Energy : Air : Water:

Sustainability : Mobility : Affordability : Resilience : Technology

CITIES

Power cuts trigger water shortage in Gurgaon

HUDA officials claimed that damage to Basai pipeline — which is main source of water supply to the city — has caused short supply

Sushant Lok. Meanwhile, HUDA officials claimed that problem had arisen because of damaged Basai pipeline — which is main source of water supply to the city. Officials however claimed that the normal supply of 60 MGD water was badly hit. “We are currently supplying 45 MGD water against the demand of 26 MGD and we do understand that residents are suffering because of the water shortage. Also, due to power outages sometimes pumps do not work hampering the water supply. We hope to overcome the problem in a few days,” said a senior HUDA official. He added that the problem was fixed on Tuesday but pipeline broke again on Monday and repair work is going on.

Residents, meanwhile, alleged that the maintenance of the pipeline was poor by the department because of which the people suffer every summer.

“Avoid the demand of over 20 MGD for the population of 12 lakh, they supply 50-60 MGD and even that is erratic because of lack of maintenance and power crisis. We are victims of government’s apathy even after paying taxes,” Rithu, a resident of Chatekar, told awaaz.com.

Chatur Chaudhary,

Delhi world’s most polluted city

India slips to 155 among 178 countries on environment performance index, Capital tops Beijing to be city with dirtiest air pollution

Air

Capital Breaths Uneasy

Top global cities with worst air pollution

India slips in rank too; air pollution listed among its hazards

Bangladesh

Bangladesh 155 125

India 155 125

Pakistan 150 127

Nepal 150 127

China 150 125

Sri Lanka 129 120

India slips in rank too; air pollution listed among its hazards

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Chatur Chaudhary,
Is Population the issue?

India’s population: 1.22 Billion People

No: of people per Family: 5 – Total 244 Million Families

Each Family of 5: 200 sq m of Land
(800 sq m of Land including roads and Social Infrastructure @25%)

Therefore, total land required: 195,200 sq km

Total Land Area of India: 3,060,500 sq km
(3.06 Million sq km)

Which means Only 6% of India’s Land Mass is required to house India’s population – Each family with a 200sqm plot of land
Is Clean Energy the issue?

The current yearly per capita energy consumption in India is **680 kWh**, after considering transmission, distribution, transformation losses of 20%, etc (source: World Bank)

India’s population: 1.22 billion

Total Consumption: 829600000000 kWh

Average annual solar radiation: 365 * 5.5 = 2000 kWh/m²

Average efficiency of solar unit (inc. transmission losses): 15%

Average output per year: 2000 x 0.15 = 300 kWhr/m²

Area of solar panels required to produce required output: 2765 sq km
Land area required: 10,000 sq km

Land area required to house the panels is **0.003% of India's land mass** or **2.2% of India’s wasteland**
Is Water the issue?

**Shortfall:** Currently only 25% of India’s population has drinking water on their premises. According to World Bank estimates, India will exhaust its fresh water by 2050 at the current rate.

(source: Hindustan Times, Aug 26, 2012)

**India’s average yearly precipitation:** 1083mm (source: World Bank)

**Total Land Area of India:** 3,060,500 sq km

(3.06 Million sq km)

**Total Precipitation, therefore:** 3,314,500 billion litres

**Per capita Precipitation:** 2,500,000 litres/person for our population of 1.22 billion.

Even if 2% rainfall could be harvested, each person would have 150 litres a day - their daily water requirement
## Delhi: Water Carrying Capacity

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delhi’s Area</td>
<td>1,483 sq.km.</td>
<td>Delhi masterplan 2021</td>
</tr>
<tr>
<td>Annual fresh-water consumption per person in Indian households</td>
<td>32.85 cu.m./yr.</td>
<td>NBC-2005 Recommends 90 lphd</td>
</tr>
<tr>
<td>Annual domestic fresh-water requirement for Delhi’s population</td>
<td>551,483,862 cu.m./yr.</td>
<td></td>
</tr>
<tr>
<td>Annual Rainfall</td>
<td>0.7554 m/yr.</td>
<td><a href="http://www.rainwaterharvesting.org/rainfall_htm/delhi.htm">http://www.rainwaterharvesting.org/rainfall_htm/delhi.htm</a></td>
</tr>
<tr>
<td>Run-off factor</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>Total rainwater collected (including 20% evaporative losses)</td>
<td>560,129,100 cu.m./yr.</td>
<td></td>
</tr>
<tr>
<td>Carrying Capacity for Delhi</td>
<td>17,051,114 ppl</td>
<td></td>
</tr>
</tbody>
</table>

Delhi has the potential to be Net-Zero on domestic fresh-water demand on an annual cycle.
## Delhi: RE Carrying Capacity

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Delhi’s Area</td>
<td>1,483 sq.km.</td>
</tr>
<tr>
<td>Annual energy consumption of Delhi (2014-15)</td>
<td>29,000,000,000 kWh</td>
</tr>
<tr>
<td>Required installed capacity of solar PVs</td>
<td>19,333,333 kWp @ 1500kWh energy generated annually per 1kWp of installed capacity</td>
</tr>
<tr>
<td>Area required for installing solar PVs</td>
<td>193,333,333 sq.m. @ 1kWp for every 10 sq.m.</td>
</tr>
<tr>
<td>% of Delhi’s land area required for installing PVs</td>
<td>13%</td>
</tr>
</tbody>
</table>

Delhi has the potential **to be Net-Zero on energy demand by installing solar PVs over 13% of the city’s area**
Kolkata has the potential to be Net-Zero on domestic fresh-water demand on an annual cycle.
Kolkata has the potential to be Net-Zero on energy demand by installing solar PVs over 4% of the city’s area.
Warm Humid (3000mm Rainfall): Uttorayon Township, Siliguri, 400 Acres

A Low Cost Sustainable Model for Townships of Tier 2 Cities in India

Location: Siliguri, West Bengal
Climate: Wet (13m of rain/yr)
Total Site Area: 440 Acres
Construction Cost: $20/sqft

- Central Park
- Commercial
- School
- Communal Area
- Community/Walkability
  - A network of courtyards, walkways and bicycle paths
- Surface Drainage System
  - A natural topographical network with no site runoff
- Natural Ventilation
  - Spatial planning to control elevated humidity levels
- Passive Solar Design
  - Optimal north-south orientation to control solar gain
Hot and Dry Climate: Desert Township, Dubai, 532 Acres

- 3 KM Stepwell recharge Ghats
- 500 Acre Uninterrupted Pedestrian precinct
- Onsite NET-ZERO Energy Development
- 100% pedestrian connected Amenities
- Low common area maintenance • Low operative costs
- 10K Reduction in Microclimatic } North-South Oriented Residences
Composite Climate: Campus for Infosys, Nagpur, 142 Acres

Net Zero Energy for 20,000 people
Zero Water Balance for 20,000 people
Zero Waste Discharge for 20,000 people
Naturally day-lit, Glare-free Workplace
15 acre Lake for Rainwater Harvesting
Productive Landscape and Bio-diversity Park

LEGEND
1. Ceremonial Entry
2. Lake
3. Open Courts
4. Amphitheatre
5. Employee Care Centre Block
6. Native Tree Plantation/Future Development
7. MLCP and Solar Farms
8. Employee Entry
9. Utilities
10. Turnstile Bay
11. Pedestrian Canyon
12. Software Development Blocks
13. Boardwalk
Cold Climate: Amarnath Yatra, 13000ft Altitude
Can buildings be built that consume 75% lesser energy than green building benchmarks and Cost Lesser to Build?
Net-Zero Project

Maximise Renewable Energy
- Photovoltaics
- Geothermal Power
- Wind | Biomass | Wave | Tidal

Maximise Efficiency of M&E
- Energy Efficient Equipment
- Façade Systems
- HVAC | Heat Recovery
- Electrical Systems
- Control Systems | Sensors and Actuators

Passive Design - Reduce Demand by 75%
- Optimized Form | Orientation
- Thermal Mass | Insulation
- Shading Design
- Maximize Day lighting | No Glare
- Natural Ventilation

Microclimate - 10K Reduction in Perceptible Temp
- Orientation | Morphology
- Shaded Spaces | Addressing Urban Heat Island Effect
- Harnessing cool winds | Blocking hot-winds
- Evaporative Cooling
- Vegetation (Trees for shade, Green Roofs etc.) | Xeriscape
- Local Materials | Waste management
- Rainwater Harvesting | Water reservoir design
Microclimate Commercial | 10K Reduction in Perceptible Comfort

Evaporative Cooling | Shading the ground plane | Capturing prevailing winds in Monsoon | Blocking winds in hot & dry season | Vegetation | Green Roofs
**Sustainability | Residential: Envelope Optimization**

<table>
<thead>
<tr>
<th>Efficiency Parameters</th>
<th>ECBC</th>
<th>Morphogenesis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Visual Comfort:</strong> Efficient Lighting Systems (LEDs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Day-lit living spaces (from available daylight hours)</td>
<td>25%</td>
<td>90%</td>
</tr>
<tr>
<td><strong>Robust Envelope Design:</strong> Optimal Thermal Properties and Element Proportions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency Parameters</td>
<td>ECBC Baseline Metrics</td>
<td>Design Considerations</td>
</tr>
<tr>
<td>U-value of Walls (W/sq.m.K)</td>
<td>0.44</td>
<td>0.624</td>
</tr>
<tr>
<td>U-value of Roofs (W/sq.m.K)</td>
<td>0.26</td>
<td>0.345</td>
</tr>
<tr>
<td>U-value of Glass (W/sq.m.K)</td>
<td>3.30</td>
<td>1.70</td>
</tr>
<tr>
<td>Max. Window : Wall Ratio (WWR)</td>
<td>60%</td>
<td>≤ 20%</td>
</tr>
<tr>
<td><strong>Solar Control:</strong> Effective Shading Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effective SHGC for Glass (75-90% Shading)</td>
<td>0.20</td>
<td>0.20</td>
</tr>
</tbody>
</table>

**Resultant Envelope Load***

| | ≥ 10.0 W/sq.ft. | ≤ 2.5 W/sq.ft. |

*Envelope Load : Heat loads for HVAC systems

**Energy Performance Index**

(kWh/sq.m./yr.)

- 100 / 200
- 50

**BEE Baseline recommendation**

**Target EPI**

*Overall Energy Consumption of residences can be reduced by ~75% over conventional practices through efficient design*
Sustainability | Commercial: Envelope Optimization (<1w/sft Envelope Heat Load)

Efficiency Parameters | ECBC | Morphogenesis
--- | --- | ---
Robust Envelope Design: Optimal Thermal Properties and Element Proportions

<table>
<thead>
<tr>
<th>Efficiency Parameters</th>
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</tr>
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<td>0.26</td>
</tr>
<tr>
<td>U-value of Glass (W/sq.m.K)</td>
<td>3.30</td>
<td>1.70</td>
</tr>
<tr>
<td>Max. Window : Wall Ratio (WWR)</td>
<td>60%</td>
<td>≤ 30%</td>
</tr>
</tbody>
</table>

Solar Control: Effective Shading Design

<table>
<thead>
<tr>
<th>Efficiency Parameters</th>
<th>ECBC Baseline Metrics</th>
<th>Design Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective SHGC for Glass (75%-90% Shading)</td>
<td>0.20</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Inference:

Electrical consumption for the project can be reduced by ~80% through efficient design of the building envelope.
### Sustainability | Energy Optimization

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description</th>
<th>EPI (kWh/Sqm Yr)</th>
<th>Envelope Load (W/Sqft)</th>
<th>Chiller Sizing (Sqft/TR)</th>
<th>Interior Lighting Savings %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BEE Benchmark</td>
<td>140</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Conventional Building Parameters</td>
<td>118</td>
<td>3.4</td>
<td>211</td>
<td>0%</td>
</tr>
<tr>
<td>3</td>
<td>ECBC Compliance Parameters</td>
<td>86</td>
<td>1.6</td>
<td>320</td>
<td>0%</td>
</tr>
<tr>
<td>4</td>
<td>ECBC Compliant + Daylight Sensors</td>
<td>57</td>
<td>1.6</td>
<td>342</td>
<td>65%</td>
</tr>
<tr>
<td>5</td>
<td>4 + LPD- 0.5 W/Sqft</td>
<td>49</td>
<td>1.6</td>
<td>362</td>
<td>84%</td>
</tr>
<tr>
<td>6</td>
<td>5 + DGU (SHGC- 0.15, U Value- 1.6 W/ Sqm. K)</td>
<td>44</td>
<td>1.1</td>
<td>373</td>
<td>84%</td>
</tr>
<tr>
<td>7</td>
<td>6 + WWR 25%</td>
<td>43</td>
<td>0.9</td>
<td>378</td>
<td>83%</td>
</tr>
<tr>
<td>8</td>
<td>7 + Chiller COP 6.3</td>
<td>42</td>
<td>0.9</td>
<td>386</td>
<td>83%</td>
</tr>
<tr>
<td>9</td>
<td>8 + UFAD</td>
<td>35</td>
<td>0.9</td>
<td>418</td>
<td>83%</td>
</tr>
<tr>
<td>10</td>
<td>8 + Radiant Cooling Panels</td>
<td>34</td>
<td>0.9</td>
<td>440</td>
<td>83%</td>
</tr>
</tbody>
</table>

**Inference:**

- A benchmark of 43 kWhr/sq.m/yr has been targeted with conventional air-conditioning system.
### Hybrid Building

<table>
<thead>
<tr>
<th>Building</th>
<th>EPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearl Academy, Jaipur</td>
<td>25 kWh/sq.m/yr</td>
</tr>
<tr>
<td>JRE University</td>
<td>80 kWh/sq.m/yr</td>
</tr>
</tbody>
</table>

### Air-Conditioned Institutional Buildings

<table>
<thead>
<tr>
<th>Building</th>
<th>EPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>IILM, Greater Noida</td>
<td>50 kWh/sq.m/yr</td>
</tr>
<tr>
<td>The British School</td>
<td>65 kWh/sq.m/yr</td>
</tr>
<tr>
<td>British Council</td>
<td>86 kWh/sq.m/yr</td>
</tr>
<tr>
<td>Lalit Suri Hospitality Inst.</td>
<td>55 kWh/sq.m/yr</td>
</tr>
</tbody>
</table>

### Energy Performance Index (EPI) on primary energy consumption (kWh/sq.m./yr)

<table>
<thead>
<tr>
<th>Year</th>
<th>Pearl Academy</th>
<th>JRE University</th>
<th>IILM</th>
<th>The British School</th>
<th>British Council</th>
<th>Lalit Suri Hospitality Inst.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>25</td>
<td>80</td>
<td>50</td>
<td>65</td>
<td>86</td>
<td>55</td>
</tr>
<tr>
<td>2011</td>
<td>140</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>50</td>
<td>65</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>65</td>
<td>86</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>86</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>55</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Prior to rating systems

- GRIHA 5 Star (targeted)
- USGBC Platinum (certification)
- GRIHA 5 Star (targeted)
**Sustainability | Energy Performance Index**

**Air-Conditioned Buildings**

<table>
<thead>
<tr>
<th>Building</th>
<th>EPI (kWh/sq.m/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRIHA Baseline</td>
<td>140</td>
</tr>
<tr>
<td>India Glycols Ltd. Noida</td>
<td>60</td>
</tr>
<tr>
<td>GYS Vision Gurgaon</td>
<td>58</td>
</tr>
<tr>
<td>ITC Offices, Kolkata</td>
<td>43</td>
</tr>
<tr>
<td>Campus for Infosys, Nagpur</td>
<td>25</td>
</tr>
</tbody>
</table>

**Energy Performance Index (EPI)**

- GRIHA Baseline
  - EPI: 140 kWh/sq.m/yr
- India Glycols Ltd. Noida
  - EPI: 60 kWh/sq.m/yr
- GYS Vision Gurgaon
  - EPI: 58 kWh/sq.m/yr
- ITC Offices, Kolkata
  - EPI: 43 kWh/sq.m/yr
- Campus for Infosys, Nagpur
  - EPI: 25 kWh/sq.m/yr

**Conventional Office Building**

- EPI: 200 kWh/sq.m/yr

**Base-line Recommendation**

- EPI: 140 kWh/sq.m/yr

**India Glycols Ltd. Noida**

- EPI: 60 kWh/sq.m/yr

**GYS Vision Gurgaon**

- EPI: 58 kWh/sq.m/yr

**ITC Offices, Kolkata**

- EPI: 43 kWh/sq.m/yr

**Infosys Nagpur**

- EPI: 25 kWh/sq.m/yr

The table above summarizes the energy performance indices (EPI) for various buildings, comparing them to a baseline of 140 kWh/sq.m/yr. The graphs visually represent the energy consumption levels for each building type.
### Older Benchmarks

**Energy Performance Index Benchmarks (EPI) – (kWh/ m²/year)**

<table>
<thead>
<tr>
<th>Climate Classification</th>
<th>Day time occupancy</th>
<th>24 hours Occupancy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 Days a week</td>
<td>7 Days a week</td>
</tr>
<tr>
<td><strong>Commercial/Institutional/Academic/Hospital buildings</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>120</td>
<td>350</td>
</tr>
<tr>
<td>Composite / Warm and humid / hot and dry</td>
<td>140</td>
<td>450</td>
</tr>
<tr>
<td><strong>Residential buildings/Hostels</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Composite / Warm and humid / hot and dry</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

### Proposed Benchmarks for GRIHA V 2015

**Energy Performance Index Benchmarks (EPI) – (kWh/ m²/year)**

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<tr>
<td><strong>Commercial/Institutional/Academic/Hospital buildings</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>75</td>
<td>225</td>
</tr>
<tr>
<td>Composite / Warm and humid / hot and dry</td>
<td>90</td>
<td>300</td>
</tr>
<tr>
<td><strong>Residential buildings/Hostels</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Composite / Warm and humid / hot and dry</td>
<td>60</td>
<td></td>
</tr>
</tbody>
</table>
**Affordability | Capital and Operation Cost**

**Capital Cost**

- **Over-buildability (20%)**: Bottom up design to strategize reduction of construction area for parking spaces <35Sqm/Car. Increase Spatial Efficiency by 20% with Inside Out Design.

- **Structure Optimisation (20%)**: Symmetrical Floor Plates, Central Cores, Optimized Grid Spans. Optimising building heights leads to lower structural cost.

- **M&E Optimisation (25%)**: Passive Design, Envelope Optimization along with efficient systems enable an overall reduction in M&E capital cost.

- **Smart Façade (33%)**: 25% WWR with 90% Daylighting and 90% Shading will enable a substantial reduction in Façade Cost compared to an all glass facade.

**Operational Cost**

- **Lighting Cost (80%)**: Reduction in lighting loads with high Continuous Daylight Autonomy through Passive building design. No lights switched on during the day with a blinds free facade.

- **HVAC Cost (60%)**: Reduction in HVAC cooling loads thorough Efficient and Passive building design with an envelope load of <1W/sft.

- **Common Area M&E (60%)**: Reduction in M&E common area maintenance costs through passive design.

- **Facility Maintenance (20%)**: Reduction expected due to lesser installation of M&E equipment.
Affordability | Residential Integrated Project Design

Project Cost Targets – Rs.1,585 / sft (< 25 $/sft)

<table>
<thead>
<tr>
<th>Structure+Civil</th>
<th>Façade</th>
<th>Electrical Systems</th>
<th>HVAC</th>
<th>Plumbing + Fire Systems</th>
<th>VT</th>
<th>Interiors</th>
</tr>
</thead>
<tbody>
<tr>
<td>850 Rs/Sft</td>
<td>150 Rs/Sft</td>
<td>175 Rs/Sft</td>
<td>10 Rs/Sft</td>
<td>100 Rs/Sft</td>
<td>75 Rs/Sft</td>
<td>225 Rs/Sft</td>
</tr>
</tbody>
</table>

- Optimum Grids Symmetry (45M)
- WWR<20%
- Envelope Load < 3W/sft
- EPI < 50 KwHr/sq.m/yr
- Common Stacks / Water saving>50%
- Interval < 45s Up Peak > 12%
- Green certified Materials
## Project Cost Targets – Rs.2900/sft (<$50/sft)

<table>
<thead>
<tr>
<th>Category</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure + Civil</td>
<td>1,150 Rs/Sft</td>
</tr>
<tr>
<td>Façade + BMU</td>
<td>500 Rs/Sft</td>
</tr>
<tr>
<td>HVAC</td>
<td>325 Rs/Sft</td>
</tr>
<tr>
<td>Electrical + IBMS</td>
<td>375 Rs/Sft</td>
</tr>
<tr>
<td>PHE</td>
<td>175 Rs/Sft</td>
</tr>
<tr>
<td>VT</td>
<td>125 Rs/Sft</td>
</tr>
<tr>
<td>Common Interiors</td>
<td>250 Rs/Sft</td>
</tr>
</tbody>
</table>

### Optimum Grids Symmetry (100M)
- **WWR<30%**
- HVAC > 600 sft / TR
- EPI < 40 Kwhr/sqm/yr
- Common Stacks / Water saving>50%
- Interval < 45s
- Up Peak > 10%
- Green certified Materials / Furniture

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**Affordability | Office Integrated Project Design**
Towards a Net Zero Future

**S**ustainability
Can buildings be built that consume 75% lesser energy than certified green building benchmarks

**A**ffordability
Can we break barriers of established price benchmarks and reduce consumption of resources through design innovation

**I**dentity
Can architecture be rooted in the Global and the Local, celebrating Diversity over Homogeneity

**L**ivability
Can Smart architecture build resilient communities by putting the user at the center of the design process

Morphogenesis.