‘Human Habitats today have become centers of energy consumption. By conserving energy with appropriate building design, reducing energy by efficient energy management and producing energy with decentralized systems that allows feeding surplus energy into the grid, we can create a shift towards energy positive habitats. Essential to this movement is the fact that humans have to change their life styles to consume less energy.’
Energy Efficient Design

Energy Positive Habitats

30 August 2012 | Auroville

Tanmay Tathagat

Environmental Design Solutions Pvt. Ltd

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Ecological Footprint

THE ECOLOGICAL FOOTPRINT: A GLOBAL CONTEXT

- Build-up land
- Food, fiber, and timber
- Energy

2050 World Average Biocapacity
Ecological Footprint Per Person (2003)
Ecological Footprint Per Person (2003)
World GHG Emissions Flow Chart

Sector

Transportation 13.5%
Energy
Electricity & Heat 24.6%
Other Fuel Combustion 9.0%
Industry 10.4%
Fugitive Emissions 3.9%
Industrial Processes 3.4%
Land Use Change 18.2%
Agriculture 13.5%
Waste 3.6%
End Use/Activity
Road 9.9%
Air 1.6%
Rail, Ship, & Other Transport 2.3%
Residential Buildings 9.0%
Commercial Buildings 5.4%
Unallocated Fuel Combustion 3.5%
Iron & Steel 3.2%
Aluminum Non-Ferrous Metals 1.1%
Machinery 1.5%
Cap & Piping 1.5%
Pipe & Piping 1.5%
Chemicals 4.8%
Cement 3.8%
Other Industry 5.0%
T&D Losses 1.9%
Coal Mining 1.4%
Oil/Gas Extraction, Refining & Processing 6.3%
Deforestation 18.3%
Afforestation -1.5%
Reforestation -0.5%
Harvest/Management 2.5%
Other -0.6%
Agricultural Energy Use 1.4%
Agriculture Soils 6.0%
Livestock & Manure 5.1%
Rice Cultivation 1.4%
Other Agriculture 1.5%
Landfill 2.6%
Wastewater, Other Waste 1.4%

Build Energy Efficiency

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Alternate Future with Low Impact

HDI vs Electricity Consumption

- India
- Argentina
- Brazil
- Turkey
- China
- Pakistan
- Zimbabwe
- Nigeria
- Chile
- Spain
- France
- Switzerland
- South Africa
- USA
- Sweden
- Canada

Per capita electricity consumption (kWh/year) vs Human Development Index
Global Habitat Scenario
Projected Emissions of GHGs in 2025

- World: 57%
- Developed: 35%
- Developing: 84%
- U.S.: 39%
- China: 118%
- EU: 19%
- FSU: 42%
- India: 70%
- Africa: 80%
- Brazil: 68%
- Japan: 26%
- Mexico: 124%

Millions of Tons of Carbon Equiv.
Uncertainty in Future CO2 Emissions

Projected Growth, 2000–2025

- India
- Mexico
- China
- Brazil
- South Korea
- Former Soviet Union
- Japan
- EU-15
- USA
- World

High Estimate
Low Estimate
Lifestyles & Aspirations

- The affluent in ALL countries have to make sacrifices in many wasteful areas but can still have a good quality of life;
- Those developing economically esp in large nations must aspire for a better quality of life without taking the same wasteful and resource intensive path
Impact of the Built Environment
Impact of the built environment

- 40% of the world’s energy
- 25% of the timber harvested
- 16% of the fresh water used
- 50% ozone depleting CFC’s
- 30% of raw materials used
- 35% of CO2 emissions
- 40% of landfill waste
Sustainability: Fulfiling needs in the present w/o compromising the potential to meet future needs

- Reducing
- Recycling
- Renewable resources
- Redefining creative solutions for common problems
Ecological Building: What can be learnt from history?

- In the past, human beings lived in harmony with their environment
  - Comfort requirements were different
  - Small population meant ample space, modest requirements, low energy needs and emissions
  - Waste products mostly recyclable & bio-degradable
  - Mobile communities
  - Low threat to the environment

Nomadic life & sparse requirements drove the architecture of the past and made it sustainable.
The Modern Building ecosystem

- input
- building
- output

Building materials → used materials
Energy → wasted heat. CO₂, CO, SO₂
Water → gray water, sewer
Consumer goods → waste, recyclable materials
Solar radiation → warm air
Wind → polluted air
Rainwater → storm water

Building Energy Efficiency © Environmental Design Solutions Pvt. Ltd.
Growth and Energy Savings Potential

Building Sector in India
Almost a third of India’s electricity is used in buildings

<table>
<thead>
<tr>
<th>Category</th>
<th>Electricity consumption (% of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic (Buildings)</td>
<td>21.1</td>
</tr>
<tr>
<td>Commercial (Buildings)</td>
<td>7.6</td>
</tr>
<tr>
<td>Industry</td>
<td>45.1</td>
</tr>
<tr>
<td>Public Lighting</td>
<td>1.1</td>
</tr>
<tr>
<td>Transport</td>
<td>2.1</td>
</tr>
<tr>
<td>Agriculture</td>
<td>19.0</td>
</tr>
<tr>
<td>Water Works</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Installed Capacity = 1,62,366.8 MW *
Projected Capacity = 8,00,000.0 MW (2030)

Growth Trend of Building Sector in India

Source: Cushman & Wakefield Sector Report 2010 & EDS Analysis

Building Energy Efficiency

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Housing Demand Growth in India

Source: Planning Commission 11th Plan Report & EDS Analysis
Housing Demand Growth in India

>70 Million New Urban Houses Needed Over the Next 20 Years

Source: Planning Commission 11th Plan Report & EDS Analysis
Energy Use of a Typical Residential Unit

- Lighting: 16%
- Celing Fans: 28%
- Refrigerator: 29%
- Hot Water: 7%
- Others: 20%

Building Energy Efficiency
Energy Use of a Typical Residential Unit

The bar chart illustrates the energy usage of typical appliances and energy-efficient (EE) appliances in a residential unit. The chart shows the following categories of energy use:

- **Others**: 263 units for typical appliances and 219 units for EE appliances.
- **Refrigerator**: 394 units for typical appliances and 307 units for EE appliances.
- **Hot Water**: 90 units for typical appliances and 12 units for EE appliances.
- **Ceiling Fans**: 384 units for typical appliances and 240 units for EE appliances.
- **Lighting**: 219 units for typical appliances and 131 units for EE appliances.

This chart helps in understanding the distribution of energy consumption in a typical residential building.
Energy Use of a Typical Residential Unit

- 40% Savings in Lighting ~ 88kWh/yr
- 35% Savings in Ceiling Fans ~ 140 kWh/yr
- 90% Savings in Hot Water ~ 80 kWh/yr
- 25% Savings in Other Appliances ~ 130 kWh/yr

Savings of Over 300 kWh/yr ~ 900 Rs/yr due to efficient Lighting, Ceiling Fans and Solar Hot Water

Domestic Air Conditioner Sales Growing at over 25% per year
Embodied Energy in the Typical Unit

<table>
<thead>
<tr>
<th>Material</th>
<th>Embodied Energy (MJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCC Roof</td>
<td>10,531</td>
</tr>
<tr>
<td>RCC Slab</td>
<td>21,062</td>
</tr>
<tr>
<td>RCC Structure</td>
<td>23,180</td>
</tr>
<tr>
<td>Ext. Brick Walls</td>
<td>82,057</td>
</tr>
<tr>
<td>Int. Brick Walls</td>
<td>23,044</td>
</tr>
<tr>
<td>Plaster</td>
<td>1,679</td>
</tr>
<tr>
<td>Steel Door/Window Frames</td>
<td>7,691</td>
</tr>
<tr>
<td>Glass Windows</td>
<td>1,310</td>
</tr>
</tbody>
</table>

Building Energy Efficiency
Embodied Energy in the Typical Unit

RCC Roof, Slabs & Frame
46%

External & Internal Walls
46%

Alternate Walling & Roof/Slab Materials and Technologies will yield the Most Benefit
20 Year Life Cycle Energy Use: Importance of Embodied Energy

Unconditioned

Air Conditioned

Year

Embodied Energy
Operational Energy

Building Energy Efficiency

© Environmental Design Solutions Pvt. Ltd.
20 Year Life Cycle Energy Use: Importance of Embodied Energy

After 20 Years
- Embodied Energy = 60%
- Operational Energy = 40%

After 20 Years
- Embodied Energy = 32%
- Operational Energy = 68%
Current Policies and Initiatives

India
Lack of Resources is the key Driver for Energy Efficiency

- Acute water and electricity shortage in most cities
- Poor air/water/power-quality
- Overloaded infrastructure
- Global environmental concerns
- Awareness of business opportunities among the building industry
- Interest of the national/international agencies
GHG Mitigation Potential in Buildings

Commercial

- Lighting: 61
- Air-conditioning: 33
- Fans: 10

Commercial ECBC compliant

- Lighting: 49
- Air-conditioning: 20
- Fans: 10

Residential

- Residential BAU
  - Lighting: 104
  - Air-conditioning: 26
  - Fans: 15
  - Refrigerator: 15

- Residential ECBC compliant
  - Lighting: 84
  - Air-conditioning: 13
  - Fans: 15
  - Refrigerator: 15
  - Evap. cooling: 48
  - TV: 15

Building Energy Efficiency

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Current Building EE and GHG Mitigation Initiatives

- **Policies**
  - Energy Conservation Act
  - Integrated Energy Policy
  - National Mission on Climate Change
  - State Level Initiatives (DSM, SDAs)

- **Programs, Codes, and Standards**
  - Energy Conservation Building Codes
  - National Building Code
  - Environmental Impact Assessment and Clearance
  - Appliance/Equipment Labeling and Standards
25%-40% EE Potential with ECBC

National Energy Savings = Code Stringency × Level of Compliance × Adoption Rate
INTRODUCING BEE LABEL. THE NEW SIGN OF ENERGY EFFICIENCY.
Other Initiatives

- Green Building Rating Systems
  - LEED India, GRIHA, Eco-Housing
  - Over 1 billion sft of Green Buildings by 2012

- Labeling and Certification
  - BEE Building Energy Labeling
  - NHB-KfW Program for EE Residential

- Programs for Green Affordable Housing
Financing Green/EE Projects

- NHB-KfW program for Energy Efficient Housing
- Banks and Housing Finance Companies
  - State Bank of India (0.25% concession in interest rate and waiver of processing fees)
- Municipal fee and tax incentives
  - Pune Municipal Corporation (PMC) provides a rebate of 10% on property tax for home owner on Eco-Housing certified projects
- State Electricity Regulatory Commissions (SERC) / Utilities tariff incentives being developed
Reducing GHG Emissions in Building

Policy Strategies

Based on study by EDS for Climateworks Foundation
Key Strategies for Reducing Building GHG Emissions

- Mandatory Building Energy Codes – Current Levels
- Mandatory Building Codes – Super Stringent (Zero Energy Target)
- Mandatory ECBC for Residential Buildings
- Voluntary ECBC for Residential Buildings
- Mandatory Appliance/Equipment Labeling
- Stringent Appliance Standards (MEPS)
- Building Benchmarking
- White Certificates
- Govt./Public Buildings EE Program
- Demonstration Projects/Training/Professional Certification
- Green Building Certification
- Onsite/offsite renewable energy incentives/promotion/standard
- EE Depreciation
- EE Retrofit Incentive Program
- DSM/Utility Incentive Programs
- CDM Incentives
- Sustainable Urban Development Policies (Smart Growth)
- Sustainable Land-Use Policies
<table>
<thead>
<tr>
<th>Strategy</th>
<th>Policy and Institutional</th>
<th>Finance</th>
<th>Business and Management</th>
<th>Awareness and</th>
<th>Material and Technology</th>
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GHG Mitigation Potential till 2030

GHG Abatement Potential (Million Tons)

- CDM Incentives
- DSM/Utility Incentive Programs
- EE Retrofit
- EE Depreciation
- Onsite/offsite renewable energy incentives/promotion/
- Green Building Certification
- Demonstration Projects/Training/Professional
- Govt./ Public Buildings EE Program
- White Certificates
- Building Benchmarking
- Stringent Appliance Standards (MEPS)
- Mandatory Appliance/Equipment Labeling
- Voluntary ECBC for Residential Buildings
- Mandatory ECBC for Residential Buildings
- Mandatory Building Codes – Super Stringent (Zero
- Mandatory Building Energy Codes – Current Levels

Based on study by EDS for Climatesworks Foundation
Key Barriers to Building Energy Efficiency Implementation

- Strong first cost bias
- Split Incentives
- Lack of availability of efficient products
- No easy accounting of Embodied Energy
- Lack of energy expertise
- Lack of awareness, info. and tools
- Electricity rate structures / rural subsidies
- Territoriality by agencies
- Lack of government & utility “Champions”
Mainstreaming - accumulation of multiple influences
Classic reasons for failure of uptake of EE

- **Market failures:**
  - The market produces insufficient information about the performance of different technologies and options.

- **Organizational failures:**
  - Neglect life cycle costs, high discount rates to evaluate energy efficiency related investments, and provide inadequate incentives.

- **Limitations on decision-making:**
  - Individuals do not make decisions in the manner assumed by economic models, but are instead subject to severe constraints on attention, resources and their ability to process information.
Energy Efficient Buildings

Based on study by EDS for Climateworks Foundation
Buildings in India: Vision 2030

[Graph showing energy use index (kWh/m²/yr) with three main categories: High Performance Buildings, ISBC 2007, and Typical Building, with percentages of all construction plotted along the y-axis.]
Buildings in India: Vision 2030
Buildings in India: Vision 2030
Buildings in India: Vision 2030
Success Factors

- Clear Quantifiable Goals
- Enabling Policy Framework
- Supporting Fiscal/Financial Mechanism
- Technical Capacity to Deliver
- Robust Checks and Balances
- Awareness and Marketing
- M&V and Refinement
Very Large Number of Stakeholders Involved
Design Process

- Integrated Design Team
  - Architect
  - Owner
  - Builder
  - Mechanical Electrical and Plumbing Engineer (MEP)
  - Structural Engineer
  - Civil Engineer
  - Landscape Architect
  - LEED Consultant/Green-Rater

- Sustainability from Day-1
- Staying focused on goals
- Accepting trade-offs
  - Energy vs. water vs. materials
  - Sustainability vs. cost
  - Up-front vs. recurring costs

- Exploit synergy, know when to stop
Design Phase

Procurement phase

Construction Phase

Post-Construction Phase

Project Life-Cycle
- Climate Analysis
- Site Level Analysis
- Building Level Analysis
- Solar Analysis
- Energy Efficiency Analysis
- Lighting Analysis
- Conceptual M& Services Analysis
- Renewable Energy Analysis
- Green Building Rating Analysis

**Procurement Phase**

- Technical Specification Review
- Material Specification Review
- Special Clauses Review
- Cost implication & Green Building rating level analysis

**Construction Phase**

- Green Education to the Project Team
- Green Education to the vendors
- Green Building strategies implementation
- Green Building Strategies documentation
- Green Building Documentation facilitation
- Fundamental Building systems commissioning

**Post Construction Phase**

- Enhanced Building systems commissioning
- Green Building documentation submission
- Coordination with Green building certifying body
- Post occupancy evaluation

Building Energy Efficiency
The Architectural Design

- Comfort
- Aesthetics
- Efficiency
- Sustainability
- Cost
- Context
Sustainable design is not a reworking of conventional approaches and technologies, but a fundamental change in thinking and in ways of operating - you can't put spots on an elephant and call it a cheetah.
Thank You

Tanmay Tathagat

Environmental Design Solutions Pvt. Ltd

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