Number of bedroom and living room for each category of built up of the residential buildings were assumed from the trend available in property tax data. Five scenarios have been developed for bedrooms and living rooms considering conservative to aggressive percentage of air conditioned area for each size of the residential unit, while anticipating present and future situation as shown in Figure 5. The difference between energy required for cooling for conventional and LEC system shows significant energy savings potential.

Results

Figure 6 shows the reduction in anticipated overall annual energy consumption for Ahmedabad city for conventional and LEC system respectively for all the spaces and respective scenario. There is a significant potential to reduce energy consumption by using LEC systems over conventional split air conditioning system.

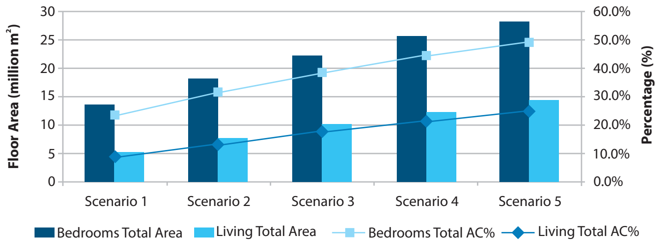

Fig5 Total AC Area for Bedroom and Living Room for Ahmedabad

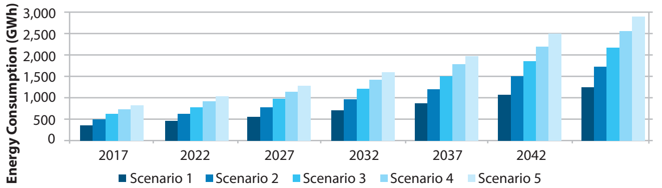

Fig6 Reduction in annual energy consumption by using LEC system for all spaces for Ahmedabad

An initiative supported by SHAKTI SUSTAINABLE ENERGY FOUNDATION

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Evaporative Cooling Techniques in India

For various cities in different climatic zones

Background: Providing thermal comfort to building occupants is very important for the health, well being and for productivity as well. Hence, the use of air conditioning may be required during hot climate. The usage of conventional air conditioning systems like split AC in achieving thermal comfort is continuously increasing in India. This also increases the electricity usage. The aim of the project is to evaluate energy saving potential and ability to provide thermal comfort by using Low Energy Cooling systems like evaporative coolers. Study focuses on standalone systems primarily used in residential or small commercial building sectors. Evaporative coolers, which rely on evaporation of water, provide cooling at a very low cost (in terms of energy consumption) as compared to the conventional vapor compression based refrigeration cycles. The project aims to find out the techno-economic feasibility of evaporative cooling techniques in Indian climatic conditions.

The project mainly consists of three steps:

1. Evaluating performance of Low Energy Cooling (LEC) Systems by conducting physical experiments
2. Whole Building Simulations to predict annual performance of LEC systems in various cities
3. City Level Impact of LEC Systems on Energy Savings

Evaluating performance of LEC systems

Experiments were conducted to analyze cooling efficiency and cooling capacity of evaporative cooler at various environmental conditions for three types of most commonly used standalone room evaporative coolers - Portable, Window and Wall Mounted. To determine best methods to measure cooling capacity and efficiency, various methods were reviewed from different case studies as well as national and international standards for evaporative coolers such as IS 3315, 1994 (Amended in March 2007) and ASHRAE 133, 2008 respectively. Figure1 shows key steps to calculate cooling capacity and cooling efficiency of coolers. Step 1 requires physical experimentation while steps 2, 3 and 4 require calculation using data available from Step 1.

2.2 Experimental Setup:

A specialized chamber (Thermal Comfort Chamber (TCC) at CEPT University) was used for conducting physical experiments for Step 1. TCC can be very precisely controlled and monitored to maintain precise Dry Bulb Temperature (DBT) and Relative Humidity (RH). Coolers are placed inside the TCC and operated at full speed by carefully varying ambient DBT and RH throughout the experiment to get their performance at various environmental conditions – wide range of DBT and RH combinations.

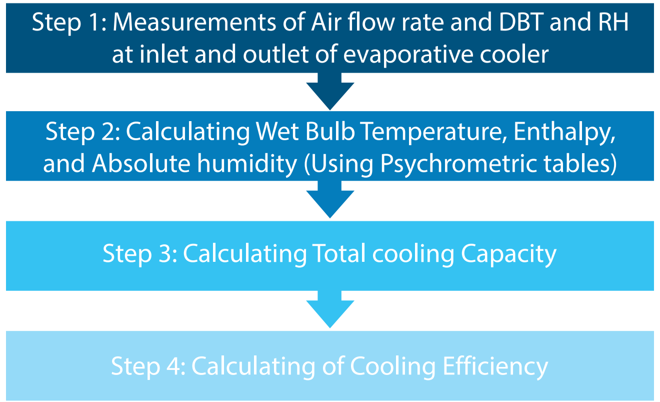

Fig1 Steps to calculate cooling capacity and cooling efficiency

Figure 2 shows the schematic placement of sensors (data loggers) to measure DBT and RH. The sensors logged data at every minute over the entire course of the experiments. The data was extracted for post-processing and further calculations.

2.3 Results of Experiments in TCC

Results of the experiment conducted for three types of coolers provide useful insight in the performance of evaporative coolers. Since cooling capacity and cooling efficiency depend on the combination of DBT and RH of the inlet air, the difference between DBT and Wet Bulb Temperature (WBT) of the inlet air is used to compare cooling capacity and efficiency.

Figure3 shows relation between cooling capacity and cooling efficiency of three types of coolers. Portable cooler has lesser cooling capacity and efficiency. While wall mounted coolers has similar cooling capacity as a window cooler, it has lower cooling efficiency.

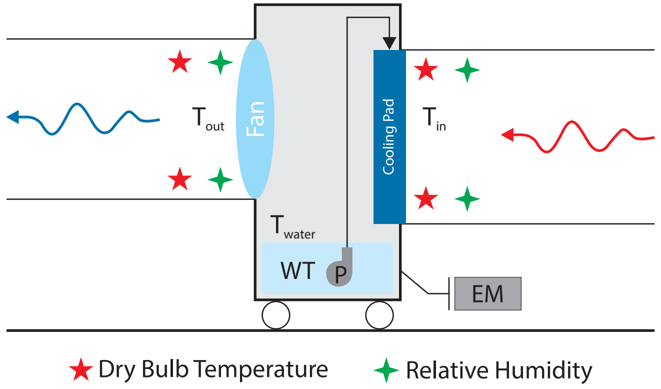

Fig2 Components of Evaporative Cooler & Schematic Sensor Placement

Key Inferences:

Following inferences are evident from the results of the experiments for three evaporative coolers:

- Higher cooling pad area gives higher cooling capacity and cooling efficiency of the cooler.
- Aspen as a cooling pad medium seems more efficient than honeycomb.
- Lower air flow rate across the cooling pad (slower air speed) increases the cooling capacity and cooling efficiency of the evaporative coolers
- Cooler efficiency significantly decreases with the increase in relative humidity.
- Higher the difference between the inlet DBT and WBT of the air, higher is the cooling capacity.
- The cooling capacity of the coolers increase with increase in the cooling efficiency.
- Of the three models chosen for experiment, window cooler has highest cooling capacity and cooling efficiency as compared to portable and wall mounted cooler.

Whole Building Simulation and Energy Performance of LEC system

For residential buildings, bedrooms and living rooms are the most commonly air conditioned spaces in India. The occupancy pattern and proportional area is different for bedroom and living room. This leads to different annual energy usage for bedrooms and living room for air conditioning to maintain thermal comfort. Hence, to know the overall energy consumption at city level, it is useful to know the Energy Performance Index (EPI) of bedroom and living room and multiply them with respective city level built up area. The study focuses on whole building simulation to predict EPI of the space conditioned using split AC system and LEC system respectively.

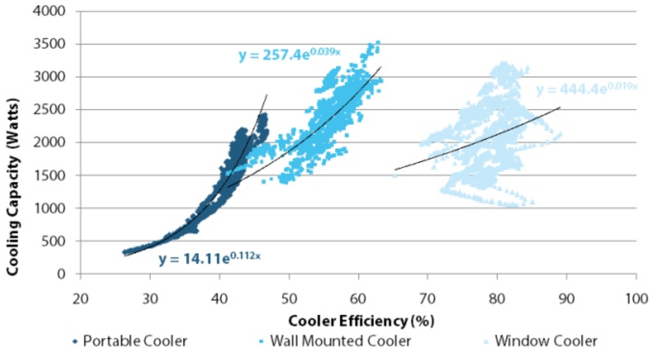

Fig3 Comparison of Cooling Capacity and Cooling Efficiency of different coolers

Simulation Model

The model is based on the 2 BHK (Bedroom Hall Kitchen) design as shown in Figure 4. Typical RCC slab and brick masonry wall have been considered. Simulations are run annually using Design Builder and EnergyPlus software to calculate energy consumption for space conditioning using split AC and LEC systems.

City Level Impact of LEC Systems on Energy Savings

To evaluate the energy savings potential at city level, various future scenarios have been developed considering the market penetration of LEC systems in place of conventional air conditioning systems. EPI obtained from whole building simulation has been multiplied with built up areas, using property tax data, to find energy consumption for cooling at city level.

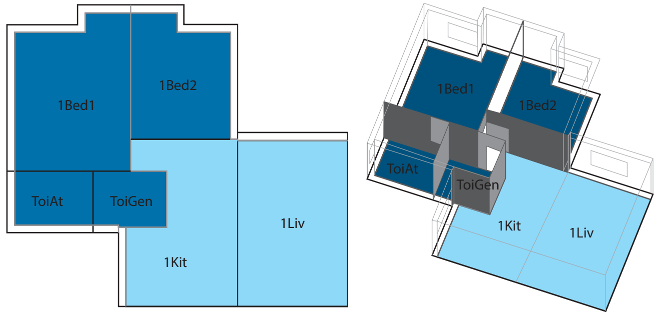

Fig4 Schematic design of the residential space for whole building simulation