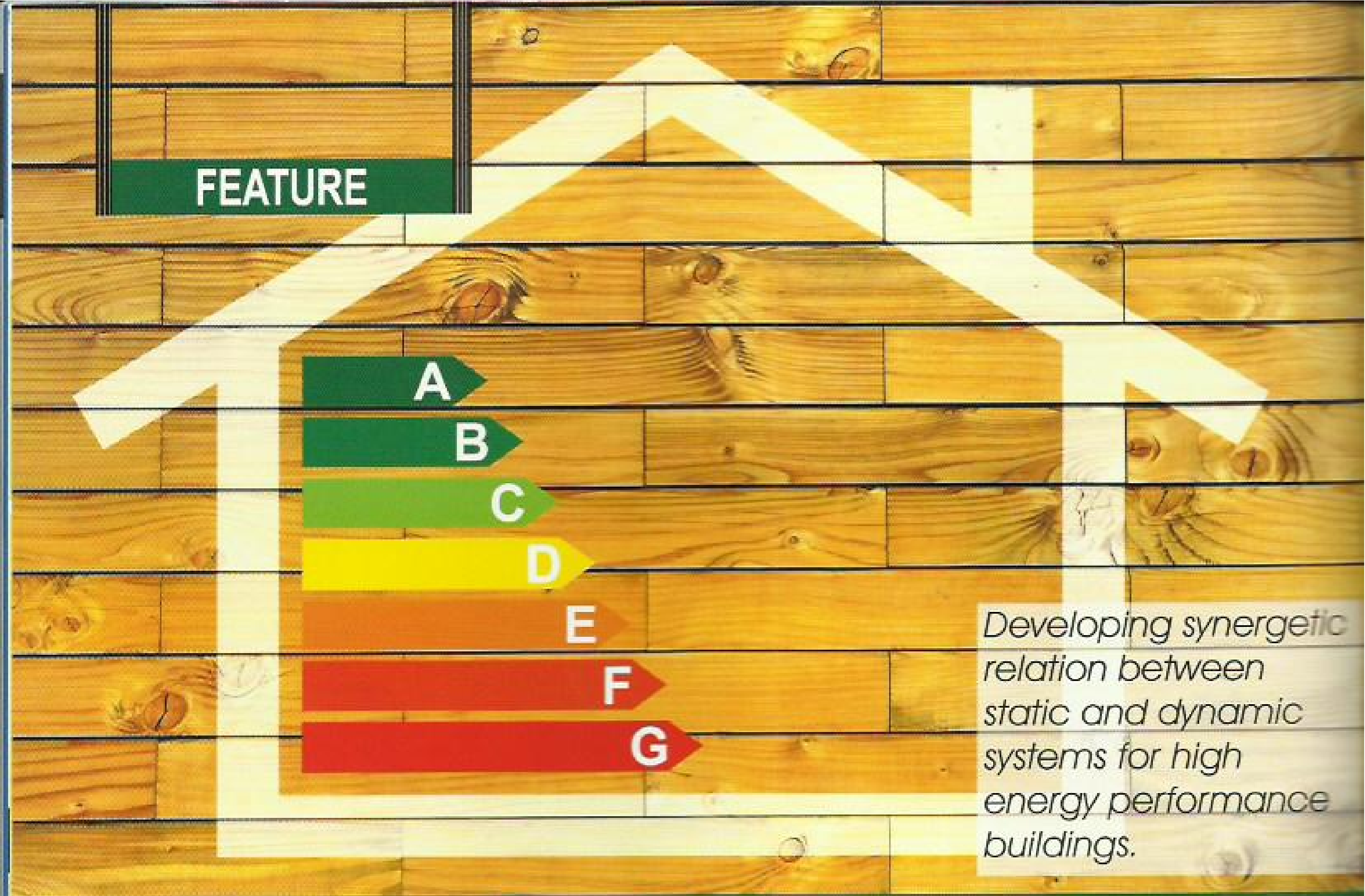

Developing synergetic relation between static and dynamic systems for high energy performance buildings.

Centre for Building Energy Research and Development

Best of two worlds

CEPT University (CEPT) in India and **Lawrence Berkeley National Laboratory (LBNL)** in United States of America (US) are jointly leading the **US-India Joint Centre for Building Energy Research and Development (CBERD)**. The CBERD program has brought together multidisciplinary expertise from eleven leading research and academic institutions in India and the U.S. to conduct collaborative research to promote energy efficiency innovations.

As an R&D collaboration spanning both sides of world under one virtual umbrella with a vision to optimize building systems integration using whole building approach across the building lifecycle CBERD will help facilitate high energy performance building design, construction, and operation. In order to meet the objectives of CBERD, and for project operational efficiency, the program has been divided into six tasks. Three of these tasks focus on the development of information technology based design and operation software tools and hardware devices, while three other tasks focus on technology development for physical building systems such as walls, windows, and roofs, to increase their potential to save operational energy and deliver occupant comfort. Designed to develop synergetic relation between dynamic systems such as information technology with static system such as building envelop, CBERD targets to develop technologies contextual to both countries. CBERD relies on its strong industry partnership to leapfrog technology development, technology evaluation, and prototyping.

Each of the R&D tasks is led by two scientists - one from each country - supported by a research team and specific industry partners. A description of these tasks is as follows:

Task 1: Simulation and modelling: Enable the use of practitioner-oriented, interoperable building energy simulation tools for integrated design, commissioning, and operation, to help reduce barriers to achieve energy efficiency.

Task 2: Monitoring and benchmarking: Develop packaged and scalable technical solutions for energy information systems for specific target building sectors, and develop new methods to advance state-of –the- art building energy benchmarking.

Task 3: Integrated sensors and controls: Integrate building energy control of several end-uses into single easy to use platform. Incorporate energy control technology for use to manage energy and load in grid – islanded 'resources constrained' buildings.

Task 4: Advanced heating ventilating and air conditioning systems: Develop and re-optimize compressor based and non-compressor based cooling and dehumidification systems.

Task 5: Building envelops: Develop materials to help buildings operate efficiently in mixed mode operations and reduce the effect of peak loads. Quantify cool roof technology benefits and develop characterization protocols. Develop testing procedures for advanced daylighting technologies.

Task 6: Climate responsive design: Advance the state of the knowledge for performance of climate responsive buildings, in terms of their indoor thermal environments, occupant's response, and role of air movement in achieving thermal comfort for elevated temperatures. Develop methods to combine both natural ventilation and low-energy mechanical systems in well-designed buildings that can improve both energy and comfort performance.

The Energy conservation building code (ECBC), India provides specific targets for Energy Performance Index (EPI) for Indian commercial buildings. Benchmarked data shows that the average site EPI for a single shift office building is 220-275 kWh/m^2 (70-87 kBTU/f2); the ECBC target is for ~50% energy reduction to an EPI level of 110 kWh/m^2 (35 kBTU/f2). The CBERD is attempting to enable an aggressive technical target of 65-90 kWh/m2 in (20-29 kBTU/f2) Indian commercial buildings.

India and the US have vast regions with climatic conditions favorable for comfortable habitation throughout the year. Recognizing this fact, one of CBERD's attempts is to promote building design and operation which is responsive to local climate. The potential to save operational energy increases many-fold when building starts recognizing favorable outdoor conditions and start interacting with it by opening up its façade. Recognizing contemporary commercial office building needs, it is also essential to reject outdoor conditions when they become unfavorable. Sometimes internal loads dominate external loads. To achieve comfort conditions in such situations, building needs to become air sealed, and start relying on active energy systems to provide thermally and visually comfortable indoor environment. It is feasible to design and operate buildings that dynamically respond to context if building has capabilities to understand context with help of sensor technology along with information technology, a combination of hardware and software technologies. Buildings physical system also should have capabilities to respond to dynamic situation and provide comfortable indoors without using much energy.

To develop comprehensive solutions to promote high energy performance building operation, the CBERD team is working towards development of the following advanced building materials and technologies.

- Advanced Building construction material and wall assemblies,
- Enhancing capabilities of energy control devices,
- Development of energy efficient space cooling and de-humidification system,
- Enhancing daylighting technology, façade shading algorithms and
- Performance evaluation of climate responsive passive building design strategies

Building construction material and wall assemblies: The CBERD team is experimenting with phase change materials for building

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application. The inclusion of phase change material (PCM) as internal thermal mass absorbs and releases excess heat, stabilizes indoor temperatures, and flattens demand-peaks to enable energy efficient HVAC operations. It also helps take advantage of nighttime air flushing within the building. A combination of external insulation and internal mass helps delay the process of starting HVAC during the daytime. It is also envisaged that HVAC operational hours during the day time will charge PCM quickly, which in turn may allow occupants to switch off HVAC much prior to the usual time and save energy without compromising on comfort conditions. This will benefit in operational energy savings.. The CBERD R&D team lead by CEPT University and Oak Ridge National Laboratory (ORNL) is working with industry partner PLUSS Advanced Technologies to characterize a novel PCM for wall application. The research task includes conducting inter -laboratory comparison of test protocol of PCM testing, enhancing infrastructure to characterize PCMs in India, evaluating PCMs in field, and conducting life cycle cost benefit analysis of PCM as part of wall material.

Enhancing capabilities of energy control devices: The CBERD R&D team lead by researchers from International Institute of Information Technology Hyderabad (IIITH) and LBNL have developed an early prototype of a low power wireless motion sensor using bluetooth low energy (BLE) and infrared (IR) technologies. This motion sensor can be used to switch on/off an air-conditioner or any other gadget which has IR control interface. Based on the human occupancy in a given space, any energy-consuming device can be controlled. These devices are beneficial in detecting usage of electrical loads such as lighting, HVAC devices even when the space is unoccupied. Wastage of energy can be tackled by detecting occupancy and turning the devices off wherever required. The BLE motion sensor detects the presence of human motion in a given space and transmits the status wirelessly. At the receiver end, the BLE to IR Bridge sends the control signal (on/off) to target energy consuming devices based upon the received status. An IR learning remote is used to emulate the existing IR remote which originally comes with the device. On the BLE to IR Bridge module, IR learning remote (universal remote) functionality has been implemented to control the target IR-enabled devices wirelessly, which also saves wiring material and labor cost. The wireless technology gives the flexibility to place the sensor anywhere in existing built spaces. This cost-effective wireless technology, with its small size, and extremely low power usage makes it an ideal solution for retrofit applications as well.

The CBERD R&D team has also developed prototype of an affordable smart power strip. This WiFi communication based smart power strip monitors connected devices and characterizes the device IDs, usage time, location, and power consumed. This provides the load profile of the plug loads in a building to help in developing strategies for plug load management. The smart strip also allows users to manage the connected device. The CBERD team is incorporating latching relays to this device into the same power strip that will help in remote control of plug loads, switching off loads when not in use and demand response. This can also help in preventing unauthorized access to the power from the socket.

Development of space cooling and dehumidification systems: Operation of windows to allow fresh air inside building become difficult to manage due to high levels of outdoor noise and air pollution in certain in urban areas. In such situations, a technology called dedicated outdoor air system (DOAS) become viable. A CBERD team led by Indian Institute of Bombay (IITB) and ORNL is working on DOAS technology, which delivers filtered outdoor air when outdoor air temperature is within comfort zone or use cool exhaust air from building back into the building to provide indoor thermal comfort. Such a system saves energy by transporting comfortable outdoor air without cooling it through mechanical means or relies on already cooled air. Additionally, even for situations when the outdoor temperature conditions are not favorable, CBERD team is working on a Dedicated Outdoor Air System (DOAS), with indirect evaporative cooling system. This is a promising low energy cooling technology that meets adaptive thermal comfort standards, and provides considerable amount of cooling energy savings.

The CBERD R&D team is also co-developing with an industry partner a diabatic rotating contacting device based evaporative cooling technology for water. This technology saves operational energy by using the water in a closed loop for space cooling. This technology has significant potential to provide thermal comfort especially in hot and dry climates.

Enhancing daylighting technology and façade shading algorithms: In hot or warm climates, it is essential that windows remain well shaded, especially during periods when the outdoor temperatures exceed the comfort zone. Good shading of windows substantially reduces direct solar heat gain through windows. CEPT and LBNL is working on development of algorithms which will help predict impact of non-coplanar shading devices on windows. The development of this algorithm will be integrated within whole building simulation engine and modeling software. It is expected that development of such algorithm will help designers predict energy demand better, and will help policy makers develop a program for rating window and shading devices performance.

The CBERD R&D team is engaged with industry partner 'Skyshade' to enhance Daylighting potential through the development of high-performance laser cut panels technology, that provides bi-directional scattering of light. In parallel, an easy-to-use software tool is being developed to enable the use and popularize such technologies, which is capable of providing enhanced Daylighting penetration in buildings with large floor plate.

Performance evaluation of climate responsive passive building design strategies: CBERD team consisting of CEPT, University of California at Berkeley (UCB), Malaviya National Institute of Technology, and Centre for Scientific research, Auroville are working on this task to evaluate climate responsive passive building design strategies. Approximately twenty buildings in India are under year-round monitoring for their indoor environmental performance for thermal comfort. The primary objective of this task is to develop protocols and study occupant thermal comfort in a range of commercial buildings in India, as well as through thermal comfort chamber experiments, with a particular focus on the role of air movement in elevated temperatures. Additionally, the CBERD team is also evaluating the thermal environments produced by climate-responsive design strategies in India and the US, with a focus on strategies such as natural ventilation, mixed-mode, thermal mass, and earth-air heat exchangers. Significant work in area of bioclimatic charts has been undertaken by the research team, through analyzing climate of representative cities in Indian climate zones, and identifying comparable climate zones in the U.S. The team is creating a Bioclimatic Comfort Chart specifically for the Indian context.

The CBERD R&D partners are well positioned to transfer CBERD outcomes to key stakeholders in both countries. The CBERD Industry partners are critical facilitators and torch bearers of CBERD R&D activities. The CBERD team is committed to outcome oriented R&D , by developing approaches and technologies to help transform building design, construction and operational practice to reduce energy consumption and improve building performance.