



Making Telangana a Cool State

State Wide Cool Roofs Program

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Draft for Discussion



Knowledge Partners

Administrative Staff College of India

Natural Resources Defense Council

International Institute for Information Technology, Hyderabad

Greater Hyderabad Municipal Corporation

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1. Introduction

In India, nearly half a billion people live in rapidly urbanizing cities, with skyrocketing development, that converts open space into paved, heat-trapping roofs and roads. These hot surfaces worsen the heat island effect, drive temperatures higher, and lead to poor air quality, with greater energy needed to keep cool with fans and air-conditioning. Cool roofs offer a simple and cost-effective solution to urbanization challenges. Cool roofs reflect sunlight and absorb less heat. Depending on the setting, cool roofs can help keep indoor temperatures lower by 2 to 5°C (3.6 - 9°F) as compared to traditional roofs.

Cities can lead the way in cool roof implementation. In 2017 and 2018, the cities of Ahmedabad and Hyderabad initiated pilot cool roof programs. These initial programs include citizen awareness campaigns, pilot initiatives targeting many roofs, cooperation with businesses, and applying cool roof techniques to government buildings and schools.

The Telangana Cool Roofs Program is a target-based program to increase the percentage of cool roofs in the state. Using three main strategies for different building types, the Cool Roofs Program focuses on yearly targets and implementation plans to increase installation of cool roofs across the city. The Telangana Cool Roofs Plan is a unique initiative building on the pioneering Telangana Energy Conservation Building Code (ECBC) to increase energy savings in buildings and contribute to reduction of the urban heat island effect.

II. Context

Cool roofs save energy, increase thermal comfort and reduce cooling demand in the long run. An important component of the building envelope having a direct impact on building's energy needs and ensuring thermal comfort to its occupants, is the roof. Cool roofs function primarily by reflecting more sunlight incident on the roof back to the atmosphere than a regular roof surface. Cool roofs are widely accepted internationally as an effective energy and money saving strategy that keeps cities cooler and reduces the urban heat island effect. Leading cities across the world have adopted cool roof programs.

Cool roofs work in the Indian context.¹ Leading studies have shown that cool roofs work to guard against increasingly warmer temperatures in Indian cities.² Cool roofs need limited maintenance, and a cool protective coating can be reapplied every 7-10 years and increase the longevity of the roof beneath it. This combined with the nearly 20% savings on air conditioning costs of the building make cool roofing very cost effective over the long run.³

In a country where less than 10% of households have air conditioning, access to affordable cooling can be a matter of survival for millions of people and not just comfort. Light-colored roofs have been used as traditional heat management techniques in India. Studies in Hyderabad and Ahmedabad have established that often the initial material costs are comparable with traditional roofing materials and can also be applied on existing buildings. Slum communities are one of the groups that are the most susceptible to extreme heat because of the lack of access to cooling and that slum housing is often made of heat-trapping materials such as tin sheets, cement sheet (asbestos), plastic and tarpaulin without sufficient ventilation. As living standards rise, the demand for cooling and air conditioning will rise dramatically, threatening to strain the country's electric grid, worsen air pollution, increase fuel imports, and magnify the impacts of global warming. Reduced air conditioning use is critical to saving energy, consumer costs, reducing emissions and reducing hydrofluorocarbons – the super-pollutant used as a refrigerant in many air conditions.

¹ Hashem Akbari, Tengfang Xu, Haider Taha, Craig Wray, Jayant Sathaye, Vishal Garg, Surekha Tetali, M. Hari Babu, and K. Niranjan Reddy, "Using Cool Roofs to Reduce Energy Use, Greenhouse Gas Emissions, and Urban Heat Island Effects: Findings from an India Experiment", Ernest Orlando Lawrence Berkeley National Laboratory, 2011 (accessed on 02 May 2017)

² ibid

³ Cool roofs for cool Delhi: a design manual, Bureau of Energy Efficiency.

The Municipal Administration and Urban Development (MAUD) department of Government of Telangana and the Greater Hyderabad Municipal Corporation (GHMC) piloted cool roof programs in 2016 and 2017. The two years of the pilots along with MAUD Steering Committee meeting provide the basis of the program. The evidence base for cool roof programs is further supported in *Cool Roofs, Protecting Local Communities and Saving Energy (2018)* and *Keeping It Cool: How Cool Roof Programs Protect People, Save Energy and Fight Climate Change*.

2. Objectives of the Cool Roofs Program

The state of Telangana situated on the centre-south stretch of the Indian peninsula on the high Deccan Plateau, is the 12th largest state, with a geographical area of 112,077 Km² and the 12th most populated state with nearly 35 million residents, as per the Census 2011. It is also the 8th largest economy in the country and is rapidly growing with an evolving hub for robust IT software, industry and services sector.

Within Telangana, Hyderabad, the state capital is the one the fastest growing cities of India. With a population of about 9.1 million (2011, Census), it is the sixth most populous urban agglomeration in India and ranked 1st in the top 10 cities out of the 30 top global short-term growth cities. The city is growing as a business destination and increasingly being identified as the next tech capital of the country. The city located in the hot and arid Deccan Plateau and also in wake of rising population, and fast expanding built-up area, is facing challenges of urbanization, with a growing urban heat island.

Hyderabad's 1,468 notified low-income communities house a population of over 1.9 million people. A majority of the houses within the cities of the state in low-income neighborhoods are constructed with concrete slab or asbestos roofs. As the state works to improve living and housing conditions in these neighborhoods, the use of cool roofs provide great opportunity to impact human health and comfort in the state and the city of Hyderabad. Particularly for low income communities, cool roofs provide increased thermal comfort, these also lead to improved productivity, as these homes are also places of work of large proportion of slum community.

The Telangana Cool Roofs Program aims to meet the following specific objectives:

1. Drive rapid state-wide adoption of cool roofs to save energy, strengthen heat resilience and increase thermal comfort.
2. Support inter-agency coordination to implement the city-wide cool roof program.
3. Identify financing frameworks and outreach and awareness building tools for implementing cool roofs
4. Support workforce development and training programs for cool roof application

Three main program areas that will help achieve these objectives:

- **Mandatory Program (government and commercial):** Mandatory cool roofing for all municipal, government-owned, and commercial buildings covered under the state building efficiency codes, for new and major upgrades.
- **Voluntary Program (residential):** Voluntary cool roofing for residential and smaller buildings for new and major upgrades.
- **Vulnerable Communities Program:** Cool roofing for all low-income housing related to the city's Heat Action Plan.

3. Mandatory Program: All municipal/government and large commercial buildings

A. Municipal/Government buildings (office, educational and healthcare)

With government spearheading the Telangana Cool City Program, it is important for all municipal and government office buildings and structures, new or existing, to adopt cool roofs. The key driver for municipal/government buildings is to spur adoption of cool roofs with the benefits of thermal comfort, energy savings and reduction of urban heat island affect.

Types of buildings: municipal buildings, government owned schools, hospitals and health care facilities.

Regulatory/policy tool: As an initial step, MAUD formally adopts the “Cool State Program” as a policy measure for the State of Telangana. In the long run to ensure adoption of cool roofs by municipal buildings MAUD could announce mandatory adoption of cool roofs in all new construction and retrofits of existing government buildings and incorporate cool roofs when buildings are undergoing roof maintenance. If a building is not due for maintenance within the next 3 years, MAUD could consider implementing cool roofs sooner as part of larger effort. Government of Telangana is also retrofitting 100 government buildings and could include mandatory application of cool roofs in these retrofits within the next year.

Proposed funding mechanism: Installation costs of cool roofs for municipal buildings will be part of existing government budgets for building construction, repair and maintenance, as well as part of retrofit measures.

Outreach and awareness measure:

- Internal government outreach programs highlighting the program and benefits including thermal comfort and energy savings from cool roofs
- Government meetings highlighting new program
- Media articles on new program

B. Commercial (including offices, retail complexes/shops, hotels, industrial, private education and healthcare)

Commercial buildings include those in government order 30 governing the Telangana Energy Conservation Building Code (TSECBC). This building type includes offices, such as IT companies, retail complexes/shops, malls, hotel, industrial buildings and private educational and healthcare. The key driver for adoption of cool roofs for commercial buildings is reducing cooling load and energy savings.

Regulatory/policy tool: The Government of Telangana notified the mandatory compliance to the TSECBC in 2014. The Telangana ECBC applies to any commercial building or building complex that has a plot area of 1,000 square meters or more or a built-up area of 2,000 square meters or more. The state also has an online platform for building applications, the Development Permission Management System (DPMS). The online DPMS integrates the TSECBC requirements into the online process for building permits, making the ECBC mandatory for commercial building. In order to ensure adoption of cool roofs by the commercial building, the draft TSECBC 2017 includes mandatory adoption of cool roofs in new construction and any major upgrades as part of a formal government order, making it mandatory for any air-conditioned commercial building with a connected load of 100 Kw or more to install cool roofs.

Proposed funding mechanism: Installation costs of cool roofs for these building segments is included in the budget for building construction by the real estate developer or individual owner. For un-airconditioned private small hospitals and educational institutes a potential subsidy or full support can be provided by the government.

Outreach and awareness measure: Similar to the residential sector, for the commercial sector as well it is proposed that nodal agency of the cool city program (MAUD) along with city municipal

corporations such as Greater Hyderabad Municipal Corporation (GHMC) and Hyderabad Metropolitan Development Authority (HMDA) undertakes outreach and awareness building programs (listed below). These programs could be designed by technical partners of the cool state program. Such programs could be undertaken along with real estate associations such as CREDAI-Telangana Chapter, Association of Architects, Resident Welfare Associations.

- Awareness program with local resident welfare associations
- Presenting the program at trade shows and conferences
- Website and social media to support the program
- Distributing flyers and posters to spread the work
- Ad through bill boards across the city
- Awareness generation through focused events on low cost installation of cool roofs for building owners
- Preparation of a how-to manual on installing cool roofs
- Engage volunteers from companies to coat rooftops.

4. Voluntary Program (residential): cool roofing for all residential buildings

The residential and smaller commercial building segment includes multi-level apartment complexes individual houses and any other building not covered by the government and commercial building mandatory program. The key driver for this segment of the population staying in these buildings in addition to the thermal comfort would be the cooling load reduction and resulting energy savings.

Regulatory/policy tool: for this segment of building type, the adoption of cool roofs would be voluntary but facilitated by periodic outreach and awareness measures on cool roofs, led by city municipal corporations such as GHMC and HMDA.

Proposed funding mechanism: Installation costs of cool roofs for these building segments is part of the total building development costs or upgrade by property developer or individual house owner. To encourage the home owner for installation of cool roofs, city municipal corporations could have focused educational programs on benefits of cool roofs.

Outreach and awareness measure: A nodal agency of the cool city program (MAUD) along with city municipal corporations such as GHMC and HMDA undertake outreach and awareness building programs. These programs could be designed by technical partners of the cool city program. Such programs could be undertaken along with real estate associations such as CREDAI-Telangana Chapter, Association of Architects, Resident Welfare Associations.

- Awareness program with local resident welfare associations
- Presenting the program at trade shows and conferences
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- Ad through bill boards across the city
- Awareness generation through focused events on low cost installation of cool roofs for building owners

5. Vulnerable Communities Program: Cool roofing for all low-income housing related to the Telangana Heat Action Plan

In low-income communities, cool roofs keep temperatures lower and increase thermal comfort. In the long run, cool roofs for vulnerable communities also introduce the concept of cool roofs for existing buildings and potentially new buildings in the future, thus locking in energy savings and reducing the demand for cooling. conditions indoors. The driver for this segment of the population for cool roofs is increased thermal comfort and lower indoor temperatures. Also, since for a large proportion of these households, their homes are also their place of work, increased thermal comfort due to cool roofs, would also lead to enhanced productivity.

Regulatory/policy tool: in order to implement the cool roofs in low income households two mechanisms can be deployed.

- For government financed low income housing projects, government order by MAUD and executed by the Telangana State Housing Corporation Limited (TSHCL), mandating cool roofs in all new and existing government low cost housing is proposed. Government of Telangana is already in the process of constructing 20,000 low cost housing in which cool roofs can be incorporated to be implemented within the next 5 years, through a government order.
- For cool roofs implementation in low income households in slums, a program of implementation led by city municipal corporations such as Greater Hyderabad Municipal Corporation (GHMC) and Hyderabad Metropolitan Development Authority (HMDA), for the city of Hyderabad, through the Heat Action Plan is proposed.

Proposed funding mechanism: Implementation of cool roofs in government low cost housing for the poor (existing and major upgrades), is proposed to be funded by the government budget (TSHCL) and inclusion of cool roofs in their procurement criteria.

Implementation of cool roofs in houses in slums would need to be funded jointly through government budgets and Corporate Social Responsibility funds. Hyderabad’s Slum Free City Plan seeks to prioritize slums for development and provide them additional infrastructure and resources. The funds under the program could be used for installation of cool roofs in slums as well as through the Heat Action Plan funds.

Outreach and awareness measure: To ensure implementation of program in low income/slum area, the nodal agency, will be required to undertake awareness campaign on benefits of cool roofs, also highlighting the maintenance needs. This needs to be coupled with spreading the word on the program through advertisements through bill boards across the city.

6. Program Design by Building Type

Table 1: Cool City Program by Type of Building

Building Type	Regulatory/Policy tool	Recommended cool roof techniques for implementation	Options of Funding Mechanisms	Outreach and Awareness measures
1. Low income/slum areas	TSHCL GO on mandating cool roofs in government low income housing projects. Inclusion of cool roofs in construction of 20,000 low cost housing by the government Implementation under the heat action plan by GHMC	<ul style="list-style-type: none"> • Existing buildings- Recycled advertisement flex sheets/membranes/ cool coatings. • New construction- ceramic tiles and pre-coated corrugated metal and non- metal sheets. 	<ul style="list-style-type: none"> • Government budgets (heat action plan and slum free city plan) and inclusion of cool roofs material in their procurement criteria • CSR 	<ul style="list-style-type: none"> • Local slum level awareness campaign on benefits of cool roofs • Awareness program with local resident welfare associations • Presenting the program at trade shows and conferences • Website and social media to support the program • Distributing flyers and posters to spread the work.
2. Residential	Voluntary Awareness on benefits of cool roofs and encourage them to apply	<ul style="list-style-type: none"> • Existing buildings- Cool coatings/ tiles for new or major retrofit/ membranes • New construction- ceramic tiles 	Self-funded by developers of residential complexes	
3. Government (offices, educational and healthcare)	GO on mandating all government buildings to retrofit roofs with cool roofs and mandatory installation in new	<ul style="list-style-type: none"> • Existing buildings- Coatings • New construction- Cool tiles 	Government budgets	

	construction 100 government building retrofit to include cool roofs			<ul style="list-style-type: none"> • Ad through bill boards across the city • Awareness generation through focused events on low cost installation of cool roofs by building owners • Prepare how to manual on installing cool roofs on their own
4.Commercial (offices, retail complexes, hotels, industrial, private educational and healthcare)	Modified ECBC to include mandatory cool roofs in new construction and mandatory in existing buildings or a GO mandating any air-conditioned commercial building with a connected load of 100 Kw or more to install cool roofs.	<ul style="list-style-type: none"> • Existing buildings- High performance Coatings • New buildings-Cool tiles/ Sandwich tiles/ membranes/ insulation 	Self-funded For un-airconditioned private small hospitals and educational institutes a potential subsidy or full support can be provided by the government.	

7. Telangana Cool Roof Program Targets

The total area of Hyderabad is 650 sq. kms. Assuming the eligible roof area for cool roofing to be 15%, the targeted cool roofing area with the current size of the city would approximately be 100.3 sq.kms.

For the state of Telangana, taking a simplified assumption that the eligible roof area would be three times the city of Hyderabad, would imply a cool roof area of 300.3 sq.kms.

Table 2 below mentions the yearly target of cool roofs the current program aims to add till 2030.

Table 2: Annual Targets of Cool Roofs for Hyderabad and Telangana under the Telangana Cool State Program

Year	Hyderabad Cool roof area (sq.kms) targets	Telangana Cool roof area (sq.kms) targets
2019-20	0.1	0.1
2020-21	0.2	0.2
2021-22	0.3	1
2022-23	0.7	2
2023-24	1.7	5
2024-25	3.3	10
2025-26	6.7	20
2026-27	12.3	37
2027-28	25	75
2028-29	50	150
2029-30	100.3	300.3

Source: market survey by IIIT-Hyderabad

Hyderabad Year 1 Goal: 100,000 sq.m of cool roofs citywide (equivalent to 1,000 roofs)⁴

Hyderabad Year 5 Goal: 30,00,000 sq.m of cool roofs citywide (equivalent to 11,000 homes) and 100 government buildings in the state retrofitted including cool roofs

⁴ These numbers are calculated based on the target announced by Principal Secretary Arvind Kumar in September 2018.

Hyderabad Year 10 Goal: 100,30,000,000 sq.m of cool roofs citywide (equivalent to 11,000 homes), 20,000 low cost housing units across the city have cool roofs and 1000 commercial buildings

AND

Telangana Year 1 Goal: 100,000 sq.m of cool roofs in state (assuming its only Hyderabad)

Telangana Year 5 Goal: 83,00,000 sq.m of cool roofs citywide approx. equivalent

Telangana Year 10 goal: 300,30,000,000 sq.m (300.3 sq.kms) of cool roofs state wide

Detailed targets by building types for 2019: the program covers government office buildings, commercial buildings (such as IT buildings), educational institutions, government hospital buildings, residential housing societies/individual house and low-income housing.

For the start year of the city-wide program, the program aims to cover the following buildings to be cool roofed before the start of the summer season in 2019.

Table 3: Cool City Program Targets⁵ for the Summer of 2019- Hyderabad

Building type	Number of buildings	Total area (sq.mts)	Possible technologies	Rate/sq.m	Cost (Rs.)	Funding
Government offices	5	10000	Coating	200-400	20,00,000-40,00,000	Government
Government schools	10	3000	Coating	200-400	6,00,000-12,00,000	Government
Government hospitals	5	15000	Coating	200-400	30,00,000-60,00,000	Government
IT companies	5	15000	High performance coating	350-	52,50,000	IT companies
Low income/EWS housing	150 homes	7500	Coating- cool roof sheets	200	15,00,000	Government

The 2019 targets have been set with a focus of exemplifying the comfort provided by the cool roofs by targeting buildings such as in low income house, government schools and hospitals where the comfort provided by a cooler roof is more important. A realistic number of buildings have been proposed across the types. Commercial buildings in form of IT companies have been included to propel the commercial segment to implement the technology to be able to showcase the benefits, in form of better comfort and also energy savings.

8. Cool Roofing Material

The choice of an appropriate cool roof material in a particular context would be dependent on a range of factors, from existing roof material, life and maintenance, availability, cost, time needed for installation and availability of skilled labor. To help cater to a range of contexts, cool roofs techniques can be broadly divided into four categories and building owners can choose from these techniques as appropriate for implementing cool roofs.

⁵ The numbers are calculated based on market survey of building area in Hyderabad by IIIT-H. An indicative estimate of building area by the type of specific building is provided in Annexure II.

- *Coated cool roofs*: these roofs involve the coating of a material or paint with high reflectivity on top of a conventional roof material to increase the roof surface's SRI. These are liquid applied coatings made of simple materials such as lime wash, or an acrylic polymer or plastic technology and are usually white in color.
- *Membrane cool roofs*: these roofs involve using pre-fabricated materials such as membranes or sheeting to cover an existing roof in order to increase the roof surface's SRI. These types of roofs can be polyvinyl chloride (PVC) or bitumen-based.
- *Tiled cool roofs*: these roofs involve the application of high albedo, china mosaic tiles or shingles on top of an existing roof or to a new roof.
- *Special cool roof materials such as ModRoof*: these roofs, made of coconut husk and paper waste, have been installed in households around Gujarat and Delhi and can serve as an alternative to RCC roofs.
- *Green roofs*: green roofs make use of vegetation to help the roof absorb less solar energy by providing a thermal mass layer to reduce flow of heat into a building. Vegetation is especially useful in reflecting infrared radiation. Green roofs are also considered cool roofs, but due to higher costs and need for water, they are likely not a cost-effective solution for heat reduction in low-income communities in India.

9. Program Partners and Institutional Mechanism

For a collective impact to reduce the urban heat island effect, the cool roof program for the state is proposed to be implemented through a robust interagency coordination mechanism, replicated at the city level. The successful implementation of the program will require collective effort from different state and city level agencies as well as technical, research, NGOs, civil society organizations and private companies.

The Figure 1 below highlights key agencies proposed to be engaged in the cool city program.

The Program is proposed to be housed in the Municipal Administration and Urban Development Department (MAUD) of the state of Telangana with Hyderabad city level implementation being coordinated by GHMC and HMDA as the nodal agencies. Similarly, by other city level municipal corporations in the respective cities.

It is proposed the program design to be led and overseen by a Cool Roofs Oversight Committee. This committee could have same members as the current technical committee of the ECBC for Telangana chaired by the Principal Secretary MAUD and members from department of energy, roads and building, department of town and country planning, housing, GHMC, HMDA, as well as leading real estate developers and academic experts (ASCI, IIIT-H).

MAUD as the state nodal department for the program will lead the overall program implementation and oversee program progress. It will be responsible for mandating the cool roofs through government orders where required and allocate funds for implementation by building type.

The city level implementation will be led by the respective ULBs in the city. In case of Hyderabad, it is the GHMC and HDMA that will be the city implementation agency responsible for overall program coordination and implementation. The city implementation agency will also mobilize funds required for example implementation of cool roofs in low income housing and slums through the heat action plans. ULBs will also coordinate and conduct the meetings of the oversight committee and undertake program review and impact evaluation. It will submit periodic program implementation reports to MAUD and oversight committee.

The ULB will also coordinate with its publicity department to undertake outreach and communication activities for the cool roofs program with the help of program technical partners (ASCI, IIIT, NRDC etc). the technical partners will also support the ULBs in overall program implementation where

required such as identifying technical criteria, drafting GOs, developing training and communication material etc. ULBs will also seek support from community partners such as the local RWAs, NGOs and civil society organization for undertaking awareness building campaigns and mobilizing participation. In addition, the ULBs will also coordinate with other city departments for implementation of aspects related to the program. The technical partners will also support the ULBs in identifying and defining the role of other city departments for program implementation.

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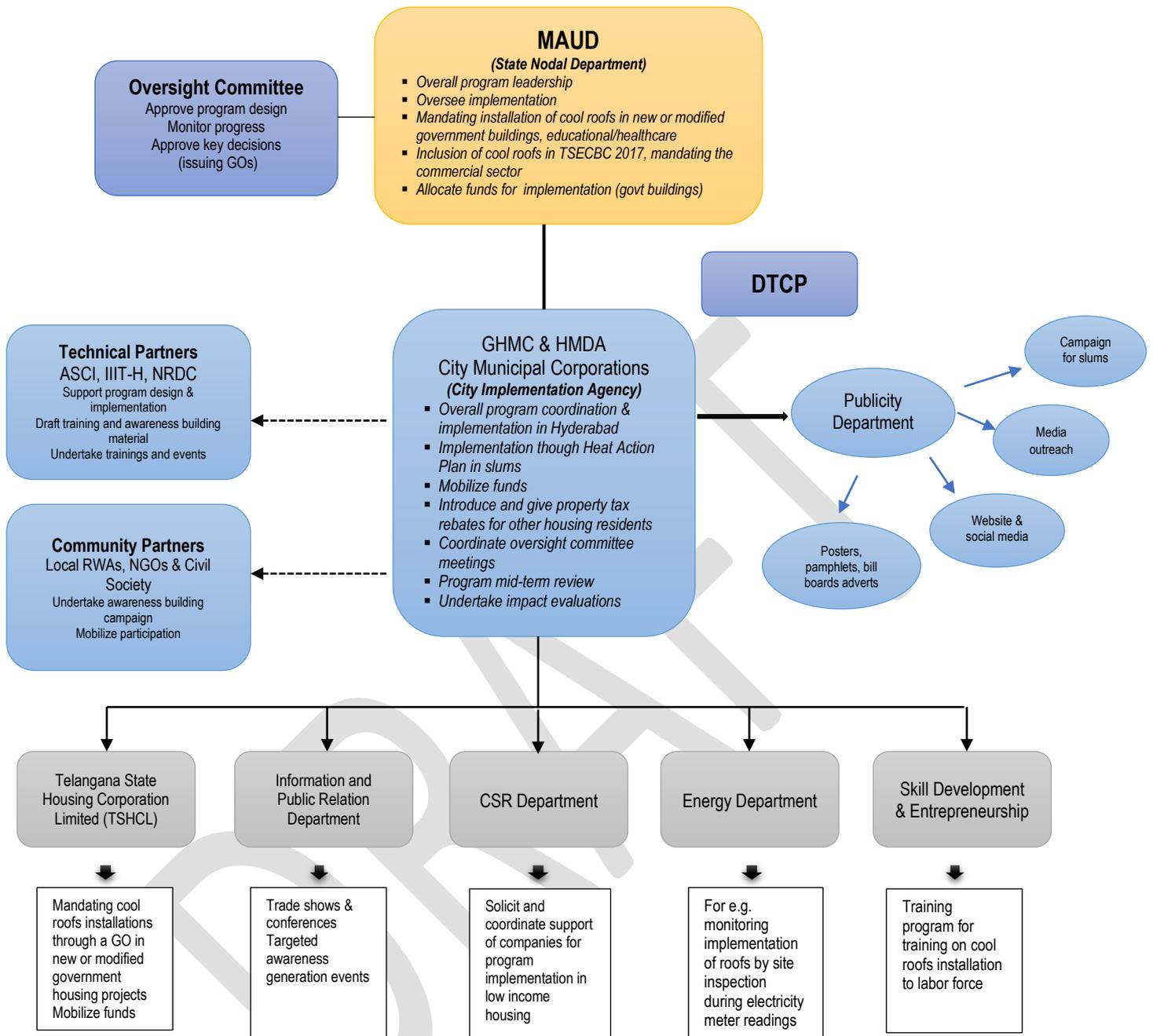


Figure 1: Proposed Agencies for Implementation of the Cool State Program-Telangana

10. Implementation Plan

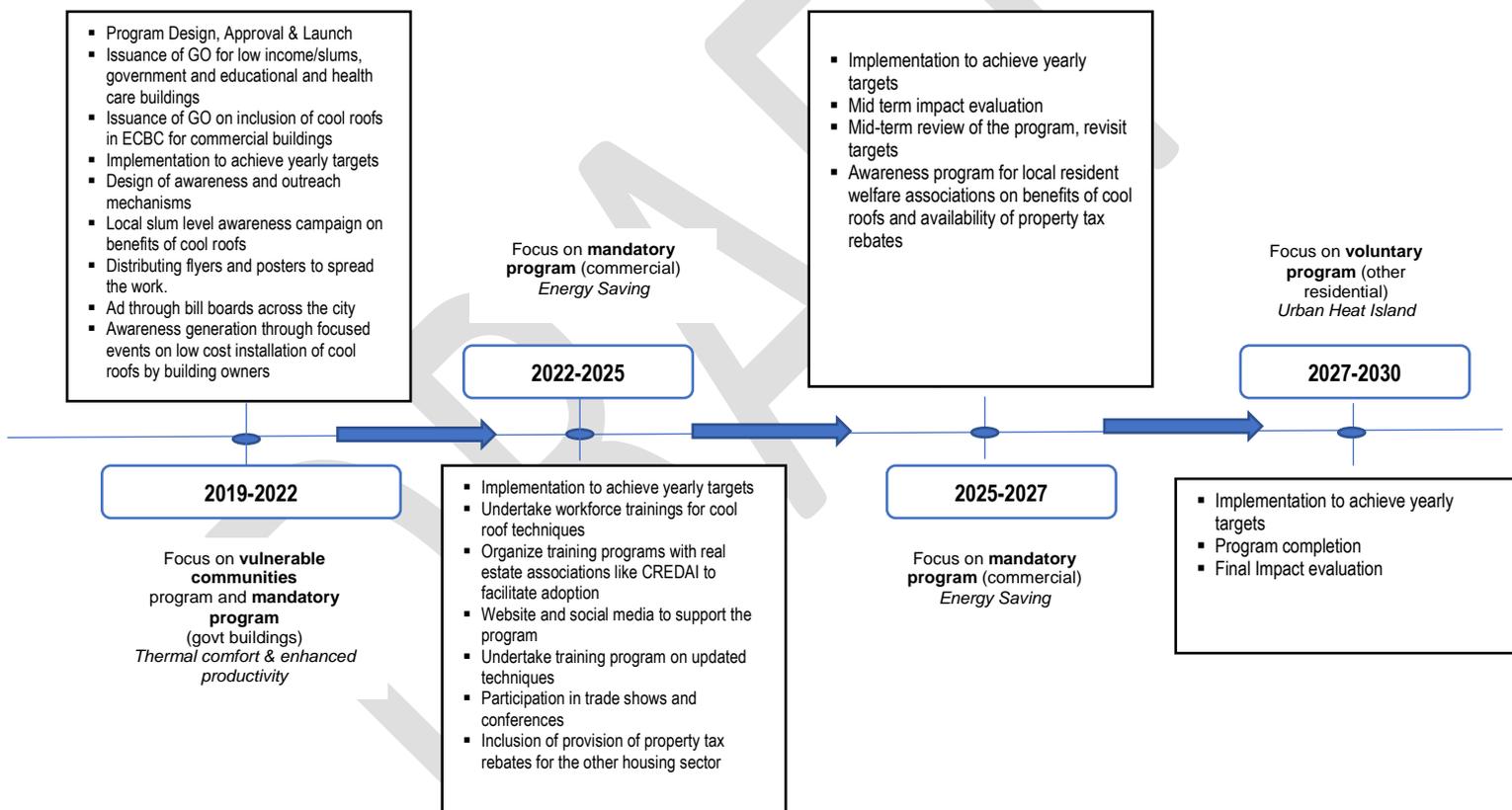
The program is proposed to be implemented over a period of 10 years until 2029-2030 with a target of 300.3 sq. kms of roofs to be cool roofed by 2030. It is also proposed to be implemented in a phased manner, guided by the type of desired impact. As highlighted in section 5 that the key driver of adoption of cool roofs would vary by the type of building targeted, a phase wise implementation would enable plugging in these drivers to achieve the desired overall targets of the program.

It is expected that the residential segment comprising of individual houses and multi-level residential complexes will be last to come up having seen the implementation and results achieved of the cool roof

technology in the earlier years, this segment is therefore proposed to be focus of the latter part of the implementation plan.

The implementation progression is expected to proceed from focus on improved comfort in the initial phase by focusing on low income/slum houses, government building and educational and healthcare buildings in the initial years (program 1 and 3) (2019-2022). When some level of success and results of the program have been showcased in the initial phase, along with rigorous outreach and awareness measures, the commercial sector could be the focus of implementation in the next couple of years (2022-2025) (program 1) driven by energy saving potential of cool roofs. Within the commercial sector while mandating the cool roof installation through the ECBC code would ensure adoption in new construction, the existing commercial building sector would come by at later stages (2025-2027). By this time, it is expected that the other housing sector (program 2) through the impacts achieved in the earlier stages and implementation of the enabling measures in form outreach and awareness building would come by (2027-2030), this will move the city to the reduction in the urban heat island effect.

Figure 2: Proposed Implementation Plan



Annexure I

NRDC, ASCI and IIIT-H along with IIPHG and IMT have developed a set of cool roof resources that contain detailed information about how cool roofs work, their benefits and the different programs around the world focused on cool roofs. A short summary is provided below, and the detailed reports can be accessed at:

- Keeping it Cool: Models to Develop City Cool Roof Programs in India
(https://assets.nrdc.org/sites/default/files/fs_-_keeping_it_cool_-_hyd_workshop.pdf?_ga=2.115450566.1325593029.1547750664-43125282.1547750664)
- Cool Roofs: Protecting Local Communities and Saving Energy
(https://assets.nrdc.org/sites/default/files/ib_-_cool_roofs_-_hyd_workshop.pdf?_ga=2.111913028.1325593029.1547750664-43125282.1547750664)

A. Cost Estimates of Cool Roof Implementation

Costs as per material type

Costs associated with some of the cool roofing material have been estimated by few studies. These numbers are included below:

Table 1: Approximate Estimates of Cool Roofs Material

S.No	Material	Cost per sq.ft (in rupees)
1	Lime wash	1.5 plus labour costs for two coats (needs to be re-applied every 2 years)
2	Lime concrete	120 including labour costs
3	Heat reflective paint/ cool roof coating	Starting at 20-25; 35 for industrial grade plus labour costs
4	China mosaic tiles	Starting at 25; discarded or damaged tiles can be sourced at 10-12 plus labour costs
5	Heat resistant tiles	150 plus labour costs
6	Membranes (such as Tyvek)	Starting at 25 plus labour costs
7	ModRoof	260 plus labour costs
8	Hollow clay tiles + china mosaic tiles	172 including labour costs
9	Extruded polystyrene sheet	160 including labour costs

Source: Mahila Housing SEWA Trust, Taru Leading Edge, International Institute of Information Technology, NRDC-ASCI market research

Approximate payback in terms of energy savings, by material type

Table 2: Paybacks in terms of energy savings of cool roofs material

S.No	Material	Cost per sq.ft (in rupees)	Payback
1	Coatings	20-40	20-30 kWh/m ² /Year -2 years
2	Cool tiles	50-100	25-40 kWh/m ² /Year - 2 years
3	Membranes	20-55	20-30 kWh/m ² /Year -2.66 years

Source: IIIT-H market survey

Minimum requirements of the cool roofs

Any roofing material is eligible as long as it meets the requirements of the Telangana Energy Conservation Building Code (TSECBC) 2017. According to the ECBC- For qualifying as a cool roof, roofs with slopes less than 20° shall have an initial solar reflectance of no less than 0.70 and an initial emittance no less than 0.75. Solar reflectance shall be determined in accordance with ASTM E903-96 and emittance shall be determined in accordance with ASTM E408-71 (RA 1996).

The International Institute of Information Technology, Hyderabad has built a Cool Roof Calculator. To determine if a material meets the criteria, it can be tested in the calculator. More details can be found at the Cool Roofs Calculator <http://coolroof.cbs.iiit.ac.in/>.