India's in-door cooling sector: updating student curricula to the DSM challenge

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Abstract

Fairconditioning's Academic Curricula Integration Ambassador Project is a social enterprise active in India to bridge the gap between present student curricula in architecture & engineering and available knowledge on designing energy efficient buildings and buildings services. The project, sponsored by the State of Geneva and the Oak foundation engages educational institutions to stimulate the interest of students for Energy Conservation Building Codes, energy efficient cooling technologies and energy demand-side-management in the study of building design and construction processes. Trained Technology Ambassadors disseminate information through workshops and certification programmes that update academic programme curricula in the fields of architecture, mechanical/electrical/plumbing services (MEP) courses etc. Academic Ambassadors establish collegiate steering committees that provide localized input and intelligence to tailor-made certificate programs that integrate existing knowledge on the issue, organize knowledge transfer and help to build capacity for teachers.

Introduction

Doing the maths on current GHG emissions in India leads to a simple conclusion, cooling indoors means global warming: Power generation in India accounts for approximately 38 % of GHG emissions in the country. While thermal power represents approximately 65 % of the installed power generation capacity, coal contributes to the actual fuel mix at the level of 90 %[1]. Coal-fired power plants are the biggest GHG emitters – spewing out 647 million tonnes of CO_2 per year, with coal combustion as a whole from India representing approximately 8 % of global coal-related GHG emissions in 2011[2]. The projected growth in total energy generation capacity will create the need to build 150 standard-sized (245 MW) coal-fired power plants each year. As the Indian middle class grows and aspires to improve its living conditions, the demand for ACs is developing exponentially. Of all the lifestyle enhancements sought by the growing middle class, reducing interior temperatures with air conditioning is amongst the first steps on the consumption ladder being taken by households with increasing disposable income. The annual AC sales growth rate is a staggering 19 % (for Unitary ACs) and 52 % for Commercial Central ACs, far exceeding India's GDP at 8 %. Within 15 years (from 2015 to 2030), this will lead to a 3-fold increase in installed Unitary ACs and 8-fold increase in installed Centralized AC systems.

HIDING BEHIND THE POOR

Energy production in India will increasingly impinge upon its climate change mitigation goals under the UNFCCC decided during the COP-15 in December 2009 i.e. 20–25 % reduction in GHG intensity of its GDP by 2020 from 2005 levels in terms of GHG emissions per Rupee of India's GDP. Energy intensity of the GDP of developing countries is, in general, much higher than that of developed nations. India's Energy Intensity in 2008–2009 was 0.55 kg oil equivalent (OE)/$GDP, while the

1. India: Greenhouse Gas Emissions 2007, Indian Network for Climate Change Assessment, Ministry of Environment and Forests Government of India, May 2010.

2. Ministry of Power, 2009–2010 statistics, http://www.powermin.nic.in/JSP_SERVLETS/internal.jsp.

world average, that of the United States and the EU were 0.30 and 0.20, and 0.17 respectively[3]. Furthermore, India faces an energy shortage of 8.7 % and a peak shortage of 9 %[4] as the number of households connected to the grid increases and household energy use soars. Per-capita energy consumption in India has increased from 1,471 kWh/year in 1980–81 to 4,816 kWh/year in 2010–2011[5]. A portion of this increase actually brings no added comfort or service but is lost in the form of pure waste generated by poorly designed buildings, inefficient appliances and inappropriate behaviour by end-users. The increasing energy demand from air conditioning will exacerbate the already broadening gap between the energy consumed by the privileged economic strata of India and households with below-poverty-line or near-poverty-line incomes. A very small portion of society uses up a large part of India's *Carbon Space*. The phenomenon referred to as 'Hiding Behind the Poor'[6] has led to a situation whereby the carbon footprint of the very wealthy 1 % of population is camouflaged by the 823 million officially poor people who keep overall per capital missions well below 2 tonnes of CO_2 per annum.

Following current trends, by 2030, India will multiply by 10 the area of built space, as compared to 2010 levels. The key to avoid this building boom from unfolding into a national and global catastrophe is to reduce the average Energy Performance (EPI) of buildings, old and new.

The potential to reduce the energy demand from buildings in India is huge considering this sector's growth rate and the current lack of regard for how much energy and GHG emissions could be avoided. The energy demand to cool interiors could be drastically reduced, provided actionable knowledge, financial models, and relevant tools are made available at the appropriate levels of the complex chain, from the training of architects to the actual construction site, from the implementation, measurement and verification of green building codes to the choice of the most efficient cooling technology on the market and the behaviour of end users.

The goal of the Fairconditioning programme is to help India leapfrog directly to an energy efficient economy. Continuing on the business-as-usual path of development would lock these countries in a model of energy wastage and GHG emissions on a dramatic scale, mainly in the form of buildings designed with no attention to subsequent energy consumption levels. This unbearable scenario would see India almost quadruple its mostly coal dependent energy consumption for just the cooling sector (from residential and commercial building AC use) in 2030 (304 Gigawatts) as compared to 2015 levels (82 Gigawatts).

WHY INDIA?

India, as a developing market economy in a very hot climate zone, makes it a perfect incubator for Fairconditioning. Successful implementation of Fairconditioning in India would set a sustainable model for intervention in other countries with similar climate conditions. Having extended hot and humid as well as hot and dry climate zones, being a democracy and a BRICs market economy, India can become a very interesting role model to follow regarding how it deals with indoor cooling challenges. Provided it enacts a trend shift in its attitude towards energy efficiency (EE) in this sector.

The know-how and technology currently available mean that delivering zero or near-zero energy buildings is feasible – provided a skilled workforce is available – at low additional costs that are paid back by reduced energy bills.

For existing buildings, modern retrofitting capabilities can also significantly reduce EPIs. Although enhancing EE in the building sector seems to be an obvious move today, a wide gap remains to be filled between available expertise and real-world building and retrofitting practices.

This is the context *Noé21*, a Geneva based NGO and *cBalance*, a Pune based social enterprise were assessing while designing the Fairconditioning programme, to cool Indian indoors sustainably and efficiently.

Bridging the knowledge gap at curricula level

Every year, 1.6 million Indian architecture and engineering students graduate from their respective universities and colleges with hardly any knowledge on how to integrate EE while designing buildings and selecting cooling technologies. Indian graduates have a high reputation, their level of technical expertise being highly looked upon at the international level; in the USA, 36 % of engineers at NASA are of Indian origin[7]. However, today in the specific fields of building design and building services, as gifted and dedicated as they may be, most graduates joining the Indian workforce represent a failure to future generations regarding their capacity to address national energy challenges described in the introductory section: Tomorrow, even if strict building codes were passed into law and seriously enforced, the lack of a skilled workforce to design and carry out the construction of green buildings would be a serious liability. Hence the vital need to bridge the knowledge gap and make tomorrow's Indian workforce ready to reduce to the minimum the cooling load of future and existing buildings and to address the remaining cooling demand with the most efficient technology available. In the words of Fairconditioning's Advisory Board member Aalok Deshmukh, General Manager at Schneider Electric in Mumbai, "Carbon design fluency needs to become a core competency for architecture professionals".

Integrating EE in student curricula of architecture and engineering (civil and mechanical) universities across the 8 largest urban areas is the main section of the Fairconditioning programme, coined Academic Curricula Integration Project ACIP. The project adopts a bottom-up strategy directly reaching out to universities instead of targeting the Ministry of Education or the Ministry of Power. In India Universities have to follow the minimum guidelines set by the specific State Ministry (education is a State Subject in India), and the respective professional National Councils for accreditation (All India Council

3. Interim Report of the Expert Group on Low Carbon Strategies for Inclusive Growth, Planning Commission, Government of India, May 2011.

4. India: Greenhouse Gas Emissions 2007, Indian Network for Climate Change Assessment, Ministry of Environment and Forests Government of India, May 2010.

5. Energy Statistics 2012 Central Statistics Office, Ministry Of Statistics And Programme Implementation, Govt. of India, Table 6.2.

6. Hiding behind the poor, Greenpeace India society, 2007, G. Ananthapadmanabhan, K. Srinivas and Vinuta Gopal.

7. 36 % of scientists at NASA are Indians: Gov. survey, The Times of India, Akshaya Mukul, March 11, 2008.

for Technical Education and Council of Architecture). Besides these minimum guidelines, Universities can evolve their own curricula structure that is additional to these minimum requirements. Colleges are responsible for teaching a curriculum decided by State Universities, in this sense they have a passive role. However, colleges can design certificate level elective courses for students in year 4 and 5. This is why we generally aim for Universities rather than colleges, so as to scale curriculum change more rapidly.

Even if the programme were able to obtain a curricula policy shift at the federal government level, change at academia level would not be assured. Red tape and need for integration at the state level (India is constituted by 26 states) would be another obstacle. And most of all, change in government policy is never well implemented at society level if there are no prior will and understanding. Accumulating curricula shifts in Universities also serves the purpose to influence legislators at the State level and generate adaptation of guidelines for academia. This follows an Evidence Based Policy Making strategy typical of social enterprises.

INCUBATING CHANGE THROUGH SOCIAL ENTERPRISE AND RETRO PLANNING

This programme is a social enterprise campaign, whereby social change is sought through the identification of the key stakeholders involved in bringing or hindering the change sought out. A strategy (see process flow in Figure 1) is mapped out to reach out to these stakeholders and engage them directly through meetings and sharing of views on their perceived interests and the interests the campaigners hold as important for society's common good (in this case a reduced risk of runaway climate change and the sharing of finite resources) as well as for stakeholders themselves.

ACIP planners started positioning themselves in a hypothetical future where the main targeted universities had integrated EE across their compulsory student curricula. They then started evaluating realistic paths backwards to the present situation where student curricula are only exceptionally ingrained with knowledge of energy efficient building design. The Path chosen to bridge the knowledge gap between current available technical knowledge and student curricula started by assembling a proactive advisory board of specialists, each having a specific engagement with EE in the field of reducing beginning-of-pipe cooling load, end-of-pipe mechanical / passive cooling or calculating energy performance index of buildings.

Select members of the 15 strong advisory board are called upon by ACIP staff to become Fairconditioning Technology Ambassadors active during Training of Trainer (ToT) workshops organised in upcoming universities. Selected universities are also contacted to engage a discussion on how they see themselves integrating EE into their curricula. Until now every university contacted by ACIP staff has shown keen interest and some had been waiting for such exterior guidance as to how to adapt their courses to India's energy challenge. When we do encounter university management personnel that feel they are already doing all that is possible and are at the cutting edge of EE education – thereby claiming they couldn't gain much from the program – we use our social-entrepreneurship zeal to fire them up to become Hubs for training other professors to replicate this success in smaller, less privileged colleges in the same or in neighbouring cities, serving thus a dual purpose. Technology Ambassadors are made freely available to assist this process with their validated expertise.

Three to five days ToT workshops (see below) organised on-site in collaboration with university staff are used to showcase the corpus of knowledge and tools on EE in building design. After an introductory note on the energy and climate challenge by ACIP staff, Technology Ambassadors give 30 to 40 minute presentations followed by question time. Professors and academic staff from several universities in the same

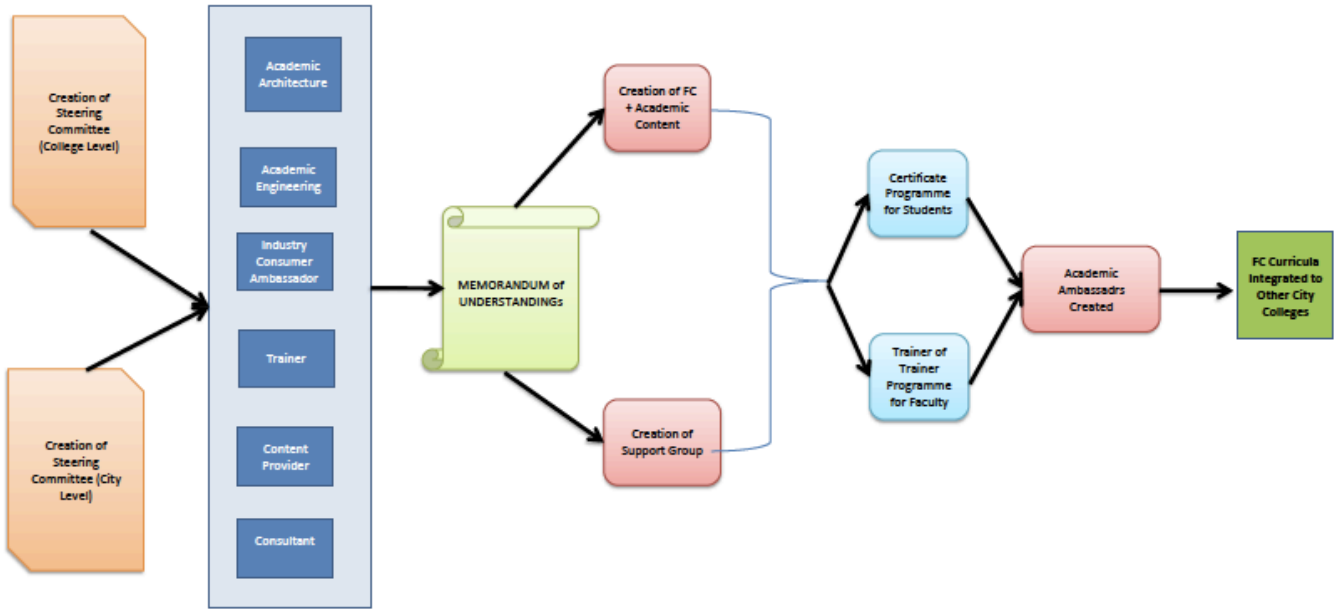

Figure 1. Process flow.

urban area attend ToTs. The goal is to incubate interest not only among the hosting university. Practising architects, engineers and HVAC consultants, as well as students have also attended ToTs.

TRAINING AT THE RACHANA SANSAD INSTITUTE OF ENVIRONMENTAL ARCHITECTURE

For its first ToT in early January 2015, the ACIP team chose to host the event at the *Rachana Sansad Institute of Environmental Architecture* (RSIEA) in Mumbai, an architecture school familiar with teaching building codes, EPIs and EE technical alternatives to ACs. The foremost goal for hosting the event there was to attract teachers from other schools in the vast Mumbai area (21 million inhabitants) and its 7 architecture schools. RSIEA staffs collaborated in reaching out to these schools, one after the other and was able to have teachers from 6 schools attend the event. Even though the end-goal with such events is to integrate EE knowledge in elective, then into mandatory courses, ACIP staff also reached out to practising architects through collaboration with the Mumbai bureau of the *Indian Institute of Architects,* official partners of the event. Students were also invited; they attended from 12 different schools, either through their personal commitment to the cause, to obtain the certificate for attendees to the full three-day training or for both reasons. During the plenary sessions, FC Advisory board members dispensed teachings on their respective field of specialization. These speakers represented academia, energy auditing firms, HVAC consultants, cooling sector companies and architecture firms. Speakers covered the following topics:

- Energy Conservation Building Code & voluntary green rating systems
- Building Energy Modelling & Simulation
- Climate Change, Ozone Depletion and Cooling Systems
- Natural Refrigerants replacing F-gases in Air Conditioners
- Beyond cooling, Thermal comfort – concepts, measurements and standards
- Deep retrofits: Case study – Empire State Building
- Passive cooling techniques – theory and practice
- Efficient Building Envelope Design
- HVAC system level design
- Direct & Indirect evaporative cooling systems
- Radiant cooling techniques: Structural cooling
- Solar Vapour Absorption systems
- Methods for comparative assessment of cooling technologies
- Pedagogy and teaching tools for integration of new knowledge
- The Challenge of Curriculum Integration

The event ended with a panel discussion on curriculum integration. Among the main issues was a discussion on the most relevant stage in student curricula where EE should be integrated. It was generally agreed that a seamless integration from year one onwards was the best option. The first step is an additional certificate elective course for year 4 and 5 students. This step does not require a formal curriculum change. The audience was active; speakers were addressed with numerous questions, testimonials and interventions.

On the third day a field visit was organized to see on site how a structural cooling installation functions. At the end of the three-day visit 70 certificates were distributed to attendees.

Organizing and holding the 3-day event is the first part of the intervention for Mumbai. The second part involves more adaptation and demands more creativity: Networking was a highlight during these days, business cards were exchanged, resolutions for action were taken and several teachers were fired-up to contact their Head of department and start working on curricula updating in their own school. This is where the programme earns its social enterprise stripes. ACIP staff is conducting a school-by-school tailored follow-up with Academic Ambassadors (motivated persons who had attended the workshop we gave), to help them in their initiatives to integrate EE curricula in their respective schools. Further one-day ToT sessions are organised in coordination with Academic Ambassadors to sensitize staff and deans who hadn't attended the RSIEA event and counselling is given to Academic Ambassadors to tool them and strategize with them. The end goal is to gain the support of Faculty staff to the need of updating student curricula, first with elective courses, then on integration of EE in the core compulsory course material.

Challenges ahead

In the near future, for all the progress India could be making in seamlessly integrating EE principles in universities and mainstreaming certified energy efficient buildings, there could still be close to no progress made in the real world of post-construction energy performance of green buildings. For all that glitters isn't green! Most of the certification systems in place in India are prescriptive and not performance or outcome based. According to Professor's Roshni Yehuda Udyavar's personal experience (Head of Rachana Sansad's Institute of Environmental Architecture), buildings in which the developer is also the user tend to maintain their green infrastructure, while the overwhelming majority of those where the developer sells property to another end-user; there is no incentive (or even knowledge) for the user to maintain the green systems. So usually, waste water systems, PV solar panels and green roofs tend to be the first casualties. Worse still, it is now widely recognised in the concerned community that LEED certificates for buildings have often been liberally granted, based on bogus claims and fake intents. According to Yehuda Udyavar, developers often use green certifications as a means to obtain fast tracking of environmental clearances as per Govt. of India regulations. Buildings are pre-certified, the paperwork is all there, but buildings never take shape as per documentation in the certifications. Monitoring & Verification was intended to avoid such situations, however there is no monitoring or post-occupancy evaluation. Incidentally, this is why the Fairconditioning programme designers decided to promote curricula change directly in each university or college instead of going overhead towards Ministries: since, again, successful decision-taking at

government level does not necessarily imply subsequent regulation implementation or enforcement.

After documenting the performance gap in numerous LEED certified buildings, the Centre for Science and Environment[8], an advocacy organization in Delhi, publicly demanded full disclosure of resource consumption data of all rated buildings to see if rating had been delivered on actual performance. This is needed urgently before more official standard operations procedures are tied up with private green rating systems. This current situation is disheartening and leaves a wide space for improvement.

The CSE and similar organizations are currently lobbying Government bodies and raising social awareness on the dire need to make the ECBC mandatory and verified (with passive cooling taken in consideration), in place of currently more lax LEED certification. This indeed is highly strategic. However soon success is reached by these parent organizations, the Academic Curricula Integration Project will still be needed up front. Both endeavours are leading to the same outcome: putting India on the right path to ensure the current building boom doesn't leave a legacy of a building stock unfit for the 21st century, needing to be deeply retrofitted in the near future, at a multiple of the cost of building them with contemporary EE know-how from the start.

As a note of hope and progress, a small but growing number of developers led by highly motivated founders in India are designing and constructing buildings with exemplary EPIs as well as water and waste-management systems. Also, the latest of ACIP's achievements has been the signing of a Memorandum of understanding (MoU) with the Maharashtra Institute of Technology, Pune, whereby yearly 5-day certified workshops on thoughtful cooling will be given by Technology Ambassadors for 3rd and 4th year and Masters students in mechanical engineering. These workshops will be reinforced by train-the-trainers sessions for MIT Pune staff, to pave the way for an in-staff uptake of the curricula.

In the 2 next years until June 2017, ACIP plans to sign such MoUs and implement the agreements in universities across Delhi (National Capital Territory), Kolkata (West Bengal), Chennai (Tamil Nadu), Bangalore (Karnataka), Ahmedabad (Gujarat), and Hyderabad (Andhra Pradesh).

ACIP staff also wishes to dissolve artificially created boundaries between HVAC engineering students and architecture students by looking to establish engineering-architecture co-learning partnerships where common training sessions are held for students from diverse academic backgrounds and pre-existing skill sets and getting them to work on collaborative projects in the field of energy efficient building design and sustainable cooling technologies. This still has to be experienced, evaluated and eventually added to the tools we put before the growing number of Academic Ambassadors we work with.

The future is unwritten; programmes such as Fairconditioning's Academic Curricula Integration Project are planting seeds of knowledge and awareness, in the long impatience of germination.

Glossary

AC	Air Conditioner
ACIP	Academic Curricula Integration Project
BEE	Indian Bureau of EE
DSM	Demand Side Management
EE	Energy Efficiency
ECBC	Energy Conservation Building Code
EPI	Energy Performance Index
F-gas	Fluorinated (synthetic) gas
GHG	Greenhouse gas
HVAC	Heating, Ventilation and Air Conditioning sector
LEED	Leadership in Energy and Environmental Design. North American green building standardisation code
MEP	Mechanical/Electrical/Plumbing services
MOU	Memorandum of Understanding
TOT	Training of Trainers workshops
UNFCCC	United Nations Framework Convention on Climate Change

8. Building sense: Beyond the green facade of sustainable habitat, Anumita Roychowdhury & Avikal Somvanshi, Centre for Science and Environment, Delhi, 2014.