Innovation and Implementation of Climate-Related Energy-Efficient Building Design in India

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Introduction

In the next 40 years, the current world population will increase by 30%. Constantly shrinking resources and deteriorating environmental conditions are the core challenges of the global humanity. Therefore, population growth and the booming economy in emerging countries like China and India have a big impact of demand of natural resources and environmental change. As novel price winner Joseph Stiglitz stated, the rising power of Asian countries is at least the "correction of a 200-year historical anomaly, in which Asia's share of global GDP fell from nearly 50% to, at one point, below 10%. The pragmatic commitment to growth that one sees in Asia and other emerging markets today stands in contrast to the West's misguided policies, which, driven by a combination of ideology and vested interests, almost seem to reflect a commitment *not* to grow."[1] This rebalancing of economic power goes along with a high demand and supply of energy in China and India and other BRIC countries as well as with an acceleration of energy security, energy saving, energy efficiency, and renewable energy production. Energy efficiency as a core issue of sustainability offers immense opportunities for innovation-driven economic growth and prosperity. India's middle class will grow from nearly 150 million people today to nearly 600

[1] http://www.project-syndicate.org/commentary/the-perils-of-2012

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K.B. Akhilesh (ed.), *Emerging Dimensions of Technology Management*,
DOI 10.1007/978-81-322-0792-4_9, © Springer India 2013

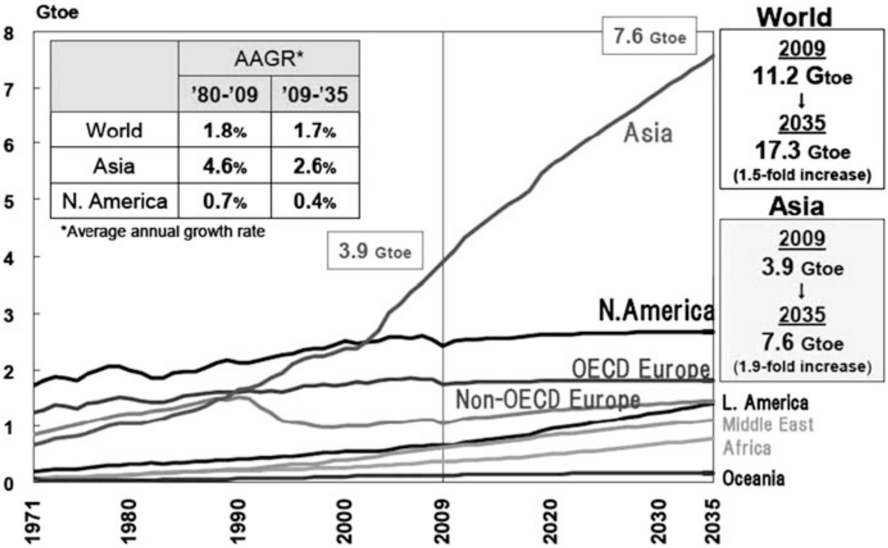

Fig. 1 Energy growth rate of OECD and non-OECD countries (IEEJ 2011)

million (50% of total population) by 2030.[2] But most importantly, it is an enabler for combing science and business with sustainable economic development and societal interest. Population explosion, environment degradation, and paucity of all kinds of resources elevate high local and global risks, but all the risks involve themselves in infinite opportunities for sustainable based businesses and corporate social responsibility.

This chapter investigates the relevance of buildings and constructions in terms of energy consuming and issues of energy efficiency combined with living comfort in a historical perspective. Today, buildings account 40% of the total US energy consumption[3]; in India it is estimated by 30% of the total energy consumption.[4] Depending to the growth of the building sector, this share will increase extremely. Advisers reported that “by 2025, buildings worldwide will be the largest consumers of global energy – greater than the transportation and industry sectors combined.”[5]

Statistics show that the total energy demand of Asia (including China and India) will be nearly doubled within the next 25 years and so exceed by far that of the other continents (Fig. 1).

However, the most important point is the gap in developed countries and in emerging economies between challenges on energy efficiency living, awareness of

[2] McKinsey Global Institute (2010). India’s urban awakening: Building inclusive cities, sustaining economic growth. (http://www.mckinsey.com/insights/mgi/research/urbanization/urban_awakening_in_india)

[3] http://newscenter.lbl.gov/feature-stories/2009/06/02/working-toward-the-very-low-energy-consumption-building-of-the-future/

[4] Vivek Gautam (2009). Energy Efficiency in Buildings: Indian Market Landscape. (www.frost.com)

[5] http://www.clearpathsus.com/articles/buildgreen.html

energy saving, institutional learning and education on these fields, research and development, and last but not least implementation of best practices in public and private areas and in residential and commercial buildings.

Nevertheless, usually there is no transfer of knowledge and design specifications from the design phase to operations. Very few new buildings are planned in a comprehensive life-cycle model, and most building facilities management staff do not have access to the design specifications of building systems they maintain.

When buildings are designed so that their systems work together to maximize energy efficiency, they can use less energy than they do on average today, even as they provide heating, ventilation, air-conditioning, and lighting, together with power at the electrical outlet. For this enhanced performance level to be achieved, the building needs to be constructed according to environmental specification.

This chapter is a first outline of a long-term joint research project between Germany and India on innovation and implementation of climate-related energy-efficient building design. We thank all Indian and German partners, namely, the International Bureau of BMBF, the Indian Institute of Science (IISc), and Bayer Material Science (BMS) for the great support and fruitful collaboration.

Climate-Related State of the Art in Energy-Efficient Buildings

Research and praxis in architecture and building industry have developed many technological and material solutions within the last decades. In Europe, the energy saving became a crucial aspect after the oil crisis in 1973; regulations for buildings started in the 1980s and have been further developed and sharpened until today. The European Union's Directive on the Energy Performance of Buildings from 2010 has now introduced the standard of the "nearly zero energy building (ZEB)" that has to cover a "significant amount" of its energy demand by renewable energies "on-site or nearby" as a European standard to be realized until 2020. The future of energy-efficient buildings will be the standard of plus energy buildings that are producing more energy than they demand themselves. This will be a paradigm change with huge impact the grid structure and the energy-providing system that will be answered differently in certain countries.

The certification of buildings has become common practice to label the buildings; still different and competing systems appear worldwide: BREEAM, LEED, GREENSTAR, Cradle to Cradle, DGNB, and more. The approaches differ in content and weighting of the factors and cannot directly be compared. Most of them are not dealing with embodied energy and life-cycle assessment but focus on energy consumption in operation of the buildings. As for India, the need of energy saving is described in different documents, among them the Energy Conservation Building Code (ECBC) from 2007 and the ECBC User Guide from 2009 (BEE 2007). Also in 2007, the LEED certification has been introduced by the Indian Green Building Council (IGBC) to raise awareness and to reduce energy consumption (IEA 2011). Finally in 2010, the Green Rating for Integrated Habitat Assessment (GRIHA) has been introduced as the National Rating System and a tool to design, operate, evaluate,

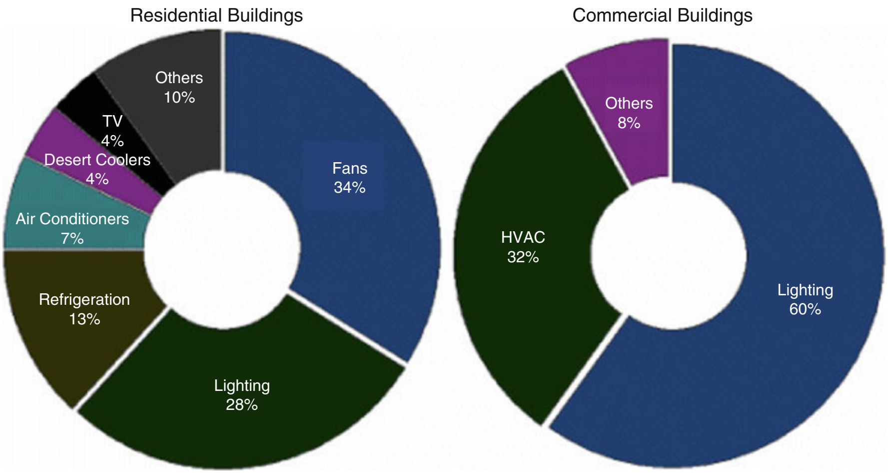

Fig. 2 Energy consumption of residential and commercial buildings in India (BEE 2009)

and maintain green buildings over all climate zones and building typologies (IGBC 2007).

Nevertheless, 40% of the total energy consumption worldwide is linked to buildings, mainly used for cooling, heating, and artificial lighting; fans and water heating are specific. Further distinction can be made between residential and nonresidential buildings and industrial plants. It is obvious that residential buildings show an increasing demand of energy owing to the improvement of quality of life in the middle class and also the implementation of minimum standards for the poor (Fig. 2).

The McKinsey Global Institute estimates that the most cost-effective measures taken to reduce greenhouse-gas emissions involve building efficiency (MNRE 2010). The measures are:

- Building insulation
- Lighting systems
- Air-conditioning
- Water heating

Looking back into history, India has a rich tradition of climate-adapted buildings that worked properly. Many scholars in India are aware of those qualities and principles and want them to become part of future-oriented design strategy in architecture and building construction (McKinsey Global 2010). Related to its five climate zones, different forms of architecture, materials, orientation, and principles can be found – most of them are perfectly adapted to the climatic requirements and in local building materials (Fig. 3).

In the eighteenth and nineteenth century, a period of colonial British architecture is characterizing part of the different Indian state capitals before all New Delhi with its public buildings such as train stations, colleges, museums, and monuments.

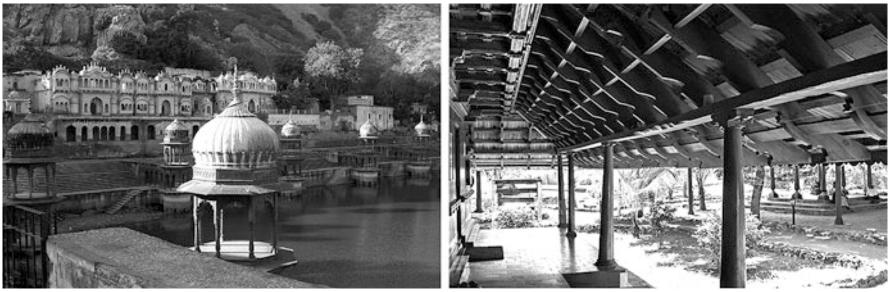

Fig. 3 Traditional tropical architecture of the last centuries was aware of the importance of solar shading in combination with natural lighting and ventilation. Depending on the climate zone, massive or wooden construction was preferred

Fig. 4 Modern tropical architecture is very present in India since the 1920s using traditional principles with new materials and in another formal languages; examples are residences in Mumbai and the buildings in Chandigarh

Those are primary representative but they are not showing specific of climate-related characteristics. More interesting in this regard is the huge amount of modern movement buildings that, for example, in Mumbai, can be compared to the famous Art Deco building stock in Havana (Cuba) or Miami (USA). In many cities, large-scale residential complexes from the 1930s are still in use – marked by overhanging balconies and horizontal brise-soleils (sun protection). More importantly, they are part of a human-scaled urban infrastructure offering private and public spaces in transition and in combination with trees and plants. After independence in 1947, more public, administrative, and governmental buildings followed in the tradition of the modern movement. Most famous is the capital of Chandigarh as a completely planned city (Figs. 4 and 5).

Urban and architectural planning in India will have to rise to the challenges of improving the building stock and new buildings at all levels with energy-efficient structural and technical measures. In the case of the building stock, the field of operation is of course reduced compared to new buildings. Orientation, plan, and

Fig. 5 The design of the facade and of solar shading is a crucial factor for the climate control and the energy-and cost-efficient design of buildings on the construction side

Fig. 6 Most Indian megacities are characterized by the uncoordinated superposition (overlay) of architectural and infrastructural elements owing to the fact of extraordinary and rapid growth

facades allow only limited interventions and have to be verified in every single case. Lighting, cooling/heating, and the use electronic devices are highly depending on the user's awareness (Fig. 6).

The measures for implementation have to be applied at different levels of the planning and building process (urban, constructive, and technical) and in the operation of the buildings. The user's comfort is the main issue to obtain acceptance and create identification with a building. Their behavior is a crucial part to realize an optimal operation of the buildings. The following table compares the most important measures (Table 1).

In any case, the implementation of energy-efficient technologies in buildings has to go along with a nationwide educational campaign. Next to the improvement of the building stock, it is of highest priority to ensure and to improve the quality of life, the provision of water and electricity, and the disposal of water and waste.

Table 1 Measures at urban, constructive, technical, and operating levels to ensure energy-efficient buildings

	New buildings	Building stock
Urban measures	1. Respect building tradition	1. Elaborate traditional elements
	2. Orientation for wind and shading	2. –
	3. Interaction with ecosystem	3. Reactivate or create if possible
	4. Provide private and public spaces	4. Modify or adapt if possible
	5. Zoning according to usage	5. Modify or adapt if possible
Structural measures	1. Insulation (preserve, heat, or cool) (suitable for all building elements)	1. Insulation (preserve heat or cool) (suitable for roofs and part of walls)
	2. Storage mass – water cooling (massive construction – cooled air)	2. If possible
	3. Sun protection – solar shading (prevent overheating + direct sun)	3. Retrofitting possible
	4. Natural daylighting – light control (allow indirect solar radiation)	4. Retrofitting possible
	5. Natural ventilation (conduct heat and moisture away)	5. If possible
Technical measures	1. Minimizing electrical consumption (energy-efficient lighting + appliances)	1. Minimizing electrical consumption (energy-efficient lighting + appliances)
	2. Producing renewable energy (photovoltaics, wind)	2. Producing renewable energy (Photovoltaics, wind)
	3. On-site heat recovery (Solar thermal, heat pump, combined heat and power)	3. On-site heat recovery (solar thermal, heat pump, combined heat and power)
	4. On-site cooling (absorption/ compression cooling)	4. On-site cooling (absorption/ compression cooling)
	5. Mechanical ventilation (with heat/ cooling recovery, foster cross ventilation/exhaust-air extraction)	5. Mechanical ventilation (with heat/cooling recovery, foster cross ventilation/exhaust-air extraction)
User behavior	1. Knowing and applying energy-saving measures	
	2. Maintenance and service have to become a routine	

Population Growth in India and Energy Demand

In the next 20 years, India has the fastest growth in population from nearly 1.2 billion people by 2011 to nearly 1.5 billion people by 2030. As the McKinsey forecast[6] in a trend report for India shows, accompanied with this demographic trend are sprawling suburbs and migration from remote rural areas to metropolitan regions for better choices of work, income, and living standards (see Fig. 7).

[6] McKinsey Global Institute (2010). India's urban awakening: Building inclusive cities, sustaining economic growth

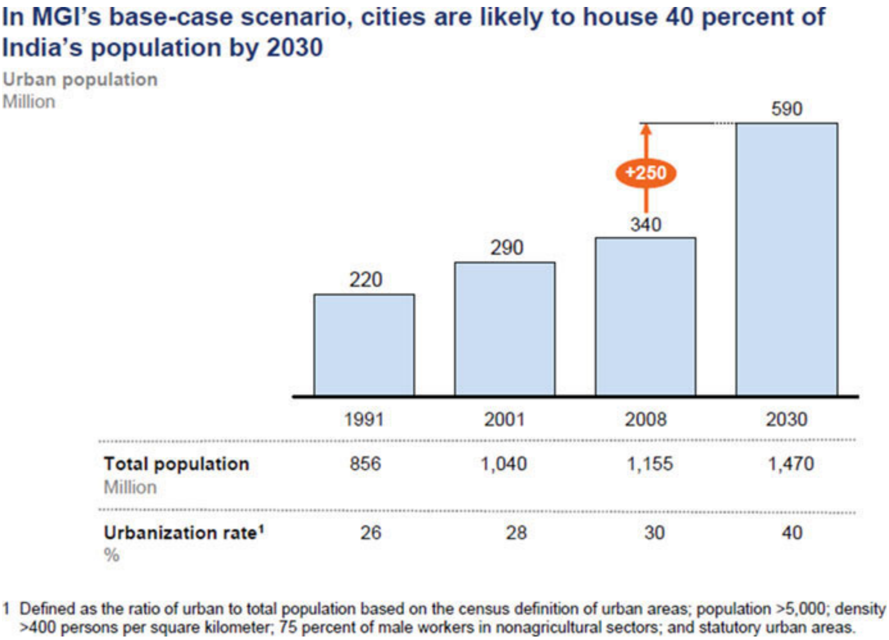

Fig. 7 Population in Indian cities in 2030 (MGI (2010). India's urban awakening: Building inclusive cities, sustaining economic growth)

This population growth in urban areas and the rapid increasing middle class accelerate a growing demand on goods, material, and different types of energy. In 2030, nearly 70% of the GDP will account by cities all over India. The compound annual growth rate will be nearly 8%. In 2030, about 40–50% of the energy demand by non-OECD countries is coming from China and India. The share of energy demand by buildings (construction and operation) in India will rise from currently 30 to 40% of the total amount. On the base of a strong governmental energy-saving and efficiency policy and regulation as well as an ability, affordability, and accessibility, India can save between 40 and 50% of energy demand and growth in the future (Fig. 8).[7]

In all natural resources, India has a lot of technological, financial, and governmental constrains to explore, procure, and supply these resources. Without international collaboration and domestic development of energy-efficient frameworks and instruments, the energy demand will not be supplied. High-energy efficiency buildings and on the edge operations can reduce the energy demand dramatically. Buildings can change from the energy consumer to an energy producer; it is time for zero plus buildings. Buildings like that produced more energy than they consumed (Fig. 9).

[7] IEA (2011). World Energy Outlook 2011

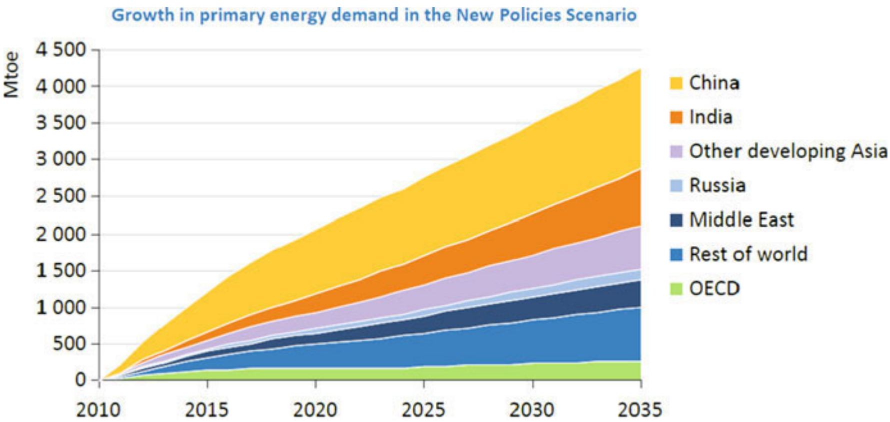

Fig. 8 World primary energy demand in China and India and ROW (IEA 2011. World Energy Outlook 2011)

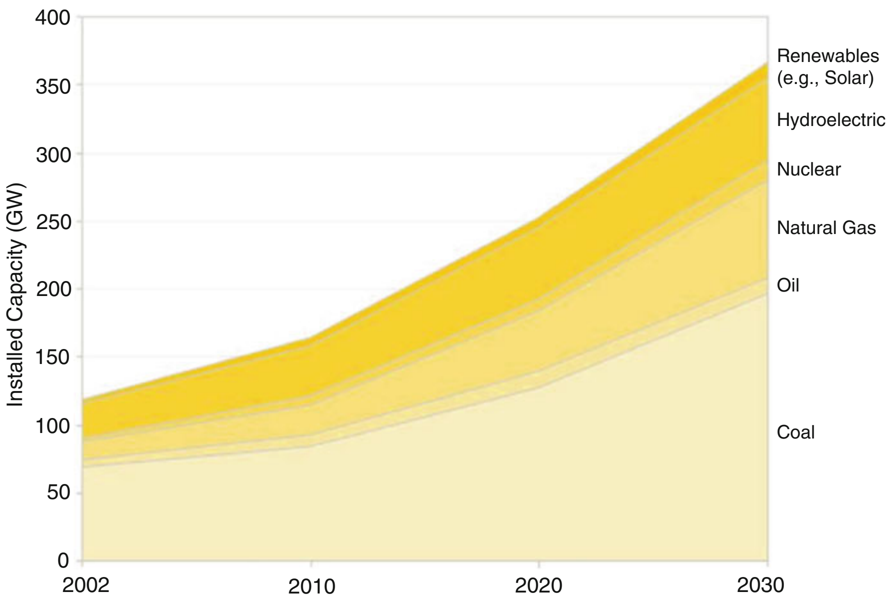

Fig. 9 India's installed energy capacity 2002–2030 (IEA 2004. World Energy Outlook 2004)

Growing Awareness of Energy Efficiency in India

As we guess, the higher educated middle class in India with increasing income and international experience has a high interest and demand of environmental protection and energy-saving actions. They want comfortable living in their residential, clean air in the city, comfortable transport systems, and world-class equipment of energy

Good cities deliver robust economic growth, as well as a sustainable quality of life

	What good cities deliver	
Robust economic growth	Sustained productivity advantage	▪ Cities have established a robust economic growth agenda and provide a favorable investor climate
	Robust job creation	▪ Ensures creation of sufficient jobs and livelihoods
Sustainable quality of life	Scaled public infrastructure	▪ Uninterrupted access to clean water supply for every resident ▪ 100 percent coverage, proper treatment of sewage and solid waste ▪ 45 minutes maximum intra city travel time for all citizens
	Reliable social services	▪ Quality, affordable education and health care facilities for all ▪ Access to affordable housing for all sections of the society; no urban slums
	Good recreational and community infrastructure	▪ Parks within 15 minutes of walking for every resident ▪ Open spaces throughout all cities ▪ Entertainment hubs and community spaces that celebrate diversity and foster innovation for all residents
	Sustainable environment	▪ Preservation of natural resources and ensuring access to clean air, water, and land ▪ Matching national standards on climate change, emissions, and sustainability

Fig. 10 *Robust economic growth and sustainability in good cities* (McKinsey Global Institute (2010). India's urban awakening: Building inclusive cities, sustaining economic growth)

saving in their new or old houses. At the moment in India, one can observe a massive trend in the upper middle class to move with family in new houses in the suburbs.

For that, the McKinsey report figured out criteria for robust economic growth and sustainable quality of life in cities (Fig. 10).[8]

Unfortunately, all these expectations and guideline stand in opposite to the quality of life trends from the same report.[9] From water supply to sewage, solid waste, private transportation, rail-based mass transport, and affordable houses, all these good infrastructure needs could be deteriorated without effective interventions (see Fig. 11).

Education and Training in Energy Efficiency

A key point of sustainability, environmental protection, resource effectiveness, and renewable energy production and supply is education and training of young people. From the "kindergarten" until the high schools and universities, methodological and

[8] McKinsey Global Institute (2010). India's urban awakening: Building inclusive cities, sustaining economic growth

[9] McKinsey Global Institute (2010). India's urban awakening: Building inclusive cities, sustaining economic growth

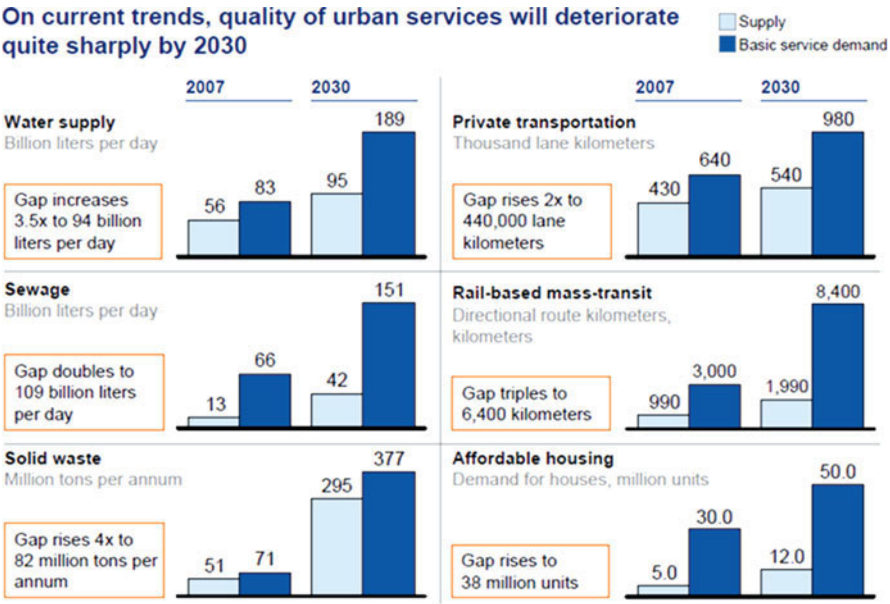

Fig. 11 Quality of urban services will deteriorate till 2030 (McKinsey Global Institute (2010). India's urban awakening: Building inclusive cities, sustaining economic growth)

didactical concepts have to be developed. Schools, colleges, and universities must be an enabler for energy-efficient living and environmental protection. A school – in visionary sense – is a building which has four walls and the future inside. A "green learning environment" is an energy-efficient, higher performing school that can be environmentally beneficial, economical to build and operate, and offer improved learning environments and labs for applied sustainability. Public school facilities are increasingly designed and constructed to be efficient, effective, and sustainable for their expected building life to enhance energy efficiency and environmental awareness. The actual student competition of the Indian Green Building Council (IGBC) for a sustainable school is a starting point of detailed discussions on buildings, spaces, products, and user's needs for a successful implementation of measures for the improvement of life conditions. Students from Deenbandhu Chhotu Ram University of Science and Technology, Murthal/Sonepat, and Ostwestfalen-Lippe University of Applied Sciences, Germany, have made several design interventions for sustainable schools. The next step is to realize a school pilot project on the edge.

Looking around in India, there are already established first pilot schools for sustainability. These schools are Auroville (Suhasini Ayer Guigan); The Doon School (Kothari and Associates); Delhi Public School, Agra; Vidyanidhi Education Society, Gurgaon; The Shri Ram School, Gurgaon; Salwan Public School, Woodstock School; Mussorie (Ar Niraj Manchanda); Druk White Lotus School, Leh (Ove Arup); Green Schools Program, CSE; Mirambika, New Delhi (Ar Sanjay Prakash); Shikshantar, Gurgaon; Pragyan, Greater Noida (Ar Sanjay Prakash); and Earth School, Jalandhar

(Ar Sanjay Prakash). These identified pilot schools in India must be evaluated and analyzed to design new innovative ideas for further facilities and applications.

Research and Development in Energy-Efficient Buildings

To accelerate the change process in the Indian energy efficiency scheme, it is helpful to have a look to the European and other Western societies. Innovation has become a key factor of European economy, research, and society. Upcoming research programs in Europe are created to react “in this the second decade of the twenty-first century, on the backdrop of a changing world order, (in which) Europe faces a series of crucial challenges: low growth, insufficient innovation, and a diverse set of environmental and social challenges” (MGI 2011). Many specific calls are related to the building sector looking for holistic approaches to combine the so far developed technologies within consistent building concepts. The well-being of the users is another focus to be considered to guarantee acceptance and so the efficient use of the applied technologies. Not only in India but everywhere in the world cost-effective solutions for the energy-efficient design of buildings and cities are needed. The existing innovations in architecture have to be transformed into innovation architecture.

For private and public organizations, one well-known approach to identify the best solutions is the method of construction radar to match, verify, and evaluate the different options according to the climate zones and building typologies. It allows to compare existing technologies, materials, or concepts and to visualize the potentials. The radar could give further input to the development of a strategy for the implementation of energy-efficient buildings (Fig. 12).

Construction radar is an operational instrument of Bayer Material Science (BMS) for strategic research, development, and daily business to identify short-term and long-term trends in material, application, technology, and market conditions. Each of these four radar segments is shared in four subsegments. In each segment and subarea, different trends must be identified for the next 3, 8, and 18 years. Between each short-term and long-term trend or aspect exists mostly a strong or slight link to each other. Through this combination and analysis, the stakeholder or interest group can assemble a development and marketing strategy and action plan. The following user survey should help to identify these trends and market demands from the costumer’s perspective.

User Survey on Energy Consumption in Living

The transnational and transcontinental sharing and dissemination of knowledge in the field is as well important and can only be improved with the help of diverse stakeholders – including science, politics, and industry. For that, all stakeholders and guests can join the CREED-PS website http://www.hs-owl.de/creed/ to find further information on climate-related energy-efficient development.

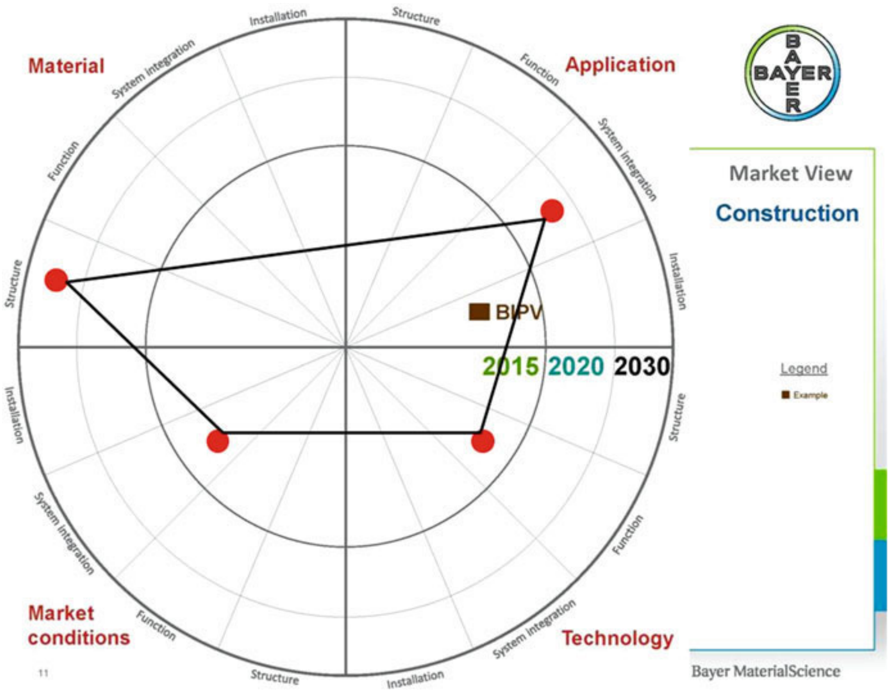

Fig. 12 The technology radar could be applied to identify and visualize the best solutions for energy-efficient buildings (BMS-Chart adapted by author)

As well the CREED-PS project provided an investigation of people in five Indian cities to explore the awareness and needs of the stakeholder. People of the city of Mumbai, Bangalore, Chennai, Delhi, and Pune can attend the investigation on the questionnaire at http://www.hs-owl.de/creed/events/investigation/.

Overall aims of the investigation and survey are:

1. To integrate the stakeholder's mindset in knowledge sharing and decision making on energy-efficient buildings and living style
2. To extend the awareness and the knowledge on energy-efficient building design
3. Identification of awareness/needs/methods/approaches to improve the Indian energy scheme
4. Development of instruments for the promotion of sustainable consumption such as new material, comparative testing, and awareness campaigns; life-cycle assessment; and green public procurement
5. Involving businesses and corporate social responsibility for the promotion of energy efficiency and sustainable consumption
6. Identification of a stakeholder strategy for energy efficiency and sustainable consumption

For the questionnaire, we designed following hypothesis:

1. Higher educated people of the new middle class in urban areas have a clearer awareness and higher needs on energy-efficient lifestyle than lower educated people.
2. Females are better informed on energy saving and efficiency than males.
3. Younger dwellers are better informed on energy saving and efficiency than older dwellers.
4. Living in the city center has a higher priority than living in the suburbs.
5. A good residential place has a higher priority than the distance to the working place.

The investigation design included a questionnaire with 22 questions within individual profile data on age, sex, and qualification. In the first section, data on mobility are explored. In the second section, data of housing and lifestyle are investigated. In the third section, data of living preferences, environmental aspects, and general topics are diagnosed. In each city, at least 200 questionnaires are collected. The evaluation would make with SPSS and EvaSys. The duration period is April 2012 till January 2013. After each city investigation, part results are delivered. In 2013, the final report will be finished and published on the website above.

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