



MALAWI

Integrated Energy Plan

MEDICAL COLD CHAIN & COVID-19 VACCINE DISTRIBUTION

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10 AUGUST 2022



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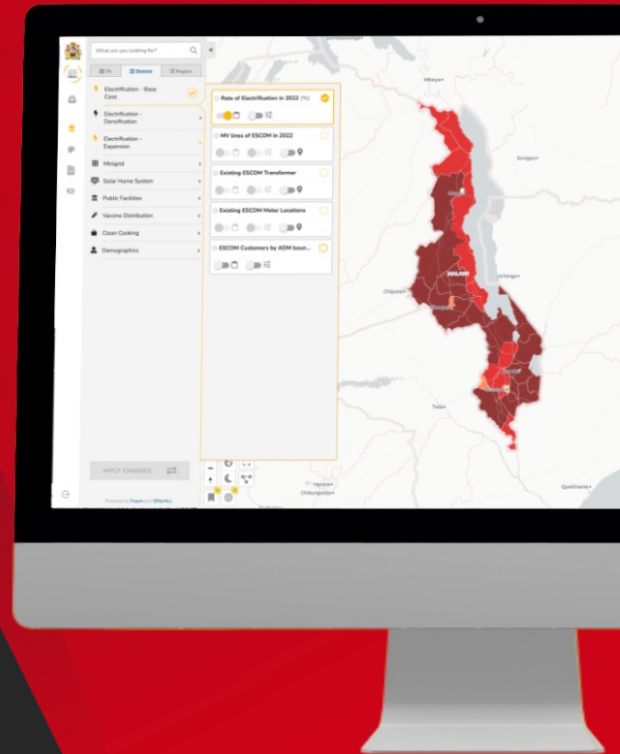




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Acronym List

EPI	Expanded Program on Immunization
CCE	Cold Chain Equipment
DVS	District Vaccine Store
HF	Health Facility
MOH	Ministry of Health
PQS	Performance, Quality and Safety
NVS	National Vaccine Store
RVS	Regional Vaccine Store
UCC	Ultra Cold Chain
WHO	World Health Organization
WICR	Walk-in Cold Room
WICF	Walk-in Cold Freezer

MALAWI IEP – COLD CHAIN

Executive Summary



Malawi Health System Overview

Total number of facilities	1,580
Number of facilities with grid electricity	593
Number of facilities without grid electricity	346
Number of facilities with CCE and providing immunization	939
Number of District Vaccine Stores	29
Number of Regional Vaccine Stores	3
National Vaccine Store with CCE	1

Vaccines must be stored in the cold chain, mostly at 2°C to 8°C.

Exceptions:

- Pfizer COVID vaccine is stored at -70°C for up to 6 months before shifting to a health facility (2°C to 8°C).
- It is recommended for Polio Vaccine to be stored in a freezer (-20°C) at the National, Regional and District level to extend the shelf life of the vaccine.

Source: MOH and ESCOM



COVID community campaign,
"Vaccinate My Village"

COVID Vaccine Roll-Out: Current Situation

- About 6 million doses of the COVID vaccine have been received in country since March 2021. Pfizer is used for 12-17 year olds.
- Almost 2.9 million doses have been administered. 14% of population is fully vaccinated as of the end of June 22. While coverage is lower in the southern part of the country, that is likely due to vaccine hesitancy. The MOH has introduced a new strategy to address this roadblock.

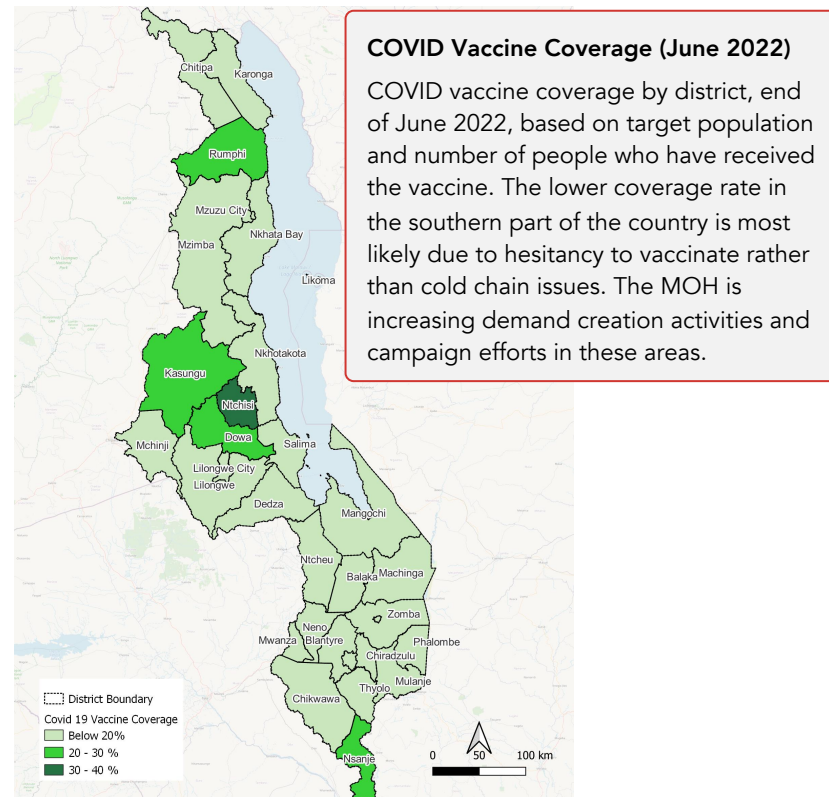
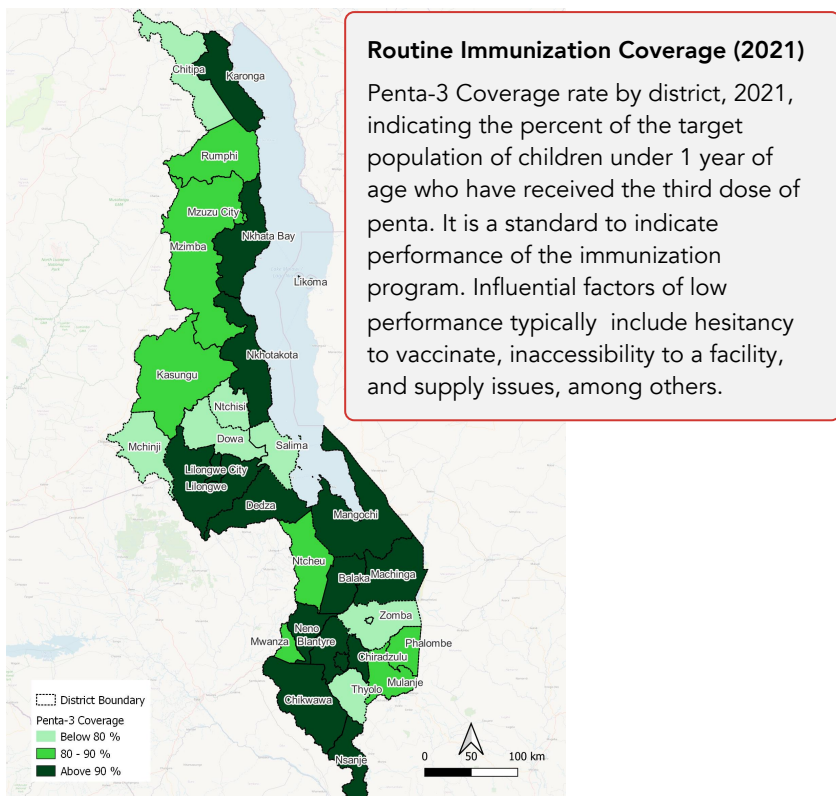
Number of Doses Received, March 2021 - June 2022



COVID vaccine roll-out strategy:

- “Vaccinate My Village” campaigns are planned for 2 weeks of every month for the immediate future:
 - A team of 4-5 health workers travel in a vehicle to outreach sites at community locations (school, church, market)
 - Vaccines are transported from the DVS by a cold box or vaccine carrier, carrying some risk of temperature excursions
 - Health workers promote door-to-door, engage community leaders and administer vaccines
- The COVID vaccine is also available in health facilities for routine administration; school campaigns are also conducted to reach 12-18 year olds
- The country is concurrently implementing a polio campaign to address recent polio cases, adding additional strain to the health system.

Comparison: Routine immunization coverage and COVID vaccine coverage



Source: EPI health information system

Vaccine Storage

Country Cold Chain Landscape

1 National Vaccine Store (NVS): 11 WICR, 2 WIFR, 5 UCC

3 Regional Vaccine Stores (RVS): 8 WICR, 4 WIFR, 2 UCC

29 District Vaccine Stores (DVS): Refrigerators and freezers

Health Facilities (HF): Health posts, health centers, hospitals
(939 cold chain points)

NVS: Receives routine vaccines from the international shipments bi-annually, COVID vaccines as necessary. Procurement done through UNICEF. Walk-in cold rooms and freezers (WICR, WICF) maintain the vaccines in the ideal temperature range

RVS: North, Centre, South, hold quarterly stock

DVS: operational districts, collect vaccines on monthly basis from their corresponding RVS

HF: Receives vaccines monthly from District

Vaccine Distribution

Supply Chain Level	Method for Routine Vaccines
National	Stores vaccines, makes decisions about quantities to distribute
Regional	Use own vehicles (7-20 ton trucks) to fetch from National on a quarterly basis using cold boxes
District	Use own vehicles (1-3 ton, typically Toyota Land Cruiser/Hilux) to fetch from Regional, monthly basis, packed in cold boxes. WHO standards recommend quarterly distribution to the district level; however, Malawi follows monthly distribution due to the unreliability of the electricity to avoid spoilage of large quantities of stock if the CCE fails.
Health Facility	Delivered by district via truck and cold boxes, monthly basis
Outreach	Health facility staff use bicycles or motorcycles with small cooler for a day of service provision 5-10 km away from the facility

COVID-19 Vaccines

Vaccines are delivered directly from the NVS to the district using consumption to calculate quantities. The long-term plan is to begin using Regional stores to relieve constraint at the National level. COVID vaccines are stored in the same cold chain as routine vaccines. Pfizer is the exception that must be stored -60°C up to 9 months; because of the special temperature needs, distribution is conducted by an outsourced logistics group.

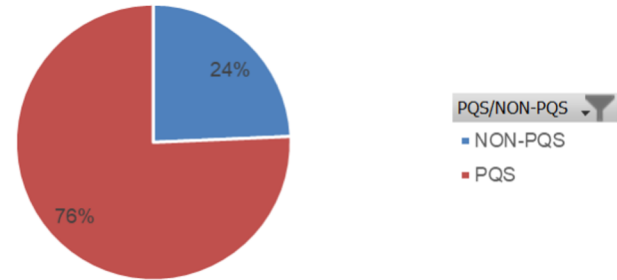
Policy versus Practice

This distribution schedule is the standard practice as designed by the MOH. Experience shows that reality may shift the frequency of delivery, depending on truck or fuel availability, or emergency “top-ups” between scheduled deliveries, particularly at lower levels.

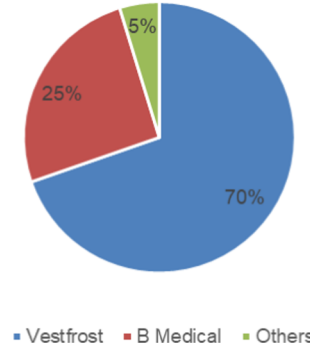
Cold chain equipment overview

- The supply chain has about 2,000 pieces of CCE across the multiple levels of the system, with larger walk-in cold rooms and freezers (WICR, WICF) at the national and regional levels.
- The WHO Performance, Quality and Safety (PQS) process prequalifies products and devices to assure of their suitability for use in immunization programs.
 - 24% of the CCE is non-PQS; while these may still function, they are being phased out of the system to newer, more reliable equipment
- The cold chain system is dominated by two PQS-approved manufacturers (B Medical, Vestfrost).

% OF CCE BY PQS AND NON-PQS



% OF CCE BY MANUFACTURER



Number of PQS pieces of CCE by manufacturer

Manufacturer	Functional	Non-functional	Working But Need Repair	Grand Total
A	1032	63	8	1103
B	367	35	3	405
C	30	4	0	34
D	19	0	0	19
E	2	0	0	2
F	1	1	0	2
G	5	0	7	12
H	1	0	0	1
I	0	1	0	1
J	2	0	0	2
Grand Total	1459	104	18	1581

It is typical for a country to have multiple CCE manufacturers and models. While this provides options if one brand/model is underperforming, it adds a layer of complexity for cold chain technicians to provide maintenance or repair, and to plan, procure and manage spare parts.



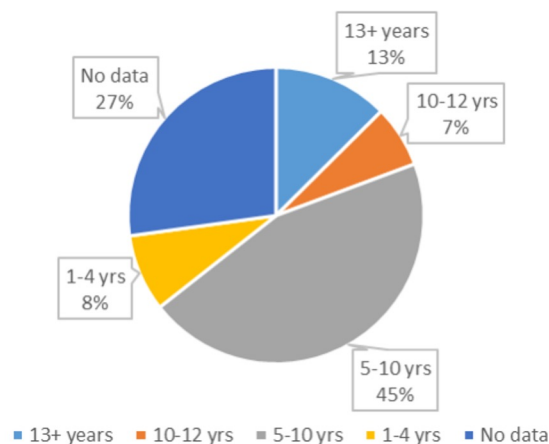
CCE: TCW 3000AC, capacity 150 liters, often used at larger health facilities

PQS-Approved CCE is largely functional with varying ages

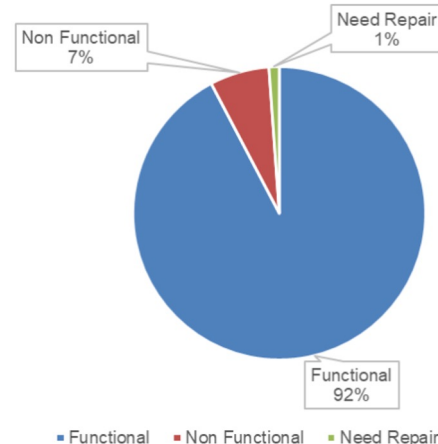
The CCE inventory tracks all CCE, including walk-in cold and freezer rooms at the national and regional levels. The equipment is largely functioning, with 7% non-functional (and should be decommissioned and moved out of the facility space) and 1% that needs repair.

The industry standard life expectancy of CCE is ~10 years, which is the benchmark EPI uses for long-term planning. CCE in Malawi ranges from 20 years old to brand new. Older equipment, even if still working, should be prioritized for replacement with newer, more reliable and energy-efficient equipment. Based on the reported age of the CCE, almost 50% of the CCE will need to be replaced in the next 3-5 years.

AGE OF FUNCTIONAL EQUIPMENT



FUNCTIONALITY OF PQS APPROVED CCE



Capacity Utilization Analysis: Routine Vaccines

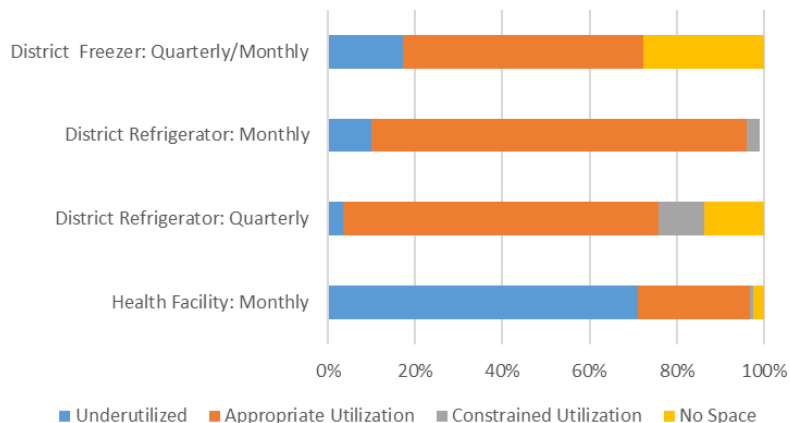
To determine the capacity utilization throughout the Malawi vaccine PQS cold chain for each store and facility, we used the vaccine quantity required based on the EPI schedule (e.g., vaccines and number of doses required of each); stated distribution schedule (e.g., monthly distribution to facility level and district); target population of each facility and district; and vaccine characteristics (vial size, cubic liters per dose, wastage rate, buffer stock). This is assessed against the total net cubic liters of the PQS-approved CCE available and functioning at the facility and used for vaccines. Utilization categories are defined as appropriate if 10–80% of capacity is used; underutilized

if <10% of capacity is used; and as constrained if >80% of capacity is used. Appropriate capacity use is considered ideal. The estimated need for the COVID-19 vaccine is based on average consumption to date by district to set a benchmark for expected on-going campaign efforts. Due to the multiple COVID-19 vaccines with different vial size characteristics and the unknown nature of which district will receive which vaccine, this analysis is generalized for COVID-19 vaccines with the focus on the routine schedule as baseline.

Key takeaways:

- Health facility: The majority of facilities with CCE (70%) use less than 10% of the space with the monthly distribution schedule, allowing more than sufficient space for COVID vaccine; about 500 facilities do not have CCE so do not provide vaccines regularly.
- District refrigerator: Vaccines are delivered to the district level monthly and only one district (Blantyre) has constrained space. Analyzing for quarterly distribution as an option for efficiency, the majority (72%) are still in the appropriate utilization category, indicating there is sufficient space with this alternative distribution frequency, except possibly in surge situations such as multiple campaigns (COVID, polio). Three districts are constrained and would benefit from additional CCE.
- District freezer: 28% of districts do not have freezer space, which, if available, could be used to extend the shelf life of polio vaccine and create more fridge space for COVID vaccine.
- Estimates of COVID-19 vaccine needs have a minimum impact on the CCE, increasing the utilization rate between 1% and 5%, depending on the population size.

CCE Capacity Utilization

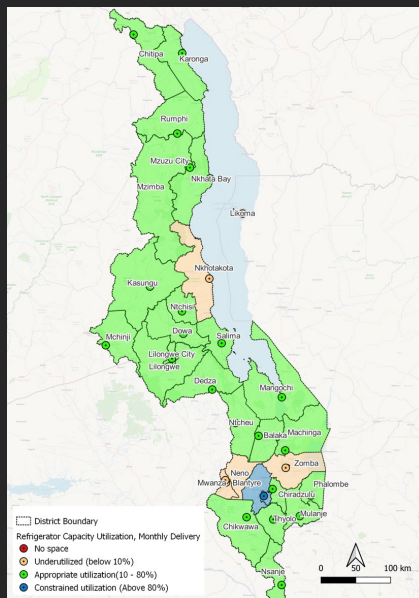


District CCE capacity utilization analysis with alternative distribution frequency

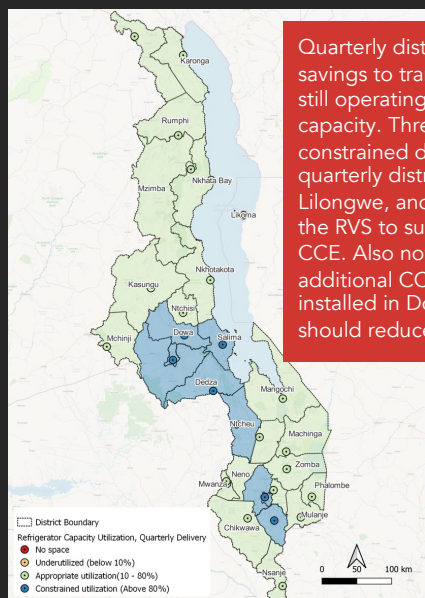
Sustainable Energy for All

REFRIGERATOR SPACE

Monthly distribution to DVS
(current policy)

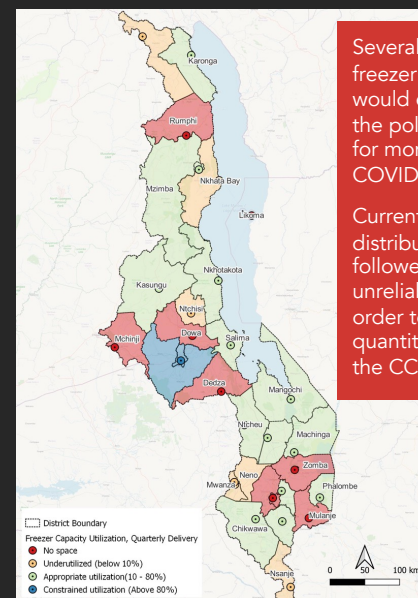


Optional quarterly distribution to
DVS



Quarterly distribution could bring savings to transport costs while still operating with sufficient capacity. Three of the constrained districts with quarterly distribution (Blantyre, Lilongwe, and Lilongwe City) use the RVS to supplement their CCE. Also note anecdotally, additional CCE has been installed in Dowa district so this should reduce the constraint.

FREEZER SPACE, MONTHLY DISTRIBUTION TO DVS



Several districts do not have freezer space. If available, it would extend the shelf life of the polio vaccine, and allow for more space in the CCE for COVID and other vaccines.

Currently, a monthly distribution schedule is followed due to the unreliability of electricity in order to avoid having large quantities of stock on hand if the CCE fails.

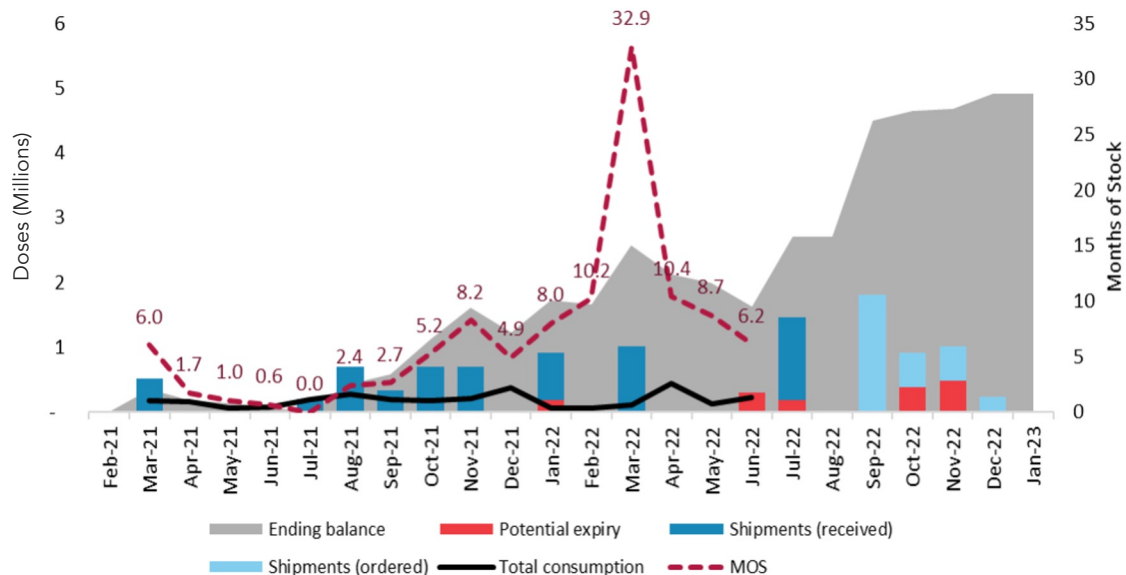
National and regional store capacity utilization

Store	Refrigerator Space	Freezer Space
National	14%	11%
South RVS	16%	3%
North RVS	6%	1%
Central RVS	57%	11%

Capacity utilization is calculated based on the quarterly stock that is held at the regional levels, and the periodic shipments received at national level for routine vaccines. The analysis shows there is sufficient capacity for routine vaccines and for the COVID vaccines. The Central RVS shares freezer space with the National store as it is not available at the RVS, which is an efficient work-around for this situation.



Malawi COVID vaccine: stock received, consumption, and planned shipments

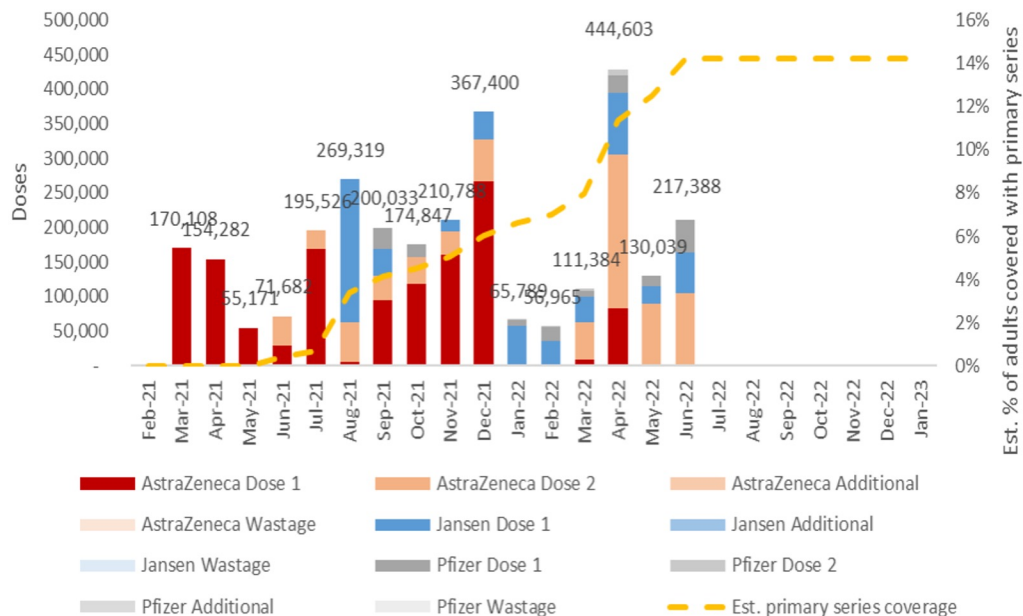


The EPI team is proactively planning and managing cold chain space with upcoming shipments of both COVID and routine vaccines, particularly for the on-going polio and malaria campaigns. The EPI is shifting COVID vaccines to the regional warehouses to create more space at national level. The EPI has adjusted its order for vaccines downward, based on the months of stock on hand, potential expiries, and realistic expectations of what can be administered.

Additional J&J shipments are planned for Sept, Oct, Nov, Dec.

Expiries are to be expected in this rapid vaccine introduction phase; additional campaign efforts in the recent past have been successful at reducing expiries.

Malawi COVID vaccine coverage and expected campaign efforts



The average consumption of COVID vaccines in Malawi, including successfully administered vaccines, plus expired/discarded vaccine doses, is approximately 264,000 per month. The highest consumption rate was over 444,000, achieved in April of 2022. However, due to reduced vaccine demand and increased supply availability, vaccine inventory is now at its highest point in the past 18 months of the pandemic.

When planning for cold chain volume in health facilities, it is common to forecast the estimated maximum vaccine consumption rates that can be sustained in proportion to the district population, which provides an estimate of cold chain space required. Reductions in demand could result in overstocking inventory, which could result in vaccine spoilage and wasted doses.

Additional factors to be considered in planning future cold chain investments include unknown or unspecified monthly targets by government or organizers of campaign efforts. Further complicating the Malawi COVID-19 vaccination program is the unknown timing and quantity of vaccines distributed to the district level, since the vaccines from different manufacturers have different vial sizes and doses.

District-level COVID vaccine management

Generally, based on the capacity utilization analysis, districts have sufficient space for the COVID vaccine. Using population estimates and assuming monthly campaign efforts, districts will require between 15 and 40 liters of cold chain space for the COVID vaccine, which translates into 3,000-7,000 doses. The average CCE space available at district is 1,000 liters, implying sufficient space for monthly distribution of the COVID vaccine, in addition to routine vaccines.

The three districts (Ntcheu, Salima, Thyolo) that are already constrained with routine vaccines will be more constrained with the COVID vaccine and would benefit from additional CCE or more frequent distribution, an estimated 500 liters in each one. Two additional districts would need an estimated 1,000 liters (Dedza, Dowa); Blantyre and Lilongwe are currently sharing space with the regional and national stores, so although their space may be constrained, they have created a workaround. Additional capacity up to 2,000 liters would reduce the constraints in each of these sites but also potentially require additional warehouse space for the CCE. Estimated purchasing costs of the CCE is between \$3,000 and \$6,000 USD, depending on the model. Ongoing maintenance and operating costs are additional considerations.

Pfizer should be stored in Ultra Cold Chain (UCC) for up to 9 months then can be stored in the traditional refrigerator for up to 10 weeks. Each district has UCC equipment for storage and transport of the Pfizer vaccine. National level has 5 UCC (828 liters each) for Pfizer; UCC is also available at two regional stores.



UCC Model DW-86L828J

located at National and Regional stores

Capacity: 828 liters which can hold about 45,000 doses of Pfizer

UCC Model ULT25NEU for Pfizer transport and storage; available at each district

Capacity: 25 liters which can hold about 1,365 doses of Pfizer



Malawi Detailed Vaccine Transportation Logistics

1. Vaccines arrive at Kamuzu international Airport (Lilongwe) in specialized cooling containers as packaged by manufacturers. Vaccines are cleared at airport by Malawi Revenue Authority (MRA) .
2. Cold chain shipment is transported to the National Vaccine Store (NVS) using Central Medical Stores refrigerated van, checked and unpacked within 24 hours of flight arrival.
3. Vaccines are processed and then cleared with Pharmacy and Medicines Regulatory Authority (PMRA). This takes 1 to 14 days. At the National Vaccine Stores, the EPI Pharmacists perform additional quality checks, and the logisticians “break bulk,” or split the packaging into units that can be transported to the 3 regions of the country.
4. Open trucks from the National Vaccine Stores (2 trucks of 20 ton capacity and 1 truck of 3 ton capacity) with support from trucks belonging to the 3 Regional Vaccines stores (5 trucks with, 10 ton capacity) are used to transport the vaccines in their original packaging to the Regional Stores on quarterly basis (routine vaccines).



5. Vehicles from the district (1 to 3 tons) collect and move the products from the Regional Vaccine Stores to the freezers/ fridges at District Vaccine Store on monthly basis. The trucks may also carry the syringes required to administer vaccine doses, or those can be transported separately. Transport usually takes one to 2 days for a one-way trip, depending on the distance to be covered.
6. For Pfizer, three specialized vehicles for third party logistics are used where mobile freezers are connected to cigarette lighter of vehicle (12V/120W) for charging to maintain the -60 to -80 degrees temperature. The vehicle is not turned off until it reaches its final district destination. For Pfizer and all COVID-19 vaccines, distribution is from NVS direct to district
7. In some circumstances, a healthcare facility may perform immunization-outreach visits to remote villages by motorbike or car using a small quantity of vaccines in a vaccine carrier with ice packs or other cooling agents.



Health Facility Energy Analysis

Based on data provided by the MOH, an estimated 83% of health facilities in Malawi are served by ESCOM, the national utility. These facilities may benefit from on-site solar hybridization, PQS equipment replacement, and battery energy storage retrofits to increase the reliability and resiliency of vaccine storage and distribution. For the remaining 17% of health facilities, standalone solar infrastructure is necessary for off-grid cold chain infrastructure to facilitate last-mile vaccine distribution.

Health Facility Type	Total Facilities	Facilities on grid (2022)	Facilities off-grid (2022)	Percent Electrified
Health Post (HP)	157	65	92	41%
Health Center (HC)	786	692	94	88%
Hospital (H)	109	109	-	100%
Regional/District Vaccine Store (S)	29	29	-	100%
Totals	1081	895	186	83%

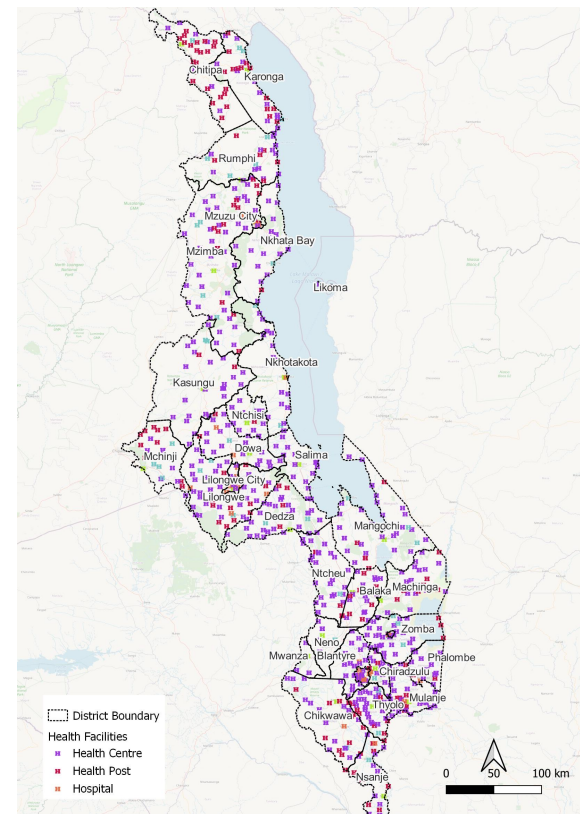


Typical equipment and energy requirements by facility

Type of facility	Typical energy requirements and equipment
Health Post (HP)	Lighting during day and night, a power operated scale for pre-natal and post-natal services, and a refrigerator for vaccine storage
Health Center (HC)	Offer outpatient and maternity services; lighting and cold chain, oxygen concentrator, suction machine, incubator, nebuliser, resuscitation machine, autoclave, and basic laboratory equipment such as microscope and Haematology mixer.
Hospitals (H)	In addition to previous levels, sophisticated diagnostic devices such as x-ray machine, CD4 counters, blood-typing equipment
Regional and district vaccine stores (S)	Lighting, multiple pieces of cold chain equipment, computer, air conditioner; regional will have WICR and WICF

Energy needs assessments were based on Powering Health: Load Calculation Examples (USAID, 2020) and modified based on key stakeholder consultations with Malawian health officials.

<https://www.usaid.gov/energy/powering-health/load-calculation-examples>



Map of Facilities and electrification status

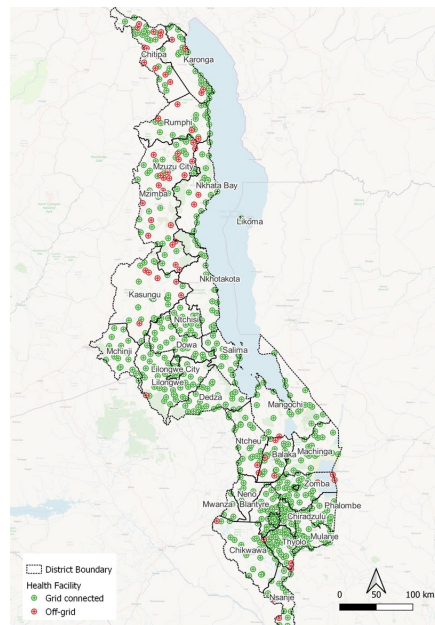
The present-day electrification status of Malawi's health facilities is presented in the 2022 status map (right).

As part of the national electrification analysis, all of the clinics that are presently unelectrified will gain access to electricity from either grid expansion, solar mini-grids, or standalone solar systems. Forecasted electrification gains are illustrated in the table below:

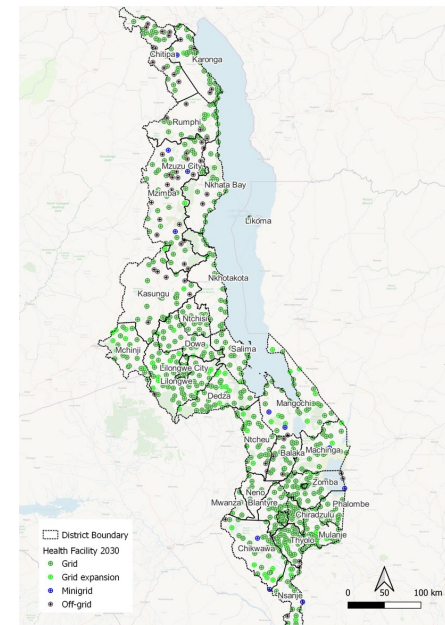
Health Facility Type	Total Facilities	Facilities on grid (2022)	Facilities off-grid (2022)	Percent Electrified	2030 Electrification Modality		
					Grid Expansion	Mini-Grid	Standalone Solar Systems
Health Post (HP)	157	65	92	41%	40	9	43
Health Center (HC)	786	692	94	88%	53	4	37
Hospital (H)	109	109	-	100%	-	-	-
Regional/ District Vaccine Store (S)	29	29	-	100%	-	-	-
Totals	1081	895	186	83%	93	13	80

Based on the electrification analysis, the ESCOM grid will reach an additional 40 health posts and 53 health centers by 2030. Meanwhile, a total of 9 health posts and 4 health centers will be interconnected to new solar mini-grids by 2030.

**2022 ELECTRIFICATION STATUS:
MOH AND ESCOM DATA**



**2030 ELECTRIFICATION STATUS:
MALAWI IEP ELECTRIFICATION RESULTS**



Cold-chain capacity analysis

Health facilities with CCE have sufficient capacity for routine and COVID vaccines with 70% of the facilities using less than 10% of their available space for routine vaccines. This allows for more than enough space for the required amount of COVID vaccines when provided through routine or campaign services.

The majority of districts have sufficient cold chain space for routine vaccines following the monthly distribution frequency. Blantyre, as the exception, uses the nearby RVS for additional space. Switching to quarterly distributions would introduce cost savings for transportation costs through fewer distribution cycles; regarding CCE capacity, this switch could be easily accommodated in the northern region; a few districts in the central and southern region (7 out of 29) would benefit from additional refrigerator space (between 500 and 2,000 liters) if frequency is changed. Having a more reliable electrical grid could justify this shift in frequency.

Only 8 of 29 district stores do not have freezer space for storage of OPV vaccines, which requires freezing temperature (-20°C) at that level as per WHO recommendations. Provision of freezers to those DVS will free up refrigerator space for COVID and other routine vaccines. It would also extend the shelf life of the polio vaccine.



CCE: B-Medical Model TCW 40 SDD (solar)

Cold chain performance analysis and replacement planning

Generally the CCE that is available is working well with only 7% that is not functioning and should be decommissioned. A decommissioning plan maps out the country's approach to remove non-functional equipment from the system, considering best environmental practices, technical and safety considerations, and documentation in assets management systems. Additionally, about 1% of all CCE needs repair and should be prioritized.

As the country works with donors and partners to upgrade and expand the cold chain system, a few notable areas to prioritize include:

- Outdated equipment that is non-PQS should be replaced (about 24% of all CCE). Equipment that was previously PQS approved but no longer has this approval can still be used if functioning but should be included in the medium- and long-term CCE replacement and expansion plan.
- Prioritize replacing older equipment (10+ years), particularly those that rely on gas/propane.
- Consider moving some CCE from "under-utilized" sites to "constrained utilization" sites to alleviate some of the constraint.
- Consider procuring CCE for health facilities that currently do not have CCE (~500 facilities) yet are growing in population or have demonstrated a high need or demand for immunization. Expanding CCE to new health facilities must also consider the human resources required for expanding immunization services to a new facility, and the long-term costs of maintaining the CCE.
- CCE costs are between \$3,000 and \$6,000 per unit that would be applicable at facility or district level.

Health facility energy needs assessment

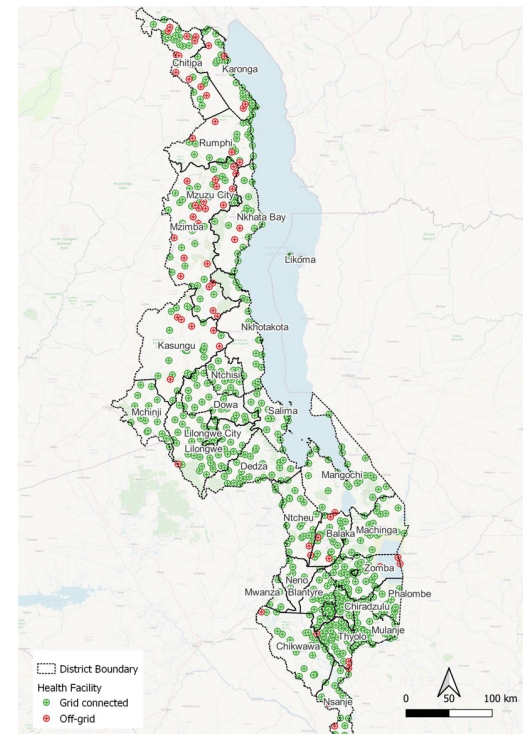
		Off-Grid Solar Systems			Grid-Tied Hybrid Systems			
Health Facility Type	Total Facilities	# Off-Grid Facilities	Cost per Facility (USD)	Off-Grid Cost (USD)	# Grid-Tied Facilities	Cost per Facility (USD)	Grid-Tied Cost (USD)	Total Program Cost (\$USD)
Health Post (HP)	157	92	\$ 2,278	\$ 209,576	65	\$ 1,587	\$ 103,155	\$ 312,731
Health Center (HC)	786	94	\$ 35,735	\$ 3,359,090	692	\$ 16,027	\$11,090,684	\$14,449,774
Hospital (H)	109	0	\$ -	\$ -	109	\$ 35,136	\$ 3,829,824	\$ 3,829,824
Regional/District Vaccine Store (S)	29	0	\$ -	\$ -	29	\$ 89,559	\$ 2,597,211	\$ 2,597,211
Totals	1081	186		\$3,568,666	895		\$17,620,874	\$21,189,540

There are 186 health facilities in Malawi that currently do not have access to the ESCOM national grid. Of these facilities, 92 are Health Posts and 94 are Health Centers. There are no hospitals or RVS locations that do not have grid access. The total capital cost to electrify these remaining 186 locations is estimated to be USD \$3.6M in the near term, not including recurring operations and maintenance costs. In the longer term, 93 of these facilities are included in IEP grid expansion plans by 2030 and an additional 13 facilities are envisioned for mini-grid electrification by 2030.

The existing cold chain could be made more reliable by hybridizing solar and battery systems within the grid-tied facilities. The total cost to hybridize all grid-connected health facilities is USD \$17.6M, however this investment could be prioritized according to facility type and other considerations.

Therefore, the total program cost for energy access and cold chain resiliency is estimated to require USD \$21.2M in investment on behalf of 1,081 Malawian health facilities, or an average of USD \$19,602 per facility.

2022 ELECTRIFICATION STATUS: MOH AND ESCOM DATA



Best practices and recommendations for cold chain management and COVID

The cold chain system in Malawi is typical of many systems across the African continent. Ministries of Health have had to pivot and quickly adjust to the COVID-19 pandemic and rapidly scale up introduction of this new vaccine, leveraging vaccine supply chains and health systems that were already constrained. Malawi is implementing their new vaccine introduction plan and has created processes, campaign strategies, and reporting structures to track progress. This vaccine distribution and energy analysis provides insight into a few key areas of cold chain management that, if addressed, could strengthen the overall vaccine supply chain in the country. These recommendations should be validated with the MOH and EPI team, and can be used as justification and advocacy for donor investment.

- The cold chain maintenance system is often overlooked yet is quite important for cost-effectiveness and to ensure functionality and longevity of the CCE. Typical entrenched obstacles to a maintenance system have been

documented elsewhere, as well as novel ideas for redesigning maintenance to be more effective. Any investment by donors into the cold chain infrastructure in Malawi should also be accompanied by maintenance support, including forward-thinking planning for spare parts, training for technicians, and the financial flow to support the technicians to do their work.

- As cold chain space is largely sufficient at the district level, EPI could consider adjusting the distribution frequency to the DVS to quarterly deliveries instead of monthly to reduce costs in transport. This also reflects WHO standards.
- EPI has already demonstrated their ability to manage a flexible and agile supply chain for the COVID vaccine by proactively shifting stock to different warehouses to avoid constraints. This best practice would benefit the routine immunization supply chain as well, and could potentially reduce overall costs.

Recommended future analysis

While this analysis responded to the questions posed for this project, the insight raised additional questions that would be beneficial to explore further in future projects:

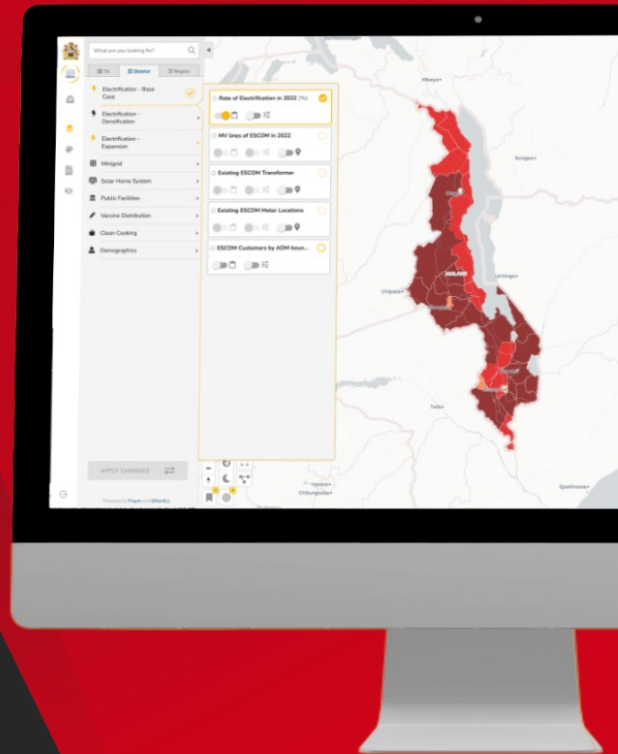
- True costs related to running an immunization program and its supply chain, including community engagement, different transportation routing options to optimize space and routes, outreach efforts and its effectiveness in reaching children if cold chain is not available.
- Accurate master health facility list cross-referenced to cold chain inventory and MOH expansion plans



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