HSLU Hochschule Luzern

Final Report

Horw, May 7, 2022

BEEP Review

Indo-Swiss Building Energy Efficiency Programme
(BEEP Phase III & BEEP RE)

Horw, May 7, 2022

BEEP Review – Final Report

Imprint

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Executive Summary

This document covers the review of the phase III of the Indo-Swiss Building Energy Efficiency Programme (BEEP) lasting from Oct 2017 to Dec 2022 and the additional component BEEP-RE initiated Dec 2018, supported by the Swiss Agency for Development and Cooperation (SDC) and being part of its Global Programme Climate Change and Environment (GPCCE). BEEP is implemented under a Memorandum of Understanding (MoU) between the Ministry of Power, Government of India, and the Swiss Federal Department of Foreign Affairs (FDFA). BEEP-RE was launched to broaden the work done by BEEP and is implemented by a different consortium, although the project teams do collaborate closely. The goal of the review is to evaluate, if the programme has achieved or is on track for achieving the objectives that were defined, and to evaluate the relevance, impact, coherence, effectiveness, efficiency, and sustainability of both programme components.

Based on the analysis of the documentation available and on the interactions performed by the review team in Switzerland and India, the achievements of the programme at its current state are assessed in this report.

The Phase III of BEEP main component builds on the work carried out in the earlier phases. There were significant achievements from all the outcomes. The achievements for each outcome are listed below.

Outcome 1 (Building Design) - A critical mass of Indian building sector professionals adopts energy-efficient and thermally comfortable (EETC) building design as Standard practice: Some 700 professionals (builders / developers / officials[1]) received thorough training on EETC matters, some 200 students from 50 institutions attended BEEP-Camps and an online networking forum is established and frequently used for further developing ideas and networking purposes. Whether this number reaches the “critical mass” or rather sets a seed cannot be answered yet. Unfortunately, the pandemic caused some of the training and camps to be held virtually, which was less effective in terms of networking and contributing to that “critical mass”. The online survey will show whether the trainings have already led to incorporation of EETC in building design.

Outcome 2 (Building Technology) - External Movable Shading Systems (EMSYS) are established in the market in 1-2 urban clusters in India: The scientific and systematic approach elaborated in the current phase has not penetrated the community of builders / developers / building designers. Furthermore, it was not possible to convince Indian producers of EMSYS to promote the importance of shading windows.

Outcome 3 (Building Policy) - Measures for Energy-Efficient and Thermally Comfortable (EETC) buildings are integrated in the regulatory frameworks at the national and state levels: A big leap forward was made with the development and approval of a building code for residential buildings (ECBC-R). BEE took ownership of it and will bring it into national parliament to include it into the next amendment of the Energy Conservation Act in one of the next sessions[2]. This will further promote the integration into state legislation. Also, Indian Cooling Action Plan strongly recommends applying the code. Some stakeholders (e.g. Indian Railways, MLDL) already voluntarily apply the code for their new buildings.

Outcome 4 (Outreach) - Knowledge on EETC buildings is effectively delivered to targeted stakeholder groups: The media coverage on energy efficiency in buildings allowed a big audience to take note that this focus must be pushed forward. This media coverage was promoted through the trainings delivered within the framework of BEEP. The participation in international conferences presenting result obtained by BEEP delivered the importance into the international community. The free availability of electronic tools (compliance tool and CFD-tool) further helped the promotion and implementation of EETC measures.

The development of both the CFD-tool and ECBC-R relied heavily on Swiss know-how.

[1] state and municipal Level

[2] https://m.economictimes.com/industry/energy/power/energy-conservation-norms-may-be-must-for-residential-buildings/articleshow/90943985.cms

The outcomes under the additional component (BEEP-RE) are assessed as follows:

Outcome 1 (Demonstration pilots) - Building Integrated Renewable Energy Technologies are demonstrated for scaling-up in India: After collecting all the aspects of numerous renewable energy techniques, it was possible to assist five pilots in implanting some of these (wind, photovoltaics, biogas generation). Unfortunately, the pandemic brought all the construction works to a stop, and the pilots were not erected as per review date.

Outcome 2 (Research and Monitoring Methods) - Research and Monitoring Methods to Measure the Performance of Systems are adopted by practitioners; and Outcome 3 (Dissemination) - Knowledge on performance monitoring methods is effectively delivered to targeted stakeholder groups: As no pilot has been finished up to now, the identified monitoring methods could not be verified and brought forward to practitioners nor delivered to targeted stakeholder groups.

Overall Assessment

Relevance/coherence

There was no energy conservation building code for Indian residential buildings before the start on BEEP III project. Therefore, the relevance for such a code was high and confirmed by the interviewed government, state and municipal officials. The strategy and approach where holistic which included developing the code, tools for code checking, design guides, training, demonstration, design charettes etc. Al these were well appreciated by the stakeholders and were relevant and coherent. The code will be made mandatory soon once the Energy Conservation Act[2] is amended to include residential buildings also. This is relevant to GPCCE strategic components 2 (low-carbon development) and 3 (climate-resilient development) and their respective objectives. The BEEP team contributed to similar activities within the framework of IEA (speech at the training programme of IEA in Singapore).

Impact/effectiveness

Most of the project objectives have been reached for the BEEP main component and – because of building activities came to a complete halt during the lockdown – to a lesser extent for the BEEP RE component. The project teams managed to bring the relevant information and know-how to ministries, state agencies of three states (Andhra Pradesh, Gujarat, Rajasthan) and the community of builders / developers and academia. The delivery of an open-source CFD-tool for natural ventilation is new to that community. The project contributed to the policymaking by delivering ENS and the relevant training to officials, BEE took ownership and will introduce it into legislation[2]. Both the CFD-tool and the development of ENS heavily leverages the Swiss know-how. More effort will be needed to bring the legislation to the states and the authorities, who are issuing the building permits.

Efficiency of strategy

Most of the recommendations of the BEEP II review were implemented. Work done on insulation in BEEP II was not effectively carried forward in BEEP III. The project team has been efficient in fund utilization and continues the project in the no-cost extension. The COVID lockdown must have also impacted the finances as the project is still moving towards meeting all the original targets. Overall management and dissemination have been very good, especially in the EE component. The synergy between the two projects was very visible in the MLDL project, however, there is still scope for further integration and joint efforts in improving the building designs and including RE as tightly integrated part of the building design. See chapter 5 for recommendations for the remaining period of BEEP.

Sustainability

Sustainability is the key aspect of this project. There are lot of assets the project has generated (digital: CFD-tool, ENS compliance tool, ENS base model, RE selection tool and training materials [videos etc.]; Physical: books, leaflets, handouts) and there is a need for a robust plan for maintaining and further developing these assets. Previous experiences in other similar projects have shown that without proper plan in place before end of the project, there is a high likelihood that the assets will be lost in a short time.

There seems to be a possibility that BEE will engage a small team with IT and domain expertise and take over all these assets. It is highly recommended that these assets be transferred to a responsible team (before end of the project) to ensure their availability and continuity.

Some of the proposed EE and RE solutions are not yet matured and would need sustained efforts to make them mainstream. There is a need for more projects like the demonstration projects, which are focused, well planned, and well executed. There are several areas in the building space cooling sector, where interventions can be made. More details on the possible future activities are given in chapter 6. The biggest game changer will be the passing of the amendment of Energy Conservation Act including residential sector in it. This will spurt the growth of EE and RE in residential sector and intense dissemination and capacity building at that time will have a huge impact and will leverage the foundational work done in all the BEEP projects so far.

Recommendation for the remaining time of the programme

Concerning BEEP main component

- The training programme for younger professionals (BEEP camp) should be transferred into new hands (BEE has shown interest in ownership) or institution involved in teaching and training and be carried out once again in person.
- The survival of all the (electronic and physical) tools can only be guaranteed if a sustenance plan is found and implemented or if they are transferred to and managed in collaboration with an institution having the ability to maintain, make it evolve to new standards, practices, and requirements.
- Enhance the effort to establish EMSYS as a valuable component in energy demand reduction in buildings

Concerning BEEP RE component

- Extend project duration to finish demonstration/pilot projects (at least those which can be finished in a short duration), as they were slowed down because of the pandemic and only finished demonstrators will give good examples of RE integration
- Enhance outreach by promoting documents / tools developed in the BEEP RE component
- Bring the waste to biogas solution to other business sectors (as academic institutions, IT companies with own restaurants) with a broader dis-semination possibility

Suggestions for future work after the end of the programme

Four major areas of work to be considered for further activities have been identified. These areas are given below.

Reducing cooling demand and energy consumption in buildings and enabling the demand response possibility in the cooling component of building will be an important area of focus for the near future. This may include passive building features (cool surfaces, retro reflectors, locally developed thermal insulation specially for low-income housing, energy efficient designs for homes built by government), field evaluation of recent and innovative technologies, dynamic facades, smart homes etc.

Utilize Renewable energy: Distributed generation, storage and integration with buildings are potential areas for research and demonstration: building integrated and other new and innovative applications of Photovoltaics.

Explore Neighbourhood level: Interventions at neighbourhood levels might bring new opportunities and better scale: Mixed mode development, District cooling, Neighbourhood planning for better ventilation, shading and solar access to rooftop photovoltaics, thermal storage of cooling energy.

Enforcement/Dissemination: Eco Niwas Samhita (ENS) is expected to be made mandatory after incorporation of residential sector in the Energy Conservation Act. While regulatory framework might take some time, activities can be taken up with bottom-up approach and market pull can be created. In Switzerland there are several “codes” which are self-adopted by the industry and implement at a large scale. These learnings may be adopted in India. Collaborate with green building rating systems (GRIHA, IGBC) for mandating ENS. These can be a good market pull.

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Acronyms and abbreviations

AC	Air conditioning
AP	Andhra Pradesh
AP Govt	Andhra Pradesh state government
BASE	Basel Agency for Sustainable Energy: Swiss PMTU for the BEEP-RE component
BB	Bigbasket
BEE	Bureau of Energy Efficiency
BEEP	Indo-Swiss Building Energy Efficiency Programme
BEEP RE	Indo-Swiss Building Energy Efficiency Programme – Integration of Renewable Energy in Buildings in India
BEPS	Building Energy Performance Simulations
BHK	Bedroom-Hall-Kitchen[3]
BIPV	Building Integrated Photovoltaics
CEA	Central Electricity Authority
CFD	Computational Fluid Dynamics
CIBSE	Chartered Institution of Building Services Engineers
COP	Conference of the Parties
COP26	The 2021 United Nations Climate Change Conference in Glasgow
DAC	Development Assessment Criteria
DST	Department of Science and Technology, Government of India
EA	Engineering Assistant
ECBC	Energy Conservation Building Code
ECBC-R	Energy Conservation Building Code for residential buildings
EDS	Environmental Design Solutions (a consulting company)
EE	Energy Efficiency
EETC	Energy-efficient and thermally comfortable
EMSYS	External movable shading systems
ENS	Eco Niwas Samhita – Building code for residential buildings
EWS	Economically Weaker Section
GHG	Greenhouse Gases
GlobalABC	The Global Alliance for Buildings and Construction
GoI	Government of India
Govt	Government
GPCCE	Global Programme Climate Change and Environment of SDC
GPS	Green Power System Renewables (a consulting company)
GRIHA	Green rating for integrated housing assessment
GW	Gigawatt
ICAP	India Cooling Action Plan
IEA	International Energy Agency
IGBC	Indian Green Building Council
IIEC	International Institute for Energy Conservation: Indian PMTU for the BEEP-RE component
IIITH	International Institute of Information Technology Hyderabad
IIT	Indian Institute of Technology
IPCC	Intergovernmental Panel on Climate Change
JAC	Joint Apex Committee
JIG	Joint Implementation Group
KCAP	Kigali Cooling Efficiency Program
LFA	Logical Framework Approach
LIG	Low Income Group
LoC	Letter of Commitment
MLDL	Mahindra Lifespace Developers Ltd.
MoHUA	Ministry of Housing and Urban Affairs
MoP	Ministry of Power
MoU	Memorandum of Understanding
NGO	Non-governmental Organization
OECD	Organisation for Economic Cooperation and Development
PMTU	Project Management and Technical Units
PV	Photovoltaics
PSC	Project Steering Committee
RE	Renewable Energy
RESCO	Renewable Energy Service Company
SDC	Swiss Agency for Development and Cooperation
SE4All	Sustainable Energy for All
WEF	World Economic Forum

[3] 1BHK refers to 1 Bedroom, a hall, and a kitchen

1. Introduction

This review is expected to provide a critical independent view on how the SDC funded Building Energy Efficiency Programme (BEEP) is being implemented. A general overview about the BEEP is given in chapter 2 and the methodology used is presented in chapter 3. Chapter 4 “Evaluation” covers the review of the designated outcomes. The recommendations regarding the improvement of the project strategy for the remaining project phase (until Dec. 2022) follow in chapter 5. Suggestions for possible future work are given in Chapter 6. The annexes are bundled in chapter 7.

1.1. Evaluation objectives

The objective of the present external review is to

- assess the overall performance of the two project components for the ongoing last phase of the project BEEP (01.10.2017 – 31.12.2022) and BEEP RE (18.12.2018 – 31.12.2022). This means, provide a critical independent view on how the SDC funded Building Energy Efficiency programme has been implemented, how synergies have been exploited and to what extent the expected results have been achieved.
- make recommendations on how to best use the remaining time until the end of the project (planned December 2022) to achieve the expected results and/or make them sustainable.
- provide recommendations on how the results, experiences and knowledge in the BEEP project could feed into a potentially new initiative on cooling; provide an external view on whether elements related to cooling in the BEEP and BEEP RE project are relevant and innovative, whether there is a demand and further upscaling potential for them and if so, what the potential impacts could be in terms of low carbon development and climate change adaptation.

1.2. Scope of work

The review is based on the set of criteria prescribed by OECD/DAC: relevance, coherence, impact, effectiveness, efficiency, and sustainability in general. More specifically, the following key points and questions are considered in the assessment of the project’s achievements during the review. The review focuses on both the improvement itself and documentation of achievements. Based on these analyses it formulates recommendations for the remaining period of the project and the future orientation.

The questions below are answered in a summarized form in chapter 4.3 on page 24 of this report.

1.2.1. Relevance/Coherence

- How relevant are BEEP and BEEP RE to the Indian context and its challenges (incl. in terms of mitigating carbon emissions and meeting energy needs)? How do the different stakeholders at the national and state level see the relevance of these two components?
- How relevant are the strategy and approach followed under the two components of the project?
- How relevant is the BEEP/BEEP RE contribution to the GPCCE goals and objectives? Does it add to the coherence with or has it influenced other GPCCE Energy Efficiency projects elsewhere?
- How has the project contributed to global initiatives such as IEA, SE4All, GlobalABC, etc. with a link to the built environment

1.2.2. Impacts/effectiveness

- Have the project objectives of both components (BEEP and BEEP RE) been reached?
- Has the project managed to bring the expected impact on different stakeholders i.e., ministries (BEE, MoHUA, etc), state agencies, builders, developers, academic institutions etc.?
- What have been the pioneering contributions (innovations) of BEEP and the recommendations made on building energy efficiency and GHG mitigation? Are quantitative impacts figures available?
- Has the policy impact of the project been adequate? Has the project managed to contribute to policy (including various missions/initiatives/schemes/programmes) processes at national and state/city level? Is there still scope for further enhancements such as on India Cooling Action Plan, etc.?

- What has been the impact in terms of transfer of Swiss technical know-how from the project under both components of energy efficiency and renewable energy?
- What are potential recommendations to achieve the expected results until the end of the project and make them sustainable/scale them up?

1.2.3. Efficiency of Strategy

- Have the recommendations of the previous review (BEEP) been implemented?
- Has the project been efficient in using the provided SDC funds (cost-benefit ratio)?
- Has the overall management of the two project components been efficient?
- Has the implementation and dissemination strategy followed by the project under the EE and RE components been adequate - nationally as well as internationally?
- Have synergies between the BEEP and BEEP-RE components been exploited, and with what impacts? Can they be further improved?
- Are there any recommendations to increase the efficiency until the end of the project?

1.2.4. Sustainability

- Are the achieved results sustainable? Are the current strategy and partnerships sufficient to guarantee the sustainability of results?
- Should the project continue to focus on Swiss know-how transfer or rather on expanding with Indian stakeholders in the remaining period? What strategies does the project need to adopt to accelerate the dissemination of energy efficiency measures (e.g., ENS, CFD Tool) and renewable energy integration in buildings? Are the proposed solutions mature enough for the market?
- Do the results achieved under BEEP have the potential to replicate in other areas, such as cooling, of the built environment?
- How could a potential new project on cooling in the building sector, etc. build on and consolidate BEEP outcomes and would there be a demand for it? Who could be the key partners and initiatives?

2. Programme background

2.1. Overview

In India, the building sector has been experiencing an unprecedented growth. As per estimates, approximately 75% of the building stock, which India will see in the year 2047 is yet to be built. Demographic boom combined with the growing demand for thermal comfort and affordable cooling solutions are expected to exponentially increase the energy consumption in buildings. Currently, buildings in India (commercial as well as residential) account for 34% of the country's total electricity consumption. The projections indicate a 6 - 10 times increase in electricity demand in commercial buildings and a 4 - 10 times increase in residential buildings during the period 2012 to 2047. Various governmental schemes such as housing for all, smart cities mission and a massive private construction spree are some reasons for the construction boom in India. Buildings need to be constructed with better architectural design, use suitable building materials/technologies, and integrate renewable energy technologies to reduce environmental challenges and a massive increase in energy consumption and green- house gas emissions.

As India is rapidly adding to its building stock, a large scope exists for energy conservation by ensuring that the new buildings integrate energy efficiency measures and renewable energy technologies. To work towards this objective, the Government of India issued the Energy Conservation Building Codes (ECBC) in 2007 for commercial buildings with its revised version in 2017. Such codes have been adapted and declared mandatory in many but not yet all the Indian States. For the residential buildings, the Energy Conservation Building Codes for residential buildings (ECBC-R or Eco Niwas Samhita Part 1), developed with the support of SDC's BEEP project, was released in 2018. Additionally, there is also growing acceptance to make buildings shift from energy consumers to become energy generators by the integration of renewable energy technologies. In 2016 India had set a massive target to install 225 GW of renewables by 2022, out of which 40 GW is set aside for solar rooftops in the country. At COP26, Prime minister Modi had announced India's intent to achieve 500 GW of its installed capacity through non-fossil fuels and 50 % of its energy requirement from renewables by 2030[4]. India's current capacity (2021) is at just about 101 GW. The IPCC report addresses the importance of design, construction and operation of buildings and estimates that by adopting energy efficiency (EE) and renewable energy (RE) measures, there is potential for 50-90% energy savings in buildings globally.

Since 2011, the Swiss Agency for Development and Cooperation (SDC) has been supporting the "Indo-Swiss Building Energy Efficiency Project (BEEP)" in partnership with the Ministry of Power (MoP), Government of India, to reduce energy consumption in new commercial, residential, and public buildings. A Memorandum of Understanding (MoU) was signed between the Swiss and the Indian governments on 8th November 2011, and later extended to November 2021 and December 2022. The project has demonstrated the potential of 30-45% energy savings through the adoption of various energy efficiency measures. In the year 2018, SDC added a new component to this project with a focus on the "Integration of Renewable Energy in Buildings" (BEEP RE) to complement the BEEP project initiatives on energy efficiency[5].

2.2. Objectives of the project components

The project components have following targeted outcomes respectively (see also Project Log Frames and Project Documents – Annex A in chapter 7.1)

[4] https://economictimes.indiatimes.com/industry/renewables/2030-renewable-energy-target-panel-to-be-set-up-soon-for-mission-500gw/articleshow/88267104.cms

[5] BEEP RE is not covered by the MoU and is implemented by a different consortium.

2.2.1. BEEP Main component

Outcome 1 (Building Design): A critical mass[6] of Indian building sector professionals adopt Energy-Efficient and Thermally Comfortable (EETC) building design as standard practice.

Outcome 2 (Building Technology): External Movable Shading Systems (EMSYS) are established in the market in1-2 urban clusters in India.

Outcome 3 (Building Policy): Measures for Energy-Efficient and Thermally Comfortable (EETC) buildings are integrated in the regulatory frameworks at the national and subnational levels.

Outcome 4 (Outreach): Knowledge on EETC buildings is effectively delivered to targeted stakeholder groups.

2.2.2. BEEP RE component

Outcome 1 (Demonstration pilots): Building Integrated Renewable Energy Technologies are demonstrated for up-scaling in India

Outcome 2 (Research and Monitoring): Measure the Performance Systems are adopted practitioners

Outcome 3 (Dissemination): Knowledge on performance monitoring methods is effectively delivered to targeted stakeholder groups

[6] Critical Mass: Sufficient number of adopters of EETC building practices so that the rate of adoption becomes self-sustaining and EETC buildings becomes the norm in the future. This term is adapted from its definition in social dynamics and is originally borrowed from nuclear physics.

3. Methodology used

The review is a qualitative assessment based on four main parts: (a) a documentation review, (b) interaction with the main stakeholders and the implementation partners in Switzerland and India, (c) site visits., (d) Survey to assess the outreach.

3.1. Documentation review

The first part of the work offers insight into the project and the objectives. The relevant project documentation received from the SDC were analysed (see list of available documentation in Annex A). Special attention was paid to the review report of the Phase II.

3.2. Interaction with stakeholders and partners

To report about the project implementation and findings, semi-structured interviews were performed by the review team; most of them during the visit in India. The interview covered all stakeholder groups, be it engineers, architects, government officials, academia, builders, developers, implementing partners.

Table 1 gives the list of the persons interviewed with their respective link to the project and the site visits.

Table 1: List of interview Partners / site visits

Date	Place	Participants	Affiliation/organization	Role in the Project
March 11, 2022	Virtual	Ashok Lall	A.B. Lall Architects	JAC Member
March 16, 2022	Berne	Pierre Jaboyedoff	Effin'Art Sarl	Swiss PMTU
March 21, 2022	Delhi	Anand Shukla, Jonathan Demenge	SDC	Funder
	Delhi	Sameer Maithel, Saswati Chetia, Prashant Bhanware, Vernica Prakash	Greentech Ltd	Indian PMTU BEEP
	Gurugram	Sanjay Dube, Anant Joshi, Sonja Shukla	IIEC	Indian PMTU for BEEP-RE
	Virtual	Sanjay Seth	TERI	Chairman of GRIHA
March 22, 2022	Delhi	Vikash Ranjan	GIZ	International Agency Assessment
	Delhi	Saurabh Diddi	BEE	Government Agency
	Delhi	Apurva Chaturvedi	USAID	International Agency Assessment
March 23, 2022	Virtual	Dr. Udayraj	IIT Bhillai	Instructor at BEEP Camp
	Virtual	Rishabh Kasliwal	Kamal Cogent, Jaipur	Tech Support & ENS capacity building in Rajasthan
	Virtual	Shankar Sivan	Sun Edison	Technology provider for BEEP RE
March 24, 2022	Rajkot	Smart GHAR III	site visit	
	Virtual	Annu Ashval	Centre of Media Studies	Leader of Journalists Training Program
March 25, 2022	Ahmedabad	Rajan Rawal	CEPT University, CARBSE	Teacher at Student Camp / ENS development

Date	Place	Participants	Affiliation/organization	Role in the Project
March 26, 2022	Hyderabad	Rajkiran Bilolikar	Administrative Staff College of India (ASCI)	Co-Teacher in Training for Govt Staff AP
March 28, 2022	Vijayawada	Chandra Sekhara Reddy	AP State Energy Conservation Mission	ECBC & ENS implementation at AP state level
	Virtual	Ajay Jain	AP State Housing Construction Limited	Builder of Govt funded houses
March 29, 2022	Bengaluru	MLDL	site visit	
	Bengaluru	Sunita Purushottam	MLDL	Implementer of RE and BEEP design elements
	Bengaluru	Ram Bhat	Options & Solutions	Teacher at BEEP Camp
	Virtual	Tammay Thathagat	EDS	Consultant
March 30, 2022	Bengaluru	Bigbasket	site visit	
	Bengaluru	Ganapathi Subramanyam	Bigbasket	Implementer of RE design elements
	Bengaluru	Rajesh Ayyappasur	GPS	Consultant/ Technology provider
March 31, 2022	Delhi	Anand Shukla, Jonathan Demenge, André Mueller	SDC	Funder, Debriefing

3.3. Site Visits

The project review team visited four sites where BEEP/BEEP-RE teams have made interventions and supported projects to improve their energy performance. This section describes the four project sites.

3.3.1. Smart GHAR III, Rajkot, Gujarat

Smart GHAR III (Green Homes at Affordable Rate) is an affordable housing project in Rajkot under the Pradhan Mantri Awas Yojana (PMAY) Untenable Slum Redevelopment, funded by the state. Rajkot Municipal Corporation (RMC) is executing the project. The project has 11 residential towers with 1176 one-bedroom units, each with a 34 m² built-up area. BEEP team provided technical assistance to the project design team by conducting a design charrette in the early design phase. The BEEP team helped to choose aerated blocks for walls, to introduce reflective tiles on the roof, to redesign the windows and designed an interesting exhaust-fan-assisted ventilation system. The ventilation system was further enhanced by providing vents over the doors (the main entrance of the flat and internal doors) in each flat. The BEEP team provided support from the design to the construction stage of the project and monitored the ventilation system's performance.

3.3.2. YSR Jagananna Colony site at Ibrahimpatnam, Vijayawada, Andhra Pradesh

Andhra Pradesh state Government (AP Govt) has proposed constructing 3 million houses for Below Poverty Line (BPL) families across the state in two phases. As part of this scheme, 1800 plots of 5.2x6.1 m (roughly 32 m²) were allotted on the site at Ibrahimpatnam. AP Govt has provided subsidies to the beneficiaries to construct their houses on these plots. A default house plan was provided to beneficiaries; however, they are allowed to make any modifications within the designated plot area. AP Govt also provided an Engineering Assistant (EA) per 250 beneficiaries to assist them in constructing their homes and incorporating energy efficiency measures. The EAs have attended BEEP training programs. As a part of their work, they are expected to suggest the beneficiaries to use energy-efficient materials, incorporate more openings, implement cool roof solutions, and use energy efficient appliances (fans) to improve thermal conditions in the homes and to save energy.

3.3.3. MLDL Kanakpura, Bengaluru, Karnataka

This project is an under-construction housing project by Mahindra Lifespace Developers Ltd. (MLDL) with four high rises (more than 26 storeys) residential towers. There will be 527 units comprising 1 to 3.5 Bedroom-Hall-Kitchen (BHK). Besides the residential buildings, there is also a clubhouse which is currently being used as a sales and marketing office. In this project, both the BEEP and BEEP-RE teams provided joint technical assistance to the design team and the developer. They recommended EE and RE strategies (rooftop solar and rooftop wind). The site is under construction, and it will take several years for the project to complete.

3.3.4. Bigbasket Warehouse, Chokkahalli, Bengaluru, Karnataka

Bigbasket (BB) is a Bengaluru based online grocery delivery company with a large warehouse for vegetables and fruits in Bengaluru. This warehouse generates about eight tonnes of vegetable and fruits waste daily. The company currently pays to dispose of this waste. There are cold storages in the warehouse where fruits and vegetables are stored. BB buys cashew nuts shell waste, burns it, and operates vapour absorption chillers (VAM) to cool those cold storages. Though they are currently using waste to generate energy, they are spending money procuring this waste. The BEEP-RE team supported the project by designing a system that will replace the currently used burning material with biogas obtained by fermenting the organic waste and provides an opportunity to sell the residues of the fermentation to the farmers as a natural fertilizer. The biogas will be used to operate the existing VAMs. This also aligns with BBs thrive to circular economy.

3.4. Survey

A special focus shall address the scaling-up, scaling-out and the adaptation (see Figure 1 below).

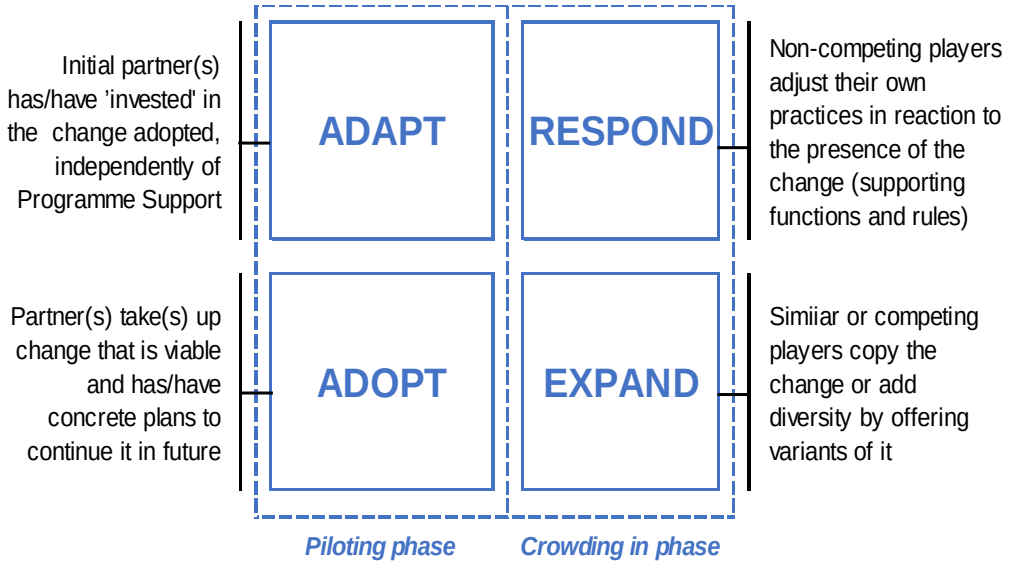

Figure 1: The Systemic Change Framework

To assess the scaling-out, scaling-up and the adaption, an on-line survey will be conducted under the guidance of Mr Saurabh Diddi (Director, BEE) with two groups of persons:

a) Persons having followed a training or workshop of the project and

b) persons with no contact to the project.

The questions to be asked are given in Annex D (chapter 7.4).

4. Evaluation

The subchapters below give a quantitative and qualitative assessment of the outcomes and outputs respectively. The tables giving the quantitate analysis against Logical Framework Approach (LFA) rely on the reports of the implementation partners (PMTU) and their respective progress. Colours in the column "Indicators" represent following achievement level:

Green – (over-)achieved, orange – nearly achieved, red – not (yet) achieved, black – not documented/activity not yet started

4.1. BEEP Phase III

The impact (overall goal) was given as[7]: "Energy consumption in new commercial, public and residential buildings is reduced through energy-efficient and thermally comfortable design. Thus reducing the energy consumption in new commercial, residential and public buildings by 25-40% compared to business-as-usual scenario and improving quality of life through reduced exposure to thermally uncomfortable hours."

The review team met a passionate and very involved PMTU team.

4.1.1. Outcome 1: Building Design

A critical mass of Indian building sector professionals adopts energy-efficient and thermally comfortable (EETC) building design as Standard practice.

Table 2: Indicators for Outputs related to Outcome 1 (Building Design) of the BEEP main component[7] and results achieved so far

Output	Indicators	Results
Competencies of selected developers for EETC building design are strengthened	a) Intense engagement with 20 - 30 builders on incorporating EETC and IDP methodology in their projects b) 0.5 mill m² through strategic charrette projects (8 charrettes) and 2.5 mil m² through indirect influence c) 250 (100 through charrettes + 150 through trainings) building professionals trained on the job in design and performance monitoring	a) Engagement with 20 developers[8] b) 8 million m² through strategic charrette (AP BLC scheme) and 1.23 million m² through other technical support[9] c) 700 professionals (90 through charrettes + 610 through training)[10]

[7] Source: BEEP-III_LFA_revised2020_final.pdf

[8] During 2020/2021 due to COVID restrictions, the process of in-person interactions of BEEP PMTU with developers/ organising charrettes was severely impacted

[9] technical support through energy simulation studies and provided to 10 developers for 1.03 million m² of built-up area & ENS compliance check and technical advice to 9 developers for 0.2 million m²

[10] 90 Professionals through charrettes/technical support session + 40 design professionals from MLDL and partners through a dedicated training programme + 570 engineers of AP Government through special training.

Output	Indicators	Results
National award on EETC buildings is established	a) 40 awardees during 4 years b) Increasing trend in the application	a) First cycle of the awards is still ongoing[11] b) 45 entries received in first cycle; trend will be known only after the second cycle
Case studies of EETC buildings are made available	a) Documentation of energy efficiency approach and strategies of the 30 awarded projects b) Documentation of energy efficiency approach, strategies, construction details and measured energy performance of up to 8 charrette projects	a) no documentation (see footnote 11) b) 2 Case studies with monitored performance available for Smart GHAR and Jupiter Hospital
Architecture and engineering education system is strengthened on EETC buildings	a) 20 architecture/engineering colleges offering courses based on the revised curricula b) 200 students (architecture & engineering) attending summer schools c) 60 number of faculty members are in the network d) A young multidisciplinary professionals' network is developed e) 10 master theses completed	a) Faculty members from 40 institutions trained on building heat transfer[12], 1 institution offered BEPS course b) Over 200 students from 50 institutions and organisations trained through BEEP Student Camp[13] d) An online BEEP Youth Forum with over 160 participants e) 8 master theses related to EETC building design at CEPT University and 2 masters students interned on CFD tool with the Swiss PMTU
A public-domain Computational Fluid Dynamics (CFD) based interface for natural Ventilation design is developed	a) Launch of the public domain CFD based design tool and interface for natural ventilation design b) Training of at least 20 professionals in the use of tool tailored to the need of natural ventilation design of large residential projects c) CFD design curricula in building design and building energy (for engineers)	a) Vayu Pravah - an opensource CFD tool developed and launched [14] b) Over 240 professionals trained with the tool

[11] NEERMAN awards are national awards of BEE. BEEP provided support to BEE to conceptualise and conduct 4 cycles of the award. However, the approval of the Award concept from BEE took a long time (around 2 years). The first cycle of the award could only be launched in 2021 and the activity is running behind schedule due to COVID-19 and slow decision making at BEE.

[12] Using the Book "Building Heat Transfer" (https://www.beepindia.org/wp-content/uploads/2021/12/Building-Heat-Transfer_Web.pdf) developed under BEEP

[13] BEEP Student Camp received the international CIBSE Award 2022

[14] Available under: https://www.beepindia.org/resources/

The document review, interviews and site visits revealed the following:

Positive aspects	negative aspects
o Training of engineers and faculty members o Publishing Building Heat Transfer book [12] o BEEP camps – highly appreciated o Vayu Pravah - an opensource CFD tool o Technical support to designers/developers o Design elements put into a housing pilot project at Rajkot and monitored	o Online BEEP camps (conducted online due to COVID-19) were not as effective as in-person camps o Thorough evaluation required for design effectiveness implement in various pilots, especially the Rajkot project o Insulation work done during BEEP Phase II not leveraged in Phase III

The site visit to Smart GHAR III, project at Rajkot, Gujarat revealed the following:

The efforts of the BEEP team are commendable. They provided long term support to the project by improving the design and monitoring the project. They could convince the design team to make changes even when the project was already contracted, and the budget was fixed. The approach to EE measures was scientific and reflected the combined strengths of the Indian and Swiss teams. By adopting the energy efficiency measures it is estimated to reduce peak summer room temperature by more than 5°C, as well as increase the number of comfortable hours (those below 30°C) from ~2600 hours to ~6300 hours. The team also published a scientific paper on this project. The project has received good visibility among policymakers and design professionals.

The site visit to YSR Jagananna Colony project at Ibrahimpatnam, Vijayawada, Andhra Pradesh revealed the following:

The efforts of the BEEP team in training several EAs and taking their help in communicating the energy-saving strategies to thousands of prospective homeowners are appreciated. There is a huge potential to improve thermal comfort and save energy in these homes. The proposed interventions (cold roof, larger openings, aerated blocks) are impactful and cost effective. The real impact will be observed when the EAs are able to influence the homeowners in incorporating these suggestions. By installing energy efficient fans, BEEP team estimates the savings to 400 kWh/y per household. If these measures are adopted on a large scale in the whole BPL scheme in AP, BEEP team expects to save 1200 GWh/y.

4.1.2. Outcome 2: Building Technology

External Movable Shading Systems (EMSYS) are established in the market in 1-2 urban clusters in India

Table 3: Indicators for outputs related to Outcome 2 (Building Technology) of the BEEP main component [7] and results achieved so far

Output	Indicators	Results
Innovative EMSYS products are developed either through incubation or self-supported; and the respective market is developed	a) 3 available EMSYS products are tested for performance in real buildings b) a network of at least 20 manufactures/ suppliers is developed	a) 2 available EMSYS products tested/monitored [15] b) Meetings held with around 15 EMSYS manufacturers and suppliers from India. Contacts established with the European Solar Shading Organisation.
Manual on EMSYS for builders is developed	a) Manual on selection, installation, operation & maintenance of EMSYS products is developed.	a) The manual is available[16]

The document review, interviews and site visits revealed following:

Positive aspects	negative aspects
o Testing of EMSYS – Scientific and systematic approach	o The importance of EMSYS seems not to have penetrated the community of builders / developers / building designers and the Indian community of producers of EMSYS are not able to promote their products efficiently.

[15] The work involved developing methodology, sourcing of instruments, conducting monitoring, analysis of data and writing of technical report. The monitoring report has resulted in a detailed technical report

[16] https://www.beepindia.org/wp-content/uploads/2021/12/EMSYS-Manual_Web.pdf

4.1.3. Outcome 3: Building Policy

Measures for Energy-Efficient and Thermally Comfortable (EETC) buildings are integrated in the regulatory frameworks at the national and state levels.

Table 4: Indicators for outputs related to Outcome 3 (Building Policy) of the BEEP main component[7] and results achieved so far

Outcome/Output	Indicators	Results
A national regulatory framework for EETC residential buildings is submitted to the GoI	a) Process for consideration of the proposed regulatory framework has been initiated	a) Eco-Niwas Samhita 2018 developed, approved, and launched by the government (MoP & BEE), BEE took ownership of it and will bring it into parliament for one of the next sessions[2]
A roadmap for mainstreaming EETC buildings is accepted in selected states; and building regulations at the state and city levels are strengthened regarding EETC	a) Roadmaps for EETC buildings framework are developed and accepted by at least 2 selected states b) EETC design features are integrated in the building byelaws of 4-8 cities in the selected states	a) Development of draft state specific ENS solution sets for Rajasthan & Gujarat[17] b) NA
Capacities at state and city levels are strengthened for roadmap implementation of EETC buildings	a) Concerned personnel in the state and city administration are trained in regulating and facilitating the implementation of EETC buildings. b) At least 40 third party assessors involved in the regulation implementation of buildings are trained for preparing and evaluating documentation for EETC regulations	a) 20 workshops on ENS conducted with participation from over 2000 professionals both at the national and state level.[18] b) 7 city level ENS orientation programs organised which were attended by 720 professionals including city level officials

The document review, interviews and site visits revealed:

Positive aspects	negative aspects
o Development and launch of ENS in a short span o ENS compliance tool for calculating RETV o ENS solution sets for states of Rajasthan and Gujarat o Revised Schedule of Rates with ENS inclusion for the state of Rajasthan o Engagement at different levels (national, state, city)	o EETC design features integration in the building byelaws of 4-8 cities not yet established

[17] The Energy Conservation Act (2001) does not yet cover residential buildings, making it difficult to include ENS into state legislation.

[18] Source: BEEP draft annual report 2021_v3.pdf

4.1.4. Outcome 4: Outreach

Knowledge on EETC buildings is effectively delivered to targeted stakeholder groups

Table 5: Indicators for outputs related to Outcome 4 (Outreach) of the BEEP main component [7] and results achieved so far

Outcome/Output	Indicators	Results
Media is oriented to report on EETC buildings	a) 30-40 media professionals oriented to write on building energy efficiency issues b) 5 fellowships awarded to journalists to publish articles on building energy efficiency c) At least 5 media reports / articles published	a) Over 120 media professionals and 30 media students oriented to write on building energy efficiency b) 12 fellowships awarded to media professionals and 6 media student awards c) Over 50 news stories published
Web based knowledge dissemination for developing market for EETC buildings	a) BEEP website is revamped and used for discussion and dissemination. b) Mobile app for design of EETC residential buildings (based on design guidelines of BEEP II) is developed.	a) The BEEP website was revamped. b) ENS compliance tool (for Windows) is developed and made available [19] - mobile app not yet available
Knowledge generated through BEEP is used to influence discussions and processes on cost-efficient building energy measures in hot climates globally	a) BEEP participates and plays a leading role in various international platforms b) Indian policy makers have increased awareness on EETC building policies in other countries c) An international conference is organised by BEEP near the end of the Phase III to highlight its achievements	a) e.g. several speeches at ENERGISE conference, presentation at WEF Davos b) BEEP provided a faculty member in the IEA training programme in Singapore

The document review, interviews and site visits revealed only positive aspects:

- Media engagement and fellowship to journalists
- Short videos, films (also translations to Gujarati and Telugu), YouTube channel (10000 views)
- Social media engagement (120 posts and 150000 views)
- Participation on national and international platforms (Participated as a panellist in the webinar 'Not Passing on Passive Cooling', organised by SE4ALL and the Cool Coalition in collaboration with KCEP and CEA)

[19] Under: https://www.beepindia.org/wp-content/uploads/2021/01/Eco-Niwas23-7-19.zip

4.2. BEEP RE

4.2.1. Outcome 1: Demonstration projects

Building Integrated Renewable Energy Technologies are demonstrated for scaling-up in India

Table 6: Indicators for outputs related to Outcome 1 of the BEEP RE component [20] and results achieved so far

Outcome/Output	Indicators	Results
Final Specifications for identified technologies to support the implementation	a) Identification of commercially viable technologies (2 – 3 appropriate technologies) b) Draft specifications for Integration of identified technologies in buildings/housing societies.	a) RE technologies for the pilots identified (PV, wind, biogas) b) specifications prepared, to be finalized
Develop business models to support the integration of RE technologies in buildings/housing societies	a) At least 2 business models to support the integration of RE technologies into buildings/housing societies	a) Business models finalized and documented for PV, wind and biogas
Commitments from technology providers, building/housing society management for Integration of RE at design stage	a) Engagement with technology providers b) Engagement with building/housing society management c) Engagement with other stakeholders including academia, research Institutes, RESCO's, etc..	Technical assistance to 5 pilots provided[21]
Support for internalization of RE integration process in buildings portfolio.	a) Guidelines for designing RE-ready buildings b) Vendor selection framework in line with the Company policy of the developer is developed c) Engagement with financing institutes for defining outline of appropriate Instruments	TOC for the guidelines prepared

[20] Source: LFA from Amendment 1 in combination with amendment 3

[21] Near-Zero Energy Strategy for MLDL Project at Kanakpura, Bengaluru; Utilisation of Organic Waste generated at the BB Warehouse to generate Biogas; PV and small wind proposed to Godrej City, Panvel, Mumbai; PV for Metro world mall, Gurugram Sector 56, Delhi; PV to Second Homes, Ratnagiri

The document review, interviews and site visits revealed:

Positive aspects	Negative aspects
o Guidebook on RE technologies o RE selection tool (currently in Excel sheet format) o Tip Sheets o Technology assistance to two projects on RE integration	o Tool not yet hosted in a browser-based format o Less outreach of the knowledge products

The site visit to the MLDL Kanakpura project at Bengaluru, Karnataka (see section 3.3.3) revealed:

As the project will be completed in a few years, the benefits of integrated rooftop wind turbines in India remain to be shown. The review team appreciate the efforts of the BEEP-RE team in making the recommendations to a prominent builder who accepted the recommendations, especially during the COVID 19 lock-down. However, it would have been helpful if the rooftop wind was demonstrated on an existing site. This would have helped pilot and monitor the technology within the BEEP-RE project duration and provided confidence to the developers. As the team has selected a large and high-end project, the demonstration has moved for several years. However, there are 3D models and marketing material in the on-site marketing office highlighting the net-zero building design and concept. This material would help disseminate the idea to prospective buyers expected to visit the marketing office in the next few years. The developer has also committed to further the cause of EE and RE in residential buildings through a detailed case study of the project and publishing a design guideline. While developers such as MLDL have sufficient in-house resources and access to technical consultants, the joint strength of BEEP and BEEP-RE was very well appreciated. The BEEP-RE team helped make a business plan, which convinced the leadership team at MLDL to incorporate the RE measures.

The site visit to the Bigbasket Warehouse project at Chokkahalli, Bengaluru, Karnataka (see section 3.3.4) revealed:

The BEEP-RE team provided a bio-methanation based solution to utilize the warehouse waste and use it to operate the existing VAM chillers for the cold storage. It is a good technical solution provided by the BEEP-RE team to BB. However, it is not clear why a big company with sufficient resources needed this technical support. BB has access to funds, already operates VAM on cashew waste, have knowledge of utilizing waste for bio-methanation and connect it to VAM. They also have access to professionals and vendors of similar technologies. The bio-methanation of waste is not a new technology; instead, India has been leading research and deployment for decades. This application of converting waste to energy in a warehouse may not be an innovative technology demonstration. However, there seems to be possibility of replication of this demonstration in other warehouses of BB and other similar companies. Also, the BEEP RE team made significant efforts in making business plans and convincing the BB team in implementing this measure. By selling the residues of the bio methanation process to the farmers as fertilizer another gap in circular economy approach can be closed, giving additional benefits both to BB and the farmers.

4.2.2. Outcome 2: Research and Monitoring Methods

Research and Monitoring Methods to Measure the Performance of Systems are adopted by practitioners

Table 7: Indicator for outputs related to outcome 2 of the BEEP RE component[20] and results achieved so far

Outcome/Output	Indicators	Results
Research and monitoring methods to measure the performance of identified RE technologies are developed, released, and distributed	a) Draft research and monitoring methods b) Consultation workshop to share and finalize the draft research and monitoring methods	Monitoring and verification methods developed

The document review, interviews and site visits revealed no positive, but following negative aspects:

- The submitted documents do not show detailed state-of-the-art monitoring and verification techniques

4.2.3. Outcome 3: Dissemination

Knowledge on performance monitoring methods is effectively delivered to targeted stakeholder groups

Table 8: Indicators for outputs related to outcome 3 of the BEEP RE component[20] and results achieved so far

Outcome/Output	Indicators	Results
Trainings/capacity building programs organized for adoption of research and monitoring methods	a) Number of training and capacity building programs for building sector practitioners b) Published training and capacity building material for professionals and practitioners	a) Two training workshops for design team of pilot projects completed, one training conducted in collaboration BEEP project under BEEP Camp. b) not visible
Communication and social media strategy for dissemination of project achievements	a) Communication strategy b) Knowledge dissemination through social media c) Participation at national and international forums and conferences	not visible

Outcome/Output	Indicators	Results
Knowledge transfer and capacity building of developer's teams	a) Self-paced e-leaming modules are delivered to developers b) Mobile or Web based app is functional for RE assessment after automation of the technology selection tool.	yet to start
Outreach	a) technical support to 1-2 architectural school for incorporation of RE- technologies in their curricula	yet to start
Technical support to state regulators	a) technical support to at least 2 state regulators (preferably the states where pilot buildings are located)	yet to start

The document review, interviews and site visits revealed no positive, but following negative aspects:

- The subject of the workshops was not on monitoring methods (and thus not in line with the outputs), but rather on integration of RE
- Strategy not (yet) visible

4.3. Overall Assessment

This section answers the questions raised in chapter 1.2. A more general assessment is given in Table 9 on page 25.

Relevance/coherence

There was no energy conservation building code for Indian residential buildings before the start on BEEP III project. Therefore, the relevance for such a code was high and confirmed by the interviewed government, state and municipal officials. The strategy and approach where holistic which included developing the code, tools for code checking, design guides, training, demonstration, design charettes etc. Al these were well appreciated by the stakeholders and were relevant and coherent. The code will be made mandatory soon once the Energy Conservation Act[2] is amended to include residential buildings also. This is relevant to GPCCE strategic components 2 (low-carbon development) and 3 (climate-resilient development) and their respective objectives. The BEEP team contributed to similar activities within the framework of IEA (speech at the training programme of IEA in Singapore).

Impact/effectiveness

Most of the project objectives have been reached for the BEEP main component and – because of building activities came to a complete halt during the lockdown – to a lesser extent for the BEEP RE component. The project teams managed to bring the relevant information and know-how to ministries, state agencies of three states (Andhra Pradesh, Gujarat, Rajasthan) and the community of builders / developers and academia. The delivery of an open-source CFD-tool for natural ventilation is new to that community. The project contributed to the policymaking by delivering ENS and the relevant training to officials, BEE took ownership and will introduce it into legislation[2]. Both the CFD-tool and the development of ENS heavily leverages the Swiss know-how. More effort will be needed to bring the legislation to the states and the authorities, who are issuing the building permits.

Efficiency of strategy

Most of the recommendations of the BEEP II review were implemented. Work done on insulation in BEEP II was not effectively carried forward in BEEP III. The project team has been efficient in fund utilization and continues the project in the no-cost extension. The COVID lockdown must have also impacted the finances as the project is still moving towards meeting all the original targets. Overall management and dissemination have been very good, especially in the EE component. The synergy between the two projects was very visible in the MLDL project, however, there is still scope for further integration and joint efforts in improving the building designs and including RE as tightly integrated part of the building design. See chapter 5 for recommendations for the remaining period of BEEP.

Sustainability

Sustainability is the key aspect of this project. There are lot of assets the project has generated (digital: CFD-tool, ENS compliance tool, ENS base model, RE selection tool and training materials [videos etc.]; Physical: books, leaflets, handouts) and there is a need for a robust plan for maintaining and further developing these assets. Previous experiences in other similar projects have shown that without proper plan in place before end of the project, there is a high likelihood that the assets will be lost in a short time. There seems to be a possibility that BEE will engage a small team with IT and domain expertise and take over all these assets. It is highly recommended that these assets be transferred to a responsible team (before end of the project) to ensure their availability and continuity.

Some of the proposed EE and RE solutions are not yet matured and would need sustained efforts to make them mainstream. There is a need for more projects like the demonstration projects, which are focused, well planned, and well executed. There are several areas in the building space cooling sector, where interventions can be made. More details on the possible future activities are given in chapter 6. The biggest game changer will be the passing of the amendment of Energy Conservation Act including residential sector in it. This will spurt the growth of EE and RE in residential sector and intense dissemination and capacity building at that time will have a huge impact and will leverage the foundational work done in all the BEEP projects so far.

Table 9: Assessment grid according SDC/OECD Rules

Key aspects based on DAC criteria	Score	Justification
Relevance Note: the assessment here captures the relevance of objectives and design *at the time of design* and *at time of evaluation*		
1. The extent to which the objectives of the intervention respond to the needs and priorities of the target group.	1 - highly satisfactory	All interviewed persons were highly positive
2. The extent to which the objectives of the intervention respond to the needs and priorities of indirectly affected stakeholders (not included in target group, e.g. government, civil society, etc.) in the country of the intervention.	1 - highly satisfactory	The regulatory framework, the knowledge of the building community was clearly brought forward

Key aspects based on DAC criteria	Score	Justification
3. The extent to which core design elements of the intervention (such as the theory of change, structure of the project components, choice of services and intervention partners) adequately reflect the needs and priorities of the target group.	1 - highly satisfactory	Trainings, tools, design interventions, code development, business models brought great benefits to the stakeholder groups
Coherence		
4. Internal coherence: the extent to which the intervention is compatible with other interventions of Swiss development cooperation in the same country and thematic field (consistency, complementarity, and synergies).	2 - satisfactory	The intervention by BEEP lies in line with other SDC funded interventions
5. External coherence: the extent to which the intervention is compatible with interventions of other actors in the country and thematic field (complementarity and synergies).	1 - highly satisfactory	GIZ, USAID funded programmes were complementary in nature and overall synergy in their objectives
Effectiveness		
6. The extent to which approaches/strategies during implementation are adequate to achieve the intended results.	1 - highly satisfactory	The knowledge was successfully transferred (see e.g. BEEP camp, Media outreach; MLDL to adapt RE strategy)
7. The extent to which the intervention achieved or is expected to achieve its intended objectives (outputs and outcomes).	2 - satisfactory	BEEP main component highly satisfactory, BEEP RE satisfactory
8. The extent to which the intervention achieved or is expected to achieve its intended results related to transversal themes.	2 - satisfactory	All interventions were supporting or neutral to the transversal themes
Efficiency		
9. The extent to which the intervention delivers the results (outputs, outcomes) cost-effectively.	2 - satisfactory	It is difficult to evaluate, as the pandemic slowed work down; nevertheless, most outputs were reached, and the teams continue to work in the no-cost extension
10. The extent to which the intervention delivers the results (outputs, outcome) in a timely manner (within the intended timeframe or reasonably adjusted timeframe).	1 - highly satisfactory	Most of the results comply with the adjusted timeframe, but the COVID-lockdown delayed results including building activities heavily
11. The extent to which management, monitoring and steering mechanisms support efficient implementation.	1 - highly satisfactory	Periodic meetings of the steering bodies and their feedback adjusted to the implementation

Key aspects based on DAC criteria	Score	Justification
Impact		
12. The extent to which the intervention generated or is expected to generate 'higher-level effects' as defined in the design document of the intervention. Note: when assessing this criterion, the primary focus is the intended 'higher-level effects'. In the event that *significant* unintended negative or positive effects can be discerned, they must be specified in the justification column, especially if they influence the score.	1 - highly satisfactory	One 'higher-level effect' will be reached, when the building code developed under BEEP enters national legislation.
Sustainability		
13. The extent to which partners are capable and motivated (technical capacity, ownership) to continue activities contributing to achieving the outcomes.	1 - highly satisfactory	BEE is willing take over ownership of ECBC, ENS and BEEP-camp, The private companies MLDL and BB strongly promotes Integration of renewables into their activities
14. The extent to which partners have the financial resources to continue activities contributing to achieving the outcomes.	1 - highly satisfactory	BEE hires extra personnel; MLDL adopted RE integration at management level
15. The extent to which contextual factors (e.g. legislation, politics, economic situation, social demands) is conducive to continuing activities leading to outcomes.	2 - satisfactory	ENS shall be adopted in legislation soon (-> highly satisfactory), pricing scheme of electricity (residential vs. commercial rates) hinders central EE installations (-> unsatisfactory)

5. Recommendations for the Remaining Period of the Project

The review team recommends the following items to be targeted in the remaining period of the project:

Concerning BEEP main component:

- Organize one more in-person BEEP camp, eventually in close collaboration with BEE, before handing over the concept to BEE (or another institution) to carry on with these successful trainings
- Develop a sustenance plan for all the (digital) assets developed in the BEEP project (CFD-Tool, RETV-tool etc.). How will they be kept alive, maintained, supported, and updated in the future?
- Continue work to promote EMSYS

Concerning the Rajkot project

- Conduct an independent third-party techno-commercial and user study for this project. Blocking more than half of each window to reduce solar heat gain may not be comfortable for the occupants from a visual access point of view. Similarly, providing vents on the main and bedroom doors might allow noise, dust, and insects to ingress. Further, the project team has observed that the benefit from the assisted ventilation system was limited as the site already has good wind availability, and the windows' opening could provide substantial ventilation. As the project has high visibility and may influence designs of other similar projects, a holistic performance evaluation must be done. This evaluation should identify aspects/features of project design that were effective and share the learnings.

Concerning the Vijayawada project

- Provide leaflets with details of EE measures in pictorial format and local language. These leaflets will help beneficiaries who may have difficulty understanding the technicalities of these measures.
- Provide QR codes on EE components on the site, which users can scan and see videos in the local language demonstrating the benefits of these measures. Since smartphones are commonly available, QR codes would provide easy access to videos. Children might find these videos informative, thus bringing the concept of EE to the next generation.
- Request the major/local material providers to periodically hold exhibitions on the site to demonstrate/explain the benefits of EE materials and provide lower rates on bulk purchases.
- Make a case study of homes that have implemented most of the recommended measures and show such houses to the beneficiaries.
- Consider the planning aspect of the project site and evaluate the possibility of providing better ventilation to homes. At this site, the plot size of individual homes is very small, and thus, it will be challenging to get sufficient cross-ventilation without sacrificing the carpet area. One such strategy could be the staggering of the plots.
- Look into incorporating low cost and locally manufactured insulation in these homes, especially on the roof. Since these homes have only one- or two-storey, the roof would play a significant role in heat gains.
- Review and improve the proposed apartments' design to be built by the government. This review could suggest a modified design to incorporate EE features without any increase in the cost of the apartment. The government will build these apartments and sell them at subsidized rates to the users. Apartments will provide better utilization of land and will give more space to the users.

Concerning BEEP RE:

- Extend project duration to finish demonstration projects, as they were slowed down because of the pandemic.
- Assess an existing building to demonstrate rooftop wind turbines, as this might be established earlier as a functioning demonstration project.
- Publish the documentations.
- Enhance outreach of the publicly available documents / tools.
- Bring the waste to biogas solution to other business sectors (as campuses [academic institutions, IT companies] with own restaurants) with a broader dis-semination possibility.

6. Outlook: Possible future work

This section discusses the potential areas of activity for SDC in India after the end of the current BEEP and BEEP RE projects. Four major areas of work to be considered for further activities have been identified. These areas are given below.

6.1. Reducing space cooling demand in buildings and enabling demand response

Reducing cooling demand and energy consumption in buildings and enabling the demand response possibility in the cooling component of building can be an important area of focus for the near future. Here are some technologies that can be pursued:

- Passive building features: cool surfaces (roofs and walls), vertical gardens, retro reflectors (for opaque surfaces and glass), locally developed thermal insulation specially for low-income housing (one of the recommendations given in BEEP II review for the future work was "Integrating insulation in building design, and use of thermal insulation practically" however, this element was missing in BEEP III, hence it is recommended again for the future activities), energy efficient designs for EWS and LIG homes built by government. Another possibility can be utilizing the earth berming[22] to keep the spaces cool. One extreme possibility can be underground buildings (such as shopping malls, offices) to reduce climatic impact[23].
- Interventions are required for training the designers and architect, developing easy to use tools for evaluating passive design features, pilot demonstration projects with field monitoring.
- Field evaluation of recent and innovative technologies (such as AC systems developed as part of Global Cooling Prize competition[24], whitest paint developed by Purdue university[25]). There are several innovations taking place around the world and some of them have a potential in the Indian context. Activities can span from laboratory testing, to piloting in real life scenario. Especial emphasis can be paid to the technologies which were winners of the Global Cooling Prize. These technologies have a potential to deliver cooling with over 5X lower climate impact
- Dynamic facades – Application of Electrochromic glazing, movable shades. Considerable work has been done on EMSYS in BEEP II and BEEP III. However, there are still no tecno-commercially viable solutions in the country and usage of EMSYS is negligible in India. We feel this area has high potential and more efforts can be put to explore newer solutions such as smart glazing. Though these solutions are very expensive they overcome several shortcomings of external movable systems which include maintenance of moving parts and direct exposure to hard climatic conditions. With large scale deployment there is a possibility of reduction in costs of smart glazing. Currently in Bangalore, world's largest installation electrochromic glazing project[26] is going on. It seems that the technology is entering the high-end buildings and can be evaluated.
- Smart homes – There is an emerging worldwide trend of Smart Energy Homes. This is triggered by advances made in the areas of IoT, AI/ML, wireless internet and cloud computing, thereby making the smart home components cheaper, faster and ubiquitous. There are several benefits of smart homes such as higher degree of comfort, energy savings and demand response. Even a basic energy feedback system with simple controls can lead to 10-20 % energy savings at homes and provide demand response possibilities. For smart grids to be effective it is imperative that the buildings and homes be also made smart. Wide range of activities can be done in this space of smart energy homes such as demonstration projects, policy development and implementation, capacity building, supporting start-ups, and standardization.

[22] https://www.new-learn.info/packages/clear/thermal/buildings/passive_system/earth_berming.html

[23] Extending Underground railway stations to shopping malls in Montreal, or - even more extreme: https://www.energy.gov/energysaver/efficient-earth-sheltered-homes

[24] https://globalcoolingprize.org/

[25] https://www.purdue.edu/newsroom/releases/2021/Q2/the-whitest-paint-is-here-and-its-the-coolest.-literally..html

[26] https://www.sageglass.com/en/article/worlds-largest-smart-glass-project

6.2. Renewable energy

India has a huge potential for utilizing renewable energy. Distributed generation, storage and integration with buildings are potential areas for research and demonstration. BEEP RE identified several technologies and made a few business models, however, the pilot projects had limited scope and visibility. There is a possibility of doing pilots with more technologies, business models, perform field measurements (which have not been done in BEEP – RE). Further, there are new technologies/applications that can be considered in this future activity such as

- BIPV, especially semi-transparent PV as window glass in high rise buildings.
- High performance PV can be used on walls and roofs as BIPV.
- New and innovative applications of RE which are land neutral

6.3. Neighbourhood level

Interventions at neighbourhood levels can bring new opportunities and better scale than at individual home level. Some of the possible areas that can be explored and promoted are:

- Mixed use development: Mixed-use is a kind of urban development, urban design, urban planning and/or a zoning type that blends multiple uses, such as residential, commercial, cultural, institutional, or entertainment, into one space, where those functions are to some degree physically and functionally integrated, and that provides pedestrian connections (Source: Wikipedia). Such kind of development can help in reducing travel related emissions and can also help in resource sharing. There are a very few such developments in the country. The future studies can do socio, techno-commercial evaluation of such developments and suggest possibilities.
- District cooling: District cooling at small scale (500-2000 flats) residential projects can be explored. It is observed, in a project at Hyderabad, that district cooling can reduce the installed cooling capacity by 85 %. Further, centralized chillers can be better managed, more efficient and reduce refrigerant leakage. There is a possibility of performing case study of such existing projects or new pilots can also be considered. A tool can be developed which can help designers estimate the requirements more accurately thus avoiding oversizing of the cooling system.
- Neighbourhood planning for better ventilation, shading and solar access to rooftop PV. This analysis can feed into byelaws and help buildings to have good access to natural ventilation and daylight, avoid urban heat island and maximise the potential for PV in the neighbourhood. These studies can be done through simulations. Part of cities which are close to such planning can be studied to see the benefits.
- Thermal storage might be a better option than battery-based storage as thermal storage is very low cost, good short term turnaround efficiency and negligible negative environmental impact. Thermal storage can be used for space cooling application. It has potential at neighbourhood level as it is difficult to implement at individual homes. The storage can be charged when RE is available (daytime in case of PV) and discharged when required, generally in night-time in case of residential applications. It can help in decarbonising the residential AC energy consumption and reducing the residential AC load specially during the evening peak.

6.4. Enforcement

ENS is expected to be made mandatory after incorporation of residential sector in the Energy Conservation Act. While regulatory framework might take some time, activities can be taken up with bottom-up approach and market pull can be created. In Switzerland there are several “codes” which are self-adopted by the industry and implement at a large scale. These learnings can be adopted in India too. One possibility is to collaborate with green building rating systems (GRIHA, IGBC) which can mandate ENS as minimum requirement. There is already a good existing market of voluntary green building rating systems in India, and it is further growing. Partnering with them will help accelerate implementation of ENS and will help in identifying the areas which can be strengthened in the next version of ENS.

7. ANNEXES

7.1. ANNEX A – Documents provided by SDC

	Document	File Name/Description	Remarks
BEEP main component			
1	Terms of Reference (ToR) Review of the Building Energy Efficiency Project (BEEP)	BEEP ToR Review	
2	Credit Proposal	Credit proposal BEEP 3	
3	Building Energy Efficiency Project (BEEP)	Factsheet BEEP	
4	Global Programme Climate Change India Strategy 2021-24	GPCC India Strategy 2021-2024	
5	Review Report Phase II	160701 BEEP Review final report.pdf	
6	Indo-Swiss Building Energy Efficiency Programme (BEEP) – Phase III	BEEP III_Project Document 2017 BEEP-III_LFA_revised2020_final	
7	Evaluation Policy Swiss Agency for Development and Cooperation	SDC's Evaluation Policy	
9	Progress reports	Annual report + Annexures 2017, 2018, 2019, 2020 Mid-Year Reports 2018, 2019, 2020, 2021	
10	Minutes of steering body meting	Joint Apex Committee (JAC) and Joint Implementation Group (JIG) Meetings: JAC 13 – JAC 15, JIG 21- 28	Handouts, Presentations, Images, Minutes
BEEP RE component			
11	Contract	SDC - BEEP Contract.pdf	w 3 Amendments
12	Progress reports	5 Semi-annual reports (March 2019, October 2019, April 2020, October 2020, March 2021)	each with financial statements
13	PSC Meetings	Presentations and Meeting Minutes of 5 Meetings (July 12019, Jan 2020, June 2020, Jan 2021, May 2021)	
14	Project Update Meetings with SDC	Presentations and Meeting Minutes of 3 Meetings (Dec 2020, Aug 2021, Feb 2022)	
15	MoU with pilot projects	5 MoU	
16	LoC of pilots	3 LoC	

7.2. ANNEX B – Additional Documents requested by Review Team from PMTU

	Document	Description	Remarks
BEEP main component			
17	latest annual report	Draft of report as of Dec 2021	
18	Output status against LFA		
19	Site report Vijayawada		
BEEP RE component			
20	Latest project report	as on Dec 2021	
21	Updated progress reports against LFA	as of Feb 2022 (two Documents)	
22	Reports on Pilot Projects	BB / MLDL	

7.3. ANNEX C - Set-up of structured interviews at personal interactions

Introduction:

- Which were the three most positive / negative aspects of the BEEP in your opinion?
- What would you miss most if BEEP hadn't been launched?

Organisation:

- Do you think the mixture of the project team was appropriate to the objectives? Does the team show the necessary skills and know-how for the project?
- Does the planned project duration fit with the objectives initially set? Could the project aims be reached in a shorter period or more efficiently? Is there any potential for optimization and eventually where?
- How efficient / effective is the administration process in your opinion? How could it be improved? What is the amount of the administration expense (in % of the total project expenses) in your estimation?

Objectives:

- Do you think the defined objectives were the right ones? Were the objectives defined correctly?
- How realistic was the achievement of the formulated objectives? Can / could they be achieved?
- Does the number of stated objectives fit with the available time and financial means?

Methodology:

- Do you think the chosen methodology is appropriate to meet the objectives?
- Is the methodology open to changes during the project?
- Does the methodology fit the local conditions?

Focus:

- Do you think the project focused on relevant topics or set the right priorities?
- Would you have chosen other priorities? Which ones?

Results:

- Do you think the results achieved the desired effects?
- Which most important targets were reached? Which relevant ones were not reached?
- What are the main reasons for possible failures?

Financing:

- Do you think the financial means were enough / appropriate to reach the project tasks?
- Are any failures caused by financial reasons or problems?
- Was the financial structure open to changes during the project?

Indo-Swiss Cooperation:

- Are there any particular negative / positive aspects in the cooperation you would like to highlight? Benefits / disadvantages?
- Should the project continue to focus on Swiss know-how transfer or rather on expanding with Indian stakeholder in the remaining period?
- Should the project engage differently with the government (national and state)? What is the potential for further enhanced cooperation with city authorities?

Various:

- What is the added value for India related to the project collaboration?
- Which suggestions would you make for future projects?
- What is the potential for further cooperation between Swiss and Indian companies (based on BEEP)?
- What are you most proud of within the achievement realized in the second phase of BEEP?
- What were your "lessons learned"?

7.4. ANNEX D - Set-up of questions for the on-line survey (preliminary)

Q1: What is your profession? → (Clickable answer with dropdown-box)

Q2: Have you heard of the following (select all that apply) from BEEP project:

a. Eco-Niwas Samhita
b. CFD tool - BEEP Vayu Pravah
c. External shade competition
d. BEE-ECBC National Awards
e. ...

Q3 (only to be asked if Q2 has at least one YES): Which of the above-mentioned resources and tools have you used and how? → DESCRIPTIVE ANSWER

Q4: Which of the following events organized by BEEP did you participate in:

a. Design charrettes
b. Trainings
c. Exchange visits
d. Stakeholder meetings
e. ...

(Q5 and Q6 only to be asked if Q4 has at least one YES)

Q5: What were the main take aways in these events? → DESCRIPTIVE ANSWER

Q6: How was the level of interaction in these events? Were you able to make contributions? → DESCRIPTIVE ANSWER - eventually also clickable scale from "NONE", "LOW", "HIGH", "EXCELLENT"

(Q7 only to be asked, if Q2 or Q4 has at least one YES)

Q7: Did your interaction with BEEP / usage of tools provided by BEEP influence your design? → YES/NO, if YES give examples

Q8: Which EE and RE ideas should be analysed more deeply in future and tested for their practicability? → DESCRIPTIVE ANSWER

Q9: Any other comments? → DESCRIPTIVE ANSWER