Access to Cooling

SELCO Foundation

www.selcofoundation.org

Note: Draft Version- for Internal Circulation only

Why Cooling?

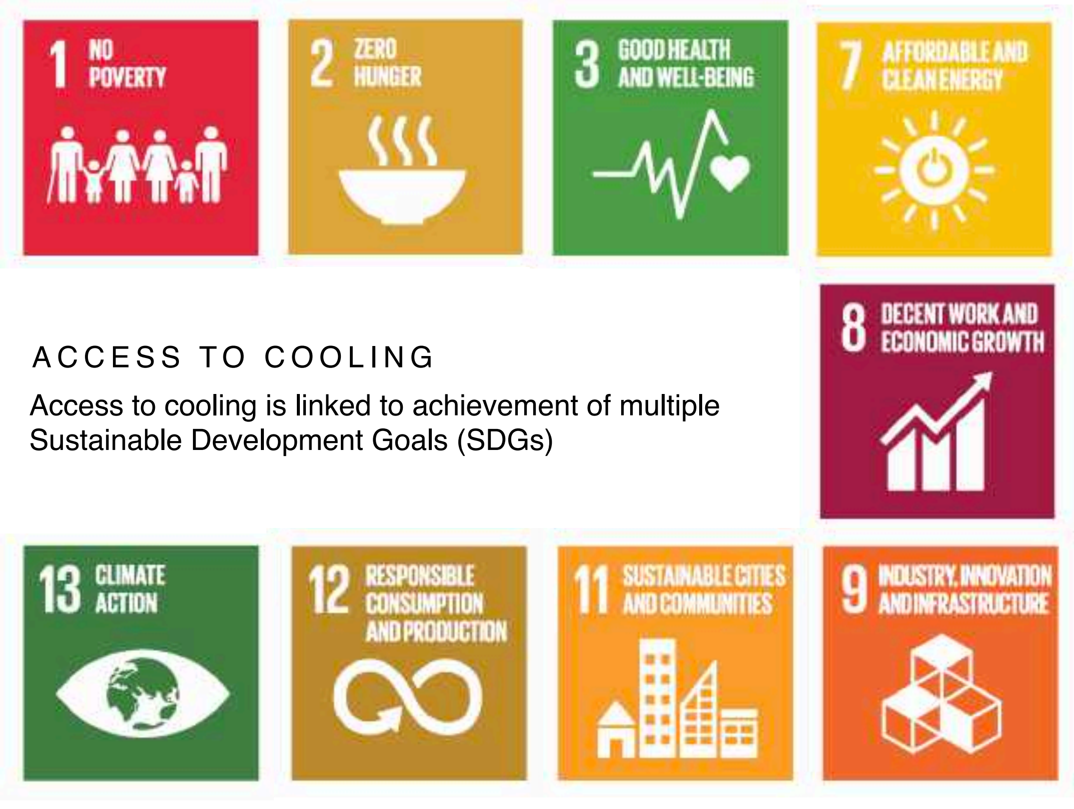
Access to Cooling, Climate Change and Energy Poverty

Global average surface temperatures are expected to rise between 2°C and 5°C at current warming rates by 2100, making summers longer and hotter. With increasing populations, and rising temperatures, cooling is no longer a luxury, but an urgent priority for health and well-being, productivity, and in extreme cases, survival.

The recent SE4All report[1] also draws attention to the social and economic aspects of heat stress and lack of access to cooling. One billion people still lack proper access to the cooling that the rest of us take for granted, and it has the potential to radically change their lives for the better. The United Nations has laid out 17 global Sustainable Development Goals (SDG's) to end poverty, protect the planet, and ensure prosperity for all. Cooling technology, properly applied, can make a dramatic difference in many of the most critical goals:

SDG 1 (No Poverty), SDG 2 (Zero Hunger), and SDG 8 (Decent Work and Economic Growth): A smallholder farmer, someone who grows crops primarily for food using family labour, will often lose at least 15% of his or her income due to food loss while harvesting and storing produce. Improved local cold storage facilities and better education about storage methods can significantly reduce post-harvest food losses and enable the sale of crops to markets that are further away—creating opportunities that could greatly increase the farmer's income.[2]

SDG 3 (Good Health and Well-being): Access to medicine and uncontaminated food is a prerequisite for living a healthy life. Every year, 600 million people fall ill and 420,000 die due to food poisoning caused by poor refrigeration or inefficient cold chains. Meanwhile, 2 million people die from preventable diseases due to damaged or degraded vaccines that were improperly refrigerated and did not follow protocols while in transit. In addition to the above, the growing challenges of heat stress affecting well-being and productivity of several thousands every year. India's National Disaster Management Authority reported that the number of Indian states hit by heat waves had grown to 19 in 2018 from nine in 2015, and was expected to reach 23 in 2019.[2]



ACCESS TO COOLING

Access to cooling is linked to achievement of multiple Sustainable Development Goals (SDGs)

[1] SEforALL (2018), *Chilling Prospects: Providing Sustainable Cooling For All*

[2] *Clean Cold and the Global Goals. Birmingham Energy Institute (2016). https://www.birmingham.ac.uk/Documents/college-eps/energy/Publications/Clean-Cold-and-the-Global-Goals.pdf*

SDG 13 (Climate Action) and SDG 12 (Responsible Consumption and Production): Cooling is already a major and growing emitter: one estimate suggests refrigeration and air conditioning cause 10% of global CO2 emissions[3] – three times more than is attributed to aviation and shipping combined.[4] Another suggests cooling emissions currently account for 7% of the total, but are growing three times faster, so cooling's share will almost double to 13% by 2030.[5]

SDG 11 (Sustainable Cities and Communities): Huge amounts of infrastructure development is required in developing economies. '70% of India remains to be built', according to a report from the McKinsey Global Institute. It is also noted that efficiency benchmarks are not implemented or accessible to the poor or under-resourced regions. A lot of the infrastructure being built is done informally in cities, resulting in long term climate risks.

SDG 9 (Industry, Innovation and Infrastructure): Much of the infrastructure required by developing countries has yet to be built. This includes not only roads, railways, water and energy networks, and entire cities (see Goal 11), but also food and pharmaceutical 'cold chains' of refrigerated warehouses and vehicles, and district cooling systems for commercial buildings and high density housing. India would need to build 70,000 pack-houses, an additional 53,000 refrigerated vehicles – five times its current fleet – and over 3 million tonnes of additional cold storage and distribution hubs simply to catch up with current levels of food production and demand – never mind satisfy future growth.[6]

Innovations in clean cold technologies and efficiency in cooling could provide cooling at lower environmental and financial cost. **But an inclusive approach, using Sustainable Energy (SDG 7: Affordable and Clean Energy) as a catalyst could also ensure that these goals are achieved to also ensure that two of the major threats of our times are tackled - Climate Change and Inequality.**

Poverty and the Burden of Cooling : Creating Sustainable Energy Ecosystems to Catalyse Innovations and Reduce Inequality

SELCO Foundation believes that the implementation strategies for access to cooling, needs to be looked at from an ecosystem approach considering the collaboration between inclusive financial models, efficient technologies, policies, capacity building programs, and necessary market linkages to make the cooling technologies feasible and to improve the access and local ownership of the cold chain.

INCLUSIVE FINANCE

Sustainable financial models, long term financing coupled with capital cost subsidies for cooling infrastructure and assets for last mile services are required as such technologies have high capital costs.

EFFICIENT TECHNOLOGIES

Innovation and promotion cooling technologies which are affordable, accessible and reliable. For example, Eco-friendly wall panels or roofing made of recycled agricultural waste, which enhances thermal cooling.

ACCESS TO COOLING

CHANNELS & LINKAGES

Building channels with service providers for cooling technologies, agriculture based organisations, farmer producer organisations (FPO) incubation organisations to mobilise farmers, build market linkages and verifying business models at the grass root level. Similarly, building partnerships with sector based organisations in housing and health.

CAPACITY BUILDING

Training and up-skilling of last mile clean energy enterprises providing need assessment support, servicing and maintenance channels for technology innovators, traders, manufacturers and vendors.

POLICY

To converge guidelines in heat actions plans with states with organisations who have been engaging in evidence building and drafting the cooling guidelines and policies for the country.

Fig 1: Energy + Cooling Ecosystem

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[3] *Sustaining the Future – Inspiring a Generation, Graeme Maidment, IOR, January 2014, http:// www.ior.org.uk/app/images/downloads/ Maidment9thJanuary2014LSBUggmFinalVersion_ USE.pdf*

[4] *http://www.c2es.org/technology/report/ aviation-and-marine*

[5] *Green Cooling Initiative, German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, http://www.green-cooling-initiative.org/*

[6] *All India Cold-chain Infrastructure Capacity Assessment of Status & Gap, National Centre for Cold-chain Development, 2015, http://nccd.gov.in/ PDF/ CCSG_Final%20Report_Web.pdf*

Space Cooling

Setting Energy Efficiency Benchmarks for Space Cooling

Increase in temperature has a profound effect on the living conditions of the poor and the related services administered to them. Small dwellings with tin sheets roofs increase the indoor temperature by more than 3-4 degrees. In Ahmedabad when the outside temperature in 39-40 degrees Celsius the in-house temperature is at-least 43-44 degrees. These conditions make it very dangerous of the poor to live or conduct any sort of livelihood activities. The structure of the low-cost housing is no different. Same conditions prevail in maternal delivery rooms in hospitals or schools that cater to the poor. These circumstances have a long-term effect on the poor and prevent them from rising out of poverty.

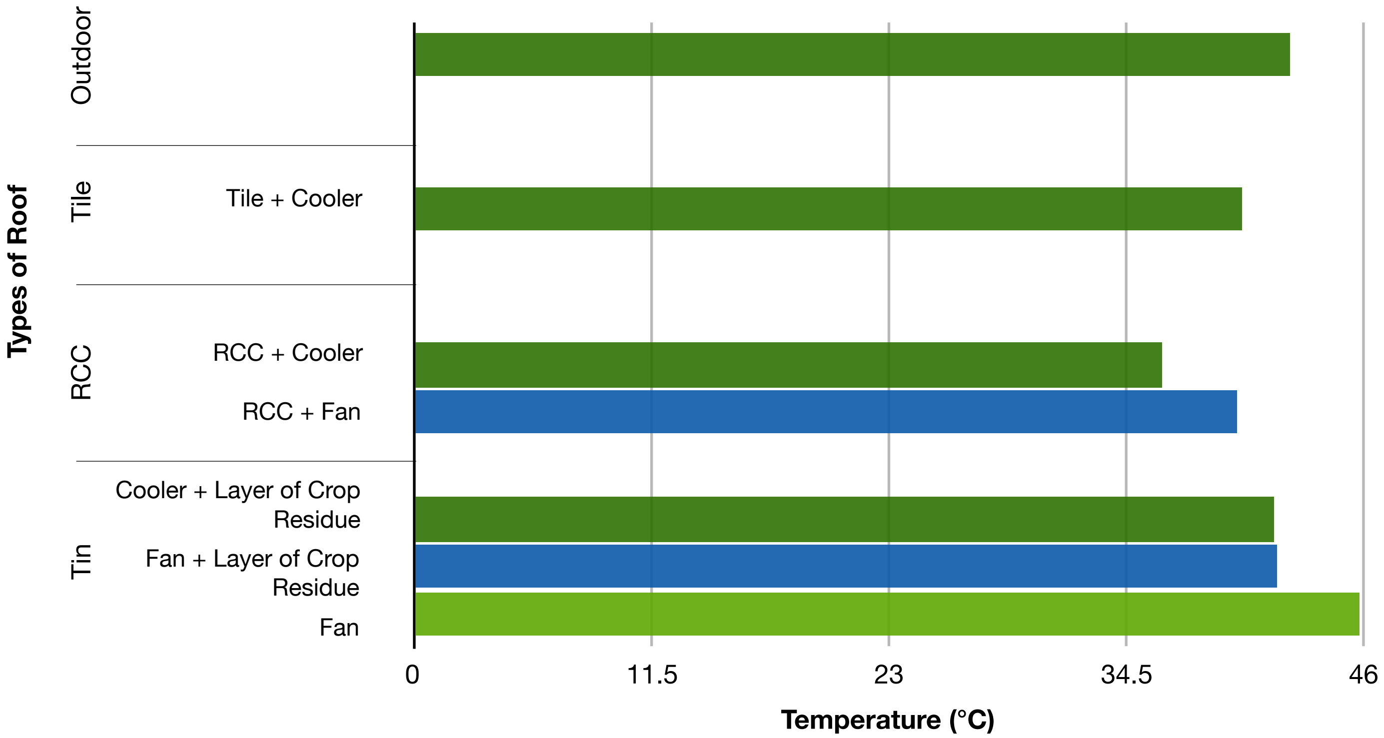

Fig 2: Average air temperature measured outdoors and indoors under different roofs[7]

It is reported that worldwide energy demand for space cooling will overtake space heating by 2060, and outstrip it by 60% at the end of the century.[8] But, while high and low income neighbourhoods both have heat going up during the day, one's ability to afford air conditioning (AC), avoid strenuous activities outdoors and presence of shade make a difference in coping with the heat exposure. But people in densely built, low-income neighbourhoods, with no open green spaces, remain unsheltered from heat even at night. Because, at night, these neighbourhoods, tend to trap the heat of the day and stay warmer.

Heat is more than just high temperature and it is influenced by several other factors such as humidity, wind, direct or indirect radiation from the sun and indices take into account these factors and give an idea of how hot one really feels.

Through SELCO's work in improving thermal comfort across typologies and communities, various solutions involving passive technology like cool roof and climate responsive designs are undertaken to improve productive use, wellbeing and long term savings in energy consumption. In Bidar, Karnataka, and Ahmedabad, Gujarat, heat stress and drought prone areas, holistic and integrated solutions are looked at with training and capacity building for energy efficiency, cooling technology, need assessments and inclusive financing with institutions and governance bodies.

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[7] Cor Jacobs, Tanya Singh et al, "Patterns of Outdoor Exposure to Heat in Three South Asian Cities", Science of the Total Environment, Vol 674, July 2019,

[8] Modeling global residential sector energy demand for heating and air conditioning in the context of climate change, Morna Isaac, Detlef P. van Vuuren (2009), Netherlands Environmental Assessment Agency, Energy Policy, Volume 37, Issue 2, http://www.sciencedirect.com/science/article/pii/S0301421508005168

Climate classification and Heat stress

According to various climate classification methods, India can be broadly categorised as the follows based on Koppen - Grieger methodology

Climate Type	Regions	Mean Temperatures	Relative Humidity (RH)
Tropical Monsoon	Western Ghats and Western Nagaland, Tripura	Max temperature of 27°C	RH levels above 75%
Tropical Savanna	Deccan Plateau, Odisha, Andhra Pradesh, Tamil Nadu	Max temperature of 45°C	RH levels above 5%
Tropical Semi-arid Steppe	Interior Karnataka, Central Maharashtra, Western Andhra Pradesh	Max temperature of 32°C	
Sub-tropical Steppe	Punjab to Kutch	Max temperature of 46°C	RH level below 55
Sub-tropical Desert	Rajasthan and Kutch	Max temperature of 48°C	RH level above 55%
Sub-tropical Humid (Dry Winter)	Punjab, Uttar pradesh, Bihar, West Bengal, Assam and Arunachal Pradesh	Max temperature of 46°C and minimum temperature of 10°C	

Indoor Heat Stress:

Many studies report a direct relation between outdoor ambient temperature and health. Outdoor conditions are a poor indicator of human wellbeing as most individuals spend more than 80% of their time indoors in houses, schools and workspaces. In addition to the material of the envelop of the building itself (impact shown in Fig 2) Primary factors that contribute to indoor heat stress in an individual are the type of activity and rate of activity being conducted in an environment and the environmental features like air temperature, airflow, humidity and radiant heat.

Indoor heat stress or overheated spaces due to poor thermal comfort can lead to lack of productivity from inability to concentrate, increased heat rate, dehydration, fatigue, sickness and even death. Multiple studies show heat stress results in increased workplace errors and accidents.

Few methods through which a body releases or gains heat and the need for thermal comfort from natural ventilation, insulation and cooling

- Most of the body's heat is released through radiation. This occurs when the ambient air temperature is lower than the body's skin temperature.

- Other methods are Convection (transfer of heat energy from a warmer object or space to a cooler object or space through differences in density and the action of gravity), Evaporation or perspiration from the skin. Evaporation is the cooling of a surface through the process of a liquid changing to a vapour and leaving that surface (high humidity levels prevent this from occurring) and Conduction i.e. through direct contact.

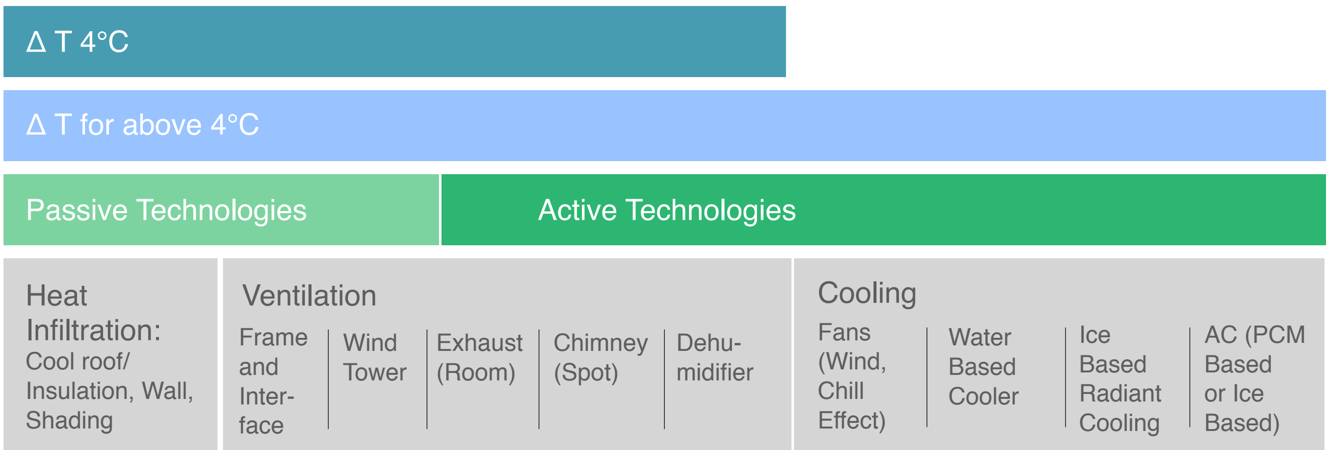
With rising global temperatures, the lack of cooling solutions is a major inequality issue. The most adversely affected are the poor and those living in densely populated areas. Some typologies where these are predominant are urban slums. With communities living in densely populated and small, cramped spaces â€“ solutions for ventilation naturally and through passive mechanisms are restricted to reactive techniques like cool roofing paints and active cooling mechanisms like air coolers and air conditioners. Both these solutions result in radiant heat (reflected off rooftops or exhaust from AC compressors) being exhaust into the micro climate furthering issues of urban heat island effect.

In rural and remote communities, the issues are worsened due to lack of shaded spaces and poor built envelops. With post occupancy interventions, not only are capital costs extremely high but this increases energy dependency and hence consumption. Operational and maintenance costs of expensive or luxury goods/ solutions result in recurring expenses for the poor. Hence furthering communities into poverty.

Function	Activity or Source of Heat	Typology
Housing	Ambient Heat	Community- Urban Slum, Peri-urban, Rural and Remote Group activities (Home based livelihoods)
	Active Heat Source (Kitchen)	
	Physical Exertion (Home based livelihoods)	
	Machine Dissipated Heat (Home based Livelihoods)	
Livelihoods	Ambient Heat	Occupancy- Single entrepreneur or Group occupancy
	Physical Exertion	
	Radiant Heat	
	Machine Dissipated Heat	
Education	Ambient Heat	Group Occupancy
	Radiant Heat (Kitchen)	
Health	Ambient Heat	Type of Care and Services Provided (Labour room, examination, Operation Theatre)
	Sterile Needs	
	Radiant Heat	

Table 1: Typology of Spaces - energy needs understood via the activity in the space and the occupancy or other special features

Technology Benchmarking for Varying Cooling Needs and Typologies



Passive technologies can be used across all climate classification, community typology and occupancy. Few methodologies for selecting technology are;

A. Prevent heat infiltration

These strategies can be used for up to 4degC temperature reduction through orientation decided based on sun path, wind direction, micro climatic factors and terrain

- Climate responsive designs and layouts
- Strategies for shading
- Envelop treatment, material and insulation choices

Depends on locally available manufactured materials or supply chain and access to markets

Material and Insulation for Efficiency Benchmarks

	Efficient Material Alternatives	Application	Availability
	External Envelope		
1	Cool roof paint	For GI Sheet as well as RCC slab on the exterior surface of the roof for thermal insulation. Hot and Dry Climate zone	Pan India
2	Hourdi Block/ Hollow clay block Roofing	Flat Roof slab alternate for cooling the roof	Karnataka, Tamil Nadu, Orissa, Goa, Kerala, Maharashtra, Andhra Pradesh
3	Precast cement/ ferrocement sandwich insulation (with foam or EPS) slabs	Flat Roof slab alternate for RCC	Pan India
4	Clay or laterite aggregate in RCC slab	RCC jelly alternate	Coastal
5	Mangalore Clay tile roofing with metal framework	RCC roof alternate for heavy rainfall zones	Coastal
6	Fly Ash or AAC Cement Blocks	External and partition walls	Pan India
7	Porotherm- Wienerberger Block or hollow clay block	External and partition walls	Pan India
8	Laterite Blocks or CSEB	External Walling Material	Coastal
9	Timber	External Walling/Roofing/Partition walls	Leh Ladhak, Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, Niligiri
10	Tombre Wall	External Wall	Leh Ladhak
	Fenestrations		
11	UPVC or Fibreglass Frame Windows and Ventilators	Fenestration	Pan India
12	Window Glazing Material (Low emissivity)	Fenestration	Pan India
	Internal Walls		
13	Strawcture boards or Sandwich panel walls (110mm thick)	Interior partition walls and external walls as sandwich panel	Maharashtra, Uttar Pradesh, Bihar, Gujarat, Delhi
14	Seamless internal finishes in white either in Vinyl or seamless flooring tiles	Optimisation of active lighting as well as easy to clean surfaces	Pan India

Table 2: Material matrix developed by SELCO Foundation through its interventions across different geographies and space functions

B. Ventilation/ Heat extraction

These strategies can be used for up to 4°Ctemperature reduction through appropriate design based on occupancy, activity type/function and sources of heat – ambient or from a source

- Design of fenestration and frames
- Design of exhausts and chimneys
- Design of spaces (Blacksmith - kolar and food making)
- Dehumidification for moisture control

C. Active Cooling

These strategies can be used in combination with passive technologies for above 4°C temperature reduction when ambient temperatures are well above 35°C

- Methods for forced ventilation
- Solutions for active cooling based on climate zone

Air conditioning (AC) is expected to increase significantly with rising incomes, but it is likely that many who need AC will not be able to get it due to its high cost. Only 8% of the 2.8 billion people living in the worlds hottest regions currently have an air conditioning unit, making it a luxury item.

In the following pages, specific cases will be discussed to showcase innovations in different ecosystems aspects-processes that have been proven and can be scaled across different geogrpahies

Case Studies

I. Customising a Cold Storage Solution for Human Comfort

Ahmedabad, Gujarat

HUMAN COMFORT, ACTIVE COOLING

CONTEXT

Ahmedabad saw the urgent need for developing the Heat Action Plan post 2010 heat wave which led to the death toll of 1344 people. With the current climate stress reaching maximum temperatures of 40-45 °C, cooling for thermal comfort of 26-28°C is required for improved productivity and wellbeing.

One such case is a school at Prahladnagar, Ahmedabad, the school would use two Air Coolers and six fans every day, especially in the summers for 2 months straight to achieve respite of – T 6°C to 8°C at max for only 2 hours per day due to the high consumptive load of inefficient appliances. Children usually study and play in dark, hot ad-hoc shelters with poor ventilation in hot climatic conditions of 35°C to 50°C with limited learning material impeding them further from accessing any form of learning or growth.

Above: Slum School Exterior
Below: Interior - Cold Room Solution

TECHNOLOGY

Modified PCM based Cold Storage Solution for Air Conditioning

Traditional Air Coolers are highly inefficient but are not suitable at higher temperatures

Air coolers can bring down ambient temperatures by 3-4 deg C. They consume an average of 150W, run at 1/8th consumption as compared to traditional air conditioners and are generally preferred for the hot and dry climate because of their humidifying properties.

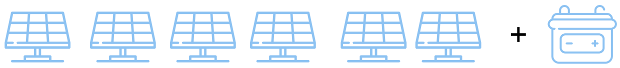
However, to achieve human comfort for around 60 occupants in geographies where ambient temperature is 40°C and above, air coolers do not perform optimally due to their limited direction of flow and cooling range.

Modifying food cold storage solutions for efficient space cooling is more viable than using conventional air conditioners

In traditional cold storages, required temperature ranges from 4 to 15 °C depending on the commodity stored as opposed to 24 to 26°C requirements for space cooling. PCM based cooling technologies by InfiCold India Private limited cooling was required for day time occupancy for humans only.

This technology has added advantages like having a customisable VFD compressor (variable frequency drive against traditionally inverter based compressor) that is compatible with solar. The work done by the compressor is higher in cold storage than space cooling due to the occupancy type. Space cooling for day time occupancy doesn't require thermal storage or battery storage. Additionally, the refrigerant gas used by the inverter based AC is R32 which is flammable gas whereas InfiColds cold storage uses R134 A which is inflammable.

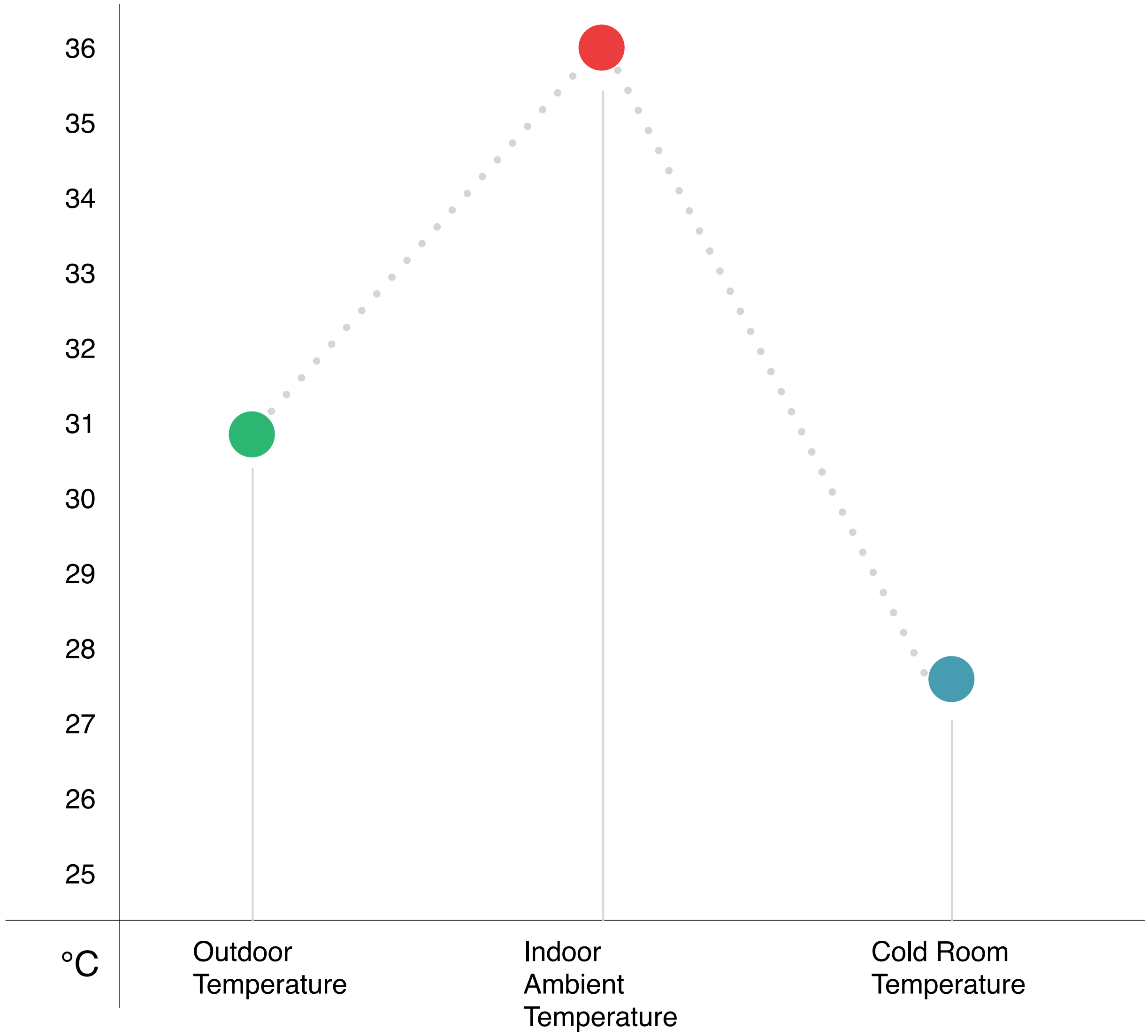
Traditional coolers have low initial investment (Costs 10-15% of a traditional Air Conditioner). The InfiCold solution costs 1.5 times less than traditional inverter based Air Conditioner as no backup energy storage is required.

	VFD Based Cold Rooms	Inverter Based AC *For 3 Tonne AC Capacity
Solar System Size*	5.5 kWp Solar Module Only 	7.4 kWp Solar Module, 48 kWh Batteries, 10 kVA Inverter 
System Cost	Price of Application: INR 2,75,000 Solar System Cost: INR 3,00,000 Total Cost: INR 5,75,000	Price of Application: INR 1,01,550 Solar System Cost: INR 8,00,000 Total Cost: INR 9,01,000

	Cooling Requirement	Energy Consumption	Cost (1530 cu. ft.)
VFD Based Cold Storage	4-15°C - Higher Compressor Capacity	Thermal Storage Required	INR 14,00,000
VFD Based Cold Rooms	24-26°C - Lower Compressor Capacity	No Thermal Storage (Day time usage)	INR 2,72,000

*Diagrams are representative

Avg. Temperature Comparisons at 12:00 pm across November 2019



Active cooling measures like this can be further made efficient by passively cooling of the refrigerant. Cost benefit analysis for varied occupancies and personal to institutional uses will be done over the next few months.

Similar technologies can be used for other extreme hot climates like Delhi, Rajasthan, Maharashtra and Madhya Pradesh in India and heat stress regions in Africa and the Middle East for various infrastructure needs like health centres, housing, educational centres etc.

Case Studies

II. Improving Space Cooling Efficiency using Passive Cooling Methods for Portable Educational Spaces

Ahmedabad, Gujarat

HUMAN COMFORT, PASSIVE COOLING

CONTEXT

Under various government and NGO initiatives, shelters are built as creches and tent schools for communities that are migratory in nature and where working parents are present. These creches are usually constructed from tarpaulin, asbestos, metal sheets, mud floors and casuarina poles tied with rope. One season of monsoon can completely wash away such structures and on a daily basis, they have no security from vandalism or rodents. Children usually study and play in dark, hot ad-hoc shelters with poor ventilation in hot climatic conditions of 35°C to 50°C with limited learning material impeding them further from accessing any form of learning or growth.

The school at Prahladnagar, Ahmedabad is around 665 sq ft in area and caters to the education of 50-60 students living in the nearby migrant slum community. The initial structure of the slum school was made up with building materials of high thermal conductivity i.e. metal sheet that resulted in very high indoor temperatures and had two openings as windows of size 2ft by 2ft which provided no respite due to limited ventilation.

Slum School Exterior (Before Upgradation)

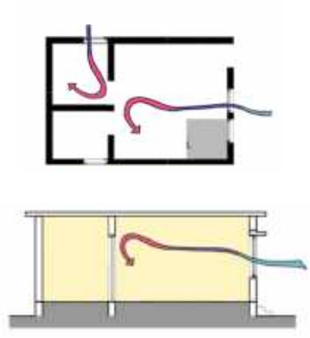
TECHNOLOGY

Using high thermal conductive material for building structures in the hot and dry climate zone like Ahmedabad, can have adverse effects on children’s psychological and physical well being, due to higher temperatures. To achieve the thermal comfort and reduce the consumption of energy inside the structure both passive and active cooling measures were taken

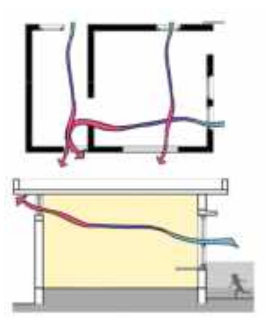
A. Prevent heat infiltration

Building Envelope:
Usage of low thermal conductivity and insulated building material like Ecoboard panels from Strawcture Eco Pvt Ltd and Puff panels for walling and roofing, respectively. This prevents the heat transfer into the classroom and reduces internal temperature

External Shading Devices:
The roof made from insulated foam sandwich panels are further cooled by a second canopy of rooftop solar panels



Before: No proper openings to facilitate cross ventilation



After: Openings that are shaded to facilitate cross ventilation

B. Forced Ventilation Techniques

Wind and Chill Effect:
4 Ceiling fans helped in maintaining even distribution of airflow across the room. Fans create a wind chill effect that helps in cooling spaces. The number of fans was also reduced post renovation from 6 numbers to 4 due to improving thermal efficiency of the structure.

C. Ventilation and Heat Extraction

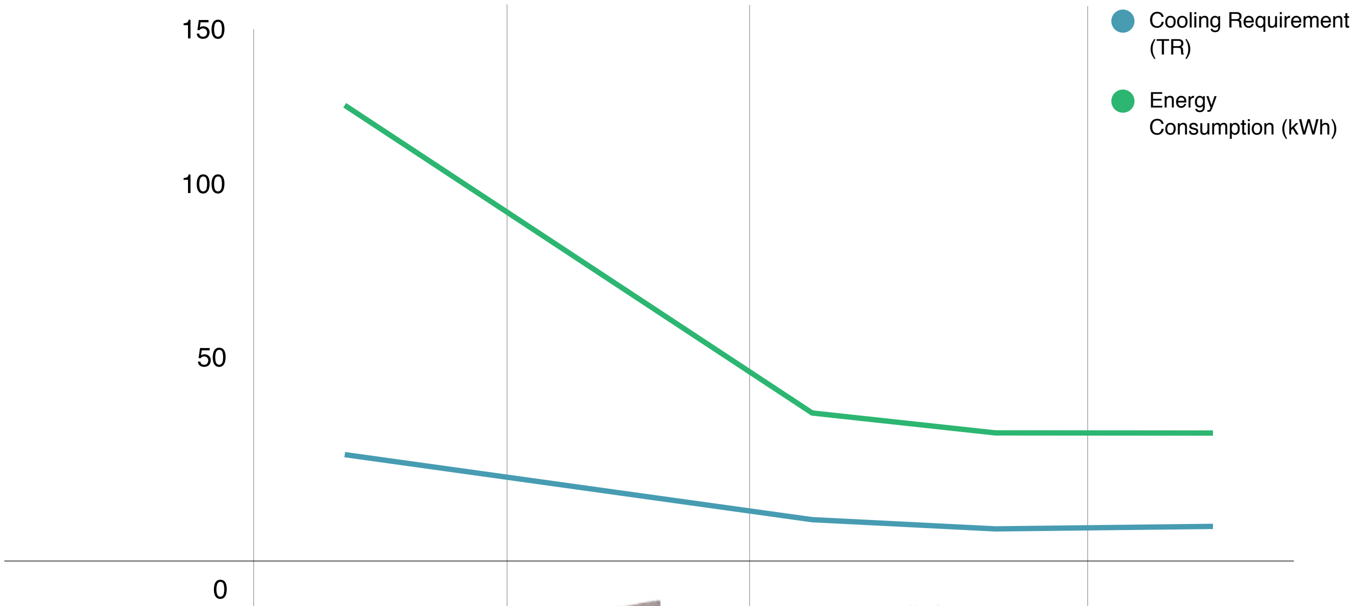
Window Orientation & Design:
The orientation, size and material used for the frame of the window and its design reduces the amount of solar heat entering the building, significantly. The windows of the slum school have aluminium insulated window frame and face north primarily. Also, the windows are located across each other so as to improve the natural cross ventilation within the building, adding to the indoor thermal comfort and air quality.

The stated passive solutions when applied together brought down the temperature of indoor environment up to T 4°C to 5°C, compared to the outdoor environment. This ultimately reduces the dependence on the active cooling measures, especially in the case of solar powered devices, as it increases its efficiency.

Slum School Exterior
(After Upgradation)

IMPACT & OUTCOMES

Technical comparisons between standard building materials for prefabricated schools



	 Metal Sheet (Original)	 Bison Boards	 Puff Panels		 Ecoboard (Upgraded)
THICKNESS	0.45 mm	18mm - 50mm (air gap) - 18mm	60 mm	100 mm	18mm - 50mm (air gap) - 18mm
COOLING REQUIREMENT	16 TR	10 TR	5 TR	4 TR	4 TR
ENERGY CONSUMPTION	127.2 kWh	79.5 kWh	39.75 kWh	31.8 kWh	31.8 kWh
AIR LEAKAGES	Yes (Can increase cooling requirement up to 24 TR)	No	No		No
THERMAL CONDUCTIVITY	Steel - 50.2 W/m-k	1.2 W/m-K	0.021 W/m-k		0.09 W/m-k
INTERNAL SURFACE TEMPERATURE	55°C	48°C	44°C	40°C	40°C

The prefabricated technology with thermal efficient materials like eco panels can be used for many applications and is currently being replicated across composite climate zones in Bihar and Jharkhand for day care centres, midday meal kitchens in schools and housing.

These passive cooling measures can be used to reduce energy requirements and needs for cooling. They are also applicable for cities like Bangalore and Pune limiting to passive solutions(T4°C) eliminating dependency on energy while using natural techniques.

Case Studies

III. Skill training for passive comfort in Heat stress communities

Bidar, Karnataka

HOUSING, INCLUSIVE FINANCING, SKILL TRAINING

CONTEXT

Bidar is a hill-top city in north-eastern Karnataka. It has a semi-arid climate with extreme summer, with the highest temperature of 42°C and relative humidity levels of less than 20% in the month of May. Semi-arid climate zones means low humidity levels in the atmosphere which leads to dryness, respiratory health problems like asthma and other allergies. Higher temperatures can lead to heat stress and lowered productivity. The majority of the community in Amlapur and Gadgi are engaged in agriculture work and daily wage labour for construction. At a household level, a lot of mechanised cooling measures and humidifiers like air coolers or air conditioners, are not affordable by the communities. Hence, having a naturally thermally comfortable living space becomes a major need for the well being of the people, living in similar climate zones and having similar socio-economic backgrounds like Bidar.

Introducing a new energy efficient technology created a sense of hesitation among the community households regarding the reliability and durability of the construction technology. Hence, awareness and capacity building of the local masons and contractors for the energy efficient construction technologies became essential. Both to develop trust for the construction technology and to build their capacity to be able to replicate the same in future.

Typology of homes observed in Bidar with a data log of internal temperature and relative humidity

TECHNOLOGY

In Bidar and other districts in North Karnataka, climate responsive design templates, modules and standard were developed for reduced energy consumption and thermal heat gain.

Applying appropriate strategies like use of efficient construction technology for improved thermal comfort like:


Laterite Wall


Boulder masonry


Madras Terrace


Rammed Earth


In-situ Filler Slab

Use of prefab components for fast construction, focusing on low drudgery construction and encouraging more self construction or service models among the community for new construction and renovation of existing dilapidated homes.


Precast Beams


Precast concrete


Tandoor or Filler Panels


Modroof

FINANCING & UNLOCKING POLICY

A revolving fund of INR 30,00,000 (USD 41,986.35) was created by local NGO Samarasa with the support of SELCO Foundation.

A loan product was devised for INR 3,00,000 (INR 2,25,000 or USD 3147.93 each) and INR 75,000 to INR 1,00,000 was subsidies via PMAY were unlocked in Gadgi and Amlapur, having non-convertible agriculture land.

Financing for constructing houses incorporating cooling strategies (300 sqft for INR 3,00,000) was provided to 10 SHG members. The loans were provided at 5% interest rates for 7 years leading to a monthly EMI of INR3180 or USD44.49.

The case study of the same proven models of repayment were shared with SKDRDP (Charitable trust functioning as banking correspondent) and Vijaya bank presently known as Bank of Baroda (public sector banks) branches in Bidar for replication at a larger scale for new home construction and retrofits or renovation with cooling technologies.

CAPACITY BUILDING

Migration of skilled labourers often occur from Bidar to Hyderabad, Mumbai, Bengaluru and other metro cities for better livelihood opportunities and standards of living. Lack of skilling opportunities locally, compromises the overall quality of construction. With prevaling drought conditions and lack of access to water, there is a need for upgradation in construction methodology. This was achieved through:

Masons training for energy efficient construction technologies incrementally in-situ during the construction of homes in Bidar villages of Amlapur and Gadgi.

Course modules were developed with Bangalore based organisation Building Resource Hub to incorporate energy efficiency and comfort principles into standard construction methodologies with local engineers and experts.

Another channel was introducing mason training content for climate response design, introduction to cooling materials and fast construction technology via local PMKVY certification centres and universities with the intention to develop ecosystem or local resource hub for self construction or kit-of-part solutions for local home/land owners.

Left: Energy efficient homes built through the program.
Above: Training carried out for masons.

Livelihood diversification for existing manufacturers/ tradespersons for fast construction methodology with sustainable materials is underway to create a building resource hub for efficient technology. Additionally training on carbon credits and energy efficiency to encourage local banks to provide green home loan products for agricultural land titled communities.

Case Studies

IV. Unlocking financing for Productive Use of Space - Model for Prefabricated and Portable Technology

Mysore, Karnataka

HUMAN COMFORT, PASSIVE COOLING, RADIANT HEAT, LIVELIHOODS

CONTEXT

Mysore is located to the South of Karnataka around 140 kilometres from Bangalore. The city lies at the base of the Chamundi Hills and has pleasant weather all year round. Mysore enjoys a composite climate, with cool winters and warm summers.The changing climate is bringing more adverse affects on the seasonal temperatures, due to which Mysore also started experiencing harsh summers and cold winters.

Geeta used to conduct her livelihood in a shed that was built using metal sheets and asbestos with 5 to 6 occupants engaged in pottery and training on a leased land. With limited resources and no land title, it was difficult for her to upgrade her livelihood space for better quality of work and comfort.

Pottery shed exterior and interior before upgradation

TECHNOLOGY

In order to improve the spatial efficiency, work space was divided into following areas - Training, Working, Storage and Baking area.

The workspace was designed based on the various activities involved in pottery making

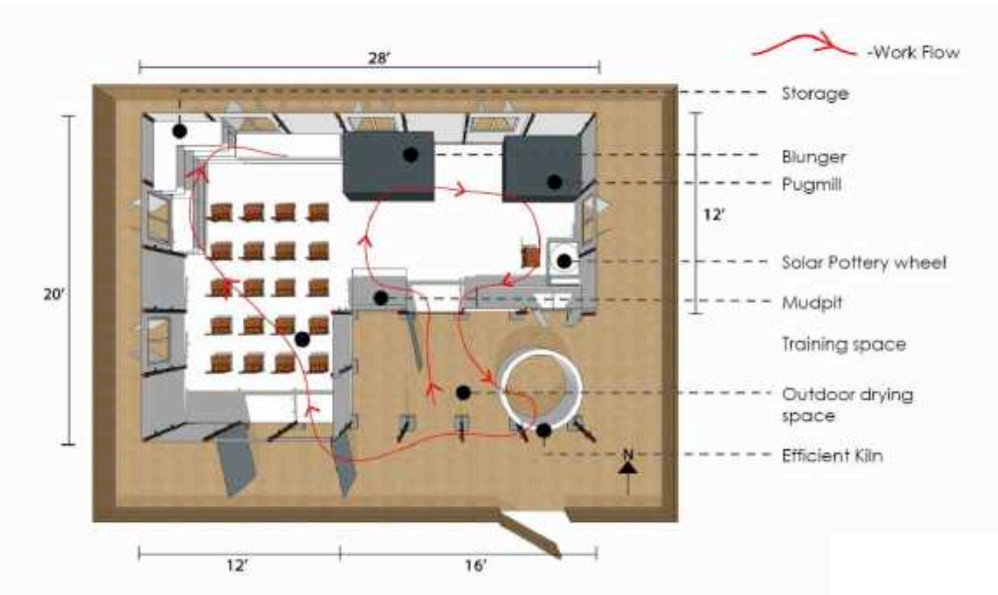
Clay mixing for even consistency using a Solar Powered Blunger

Kneading of the clay using a Pug mill

Pots shaping using Solar Powered Pottery Wheel

Sun or Air Drying and Baking of finished pots

Storage of the dried pots



Each activity area is designed with ergonomics, good lighting and ventilation to reduce the drudgery in the work resulting in increased productivity and reduced dependence on energy.

Sufficient storage is designed and built considering the production cycles and monsoon stress.

Due to long term leasing of the land, the structure built was also to be prefabricated, modular and portable to reduce wastage and reuse/rebuild with maximum of the construction material.

An efficient kiln was also designed and built to improve the baking quality, to reduce the loss of pots due to breakage, reduce consumption of fuel and the heat transfer from the kiln into the workspace.

FINANCING & UNLOCKING POLICY

With access to financing, the entrepreneur was able to motorise all activities that were manual labour intensive and invest in a facility that was naturally lit, ventilated and comfortable for long duration use.

An INR 90,000 subsidy from the Women and Child Development Department of Mysore District under the Udyogini scheme, for business development and rehabilitation of sex workers, was unlocked to make the solution affordable for the entrepreneur.

A bank loan of INR 3,00,000 at an interest rate of 10% and tenure 5 years was sanctioned by Canara Bank.

Udyogini: A scheme under Karnataka State Women Development Corporation by Karnataka Government encouraging Women to take loans from banks and other financial institutions to take up income generation activities listed by KSWDC or other profitable activities for which KSWDC assists in the form of Subsidy.

Going forward, mapping and replication of financial models with specialised policy schemes for other cooling needs in productive use spaces like tailoring, food preparation or catering etc for communities that are disenfranchised, will be carried out.

Case Studies

V. Policy Guidelines for Energy Efficient Government Healthcare Centres

HEALTHCARE, HUMAN COMFORT, POLICY

CONTEXT

India's Rural Public Health System aims to provide effective health care to the rural populace throughout the country, which have weak public health indicators and/or weak infrastructure. It's health infrastructure comprises of Sub-centres, Primary Health Centres(PHCs), Community Health Centres (CHCs), Sub-District and District hospitals following the IPHS guidelines. These health centres are the peripheral outpost and the first hope of healthcare for people living in remote areas. It fulfils the basic primary and quality health care needs of the families surviving in difficult circumstances in the remote areas. Thermal comfort becomes immensely important for these centres, specially for the well being of the patients given their medical conditions, and also for the well being of the healthcare staff for more efficient work delivery.

Typical sub-centre building in India

Most of the health centres identified in India have poor natural lighting, cross ventilation and thermal comfort for activities and functions which results in high dependence on electricity - lights and fans, especially in the heat stress provoking climate zone. 25% of Health Sub-Centres (SC) out of 150,000 have no electricity access, which leads to no access to cooling. Hence, implementation of passive strategies becomes immensely important to reduce the dependence on electricity for cooling.

TECHNOLOGY

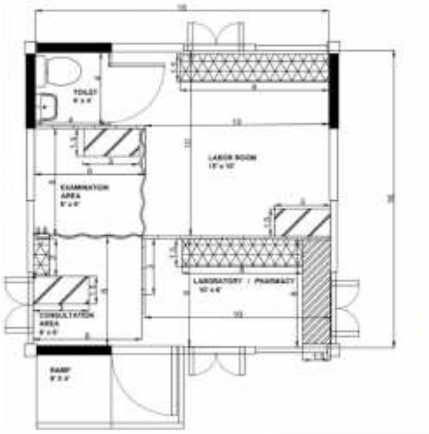
Benchmarking of the energy efficient thermal comfort and daylighting aspects were provided in terms of dry bulb temperature, relative humidity and lux value, for different spaces in the health centres as per the need and usage, considering the medical requirements of the patients, work staff and vaccine storage and standardised as per climate zones and microclimate parameters.

Model Sub-Centre sub-centre building in Keba, Arunachal Pradesh

Layout of the health centre was modified for comfort, natural ventilation and daylighting. This was done by suggesting appropriate orientation of building volume, position and size of the window considering the sun path analysis to avoid solar heat gain. The spatial design was modified to enhance the ease of use of the space and productivity.

A Material Matrix was suggested encouraging use of sustainable and efficient composition of local materials and construction technology for low thermal conductivity, depending on the geography and climate with best possible sources for procurement and maintenance.

Energy efficient equipments and appliances were also introduce to reduce consumption of energy and hence reduce the system design for complete off-grid efficient health centres.



Left: Layout of a sub- centre
Above: Energy efficient baby warmers and vaccine storage

IMPACT & OUTCOMES

Improved thermal comfort environment for both patients and health centre staff.

Improved productivity of health centre staff due to effective use of space.

Reduced dependency on energy for active cooling to maintain the required thermal comfort within the health centre as per the requirement of different spaces.

Influencing the national policy guidelines will help implement energy efficient construction technology at Pan India level.

Going forward, Capacity building for government engineers on certification of energy efficient health centres by conducting workshops at state level and district level will be carried out. As well as capacity building for healthcare providers and workers on energy auditing.

Procurement guidelines will be developed for efficient appliances and building construction tender process

Cold Chain

● All Climates

	Sub-Zero or Negative Temperatures				
	Positive Temperatures				
	Active Technologies				Passive
	Air Conditioning: PCM or Ice Based	Freezer and Refrigerators	Vaccine Refrigerators (ILR)	Vaccine Carrier	Carriers (Heat Infiltration)
Housing					
Kitchens		●			
Livelihoods					
Animal Husbandry	●	●	●	●	●
Retail		●			
Silk Worm Rearing	●				
Agricultural Storage	●				
Education					
Kitchens		●			
Health					
Medicine Store		●	●	●	●

Case Studies

VI. Unlocking financing for On-Farm Cooling Needs

Raygada, Odisha

ACTIVE COOLING, COLD CHAIN, INCLUSIVE FINANCE, LIVELIHOODS

CONTEXT

Rayagada district is situated in the southern part of Odisha. Bissamcuttack is one of the administrative blocks in Rayagada district where agriculture is the primary source of income. Harsha Trust an NGO in Odisha works toward improving the quality of life of people through production and productivity enhancement. They worked with farmers of Bissamcuttack at the grass root level by familiarising them with modern techniques for practice of agriculture with a focus on intensive vegetable cultivation in order to double the income of the farmers. After this intervention, bulk quantity of vegetables were harvested at the same time. Market price of such products came down because of the low local demand and high volume of supply.

Majority of farmers in this area prefer to sell their products to middlemen instead of retail sales who controlled selling and buying prices. Thus farmers were negatively affected. Other factors affecting market were vendors of nearby villages selling at lower prices.

Typical farm collection and storage systems, creating waste at all levels of the supply chain.

Availability of all vegetables in every season was also not possible because of non-feasibility in producing crops round the year in this area.

Storing and selling of vegetables were commercially not feasible because of non-availability of cold storage in Bissamcuttack area.

Traditional method of storing for highly perishable commodities like vegetables is not suitable.

Farmers started selling their vegetables to farther markets because of comparatively lower prices in the local markets. However, sending vegetables to large markets of cities during the peak production time was a challenging task for the local farmers.

TECHNOLOGY & OWNERSHIP

Setting up a cold storage unit

To fulfil the market demand and maintaining the supply chain, a medium sized cooling chamber with range upto 4°C was needed where vegetables can be stored up to a period of one month without degradation of its quality.

Management by a Farmer Producer Organisation

For marketing of Agri produces, a Farmers Producer Organisation naming Markama Agri Producer company Limited (MAPCL) was promoted by Harsha Trust. The objective of the company is to bring farmers closer to the market and providing better price and value for their money against fluctuation and competitiveness in the market.

Lease models and soft loans

The FPO consisting of 400 farmer members leased the cold storage solution along with mobile app costing INR 140,0000 from Ecozen Solutions. The 6 metric ton capacity solar cold storage solution could be used by the FPO for a year before making payments from profits earned and funds raised to fully own the technology and pay for managerial costs and expenses.

ALTERNATIVE MODELS

New models of financing and ownership are being innovated upon to increase access to more FPOs like Markama in Odisha.

For Eg. in Jharkhand, an FPO using a 35% capital subsidy will pay the delta amount via a bank loan, EMIs for which will be driven by earnings from the cold storage solution.

Currently three main channels for mobilising large community centric infrastructure have been identified and being piloted.

- NGOs or Philanthropic Grants
- Bank Loans with up from capital grants
- Government Livelihood Development Programs

Going forward, such proven models will be shared with key government functionaries like - National Agricultural Banks, Ministry of Rural Development, Ministry of Renewable Energy and so on, to enable large scale replication of community use infrastructure solutions

Case Studies

VII. Improved Cooling Tech Efficiency for Animal Healthcare Delivery (Poultry)

Raygada, Odisha

ACTIVE COOLING, COLD CHAIN, LIVELIHOODS

CONTEXT

Managing and maintaining proper herd size is a challenging task for the small and marginal families having limited income and resources. The kid mortality is a major problem for the small ruminants like goat and sheep which counts upto 70% in the normal condition and upto 90% in extreme conditions. Similar situation persists in poultry rearing as well in those areas. This type of kid mortality is exclusively due to lack of proper basic animal health care practices like vaccination and deworming. The proper vaccination and deworming can bring the kid mortality down to 20% by following the proper schedule. Managing proper cold chain, especially for vaccines is a challenge in the most remote pockets of South Odisha.

Harsha trust, an NGO, promotes livestock rearing activities with the landless families in a large scale which is managed by the Farmer Producer Companies in the most remote areas of South Odisha. As most of the farmers are small and marginal category, the source of income depends upon the livestock population (herd size) they have. In order to enhance their livelihoods in sustained manner, the optimal herd size needs to be maintained throughout the year.

Storage of vaccines at a centre run by the Farmer Producer Organisation

TECHNOLOGY

A cold storage solution was provided to improve the effectiveness of the animal cold chain for vaccine protection. The vaccine storage solution used is the same as the one described in case study VI.

Owner/Supported by: Farmer Producer Company promoted by Harsha Trust

Operator: Poultry Cooperative

User: Para-vets providing last mile vaccine services supported by the poultry co-operative.

Harsha Trust has producer companies which deploy service providers to provide a gamut of services to its members mainly around agriculture and livestock. Among the different services provided, livestock vaccination and deworming is an important service provided by these service providers. These vaccines are procured from producer companies or vendors and stored in solar operated vaccine chambers.

The producer companies have also built the capacity of the village level cadres on vaccination wherein each cadre covers 2-3 villages depending on distance of the village and livestock population therein. The cadre ensures vaccination of all the goats and poultry available in the village at a time. Each beneficiary pays Re 1 for deworming per poultry bird and Rs 2/- for vaccination of the birds. Similarly, for goats the prices are Rs 2/- for deworming and Rs 5/- for vaccination respectively. In case of bulk purchase the cost of deworming and vaccination for both poultry and goats is substantially reduced to Rs 0.50 and added to that is the service charge of Rs 0.50. This is a commission for storing and supplying the vaccines and medicines to the village level cadres.

This is a sustainable model where qualitative and reliable services are rendered at the door step of the beneficiary and also ensures livelihoods for both cadres and service providers.

Local Para-Vets providing vaccination services

IMPACT & OUTCOMES

Ensuring the cold chain to prevent chick mortality due to vaccination failure.

Fully off grid model to ensure zero vaccination damage due to uninterrupted power supply.

Increasing efficiency and wide coverage of vaccination due to storage facility.

Case Studies

VIII. Cooling Tech for Last Mile Healthcare Delivery

Jorhat, Assam

ACTIVE COOLING, COLD CHAIN, HEALTH CARE

CONTEXT

India has the largest number of births in the world accounting for more than 26 million a year and more than 20% of child mortality worldwide. 9 million immunisation sessions are organised each year to target these infants and 30 million routine immunisation (RI) for pregnant women. India still lacks a robust system to track vaccine-preventable diseases. Some of the challenges to immunisation include limited capacities of staff, particularly in poor-performing states and at the field level, and gaps in key areas such as predicting demand, logistics and cold chain management, which result in high wastage rates.

Assam, for example, has socio-economic indices as low as literacy rates edging to 19.31%, Maternal Mortality Rate 300 per 1,00,000 live births and Infant Mortality Rate 54 per 1000. The average income barely reaches Rs.6000. The conditions are further worsened by absolute lack of basic services of health, education and infrastructure reaching these island villages.

The state has chronically lacked enough medical facilities to reach out to these last mile villages. Most of the villages in char area do not have road connectivity and people depend on boats to reach the sub-centres or PHCs located in mainland. During emergencies, most of the island dwellers can' afford to travel by boat to the nearest health centres. The cost of hiring a boat is as high as Rs.1500 to Rs.2500. Inaccessible health services also prevent island dwellers to go for regular check-ups, immunisations etc hence complicating some of the avoidable cases.

One of the solutions to the above mentioned problems have been the concept of boat clinics by CNES: to bring basic healthcare services to the doorstep of these remote island populations. These boats are equipped with OPD, laboratories and pharmacies. There are now 15 boats, under the jurisdiction of CNES that have reached 13 districts (around 415 island villages) through a Public Private Partnership (PPP) with the National Health Mission (NHM), Government of Assam.

Boat Clinic service with Solar Power in Assam

In efforts to combat the above stated gaps, CNES in partnership with SELCO Foundation commissioned the first of its kind solar project in the area- Solar powering of Jorhat Boat Clinic. The boat reaches out to approx. 17000 people through 18-22 camps per month across 34 number of villages. The project took into consideration the need and utility hours of various energy efficient equipments - lights, fans, laboratory equipments, vaccine storage and audio-visual devices. An optimum solar system was designed keeping into consideration usage hours, criticality of the equipment and space available on the boat for the panels.

TECHNOLOGY

Mobile friendly solar vaccine storage

To be effective, vaccines and medicines need to be kept between 2-8°C at all times. But in many parts of the world, keeping medicines cool is often a real challenge. Frequent power cut issue or non availability of grid supply in most of the rural parts of India, could be the main reason. Cold chain is a system used for keeping and distributing vaccines in a condition that retains its ability to give protection against disease.

Godrej - GVC50DC- Solar direct drive vaccine refrigerator i.e. Sure Chill is an innovative cooling system which works via solar when off-grid and deliver the same reliable performance as the mains powered version. It doesn't need a battery to keep delivering that performance overnight or in low light conditions, and hence can be used for door to door vaccine delivery for larger distance and longer duration.

- Sure Chill doesn't rely on main electricity so loss or lack of power is simply not a problem
- Easy to install with Plug and Play solar panels
- Greater accuracy of temperature control with Grade-A freeze-free protection – Its cooling technology prevents freezing and keeps temperatures around 43°C, guaranteed never to freeze stored contents
- World Health Organization (WHO) approved by the WHO to provide active cooling without power, for over 12 days in an ambient climate of 43°C
- Battery free- Does not rely on batteries to store energy during periods of no power
- Digital display- Always visible easy to read temperature display
- Proven to work in the harshest environments- From Kenya to Columbia, this technology operates with mains or off-grid power sources and keeps vaccines at a perfectly safe temperature
- Low cost, energy efficient and planet friendly- Saving money, saving energy, saving the planet and saving lives, Sure Chill is efficient on every level
- Safe and secure - Latch locks are fitted for extra security

IMPACT & OUTCOMES

Economic Impacts

- Each boat will save around INR 3500 per month on kerosene. That is a total saving of INR 42,000 per boat year.

Better Diagnosis

- Availability of solar energy, has given them a flexibility of using laboratory equipment at any time of the day.
- More laboratory services can be added
- Patients can seek health services from the clinics even after dark especially in cases of emergencies

Reduction in vaccine spoilage

- Vaccines are now stored in DC powered SureChill vaccine refrigerators. This increases vaccine safety and reduces its spoilage.
- It saves time and man-days required to collect vaccines from the nearest Cold Chain Point (CCP).

Improved Work

- 18 increased numbers of hours of power availability
- Can use electronic services and luminaries on board for longer time.

Case Studies

IX. Refrigeration for Retail Stores and Small Businesses

ACTIVE COOLING, LIVELIHOODS, COLD CHAIN

CONTEXT

Increase in average temperatures in many parts of India and lack of reliable cooling solutions have resulted in the increase in relevance of decentralised refrigeration systems, especially in rural and semi-urban scenarios with lack of reliable power. This provides an enhanced livelihood opportunity for end users owning small retail stores, bakeries, canteens, and other smaller establishments present across these rural and semi-urban localities through the consistent demand for dairy value chain products, locally made drinks, chocolates & ice-creams, fresh meat and fish products, drinking water bottles and other cold products.

TECHNOLOGY

Appropriate refrigerators can be selected on the basis of the commodity to be stored (Water/Cold Drinks/Milk etc.), capacity of storage, cooling needs, autonomy and servicing needs. Refrigerators can then be selected based on the type of technology employed and existing power conditions - from DC powered, Direct drive with PCM technology or AC inverter based.

Refrigerators should be compact, affordable and energy-efficient in order to be viable for decentralised, small business owner's settings. Although the volume of the fridge majorly drives the price, size and usability of the system, the efficiency of the fridge which is in direct correlation with energy consumption and thus the price is greatly influenced by the insulation materials and better sealing at the doors.

FINANCIAL MODELS

Although there' a high demand for decentralised solar refrigerators, the lack of affordable financing - from awareness of available products in the financial institutions to push for financial innovation - has been one of the barriers for the solutions not scaling up. Considering the possibility of additional income that the small business micro-entrepreneurs can earn from the productive usage of the cold-storage solution, the pilot projects explored following possibilities in financing the decentralised refrigeration systems to different types of business owners.

TYPICAL LOAN PRODUCT

Total Cost:	50,000 to 5,00,000
Loan Terms:	12% interest for 36 months
Schemes:	MUDRA KISHORE/ CGTMSE

There exists a potential business case for solar refrigerators and thus visible socio-economic impact as more than 70% of entrepreneurs who were part of the study have seen a profit of more than Rs.4000 per month.

Monitoring, servicing support - Post installation support is a critical part for the intervention to have the desired impact. Access to easy servicing, annual maintenance support, and effective troubleshooting help the solution to sustain over the long-term.

Although the cost of solar + refrigerators varied from Rs. 70,000 to Rs. 1,45,000 for different typology of decentralized refrigeration solution, the entrepreneurs are comfortable in getting a loan (for fridges costing more than Rs.1,00,000) for an average of Rs. 90,000.
Around 50% of the cases, the entrepreneurs paid the remaining amount up front in cash and in other carefully considered cases, interest margin subsidies were provided to meet the cost. Hence the optimum spot that technology, financing and business models meet was found to be around Rs. 90,000 for 200-240 L fridges for (-)18degC cooling.