is critical for achieving these goals. For health facilities and subnational stores, WHO recommends the 30-day temperature recorders (30-DTRs)[1]. These devices display a) the current temperature, and b) a rolling 30-day history of all high-risk freezing and heat events[2]. This is a significant improvement over stem thermometers, which fail to alert health workers to events occurring between routine monitoring checks.

30-DTRs also facilitate more efficient reporting on CCE performance, using the monthly count of alarms. Some newer models also allow records to be downloaded and printed, by connecting the device to a PC via USB.

Note: 30-DTRs are battery powered, with devices lasting between two to five years (depending on model). As such, it is important to anticipate future procurement to replace units with run-down batteries within broader cold chain planning.

In addition to 30-DTRs, the platform also covers remote temperature monitoring devices (RTMDs). These devices use mobile phone networks to transmit temperature data to the cloud. The data can be accessed through a supplier-provided web portal or can be directed into the country's eLMIS, and enables tracking of the performance of the CCE in-country. This allows fridge suppliers to quickly identify fridges that have performance issues, and to direct their in-country service delivery partners to perform required repairs quickly.

[1] Refer to the WHO Vaccine Management Handbook Module on How to Monitor Temperatures in the Vaccine Supply Chain (Module VMH-E2-01.1) for detailed guidance.

[2] A high risk freezing event is defined as >60 minutes below –0.5°C. A high risk heat event is defined as >10h above 8°C]

The platform also covers integrated RTMDs, which are RTMDs built into the fridge or freezer. Countries may consider selecting such devices when programmatic and budgeting requirements for the recurring fees are met. However, integrated RTMD is still a future TPP 2017 criterion and is not a WHO PQS requirement today.

30-DTRS LISTED ON THE WHO PQS CATALOGUE

Supplier	Model	Data download and interface	Battery shelf life (months)	Activated life (months)	Price per unit for orders of 1-200 units, USD
Berlinger	Fridge-tag 2	USB	36	36	31
Berlinger	Fridge-tag 2 E	USB	60	60	51
Haier	HETL-01	USB	36	24	22
Logtag Recorders	VaxTag	USB cradle	n/a	36	40.8

Note: all devices have a visual alarm and non-replaceable batteries.
Purchase price represents the listed PQS price for an order quantity of 200 units.

Logtag Recorder product pricing is based on <100 units.

REMOTE TEMPERATURE MONITORING DEVICES (RTMDs)

RTMDs are typically supplied with Value Added Services to countries included in the initial equipment and/or recurring annual fees. These Value Added Services differ significantly between devices and countries should confirm directly with suppliers which services are included with their offering prior to purchase. Typical Value Added Services to enquire about include, but is not limited to:

- Installation
- System setup, validation and user activation
- Alarm threshold and recipient setup
- User and system administrator training
- Refresher trainings for users and system administrators
- Continued and proactive system management to ensure correct and current user profiles
- Proactive alarm trend and root cause analysis with corrective action tracking
- Schedule and structure of alarm reporting to country management
- Refrigerator/freezer performance analysis across different models

Countries should also ensure adequate budgeting for RTMDs by estimating the lifetime value of each unit; including UNICEF SD catalogue/ WHO PQS price, recurring fees as indicated below, as well as refresher trainings.

Service bundle indicative cost for current RTMDs is between USD 200 (lower limit) and USD 400 (upper limit), if not included in the Value Added Services provided with the device.

Supplier	Model	Number of wired temperature monitoring channels	**Initial equipment fees, USD	*Estimated recurring fees (web portal, SIM card, etc.), USD, per year	Total 5 year equipment and operating fees, USD
Berlinger	Fridge-tag 3 GSM	1	244	144	964
Beyond Wireless	ICE3-BC140	4	335	365	2,160

Supplier	Model	Number of wired temperature monitoring channels	**Initial equipment fees, USD	*Estimated recurring fees (web portal, SIM card, etc.), USD, per year	Total 5 year equipment and operating fees, USD
Nexleaf Analytics	ColdTrace 5	5	251	98	741
TempAlert	TM-CELL-400-Z	4	0	317	1,585

Note: all devices have a visual alarm and non-replaceable batteries.

*NOTE: Global SIM fees are based on an average provided by manufacturers and may differ on a country by country basis.

**NOTE: Includes fees for all needed battery replacements for 5 years where applicable.

Before filling out the CCEOP Budget Template, countries should confirm with the supplier to obtain country-specific global SIM costs and subsequently update the annual recurring cost in the budget template accordingly

Voltage Stabilizers

Voltage stabilizers are used to protect on-grid, mains-powered refrigerators and freezers from damage caused by fluctuations in the electricity supply. They protect the refrigerator or freezer's control unit, compressor, fuses and other electronic components against damage resulting from power fluctuations such as:

- Voltage levels that either too low or high
- Voltage spikes caused by nearby lightning strikes or switching effects
- Frequency deviations

Some refrigerator and freezer manufacturers choose to integrate voltage stabilizers into the bodies of their devices, while others choose to provide a stand-alone, external voltage stabilizer along with their devices. This guide only includes voltage stabilizers of the external type, since integrated stabilizers are a de facto option determined by the refrigerator or freezer manufacturer.

It is critical that all on-grid refrigerators and freezers are only used in combination with a quality voltage stabilizer, as power fluctuations can substantially reduce the reliability and lifetime of this type of equipment, as well as increase its maintenance costs.

The following table shows expected WHO PQS-compliant voltage stabilizers. These stabilizers are available for inclusion in Platform applications and budget templates.

PQS Stage	Supplier	Model Number	Input Voltage Type	Input Range Type	Power Rating (VA)	Purchase Price, USD
Testing	AEL	AVS 1000	230V/50-60Hz	Standard	1000	245
Testing	AEL	AVS 1500	230V/50-60Hz	Standard	1500	260
Testing	Haier	HVS-1000	230V/50-60Hz	Standard	TBC	TBC
Testing	Sagar Electricals	WTS-1KS	230V/50-60Hz	Standard	1000	40
Prototype	Sagar Electricals	ER-1KS	230V/50-60Hz	Extended	1000	75
Testing	Sollatek	SVS04-22	230V/50-60Hz	Standard	1000	65
Testing	Sollatek	SVS04-22E	230V/50-60Hz	Extended	1000	96
Testing	Sollatek	SVS08-11	120V/50-60Hz	Standard	920	65
Prototype	Godrej	TBD	230V/50-60Hz	Standard	1000	TBC

Note: Standard range voltage stabilizers will continue to operate normally with input voltage fluctuations between 82V and 159V, 173V and 278V, or better
Extended range voltage stabilizers will continue to operate normally with input voltage fluctuations between 110V and 278V, or better

CONCLUSION

Gavi's cold chain optimisation platform is designed to support countries with rehabilitating and expanding the cold chain by appropriately selecting, procuring, and deploying the optimised products presented in this brochure. Countries could benefit in three ways from these optimised products. First, the products would enable the cold chain to reach more facilities, including facilities that were previously hard-to-reach. Second, the products would offer improved temperature control to vaccines, including the elimination of the risk of freezing. Third, the products would remain functional in challenging operating conditions for longer periods of time; additionally, recorded temperature data would offer the potential to inform preventative maintenance and repair systems.

Together, these three benefits could enable countries to improve vaccine availability, increase vaccine safety, and maintain vaccine potency. As a result, more children in more locations could receive effective vaccines, thereby improving country immunisation coverage. This, along with the lower operating costs of many of the optimised products, could support countries with implementing more cost-effective and high-impact immunisation systems.

ACRONYM KEY

CCE
Cold chain equipment

EVM
Effective vaccine management

Gavi
Gavi, the Vaccine Alliance

ILR
Ice-lined refrigerator

PCM
Phase change material

PQS
Performance quality safety

SDD
Solar direct drive

TCO
Total cost of ownership

UN
United Nations

UNICEF
United Nations International Children's Emergency Fund

WHO
World Health Organization

DEFINITIONS

Autonomy: The autonomy of a solar refrigerator measures the ability of the equipment to store vaccine during periods of heavy cloud. It is defined as the maximum number of days during which the refrigerator can maintain a full vaccine load at a temperature between 2 °C and 8 °C when the photovoltaic panels are not generating electricity.

Holdover time: The time in hours during which all points in the vaccine compartment of a vaccine refrigerator remain below 10°C, at the maximum ambient temperature of the temperature zone for which the appliance is rated, after the power supply has been disconnected. For vaccine freezers, the holdover time is the time in hours during which the vaccine compartment remains below -5 °C.

Cold life and cool life for cold boxes and vaccine carriers: Cold life applies when fully frozen water packs are used as the coolant. These will continue to be used for transporting oral polio vaccine and single antigen freeze-dried vaccines. Cool life applies when cool water packs are used.

- ***Cold life with frozen water packs:*** Cold life is measured from the moment when the container lid is closed until the temperature of the warmest point in the vaccine storage compartment first reaches 10 °C, at a constant ambient temperature of 43 °C.
- ***Cool life with cool water packs at 5 °C:*** Cool life is measured from the moment when the container is closed, until the temperature of the warmest point inside the vaccine storage compartment first reaches 20 °C, at a constant ambient temperature of 43 °C.

APPENDIX A

For total cost of ownership (TCO) figures, this guide uses the PATH total cost of ownership (TCO) tool with the key assumptions below. As these assumptions will vary by cold chain system, the tool should be used with assumptions for your cold chain so you can estimate the most accurate TCO for your purchase. All costs are in US Dollars (USD) using UN exchange rates as of December 2017.

Country inputs:

- Cost of technician labour: $5.63 per hour
- Cost of electricity: $0.09 per kilowatt hour (kWh)

Purchase price assumptions:

- Devices: all device pricing is the price for a single unit with 200+ units purchase. Device pricing is provided by all of the suppliers.
- Accessories: the purchase price includes the cost of a temperature monitoring device and a voltage regulator when one must be bundled with the device to meet platform requirements.

Delivery and installation assumptions for Nigeria as an example:

Delivery and installation assumptions	ILR	On-grid freezer	Long-term passive device	SDD device
Cost of freight from supplier to country port	7% of unit, spare part and installation kit cost	7% of unit, spare part and installation kit cost	7% of unit, spare part and installation kit cost	7% of unit, spare part and installation kit cost
Cost of in-country freight	$550	$550	$150	$550
Amount of installation labour (at assumed rate of $150 per day per technician)	1 technician for 1 day	1 technician for 1 day	1 technician for 1 day	2 technician for 2 days

Opex assumptions:

- Spare parts: the set of parts is per UNICEF catalogue recommendations per unit (where spare parts are for 10 units, the cost is divided by 10). Where available, parts pricing is provided by suppliers. Otherwise, it is taken from the WHO PQS Catalogue.
- Temperature monitor: the first TMD is bundled in purchase price. Opex cost includes the replacement of TMD based on its activated life and the assumed lifetime of the refrigerator. Generally this means three to four 30-DTRs will be required over the 10-year lifetime of a refrigerator.
- Warranty: repair maintenance and spare parts costs are covered by the supplier when the equipment is under warranty. Some suppliers have begun offering extending warranties up to 10 years. Other suppliers may offer extended warranty services for an additional cost that is not captured in this Guide

Maintenance assumptions	ILR	On-grid freezer	Long-term passive device	SDD device
Routine maintenance	1 hour per month for defrosting/cleaning; 1 hour onsite preventive maintenance visit annually	1 hour per month for defrosting/cleaning; 1 hour onsite preventive maintenance visit annually	1/4 hour per month for cleaning; 1 hour onsite preventive maintenance visit annually	1 hour per month for defrosting/cleaning; 2 hour onsite preventive maintenance visit annually
Repair maintenance	4 hours in workshop every 4 years	4 hours in workshop every 4 years	n/a	4 hours in workshop every 4 years

The cold chain equipment optimisation platform has been developed through the collaboration of the following Vaccine Alliance partners:

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