Frankfurt School
FS-UNEP Collaborating Centre
for Climate & Sustainable Energy Finance

Stakeholder Consultations Report

REDUCE SHORT-LIVED CLIMATE POLLUTANTS IN INDIA

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Prepared by

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CLIMATE & CLEAN AIR COALITION TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

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ABBREVIATIONS

AC	Air Conditioning
AEEE	Alliance for an Energy Efficient Economy
AMC	Annual Maintenance Contract
AR	Avishkar Realtors
BAU	Business As Usual
BMS	Building Management Systems
BOQ	Bill of Quantities
CAAS	Cooling-as-a-Service
CEPT	Centre for Environmental Planning and Technology
CII	Confederation of Indian Industry
CSE	Centre for Science and Environment
DEC	Direct Evaporative Cooling
DISCOM	Distribution Company
DOAS	Dedicated Outdoor Air System
DSM	Demand-Side Management
EE	Energy Efficiency
EMI	Equated Monthly Instalment
EPC	Engineering Procurement and Construction
EUR	Euros
FI	Financial Institution
FS	Frankfurt School of Finance & Management
FSI	Floor Space Index
GHG	Greenhouse Gas
HCFC	Hydro chlorofluorocarbons
HDFC	Housing Development Finance Corporation Bank
HFC	Hydro fluorocarbons
HVAC	Heating Ventilation and Air Conditioning
IDEC	Indirect Direct Evaporative Cooling
IDU	Indoor Unit
IFC	International Finance Corporation
IIM	Indian Institute of Management
IIT	Indian Institute of Technology
INR	Indian Rupee
IPMVP	International Performance Measurement and Verification Protocol
IRR	Internal Rate of Return
ISHRAE	Indian Society of Heating, Refrigerating & Air-conditioning Engineers
KM	Kilometers
LBNL	Lawrence Berkeley National Laboratory
LED	Light Emitting Diode
MCLR	Marginal Cost of Funds based Lending rate
MOOC	Massive Open Online Course
MRV	Measurement, Reporting, Verification
NCAP	National Cooling Action Plan
NGO	Non-Governmental Organization
OC	Orange County
OD	Oricon Developers
ODU	Outdoor Unit
OPEX	Operating Cost
PACE-R	Partnership to Advance Clean Energy – Research
PCU	Pre-cooling Unit
PE	Private Equity
PRGSF	Partial Risk Guarantee Sharing Fund
PRSF	Partial Risk Sharing Facility
PV	Photovoltaic
RE	Renewable Energy
REC	Rural Electrification Corporation
RERA	Real Estate Regulatory Authority
ROI	Return On Investment
S&M	Service & Maintenance
TERI	The Energy and Resources Institute
TIDE	Technology Informatics Design Endeavour

TR	Ton of Refrigeration
ULB	Urban Local Bodies
USD	US Dollars
UV	Ultraviolet
VAM	Vapour Absorption Machine
VFD	Variable Frequency Drive
WB	World Bank

Disclaimer

Executive Summary

This report elaborates and summarizes salient learnings and insights from stakeholder consultations conducted in the form of two workshops – one focused on the residential-sector during 15-17 December 2017 in Mumbai, India, and one focused on the IT-sector on 14 March 2018 in Bengaluru, India. It distils the primary barriers, and indicative solutions for addressing them, that emerged from the workshops and consultations. These outputs can be harnessed for designing a technical assistance facility that seeks to accelerate the uptake of sustainable cooling technologies (SCTs) in India to achieve the goal of mitigating emissions of short-lived climate pollutants (HCFCs and HFCs from the space cooling sector, in this case).

The barriers were seen to cluster amongst four barrier 'types': 'Performance uncertainty', 'unawareness and misinformation', 'lack of standardization', 'higher first cost'. Technology specific barriers have also been identified and are articulated explicitly in the report. The understanding of pivotal barriers and their causes, as expressed herein, have evolved, deepening and expanding, concomitant with the progress of the consultation process in time and scope.

Consultations with stakeholders provided possible interventions for consideration in the proposed Technical Assistance (TA) Facility, which is designed to address financial as well as non-financial barriers to accelerating uptake of non-HFC comfort-cooling technologies in India. These possible interventions are explored in the Solutions section.

The consolidation process has begun of the insights, ideas and high-level solutions that have emerged emphatically (and have in-principle buy-in from stakeholders consulted), and will be synthesized into learnings to aid the technical assistance finance-facility design process by Frankfurt School of Finance & Management (FS).

The TA Facility detailed design process will continue by working with select stakeholder organisations to evolve new ideas and refine solutions arrived during the stakeholder consultation phase. The detailed TA design will outline features of each element and modalities of implementation including indicative budget.

Post that, in May 2018, stakeholder re-consultations will commence to ensure that all barriers to mainstreaming sustainable cooling technologies in the IT/commercial and residential sectors have been addressed in an adequate manner through the TA facility, and partnerships are in place for the successful execution of the facility.

1. Introduction

Climate and Clean Air Coalition (CCAC) is implementing a project on reduced short-lived climate pollutants (SLCPs) in India. The project envisages (i) conducting a feasibility assessment for designing a technical assistance finance facility that seeks to provide technical assistance and associated funding supports for switching from high-GWP HFC cooling technology to fluorinated and non-fluorinated alternatives that are more sustainable and hence (ii) to increase awareness about these alternative technologies (named as sustainable cooling technologies – SCTs). The project aims to design a sustainable cooling finance programme by involving ESCOs, financial institutions, end-user-adopters, architects, HVAC engineers, and suppliers/manufacturers. The project is expected to result in dedicated technical assistance finance facility to overcome some entrenched perception, financial, and implementation barriers that curb the reduction of energy usage, operational cost, and carbon emissions from the use of low-GWP/ alternative cooling technologies. The project thus aims to contribute to India's intended nationally determined contribution (INDC) and Montreal protocol commitments.

Two stakeholder consultation workshops were organized - one during 15-17 December 2017 at the Govardhan Eco-village near Mumbai, and one on 14 March 2018 at the Le Méridien in Bengaluru. While the objective of both workshops was to engage with the sustainable cooling ecosystem in a meaningful discussion to identify the barriers to adoption of SCTs and hence to attempt to evolve practical approaches to overcome these barriers, the Mumbai workshop focused the residential-sector, and the Bengluru workshop focused on the commercial/IT sector. The agendas of both the workshops are enclosed in the Annex A & C.

The barriers were identified through collective-intelligence dialogues during the workshops with the *influencers* of built-space eco-system. These influencers are companies who design/build/operate real-estate for their own use or as a service, IT companies, sustainable cooling manufactures, HVAC Consultants, ESCOs, financial institutions that can catalyse the mainstreaming of sustainable cooling through appropriate financing approaches.

A solutions-oriented approach was followed to seek innovative ways to overcome the identified barriers to sustainable cooling adoption, deconstruct the status-quo prevalent in the built-space economy and redirect the consequent trajectory of rising greenhouse gas emissions through cooling built-spaces efficiently.

There were 18 total participants at the Mumbai workshop. There were 11 participants from stakeholder organisations comprising SCT suppliers (3), builders / developers (5 officials representing 4 developers), an ESCO (1), a FI (1) and industry association (1 - AEEE). Other attendees (7) included representatives of cBalance (4), FS (2) and UN Environment (1). The workshop was facilitated by two professionals.

There were 38 total participants at the Bengaluru workshop. There were 32 participants from stakeholder organizations comprising IT companies (4 officials representing 3 companies), SCT suppliers (4), builder / developers (5 officials representing 4 developers), HVAC Consultants (4), ESCOs (3), FIs (8 officials representing 5 FIs), industry associations (4 officials representing AEEE (2), CII-GBC, ISHRAE)

Annex B & D provides the list of participants at the workshop.

2. Brief Summary of the Residential-Sector Workshop

Initially groups of individual stakeholders (developers, SCT suppliers, FIs and ESCOs) were formed. Each subgroup provided background to their respective business environment and indicated perceived barriers to adoption of SCTs. These inputs were used subsequently in the follow-up discussions. On the second Day workshop began with the presentation on the project by Ms. Yekbun Gurgoz, Coordinator – Finance & Household Energy, CCAC Secretariat. Ms. Gurgoz introduced CCAC initiatives, explained different programmes being implemented and highlighted a few success stories. Mr. Vivek Gilani, Managing Director – cBalance Solutions, provided detailed overview of all SCTs and outlined characteristic features of each of the technologies (structure cooling, radiant cooling, indirect direct evaporative cooling, solar assisted vapour absorption System, and R290 based system). Mr. Sandeep Sonigra, Chairman – Orange County Construction, outlined green features of the proposed Green City being constructed by his company. These presentations followed up with series of discussions among the groups to discuss barriers to SCTs and possible approaches to overcome these barriers. Discussion among the groups comprising different stakeholder groups particularly helped understanding perspectives of each other (e.g. SCT suppliers could appreciate views of construction companies).

3. Brief Summary of the IT-Sector Workshop

Mr. Vivek Gilani, Managing Director – cBalance Solutions, introduced the workshop with a round around the room of friendly introductions. This was followed by a presentation about the project by Mr. Hirak Al-Hammad, Project Manager, Frankfurt School - UNEP Collaborating Centre for Climate & Sustainable Energy Finance. Next Ms. Yekbun Gurgoz, Coordinator – Finance & Household Energy, CCAC Secretariat, presented on the CCAC Secretariat. Ms. Gurgoz introduced CCAC initiatives, explained different programmes being implemented and highlighted a few success stories. Then, Mr. Gilani provided a detailed overview of all SCTs and outlined characteristic features of each of the technologies (structure cooling, radiant cooling, indirect direct evaporative cooling, solar assisted vapour absorption System, and R290 based system). This was followed by 15 minutes of silent thinking time for participants to write down what barriers they feel exist towards mainstreaming sustainable cooling technologies in the IT-Sector, and which stakeholders are responsible for these barriers. Then, individual stakeholder groups were formed for individuals to collectively share the barriers they wrote, and to reach a consensus as to the root cause of barriers faced within their own group and from other groups. Following lunch, two intersection dialogues proceeded. During these intersection dialogues, groups asked questions to their counterparts to understand the rationale behind their barriers, and shared some solutions to overcome barriers to root causes. Mr. Guruprakash Sastry, Regional Head – Infrastructure/Green Initiatives at Infosys made a presentation on Infosys's consistent use of radiant cooling, along with several other passive design measures, that has resulted in lower operating energy costs, lower capital cost from their pre-radiant cooled building designs, and higher satisfaction from employees on thermal comfort. Mr. S. Srinivas, Confederation of Indian Industry – Green Building Council, shared a presentation on leapfrogging energy efficiency benchmarks through green buildings. The dialogue was concluded, and next steps summarized, by Mr. Sanjeev Tamhane, Senior Consultant – Frankfurt School, followed by a brief vote of thanks from Ms. Gurgoz.

4. Barriers in the Sustainable Cooling Ecosystem

The barriers described below emerged through stakeholder consultations through meetings and collective-intelligence dialogue-based workshops. Complex, multi-faceted, and layered barriers, clustered amongst four broad categories, were divided further using diagrams which enabled exploration and consideration of the numerous causes related genesis of the barriers. Mapping of the individual barriers and the discussion at the workshops helped to determine the most resounding causes of the barrier. These causes are marked as a '**Key Cause**'. Causes that appear more than once among different barriers are also noteworthy; hence they are marked with the '**Duplicate Cause**' tag. A similar approach was also used to discuss the unclear / vague perceptions and specific challenges faced by stakeholders engaged with each of the five chosen sustainable cooling technologies.

These barriers are aligned with the original hypothesis of the project that predicted the following constraints to mainstreaming sustainable cooling technologies:

- An inadequate technical awareness of SCTs with a verifiable track record of performance,
- absence of a mature sustainable-cooling sector (business) environment,

- the split-incentive or principal-agent conflict in the residential & commercial buildings sector, and
- the difficulty to guarantee cost savings due to absence of measurement and verification protocols to estimate energy savings.

4.1 Performance Uncertainty

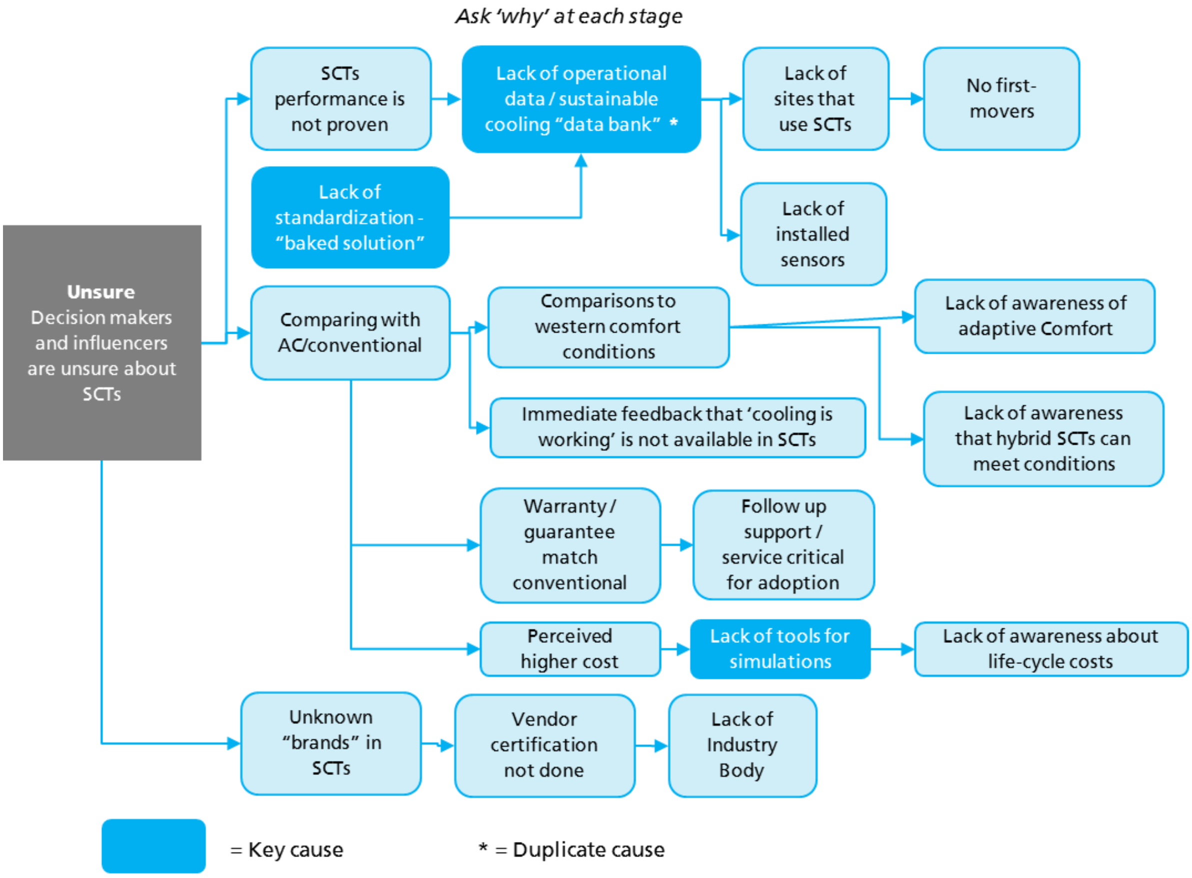

Figure 1: Causes of performance uncertainty

Consultations indicated that end-users (IT-company facility management, real estate builders) and financial institutions (FIs) are unsure about the overall merits of SCTs relative to established business-as-usual technologies. While apparently there is awareness about sustainable cooling, the understanding is meagre relative to the extensive understanding of dominant conventional technologies and this perpetuates uncertainty about adopting the technologies for mainstream applications. The performance uncertainty is exacerbated by the lack of performance standards (related to energy, air quality, thermal comfort provision) that can enable comparison with corresponding attributes of conventional systems. In this manner, uncertainty about performance is conflated with inadequate awareness and lack of standards/standardization process established by trusted certification bodies. Both these ecosystem lacunae are explored further in later sections.

Another independent contributor to performance uncertainty is the fact that the alternate cooling ecosystem is comprised of largely unknown 'brands' that aren't a household name. SCT solution providers have not yet built the brand recognition, reputation and perception of reliability. Further, most of the SCT solution providers currently do not offer performance and equipment guarantees/warranties that compare with the robustness of the corresponding assurances provided by established conventional cooling technology brands/companies. An undeniably pivotal barrier is therefore the unmet expectation (which spawns a discernible degree of trust deficit) harboured by end-users of a comparable calibre of after sales service from sustainable cooling as conventional cooling, including matching warranty / guarantee periods. This is especially important in the context of the recently passed national legislation that established the Real Estate Regulatory Authority (RERA) which mandates that builders are responsible for building maintenance for five years after sale of the last unit in a real estate development project.

Uncertainty about the measurable, reportable and verifiable operational benefits of SCTs is also compounded by the relative dearth of real operational data and estimate of avoided energy, GHG emissions savings from installations relative to business as usual (BAU) scenarios. Furthermore, it was discovered that while some technologies have a sizable number of installations, the manufacturers have not fitted these sites with sensors to measure comfort conditions / performance. This scenario also precipitates the conditions that give rise to a related barrier (discussed subsequently), namely "Unawareness".

Another contributor to performance uncertainty expressed by real-estate developers was the absence of comparable sensory and cognitive 'feedback' information for end users to validate the fact the systems are operating and that the relative merits of using SCTs relative to conventional systems are adherent to claims made by SCT manufacturers. To illustrate, while air-conditioning provides users thermal comfort through blowing a stream of cool air from visible devices which provide sensory and cognitive feedback (i.e. the sensation of a cool stream of air and displays indicating the air temperature etc.), SCTs such as radiant and structure cooling are usually devoid of these feedback systems. It is, however, noteworthy to mention that radiant and structure cooling systems will usually need to be combined with a conventional system to address the humidity; in these cases of a hybrid system (sustainable and conventional cooling system) this would not be a barrier.

Causes of 'performance uncertainty' about SCTs:

1. No standards in place for objective comparisons with BAU technologies
2. No independent authority established to implement certification systems
3. SCT ecosystem not comprised of known 'brands'
4. SCT manufacturer's guarantees not comparable with BAU scenario
5. Dearth of independently verified operational energy savings and life-cycle cost data
6. Absence of sensory and cognitive feedback systems to convey operational performance to users

4.2 Unawareness and Misinformation

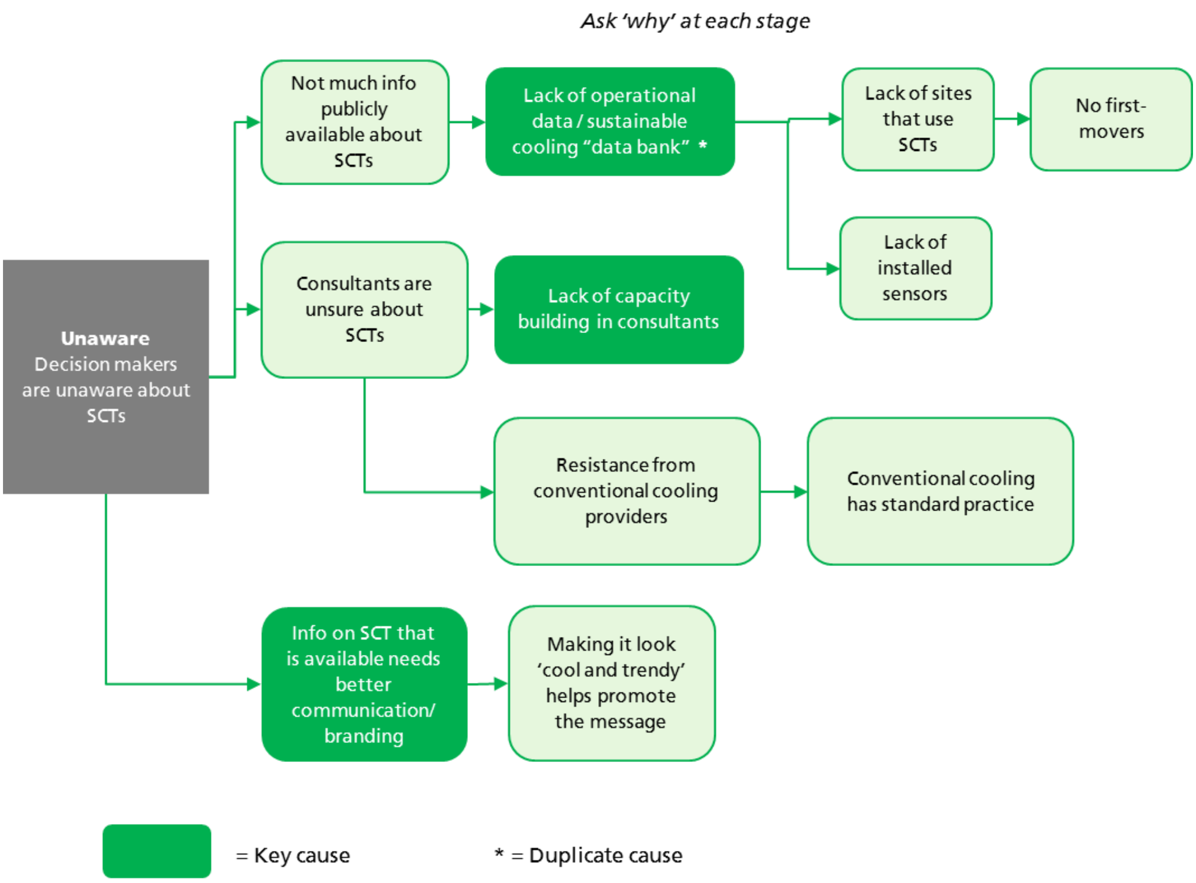

Figure 2: Causes of unawareness and misinformation

Consultations have made it unequivocally clear that there is a relatively poor awareness prevalent amongst key decision makers in the built-space ecosystem about SCTs. This 'unawareness' manifests in many forms (including performance uncertainty as described earlier in the report) and stems from many causes of its genesis which are dissected further below.

The absence of a robust and competently collated set of and easily accessible, independently verified and reported, performance case studies related to SCTs is a significant contributor to this pervasive state of unawareness about SCTs in the ecosystem. While the low quantity of compelling, relevant and quantified information is acute, the quality (e.g. poorly compiled and communicated information) of the information available is also a source of ambiguity about SCTs and contributes to obfuscation of the multiple environmental, economic and social merits of these technologies.

The SCTs ecosystem 'players' do not have the benefit of a 'level playing field' or a meritocracy. The industry is riddled with concerns about information asymmetry which diminishes the chances of economic success of SCT manufacturers. Chief amongst the detrimental practices which impede efficient operation of markets is the amplification of technical and safety concerns about alternate cooling systems by HVAC consultants. This stems from conventional manufacturers flooding the market with these concerns, and HVAC consultants lack of understanding of sustainable cooling systems, and hence a lack of ability to convince clients to adopt sustainable cooling. While oversizing and exclusively selecting conventional technologies helps guard against situations where cooling systems are inadequate in meeting exacting thermal comfort expectations of behaviourally-conditioned air-conditioning users, they lead to higher life-cycle environmental and cost impacts, and thermal discomfort through overcooled spaces, both of which are less visible to end-users who are disproportionately influenced by lower first costs. This practice of misinformation or incomplete information dissemination (i.e. not making clients aware of all possible cooling solutions relevant to a project) by HVAC consultants, adversely affects the mainstreaming of SCTs. This phenomenon has a significant influence in the case of commercial buildings wherein building design teams engage with professional HVAC consulting firms.

A unexpected source of unawareness about the energy efficiency merits of SCTs which the stakeholder consultation process revealed was the fact building inspectors employed by Urban Local Bodies (ULBs) which oversee the compliance with energy efficiency codes (in cities where these have been included into building bye-laws or environmental clearance norms of the state) are civil engineers and not mechanical engineers; as building approvals were only concerned with civil aspects of construction, and there is no city-led Energy Conservation Building Code (ECBC) implementation as yet. Policy advocacy bodies have expressed that this has severe implications on the efforts towards stimulating uptake of energy conservation building codes (currently) or any future codes related to SCTs. This can be attributed to the 'abstract' nature of energy efficiency related physics principles (especially heat transfer principles) which are largely discordant with the material physical properties related considerations of the civil engineering framework of analysis. This dissimilarity in frames of reference of mechanical engineering vs. civil engineering ways of seeing the buildings approval process is thought to create trepidation amongst ULBs and buildings inspectors, who are expected to shoulder the additional burden of encompassing new energy efficiency codes into their already daunting magnitude of work. This could prevent ULBs from changing the bye-laws and environmental clearance processes if these changes are incongruent with physical material considerations of traditional environmental clearance aspects such as water and wastewater treatment etc.

Causes of 'unawareness and misinformation' about SCTs:

1. Inadequate quantity and unsatisfactory quality of verified performance information
2. Misinformed playing field created by risk-averse HVAC consultants who oversize systems and use conventional technologies to stay within their comfort-zone
3. Misinformation related to safety and technical operation aspects of SCTs by HVAC consultants who are influenced by conventional manufacturers
4. Civil engineering-knowledge rooted ULBs unable to embrace energy efficiency or SCT related codes into current building permitting processes

4.3 Lack of Standardization

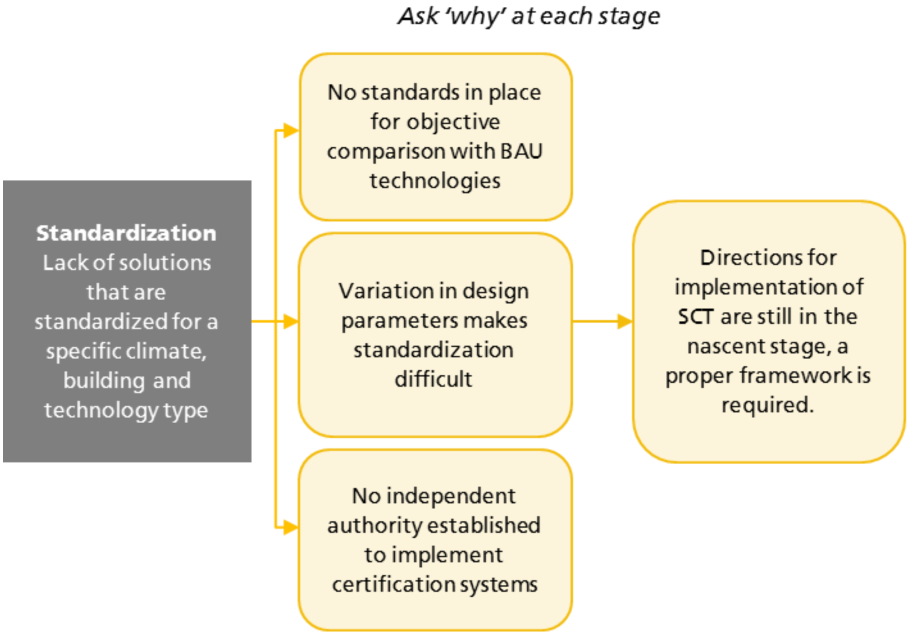

Figure 3: Causes of lack of standardization

In addition to the 'standardization' issues that are enmeshed with 'performance uncertainty' issues, as discussed earlier, are some explicitly articulated lacunae related to 'standards (processes and technology) that were identified and underscored by IT-sector facility managers, real-estate developers, representatives of financial intuitions and energy service companies. These stakeholders underscored that technologies that "take off" or achieve a formidable adoption rate are ones that offer a "well-baked solution" for specific project-solution intersections (also referred to colloquially as a "sweet spot") between a specific technology, specific built-space sector, and specific climate type. For example, "indirect-direct evaporative cooling (technology), pharma (sector), hot/dry (climate type). It was abundantly clear that SCT manufacturers haven't achieved a degree of sophistication in their business strategizing process to trigger significant shifts in the proclivity of ecosystem actors that operate in the identified 'sweet spots' from overwhelmingly favour conventional cooling technologies, which is currently the case.

A significant cause of the general dearth of standardization amongst SCT solutions is the unresolved 'principal agent' conflict or 'split incentive' issue which inequitably apportions risks and rewards for energy efficiency or SCT investment in the residential and commercial built-space ecosystem (builder – tenant/owner). This issue has hitherto prevented establishment of standardized templates of financial and technical solutions for mainstreaming SCTs. This barrier is also causally linked with the prevalent practice of builders largely dealing with space cooling as a function of product-based solutions wherein end-user buyers/leasers have complete autonomy in the technology decision making process. In the residential real-estate sector, the absence of 'cooling as a utility' as a recognized feasible concept hampers the creation and widespread use of standardized, reliable financial and technical models that engage financial institutions, energy service companies, SCT Manufacturers, real-estate developers and property owners in a mutually beneficial economic relationship. In the commercial real-estate sector, builders usually offer bare-shells, making provisions for occupants to install their own HVAC system.

Causes of 'lack of standardization' within SCT ecosystem:

1. No standards in place for objective comparisons with BAU technologies
2. No independent authority established to implement certification systems
3. Lack of 'well-baked' solutions for 'sweet-spot' intersections of projects and technical solutions
4. 'Cooling as a utility' is a unexplored concept and standard financial and technical models for these are consequently lacking

4.4 Higher First Cost

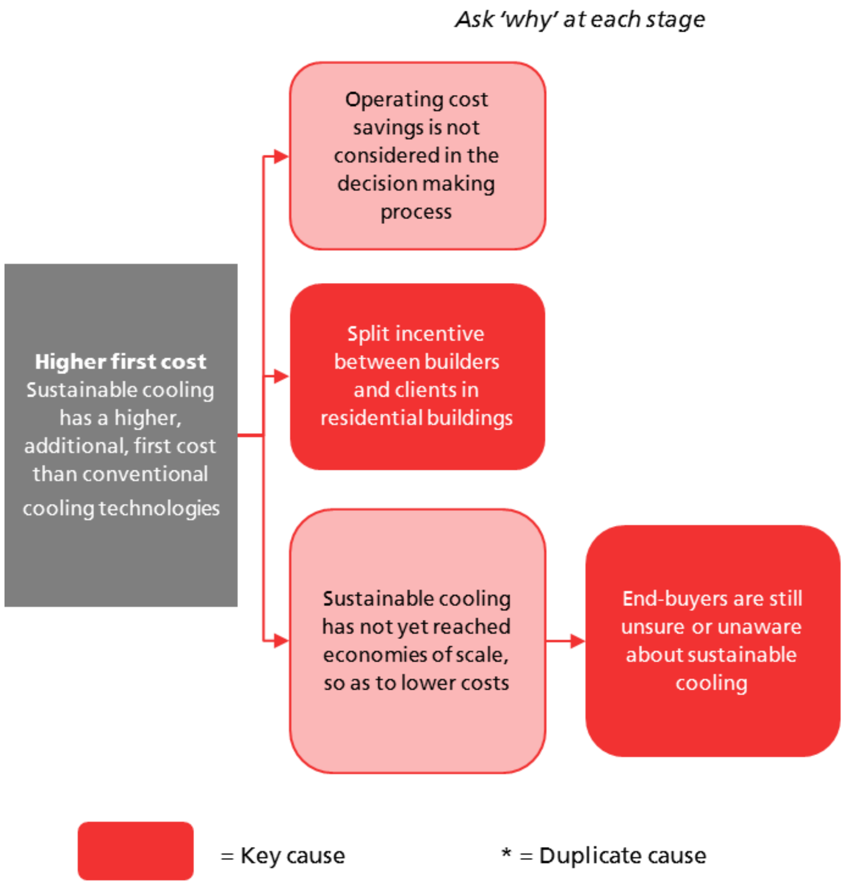

Figure 4: Causes of higher first cost

Currently, sustainable cooling technologies are defined, on average, by higher initial capital costs relative to conventional cooling systems. While it is anticipated that as SCTs achieve economies of scale, the capitals cost will correspondingly reduce. On the other hand, conventional cooling technologies have already achieved economies of scale and have strong brands.

The consultation process also emphatically underscored the fact that the detrimental effects of higher first cost on adoption rates of SCTs aren't an insulated phenomenon; instead it behoves consideration that this barrier is greatly compounded by the lack of decision support tools designed for providing robust and verified information to key ecosystem decision-makers (Builders, Consultants, Architects, HVAC Consultants) related to the life-cycle cost benefits of SCTs which provide compelling financial evidence for supporting procurement of SCTs despite their higher first cost.

Causes of 'higher first cost' of SCTs and related ecosystem impeding effects:

1. Modest manufacturing capacity and sales of SCT manufacturers hampers economies of scale
2. Absence of high quality reliable decision support tools for comparing overall life-cycle cost benefits of SCTs relative to BAU technologies

4.5 Technology Specific Barriers

4.5.1 Structure Cooling

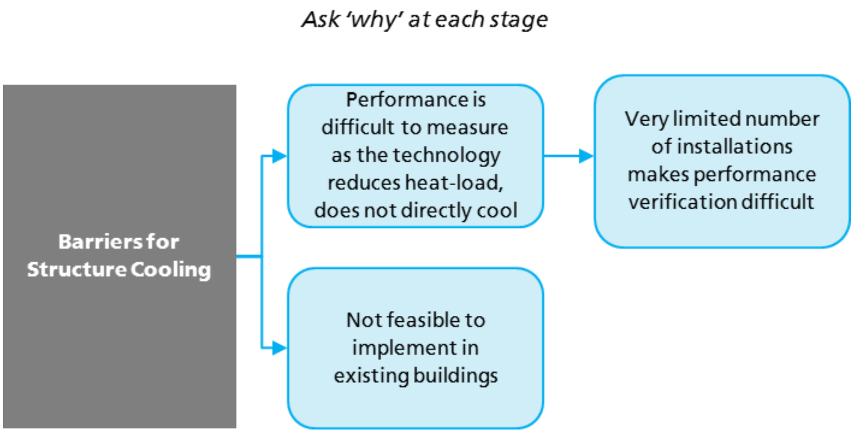

Figure 5: Barriers for structure cooling

As structure cooling is a system that reduces solar radiation from entering the building structure, and drains the heat out that has entered the structure, it is close to being a passive system (a system that uses zero/very little energy). Hence, it does not "actively" cool the structure. The technology has also had limited installations. For these two reasons – no "active" cooling component and limited installations – makes it is difficult to verify the performance of the system.

For the structure cooling system to drain the heat from the structure, it needs to be embedded in the building slab or in the screed (the material above the slab, but below the flooring). Hence, this technology cannot be retrofitted.

4.5.2 Solar VAM

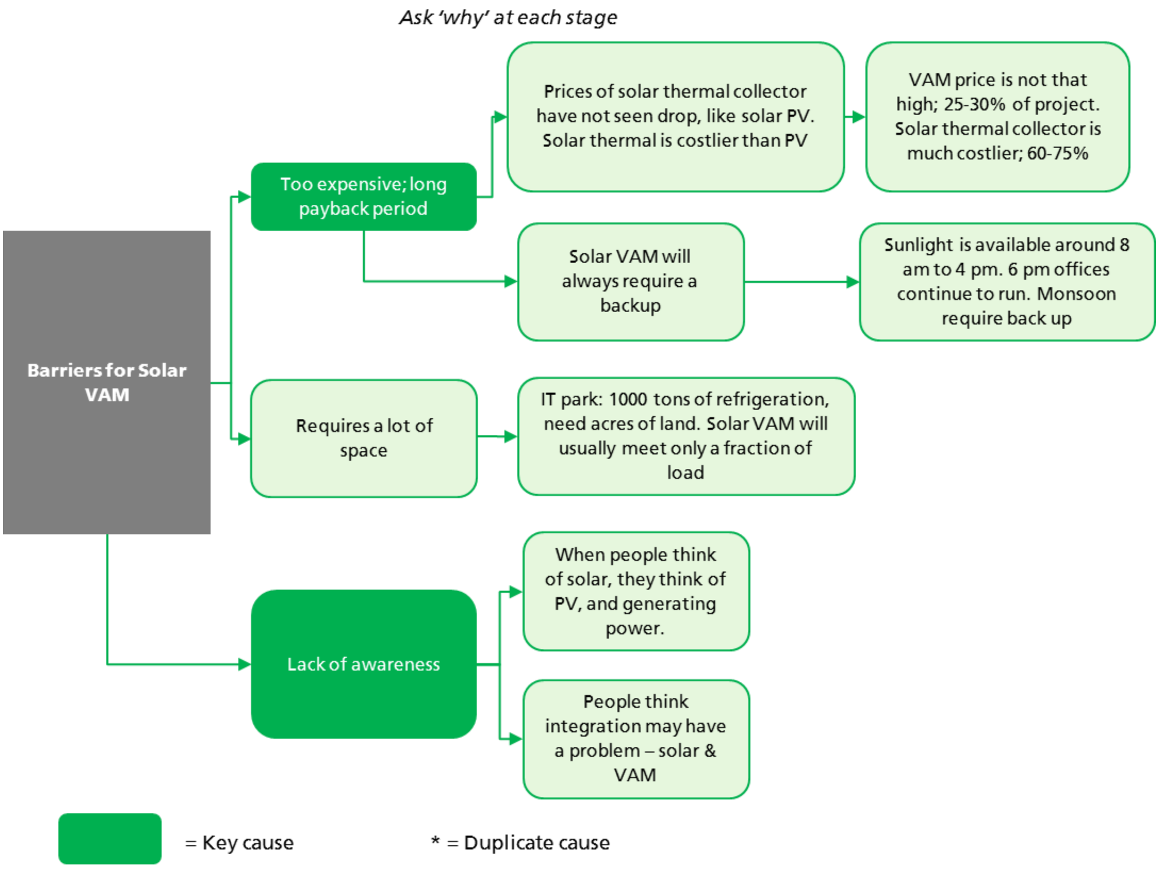

Figure 6: Barriers for solar VAM

Barriers for adopting Solar VAM:

Too expensive; long payback period: From the five chosen sustainable cooling technologies, Solar VAM has the longest payback period. This detracts potential adopters.

Requires a lot of space: Solar thermal collectors require a significant amount of space. A Solar VAM manufacturer gave us a hypothetical example of a company requirement of 1000 tons of refrigeration; this would require acres of land. Hence, such companies may only receive a fraction of their cooling from solar VAM.

Lack of Awareness: The word "solar" has become synonymous with solar photovoltaic (PV) panels; they think of generating power rather than collecting heat. Further, there is unawareness, and scepticism that solar and VAM can be integrated.

Solar VAM will always require a backup: As most modern offices continue to operate past sunset, the Solar VAM will require a backup system. Hence, this increases the capital cost.

4.5.3 R290 Split ACs

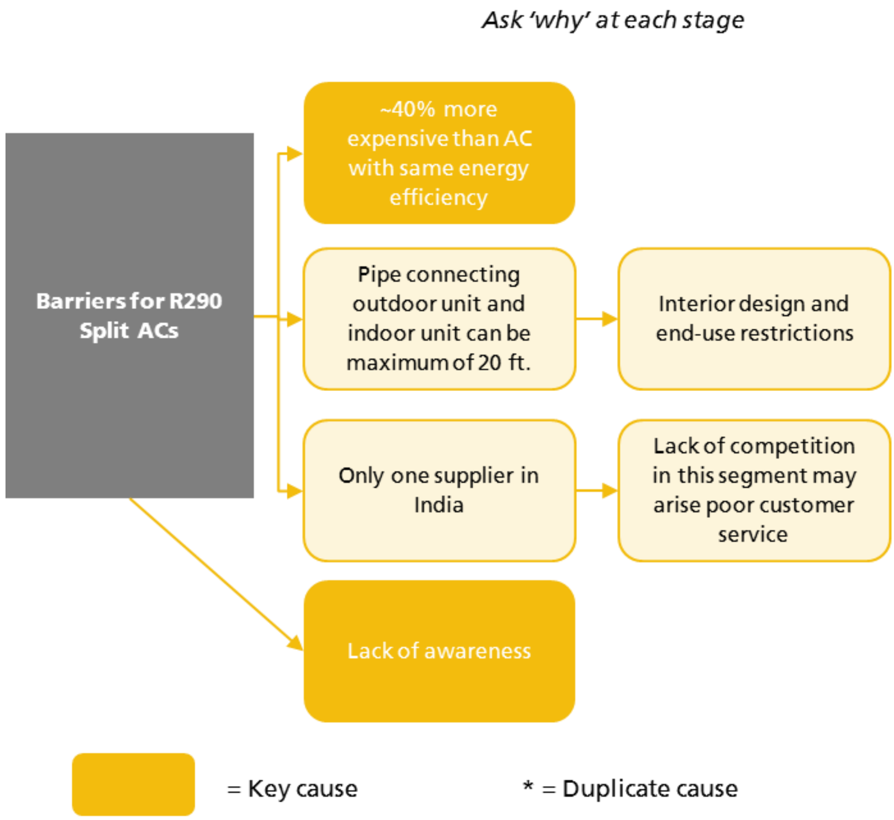

Figure 7: Barriers for R290 Split ACs

Barriers for adopting R290 Split ACs:

~40% more expensive: Godrej's R290 split AC provides the same functionality as a conventional split AC, with greater efficiency and utilizing the R290 natural refrigerant. However, when compared with a conventional AC of the same tonnage, it is about 40% more expensive.

Pipe connecting outdoor unit (ODU) and indoor unit (IDU): For safety reasons, the total R290 charge within a system must be capped. This subsequently caps the pipe length between the ODU and IDU. This could impose restrictions on interior design and end-use.

Only one supplier in India: As Godrej is the only supplier of natural refrigerant ACs in India, the lack of competition may arise poor customer service. However, this barrier has not been supported by evidence.

Lack of awareness: The AC refrigerant industry has been flooded by high-GWP refrigerant R410A promoted as a "green refrigerant". There is a lack of awareness about natural refrigerants and their benefits among the general public.

4.5.4 Radiant Cooling

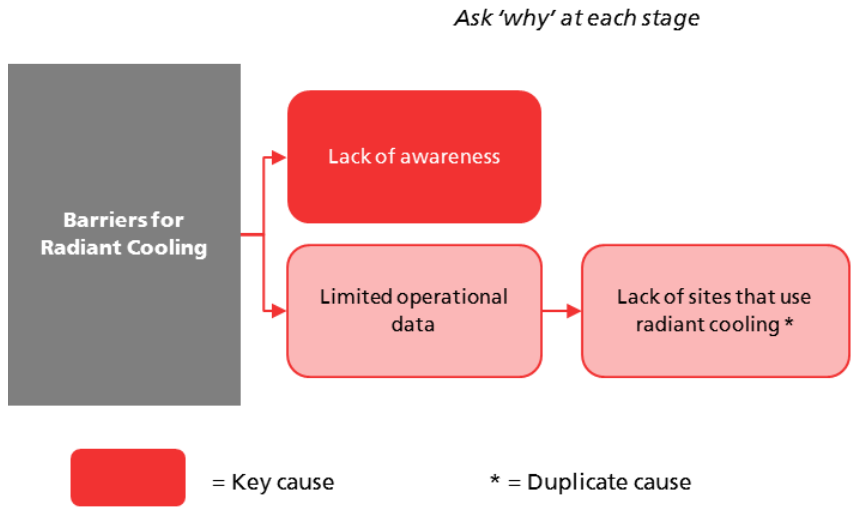

Figure 8: Barriers for radiant cooling

Barriers for adopting radiant cooling:

Lack of awareness: Unlike in the west and industrialized Asian countries where radiant heating has become popular, radiant cooling is still largely uncommon in India currently.

Limited operational data: Due to a lack of sites that have installed radiant cooling, and are sharing data through sensors, there is limited operational data.

4.5.5 Evaporative Cooling

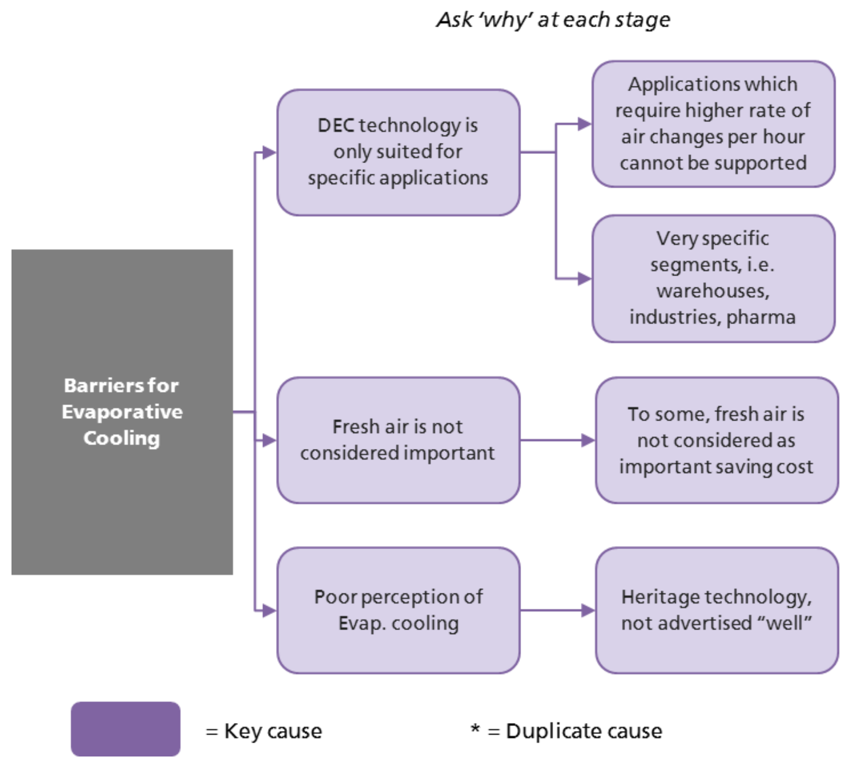

Figure 9: Barriers for evaporative cooling

Barriers for adopting Evaporative Cooling (IDEC-DEC):

Direct evaporative cooling (DEC) is only suited for specific applications: DEC is only suitable for areas that don't have very strict thermal comfort requirements, i.e. in places where low performance in monsoon months due to humidity is not much of a problem. It works best in where conditions such as low noise, no humidity level are not requirements.

Fresh air is not considered important: A Pre-Cooling Unit (PCU) that uses indirect-direct evaporative cooling (IDEC) pre-cools the fresh air intake, resulting in energy-savings. However, our stakeholder consultation with India's largest evaporative cooling manufacturer resulted in our learning that fresh air is occasionally not considered important by building operators as it increases the heat load on the overall HVAC system due to an increase in the intake of warmer fresh air. Hence, even when it is installed, some of these operators turn off the fresh air in order to save money.

Poor perception of evaporative cooling: While AC is considered a status symbol, evaporative cooling is considered a heritage technology in the negative sense, "the poor cousin of an AC". This perception limits adoption in the modern commercial world.

5. Group Discussions at Stakeholder Consultation Workshop

Two stakeholder consultation dialogue workshops were held under the auspices of CCAC / UN Environment and identified and analysed barriers that prevent stakeholders from adopting sustainable HVAC systems.

The first stakeholder consultation workshop was held on December 15-17, 2017 and focused on barriers in new residential townships. The second collective stakeholder consultation workshop was held on March 14, 2018 and focused on barriers in new and existing IT/Corporate parks.

The workshops generated strategic response(s) to the barriers faced by each stakeholder group in adoption of sustainable HVAC systems. The first workshop achieved the vision of a thoughtfully crafted, intimate and candid dialog and group-work session to spur collective thinking. While the second workshop achieved the vision of a one-day balanced blend between facilitated listening to stakeholders, and sharing information in a presentation format.

As the group discussions at the workshops dealt with pertinent questions that drew out barriers/reservations to adoption of sustainable HVAC systems, an effort was pursued to create a profound and transformative ownership of a common intervention roadmap that seeks to deconstruct the status-quo prevalent in the built-space economy and redirect the consequent trajectory of rising greenhouse gas emissions. The stakeholders present collectively discussed barriers they feel other stakeholders present at the dialog were responsible for creating. This discussions was amicable and candid, and resulted in “asks” between stakeholder groups and subsequently “key areas of stakeholder interest” emerged signifying that stakeholder groups were open to recognize that the control to resolve barriers lies internally (within their firm or industry).

5.1 Asks to/from Each Stakeholder at the Residential-Sector Workshop

From builders to manufacturers:
1. Provide cooling as a utility (subscription based) by developing cooling-as-a-service (CAAS) model
2. Payback period can be up-to 8 years; please bring it lower
3. Work on performance guarantees of equipment/systems
4. Annual maintenance contract (AMC) cost escalation made linear
5. Product quality has to be good; increase end-user visibility (indicators)
6. Pay attention to operational data (sensors)

From manufacturers to builders:
1. Move to centralized / district cooling[1]
2. Builders offer cooling as an incentive
3. Demonstration pilot projects

From builders to FIs:
1. Reduce interest rate on construction finance for sustainable cooling

From stakeholders to the technical assistance facility:
1. Gather clear data on cost (capital cost & operating cost), and do a cost/benefit analysis on the sustainable cooling technologies
2. Provide specific solutions and standardize product by industry and climate type. Create standardization/certification similar to star rating / kW/TR.
3. Ensure govt. incentive for builders and users (% savings in equated monthly instalment (EMI) housing loan)
4. Provide sustainable cooling subsidy like solar subsidy

[1] There is an on-going UN Environment-EESL-GEF project that is aimed at bringing district cooling to several Indian cities: http://www.districtenergyinitiative.org/accelerating-district-cooling-india-delivering-smart-and-efficient-cities; http://www.districtenergyinitiative.org/tackling-india%E2%80%99s-cooling-growth-head-eesl%E2%80%99s-expansion-district-cooling-and-trigeneration

5.2 Asks to/from Each Stakeholder at the IT-Sector Workshop

Manufacturers/consultants/ESCOs to IT companies & builders:

1. IT companies should take the *responsibility* to be the decision makers as ultimately it is affecting their sustainability reporting (carbon emissions), and electricity bills; as they are the *occupiers* of the space.
2. End-users, like IT companies, are aware about the benefits of energy-efficient buildings. For example, LEED certified buildings go at a *premium*. Some multinational companies - including Builders & IT companies - have carbon reduction mandates linked to COP 21, India's INDCs, etc.
3. NASSCOM (IT industry-body) should mandate IT companies to publish resource consumption data (per capita or per sq. ft.), and further, and benchmark IT companies to achieve ambitious targets such as 450 sq. ft. per TR.

Builders/IT companies to consultants:

1. Develop a life-cycle cost model, approved by ISHRAE, NASSCOM, for sustainable cooling technologies and use it to pitch to builder & IT company together so they understand why the premium is important.

FIs to TA facility:

1. TA Facility can create linkage with funding/financing resources, and through awareness creation/capacity building among stakeholders, share how they can get access to it.

Manufacturers, AEEE to TA facility:

1. Develop tailored capacity building programmes for FIs and consultants.
2. Develop a guideline for sustainable cooling technologies with third-party verification/certification that can be circulated to NASSCOM (IT companies), builders, FIs (loan officers). This could be similar to SIDBI's Energy Saving Equipment List[2] that has the list of equipment, range of energy-efficiency that can be achieved, approximate cost, and manufacturers.

Builders to manufacturers, FIs:

1. Builders: Need concessional rate to buy / borrow, as often there is a lack of premium offered by end-users/IT companies for buildings which are energy-efficient
2. Manufacturers: Since SCTs are relatively nascent, manufacturers are seeking to recover their R&D costs sooner, at every project, rather than reducing their profit margin and aiming for volumes. Manufacturers present are willing to move to a price point that is acceptable by the market
3. FIs: If the borrowing cost is less, FIs wouldn't mind bringing down the interest rates. This can happen once there is a policy framework at a macro level.

[2] Energy Saving Equipment List, JICA - SIDBI MSME Energy Saving Project (Phase - III), Release 9.1. Available at URL: https://www.sidbi.in/downloads/Energy%20Saving%20Equipment%20List_9.1.pdf

5.3 Key Areas of Stakeholder Focus in the Residential-Sector Workshop

Table 1: Key areas of stakeholder focus

Category	Focus Areas
Solution providers	- to work on "whole cooling" packages
	- to improve feedback provided to customers
	- to review warranty extension/AMC
	- to project costs at hypothetical scenarios
	- to improve cost/benefit
	- to work on standards/labels (kW/TR)
	- agree to purchase/install sensors for their installations
Builders	- to collaborate with solution providers on design of sustainable cooling systems to lower costs / compare data
	- to share BAU benchmark data
	- to collaborate on pilot buildings that use sustainable cooling
	- to work towards providing cooling as a utility
Financial institutions	- to consider how to fund the additional capex on pilot projects, and scale up project size
ESCO	- to explore cooling as a utility
	- to help with measurement and verification
ESCO industry-body	- to work towards specific sustainable cooling solutions in the technical-specific standardization (process & technology) framework - to Benchmark residential energy building

5.4 Key Areas of Stakeholder Focus in the IT-Sector Workshop

Table 2: Key areas of stakeholder focus

Category	Focus Areas
Builders	- to share BAU benchmark data to develop industry level benchmarks
	- to consider working with "new" suppliers of cooling, not conventional suppliers
	- to accept capacity building for their in-house technical team / building services team
IT companies	- consider taking responsibility to be the decision-makers on adopting sustainable cooling, and publishing data on resource (energy) consumption (per capita or per sq. ft.)
	- to accept capacity building for facility managers at IT companies, so they can become the internal influencer to push management to adopt SCTs
	- to explore using other materials to achieve energy-efficient cooling, for example interior partitions
	- to work with the consultants to persuade the builders to go for sustainably cooled structures when new buildings are planned
FIs	- to accept technical capacity building for loan officers / technical teams to understand how to mitigate risks involved in financing SCTs
Manufacturers	- to review moving SCT to a price point that is acceptable by the market
	- to work on standardization and certification for SCTs
Consultants	- to work on developing a life-cycle cost model for sustainable cooling technologies and use it to pitch to builder & IT company together so they understand why premium is important.
	- to accept capacity building for HVAC Consultants, team-members in SCTs
ESCOs	- to increase equipment price transparency with end-users to avoid end-users mistrust and bypassing ESCOs to go for the original-equipment manufacturers.
	- to focus on implementing the ESCO model, rather than representing themselves only as consultants

6. Solutions[3]

Consultations with stakeholders have illuminated upon the following possible interventions for consideration in the proposed technical assistance facility that is designed to address financial as well as non-financial barriers to accelerating uptake of non-HFC cooling technologies in India.

A) To address 'performance uncertainty' barriers

1) Working with accomplished ratings agencies (including possibly BEE and allied programs, industry bodies (ISHRAE, AEEE) and other civil society organizations (e.g. TERI and CSE) to establish a life-cycle GHG emissions and electricity-savings based ratings program for sustainable cooling technology products (starting with radiant cooling/structure cooling, and direct/indirect evaporative cooling, and then expanding subsequently to less mainstream yet scalable sustainable cooling technologies/products). It may be essential to develop measurement and verification (M&V) protocols which could be used in the guaranteed-savings or energy performance contract based approaches.
2) Real-time SCT performance monitoring program working with IGBC, ISHRAE and other InfoTech associations (NASSCOM) who are engaged in data-driven policy making initiatives with the Government of India.

B) To address 'unawareness and misinformation' barriers

3) Working with sustainable space cooling technology suppliers, state energy development authorities and urban local bodies (ULBs) of Indian cities who have integrated ECBC into local building bye-laws to devise and implement awareness creation and capacity building programs related to SCT implementation in various building types. The awareness programme could be targeted to civil engineers in relevant government departments charged with the responsibility of checking compliance and issuing clearances. The awareness building programme can drive evidence-based policy change to transform the current building energy efficiency-based capacity building efforts undertaken by BEE and related government authorities to address future barriers to SCT integration by ULBs in their building bye-laws.

C) To address 'lack of standardization' barriers

4) Working with ESCO-industry bodies (AEEE etc.), builders of upcoming residential townships or gated communities, and SCT manufacturers to devise and pilot passive-ESCO and cooling-as-service models[4] for a small set of technology and use-case intersections (sweet-spots) e.g. a) pre-installed radiant-cooling/structure cooled slabs for new residential units where customers pay based on 'metered' cooling consumed as per the cooling-as-a-service (CAAS) model[5], b) passive design-ESCO integrated models where passive-design features (insulation, shading systems, low-emissivity films, double-glazed windows/glass walls, heat reflective paints/plasters, cool roof products) are applied as energy efficiency 'products' in retrofit or greenfield construction projects and reduced energy relative to baseline energy consumption/costs are used by homeowners to pay-off investments by the ESCO.

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[3] These are not the final solutions evolved under the project. These are indicative solutions discussed in the workshop. These are not backed up by any numbers or specific evidences

[4] Ellenmacarthurfoundation.org. (2018). *Air conditioning as a service reduces building carbon emissions, Kaer, Case Studies*. [online] Available at: https://www.ellenmacarthurfoundation.org/case-studies/air-conditioning-as-a-service-reduces-building-carbon-emissions [Accessed 23 Mar. 2018].

[5] A company that offers CAAS would be responsible for the cooling system investment, maintenance, upgrading/retrofits, monitoring consumption, and optimization. The end-user – a building owner, housing society, IT company – would "Pay-as-you-use" at a fixed rate per unit (for example: $ / Refrigeration Ton per Hour (RTH).

5) Establish a robust residential housing energy cost benchmarking program for pilot urban residential clusters, working synchronously with other DSM-focused partners of the smart and sustainable space cooling coalition (e.g. Prayas Energy Group) and reputed civil-society organizations working in residential energy conservation. Outputs of this will be instrumental for enhancing measurement, reporting and verification (MRV) aspects of subsequent market-transformation interventions including SCT performance-based finance, passive design-ESCO integrated models, etc.

D) To address higher first cost' of SCTs and related ecosystem impeding effects

6) Direct preferential line-of-credit (low-interest) financing for SCT manufacturers in the radiant cooling, structure cooling, IDEC cooling sector to spur expansion of manufacturing capacity, improvements in product engineering quality/design, enhancing after-sales service support capacity, exploring the kit-of-parts approach[6], and technology modification for cross-technology integration to enable complementarity with mainstream cooling technologies for hybrid-mode operations.
7) Working with established entities in the building energy finance decision-support-tools space (eg. IFC's EDGE program, ISHRAE's SMART-ENERGY program) to integrate sophisticated life-cycle energy cost modelling decision support modules for SCTs

[6] A.S. Howe (2003). Design Principles for Kinematic Architecture. Proceedings of the Second International Conference on Construction in the 21st Century (CITC-II). 10–12 December 2003, Hong Kong

7. Conclusions and the next steps

The stakeholder consultation workshops and meetings provided inputs on the main barriers to adopting SCTs in the commercial and residential real-estate sectors in India. These workshops and meetings were a part of the research phase which will continue further with one to one meetings with suppliers of SCTs, ESCOs, financial institutions and end user groups. **It may be note that the conclusions emerged at the consultation workshops need not be taken as final learning of the consultation process.** It is essential to meet with construction companies / developers and other organisations that did not participate in the workshops to receive a balance and independent views.

The discussions during this phase provided the following conclusions:

Conclusions

1. Barriers to SCTs and their wider adoption include:
    a. **Inadequate technical awareness** of SCTs among different stakeholder organisations. A few developers were aware of SCTs and indicated willingness to try out such technologies in their upcoming projects;
    b. **the split-incentive or principal-agent (i.e. developer / end-user occupier) conflict** in the building space;
    c. **lack of independently verified and certified published data** on the performance of SCTs;
    d. **performance uncertainty** about the overall merits of SCTs relative to established business-as-usual technologies;
    e. **lack of standardization** of specific SCT project-solution intersections, to compare with conventional technologies, certification from a neutral apex body, and 'cooling-as-a-utility'.
    f. **higher first cost**, actual and perceived, of SCTs.

2. Construction companies / developers, and IT-companies are unsure about SCTs due to variety of reasons such as perceived higher initial cost, lack of image or branding, lack of understanding of adaptive comfort and lesser known vendors in the market. By and large end-users are not aware of health benefits of fresh air circulation.

3. Issues associated with SCTs:
    a. Performance parameters are difficult to define and measure in the case of radiant cooling systems. In addition, it is difficult to standardize radiant cooling systems;
    b. fresh air is occasionally not considered an important aspect by building operators as it increases the heat load on the overall HVAC system due to an increase in the intake of warmer fresh air;
    c. solar thermal assisted vapour absorption systems need substantially higher area / floor space for installation. This leads to higher capital cost;
    d. evaporative cooling systems are perceived as a poor alternative.

4. The workshops provided much needed technical overview of SCTs;

5. Participants were keen to know **details of the cost-benefit analysis.** Cost benefit analysis were subsequently sent to suppliers of SCTs.

6. Following **indicative solutions** were evolved out of the discussions at the workshops:
    a. Appropriate **training and capacity building** of architects, HVAC consultants and officials of ULBS was recommended.
    b. **Financing of demonstration projects** could help in generating much needed verified data on performance of SCTs. Case studies based on these demonstration projects could be widely disseminated.
    c. **Working in partnership**, overall, with the Smart & Sustainable Space Cooling Coalition, and Alliance for Energy Efficient Economy could help addressing several aspects such as standards and verification, financing models with ESCOs involvement.
    d. Additionally, **explore working with BEE (on ECBC), EESL, MoEFCC and other select ministries** suitably to drive policy issues associated with SCTs.

The Next Steps

The consultation phase will be continued with one-to-one meetings with select organisations. These one-to-one meetings not only help in receiving additional information but also help in developing partnerships for eventual actions in the sector. Meetings with FIs and banks help in securing information on the existing operating financing schemes. Besides, information on current business environment helps in developing sector perspective through these meetings.

Detailed design of technical assistance finance facility to commence. The main purpose of this facility will be to support growth of SCTs in the commercial & residential sector in India. The project team proposes to continue working with select stakeholder organisations to evolve new ideas and refine solutions arrived during the stakeholder consultation phase. The detailed TA design will outline features of each element and modalities of implementation including indicative budget. E.g. awareness building and communication programme will describe principal media to be used, communication message and indicative partners.

Stakeholder re-consultations to share & collaborate on TA design. Once the TA facility design is relatively mature, relevant sustainable cooling ecosystem stakeholders will be re-consulted to ensure that their barriers were heard, and are addressed by the TA facility. These re-consultations will also help in developing partnerships with the TA facility for eventual actions in the sector, and act as promotion vehicles for the facility.

It is proposed to develop a few pilot demonstration projects that lie in the project-solution intersections. These projects could be implemented in collaboration with the Smart & Sustainable Space Cooling Coalition, and a consortium of developers, SCT suppliers and financial institutions. Several developers in Mumbai & Pune have shown interest in the demonstration projects.

The present effort under this initiative also **explore the possibility of establishing a dedicated fund for financing projects based on SCTs**. Innovative financing structures could be designed for financing SCTs with possible association of ESCOs.

The discussions at the workshop gave much needed impetus to stakeholder consultation process which will help achieving the objectives of the initiative.

Annex – A: Residential-Sector Workshop Agenda

Day 1 (15 Dec):
Intention:

1. Create a safe, non-judgmental space for participants.
2. Build rapport and introduce workshop format and purpose
3. Environmentalism is not as radical an idea as it might seem. Share Bill McKibben quote on how environmentalists are thought of as asking for radical change. But really, what is changing the natural environment totally is business-as-usual, and that is what is radical. Environmentalism is actually asking us to stick with what Nature has made available for free.
4. To counter the goliath of climate change, we often assume we need to scale to the same size as well. We need to find where the basis for these global forces is weakest and focus on these areas.
5. Don't want to portray sustainability as a value-add for your company (Builder, FI, ESCO, SCT Supplier) which helps you differentiate, have to find marketing differences elsewhere, this is about it being a code of practice or best practice.
6. Get them to recognise that they are living in an example of sustainability - Govardhan Eco-Village story / Walk around the campus.

Table 2: Residential-Sector Workshop flow on Day 1

Sr. No	Duration	Activity
1.1	12 noon - 2 pm	Arrival
1.2	3:30 pm - 4:30 pm	Visit to facilities around the campus (sewage treatment plant)
1.3	4:30 pm - 5:15 pm	Personal introductions & safe Space, commitment to fellow participants
1.4	5:15 pm - 6:30 pm	1-on-1 Interviews *(mutual interviewing by Builders/FI/ESCO Group Members)*
1.5	6:30 pm – 7 pm	Understanding workshop format / why we're here / intention-setting
1.6	7 pm - 7:30 pm	Check out - share thoughts/reflect on what's learned

Day 2 (16 December):
Intention:

1. Participants understand, and carry throughout the day, why this is important
2. Understand the complex web of activities, and see their role in this web
3. Acknowledging there are limits or that there is a crisis of limit
4. Each participant analyses own, and their groups', situation as to why (what barriers) SCT adoption has not been mainstreamed
5. All participants understand the barriers that their group face, and agree on joint barriers faced by their community
6. All communities understand the barriers faced by the other communities
7. All participants work creatively to come up with approaches/actions to address the barriers faced by their own community, and other communities

Table 3: Residential-Sector Workshop flow on Day 2

Sr. No	Duration	Activity
2.1	9:30-9:45 am	Check-In, share learning from Day 1, Intention for the Day
2.2	9:45-10 am	Vision setting + presentation by Ms. Yekbun Gurgoz, CCAC (Introduction to the Project - Reduced Short-lived Climate Pollutants (SLCPs) in India
2.3	10-11 am	Presentation on a Green City by Mr. Sandeep Sonigra – Orange County
2.4	11 - 11:45 am	Presentation on Initial findings of Cost Benefit Analysis conducted by Frankfurt School of Finance & Management by Ms. Srishti Gupta

2.5	11:45 am - 1 pm	Break - Reflection
	1 pm - 2:15 pm	Fear mapping *(mapping apprehensions about changing the status quo of cooling in stakeholder-specific contexts)*
2.6	2:30 - 3:30 pm	Lunch break
2.7	3:30 pm – 5:30 pm	Parallel group sessions
	5:30 pm - 6:00 pm	Break
2.8	6:00 pm - 6:45 pm	Group facilitators summarize dialogs and present as themes for reflection
2.9	6:45 pm - 7:30 pm	Check out / Reflection
	7:30 pm - 8:30 pm	Dinner

Day 3 (17 Dec):

Intention:

1. Each community reflects on the approaches & actions identified in Day 2 to see how they can be enhanced to truly overcome their barriers
2. Each community identifies/agrees on key approaches & actions that will help them overcome their barriers, and the HOW to do so (including help required within and outside their communities).
3. Formulate and agree on a best-practice to stay in touch. Also, when is a good time to check-in

Table 4: Residential-Sector Workshop flow on Day 3

Sr. No	Duration	Activity
3.1	9:15 am - 9:45 am	Check-In, intention for the Day
3.2	9:45 am – 10:15 am	Group activity
3.3	10:15 am - 11:30 am	Intersection (Builders + FI/ESCO) session 1
	11:30 am - 11:45 am	Break
3.4	11:45 am - 1:00 pm	Intersection (Builders + SCT) session 2
	1 pm - 2 pm	Lunch
3.5	2 pm - 3 pm	Check-out: reflections & learnings, commitment to fellow participants
3.6	3 pm	Departure

Annex – B: Residential-Sector Workshop Participants

Table 5: List of Residential-Sector Workshop Participants

People	Organization Name	Sector	Email ID
Sameer Kulkarni	TataCleanTech	Financial Institution	sameer.kulkarni@tatacapital.com
Sandeep Sonigra	Orange County	Builders	ssonigra@yahoo.com
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Saranya Acharya	cBalance Solutions	Team	saranya@cbalance.in

Annex – C: IT-Sector Workshop Agenda

Table 6: IT-Sector Workshop Agenda

Duration	Activity	Presenter
10:00 – 10:30 am	Registration	
10:30 – 10:45 am	Welcome, Outline of the day's Programme and round of introductions	Vivek Gilani, cBalance
10:45 – 11:00 am	Introduction to CCAC and its initiative	Yekbun Gurgoz, UNEP-CCAC
11:00 – 11:30 am	Outline of the SCTs initiative, partners, roles, end results and status of implementation	Hirak Al-Hammad, Frankfurt School
11:30 – 11:45 am	Coffee / Tea Break	
11:45 – 12:45 pm	Introduction to SCTs and the urgency to adopt SCTs	Vivek Gilani, cBalance
12:45– 01:45 pm	Exploration of barriers to SCTs adoption in break-out groups	Facilitators, Note Takers
1:45 – 02:45 pm	Lunch Break and Networking	
2:45 – 03:45 pm	Intersection Dialogs to identify causes of adoption barriers	Facilitators, Note Takers
3:45 – 04:15 pm	Success stories of IT and Commercial Buildings sector – Early adopters	Guruprakash Sastry, Infosys
4:15 – 04:45 pm	Leapfrogging Energy Efficiency Benchmarks through Green Buildings	S. Srinivas, CII GBC
4:45 – 05:00 pm	Coffee / Tea Break	
5 – 05:45 pm	Open discussion, Summary and Conclusion	Vivek Gilani, cBalance
5:45 – 06:00 pm	Next steps and Close	Sanjeev Tamhane, Frankfurt School Yekbun Gurgoz, UNEP-CCAC

Annex – D: IT-Sector Workshop Participants

Table 6: IT-Sector Workshop Participant List

People	Organization Name	Sector	Email ID
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