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CENTRE FOR RESEARCH ON
SUSTAINABLE BUILDING SCIENCE
CAPABILITY STATEMENT



The Energy and Resources Institute Overview

Established in 1974, The Energy and Resources Institute (TERI) is a not-for-profit research organisation with a global vision and local focus. While in the initial period the emphasis was mainly on documentation and information dissemination activities, research activities in the fields of energy, environment, and sustainable development have been going on since 1982.

A unique developing-country institution, TERI is deeply committed to every aspect of sustainable development. It is one of the most reputed institutions in India to have pioneered several success stories on environmental sustainability. The Institute's growth has been evolutionary, driven by a vision of the future and rooted in challenges looming today, based on an approach that looks beyond the present and across the globe. TERI has, therefore, grown to establish a presence not only in different corners and regions of India but is perhaps the only developing country institution to have established a presence in North America and Europe and on the Asian continent in Japan, Malaysia and the Gulf.

TERI now has staff strength of over 700 dedicated employees, drawn from a range of disciplines and experience, supported by infrastructure and facilities, which are world class and distinctively state-of-the-art.

The principal activities of TERI are grouped into thirteen Divisions.

- **Energy Environment Policy:** The Energy Environment Policy Division is engaged in policy research to effect an improvement in the quality of the environment, and to bring about efficient management of, and equitable access to, natural resources.
- **Energy-Environment Technology:** The EET Division is engaged in the development and promotion of technological solutions for efficient utilization of energy, sustainable exploitation of renewable energy, pollution reduction, and waste treatment.
- **Environmental and Industrial Biotechnology:** In its relentless quest to harness India's bio-potential, the Division conceptualizes and produces an array of ready-to-use and commercially viable products that are consumer-friendly, cost-effective, and environmentally sound.
- **Biotechnology and Bioresources:** The Division, on one hand, focuses on basic and applied research on using microbial resources for biotechnological intervention to address agriculture and energy- and environment-related issues, and on the other, supplements conventional methods of improving plant species with biotechnological techniques.
- **Regulatory Studies and Governance:** The Division has three key areas of work, i.e. energy reforms, regulatory policy, and urban systems and infrastructure. The Division facilitates the strengthening of new and emerging forms of governance and regulation in infrastructure sectors such as electricity, water, coal, oil and natural gas, and transport.
- **Resources and Global Security:** The Resources and Global Security Division serves as a focal point for TERI's work on international studies and strategies for resources - conserving, sharing, responsible development, and use - to assist India's efforts at developing a positive vision for a more global and regional security.
- **Social Transformation:** The Division takes into account the complexities that emerge when environmental issues are married to a region's unique social and economic profile, and initiates comprehensive solutions for the poor. The focus of the Division is on delivering a combination of integrated-technology-based solutions as against isolated, sector-specific interventions.
- **Information Technology and Services:** The Information Technology and Services Division is mandated to provide accurate, timely, and relevant information to those who need it the most. It uses a variety of media - print, television, the Internet, video, and CDs - to reach out to researchers, policy-makers, administrators, technocrats, and scholars, aiding their activities through effective value-added information that positively impacts their projects.
- **Sustainable Development Outreach:** Established with a goal to broaden the scope of disseminating knowledge on the issues concerning the environment and sustainable development, the prime objective of the division is to share TERI's research work & experiences with the masses.

- **Technology Dissemination and Enterprise Development:** The focused R&D efforts of TERI have resulted in the development of several technologies related to energy, environment and sustainable development. The Enterprise and Technology Development division was set up to ensure the smooth and systematic movement of these technologies from TERI's laboratories to commercial enterprises, and also to ensure a match between the needs of industry and development of suitable technologies.
- **Water Resources:** The division through its diverse group of experts including hydrologist, economists, planners, geographers and engineers envisions providing services to various stakeholders including rural and urban communities, industry and Government bodies to ensure the social, environmental, and economic sustainability of this precious natural resource.
- **Climate Change:** Different focus areas of climate change research include, impacts and vulnerability assessment, adaptation strategies, exploring GHG mitigation options and issues therein, climate change policies and climate modeling activities.
- **Industrial Energy Efficiency:** The Industrial Energy Efficiency Division of TERI focuses on development and promotion of technological solutions for efficient utilization of energy in the industrial sector.

Sustainable Building Science: Overview

One of the prime areas of activity within the Energy Environment Technology division is adoption of efficient and environment-friendly technologies in new and existing buildings. The activities of this area focus primarily on energy and resource use optimization in existing buildings and design of energy efficient sustainable habitats.

The Centre for Research on Sustainable Building Science (CRSBS) comprising architects, planners, engineers, environmental specialists, specialised in urban and rural planning, low energy architecture and electro-mechanical systems, water and waste management and renewable energy systems has been offering environmental design solutions for habitat and buildings of various complexities and functions for nearly two decades. The group also undertakes LEED facilitation for buildings.

The Green Rating for Integrated Habitat Assessment (GRIHA) cell, also comprising professionals from the above-mentioned fields is actively involved in facilitation of green rating for buildings under the GRIHA framework. Inputs from CRSBS feed into the processes undertaken at GRIHA cell.

The different services offered by the Sustainable Building Science (CRSBS and GRIHA) are as follows:

Environmental design consultancy

- Specialised environmental design consultancy and building performance analysis are conducted. A wide range of computations and simulation tools including DOE2, TRNSYS, ECOTECT, RADIANCE, FLOVENT, AGI32, LUMEN DESIGNER, BLAST, Phoenix, RETScreen are used to assess the environmental and cost impact of the design decisions.

LEED and GRIHA facilitation

- The team has experience in technically facilitating LEED accreditation [LEED India for New Construction (LEED India NC) and LEED India for Core and Shell (LEED India CS)] for buildings. The group also assists and administers GRIHA, an indigenous green building rating system for buildings, developed at TERI. GRIHA has now been endorsed by the Ministry of New and Renewable Energy, Government of India, as the national building rating system for India.

Energy audits and energy management programs

- Energy conservation studies for a large number of buildings are conducted. There exists a vast experience in conducting energy audits and evaluating a whole range of building upgrade options including envelope retrofit and system retrofit or changes in operational patterns. In addition to establishing operating efficiency of electrical, HVAC, lighting and thermal systems, recommendations to improve upon the same by suitable retrofit measures or by refinement of operational practices are also offered. The group also has expertise in development of energy management programs for service industries like hotels and the corporate sector.

Capacity building

- Capacity building for architects, building developers and service engineers on issues such as energy efficiency in building envelopes and systems has been undertaken. Over 1000 architects, developers and engineers in the area of green buildings, energy efficiency and sustainability aspects of built environment have been trained through training programmes, refresher courses, seminars and workshops.

Policy inputs

- Several policy initiatives at central and state governments' level towards mainstreaming high performance buildings in India have been successfully completed. Senior members of the group are members of the Committee of experts for development of the Energy Conservation Building Code (ECBC) of India (2007). The manual for environmental clearance of large construction for the Ministry of Environment and Forests, Government of India has also been developed at CRSBS.

Climate Change related projects

- Climate change is increasingly being recognized as a major global challenge. The group has provided inputs to the National Mission on Sustainable Habitat (a part of the recently released India's National Action Plan on Climate Change). Project Design Documents (PDD) are prepared in order to facilitate trading in carbon through the Clean Development Mechanism (CDM).

Project details

1. Environmental design consultancy/design advisory

TERI has been actively involved in providing technical consultancy for the design and development of sustainable building complexes. The scope of work has been to review designs provided by architects so as to incorporate energy efficiency measures in the building envelope and systems design. TERI provides complete green design consultancy, including site planning inputs, full building performance analysis, evaluation of energy systems, renewable energy integration, water and waste management strategies, and achieving indoor air quality standards.

Extensive interaction with the client and the design teams is undertaken in order to deliver the required analysis. Services offered for various green design projects include the following:

- Design charettes and review
- Energy consultancy
- Complete green design consultancy
- Consultancy for green rating (LEED and GRIHA)
- Renewable energy potential assessment and design
- Building envelope study for shading, daylight and material solution
- Artificial lighting optimisation and daylight integration
- Landscape assessment for water efficiency
- Water use estimation and water efficiency calculation, evaluation of systems for on-site treatment of waste-water.
- Estimation for rain-water harvesting potential
- Appropriate waste management schemes and systems

The specific areas of inputs and methodology followed to achieve the green design intent have been described briefly below.

Concept planning and design

Best results in green design are achieved if concepts are integrated at design stage. In order to equip the design team to achieve the green design intent, development of concept design through design charettes, design guidelines for master planning and layout, design review and site visit and preliminary analysis are undertaken.

Climate analysis

Analysis of climate is a prerequisite to determining appropriate solar passive strategies suited to a particular climate regime. Climate analysis studies are performed to yield following output:

- Determination of appropriate solar passive strategies
- Solar exposure and shading analysis
- Thermal zoning and shade programming
- Development of weather files for building simulation
- Rainfall assessment to help design rain-water harvesting system
- Wind flow analysis to enable design for natural ventilation

Site planning

Extensive project specific inputs are provided in order to facilitate sustainable site planning. This includes:

- Guidelines for conservation and efficient utilisation of resources (land, water, natural habitat, avi fauna and energy)
- Storm water and run off management
- Landscape water consumption recommendations (species factor, climate factor)
- Rainwater harvesting potential
- Recommendations to reuse waste water for irrigation
- Recommendations to reduce heat island effect
- Energy efficient street lighting- renewable energy
- Guidelines to minimize site circulation & provide aggregate utility corridor

Water efficiency

In addition to the water management guidelines provided at the site planning stage, at building level, the

following analysis is performed in order to achieve water efficiency:

- Water budget calculations for the building based on the occupancy and flow rates of the suggested fixtures.
- Recommendation on selection of appropriate low flow devices.

Waste water and solid waste management

- Quantification of waste water
- Wastewater treatment and re-use strategies
- Solid waste generation potential
- Resource recovery potential and appropriate measures
- Suitable collection & disposal strategies
- Recommend reuse strategies

Energy efficiency

Depending on the brief and nature of the project, non air conditioned (non AC) and air conditioned (AC) spaces are treated differently. Non AC areas are designed to maximize the thermal comfort levels with the use of natural ventilation, passive techniques and low energy consuming evaporative cooling strategies. The AC areas on the other hand are designed to minimize the load of installed HVAC systems and hence reduce energy consumption in building.

The basic route to design followed to achieve energy efficiency in buildings is as follows:

- Minimize energy demand in AC areas (thermal comfort in AC areas is ensured through HVAC design) and increase comfort levels in non AC areas of the building (by use of passive techniques in the architectural design suitable for the particular climate)
- Meet the electrical demand by use of efficient equipments e.g. efficient lighting systems, efficient air conditioning systems
- Use of onsite sources and sinks e.g. earth air tunnel system, solar energy etc.

In order to achieve the above, following activities are undertaken:

Review & analysis of design, followed by recommendations for modifications to include:

1. Thermal performance evaluation of building design
2. Design inputs to reduce energy demand and increase comfort levels in the building by design interventions in:
 - Orientation (with limitations of existing building regulations)
 - Building envelope to optimize annual energy demand
 - Fenestration Performance optimization (Glazing/Frame/Shading)
 - Wall/Roof Performance Optimization
 - Daylight analysis
 - Daylight integration
 - Energy analyses-HVAC systems
 - HVAC Load optimization (External/Internal/Ventilation/etc)
 - Optimum Equipment Selection
 - Optimizing HVAC/BMS controls and operations

Renewable energy systems for buildings

Preliminary systems design for solar Photovoltaic and solar thermal systems is undertaken and includes:

- Load assessment
- Size of PV/ and balance of systems depending on availability of space
- Estimation of energy generation
- Assessment of available products and services

Eco friendly materials

- Guidelines for selection of material are provided.

A brief overview of the important ongoing/completed projects is given in the following section.

Office building of the West Bengal Renewable Energy Development Agency (WBREDA), Kolkata

Climate: Warm and humid

Architect: Gherzi Eastern Ltd

Year of completion: 2000

Built-up area: 2026 m²

Services: Passive design and renewable energy integration

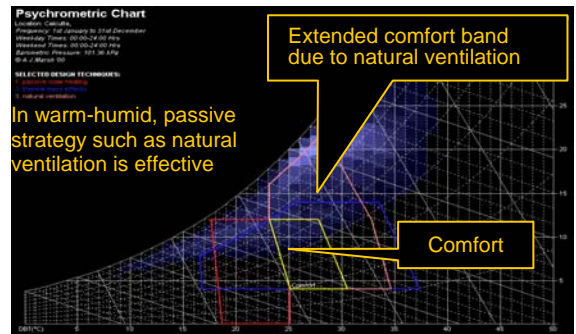
WBREDA is the state nodal agency for renewable energy development in the state of West Bengal. It has been a vision of Shri S P Gon Choudhury, Director of WBREDA and the winner of the prestigious green Oscar award, to demonstrate solar passive concepts with a judicious mix of renewable energy technologies in the WBREDA office building.



WBREDA office building

TERI has been associated as energy consultant throughout the design and detailing of the building. The key challenge was to provide thermal comfort in a non air conditioned building for the warm & humid climate of Kolkata.

The climate analysis indicated that, natural and assisted ventilation strategies should be used to achieve “near comfortable” conditions. Accordingly the design evolved around creating stacks and controlled openings to aid ventilation. Other passive strategies such as light shelves, overhangs, use of vegetation to modify the micro climate have been implemented.



Climate analysis for Kolkata

A roof integrated solar PV system that feeds to grid power has been provided. The building has been monitored after occupation and the predicted savings and thermal comfort parameters have been validated through monitoring and verification. The occupants of the building have expressed satisfaction on the performance of the building. Annual energy savings of 45000kWh have been achieved through introduction of energy efficiency measures.



Roof top solar PV plant

TERI Southern Regional Centre, Bangaluru, Karnataka

Climate: Moderate

Architect: Sanjay Mohe

Year of completion: August 2001

Built-up area: 25000 ft²

Services: Energy optimization and renewable energy integration

TERI has provided a unique environmental solution with its model energy-efficient building at Domlur, Bangalore, and affording maximum comfort through minimum use of conventional electricity.

The building boasts of an innovative design to make maximum use of the natural resources. It opens towards the northern side facilitating access to glare-free light.

A solar wall towards the south (drain side) of the building directs the flow of the breeze over the building, which, in turn, creates a negative pressure and pulls fresh air from the north into the building. In addition to basic filtration and aeration, it has been proposed that certain impurity-absorbing plants be planted in the vicinity of the drain, improving its condition in terms of sanitation and aesthetics. Investing in such a long term, yet permanent solution is necessary if the building is to eventually open towards the drain as well.

Optimum use of appropriate building envelope, use of energy-efficient lamps, luminaries, control strategies have been employed to reduce dependence on artificial means of lighting and to create comfortable conditions.

By creating atrium spaces with skylights, sections of the Centre are designed in such a way that natural daylight enters into the heart of the building, considerably reducing the dependence on artificial lighting. This is supplemented by a skylight roof and energy-efficient artificial lighting. A roof garden has also been developed to reduce heat gain.

Solar water heating meets the hot water requirements of the kitchen and other utilities. A 5-kW peak solar photovoltaic system meets a part of the power requirement. Rainwater harvesting is used to manage water in the complex. The collected water is treated and used for various maintenance purposes, like use in sprinklers for landscape covers.

The sections are worked out so as to allow hot air to rise towards the top. Natural ventilation occurs with the air flowing from the ground floor to the terrace because of the open nature of the volumes.



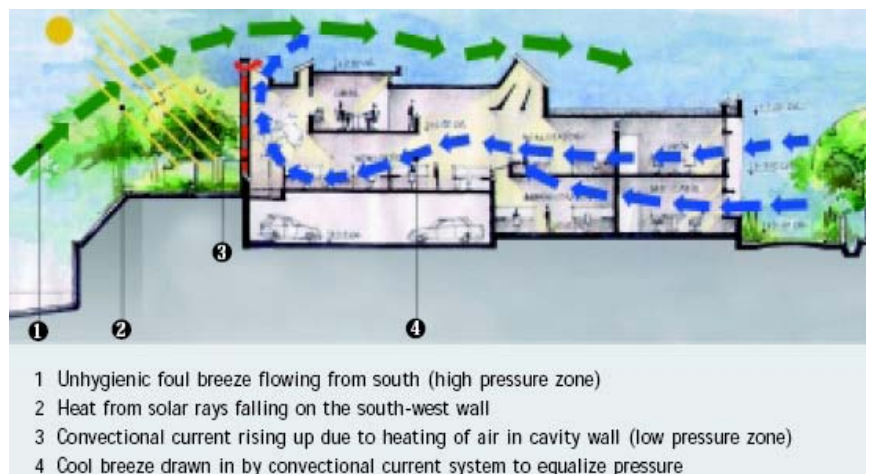
TERI Bangaluru



Solar wall cavity to aid ventilation



Atrium space with skylight



Diagrammatic representation of the ventilation system

Biological Sciences building at IIT, Kanpur

Climate: Composite

Architect: Kanvinde Rai and Chowdhury

Year of completion: August 2001

Built-up area: 5950 m²

Services: Energy optimization and renewable energy integration (including design of Earth Air Tunnel system for space conditioning)

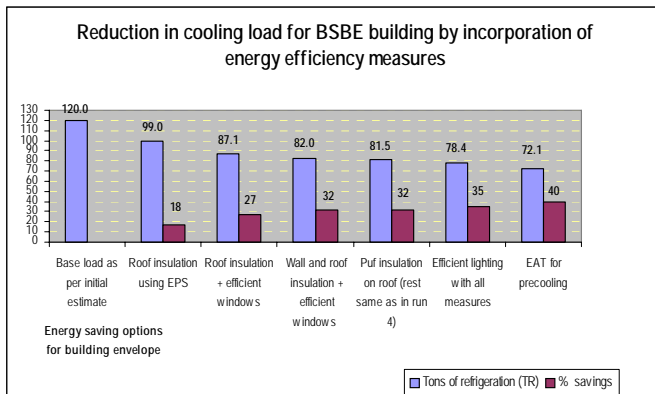
The Biological Sciences and Bioengineering building is a laboratory cum institutional building in the campus of the Indian Institute of Technology at Kanpur, a premier engineering institute of the country.

Key features of the building include climate responsive orientation, insulated walls and roof, insulated windows with low emissivity coating, ample daylight, earth air tunnel and a 3.5 kWp building integrated PV system.

The earth air tunnel is designed to pre cool the fresh air supplied to the Air Handling Units (AHUs). 40% reduction in building cooling load was achieved through all these interventions. The roof integrated PV system provide daylight to the central atrium in addition to powering a set of corridor lights.



Biological Sciences building

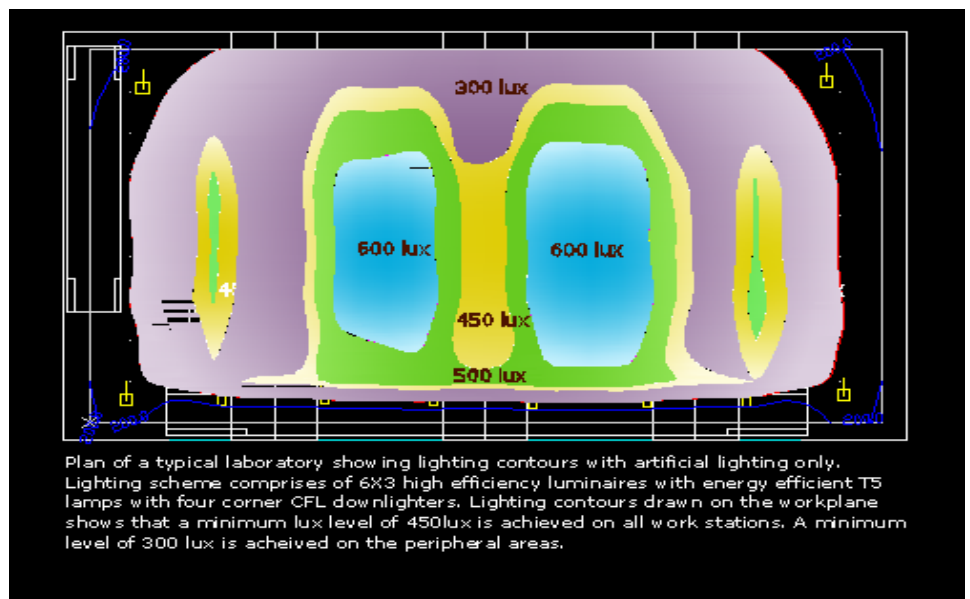


Reduction in cooling load



Roof integrated PV system

The incremental cost was paid back in first year of building operation. TERI was associated as energy consultant to the project. TERI carried out the energy analysis using Visdoe 3.1 . Daylight and artificial lighting was analysis using Lumen micro.



Plan of typical laboratory showing artificial lighting contours

Bangaluru international airport, Bangaluru

Climate: Moderate

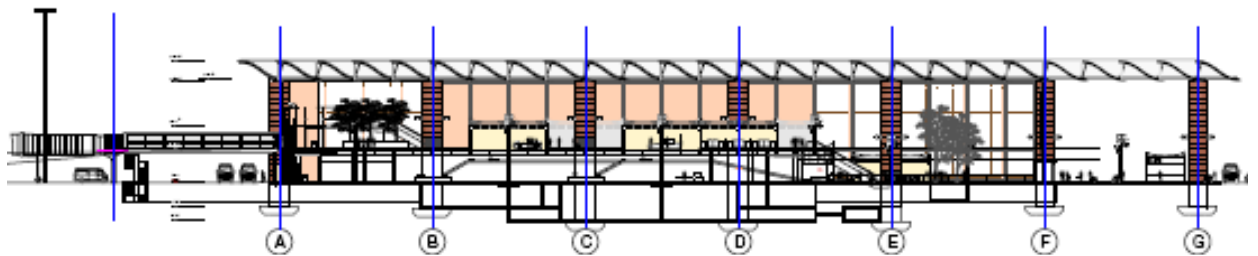
Client: Larsen and Toubro Ltd, India

Year of study: 2003

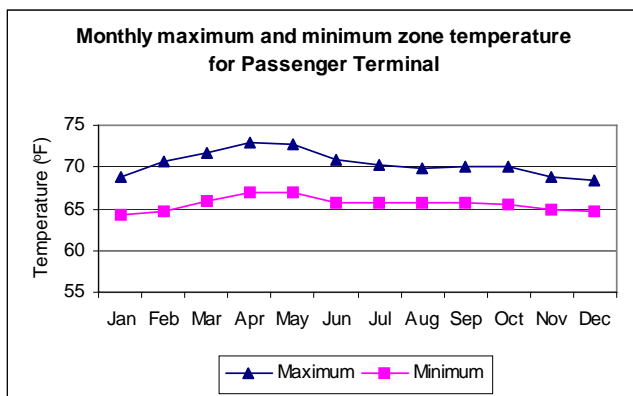
Services: Thermal and visual comfort evaluation and adequacy study for HVAC systems

Energy efficient airports design offers multiple challenges. Selection of materials, energy systems, controls play a key role in energy consumption. Parallel to this, the internal environment of the airport buildings is of immense importance. M/S L &T assigned the task of defining the acceptance criterias for the proposed International Airport Building at Bangaluru and to carry out preliminary analysis of the building environment, inclusive of temperature, humidity and lighting conditions. These parameters are crucial in providing comfort to the occupants of the building.

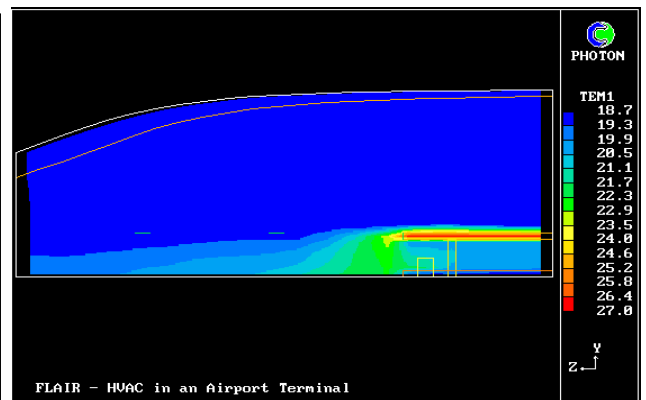
HAP 4.0 (Hourly Analysis Program) was used to check system sizing. VISDOE 3.1 was used to carry out energy analysis and to check adequacy of the system. Indoor comfort analysis was done using VISDOE 3.1E and PHOENICS 3.5. Parametric analysis has been done to quantify energy savings by use of measures such as insulation, high performance glazing and efficient lighting.



Section through proposed terminal building



Temperature profile for passenger terminal building



Air flow modeling using Phoenics 3.5

Fortis Hospital at Shalimar Bagh, Delhi

Climate: Composite

Architect: Mani Chowla Associates

Year: 2005-present

Built-up area: 64,400 m²

Services: Energy optimization and renewable energy integration

The Fortis hospital at Shalimarbagh is being designed with a vision to provide an environment friendly health care facility. The hospital has been planned as a 500-bed facility with cardio, renal, and GI specialties.

Energy efficiency and resource conservation measures will be incorporated in various aspects of the design, construction, and operation of the proposed green building. The hospital is being designed as an energy efficient building that complies with the ECBC (Energy Conservation Building Code) and is undergoing TERI-GRIHA (Green Rating for Integrated Habitat Assessment) green rating certification. It is the first hospital building in India to have registered for the green building rating system.



Fortis Hospital, Shalimar Bagh

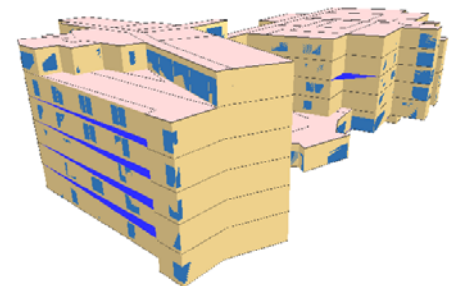
TERI has provided the following services for the project:

- Sustainable site planning recommendations
- Shading and daylight analysis
- Optimization of lighting system
- Optimization of HVAC system
- Recommendations on renewable energy
- Water and waste management recommendations

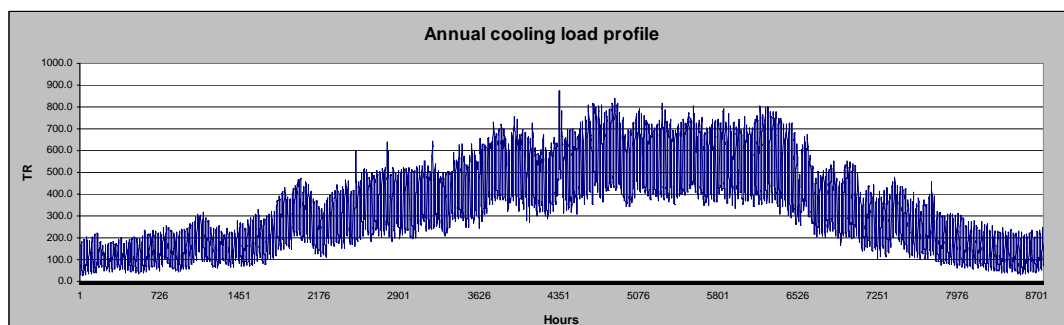
Sustainable design concepts are incorporated in different aspects of the building design, starting from sustainable site planning. Simulation and analysis of various alternatives led to optimization of building envelope including optimization of the shading devices for windows.

In-depth analysis and optimization of the lighting system has resulted in significant savings in lighting system in the building. Simulation of the air-conditioning system has enabled evaluation and selection of various energy efficiency measures based on their feasibility.

Additionally, renewable energy, eco-friendly materials and waste and water management techniques will be adopted in the hospital building as sustainable measures. The initial energy consumption of the base building was calculated to be 605 kWh/m² yr which was reduced to 312 kWh/m² yr after application of various energy conserving measures.



Model of the hospital building



Annual cooling load profile

HLL (Unilever) Development Centre

Climate: Warm-humid

Architect: Kapadia Associates Private Limited

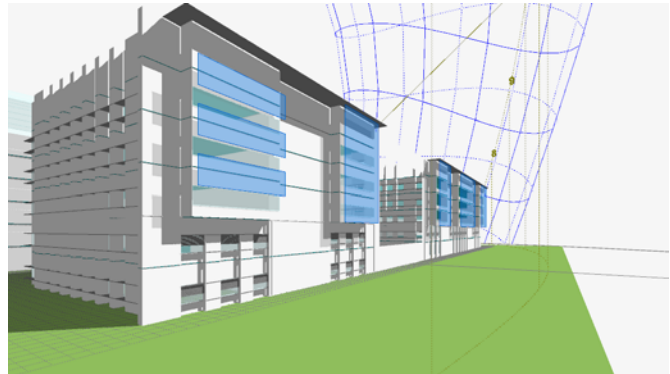
Year: 2006-present

Built-up area: 0.95 million ft²

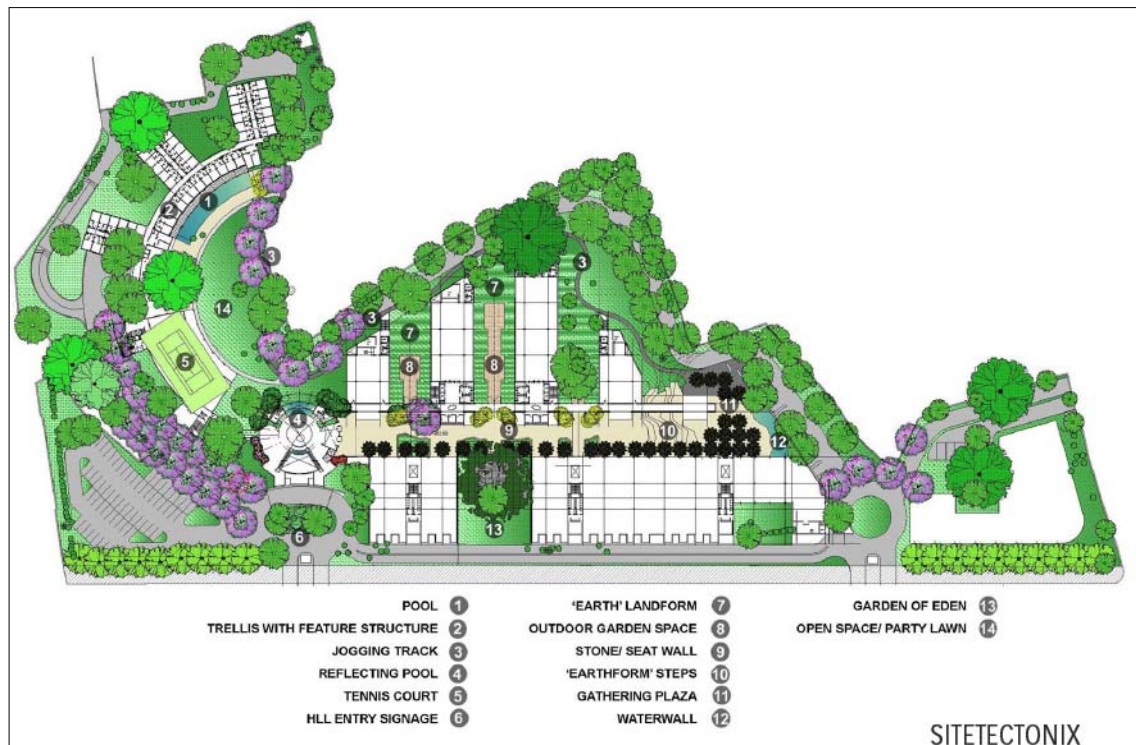
Services: Environmental design services

TERI has been providing the following services to the proposed building at Mumbai.

- Sustainable site planning recommendations
- Shading and daylight analysis
- Optimization of lighting system
- Optimization of HVAC system
- Recommendations on renewable energy
- Water and waste management recommendations



Analysis to design appropriate shading



Site plan

16 buildings of Department of Health and Family Welfare, Gujarat

Climate: Hot and Dry

Architect: Anviksha consultants, Asarpota & Asarpota, Kirloskar Consultants Limited, Urvi Associates and HCP Consultants

Built-up area: 5,65,000 sq ft

Services: Environmental design services

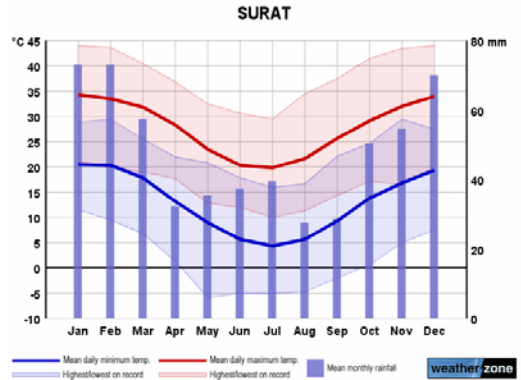
The aim of the project was to incorporate green design principles for the upcoming hostels and ancillary support buildings of the Dept of Health and Family Welfare, Government of Gujarat, in different regions of the State. TERI's services in terms of providing inputs for green building design include guidelines and design inputs for site planning, water efficiency, waste water treatment, energy efficiency, renewable energy integration, use of eco friendly materials, achieving indoor air quality and solid waste management.

Site visits were conducted to all locations for data collection. The study was followed by extensive climate analysis and specific inputs on optimum building orientation, window & shading design, thermal comfort requirements, effect of passive strategies, lighting, solar thermal and water management to be incorporated by the architects in their respective schemes.

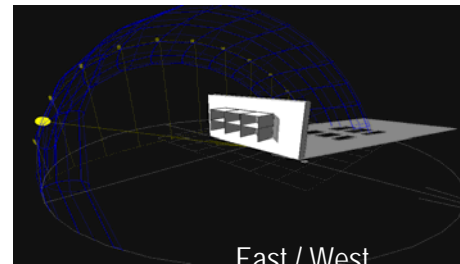
Design charrettes were also conducted for extensive discussions with architects and vetting of individual designs. Optimisation options for building design to reduce conventional energy demand (shading analysis, daylight analysis, thermal analysis, building materials, artificial lighting analysis) were provided.

Implementation of the recommendations would have the following benefits:

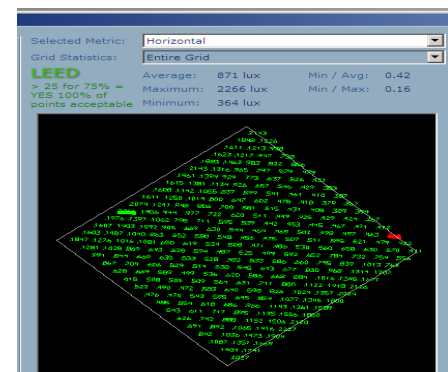
- Lower number of discomfort hours. 90% of discomfort hours below 30oC
- Lighting: suggested schemes have instant payback (less than 1year).
- Solar water heating: Payback of 2.9-3 years.
- Water savings in landscape through combination of species: 25%-50%
- RWH from roof of buildings: 450-2500m3 of water harvested annually.
- Efficient water fixtures: 25% water saving
- Solid waste management: Biogas & manure from organic waste of kitchen can replace LPG for thermal application



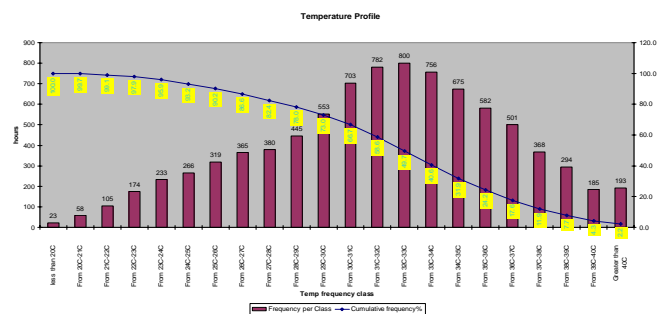
Climate Analysis



Optimum shading design



Day lighting analysis



Thermal and parametric analysis

Project details

2. Green building rating services

2a. Leadership in Energy and Environmental Design

TERI provides support to the design and construction activities of the building seeking LEED certification. The group provides guidance and support to the building team in identifying the requirements specifically needed for the LEED certification.

Areas where the group provides specific inputs, as per the LEED criteria are described as follows. All documentation required for the relevant sections of the LEED process is also prepared.

i) Energy and Atmosphere

Credits covered:

- EAp2 (Minimum energy performance),
- EAc1 (Optimize energy performance),
- EAc2 (Renewable energy)

TERI identifies energy saving options, performs building modeling and simulation (thermal and lighting), sets up the base case as per ASHRAE 90.1-2004, and estimates the energy savings in the proposed building over the base case.

The specific tasks undertaken in this section entail:

- Review of the architectural design of the building with a view to meet LEED requirements.
- Building simulation and modeling using appropriate software tools to calculate reduced building loads by use of efficient construction material. Several options of efficient systems are studied with help of simulation to determine its effectiveness to reduce energy consumption vis a vis increased cost. Some of these include:
 - Insulation of the building
 - Efficient glazing for exposed glazed surfaces
 - Appropriate shading devices

These parametric analyses enable client to arrive at optimum design for wall, roof and window. This exercise includes creation of appropriate weather files, which specify outdoor design conditions in a format compliant with the relevant software.

- Artificial lighting design is reviewed and recommendation on energy efficient lighting design is provided.
- Integration of day lighting with artificial lighting and suggestion of integration of controls to reduce lighting consumption are undertaken.
- The HVAC system design is reviewed.
- Recommendations on appropriate solar thermal systems to reduce consumption of water heating energy requirements are made.

Since a fraction of the building's total energy use can be met through the use of on-site renewable energy systems, TERI also identifies renewable energy options, provide inputs to the suppliers on basic system configuration and provide inputs to the supplier on documentation requirements to satisfy LEED criteria.

ii) Sustainable site

Credit covered:

- SSc8 (Light pollution reduction)

The following steps are undertaken in order to assist the building towards meeting the above criteria.

- Establishing exterior lighting levels and uniformity ratios to be maintained for various tasks (for eg. parking, roadways, pathways etc) as per recommended international standards.
- Suggesting appropriate fixtures that limit night sky pollution. Selection of devices (shielded, semi-cut off, full cut off) that prevent glare and light trespass beyond site boundary.
- Simulation of lighting design with the aid of software tools (Lumen Micro 2000) to determine illumination levels and uniformity ratios.
- Review of exterior lighting design and recommendation on energy efficient options for layout and fixtures.
- Demonstrate that maximum candela value of interior fixtures falls within the building and not out through the windows.

iii) Water management

Credits covered:

- WEc1
- WEc2
- WEc3

TERI's services regarding water and waste management include:

- Estimation of the water requirement for the landscape based on inputs provided by the landscape consultant (area of plantation, landscape details etc). Providing appropriate measures for meeting the irrigation demand such as designing of the rainwater-harvesting pond.
- Suggestions on wastewater treatment system and plumbing fixtures as per LEED requirements for minimizing the use of potable water use for various applications. Calculation of the reduction based on the occupancy of the building for design case as against baseline case.
- Water budget calculations indicating the percentage reduction in potable water consumption.

iv) Indoor environmental quality

Credits covered:

- EQ8 (Daylight and views)

TERI addresses the daylighting aspects of Indoor Environmental Quality as follows:

- Performs fenestration analysis and design with the help of software tools (Lumen Micro 2000 and SunTool 2000) to achieve diffuse sunlight penetration and provide direct line of sight to occupied spaces. TERI also provides documentation (drawings and a narrative) to demonstrate compliance with LEED requirements.

TERI has provided technical assistance to the Confederation of Indian Industries and ITC Green Center Gurgaon to achieve platinum rating awarded by the United States Green Building Council through LEED's green building rating programme. The building meets international efficiency standards and specifications in building envelope and systems design and in use of water resources and treatment of liquid and solid wastes.

Other LEED projects where TERI has provided important inputs are:

- LEED rating for office building of North Delhi Power Limited, New Delhi
- LEED rating for Synthesis Business Park, Kolkata
- LEED rating for Minestone Diamond factory building, Navsari, Gujarat
- LEED rating for ABN Amro office building, Ahmedabad

CII Godrej Green Business Centre, Hyderabad, India

Climate: Hot and Dry

Architect: Karan Grover and Associates

Year of completion: 2003-2004

Built-up area: 2000 m²

Services: Environmental design services and LEED consultation

The green business center building is the first platinum rated building in India under the LEED rating system of the United States Green Building Council (USGBC). The design team led by Architect Karan Grover envisioned an architecturally significant building with exceptional sustainable design measures that would be a trendsetter for future buildings. The building has served its purpose and has inspired several green buildings round the country.

TERI provided the environmental design services including detailing of fenestration and shading devices, selection of materials of construction, selection of lighting systems and controls, selection of HVAC systems, sizing of renewable energy system, rainwater harvesting system and root zone system.

Some significant green features of the building are:

- Erosion and sedimentation control
- Landscape design to reduce heat island and water use
- Storm water and rainwater management to reuse the storm water and rainwater for irrigation.
- Provision for eco-friendly means of transportation
- Use of water saving devices
- Water recycling through use of root zone technique
- Optimized architectural design of envelope
- Use of adequate wall & roof insulation
- Use of energy efficient windows
- Indoor lighting with daylight integration
- Efficient HVAC system
- 23 kWp roof integrated grid interactive solar PV system
- Use of recycled, reused, regional and rapidly renewable materials
- Maintain indoor environmental quality by use of low VOC materials, by permitting daylight and views, and limiting sources of indoor pollution



Site plan



Internal courtyard. Use of native species for landscaping



Roof lawn to reduce heat gains

ITC Green Centre, Gurgaon, National Capital Region of India

Climate: Composite

Architect: M/s. Rajinder Kumar Associates (RKA), New Delhi

Area: 15,770 sq m

Year: 2003-2005

Services: Environmental Design Services and LEED consultancy

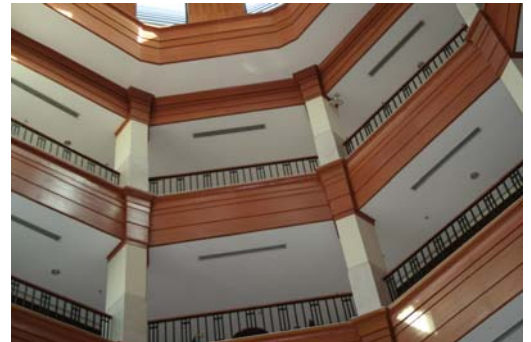
ITC is one of the largest corporate bodies in India and is a LEED 2.1 NC Platinum rated building. It is an office building comprising of two office wings held together by a central atrium. The L-shape blocking ensures self shading of facades. The atrium joins the different functions of the building and has side light from the top to provide a glare-free natural lighting in the interior without allowing direct heat gain from the roof.

Extensive energy conservation measures undertaken include autoclaved aerated concrete blocks, high performance glass, cool roof, energy efficient lighting and HVAC system. Daylight is brought in through the peripheral windows and central atrium. 51.3% energy savings over base building (as defined by ASHRAE 90.1-1999) has been achieved. 39% potable water demand was reduced by application of low flow water fixtures. On site treatment of wastewater meets entire water demand for landscaping.

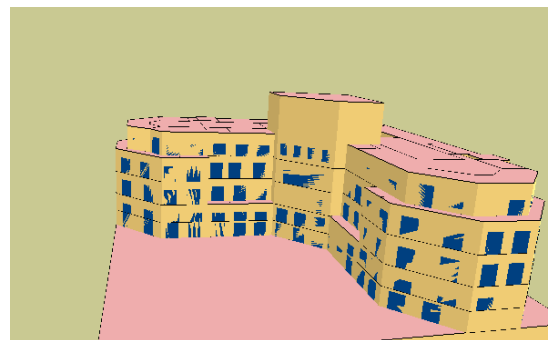
TERI, as environmental design consultants ensured that maximum energy and water savings is achieved at minimal incremental cost. Design decisions were taken after life cycle cost analysis.



ITC Green Centre, Gurgaon



Ample daylight in atrium allows switching off artificial lights



VisDOE modeling to calculate energy performance

ABN AMRO, Ahmedabad Branch

Climate: Hot and dry

Architect: Karan Grover Associates

Year of completion: 2007

Floor Area: 6863sqft

Services: Environmental Design Services and LEED consultancy

ABN AMRO's Ahmedabad branch is designed for meeting the standards of US Green Building Council (USGBC) under LEED green building rating system and has applied for the Platinum certificate. The design of the Building is done to ensure that measures for minimizing wastage and maximise utilisation of natural resources are done.

Some of the green features employed in the building are:

- Use of efficiency water system
- Use of FSC Certified wood
- Maximum utilisation of natural light
- Efficient HVAC system
- Energy efficient electrical system
- Usage of recycled materials
- Usage of local materials
- Recycled façade glazing
- Maintain indoor environmental quality by use of low VOC materials, limiting sources of indoor pollution
- Proper waste management



ABN AMRO, Ahmedabad Branch



Interiors of the building

Project details

2b. Green Rating for Integrated Habitat Assessment

TERI has developed the Green Rating for Integrated Habitat Assessment (GRIHA) that is a tool to evaluate the 'greenness' of a building in India. GRIHA has now been endorsed as the National rating system for green buildings by the Ministry of New and Renewable Energy, Govt. of India.

The GRIHA environmental performance guidelines and standards are based on established national and international building design codes. The qualitative and quantitative assessment criteria of GRIHA rate new buildings in light of current building practices and the varied climate of India. The rating system aims to achieve efficient resource utilization, enhanced resource efficiency, and better quality of life in the buildings. Currently, the system has been developed to help 'design and evaluate' new buildings (buildings that are still at the inception stages)¹.

As per GRIHA, building is assessed based on the predicted performance over its entire life cycle-inception through operation. The buildings are evaluated at various stages of development. The issues addressed through the various stages are as follows:

- Pre-construction stage- intra and inter-site issues;
- Building planning and construction stage- issues of resource conservation and reduction in resource demand, resource utilization efficiency, resource recovery and reuse, and provisions for occupant health and well being; and
- Building operation and maintenance stage- issues of operation and maintenance of building systems and processes, monitoring and recording of consumption, and occupant health and well being, and also issues that affect the global and local environment.

Currently, 20 buildings are currently registered with TERI for GRIHA rating.

A list of the GRIHA registered buildings is as follows:

1. Hitkarini college of Engineering and Technology, Jabalpur
2. Earth System & Environment Science Engineering Building, IIT, Kanpur
3. Triburg Headquarters, Gurgaon
4. Office of Public Works Department, Nashik
5. The Doon School, Dehra Dun
6. Suzlon Energy Limited, Pune
7. Delhi Public School, Aligarh
8. Fortis hospital, New Delhi
9. Commonwealth Village, Delhi
10. Haryana Technology Park, Faridabad
11. Project Garden, Hindustan Unilever, Mumbai
12. Crown Technopark, Faridabad
13. SP Infocity, Manesar
14. Embassy Pristine, Bangalore
15. Police School, Tsagaon, Maharashtra
16. Merlin Tropical Greens, 24 Parganas
17. Fortis Hospital, Gurgaon
18. Public Health foundation of India, Hyderabad
19. Municipal Corporation of Delhi, New Delhi
20. DMRC, Sushant Lok

TERI also facilitates the documentation process of GRIHA (through all criteria of GRIHA) with necessary inputs (in form of certificates, drawings, and narratives as elaborated in detailed documentation formats) from the architects/consultants team.

¹ More details of GRIHA are available at <http://www.teriin.org/bcsd/griha/>

Centre for Environmental Sciences and Engineering building, Indian Institute of Technology, Kanpur

Climate: Composite

Client: Indian Institute of Technology, Kanpur

Year of completion: 2007

Services: Environmental design services, energy consultancy and GRIHA

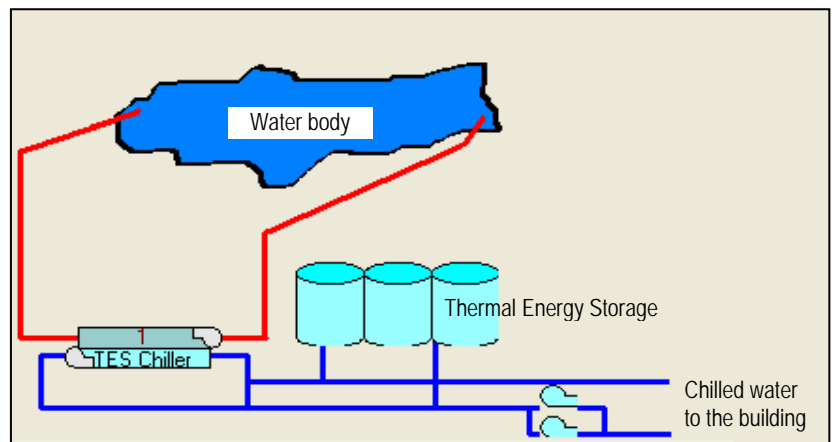
The Centre for Environmental Sciences and Engineering Building is a research facility located in the Indian Institute of Technology Campus, Kanpur. The facility, as the name suggests houses laboratories and other facilities for various disciplines of the environment sciences, like Atmospheric, Oceanographic, Earth Sciences etc.



Model of the building

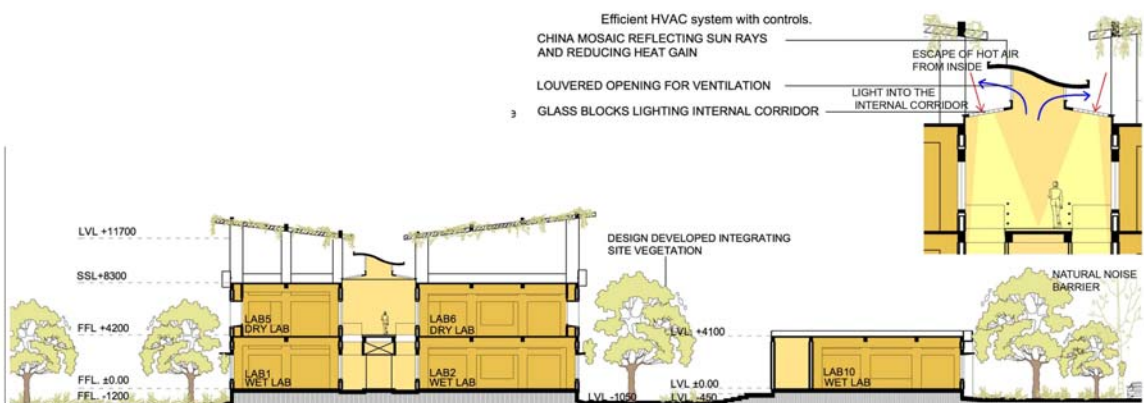
The facility houses wet labs which are non-air conditioned spaces on ground floor and dry labs that are air-conditioned spaces on the first floor. Building design and envelope has been optimised through selection of appropriate wall and roof construction and thorough adoption of solar passive measures after studying the sun path analysis to provide shading devices for windows and roof, which would reduce energy demand to condition the spaces.

All the commitments as described in GRIHA to optimise the system design and to achieve thermal comfort in non air conditioned spaces has been followed to reduce the annual energy consumption less than the benchmark established for composite climate by GRIHA. Water conservation measures are adopted in the building through selection of efficient fixtures and rain water harvesting. Utilisation of renewable form of energy through building integrated photovoltaic panels has been incorporated for use in the building. Rain water harvesting is done and treated waste water is reused for irrigation. The building is fully compliant with the ECBC.



Diagrammatic representation of concepts

Design of an earth air tunnel using the geothermal property of the earth has resulted in a reduction of more than 15% of the building cooling load. Efficient condenser cooling through an on-site water body and use of thermal energy storage has increased the efficiency and reliability of the air-conditioning system.



Architectural building section showing passive strategies

Triburg Headquarters building, Gurgaon

Climate: Composite

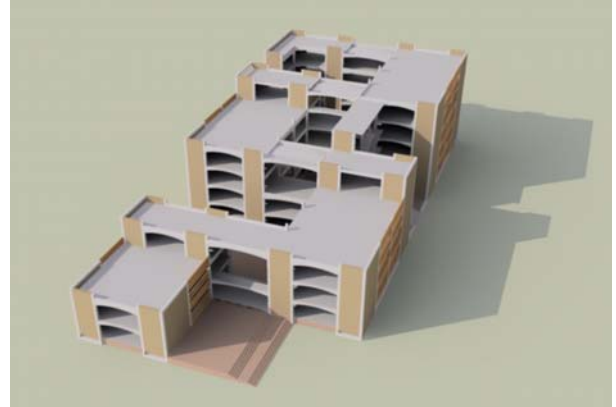
Client: Triburg headquarters building, Udyog Vihar, Gurgaon

Architect: Stephane Paumier Associates Design Pvt. Ltd.

Services: Environmental design services, energy consultancy and GRIHA

The site for the proposed Triburg headquarters building is located in the industrial area of Udyog Vihar in Gurgaon. The plot area is 7800 m² with a proposed built-up area of 10000 m² for the superstructure and 4500 m² for the basement. The office building would incorporate various sustainable measures recommended by GRIHA. The building is planned around courtyards in such a way that it measures gradually from one to four storeys towards the back of the building. The four courtyards give daylight to the offices and also increase green cover.

Roof gardens are planned to add to the green area and improve the microclimate of the site. Cavity walls and insulation for exterior walls reduce the air-conditioning requirement of the building. Efficient lighting and air-conditioning systems are planned so as to reduce the overall energy consumption of the building.



Model of the proposed building

Following the ECBC recommendations, the initial energy consumption of 186 kWh/m² was brought down to 86 kWh/m² per annum.

Energy efficiency and green features in the building

- Efficient design of the building, allowing daylight into most of the office spaces
- Efficient building envelope, resulting in reduction of cooling load in the building
- Efficient lighting system, resulting in direct energy savings and reduction in cooling load

The Doon School - Masters' Houses and Art School, Dehradun

Climate: Composite

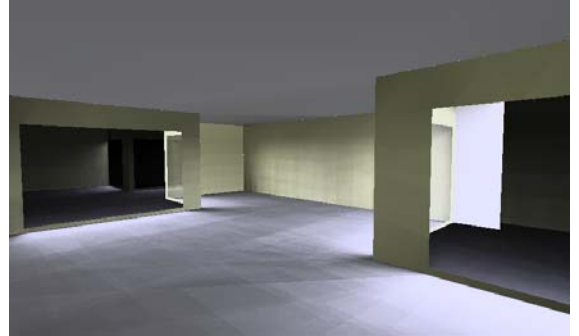
Client: Doon School

Architects: Ram Sharma and Sanjeev Khosla

Services: Environmental Design Services and GRIHA rating

Year: 2006-present

The Doon School has taken the initiative to start a long-term process towards self-sufficiency in energy, water and organic fertilizer by opting for sustainable sources of energy and recycling waste. This would serve the dual purpose of having amongst India's first 'Green' school campuses and showcasing the importance of sustainability to its students by making the responsible use of scarce resources a part of their everyday life. It seeks to bring up its students in a system that befriends nature and respects the environment even as the school's needs are met by incorporating the ongoing advance of sustainable technology that will be a part of the movement towards building a viable alternative to fossil fuels and the control of emissions.



Daylight simulation results for buildings

As a part of its drive to replace many of its old buildings (which were declared unfit for habitation) it has taken the decision to design them as per an 'architectural vision statement' that incorporates standards that shall see the Art School complex (comprising the Art School and the Art Master's house) and six teachers houses (adjoining the main playfield) built as GRIHA rated habitats.

Consequently, the school has ensured that the entire building process from demolition, through construction to occupancy be done as per GRIHA guidelines to achieve negligible environmental impact and a minimal ecological footprint in the long run.



For instance, by changing the building envelope materials alone, the requirement for artificial space conditioning systems (cooling or heating) has been reduced to a negligible minimum. This translates into a drastic reduction in electricity consumption that may have been required for air conditioning or heating under ordinary conditions.

The buildings shall also incorporate solar thermal systems to fulfill the hot water requirements and water and waste management processes for reduced environmental impact. The school proposes to install solar thermal systems on all existing campus buildings as well as tap alternative/renewable sources of energy such as biomethanation and biomass gasification at a campus level wherever possible.

Office of Public Works Department, Nashik

Climate: Composite

Client: Public Works Department (PWD), Nashik

Architects: Umesh Bagul

Services: Environmental Design Services and GRIHA rating

Year: 2007-present

Public Works Department Nashik owns land measuring 7740 Sq.m. on Sir Visvesverayya Marg at Nashik. Since some of the PWD offices are being conducted in very old buildings, the PWD has decided to construct a new building by dismantling all the old structures on this land. The new office building shall be constructed as per GRIHA requirements.

The new building will be a G +3 structure with about 6200 sq.m. built up area. The new building plan will include green concepts based on solar passive architecture with sufficient floor-to-floor height to facilitate maximum daylight and good ventilation to minimize the energy consumption.

The rubble obtained by dismantling the old structures shall be utilized for the wind tower and the other building material shall also be utilized in the building work. Rainwater from the roof will be stored and will be utilized for flushing of the toilet blocks and for the wind towers. The rainwater on the land will also be harvested; the drainage water will be treated with root zone technique. The materials that will be in use are fly ash bricks, low e-glass, low VOC paints etc. Other efficient features like waterless urinals / urinals with sensor, insulation paint, Electronic ballast, CFL and T-5 tubes, solar panels, wind mills and green generator are being thought for. As the building is a Non-A/C building wind towers will be provided for air-cooling.



Daylight simulation results for buildings

Project details

3. Energy audit and upgrades/tune ups

3a. Energy audit and conservation studies for commercial buildings in India

Energy audit and conservation studies are aimed at exploring energy conservation possibilities in commercial buildings such as hotels and hospitals. Detailed energy analyses of various energy systems (lighting, heating, ventilation, air conditioning, water heating, electrical steam boilers, steam distribution system etc) are performed through short term monitoring to recognize areas of energy wastage and suggesting ways to mitigate the same. Validation of energy performance by use of computer simulation and modeling has also been done for select projects.

The scope of work undertaken at TERI includes:

- Identification of types of energy being used in buildings
- Identification of energy streams for each type of energy source
- Quantification of energy streams into discrete functions (e.g. systems, equipment, appliances etc.)
- Evaluation of operating efficiency of each of those functions
- Identification of energy and cost savings opportunities and analyze the impact of improvements
- Preparation and submission of energy audit report having detailed information on building type, its energy use pattern and recommended energy conservation measures.

Methodology adopted for energy audit

1. Collection of primary data
2. Collection of secondary data or field survey
3. Data compilation and analysis
4. Chapter writing and submission

The following energy systems are studied in detail:

1. Electrical supply and distribution systems

Objective

- Tariff audit to estimate the opportunities for peak load savings
- Energy consumption trends for developing baseline for energy consumption
- Transformer load analysis to minimize energy losses
- Capacitor bank testing to optimize the power factor
- Motor testing to enhance the motor efficiency
- Specific energy generation ration (SEGR) of DG sets to find out its operating efficiency

Data collection

- Monthly energy bills for last three years
- Single line diagram of electrical supply and distribution
- Building load (V, I, PF, kW, kWh) monitoring, one day monitoring at 30 minutes interval at each running transformers with the help of power analyzer equipped with logging facility
- KVAR delivered by capacitors in capacitor banks
- 4 Hours monitoring of power generated and fuel consumed by each DG set using power analyzer and non intrusive type flow meter
- Electrical input (V, I, PF, kW) of motors above 15-hp rating at on load condition.

Analysis

- Identification of variables effecting energy consumption
- Transformer loading profile for optimizing the loading for transformer loss reduction
- Enhancement of power factor & variable capacitor application
- Identification of under loaded motors
- Specific energy generation ratio of DG sets and emission control

2. Lighting system

Objectives

- Energy savings by application of energy efficient lighting system
- Providing optimum visual comfort to the occupants

Data collection

- Area wise details of lighting equipment
- Area wise lighting levels measurement
- Operating hours of lighting schemes in various areas
- Monitoring of lighting load and power consumption on main dedicated lighting circuit (if available)

Analysis

- Lighting load and consumption in various spaces
- Adequacy of light quantity in various areas
- Redesigning of few lighting schemes using existing lighting equipment data and with efficient lighting equipment data
- Daylight analysis and its integration with electric lighting

3. HVAC system**Objective**

- Energy savings by retrofits/replacement of chilling plants/system components
- Energy savings by retrofits/replacement of chilling plant auxiliaries e.g. chilled water pumps, condenser water pumps, cooling towers, Air handling units etc.
- Energy savings by retrofits/replacements of unitary systems – window AC, split AC, packaged AC
- Energy savings by modifying system design
- Energy savings by optimization of operating schedule
- Thermal comfort conditions in important areas

Data collection

- Inventory of chilling plant and auxiliaries
- One day monitoring of each central plant e.g., chilled water temperatures, condenser water temperatures, chilled water flow, condenser water flow, and compressor motor input electrical parameters. All these operating parameters are recorded simultaneously at an interval of 30 minutes using eight channel temperature data logger, non intrusive type flow meters with logging facility and power analyzer with logging facility
- Sample size selection and monitoring of AHUs for power consumption, circulating air quantity and cooling coil capacity. Each AHU would be monitored for parameters like fan input kW, air flow rate, supply air temperature and RH, return air temperature and RH, fan static, and CO₂ level.
- Performance testing of each cooling tower. Parameters like fan input kW, air flow, water flow rate, entering and leaving water temperatures, entering and leaving air temperatures and RH would be monitored.
- Performance testing of each primary chilled water pump. Parameters like pump motor kW, operating head and flow rate would be measured once since they are constant speed dedicated pumps.
- Performance testing of each operating secondary chilled water pump. Parameters like pump motor kW and flow rate would be monitored using power analyzer and non intrusive type flow meter with logging facilities.
- Performance testing of each operating condenser water pump. Parameters like pump motor kW and flow rate would be monitored using power analyzer and non intrusive type flow meter with logging facilities.
- Sample selection and testing of fresh air and exhaust blowers. Motor input kW and air flow rate would be measured
- Monitoring of water-cooled packaged air-conditioning units. Each unit would be monitored for parameters like supply and return air temperature and RH, condenser water temperatures, airflow rate and electrical parameters.
- Sample selection and monitoring of split ACs and window ACs. The units would be monitored for parameters like supply and return air temperature and RH, airflow rate and input electrical parameters.

Analysis

- Calculation of zone wise tons/m²
- Calculation of individual chiller specific power consumption
- Calculation of operating efficiency for chilled water/condenser water pumps, cooling towers, AHUs etc.
- Estimation of energy consumption in air conditioning system

4. Water pumping system**Objective**

- Enhancement of pump efficiency

Data collection

- Rated pumps details
- Operating parameters (head, flow, kW) of raw water pumps, softening pumps and cold water circulation pumps
- Operating hours of pumps

Analysis

- Pumping efficiency
- Pumping system power consumption

5. Indoor Air Quality (IAQ)

Objective

- Existing pollutant levels in different zones
- Enhance IAQ for health benefits and to optimize productivity

Data collection

- Continuous hourly monitoring of temperature, RH, CO₂, CO, Aerosol and ultra fine particle in few important representative locations
- Zone volume and occupancy rate

Analysis

- State of IAQ in different zones
- Measures to improve IAQ, if required

6. Hot water and steam system

Objective

- Optimize energy use in hot water and steam applications

Data collection

- Flue gas analysis
- Study of distribution network

Analysis

- Boiler efficiency
- Optimization of hot water & steam use

TERI has conducted detailed energy audit of more than 50 commercial and 150 Industrial establishments.

Some of the buildings where such studies were conducted are:

1. Maurya Sheraton Hotel and Towers, New Delhi
2. The Oberoi, New Delhi
3. The Taj Mahal, Lucknow
4. The Taj Ganges, Varanasi
5. The Taj air caterers, New Delhi
6. The Jaimahal Palace, Jaipur
7. The Rambagh Palace, Jaipur
8. The Taj Mahal, Mumbai
9. The Taj Bengal, Calcutta
10. The Taj Mahal Hotel, Delhi
11. The Lake Palace hotel, Udaipur
12. Hotel Chandela, Khajuraho
13. Max hospital building, New Delhi
14. Northern Railways Headquarters and Central Railways Hospital, New Delhi
15. Himachal Pradesh Secretariat Buildings and Shimla PWD Rest House, Himachal Pradesh, India
16. National Science Centre, Kualalampur, Malaysia
17. Hotel Soaltee, Kathmandu, Nepal
18. Governor's house, Kolkata

Project details

3b. Design of energy efficient street lighting and common area lighting

TERI has assisted in design and optimisation of street lighting and common area lighting for Dwarka, Delhi and another ongoing project of street lighting in Pune.

i) Energy efficient common lighting in Dwarka, New Delhi

Client: Delhi Development Authority (DDA)

Climate: Composite

Year: 2003-2005

Project Services: Energy management and efficient lighting

The Delhi Development Authority (DDA) envisioned energy efficient lighting for Dwarka where 33% of the Master Plan roads did not have street lighting infrastructure in 2003. In order to accrue benefits from efficient energy management and set trends for provision of energy efficient lighting on the roads and flyovers in Delhi, TERI undertook a comprehensive study to indicate the level of improvements at selected locations of the study, which could be extrapolated to achieve energy savings at the Dwarka sub-city level.

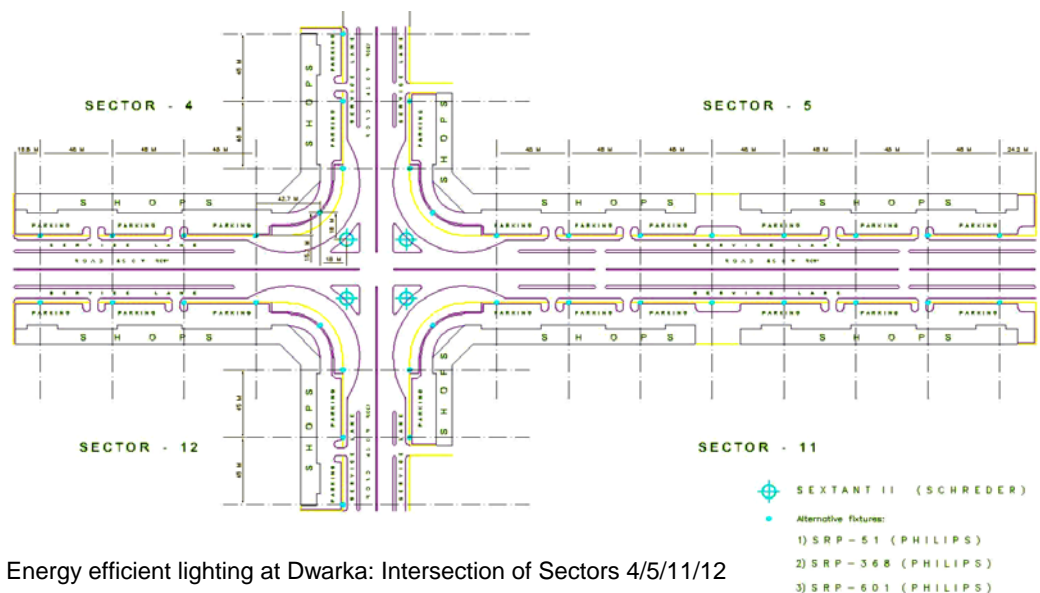
Detailed literature reviews and field surveys were taken up to evolve new energy efficient lighting schemes and recommendations for existing lighting schemes for:

- Stretch of 45-mtr road passing between the commercial pockets Sec 4, 5, 11 and 12.
- The approach road to Dwarka through cantonment area including under pass and flyover.



Suggested lighting fixture at Dwarka

TERI provided suggestions to give special effects to road crossings in Dwarka and optimised lighting schemes for different carriage widths for future reference for energy efficient street lighting. The 'code of practice for lighting of public thoroughfares' in terms of horizontal illuminations levels and uniformity coefficient were also complied with. The recommended schemes had energy saving potential up to 45% with a simple payback period ranging from one year to three years.



Energy efficient lighting at Dwarka: Intersection of Sectors 4/5/11/12

Project details

4. Information dissemination

4a. Book on “Energy efficient buildings in India”

A joint publication of Ministry of non-conventional energy sources, Government of India and TERI, the book covers 41 projects from India's various climatic zones. This book is edited and published by TERI; and provides thorough insight into the context, technique, and benefits of energy-efficient buildings. The projects included highlight design responses to varied conditions; use of appropriate materials and construction methods; implementation of energy-efficient systems; and effective utilization of renewable energy to reduce pressure on grid power.

4b. Knowledge bank on Sustainable building design

The knowledge bank is a user-friendly e-tool to enable design, development and replication of sustainable habitats in a developing country. The e-tool is a rich repository of successful examples of sustainable habitats from all over India and provides detailed insights into methodologies, technologies and tools to enable sustainable habitat design in rural, urban and peri-urban settings. The knowledge bank also has detailed technical and market information on sustainable building materials, appropriate technologies, energy efficient and low energy design, energy efficient lighting, renewable energy systems, water management, and solid waste management. Extensive market research, literature survey, analysis and validation were carried out as part of the project.

4c. Development of guidelines to assess energy conservation and energy efficiency aspects in the hospitality industry

The hospitality industry in India is a prime consumer of electrical and petroleum-based energy. Substantial saving in energy consumption is possible by proper planning, design, operation, and maintenance of hotel buildings. TERI has developed a set of specific guidelines to help design energy-efficient buildings and systems for hotels. The guidelines can help designers, architects, and engineers working on project planning in evaluating project proposals and to set up new hotels. The guidelines could also be useful to designers and architects working on air-conditioning, lighting, and hot water systems.

4d. Capacity building programs

The team had conducted numerous training programs on *energy efficient building design*, *solar buildings: sustainable design*, *energy efficiency and best practices*, *energy conservation and energy efficiency in buildings* for various bodies such as the Ministry of New and Renewable Energy, Delhi Transco Limited, Haryana Renewable Energy Development Agency, Delhi Government, Ministry of Environment and Forests, GTZ Advisory Services in Environmental Management, TERI School of Advanced Studies, United States-Asia Environmental Partnership and United States-Asia Environmental Partnership.

Project details

5. Policy/regulatory

Several policy initiatives at central and state governments' level towards mainstreaming high performance buildings in India have been successfully completed. Senior members of the group are members of the Committee of experts for development of the Energy Conservation Building Code (ECBC) of India (2007). The manual for environmental clearance of large construction for the Ministry of Environment and Forests, Government of India has also been developed at CRSBS.

5a. Environmental clearance norms for large construction project

TERI has developed a manual that would assist developers to prepare EIA reports and obtain environment clearance for large construction projects. It is envisaged that the guidelines would be useful to developers in all states of India. The manual would also be used by the officials of different state bodies such as State Development Authorities, State Pollution Control Boards, Municipal Co operations; and act as a checklist to evaluate large projects for environment clearance.

5b. Delhi Energy Efficiency Programme

DEEP (Delhi Energy Efficiency Programme) is a joint effort of TERI (The Energy and Resources Institute) and GoNCTD (Government of National Capital Territory of Delhi) to make Delhi an energy-efficient city. DEEP aims to demonstrate benefits of energy efficiency interventions in select areas of the city. Much of its activities are centered on active stakeholder participation and action.

5c. Policy research on Building energy Efficiency in India

TERI has been engaged by the Asia Business Council to carry out primary and secondary research on 'energy efficiency in urban (residential and commercial) buildings in India'. The study commissioned on India will be incorporated as a part of a pan-Asia research effort lead by the council. The objectives for the study include education of a business audience to the state of energy efficiency policies in the region, identification of the common barriers to improved energy efficiency in urban buildings and related policy prescriptions, the highlighting of successful case studies, and the identification of best practices as they pertain to policy development and implementation in the government sector, and efficient design and energy management in the private sector.

5d. Training manuals for Eco housing assessment

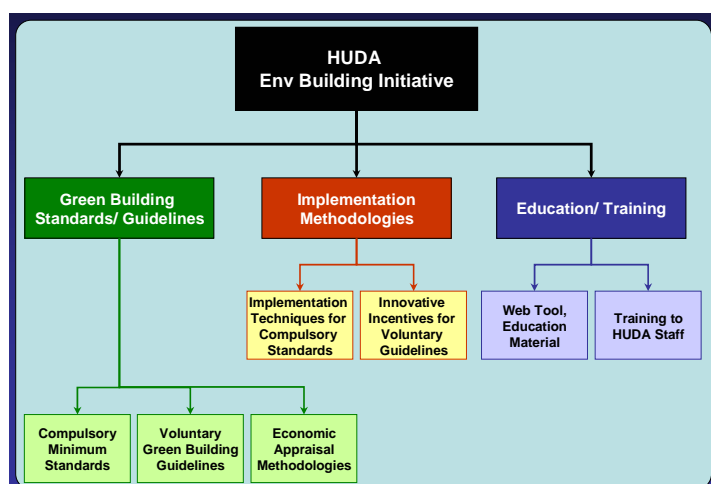
TERI has been engaged by the International Institute for Energy Conservation to develop 3 separate training modules based on eco-housing assessment criteria for three stakeholder groups - customers, enablers, and decision-makers. The training modules are a combination of classroom sessions, site visits, and project work. Modules for all three stakeholder groups covered the following aspects of eco-housing technical assessment criteria including economic, environmental, and social considerations: a) Sustainable site planning b) Energy Efficiency including environmental architecture, thermal comfort and lighting design, renewable energy systems for buildings c) Water efficiency including conservation, wastewater treatment, recycling, and reuse, low flow fixtures/ products d) Indoor environment quality products, and e) Solid waste management.

All training modules include the following:

- A trainer's presentation with notes;
- A trainer's guideline document with trainer notes;
- A student's manual with detailed course content, and reference material with limited exercises and questionnaire (excluding sustainable site planning).

5e. Study and preparation of Environmental Building Regulations and Guidelines (EBRG) for Hyderabad Metropolitan Area

The broad vision behind the EBRG project undertaken by TERI for Hyderabad Urban Development Authority (HUDA) is to assess the present and future environmental issues in the building industry, specifically with respect to urban development in the Hyderabad Development Area and propose guidelines for environmental sustainable building design, construction and operation to promote and integrate



sustainable practices and provide an affordable and higher quality environment for the residents. The specific sectors covered under this are water supply, sewerage, storm water management, solid waste management, energy, pollution and ecology. Running parallel to this, education material on sustainable building design is also being developed specifically for Greater Hyderabad in the form of information leaflets. Also, economic appraisal methodologies for each sector are being developed to help building designers through the design process. A web tool shall also be developed in which all relevant information shall be uploaded and will help stakeholders to integrate environmental aspects into their building design. TERI shall also advice HUDA on innovative incentives to promote these guidelines based on successful models of implementation in other countries and states.

5f. Exploration of sustainability in the provision of basic urban services in Indian Cities

Funded by Nandan Nilekani and Rohini Nilekani, this project aims to pave a way for Indian cities to strive towards sustainability and improvement of the quality of life. The project attempts to explore urban sustainability with respect to the provision of basic services in Indian cities- specifically covering buildings, transport, water and wastewater, power and solid waste. It would serve as a step towards the larger goal of developing a framework for guiding Indian cities towards sustainability. The developed framework is envisioned as a public good and a policy tool and could be embedded in programs such as the JNNURM.

Project details

6. Climate Change related projects

Climate change is increasingly recognized as a major challenge. It is widely accepted that the greenhouse gas emissions caused by humans are having a negative impact on the environment. TERI has taken a proactive role in taking up projects related to Climate Change. Further taking this cause, buildings groups is actively involved in a couple of projects related to climate change.

6a. FORTIS Clean Development Mechanism (CDM)-Project Design Document (PDD)

The objective of the project is to develop the baseline methodology and PDD for M/S FORTIS Hospital, Delhi for the energy efficient buildings. Article 12 of the Kyoto Protocol defines purpose of Clean Development Mechanism (CDM) "to assist Parties¹ not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under article 3". This provision has opened avenues for developing countries for carbon trading wherein GHG emissions in one country are reduced to permit an equivalent quantity of GHG emissions in another country, without changing the global emission balance. To establish this additionality, information and data on baseline emissions and a baseline methodology are required. TERI has undertaken the process of developing the same.

The baseline scenario is that which unfolds in the absence of the project activity; it is an interpretation of "what would have happened otherwise?"

Fortis Hospital is implementing energy efficiency in their buildings and is interested in getting carbon credits for some of their already existing buildings as well as for other upcoming buildings. TERI is helping them to get carbon credits. A new baseline methodology is being proposed for this project; a primary survey is also being conducted to establish the baseline for similar buildings followed by the preparation of a detailed Project Design Document (PDD).

6b. Preparation of India's Second National Communication (SNC)

The Second National Communication (SNC) envisages preparing GHG inventory for the base year 2000 and includes additional gases CO, NO_x, NMVOC, SO₂, HHC, PFC and SF₆. Further, the SNC proposes to improve upon the estimation methodologies for some of the key sectors and develop new country specific emission factors. The IPCC 2006 Revised Guidelines shall be followed for this project. The sectors covered are:

- Energy industries
- Manufacturing industries and construction
- Residential and commercial sectors
- Transport
- Agriculture and
- Waste to energy

The CRSBS section is involved in calculating the GHG emissions coming from residential and commercial sectors using Tier 3 approach (the most advanced approach for calculation of GHG emissions).

Project details

7. Research and development

7a. Standardization of weather data sets and ambient design conditions for India

Ambient design conditions for 52 Indian stations have been developed in the ASHRAE (1997) format. Design temperatures have been determined for 0.4, 1.0 and 2.0 percent of annual occurrence from the annual cumulative frequencies, and are available for cooling and heating. The project also completes the development of standardized weather data sets in international format for each of these stations.

Project details

8. Projects on mainstreaming funded under international co operations/ United Nations

8a. Sustainable building design: Strengthening capacities for planning and implementation - Asia Urbs Programme

The objective of the project (Development Project) is to improve the urban environment in the Gurgaon district of Haryana in India. The aim has been:

1. To assist the local authority in Gurgaon to develop sustainable building design plans based on the concepts of energy conservation, energy efficiency and renewable energy technologies, through consultation and engagement with key stakeholders in the planning area. LAs (Local Authorities) will provide assistance (Merton UK and ICAEN in Spain).
2. To strengthen the capacity of building practitioners (builders, plumbers, engineers, architects etc.) to implement sustainability measures in new and existing buildings

Results of the action:

- Enhanced capacities of policy makers and practitioners.
- Project activities resulted in a manual, CDs, policy seminars, learning modules, and marketing materials for dissemination through a dedicated website.

Post project actions included government mandate on energy efficiency in all public buildings in the state, and mandate on use of solar water heating systems in buildings over a certain size. The state government of Haryana has also initiated several pilot projects.



8b. Sustainable habitat design Advisor-Asia It and C programme

The overall objective of the project is to improve environmental quality by increasing awareness and creating a knowledge base applicable to sustainable habitats. The project aims to develop a network between EU and Indian building professionals, users and the student community to share best practices, facilitate transfer of technical know-how, get access to innovative design solutions which have been implemented in the EU and India. The project also aims to answer application and operation-related queries of building owners and users, to help facilitate best use of applied sustainable design options. The project also aims at developing markets for sustainable building products by bringing manufacturers, users, and practitioners onto the same platform to exchange information and arrive at customized design solutions to specific design problems.



The web, being the media for wide outreach, is the most preferred media for achieving the desired objectives. The specific objective of the project is to create awareness of benefits of environmental design by creation of a design advisory and educative forum on the web for planning of sustainable habitats.

8c. Demonstration projects of eco-cities/villages in Asia Pacific

The prime objective of this project is to prepare design guidelines for design of eco housing in Sri Lanka, Maldives and Indonesia and review designs prepared by local architects to enhance energy and resource efficiency of the houses. United Nations Environment Programme (UNEP) is providing assistance to reconstruction in select villages in Maldives, Indonesia and Sri Lanka. Demonstration projects have been undertaken for this program wherein eco concepts would be demonstrated. In consultation with local stakeholder groups, implementing agency and the government in each country, the group has formulated strategies and guidelines for steering reconstruction activities in an eco sensitive way. Design guidelines for micro-planning of the identified projects in Sri Lanka, Maldives and Indonesia have been prepared. The planning methodology involves understanding of the regional and local issues, estimation of resource availability; estimation of technical, financial and social impact of suggested measures, costs and financial support required. The completed projects shall set new benchmarks for eco housing construction in disaster prone areas in the respective countries. The project in Sri Lanka has been completed and has an inspiring example of sustainable rural habitat in the region.

8d. Baseline principles and technical criteria for eco housing in Pune city of India

Pune is a fast growing urban centre with increasing pressure on its resources. The group provided a complete framework for Municipal Corporation, developers, builders, architects, technology providers, financial institutions for promoting, developing and assessing urban house performance to meet sustainability goals. Policy recommendations were made to enable the government to implement the principles through regulations and byelaws. The study results were shared in several stakeholder forums. In order to incentivise eco housing in Pune, a set of technical criteria with weighted point system has been evolved. The group's prime responsibility in this activity was to evolve the technical criteria for sustainable site planning and infrastructure planning, environmental architecture, energy efficient lighting, and renewable energy integration. The technical criteria and the weighting system have been developed through stakeholder consultation and impact assessment at household, local, and global level of the adoptable measures.

8e. Integrated energy master plan for Bhutan and micro planning for office building for Department of Energy

This project aims to develop an Integrated Energy Master Plan for the Royal Government of Bhutan. The group is providing micro planning assistance to a demonstration project of the government of Bhutan that is being designed to set standards and benchmarks for future new constructions. Energy efficient solutions were analyzed for Department of Energy (Thimphu-Bhutan) new office building to evolve optimised envelope (for reducing space-heating demand in winters) and energy efficient space conditioning systems. Energy efficiency in existing buildings of Bhutan was analyzed and evaluated through audit of typical residential, commercial cum institutional buildings. Chapter on building energy efficiency in Bhutan will be included in the 'Bhutan energy directory', which will be published under this particular project. Another key output of the project would be to raise awareness level on energy efficiency in buildings



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