SURE CHILL | COOLING TECHNOLOGY

Working with: PATH, Bill & Melinda Gates Foundation, Brunel University London, Llywodraeth Cymru Welsh Government

THE NEED FOR OFF-GRID VACCINE STORAGE.

Development and field testing of a long term passive device

A Sure Chill study, TechNet 2017 Duncan Kerridge, Senior R&D Engineer

What's the problem?

McKinsey CCE report in 2012 found that 17% of GAVI health facilities were off-grid and required less than 5 litres of vaccine storage.

Existing products did not address this need

Solar direct drive fridges

- High equipment and installation costs.
- Deployment requires skilled technicians and takes 1 to 2 days.
- PV theft makes them unfeasible in some areas.
- In urban locations, there may not be a suitable place to fit PV array.

Absorption fridges - kerosene or LPG

- Poor temperature control and are not frost free.
- Fuel costs.

Vaccine carriers using ice packs

- Only maintain a safe temperature for a few days in hot ambient.
- High risk of freezing the payload.

The Bill and Melinda Gates Fund (BMGF) provided funding for Sure Chill to develop a proof of concept to address this gap with a long term passive storage device (LTPD).

1. Load ice packs, ice, or a combination of both, straight from the freezer into the ice compartment.
2. Insert vaccines in the cooled 8 litres of freeze-free, secured vaccine storage space.

Objectives

- Simple to use
- Robust and reliable
- No power required – 'passive' operation
- Maintain stable, safe vaccine storage temperatures for up to 35 days in hot conditions
- Guaranteed freeze free
- No 'ice pack conditioning' required
- Quick and easy to set up

Device Format

- Robust and durable polyethylene casing
- Two compartments – one for ice remains closed except for recharging
- Easy access to vaccine compartment with good visibility of payload
- State of the art insulation using vacuum insulation panels (VIPs)
- Internal Sure Chill element transfers cooling from ice packs to vaccine compartment whilst preventing freezing
- External solar powered temperature display.

Product development

Advanced modelling

Following success of the proof of concept, BMGF and the Welsh Government provided further support to develop the LTPD.

Using ice as energy storage in high ambient temperatures without active chilling facilities is a considerable challenge. A critical part of the LTPD is an innovative arrangement of Vacuum Insulation Panels to insulate the vaccine and ice compartments from the ambient environment.

A COMSOL-Multiphysics model was developed by Brunel University to simulate the performance of the LTPD and examine the impact of variation in VIP thermal conductivity, ambient conditions and manufacturing materials . The model (Fig.2) was validated against experimental data which enabled optimisation of the VIPs and geometric configuration. The thermal performance and energy storage capacity of prototypes was tested and verified in controlled environmental test chambers (Fig.3).

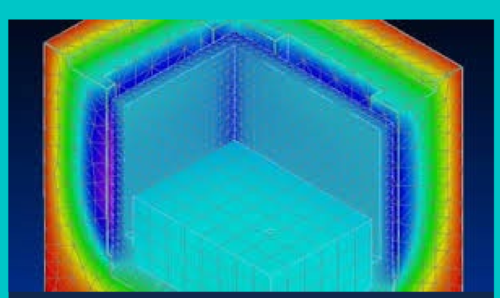


Fig. 2: COMSOL-Multiphysics model from early prototype showing heat distribution. Image of ice at -25°C inside a VIP box made up of 3 layers of 30mm VIP, in 43°C ambient temperature.

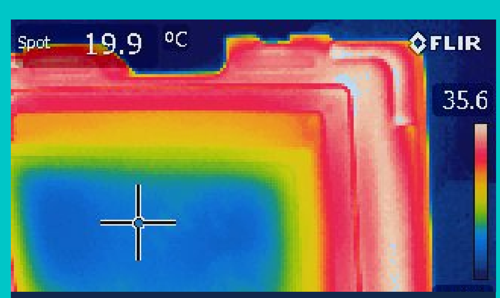


Fig. 3: Laboratory testing of prototype LTPD: Thermal camera image showing heat distribution along lid of LTPD at prototype stage.

Phase 1 Field tests

Working with the Senegalese Ministry of Health and PATH, six health posts were selected as evaluation sites in the Khombole District in the west of Senegal (Fig. 4).

These sites are approximately 100 km from the capital city of Dakar and are between 6km and 53km from the District Health Centre.

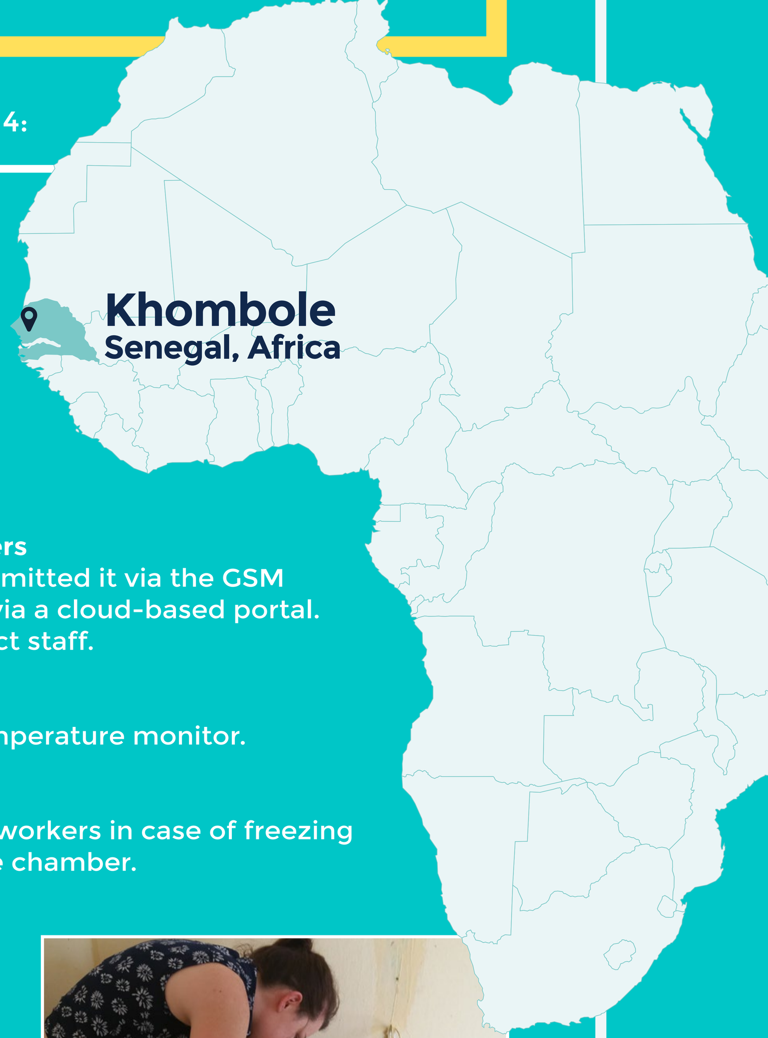
The objectives of the Sure Chill LTPD field evaluation were to:

- Collect feedback on the design, function, acceptability, and use cases
- Monitor cold life and temperature stability of the device in environments representative of potential applications.
- Identify potential opportunities for the technology to support and extend immunization services
- Identify key messages to include in training materials.

The performance of the LTPD was monitored in simulated use conditions in which the vaccine compartment was opened once per day for five minutes. A monthly supply of frozen ice packs was provided by cold chain staff from the district vaccine store (DVS) .

This field evaluation was implemented over a three-month period from mid-March to mid-June 2016. Researchers monitored temperatures inside and outside the LTPD and collected qualitative feedback from end-users and decision-makers. Real vaccines were stored in the device during this study; however, these vaccines were not used for immunization services.

Fig 4:



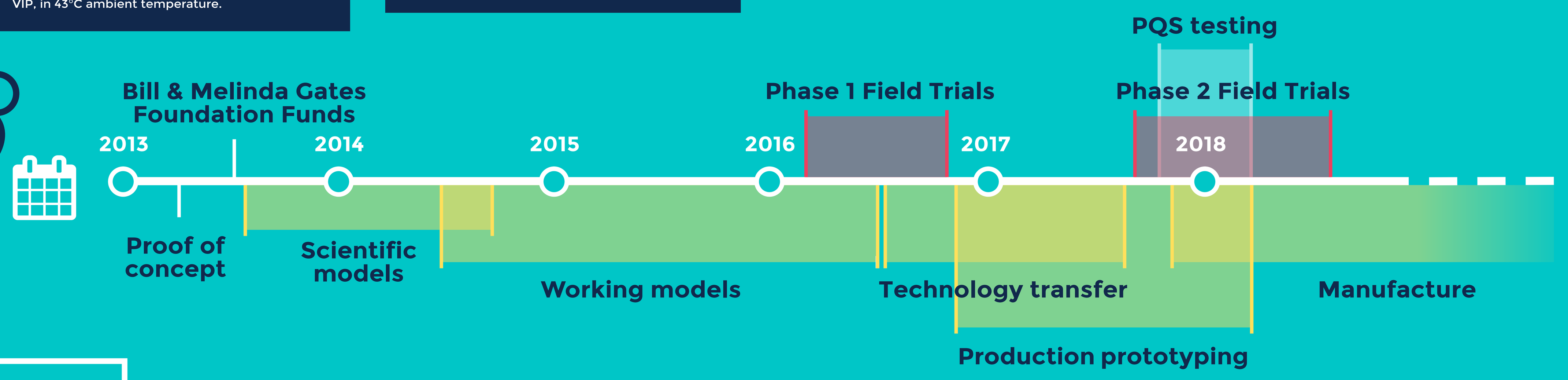
Data collection and remote monitoring

Quantitative data was gathered using three different types of monitoring equipment to track the internal temperature of the LTPDs:

1) **Nexleaf Analytics ColdTrace® loggers**
Recorded temperature data and transmitted it via the GSM network to allow remote monitoring via a cloud-based portal. SMS alerts could also be sent to district staff.

2) **LogTag® Trix-8 recorders**
Used by PATH as the official study temperature monitor.

3) **Freeze-tag® monitors**
Provided a visual indication to health workers in case of freezing temperatures occurring in the vaccine chamber.



Results

Quantitative data from the trial revealed:

- The ambient temperature ranged from 20 - 37°C inside the health posts
- The vaccine compartment remained between 2 - 8°C except when the vaccine compartment door was opened. This is seen as spikes in the vaccine compartment temperature, which returns to the safe range within 1 hour.
- Minimum temperature observed over 3 months was 4.1°C, clearly demonstrating the freeze-free safety inherent in the Sure Chill Technology cooling system
- Without ice replenishment, the LTPD maintained vaccine temperature below 10°C for 33 days to 42 days

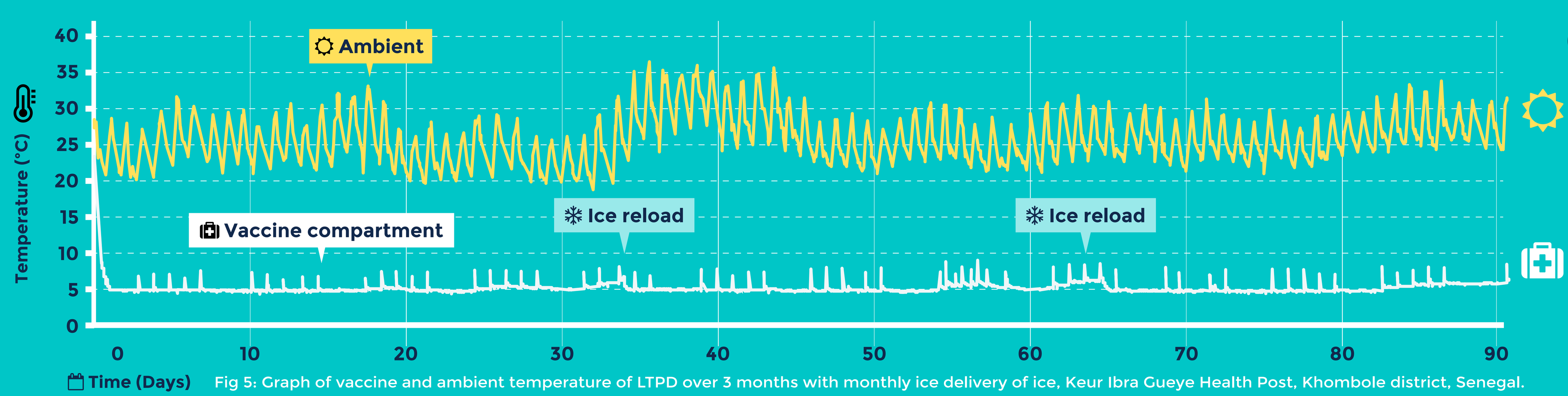


Fig 5: Graph of vaccine and ambient temperature of LTPD over 3 months with monthly ice delivery of ice, Keur Ibra Gueye Health Post, Khombole district, Senegal.

PATH gathered qualitative data through interviews both during and after the study period. These provided feedback on usability, acceptability, system fit, and equipment performance from health post and Khombole DVS staff. Decision-makers at the MOH at the national, regional, and district levels, and Expanded Programme on Immunization (EPI) specialists at UNICEF and WHO were also interviewed.

All head nurses involved in this evaluation reported that the LTPD was easy to use and maintained vaccine storage temperatures of 2°C to 8°C. They thought it could have a useful role in their facilities as well having significant potential for other sites.

Conclusions

- Ice can be used for thermal energy storage, even in high ambient temperatures.
- High quality insulation is critical to minimize heat ingress, and VIPs are currently the most practical technology to provide this.
- With a monthly delivery of ice it is possible to store vaccines safely without a power supply.
- The LTPD is a useful tool in the cold chain to support immunization strategies in the most remote locations or where conventional strategies are not suitable.

Perfect applications

Small off-grid rural:
Providing safe vaccine storage with monthly deliveries of vaccine and ice packs

High density urban
Vaccine storage where grid is unreliable and PV not feasible

Rapid deployment
First response emergency relief, or for covering equipment break down in established cold chain

Accessories

Outreach: An enhanced vaccine carrier has been developed with improved insulation and added Sure Chill freeze protection to allow use of one ice pack from the LTPD for outreach immunisation sessions

On-site ice generation: A simple 120 litre absorption freezer running on LPG or kerosene can be used to freeze ice packs. Fuel consumption is low as only runs once a month, and medical-grade controls not required.

Next steps

Phase 2 Field Trials are about to start in Senegal with the LTPD providing primary vaccine storage in each health post for an active vaccination programme over a 6 month period. This will provide data on the temperature stability and ice delivery, and also the frequency and duration of door openings of the vaccine compartment for which there is no existing information.

Pre-production LTPD units are currently being manufactured for testing to the WHO PQS performance standard which should be complete later this year. The LTPD is expected to be released on to the market in early 2018.

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Sure Chill is keen to hear from countries interested to trial the new device. Contact us at hello@surechill.com