AFRIJI

Refrigeration for all

Content

- The importance of refrigeration
- Why there is lack of access to refrigeration
- Market for off-grid and poor-grid refrigeration
- Design and requirements
- Potential technologies
- Transformative purpose: To create a module that 3rd parties will use for multiple applications across the cooling space

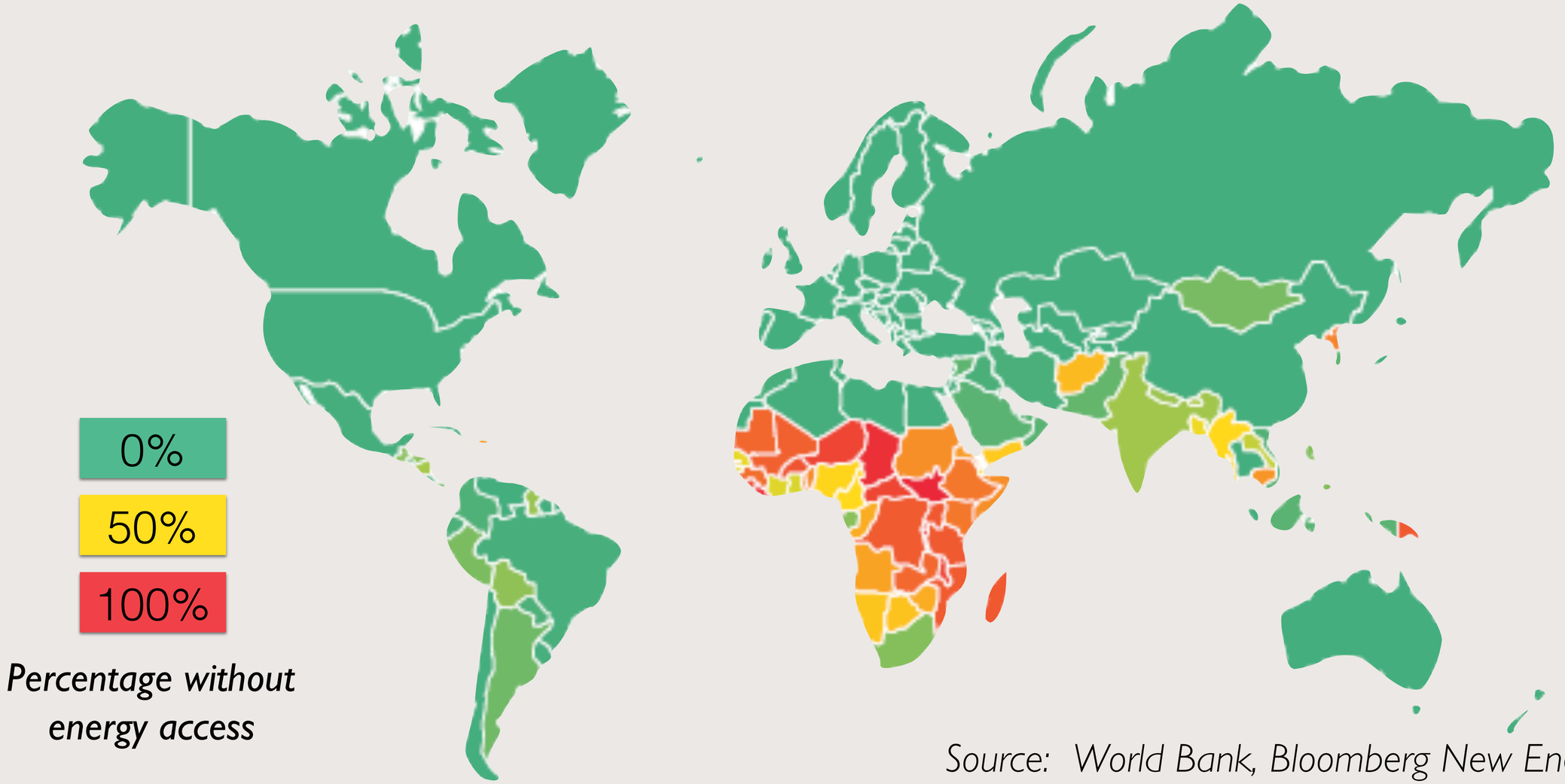
Refrigeration is essential for food, nutrition and health

Insulin

Food storage

Vaccines

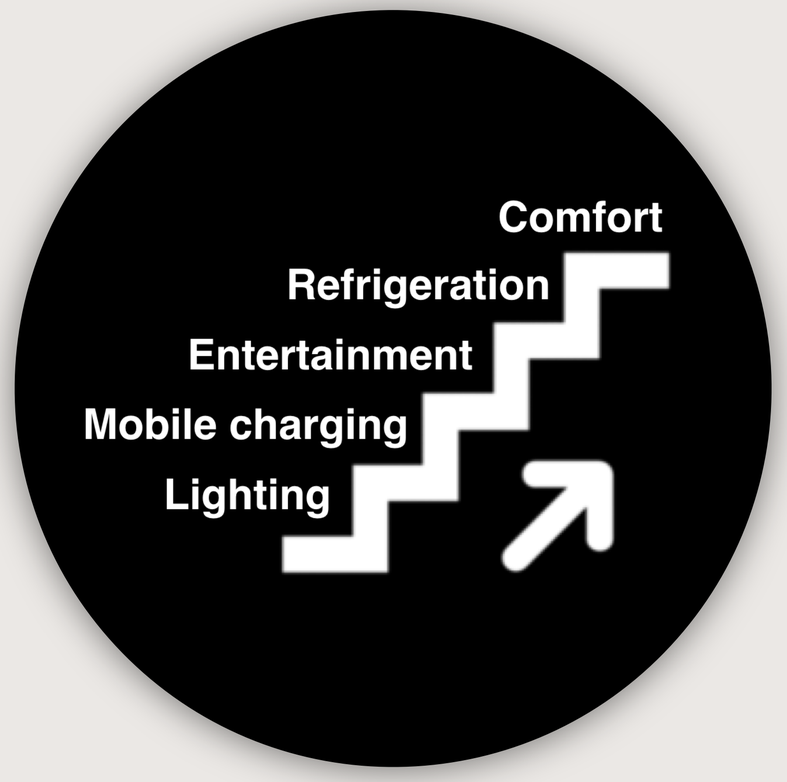
The 2B+ living off-grid or with unreliable electricity access have no good, affordable refrigeration option



Source: World Bank, Bloomberg New Energy Finance

Technical innovation for achieving energy access has been at the base of the energy ladder

Universal energy access is a **global goal**



The **next step** on the energy ladder is refrigeration

What is the barrier to refrigeration for the 2B+?

	1 Cost	2 Availability of power/electricity
Off-grid	Off-grid refrigeration often cost $700 – 2000, plus the required power system	Off-grid solar systems often not compatible with refrigerators, due to i) energy consumption and ii) startup power surge
Unreliable grids	Traditional refrigerators still often out of reach of BoP customers	Unreliable grids limit the utility of refrigeration to non-essential good (e.g. beverages), so many do not bother to get refrigerators

Current options on either end of the spectrum

Affordable

Zeer pot

ChotuKool

Desired product needs to meet both requirements

High capability

SunDanzer

SureChill

Potential customers

1

Off-grid household
- Rural
- No grid connection
- Mid to upper income (in their context)
- Has or will purchase solar system
- Has ability to pay for a PAYG system
- Distribution through PAYG companies
- Primary use: food storage

2

Off-grid retailers/shops
- Rural
- No grid connection
- May have solar system or generator
- Can pay on credit as enhances income
- Distribution through PAYG companies
- Primary use: cold drinks

3

Poor-grid household
- Urban
- Unreliable grid connection
- Middle income
- May already have a refrigerator or had in the past
- Distribution through appliance retailers
- Primary use: food storage

Household food storage

1B+

Vaccine transport

100M

Potential refrigeration applications

60M

Small and medium enterprises

… and many others

Our design question

How might we…

…enable refrigeration that delivers ***adequate and reliable*** *cooling at* ***low cost****?*

Key requirements

Temperature
- Achieve "refrigeration" (4-8°C)
- Whether a freezer (below zero) is needed TBD

Retention of cold
- Retains the desired temperature range for 24 hrs to 3 days (requirements to be determined)

Design
- Aspirational
- Transportable (not necessarily portable)

Reliable
- Low or no maintenance.
- Can handle lack of sun or grid power for extended periods.

Cost
- $100-200 manufactured cost (pre-shipping)

Size
- Smaller than typical refrigerator (50-80L), and small enough for a small shop or home

Flexible
- Can be used on both a solar home system and connected to a (poor) grid.
- Likely 12V from battery / auxiliary output for solar or 12V converter from grid.

Voltage management
- Ability to handle voltage spikes required to run heat pump, e.g. compressor.
- Manage over/under voltage spikes from poor/unstable grids

Two main tech challenges

1

How do we produce cool?

2

How do we retain cool?

Options for producing cool

1. *Vapor compression + modulate temperature of chest freezer*
2. *Stirling coolers (including Free Piston Stirling coolers)*
3. *Thermoelectric coolers (Peltier modules)*
4. *Magnetic cooling*

Options for retaining cool

1. *Insulation:*
   - *Use chest freezer (more insulation)*
   - *Insulation insert*
   - *Polar or space technology*

2. *Top-opening instead side-opening*

3. *Thermal battery (phase change material) at the needed temperature*

Simple way? Modify chest freezer

1. *Modify electronics (or separate product) that modulates chest freezer temp to refrigeration temp instead.*

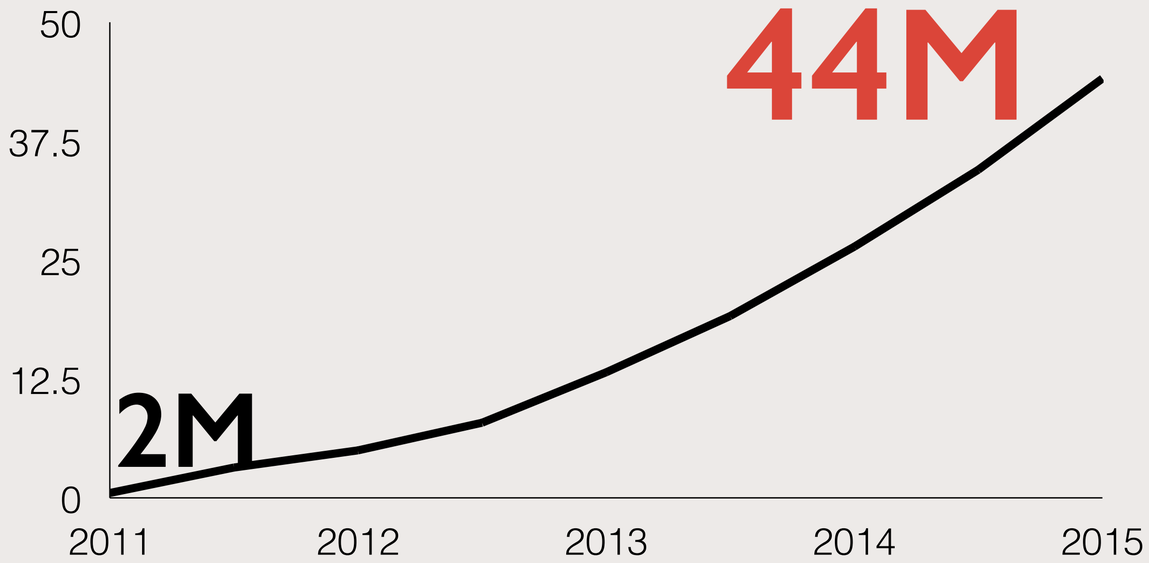
2. *Voltage spike suppression and protection*

3. *Phase change material to retain cool*

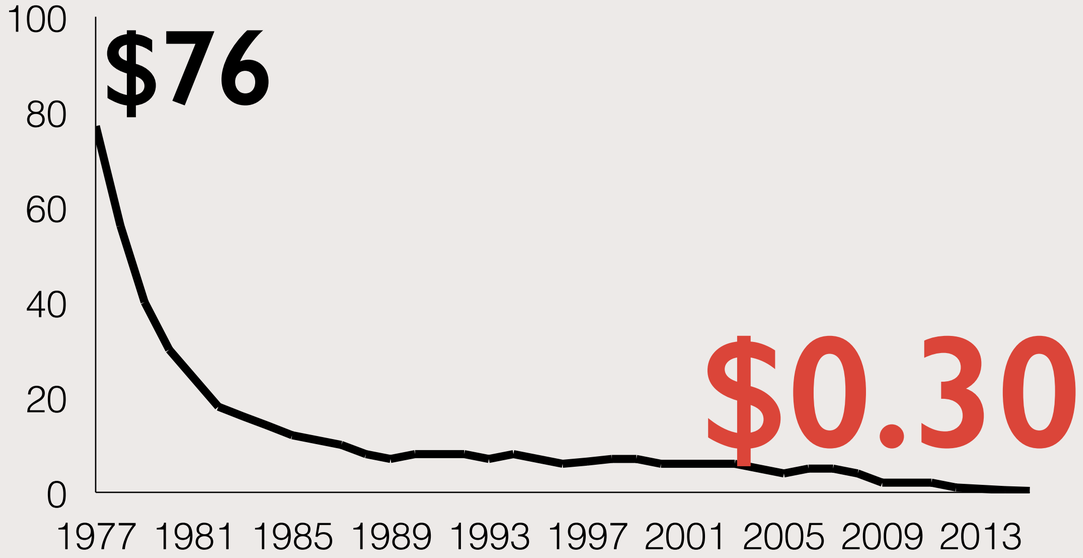
Does not meet all requirements (reliability, transportability)

Potential to leverage exponential trends in both technology and market

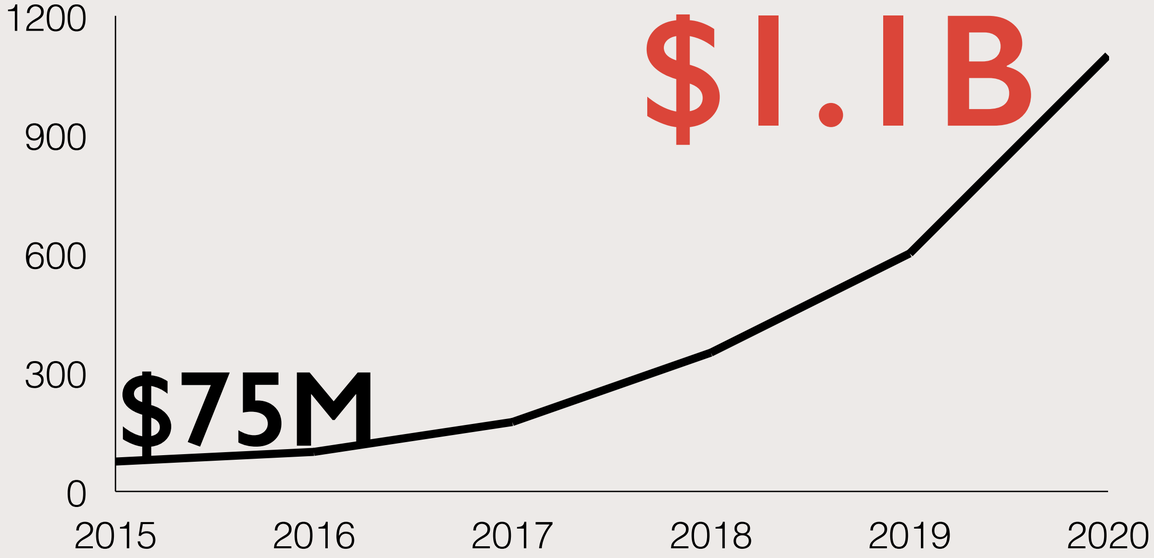
Number of **off-grid solar** customers



Cost of **solar energy** per watt



Off-grid refrigeration market size



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