Ministry of Power
Government of India

Schweizerische Eidgenossenschaft
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Swiss Agency for Development and Cooperation SDC

BEEP Integrated Design Charrettes: Methodology and Learnings

BEEP
BUILDING ENERGY EFFICIENCY PROJECT

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CHAPTER 1
BEGINNINGS

1. BEGINNINGS

The Indo-Swiss Building Energy Efficiency Project (BEEP) was a 14-year (December 2008–December 2022) bilateral cooperation project between the Ministry of Power (MoP), Government of India, and the Federal Department of Foreign Affairs (FDFA) of the Swiss Federation. BEEP was ideated soon after the launch of the first Energy Conservation Building Code (ECBC) in 2007 for commercial buildings.

The idea of an Indo-Swiss project on building energy efficiency originated during exchanges with the Bureau of Energy Efficiency (BEE), India, as part of programme development in the framework of Partnership Programme India in 2007. A workshop on energy efficient buildings was organised jointly by BEE, Swiss Agency for Development and Cooperation (SDC), and The Energy and Resources Institute (TERI) during Delhi Sustainable Development Summit (DSDS) on 8th February 2008. The objective of the event was to identify possible actions to be taken to mainstream energy efficient buildings in India and the event was addressed by presentations and inputs from a distinguished panel of Indian and Swiss experts. One of the conclusions of that discussion was that the proposed Swiss-India programme on energy efficiency in buildings has the potential to address the need for capacity building, develop design guildelines and develop an Indian building energy label for residential buildings.

The preparation and pilot action for an Indo-Swiss programme on building energy efficiency was done between 2008 and 2011 culminating with the signing of a Memorandum of Understanding between Swiss Federal Department of Foreign Affairs (FDFA) and the Indian Ministry of Power. This signalled the official start of the Indo-Swiss Building Energy Efficiency Project on 8th November 2011. The overall objective of the project was to reduce energy consumption in new buildings in India, the specific objective was to build capacities and knowledge of 'builders, architects, engineers, labs, institutions, and others, in the area of building energy efficiency in India by utilising Swiss experience and expertise, and by following a multi-stakeholder cooperation process.'

A major focus of BEEP was on working closely with the private sector builders and design professionals in order to build their capacities and to increase their participation and engagement in energy efficient buildings.

1.1 Why BEEP integrated design charrettes?

During the conceptualisation of BEEP, the project team had consultations with some key stakeholders including the two government ministries directly involved, i.e., BEE and MNRE, and DLF (one of the largest organised builders in India). The importance of an integrated design approach was already highlighted to BEE and there was an agreement on the proposed project having activities on 'Technical training of architects/engineers in integrated energy-efficiency building design'.

The meeting with DLF was important because it identified that a 2–3-day intense design workshop (integrated design process charrette) may be the best way to influence the design of the buildings with mainstream builders who have a very short time period for designing the building, while also training the design team.

BEE also supported the idea of charrettes as it increased the engagement with private builders on ECBC and would also improve practical knowledge and experience in energy-efficient building design amongst practising building design professionals.

1.2 What is integrated design? What are charrettes?

Achieving a functional, thermally comfortable building and the amount of energy consumed in a building depends on many factors – all of them are inter-related. The design, construction, and operation and maintenance of buildings also involve multiple stakeholders. All these stakeholders also influence one or more factors that influence the energy consumption in buildings. Thus, there are many inter-relationships in the making of a good energy-efficient building.

The conventional design process is sequential where different specialist design consultants/stakeholders are brought in separately after much of the architectural design has been fixed to give their respective technical inputs. Integrated Design means that most of the stakeholders, if not all, start working on the project together right from the beginning, based on the design brief. Doing this allows to tap the largest energy saving

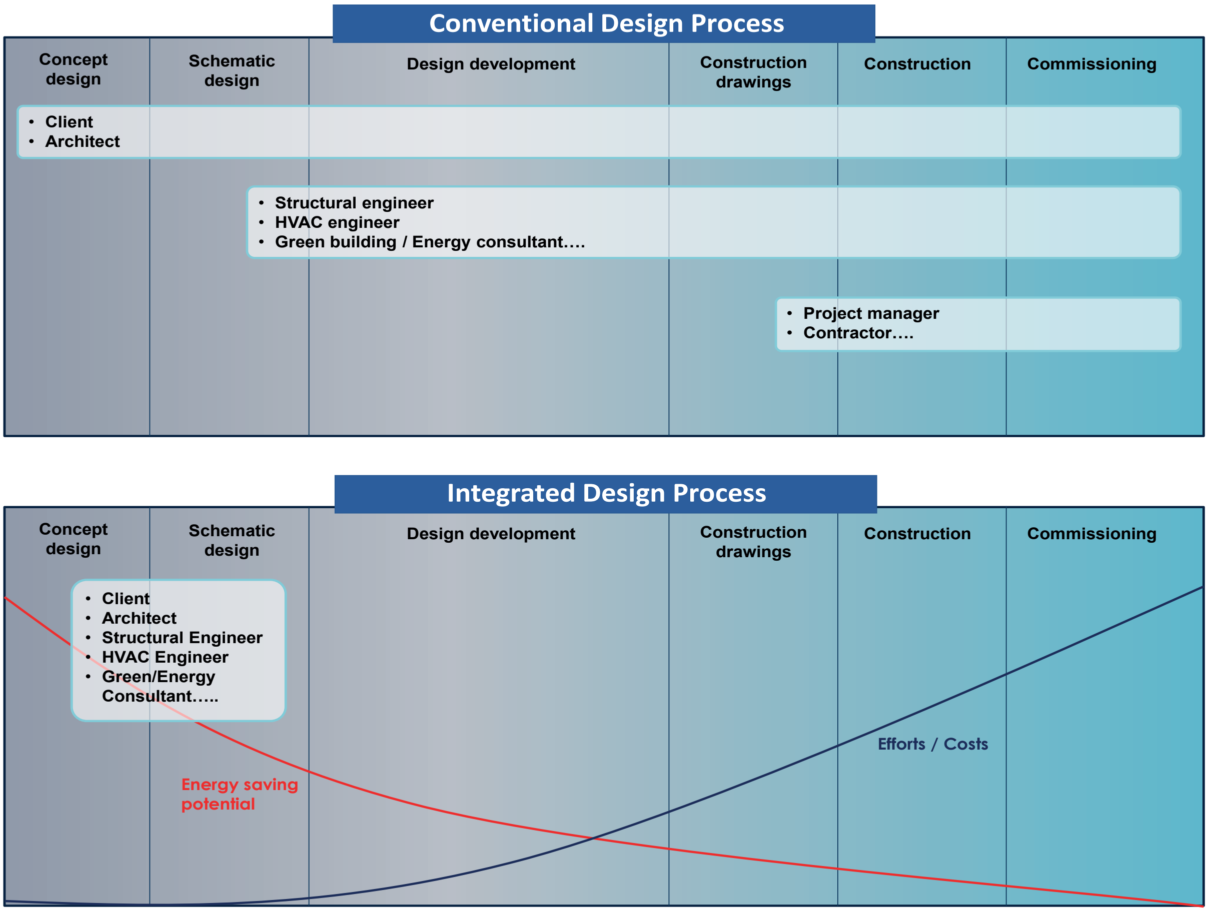


Figure 1. Difference between conventional and integrated design process

potential with minimum effort and cost. This also means that energy goals should be set at the very outset and shared with the whole team.

Integrated design is a procedure considering and optimising the building as an entire system including its technical equipment and surroundings and for the whole lifespan.[1] An integrated design process ensures that specialists of different knowledge streams are introduced at an early stage and takes into account a wide variety of opportunities and options from the very outset. A facilitated discussion on energy around a specific project allows the developer, the end-user, and every member of the design team to brainstorm different solutions to design an energy-efficient building. Availability of skills and knowledge on energy-efficient technologies and energy simulation techniques have to be supplemented by an integrated design process for achieving an optimum energy-efficient building design. Different members of an interdisciplinary design

[1] *International Energy Agency (IEA). 2003: Integrated Design Process guidelines for sustainable and solar optimized building design. Paris: IEA*

team, e.g., architect, HVAC consultant, energy expert, civil contractor, and structural consultant, in close coordination with the builder/developer and the building users, have to effectively work together to develop and implement such a design.

To design a high energy-performance thermally comfortable building, all the factors must be considered; and all the stakeholders must be on-board. An integrated design process is thus required, and the process must be used right from the beginning of the design.

A charrette is a tool to implement an integrated design process, wherein all stakeholders work together in an intense manner over a short time-period. The best and most effective time to have the first charrette is at the conceptual stage of the design, with all or most of the stakeholders (the decision-makers, the people financing the project, the ones designing and constructing, and the ones operating and using it) on board.

The word "Charrette" is a French word, originally meaning a cart. It has evolved to mean a collection of ideas or a session of intense brainstorming.

This happened in the 19th century, when students of L'ecole des Beaux Arts in Paris would ride in the cart sent to retrieve their final art and architecture projects, frantically working together to complete or improve these projects.

Today it implies an intensely focused activity intended to build consensus among participants and develop specific design goals.

Figure 2. What is a charrette?

CHAPTER 2

DESIGNING AND CONDUCTING CHARRETTES

2. DESIGNING AND CONDUCTING CHARRETTES

2.1 Developing the BEEP Charrette methodology

The BEEP Integrated Design Process (IDP) charrettes were developed with the aim of engaging and enhancing the understanding of private builders and developers on the issue of building energy-efficiency by providing assistance to them in developing energy-efficient design of their projects and build capacities of the building design teams.

2.1.1 Overall goal of BEEP IDP charrettes

The overall goal of the BEEP charrettes was to reduce/optimise energy use in buildings and improve thermal comfort.

The charrette methodology was tried out in pilot charrettes carried out with Infosys in 2008 and L&T in 2009. These pilots helped in refining and developing the methodology of the BEEP charrette. The first full charrette was conducted in 2012 with the Shapoorji Pallonji Group.

The BEEP Integrated Design Process (IDP) charrettes were initially held for commercial buildings. In 2015, the Government of India launched the ambitious Pradhan Mantri Awas Yojana, under which 12 million affordable homes were to be built. While future construction in India was always projected to be driven by residential construction, it was at this time that it was accepted that residential construction- just by its sheer quantum, people's aspiration and the growing affordability of the individual AC- would dramatically increase electricity demand in India. Thus, residential projects were also considered for BEEP charrettes.

Commercial buildings	Residential buildings
• Narrow band of expected comfort • Mostly air-conditioned • Air-conditioning used for longer duration and may be used throughout the year • Heat loads in the building may have equal or more contribution from internal loads, i.e. from occupants and equipment	• Broader band of expected comfort • May or may not be air-conditioned • Air-conditioning intermittently during the day and used mainly in summer • Heat loads in the building dominated by external loads i.e., those from the building envelope
⬇	⬇
Charrette goals	**Charrette goals**

• Reduction in Energy Performance Index (EPI), either in comparison to the base design (see section 2.2.1.4) or an existing benchmark EPI, specifically cooling EPI
• Additional parameters evaluated for specific problem identification or problem solving
  - Heat gains from different building components
  - HVAC system size/efficiency
  - Daylight
  - Free cooling potential, etc.
	• Reduction in peak summer internal operative temperature, in comparison to the base design.
	• Minimizing the Discomfort Degree Hours (DDH) mainly in summer, when assessed as per the IMAC (NV) or IMAC (MM) comfort bands
	• Additional parameters evaluated for specific problem identification or problem solving
	  - Heat gains from different building components or building envelope as a whole (RETV: Residential Envelope Transmittance Value)
	  - Cooling energy if the assessed space were air-conditioned
	  - Natural ventilation potential

What is Energy Performance Index (EPI)?

EPI is the annual energy consumption expressed in terms of electrical units, namely kilo-watt hours (kWh) per square metre of the building where this electricity is used. Generally, in India, a building may be drawing electricity from the grid, from a DG set or some form of renewable energy. The renewable energy contribution is usually not included in the EPI calculation.

What is Discomfort Degree Hours (DDH)?

DDH is the sum of hourly temperature differences greater than the maximum threshold temperature and lower than the minimum threshold temperature. In the BEEP charrettes, we used this parameter for naturally ventilated and mixed mode buildings, with the thresholds being the IMAC band for naturally ventilated (NV) and mixed mode (MM) buildings for the concerned location. *IMAC-band maximum temperature indoor, if indoor operative temperature is more than the IMAC-R band maximum temperature*.

What is IMAC?

India Model for Adaptive Thermal Comfort is a standard of adaptive thermal comfort based on Indian specific model guideline to design air conditioned, naturally ventilated and mixed mode buildings. IMAC defines a monthly comfort temperature band (maximum and minimum) for office / commercial buildings for a location, and the IMAC-R defines the same for residential buildings.

2.1.2 BEEP IDP Charrettes: How long and when to organise them

The BEEP IDP charrette was conceptualised as a 3–4-day intensive design workshop, where the participants explored various energy efficiency strategies specific to the project needs. The charrette comprises several working sessions, depending on the project, during which the participants may be divided into smaller groups to work on specific issues. These charrettes depend on various tools for climate analysis, dynamic energy simulation, etc. to help problem-solving, estimate energy savings, and decision-making. While the charrette itself may be conducted over 3–4 days, it is preceded by a charrette preparation phase. After the charrette, follow-up on the decisions of the charrette and further design development is done.

The ideal time of conducting an IDP charrette is during the concept design and schematic design stage. At this stage of the design, the team can choose from a larger pool of strategies, many of which have no cost attached to them, e.g. orientation and massing. If a design charette is conducted at a later stage in the development of the building design where many design elements are now fixed, the possibilities of adopting design options shrink and the desired improvement in the performance of the design will require costly revisions.

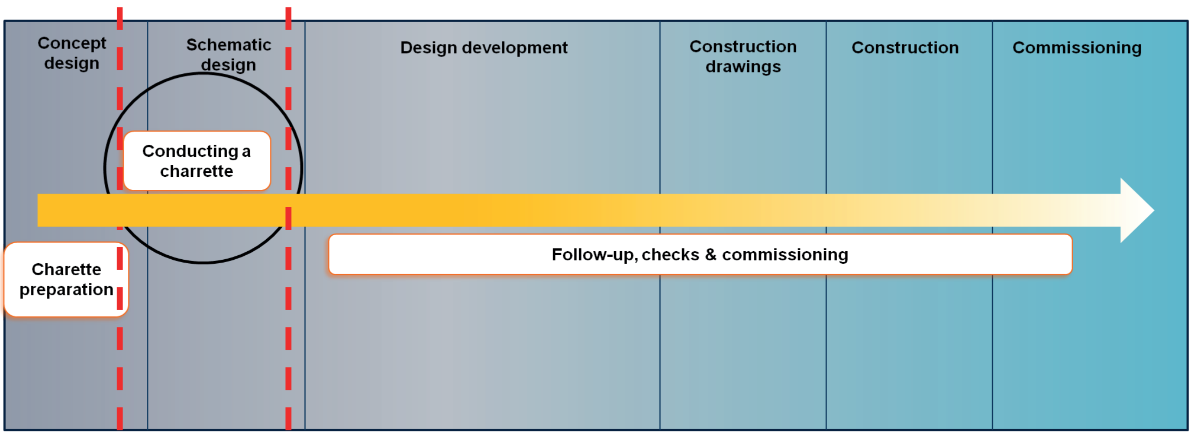


Figure 3. Timeline of BEEP IDP charrette

2.2 BEEP IDP Charrette methodology

PRE-CHARRETTE: PREPARATION	Form charrette organising team and identify charrette participants
	Identify charrette facilitator / moderator
	Collect project information
	Pre-charrette analysis • Climate analysis • Base case analysis • Listing of feasible strategies
	Decide charrette date and develop charrette agenda

CHARRETTE	Day 1: Set the energy / comfort goal
	Day 2: Identify energy efficiency strategies
	Day 3: Test out impact of the strategies
	Day 4: Presentation on impact of strategies and decisions on next steps

POST-CHARRETTE	Charrette debriefing
	Charrette report
	Follow-up discussions or mini-charrettes
	Preparation of final assessment after completion of project and after occu-pation

Figure 4. Flow chart showing the BEEP IDP charrette methodology

2.2.1 Pre-charrette: Preparation

The pre-charrette phase requires careful planning and more time than the charrette itself, as it is here that the information relevant for the objective of a charrette for energy efficient design is collated and prepared. This includes the functional data of the proposed building as well as several preliminary analysis that will aid decision making during the charrette. Following are some of the key steps of the pre-charrette phase followed in the BEEP IDP charrettes.

2.2.1.1 Forming the charrette organising team and identifying charrette participants

An integrated design process includes all relevant actors in the building from the beginning. It is beneficial to have the whole design team onboard from the outset for each of them to gain the same understanding of the context and the vision for the project.

- Charrette organising team: The charrette organising team is the core team that guides the charrette process and is responsible for the organisation of the charrette.

The charrette organising team could be in-house, i.e., from among the participants for the said charrette; or they could be an external organisation hired to organise and conduct the charrette. In the case of the BEEP IDP charrettes, the BEEP charrette team fulfilled this role.

- Charrette participants: The charrette participants should, at the very least, consist of:
  - The client, taking a proactive role in the design process. In their absence, the owner's representative, who knows the client's requirements for the building and its facilities and management
  - Project architect
  - HVAC consultant
  - Project manager
  - Energy and comfort simulation expert. In India, very often this role is fulfilled by the Green Building Consultant. They could also be part of the architect or HVAC consultant's team.
  - Electrical engineer

Other consultants like structural engineer, landscape architect etc. are onboarded initially to the vision and energy / thermal comfort goal for the building. Depending upon the design, the level of their involvement may vary. The contractor and buildings facilities manager, if identified must be part of the charrette. In addition, other experts like lighting specialist, marketing representative for the project, interior designer, etc., may be brought in at appropriate times for their expertise.

BEEP charrette team

The charrette team for BEEP IDP charrettes consisted of a 3–4-member team from BEEP and the project team from the building for which the charrette was being conducted. The BEEP team consisted of:

- Charrette coordinator / facilitator
- An architectural / passive design expert
- An HVAC expert
- An energy and comfort simulation expert

The project team consisted of, at the very least, the client / builder or their representative, project architect, HVAC consultant, project manager, and in several instances the green building consultant.

2.2.1.2 Identifying a charrette facilitator

A charrette facilitator leads the charrette, has a good knowledge and understanding of energy efficient buildings and ensures that the charrette goals are met. Their tasks are to:

- Ensure proper flow of information,
- Help set the charrette goals,
- Encourage participant involvement and challenge them,
- Help prioritise the building performance objectives,
- Overcome conflict, and
- Keep the charrette on track.

While someone from the charrette team, most often the project manager or project architect, can play the role of the charrette facilitator, it is useful to hire an outside facilitator who can remain neutral while fostering discussions and diffusing any conflict between the charrette participants.

In the BEEP Charrettes, the charrette facilitator in most cases was part of the BEEP charrette team.

2.2.1.3 Collect the site and project information

The key to a successful charrette is to have the necessary information before the charrette. The most important of the information is to have the project brief. This includes the estimated size of the project, functions, average number of occupants in the spaces, the time of use of the spaces, lighting and space condition (e.g., temperature and humidity) requirements, and any unique requirements for specific spaces. Annexure 1 shows the list of information collected before any BEEP IDP charrette.

Information necessary before charrette

- Building function
- Location and site area
- Estimated built-up area
- Area programme denoting the spaces inside the building with estimated areas, occupancies and adjacencies to other spaces
- Site map
- Drawings of the conceptual design, including any views, floor plans, elevations, sections, etc.
- First proposal of materials for the building envelope and systems (e.g., conceptual wall sections, HVAC schematic diagram, MEP design basis report, etc.)
- Expected standard of comfort conditions inside the spaces
- Any special concerns or requirements
- Project budget
- Energy efficiency targets / Green building certification targets, if any
- Any sustainability, social or other goals

Other information

- Local regulations
- Relevant policies
- Any reference building(s)
- Specific information related to passive and active strategies for energy efficient buildings

2.2.1.4 Pre-charrette analyses

The objective of pre-charrette analyses is to use the initial information about the building and site to assess thermal comfort inside spaces, estimate energy performance, characterise energy uses, and identify potential energy savings opportunities. During the charrette, the pre-charrette analyses results are presented to the participants. This is used, during the charrette, to develop design concepts that minimise energy consumption and improve thermal comfort.

> The energy performance of a building depends on complex interactions between the outdoor environment, indoor conditions, building envelope, and mechanical systems, so, computer simulation programs are the best tool to perform building energy analyses. A whole-building computer simulation tool that calculates hourly or sub hourly loads for the building is critical.
>
> A Handbook for Planning and Conducting Charrettes for High-Performance Projects, NREL, 2009

Climate analysis

Climate analysis helps identify critical periods in a year by providing information on temperature ranges, humidity levels, solar radiation, and wind characteristics that can affect the building's energy performance. For instance, we can predict when the peak cooling or heating loads may occur, at what times solar radiation can significantly impact the building's energy consumption and identify periods of the year when natural ventilation can be used to reduce cooling loads.

CLIMATE ANALYSIS (BEEP IDP Charrettes)

Selection of weather data

Hourly weather data for each year was obtained from online .epw files. If the data for the required city was not available, the weather data file for the nearest city with a similar climate was utilised instead.

Macro-climate analysis with the Climate Consultant tool

- **Temperature and humidity:** to identify critical cooling or heating months, the dry and humid months and the daily variation in temperature and humidity
- **Month-wise solar radiation intensity (global, diffused, and surface):** showed the intensity of the sun's radiation incident on the roof and surfaces facing different directions for each month
- **Annual and monthly wind speed and wind direction:** to visualise wind speed and direction for different months and across all hours of a typical day in a month. Co-relating it with the temperature and humidity helps identify times of the year as well as time of day when natural ventilation can cool a building, and the corresponding wind directions.

Micro-climate analysis

- **Sun-path diagram with concept design (if available) and surrounding buildings:** gave an idea of the time of exposure of each surface and impact of mutual shading (Tools: Ecotect / Rhino with Grasshopper)
- **Incident solar radiation analysis:** to visualise intensity of incident solar radiation of different building surfaces and impact of any mutual shading (Tools: Rhino with Grasshopper)
- **Site level CFD analysis:** to see wind access on different faces of the building (Tools: BEEP Vayu Pravah)

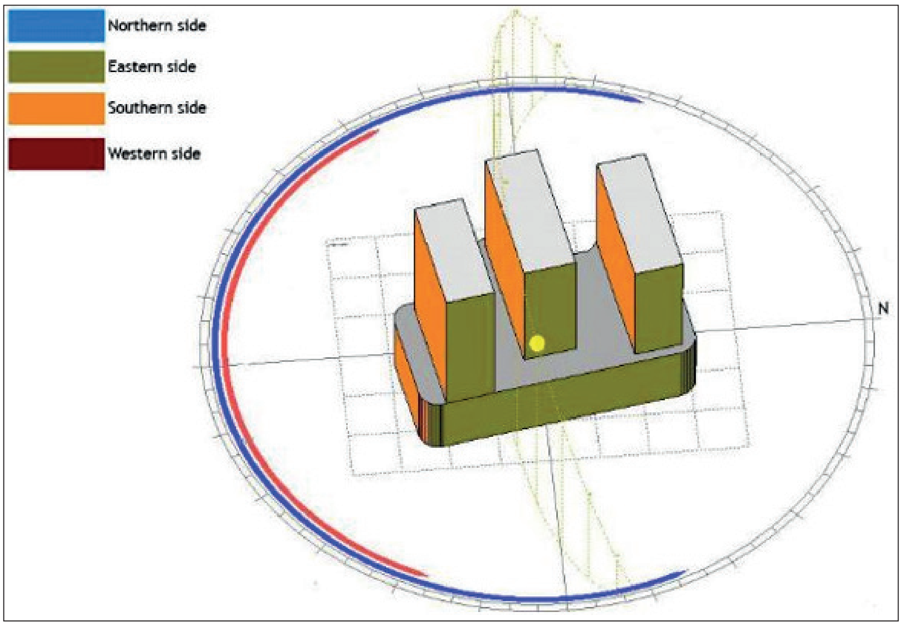


Figure 5. Solar exposure of different external surfaces seen using sun-path diagram tool and view from sun tool on Ecotect

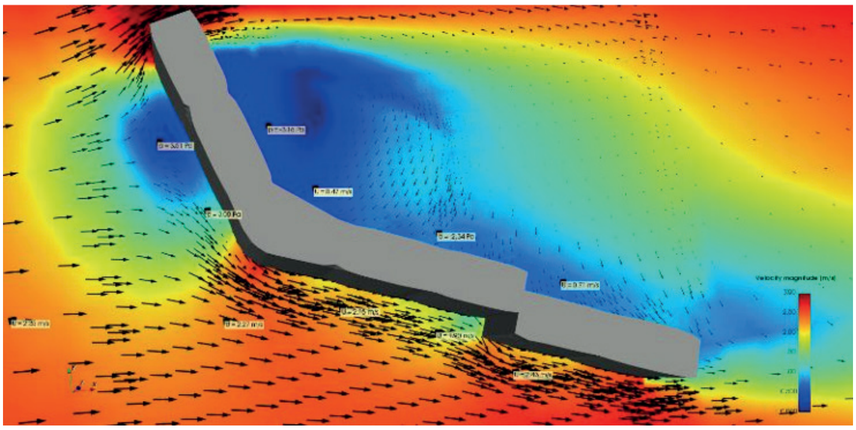


Figure 6. Wind access on different building facades seen using the Vayu-Pravah tool

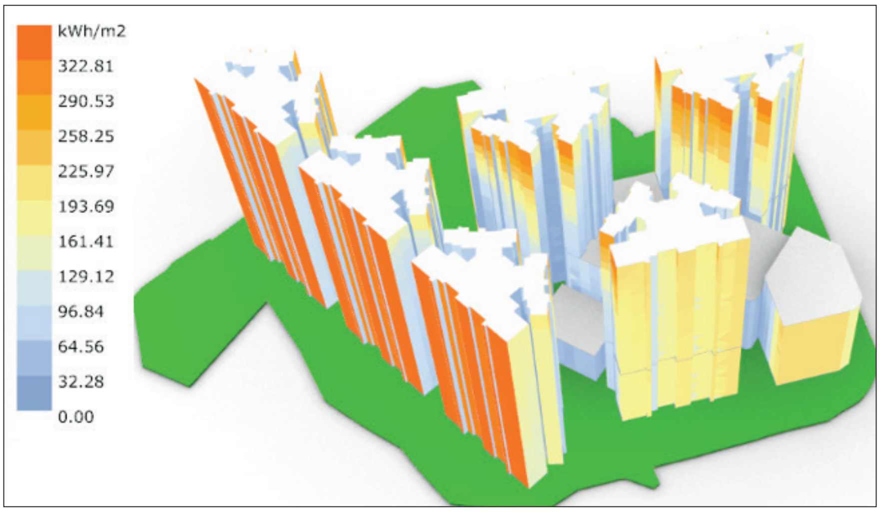


Figure 7. Incident solar radiation on different external surfaces analysed using Rhino + Grasshopper

Base case analysis

Base case analysis characterises the energy uses that would be expected if the building were to be built in the conventional way or to the minimum mandatory code requirement. Alternatively, the base case would be the building design and its walling and roofing materials and construction as proposed by the developer. If the charrette is organised at the concept design stage, the architecture and geometry have not yet been decided. The base case building is, therefore, merely a box that meets all the owner's program and flow requirements.

The base case analysis generates several results that are used during the charrette.

Table 1. Energy and comfort outputs analysed in BEEP IDP charrettes

For commercial buildings	For residential buildings
• Estimated Energy Performance Index (EPI) of the building • Breakdown of energy end-use • Seasonal or monthly energy use, which is very relevant for cooling and heating energy use • Heat balance of the building, which gives the heat gains and losses through the building envelope and the internal heat gains. This shows if the building is external load dominated and what element of the building needs to be prioritised. • Peak demand, specifically peak cooling / heating demand • Daylighting levels in important spaces	• Internal operative temperature • Degree Discomfort Hours • Heat balance of the building to show the heat gains/losses from different building envelope components • Cooling/heating demand, if the building were to be air-conditioned • Daylighting levels in important spaces • RETV

These analyses are performed with computer simulation tools. In the BEEP IDP Charrettes, DesignBuilder was used as the main simulation tool, to generate the above results. Other tools like FloVent and TRNSYS were used to simulate and address specific aspects, systems or issues in the building design.

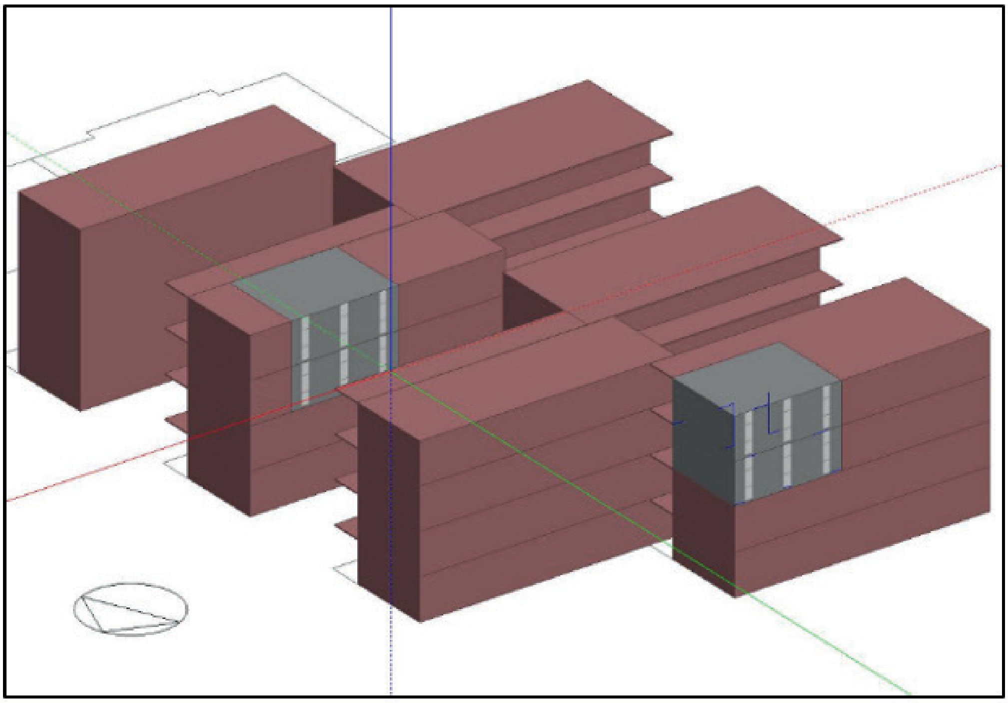


Figure 8. Model of the building developed in DesignBuilder for base case analysis and proposed energy efficiency strategies

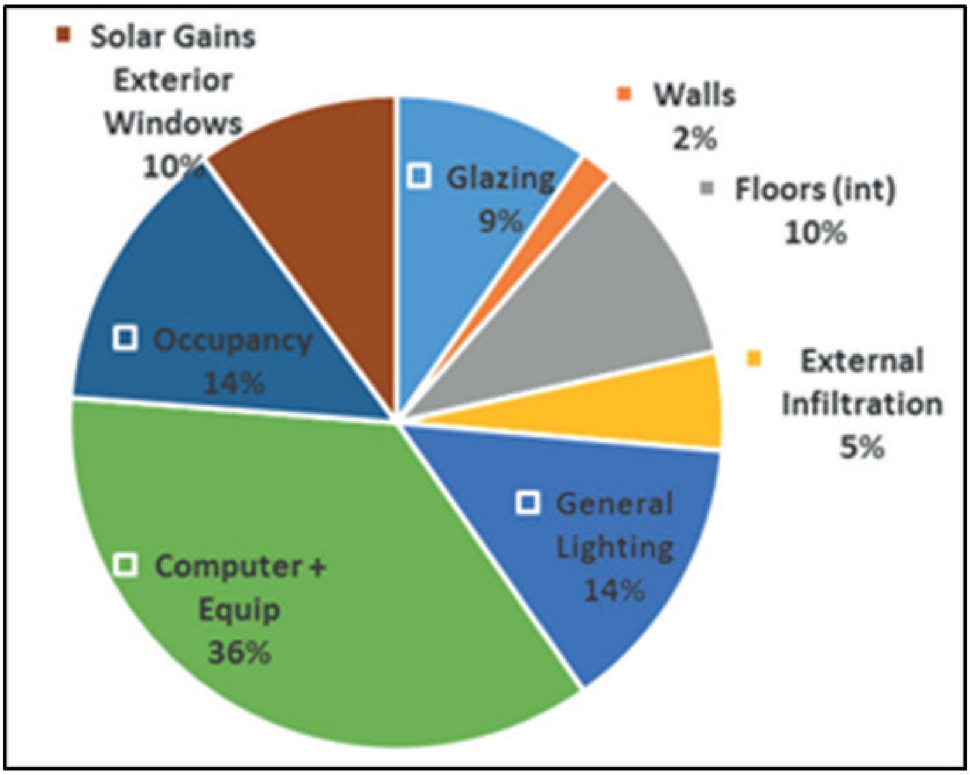


Figure 9. Example of heat balance result of a commercial building
This example shows that internal gains from equipment and occupants and external heat gains from the glazing are the major contributors of heat in this building.

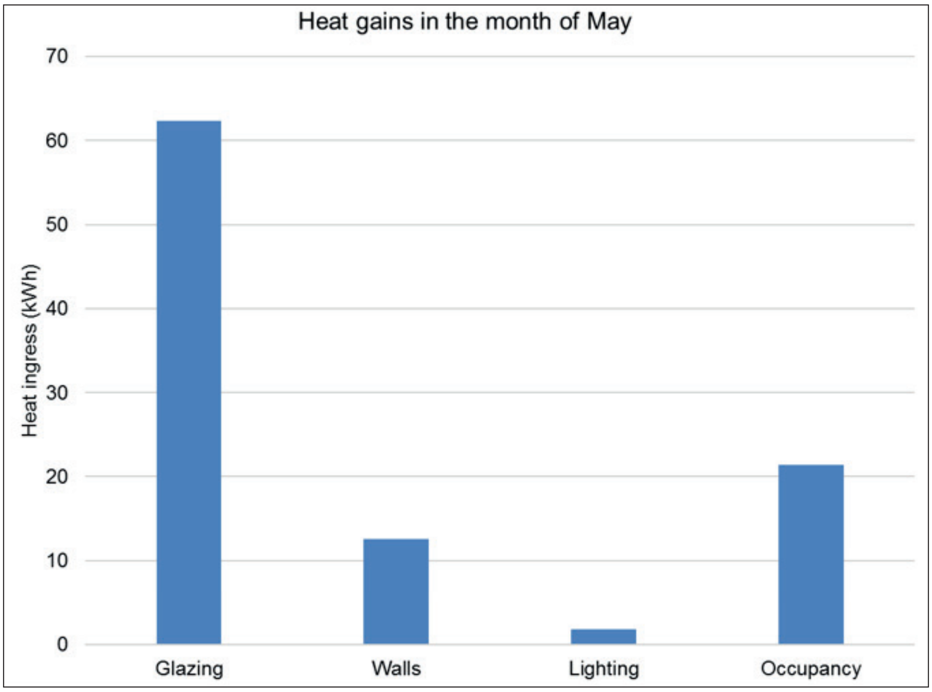


Figure 10. Example of heat balance of a residential building
In this example, the focus was on the hot months, hence the analysis was done for the month of May. Here the major contributors of heat gains are from the building envelope, namely the glazing and walls.

Make a list of feasible strategies

The design of energy efficient buildings really is about doing three things: (a) reduce energy demand (through passive strategies); (b) use efficient systems so that we get more for less use of electricity (efficient HVAC, lighting, and other equipment), and (c) source as much of our now-reduced electricity from renewable sources.

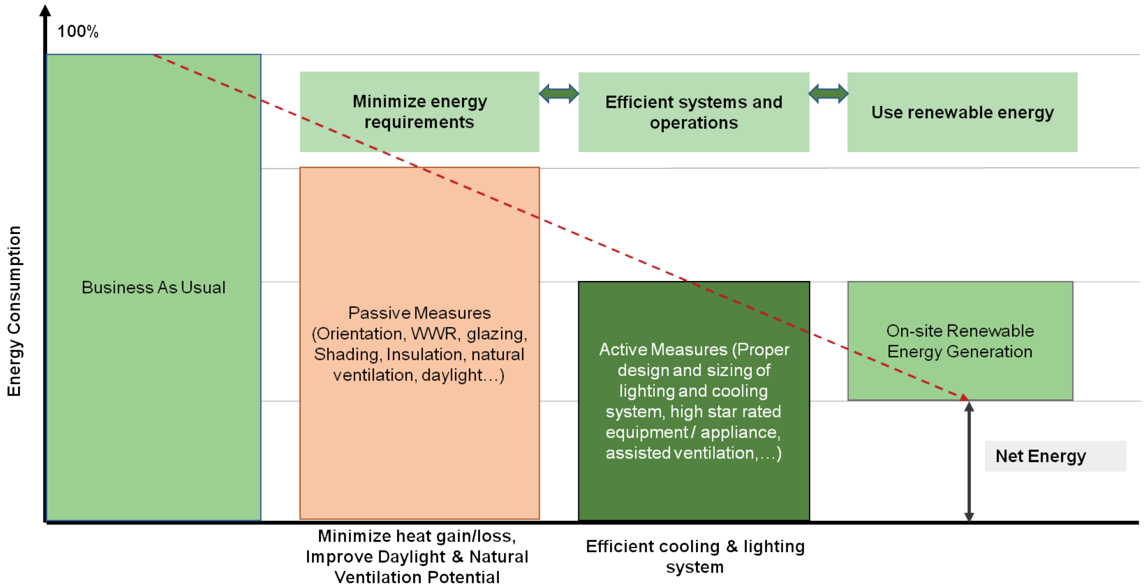


Figure 11. Steps in designing an energy efficient building

The list of feasible strategies will vary by project. The experience and expertise of the charrette participants, the climate analysis, and the base case analysis results will suggest favourable strategies. Some of the common strategies are shown in Table 2.

Table 2. Some of the common strategies to design energy efficient buildings

Passive strategies	Active strategies	Renewable energy
• Insulating walls and roofs • Shading of glazed widows and facades • Reflective or High SRI finishes for roof and walls • Optimise glazed area • Orientation • Window design for better natural ventilation and daylighting • Night cooling • Daylight controls	• Free cooling • Increase in setpoint temperatures • Water-based HVAC system instead of air-based system • Heat or Enthalpy recovery • Use of Variable Flow Drives in fans and pumps • Using high-efficiency or high-performance cooling equipment like chillers • Evaporative cooling in dry locations • Low energy cooling systems like radiant cooling, etc. where feasible	• Roof-top solar PV • Roof-top solar water heater • Hybrid wind + solar energy systems

In the BEEP IDP Charrettes, a list of the feasible strategies was created before the charrette, with explanations of each strategy through diagrams and descriptions. Application and impact of these strategies in other buildings were also collated.

Energy performance is closely tied to other environmental performance measures such as carbon emissions, water use, and IAQ. If any of these aspects are priorities for the project, they need to be taken into consideration during the base case analysis and while deciding on the energy efficiency strategies for the project.

2.2.1.5 Decide on charrette date and develop the charrette agenda

This entails setting the dates of the charrette ensuring availability of all charrette participants. A preliminary agenda is prepared, which is finalised after agreement from all participants. This is then communicated to all participants along with travel, accommodation, and other logistical details.

BEEP IDP Charrettes were usually held over 3–4 days and the general agenda followed is shown in Section 2.2.2.

Venue of BEEP IDP Charrettes

BEEP IDP Charrettes were usually held at the office of the client / builder. The charrettes required a larger meeting / conference room and smaller rooms or separate tables within the larger meeting room for breakout group discussions.

Supplies and equipment for BEEP IDP Charrettes

- Projector and screen
- Whiteboards and markers
- Hard copies of project drawings
- Tracing paper, graph paper, etc. and pencils, markers, etc

2.2.2 Conducting the charrette

4-DAY BEEP CHARRETTE AGENDA

Day 1

Objective: Set the energy / comfort goal

- Welcome and introduction (Charrette facilitator)
- Project overview (Client / Architect)
- Base case and climate analysis presentation (Energy and comfort simulation expert)
- Discussion and setting of energy / comfort goals (moderated by charrette facilitator)
- Presentation on list of possible strategies (Energy and comfort simulation expert)

Day 2

Objective: Identify energy efficiency strategies

- Discussion on passive and active strategies appropriate for the project (conducted in break-out groups)
- Detail out the strategies in the context of the building to the extent possible through diagrams, sketches, doodles, etc. (conducted in break-out groups)
- Discuss the identified strategies together in the larger group (moderated by the charrette facilitator)

Day 3

Objective: Test out the impact of the strategies

- Dynamic energy simulations to quantify the impact of each identified strategy (Energy and comfort simulation expert)
- Parametric studies to test individual strategies and combination of strategies (Energy and comfort simulation expert)
- Computational Fluid Dynamics (CFD) analysis for evaluating special strategies (Energy and comfort simulation expert)
- Cost impact of the identified strategies (relevant consultant or cost consultant)
- Development of any alternative design features to incorporate identified strategies (relevant consultant)
- Discussion with external expert or any manufacturer, as required, for further information on identified strategies

Day 4

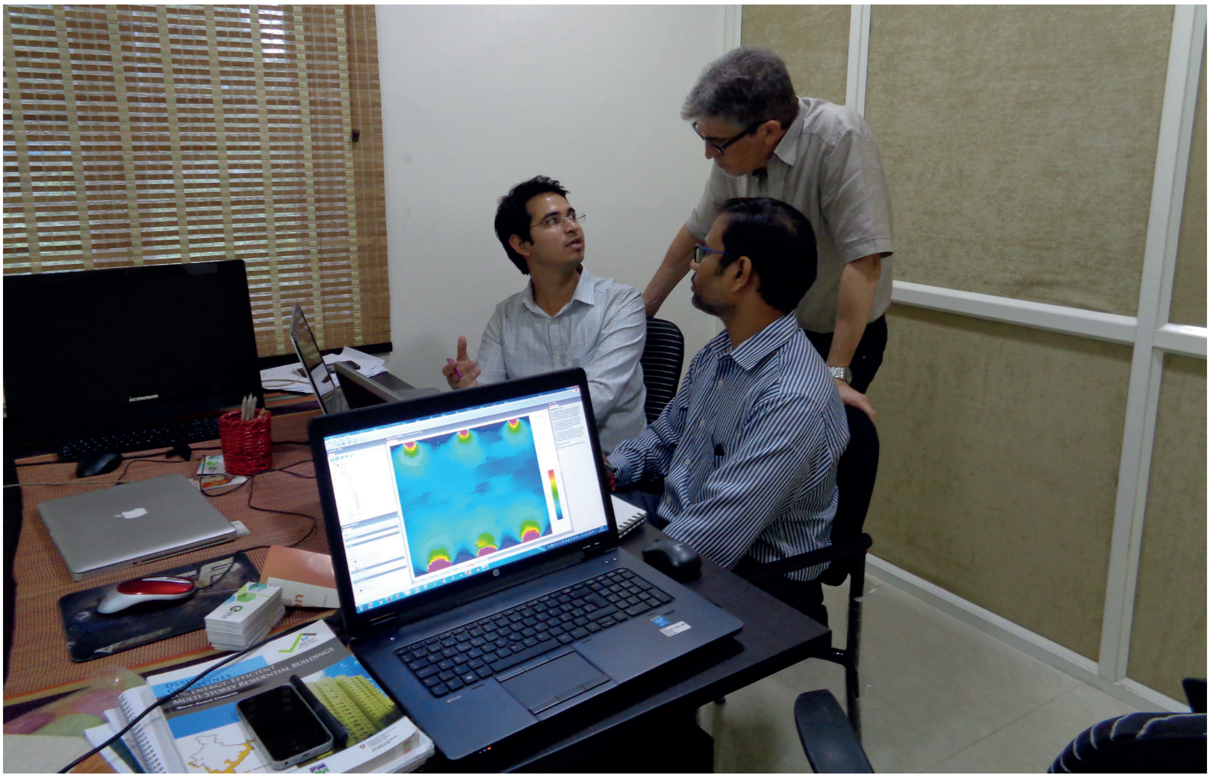
Objective: Presentation on impact of strategies and decisions on next steps

- Presentation of all impacts of the identified strategies (Energy and comfort simulation expert, relevant consultants)
- Decision on final energy efficiency strategies for the building (moderated by charrette facilitator, driven mainly by client)
- Enlisting of next steps

Figure 12. Typical agenda of a 4-day BEEP IDP charrette


CLIMATE CONTROL SOLUTIONS
1. Natural ventilation
• User-managed natural ventilation, through windows on façade and in some cases cross-ventilation
• Use the staircase as a chimney
2. Cooling Solutions
• Evaporative Cooling using corridor downdraft :
✓ To reduce glazing on corridor
✓ Eg Chandigarh
• Freecooling for conference and auditorium
POWER
Panasonic
TOSHIBA


IMMEDIATE OPERATIONAL ACTIONS
NEAR-TERM OPS. ACTIONS
FUTURE OPS. ACTIONS



2.2.3 Post Charrette

Charrette debriefing: The charrette organising team conducts a debriefing meeting to discuss the outcomes, clarify the next steps agreed on the last day of the charrette and assign responsibilities for the next steps.

Prepare a Charrette Report: A written report is developed summarising the charrette and its results. This report also includes the responsibilities assigned for the follow-up action points. It should ideally also contain a letter of commitment from the client, which promotes acceptance of the charrette results.

The report should also have the list of final strategies with the action points for implementation or further evaluation of the strategies.

Follow-up discussions or mini-charrettes, if required: In the design development phase, one may require smaller discussions to detail out the implementation of the finalised strategies.

Prepare a final assessment after the completion of the project and after occupation.

Aranya Bhawan, Jaipur

Aranya Bhawan, the office building of the Rajasthan Forest Department in Jaipur, was one of the first projects selected for the BEEP Integrated Design Charrette and the charrette was held in December 2012. The project was implemented by the Rajasthan State Road Development Corporation Limited (RSRDC) and was inaugurated on 23 March 2015.

Project details

- Built-up area: ~10,000 m^2 (excluding basement parking and service area)
- Number of floors: Five (G+4) + one basement level for parking and services
- Number of users: 344
- Types of spaces: Offices, museum, library, auditorium, guest rooms
- Operation: Day-use, air-conditioned
- Climate zone: Composite

Charrette goals

- ECBC compliance
- BEE 5-star rating, i.e., EPI less than 90 kWh/m^2/annum.

Recommended strategies

- Polyurethane Foam (PUF) insulation is used over the roof slab to reduce heat transfer. Light-coloured terrazo tile finish reflects some of the solar radiation falling on the roof.
- Extruded Polystyrene (XPS) insulation is used in the cavity walls to reduce heat transfer.
- Double Glazed Unit in windows with low-e outer pane
- A centralised high-efficiency water-cooled chiller was implemented for air conditioning
- the building instead of an air-cooled system. Given the water scarcity in Jaipur, treated waste water is used in this system.
- A 45-kWp grid-connected roof-top solar PV system with net metering. The estimated annual electricity generation is about 60,000 kWh.

Impact

- Base case EPI (pre-charrette): 77 kWh/m^2.year
- EPI estimated with the strategies during the charrette: 53 kWh/m^2.year
- EPI measured after 1 year of operation: 43 kWh/m^2.year
- 44% annual electricity savings

Smart GHAR I II, Rajkot

Smart GHAR III (Green Homes at Affordable Rate), now known as Lakshman Township, is an affordable housing project in Rajkot under the Pradhan Mantri Awas Yojana (PMAY). The project was executed by the Rajkot Municipal Corporation (RMC). The charrette for this project was held in September 2016 and it was the 18th BEEP charrette. The project was completed in 2019.

Project details

- Built-up area: 57,408 m^2
- Number of floors: Stilt + 7
- Number of dwelling units (DU): 1176 (all 1 BHK)
- Built-up area per DU: 33.6 m^2
- Carpet area per DU: 28 m^2
- 11 residential towers
- The project had already planned to use Autoclaved Aerated Concrete (AAC) blocks as the walling material

Charrette goals

- Provide acceptable comfort by reducing the duration of time when indoor temperatures are above 30°
- Reduce heat gains through the building envelope
- Utilise and improve potential of natural ventilation for better cooling

Recommended strategies

- Polyurethane Foam (PUF) insulation on the roof slab. However, this was not used.
- China-mosaic finish on the roof
- Taller, partially glazed and casement windows instead of fully glazed sliding windows
- Assisted ventilation shafts with low-energy fans on top of the existing common shafts. This feature would create negative pressure in the shaft (with / without ambient wind) improving air-change through the flats. This concept was tested in one of the shafts and not implemented throughout the project.

Impact

- Reduction of peak summer room temperature by >5 °C. A reduction from 39 °C to 33 °C was estimated in the simulations. Actual monitoring in May 2019 showed an average maximum temperature of 32 °C.
- Estimated increase in the number of hours below 30 °C from ~2600 hours to ~6300 hours.

Ela Green School, Chennai

Ela Green School is a private, co-ed independent school with students from play school to Class VIII, with plans to expand to Class XII. It has been conceived as a green school and aspires to help students imbibe the concepts of sustainable living. The charrette for this project was held in July 2017 and this was the 20th BEEP charrette.

Project details

- Built-up area: ~7900 m^2
- Number of floors: G + 3
- Occupancy period: 8 am to 3 pm
- Types of spaces: One administrative block, and seven interconnected blocks with classrooms, labs, seminar rooms, halls, auditorium, etc.
- Operation: Day-use, mixed-mode
- Climate zone: Warm-humid
- The project had already planned to use pre-fab insulated wall panels, roof insulation, and double-glazed windows before the charrette

Charrette goals

- Increase comfortable hours through passive strategies and ventilation, i.e., without the use of air-conditioning
- Improve the efficiency of the air-conditioning system
- Improve daylight in the classrooms

Recommended strategies

- Increased openable area of windows
- Increase roof insulation, decreasing the U-value of the roof from 0.74 $W/m^2.K$ to 0.5 $W/m^2.K$
- Assisted ventilation shafts with turbo ventilators on top to improve ventilation potential. In air-conditioning mode, these shafts can serve the purpose of fresh air distribution ducts.
- Use of enthalpy recovery wheel
- Increasing air-conditioning set-point to 28 °C, with the use of ceiling fans

Impact

- Number of comfortable hours during occupancy period doubled from the base case through passive measures and assisted ventilation (increased from 22% to 44%)
- 24% reduction in air-conditioning load
- 27% reduction in EPI, if the building is air-conditioned throughout the year

Jupiter Hospital, Pune

Jupiter Hospital in Pune is a 350-bed multi-specialty hospital in Pune. This BEEP charrette for this project was held in February 2014 and it was the 8th BEEP charrette, The project was completed in December 2016.

Project details

- Built-up area: 26,580 m^2 (excluding parking and service floor)
- Number of floors: G + 8, 3 underground floors and 1 service floor
- Types of spaces: Technical areas like MRI, ICUs, Cath lab, OTs; patient indoor rooms
- and recovery rooms; restaurants, emergency rooms, etc.

Charrette goals

- Propose energy efficiency measures to save energy and reduce pollution, while maintain the foot print and general layout of the buildings as the architectural design was finalised
- Keep balance between initial capital cost and maintenance cost.

Recommended strategies

- 100-mm extruded polystyrene (XPS) insulation is used on the roof (0.31 W/m^2.K)
- 150-mm Autoclaved Aerated Concrete (AAC) blocks are used as the walling material. (0.9 W/m^2.K)
- Double glazed units with U-value of 2.8 W/m^2.K
- Use of dynamic energy simulation software for chiller plant sizing instead of simplified calculation based on static design conditions. Installed chiller capacity is 560 TR (280 x 3 nos, 2 working + 1 standby).
- Enthalpy recovery wheel (75% effectiveness) for both latent and sensible heat recovery were integrated in the fresh air AHUs.
- Condenser water is used for reheating the air in AHUs for maintaining the relative humidity. Backup hot water is provided by a heat pump system with a COP of 2.81.
- Patient floors have the provision of free cooling.

Impact

- Base case EPI (pre-charrette): 154 kWh/m^2.year
- EPI estimated with the strategies during the charrette: 130 kWh/m^2.year (excluding sewage treatment plant, outdoor lighting, and basement ventilation)
- EPI measured after 1 year of operation: 136 kWh/m^2.year (all inclusive)
- 12% annual electricity savings

CHAPTER 3

WHAT WORKS DURING A CHARRETTE FOR ENERGY EFFICIENT BUILDING

3 WHAT WORKS DURING A CHARRETTE FOR ENERGY EFFICIENT BUILDING

3.1 Simulation of the whole building is not necessary for design-decisions

In most cases, it is not necessary to simulate the whole building, with all details, to take major decisions for energy efficiency. A good idea about the base case and impact of different strategies can be achieved by simulating:

- a typical floor in the building, or
- the worst affected space, as decided by the charrette team based on their experience
- a representative model made by combining zones with similar kind of activities

This is especially necessary if the charrette being held at a later stage than the concept design stage. In several cases, BEEP IDP charrettes were held for buildings in the schematic design; in a few cases, even for buildings that were in the design development stage where not much could be done about the form and orientation of the building.

Hospital, Pune

This hospital had the following functions on its 9 floors:

- Lower ground, Ground and 1st floor: Pharmacy, restaurants, emergency rooms, electrical rooms, AC plant room, etc.
- 2nd to 4th floor: Technical areas like MRI, ICUs, Cath lab, OTs with circulation and assembly areas
- 5th floor: Service floor
- 6th to 8th floor: Patient indoor rooms and recovery rooms

For developing a model, similar zones are combined to arrive at a simplified 3-storey building model, which represented all types of areas present in the building.

- One technical floor (Zones: Cath lab, MRI, OT, ICUs, Assembly and Circulation)
- One intermediate floor with patient indoors and recovery rooms (Zones: Recovery rooms and circulation) to represent typical floor with patient rooms
- Top floor with patient indoors and recovery rooms. This was done as the top floor will have the added heat gains from the roof.

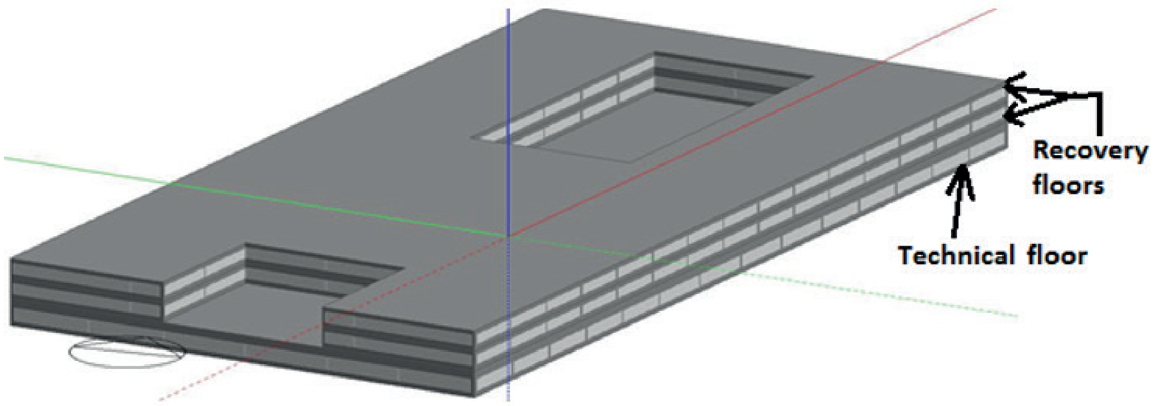


Figure 13. Simplified DesignBuilder model developed to simulate a 9-storey hospital

Residential project, Indore

At the time of the charrette, the design of the township, i.e., layout, all building plans, elevations, had already been fixed. Given these constraints, it was decided to look at specific areas of concern with regard to thermal comfort in the flats and energy efficiency.

As the flats have different orientations and different levels of solar and wind exposure, it was decided to simulate and analyse 4 bedrooms of 4 flats in different orientations. All the remaining spaces and the building blocks were modelled but not simulated. This way we optimise simulation time to get the most important results out of the analysis.

Figure 14. The four bedrooms with different orientations selected to carry out simulations for the base case and proposed strategies in a residential project

Day-use office building, Delhi

This was a G+4-storey building consisting of training halls, offices, library, record rooms, computer labs, and circulation spaces. In order to develop the base case energy performance of the building, one typical intermediate floor, and one top floor were used for energy simulation.

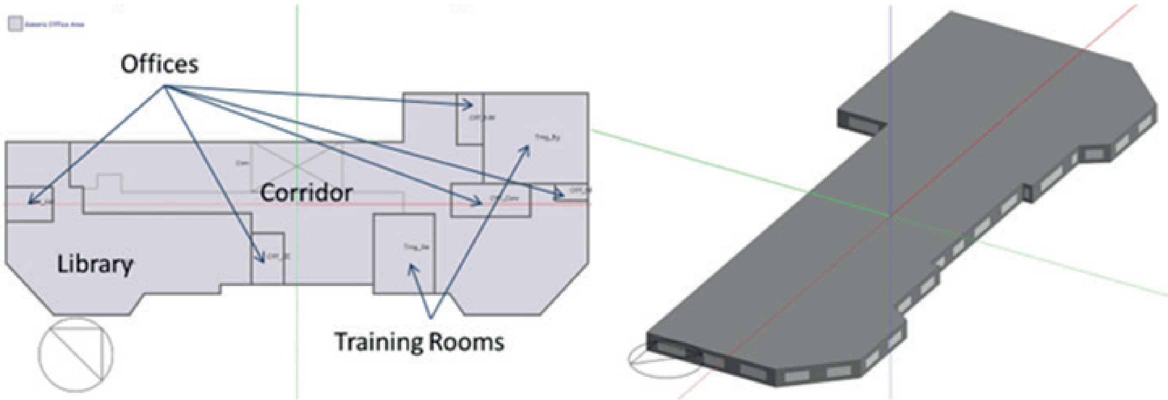


Figure 15. Simplified single floor model used for energy simulation of a day-use office building

3.2 Different building types will have different energy and comfort expectations, leading to different evaluation parameters

For energy efficient building design, one can broadly classify buildings into fully air-conditioned (AC), fully naturally ventilated (NV), and mixed-mode (MM) buildings. The expectation of comfort is different in the three building types. This means the parameter on the basis of which one would evaluate different energy efficiency strategies will differ.

Fully air-conditioned buildings (24/7 and day-use buildings)

- Energy Performance Index (EPI), or more specifically the cooling EPI.
- Cooling load

Cooling energy reduction is the focus of the BEEP IDP as it is the major consumer of electricity in the building, and the building design and materials have a significant impact on the cooling energy consumed. Another important energy end-use is lighting. Availability of daylight and consequent lighting electricity use is evaluated for buildings, especially those where light is crucial and could be a major electricity guzzler if not designed well.

Naturally ventilated buildings

- Peak indoor operative temperature of typical summer day or summer week (for most of India)
- Degree discomfort hours, especially during summer (signifies time and intensity of discomfort)

As NV buildings are not air-conditioned, thermal comfort is dependent on the design and the building envelope. One would evaluate different strategies on the number of hours in a year that the indoor operative temperature within the IMAC (NV) comfort band for the location.

One may also decide to evaluate the Cooling EPI, to see how much energy would be required if the occupants decide to install air-conditioning in the future. The reduction in the required cooling energy could also be interpreted as the cooling energy avoided due to passive strategies.

Mixed mode buildings

For mixed-mode buildings (e.g., residences, schools, and institutions) parameters applicable to both NV and AC buildings are evaluated. In such buildings, there is usually a clear demarcation of the spaces with and without air-conditioning, as well as the time of the year when air-conditioning is used.

Residential project, Rajkot

Energy simulation was carried out to calculate indoor operative temperature, in a typical week in May, inside selected flats, for the base case as well as to evaluate impact of energy efficiency strategies. The peak indoor operative temperatures were compared (Figure 16).

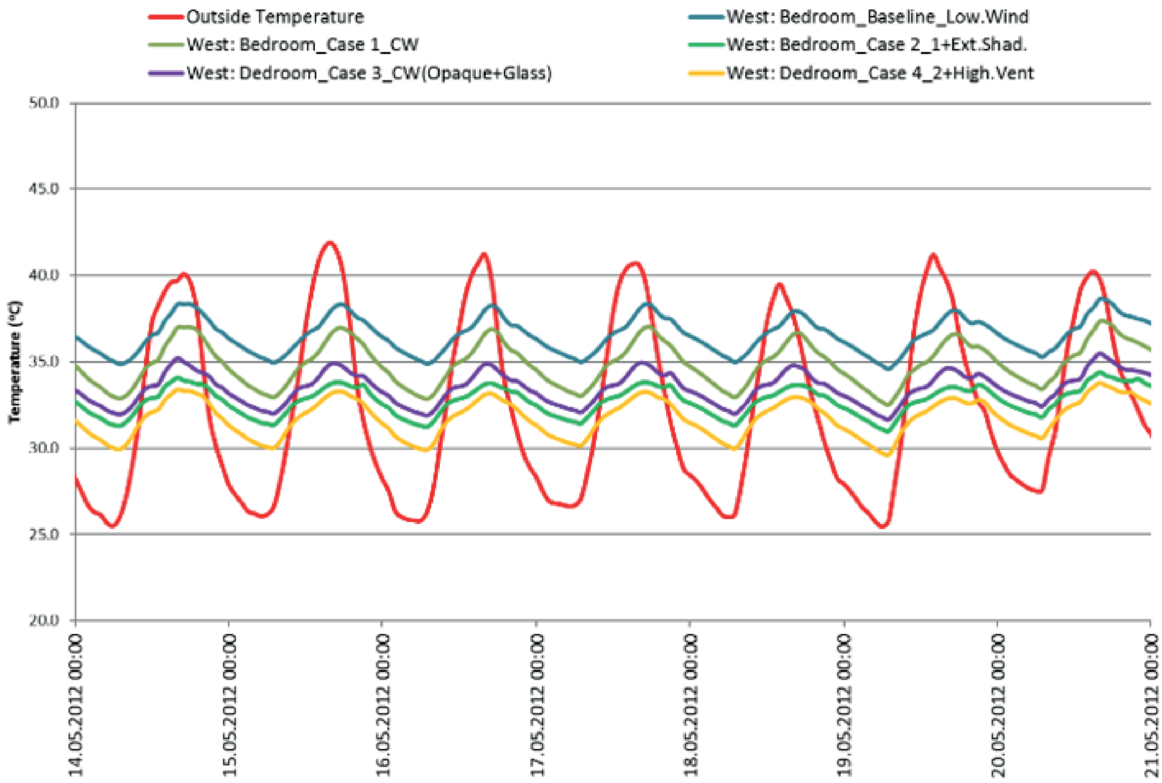


Figure 16. Indoor operative temperatures, in a typical week in May, inside a residential flat, for the base case as well as with proposed energy efficiency strategies

Residential project, Mumbai

Discomfort degree hours (DDH), in the summer months (May–October), was evaluated to compare various strategies with the base case (Case 1) in Figure 17.

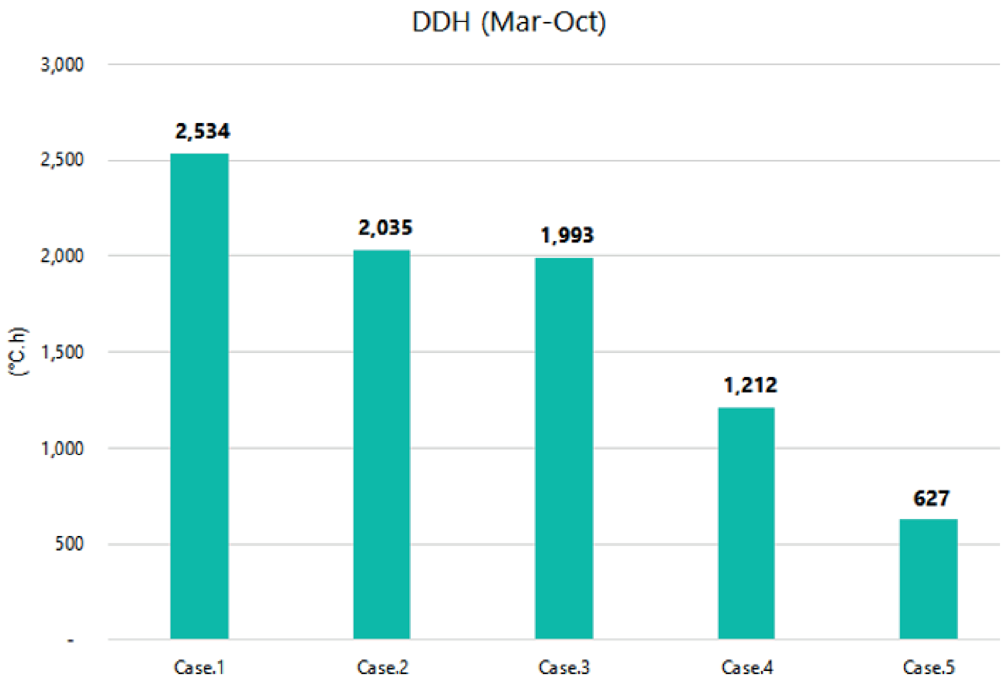


Figure 17. Comparison of DDH in summer months to evaluate energy efficiency strategies with the base case for a residential project

Institutional project, Chennai

This school in Chennai was planned to be mixed-mode building where most spaces would be air-conditioned during the hot months of the year, if indoor comfort is not achieved with passive strategies and assisted ventilation.

Peak operative temperature and DDH were evaluated with different passive strategies to:

- see improvement of comfort without air-conditioning
- if there is a reduction in the number of hours in a year that would require air-conditioning (Figure 18)

In addition, the reduction in air-conditioning energy due to the different passive and active strategies was also evaluated on the basis of EPI (Figure 19) and the cooling load.

Months	No. of operating hours	Max. adaptive comfort temperature	Base Case		Case 1: Increase in operable window area+Shading+DGU clear glass		Case 2: Case 1+Assisted ventilation	
			No. of comfortable hrs	% comfortable	No. of comfortable hrs	% comfortable	No. of comfortable hrs	% comfortable
Jan	154	28.30	82	53%	104	68%	153	99%
Feb	140	29.12	69	49%	77	55%	92	66%
Mar	161	30.44	23	14%	29	18%	47	29%
Apr	140	31.45	0	0%	11	8%	30	21%
May	161	32.23	5	3%	7	4%	11	7%
Jun	154	31.98	4	3%	7	5%	16	10%
Jul	147	31.55	13	9%	27	18%	39	27%
Aug	161	31.11	12	7%	24	15%	37	23%
Sep	147	30.98	14	10%	27	18%	41	28%
Oct	154	30.18	16	10%	32	21%	65	42%
Nov	154	29.09	67	44%	89	58%	129	84%
Dec	147	28.68	103	70%	124	84%	141	96%
TOTAL	**1820**		**408**	**22%**	**558**	**31%**	**801**	**44%**

Figure 18. Evaluation of percentage reduction in the number of hours in a year that would require air-conditioning to compare energy efficiency strategies proposed in a school

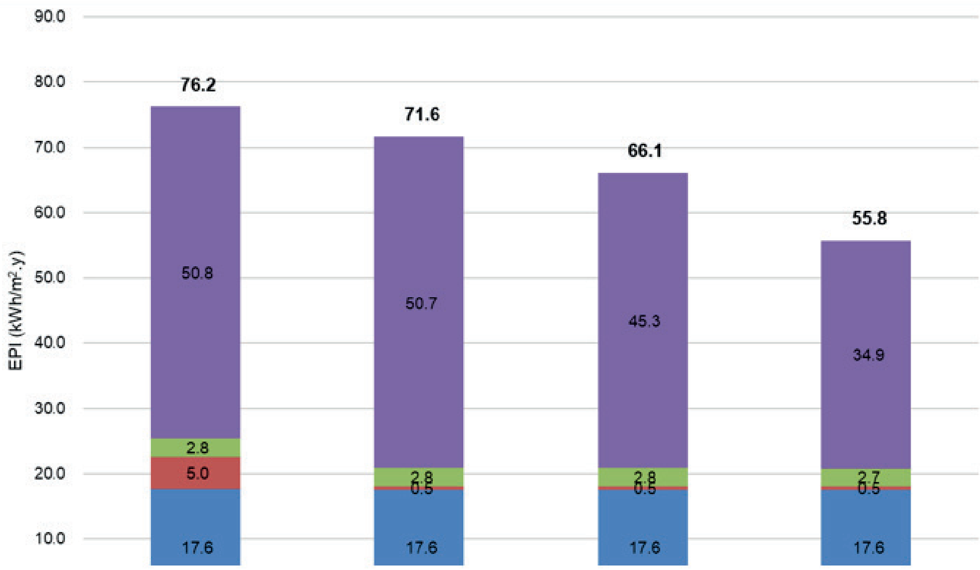


Figure 19. Evaluation of the reduction in air-conditioning energy due to the different passive and active strategies in a school

Public office building (day-use), Jaipur

This was an air-conditioned office building. The strategies were evaluated based on the EPI and the cooling load.

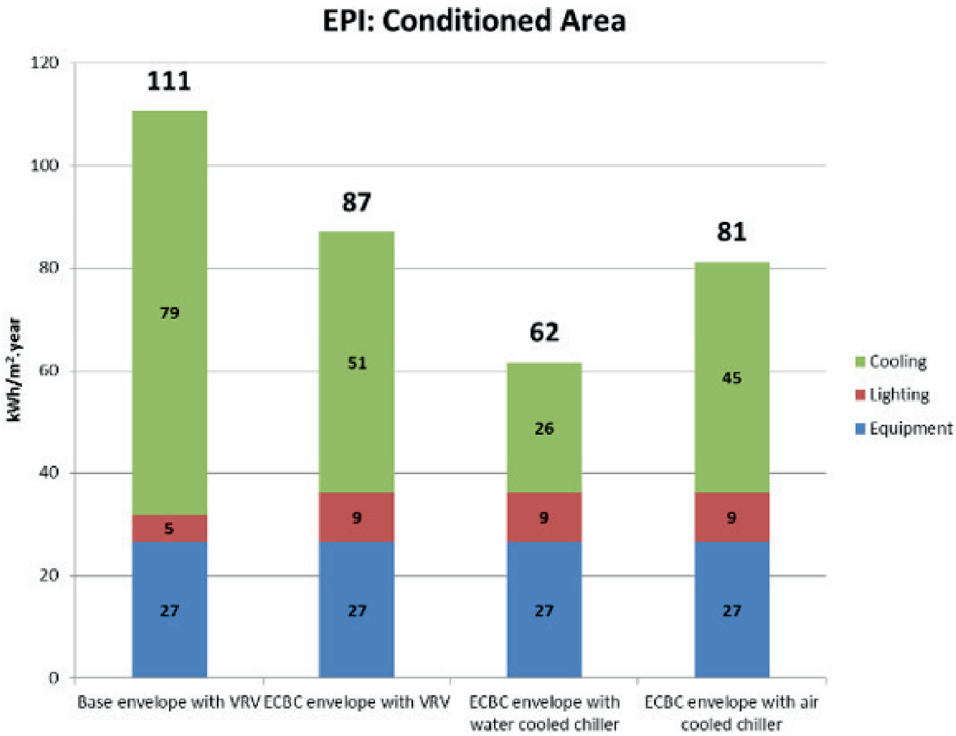


Figure 20. Evaluation of the reduction in air-conditioning energy due to the different passive and active strategies in day-use office building

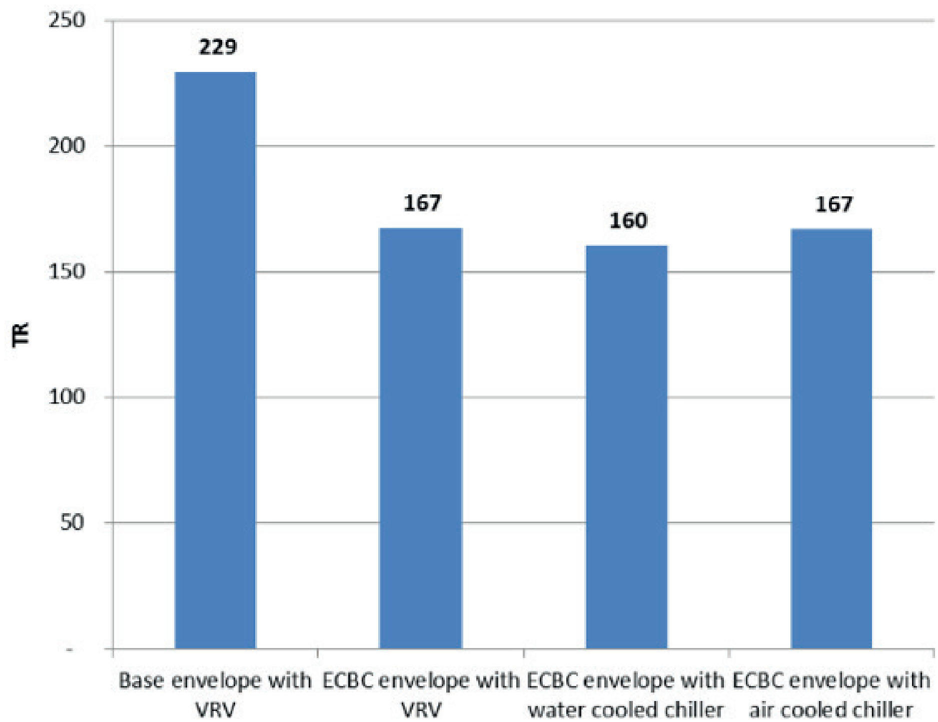


Figure 21. Evaluation of the reduction in cooling load due to the different passive and active strategies in day-use office building

3.3 There are different ways of comparing the effectiveness of strategies, and different ways of communicating them

It is not always necessary to see the impact of individual strategies on the basis of EPI or indoor operative temperature. This needs a simulation expert and requires more time to compute. Simulation time must be used smartly and efficiently during a charrette.

The impact of some individual strategies could be seen using simpler tools that require less time to compute. Based on the result, one can decide if that strategy should be applied and where in the building should it be applied. Impact on EPI or indoor operative temperature can be computed for the combination of feasible strategies.

VISUALISATION OF IMPACT OF SOLAR PROTECTION

Residential project, Mumbai

The impact of different shading design is shown by visualising the shading mask on the sun-path diagram for the two different shading design (created using Ecotect). It shows how much of the sky is visible from the window at different times of the year.

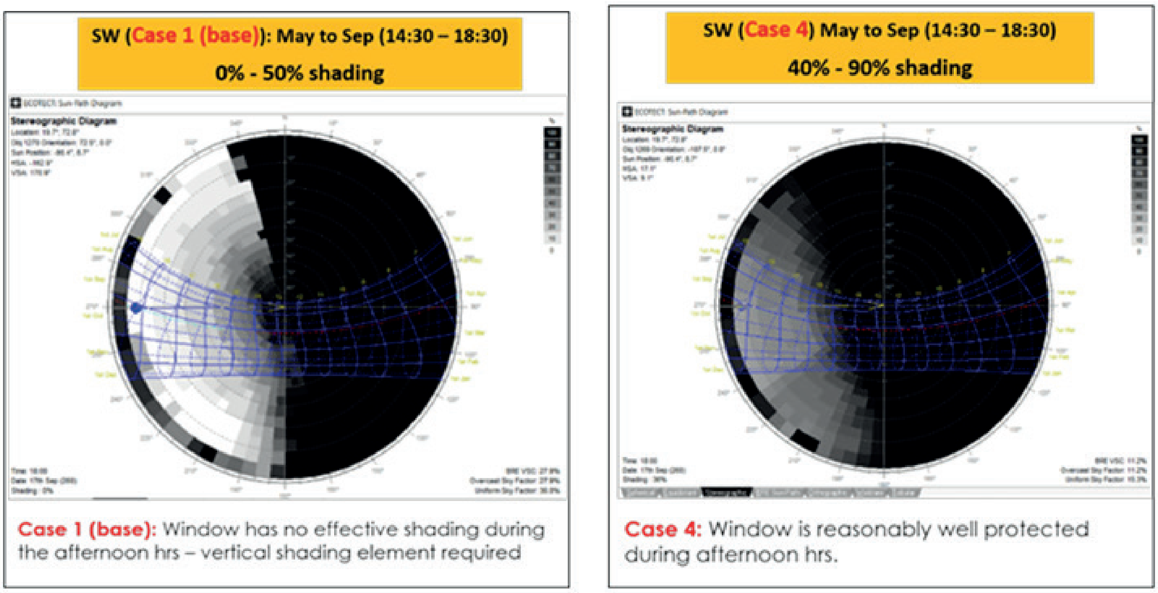


Figure 22. Comparison of shading masks on the sun-path diagram for two different shading design

Residential project, Mumbai

In this project, instead of visualising the effect of shading, a table with the average percentage shading of the concerned window with and without shading is provided (using Ecotect).

Month	% shading	
	Existing	Proposed (600mm chhajja)
Jan	59%	67%
Feb	66%	75%
Mar	74%	86%
Apr	87%	97%
May	99%	100%
Jun	100%	100%
Jul	100%	100%
Aug	93%	99%
Sep	78%	92%
Oct	68%	78%
Nov	60%	67%
Dec	59%	66%

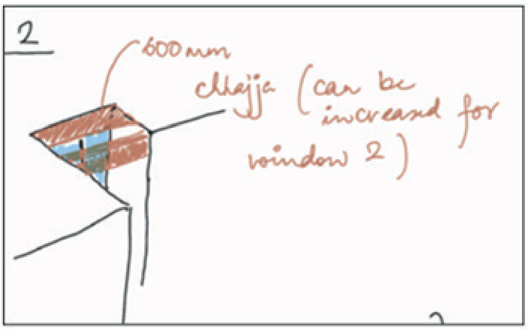


Figure 23. Average percentage shading of window with and without shading

Commercial project, Noida

This was an air-conditioned building designed with fully glazed facades. High performance glass with low SHGC was planned for in the existing design to combat the heat gains from these glazed areas, and the resulting high cooling energy. During the charrette, it was discussed that even with high performance glass, the current design of unshaded glazed façades will create both thermal and visual discomfort for the occupant. The best strategy to minimise heat gain and to improve thermal and visual comfort would be using external horizontal movable shading system.

A typical office space with glazing on the south façade was modelled in CFD software FloVENT. This showed that even with high performance glazing, occupants in the perimeter zone (3 m from the glazing) will experience higher thermal discomfort due to high radiant temperatures (Cases A and B in Figure 24). In Cases C and D (with solar protection), occupants will have better thermal comfort.

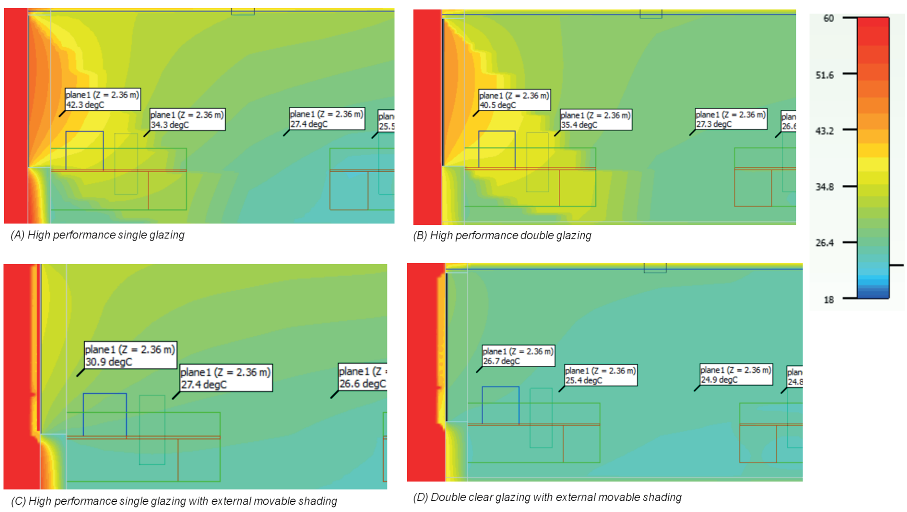


Figure 24. CFD analysis to see radiant temperatires inside with different types of glazing & shading

Commercial project, Pune

In this project, the 'View from Sun' in Ecotect was used to see the effect of simple overhangs for solar protection. This tool shows the facades that the sun 'sees', i.e., the exposed facades at any given time of any given day. On the left we see that the south-glazed façade (coloured orange) is exposed to the sun at 1 pm on 21 April. The image on the right shows that the same façade is not exposed (i.e., the orange colour signifying the glass façade is not seen) with the addition of 0.75-m deep overhangs on each floor.

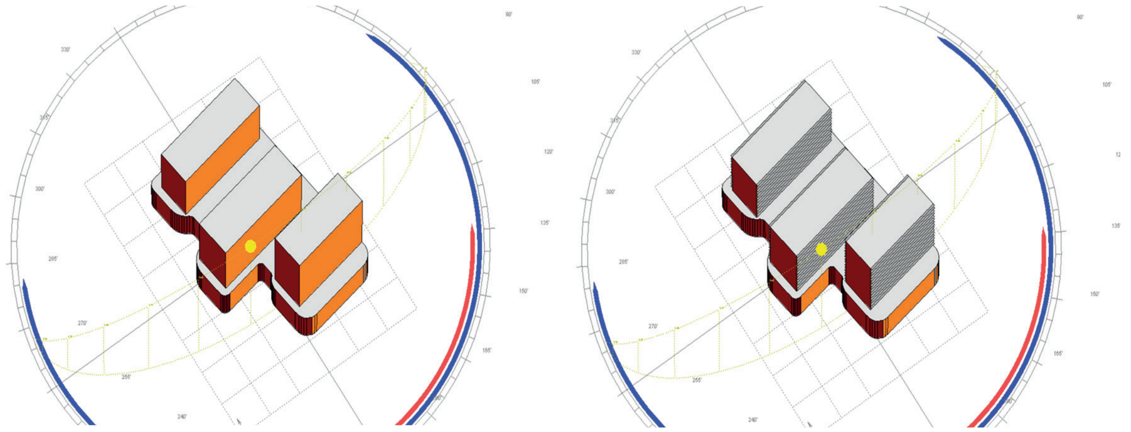


Figure 25. Using 'View from sun' tool on Ecotect to see exposure of the glazed facades without any shading (left) and with horizontal overhangs (right)

3.4 One can have a list of feasible strategies handy depending on building type and climate

There are broad strategies that work better for certain building types and climates. Description of the principles of the applicable strategies, diagrams, case studies, etc. must be kept handy during the charrette. This section enlists the more important strategies for different building types. Other strategies can also be used. However, the enlisted strategies have greater potential of energy savings and practical application for the concerned building typology.

All Commercial buildings

- Passive strategies
  - Appropriate orientation
  - Optimised WWR and shading of glazed widows and facades
  - Reflective or High SRI finishes for roof and walls
  - Insulating roof
  - Insulating walls
- Active strategies
  - Increase in setpoint temperatures
  - Water-based centralised HVAC system instead of air-based system
  - Heat or Enthalpy recovery
  - Use of Variable Flow Drives in fans and pumps
  - Using high-efficiency or high-performance cooling equipment

Specific strategies for commercial building sub-types	
Day-use office buildings (air-conditioned) • Passive strategies – Night cooling – Design for daylight • Active strategies – Incorporating hybrid cooling (with evaporative cooling) in hot and dry climates – Low energy cooling systems like radiant cooling etc.	**Institutional buildings (mixed-mode)** • Passive strategies – Design for daylight • Active strategies – Free cooling (greater potential as ambient night-time temperatures are lower) – Incorporating hybrid cooling (with evaporative cooling) in hot and dry climates
Hospitals (air-conditioned) • Passive strategies – Design for daylight • Active strategies – Using high-efficiency or high-performance cooling equipment, as allowed by the stringent indoor conditions required in hospitals	**24/7 office buildings (air-conditioned)** • Active strategies – Free cooling (greater potential as ambient night-time temperatures are lower) – Low energy cooling systems like radiant cooling etc.

Housing (naturally ventilated / mixed mode)

- Passive strategies
  - Appropriate orientation
  - Optimised WWR and shading of glazed widows
  - Window design for good natural ventilation and daylight potential
  - Reflective or High SRI finishes for roof and walls
  - Insulating roof
  - Night cooling
  - Insulating walls (for hot-dry, composite and cold climates)
  - Design for daylight
- Active strategies
  - Increase in setpoint temperatures
  - Using high-efficiency cooling and lighting equipment

3.5 Keep an eye out for specific problem areas in a building...as well as specific opportunities of energy efficiency

Institutional project, Chennai

Chennai being in the warm-humid climate zone and being a coastal city, has very good potential to use wind movement to achieve thermal comfort by ventilating the building. Increasing the window openable area improves the ventilation. One can further increase the ventilation rates or ACH by mechanically 'pushing' or 'pulling' more air from a space. This was proposed to be done here, by having two vertical ventilation shafts, which will have openings in each classroom. Turbo ventilators on top of each of these shafts will create a negative pressure, which will induce air flow through the open windows of the classroom through the room and exhausted through the shafts. Two shafts will serve four classrooms – one on each floor. It is estimated that this will give an air change rate of 16 ACH in the rooms, with an air velocity of ~5 m/s inside the shafts.

These shafts will also serve the purpose of fresh air distribution ducts when the building is air- conditioned, by being connected to a TFA installed on the roof-top of the buildings. While using these shafts in assisted ventilation mode, the connection between the TFA and the shafts is closed, the turbo-ventilator is switched on and the windows are open.

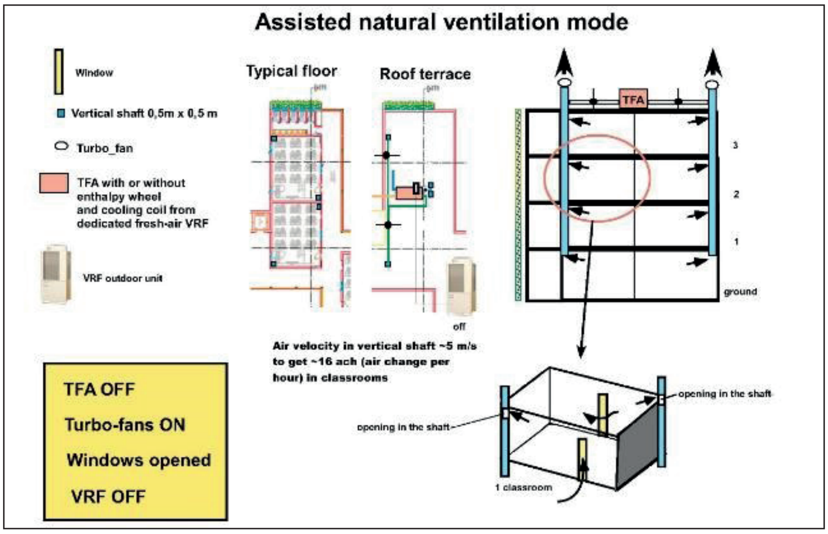


Figure 26. Use of ventilation shafts in the assisted ventilation mode

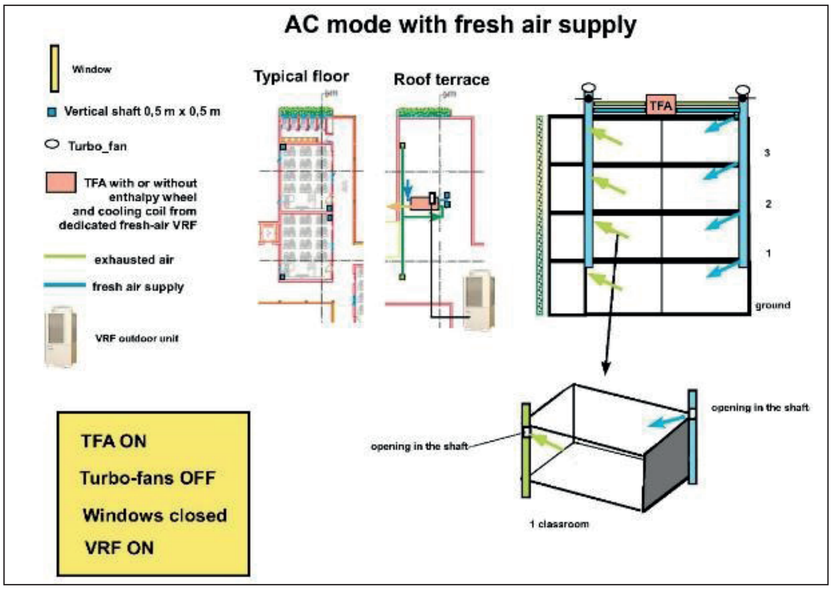


Figure 27. Use of ventilation shafts in the air-conditioning mode

Box contd....

The charrette team also recommended a schedule for the mode of operation of the building, with the visualisation as shown in Figure 28.

	Operating schedule												
	Weekdays	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	0:01- 1:00	Mode 2	Mode 2	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 2	Mode 2
	1:01- 2:00	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3
	2:01- 3:00	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3
	3:01- 4:00	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3
	4:01- 5:00	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3	Mode 3
	5:01- 6:00	Mode 3	Mode 3	Mode 3	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 3	Mode 3	Mode 3
	6:01- 7:00	Mode 3	Mode 3	Mode 3	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 3	Mode 3	Mode 3
	7:01- 8:00	Mode 3	Mode 3	Mode 3	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 3	Mode 3	Mode 3
Occupied Hours	8:01- 9:00	Mode 3	Mode 3	Mode 3	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 3	Mode 3	Mode 3
	9:01-10:00	Mode 3	Mode 3	Mode 3	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 3	Mode 3	Mode 3
	10:01-11:00	Mode 3	Mode 3	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 3	Mode 3	Mode 3
	11:01-12:00	Mode 3	Mode 3	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 3	Mode 3
	12:01-13:00	Mode 3	Mode 3	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 3	Mode 3
	13:01-14:00	Mode 3	Mode 3	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 3	Mode 3
	14:01-15:00	Mode 3	Mode 3	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 4	Mode 3	Mode 3
	15:01-16:00	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1
	16:01-17:00	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1
	17:01-18:00	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1
	18:01-19:00	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1
	19:01-20:00	Mode 2	Mode 2	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 2	Mode 2
	20:01-21:00	Mode 2	Mode 2	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 2	Mode 2
	21:01-22:00	Mode 2	Mode 2	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 2	Mode 2
	22:01-23:00	Mode 2	Mode 2	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 2	Mode 2
	23:01-24:00	Mode 2	Mode 2	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 1	Mode 2	Mode 2

Mode 1: Windows are CLOSED; All systems are OFF (Air temp. is not good for natural ventilation); AC remains OFF

Mode 2: Windows are OPEN; Assisted ventilation fans are OFF; AC remains OFF

Mode 3: Assisted ventilation is ON; Windows are OPEN; If the incoming air temp. seems hot CLOSE windows & switch OFF assisted ventilation fans; AC remains OFF

Mode 4: AC is ON; Windows are CLOSED; Assisted ventilation is OFF

Figure 28. Schedule for the mode of operation of a school building for cooling

Commercial project, Gurgaon

When the charrette was conducted, 7 × 1500 kVA DG sets were planned in the existing design to take care of the power requirement of the buildings, out of which 3 × 1500 kVA was expected to be operational 24/7 and the remaining on stand-by. At the same time, cooling was provided by 4 × 650 TR chillers and 1 × 300 TR chiller on standby.

Using the flue gas and super-heated water from one of the DG sets would result in generation of 500 TR of cooling using vapour absorption machines (VAM). With some modifications in the specifications of the DG set and the chillers, at least two of the centrifugal chillers could be replaced with a VAM. It was estimated that heat recovery based VAM on 2 × 1500 kVA would result in 1000 TR of cooling and about 40% reduction in electricity and electrical load for cooling.

Hospital, Pune

Hospitals have very stringent temperature and humidity requirements. To maintain the relative humidity in the spaces and to avoid overcooling, reheating is required. The conventional way (base case,) the reheating is done with reheating (electric) coils installed in the AHUs after the cooling coils. In the base case, it was observed that electricity required for reheating is substantial. Hence, it was proposed to use the condenser water to reheat the air. This solution provides free heating and cools the condenser water thus reducing the chiller power consumption. This would require the introduction of a PHE and distribution pumps and hot water coils in air handling units. The control system would comprise a humidity controller and hot water modulating control valve. In case the condenser water is not able to meet the reheating requirement, there is also a back-up from the heat pump used for hot water generation.

Commercial project, Pune

This building was designed to consist of three office towers (12–15 floors) over a retail block. The office towers would consist of multiple small offices, each of which was proposed to be cooled by unitary air-cooled split DX systems. The planned arrangement of this system was to have all the outdoor units (ODUs) of one floor in a common service area provided on the western façade. This service area was covered with louvres on the west, with the other two sides open. Ideally this service area should be kept open to facilitate heat rejection for maximum system efficiency. During the charrette, a CFD analysis showed that the planned arrangement would increase the inlet temperature at the ODUs by 12 °C without wind and 7 °C with normal west wind. This will reduce the COP of these units drastically thereby consuming more energy.

The BEEP team therefore suggested using water-cooled ODUs for the office towers. These units will perform well even with the louvred façade without COP reduction.

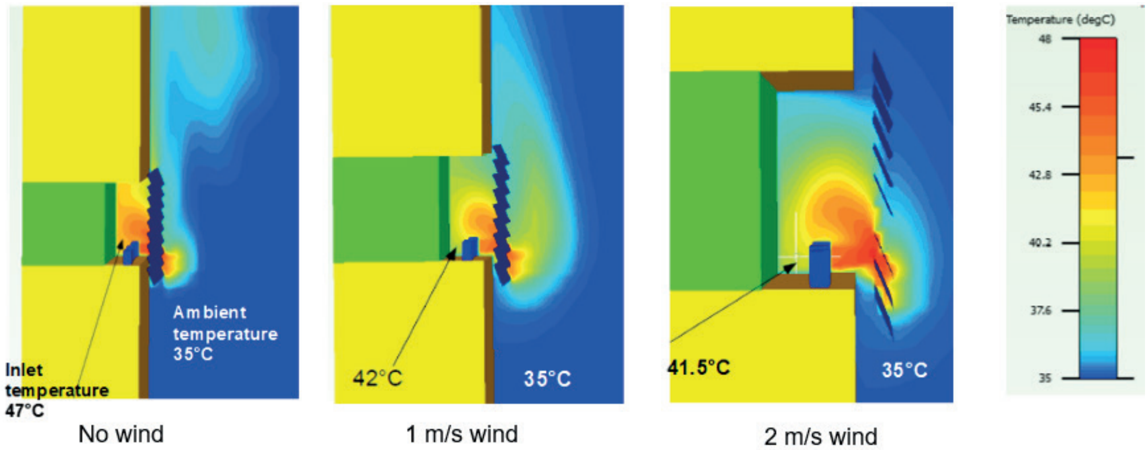


Figure 29. CFD analysis done to see the effect of the placement of AC outdoor units in a commercial building

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CHAPTER 4
LEARNINGS

4 LEARNINGS

4.1 Charrette is not an end-product, it is a process or tool to arrive at the solution

Charrettes are a means to get different perspectives, conflict areas, and opportunities while responding to the objective of energy efficiency. Thus, the charrette is not the goal and one should not expect the charrette to conclusively give detailed solutions to make the concerned building energy efficient. The charrette makes sure that all concerned stakeholders in the project start from the same page, with a cohesive understanding of what the design wants to achieve, identification of the strategies most likely to help achieve it within the constraints and other requirements of the project. The detailed design is done post-charrette.

This also means that charrettes cannot be overtly structured or have a very set agenda. It is more of a guiding agenda, where we know the start and the end. We start at understanding the project brief and end at having workable strategies for energy efficiency with their estimated impact. The path between the start and the end of a charrette need not be strictly structured and would respond to the needs of the project.

4.2 Successful charrettes always have a 'champion' driving it

The most effective charrettes have been the ones where a key person in the design team is passionately involved in it and takes ownership of the decisions of the charrette. This key person is usually the client themselves or the project manager, though it could also be the architect or someone else. This person is someone who is able to influence project decisions and is committed to the project goals.

The charrettes that have not been as effective, more often than not, saw a rotation of people in the design and management team. Without a committed person or team, it is unlikely that the charrette decisions are actually implemented.

4.3 Having highly experienced and skilled practising professionals are a huge asset

Charrettes are propelled by the expertise, experience, skill, intuition, and judgment of the participants. In all BEEP IDP charrettes, the BEEP charrette team consisted of one senior architect and one senior engineer, who were supported by professionals for analysis, detailing, and coordination. The presence and commitment of these highly experienced practising design professionals is a key factor for the success of charrettes. Without this experience, there is the danger of wasting time during the charrette by considering inappropriate or low-potential strategies as well as of analysing or simulating every tiny strategy.

These experts are also able to show case studies of other real projects they have done, which give more confidence to the charrette participants, especially the client about the potential of the energy efficiency strategies.

4.4 Having the relevant information before the charrette is necessary

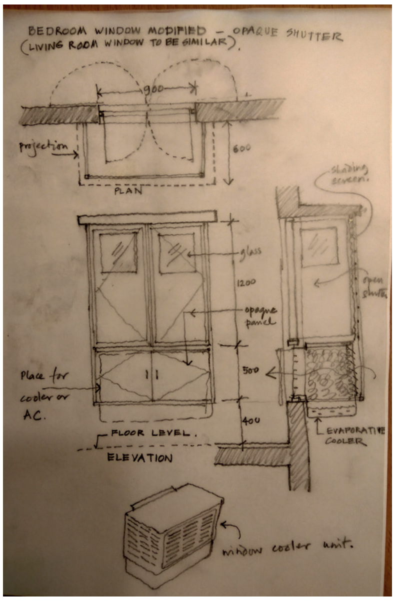
The collection of correct and relevant site and project information before the charrette is necessary. This information is used in the pre-charrette analysis to come up with the base case. During the charrette, all energy efficiency strategies are evaluated against the base case. If one gets incorrect information about the project, one loses time during the charrette and additional stress.

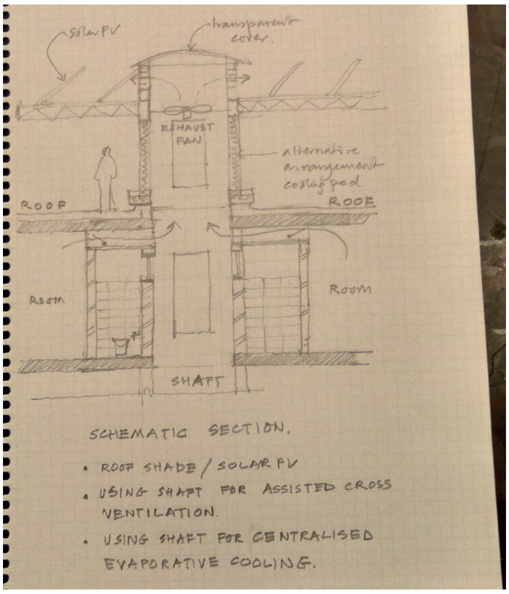
4.5 Ball Park cost information of materials, systems helps make quicker decisions

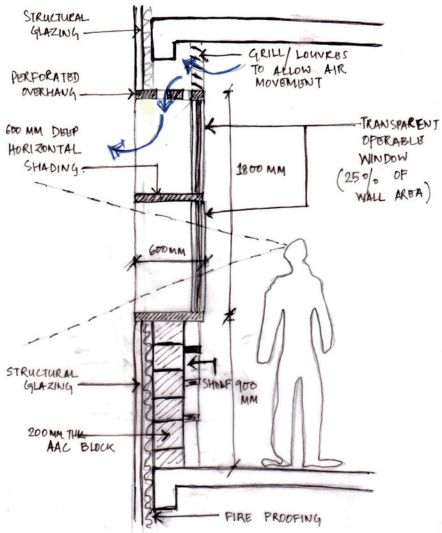
Cost of construction is one of the important, if not the most important, criteria for deciding for or against any energy efficiency strategy. One should have the ball-park cost figures of various materials, products or systems that would be proposed as energy efficiency strategies. Having a building cost consultant or expert during the charrette will be an asset.

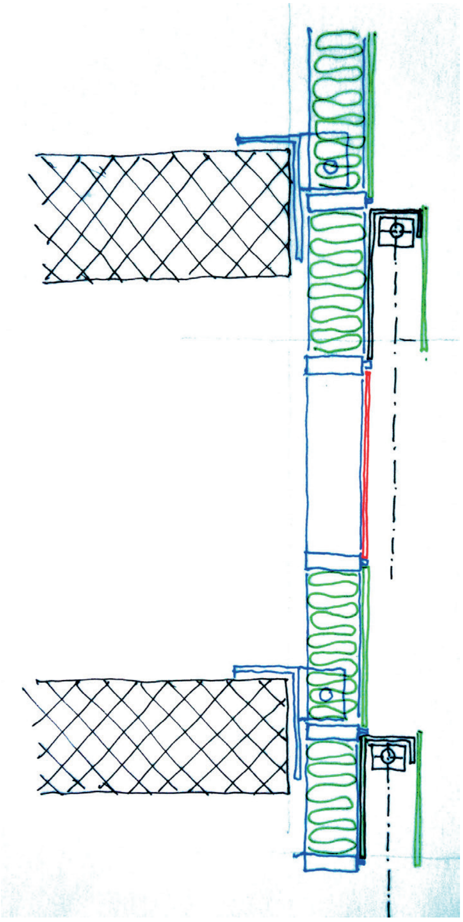
4.6 Sketching, doodling, system line diagrams are essential

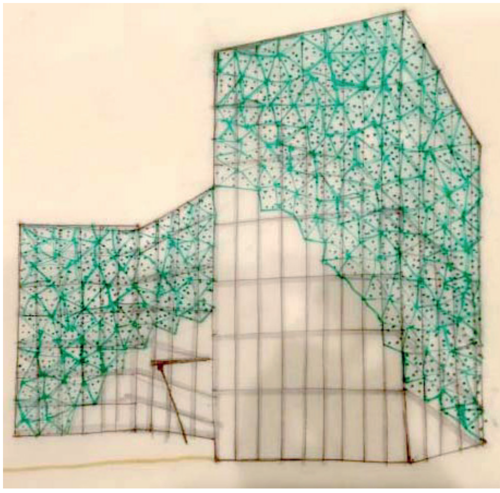
Charrettes are not just a technical endeavour; they are also an exercise in communication – sometimes more so. And eventually all energy efficiency strategies must turn into tangible objects used in the building, i.e., all the talk and calculations must turn into drawings. So, doodling, sketches, system line diagrams are key communication tools during any charrette.


BEDROOM WINDOW MODIFIED - OPAQUE SHUTTER
(LIVING ROOM WINDOW TO BE SIMILAR)
900
projection
600
PLAN
shading screen
glass
1200
opaque panel
Place for cooler or AC.
500
400
FLOOR LEVEL.
ELEVATION
EVAPORATIVE COOLER
window cooler unit.

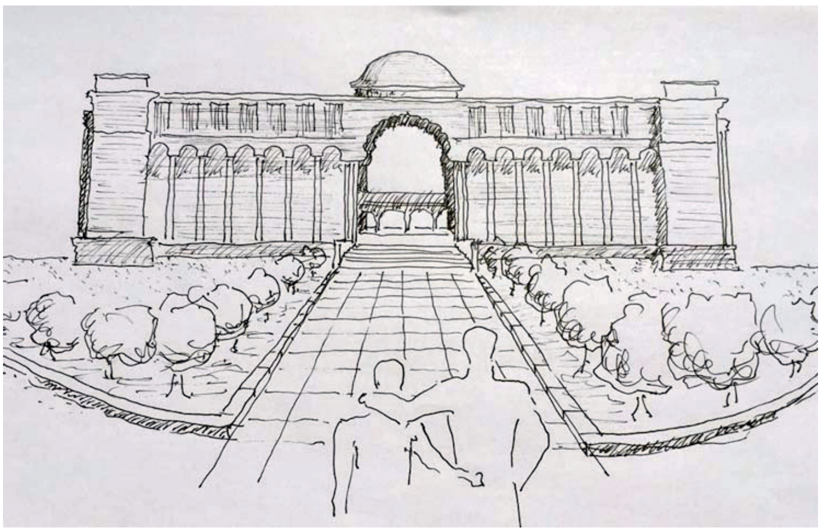

Solar PV
transparent cover.
EXHAUST FAN
alternative arrangement cooling pad
ROOF
ROOF
ROOM
ROOM
SHAFT
SCHEMATIC SECTION.
• ROOF SHADE / SOLAR PV
• USING SHAFT FOR ASSISTED CROSS VENTILATION.
• USING SHAFT FOR CENTRALISED EVAPORATIVE COOLING.


STRUCTURAL GLAZING
GRILL / LOUVRES TO ALLOW AIR MOVEMENT
PERFORATED OVERHANG
600 MM DEEP HORIZONTAL SHADING
TRANSPARENT OPERABLE WINDOW (25% OF WALL AREA)
1800 MM
600MM
STRUCTURAL GLAZING
SHELF 900 MM
200MM THK AAC BLOCK
FIRE PROOFING






bamboo board
passage.
MOVABLE SHADE SCREENS
IN TOP FLOOR & OTHER
PASSAGES WHERE THE MORNING
OR AFTERNOON SUN IS TROUBLESOME



ANNEXURE 1

Table 3. Project information collected before charrette

1.	Project Information
	1.1 Title of Project
	1.2Address of Project
2	Project Details
	2.1 Function of the building
	2.2 End users of the building (e.g., Owner occupied / Leased to multiple tenants / others – please explain)
	2.3 Who is responsible for the energy bill?
	2.4 Total site area (in m^2)
	2.5 Total built-up area (in m^2)
	2.6 Space description with area break-up
	2.7 Estimated timeline of building design and construction with some milestones
	2.8 Current status of the project
	2.9 Site context – survey plan / location plan / location marked on google earth, adjacent buildings and topography (Please attach pdf, jpeg or CAD files)
	2.10 Any special concerns (e.g., energy, water shortage problem or resource availability and applicability issues, if any) / feature which you would like to mention
	2.11 Approximate project budget (in INR)
	2.12 Whether planning to design it as energy-efficient building and/or apply for green building rating? If yes, which rating system and what is the targeted goal?
	2.13 Have any of your other building projects been designed as energy-efficient / green buildings? If yes, please provide details (Number, type, built up area, date of completion, date of registration, date of commissioning)
	2.14 Names of the architect and other key consultants for the project
	2.15 Project drawings (site plan, conceptual plan / floor plans, sketches, 3D models, etc. Please attach CAD or pdf files)

Indo-Swiss Building Energy Efficiency Project (BEEP)

The Indo-Swiss Building Energy Efficiency Project (BEEP) is a bilateral cooperation project between the Ministry of Power (MoP), Government of India and the Federal Department of Foreign Affairs (FDFA) of the Swiss Confederation. The Bureau of Energy Efficiency (BEE) is the implementing agency on behalf of the MoP while the Swiss Agency for Development and Cooperation (SDC) is the agency in charge on behalf of the FDFA.

BEEP started in 2011, with the current phase running from 2017 – 2021. The project's central focus is to help India mainstream Energy- Efficient and Thermally Comfortable (EETC) building design for commercial, public and residential buildings. The project works in the following areas

- Building Design: Technical support for design, performance monitoring and recognition of energy efficient buildings
- Building Technology: Promoting technologies for energy efficient building envelope e.g. insulation, external movable shading systems (EMSYS)
- Building Policy: Technical assistance in the development of Energy Conservation Building Code for Residential Buildings and its implementation in states
- Outreach: Knowledge dissemination through web, social media; training building professionals and students

The day-to-day implementation of the project is managed by project management and technical units based at Effin'Art Sàrl (Lausanne, Switzerland) and Greentech Knowledge Solutions (New Delhi, India).

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