Data driven high performance buildings

Guruprakash Sastry
2008 to 2014

- Increase in no. of employees in India: 100%
- Absolute Increase in energy: 13%

- 663 Million kWh avoided
- 0.56 Million Tons of CO₂ avoided
- 80 Million USD electricity bills avoided

### Per capita electricity consumption

<table>
<thead>
<tr>
<th>Year</th>
<th>Avg. Monthly kWh/employee</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007-08</td>
<td>297</td>
</tr>
<tr>
<td>2008-09</td>
<td>266</td>
</tr>
<tr>
<td>2009-10</td>
<td>239</td>
</tr>
<tr>
<td>2010-11</td>
<td>230</td>
</tr>
<tr>
<td>2011-12</td>
<td>203</td>
</tr>
<tr>
<td>2012-13</td>
<td>178</td>
</tr>
<tr>
<td>2013-14</td>
<td>167</td>
</tr>
</tbody>
</table>

44% reduction
### What is possible? Standard Vs. efficient design

<table>
<thead>
<tr>
<th>Performance metric</th>
<th>Standard design</th>
<th>Efficient design</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Building energy consumption</td>
<td>250 kWh/m²/year</td>
<td>75 kWh/m²/year</td>
<td>70%</td>
</tr>
<tr>
<td>2 Lighting design</td>
<td>1.2 W/sqft</td>
<td>0.48 W/sqft</td>
<td>60%</td>
</tr>
<tr>
<td>3 Air-conditioning design (Reduction in heat load)</td>
<td>300 sqft per TR</td>
<td>750 sqft per TR</td>
<td>60%</td>
</tr>
<tr>
<td>4 Total building electrical design</td>
<td>8 W/sqft</td>
<td>3.5 W/sqft</td>
<td>56%</td>
</tr>
</tbody>
</table>
# Benefit of efficient design on capital and operating cost

Electrical infrastructure required for 10 lac sqft building

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>System Description</th>
<th>Units</th>
<th>Standard design</th>
<th>Efficient design</th>
<th>Cost savings in INR Crores</th>
<th>Cost savings in INR/sqft</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Total electrical demand</td>
<td>Mega Watt (MW)</td>
<td>8</td>
<td>3.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>02</td>
<td>Total cost of Transformer, DG, HVAC and electrical system</td>
<td>Crores</td>
<td>85 cr.</td>
<td>60 cr.</td>
<td>25 cr.</td>
<td>250</td>
</tr>
<tr>
<td>03</td>
<td>Annual energy consumption (@ INR 6 /kWh)</td>
<td>Crores</td>
<td>14 cr./annum</td>
<td>4.5 cr. /annum</td>
<td>9.5 cr. /annum</td>
<td>95/annum</td>
</tr>
</tbody>
</table>


Approach to super efficient buildings

Step 1 • Performance based integrated design
Step 2 • Selection of efficient systems and equipments
Step 3 • Adequate automation and metering
Step 4 • Continuous monitoring to ensure performance
Step 5 • Feedback for new building design
Integrated goal oriented design process

**HVAC Goal**
- Max envelope heat gain – 0.75 W/ft²
- Total building @ 750 to 1000 sqft/TR
- 25 deg C, 55% RH

**Lighting Goal**
- Lighting power density of 0.45 W/ft²
- 90% of building to be day lit
- No glare throughout the year

**Water Goal**
- 15 LPD fresh water for office building
- Zero discharge
- 100% self sufficient

**Team Members**
- Architects
- Facade Specialists
- IT Specialists
- HVAC Engineers
- Lighting Specialists
- PHE Engineers
- Architects
- Facade Specialists
- Lighting Specialists
- Electrical Designers
- Landscape Architects
Optimization strategy

Results in ‘4x’ reduction in air conditioning energy
Inefficient building design
Inefficient building design
Inefficient building design
Inefficient building design
Light shelves allow daylight to penetrate deeper into the buildings

Mysore SDB 5 building with above strategies

Bright day light without glare at SDB-5 Mysore
Building shape and orientation

- Passive design: Right orientation - Restricted building span to 18 m

Window-wall ratio < 30%
Efficient window design
Efficient window design

To take daylight deeper into floors

Light shelves for deeper penetration of day light
Maximize natural light and views
Efficient building envelope

SDB-1, Infosys Hyderabad campus
Efficient building envelope

SDB-6, Infosys Mysore campus

West façade with no windows
Efficient building envelope

SDB-4 & 5,
Infosys Hyderabad campus
Cool roofs for all buildings

- 2.6 million sqft area covered with white roof
- About 5% reduction in HVAC energy

Reduces building heat gain and urban heat island effect
Artificial Lighting system and controls

2X reduction in the installed lighting load

~3X reduction in lighting energy consumption
Efficient HVAC system - Radiant cooling

- Requires 75% less air compared to conventional systems
- 30% more efficient than conventional HVAC systems
- Higher thermal comfort on account of better mean radiant temperature
- Highest indoor air quality
- Radiant system equipment requires lesser space
Radiant cooling
Radiant cooling - results

### Energy Reports

#### Energy Consumption - Conventional Building

<table>
<thead>
<tr>
<th>Device Type</th>
<th>Current KW</th>
<th>Today (KWH)</th>
<th>Previous Day (KWH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>7.8</td>
<td>64.5</td>
<td>321.2</td>
</tr>
<tr>
<td>Raw Power</td>
<td>23.6</td>
<td>376.7</td>
<td>731.9</td>
</tr>
<tr>
<td>UPS</td>
<td>87.4</td>
<td>694.6</td>
<td>1502.6</td>
</tr>
<tr>
<td>HVAC</td>
<td>118.1</td>
<td>770.6</td>
<td>1690.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>237.1</strong></td>
<td><strong>1926.8</strong></td>
<td><strong>4646.1</strong></td>
</tr>
</tbody>
</table>

#### Energy Consumption - Radiant Building

<table>
<thead>
<tr>
<th>Device Type</th>
<th>Current KW</th>
<th>Today (KWH)</th>
<th>Previous Day (KWH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>11.7</td>
<td>158.5</td>
<td>295.9</td>
</tr>
<tr>
<td>Raw Power</td>
<td>38.4</td>
<td>446.7</td>
<td>925.2</td>
</tr>
<tr>
<td>UPS</td>
<td>97.5</td>
<td>661.8</td>
<td>1283.9</td>
</tr>
<tr>
<td>HVAC</td>
<td>75.3</td>
<td>537.8</td>
<td>790.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>223.2</strong></td>
<td><strong>1507.4</strong></td>
<td><strong>3285.2</strong></td>
</tr>
</tbody>
</table>

### Savings - Radiant Cooling

<table>
<thead>
<tr>
<th>Component</th>
<th>Conventional</th>
<th>Radiant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>KW Savings in % - Current</strong></td>
<td>36.26</td>
<td>36.26</td>
</tr>
<tr>
<td><strong>KW Savings in % - Today</strong></td>
<td>36.29</td>
<td>36.29</td>
</tr>
<tr>
<td><strong>KW Savings in % - Prev Day</strong></td>
<td>63.25</td>
<td>63.25</td>
</tr>
</tbody>
</table>

### AHU KW/TR

<table>
<thead>
<tr>
<th>Component</th>
<th>Conventional</th>
<th>Radiant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>0.25</strong></td>
<td><strong>0.20</strong></td>
<td><strong>0.20</strong></td>
</tr>
</tbody>
</table>
Efficient equipment configuration

Chillers in series-counter flow arrangement

- Cooling is achieved in 2 smaller steps instead of 1 big step
- 7% more efficient than regular chillers arrangement

One big step  2 small steps

Standard arrangement

Series counter arrangement
Efficient equipment

Chillers with magnetic bearings

- Magnetic levitation
- Very low friction
- No oil required

8 % higher efficiency than regular chillers
Data center Efficiency

PUE: 2.5

<table>
<thead>
<tr>
<th>Operating temperature</th>
<th>24 °C</th>
<th>25 °C</th>
<th>26 °C</th>
<th>27 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUE</td>
<td>1.13</td>
<td>1.11</td>
<td>1.09</td>
<td>1.08</td>
</tr>
</tbody>
</table>

PUE: 1.13
Re-engineered chiller plants

OLD

NEW
Retrofits – Air conditioning

13.5 MW reduction in connected load for HVAC systems

- Carried out deep retrofits for 31 chiller plants
- Reduced total chiller plants from 54 to 41 plants
Retrofits – UPS

Replaced stand alone UPS with high efficiency modular UPS

10 MW reduction in connected load
Continuous monitoring at granular level
Continuous monitoring at granular level

Intelligent building system monitors number of lights, fans and computers working on every wing in the building. Data from existing buildings used to better design future buildings.
## Continuous M & V – Design Vs Actual

<table>
<thead>
<tr>
<th>Floor</th>
<th>Design Kw</th>
<th>Design Kw/Tr</th>
<th>Actual Kw</th>
<th>%</th>
<th>Actual kwh/Tr.</th>
<th>Kwh Today</th>
<th>% Today</th>
<th>Kwh Y Day</th>
<th>Kwh MTD</th>
<th>Mwh YTD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiller - 1</td>
<td>252.0</td>
<td>0.48</td>
<td>0.7</td>
<td>0</td>
<td>0.00</td>
<td>97</td>
<td>3</td>
<td>1852</td>
<td>10182</td>
<td>27.70</td>
</tr>
<tr>
<td>Chiller - 2</td>
<td>271.0</td>
<td>0.61</td>
<td>122.0</td>
<td>45</td>
<td>0.66</td>
<td>1403</td>
<td>38</td>
<td>18</td>
<td>29676</td>
<td>31.64</td>
</tr>
<tr>
<td>LT CHW Pumps</td>
<td>44.0</td>
<td>0.04</td>
<td>8.9</td>
<td>3</td>
<td>0.04</td>
<td>201</td>
<td>5</td>
<td>313</td>
<td>4886</td>
<td>8.10</td>
</tr>
<tr>
<td>MT CHW Pumps</td>
<td>60.0</td>
<td>0.10</td>
<td>41.1</td>
<td>15</td>
<td>0.18</td>
<td>714</td>
<td>19</td>
<td>792</td>
<td>17286</td>
<td>48.73</td>
</tr>
<tr>
<td>CDW Pumps</td>
<td>60.0</td>
<td>0.06</td>
<td>15.0</td>
<td>5</td>
<td>0.06</td>
<td>231</td>
<td>6</td>
<td>292</td>
<td>4293</td>
<td>5.72</td>
</tr>
<tr>
<td>Cooling Towers</td>
<td>60.0</td>
<td>0.06</td>
<td>0.0</td>
<td>0</td>
<td>0.00</td>
<td>21</td>
<td>1</td>
<td>31</td>
<td>1364</td>
<td>2.79</td>
</tr>
<tr>
<td>DOAS's</td>
<td>74.0</td>
<td>0.14</td>
<td>51.8</td>
<td>19</td>
<td>0.00</td>
<td>699</td>
<td>19</td>
<td>1097</td>
<td>18213</td>
<td>81.75</td>
</tr>
<tr>
<td>HRW's</td>
<td>18.5</td>
<td>0.04</td>
<td>15.9</td>
<td>6</td>
<td>0.00</td>
<td>284</td>
<td>0</td>
<td>352</td>
<td>7504</td>
<td>29.13</td>
</tr>
<tr>
<td>Exhaust &amp; Vent. Fans</td>
<td>14.7</td>
<td>0.03</td>
<td>17.6</td>
<td>6</td>
<td>0.00</td>
<td>338</td>
<td>9</td>
<td>351</td>
<td>7510</td>
<td>33.45</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>273.5</strong></td>
<td><strong>100</strong></td>
<td><strong>3720</strong></td>
<td><strong>100</strong></td>
<td><strong>5098</strong></td>
<td><strong>100814</strong></td>
<td><strong>359.68</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**HVAC COMFORT**

- Constant monitoring to get design efficiencies
Provides data to optimize future building designs

<table>
<thead>
<tr>
<th>Equipments</th>
<th>Inst. watt / Sqft</th>
<th>Current Year Peak Value</th>
<th>Current Year Peak Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVAC - High Side</td>
<td>0.03</td>
<td>1.16</td>
<td>7:39 AM 4/9/2012</td>
</tr>
<tr>
<td>HVAC - Low Side</td>
<td>0.04</td>
<td>0.30</td>
<td>8:05 AM 3/10/2012</td>
</tr>
<tr>
<td>HVAC - CRITICAL</td>
<td>0.07</td>
<td>0.22</td>
<td>6:10 PM 28/10/2012</td>
</tr>
<tr>
<td>Lighting</td>
<td>0.13</td>
<td>0.20</td>
<td>6:37 PM 6/11/2012</td>
</tr>
<tr>
<td>Fans</td>
<td>0.03</td>
<td>0.05</td>
<td>10:13 AM 7/8/2012</td>
</tr>
<tr>
<td>Raw Power</td>
<td>0.04</td>
<td>0.12</td>
<td>6:06 PM 27/10/2012</td>
</tr>
<tr>
<td>UPS - Work Station</td>
<td>0.56</td>
<td>0.70</td>
<td>3:16 PM 25/9/2012</td>
</tr>
<tr>
<td>UPS - Server</td>
<td>0.03</td>
<td>0.04</td>
<td>9:49 AM 16/11/2012</td>
</tr>
<tr>
<td>Misc.</td>
<td>0.00</td>
<td>0.85</td>
<td>1:45 PM 11/10/2012</td>
</tr>
<tr>
<td>Total</td>
<td>0.95</td>
<td>2.32</td>
<td>12:32 PM 27/11/2012</td>
</tr>
<tr>
<td>SDB-2 Main Incomer</td>
<td>0.92</td>
<td>1.37</td>
<td>2:46 PM 29/11/2012</td>
</tr>
</tbody>
</table>
Chiller plant efficiency trend
Central Command Center for ensuring efficient operations

Command center at Infosys Bangalore to monitor, manage and optimize resources usage
Data is important

• For ensuring long term performance
• For evaluating/deploying new technologies
• For improving new designs
• To know the reality!
Thank You

Guruprakash_Sastry@infosys.com