SIXTH SHADE

Measurable means to achieve impeccable built environment
Earth lights at night
Our Population

Source: http://www-personal.umich.edu/~mejn/cartograms/population1024x512.png
Our Gross Domestic Product
Our Child Mortality

Source: http://www-personal.umich.edu/~mejn/cartograms/population1024x512.png
Our Total Spending on Health care

Source: http://www-personal.umich.edu/~mejn/cartograms/population1024x512.png
Our Energy Consumption

Source: http://www-personal.umich.edu/~mejn/cartograms/population1024x512.png
Our Green House Gas Emission

Source: http://www-personal.umich.edu/~mejn/cartograms/population1024x512.png
Move Up
But
Without Moving to
Right Side

Access to Energy and Human Development Index

Source: http://www.interacademycouncil.net/CMS/Reports/11840/11901/11907.aspx

11 December 2012, Rajan Rawal at GRIHA, Bangalore
Buildings and Cities provide shelter, facilitate our activities & interactions, and represent our desires and provide cultural expression.
70% of the India of 2030 is yet to be built.

Electricity Demand exceeds available supply.

Commercial buildings accounts for about 8% of the total electricity supplied by utilities - growing annually at about 11-12% - resulting to peak shortages of about 8.3% and 12.3%.

Source: Rajan Rawal

11 December 2012, Rajan Rawal at GRIHA, Bangalore
Pace versus Speed ........
5 Elements

How do we use them favorably?
5 Senses

How do we use them effectively?
IMAGINE

CONCEPTUALIZE

MATERIALIZE

OPERATE

DESTROY

5 Senses

How do we measure their impact?
MEASURE

Material
Cost
Time
Structural strength
Water – Sanitation

ENERGY ? (Can not rely only on common sense approach)

11 December 2012, Rajan Rawal at GRIHA, Bangalore
6th Shade

NOT ONLY INTUTION BUT SCIENTIFIC PREDICTION

EXPERIMENT – LEARN – DOCUMENT – DISSEMINATE - INGRAINED
“A great building must begin with the unmeasurable, must go through measurable means when it is being designed and in the end must be unmeasurable.”

Source: thinkexist.com/quotation/a_great_building_must_begin_with_the_unmeasurable/213937.html
Centre for Advanced Studies in Building Science and Energy
CEPT University, Ahmedabad
(Centre for Building Energy Efficiency – USAID)
(Centre for Solar passive Architecture and Green Building Technologies – Govt. of India)
(Centre for Building Energy Research and Development in collaboration with LBNL)

Building Design & Simulation

Building Material & Component Characterization

Building Policy Research
Snapshot of Work
250 Building Material Characterized


Online Calculator

Coupling with EPI tool of BEE

Construction Material Database: Material Characterization : Wall - Roof
Construction Material Database: Material Characterization : Fenestration

U-VALUE

SHGC

VLT

FIXED WINDOW
CASEMENT WINDOW
SLIDING WINDOW

ECBC RECOMMENDED: 0.27 Min.
ECBC RECOMMENDED: 0.25 Max.
ECBC RECOMMENDED: 3.3.
Technical inputs for ECBC Implementation

Bundles of ECBC Requirements

Source: CEPT-The Weidt Group Study
## Technical inputs for ECBC Implementation

### Savings Patterns

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<th>Kwh/m²</th>
<th>0</th>
<th>25</th>
<th>50</th>
<th>75</th>
<th>100</th>
<th>125</th>
<th>150</th>
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<td>Windows Comp, Hot-Dry, Warm-Humid</td>
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<td>Windows Cold</td>
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<td>Packaged AC, Air-cooled</td>
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<td>Packaged AC, Water-cooled</td>
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<td>Pumps, Motors</td>
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</tbody>
</table>

Source: CEPT-The Weidt Group Study
Technical inputs for Building laws for Gandhinagar for Tree Plantation

Impact of Vegetation on Ambient Air Temperature

Case 1 (Plot plantation)  Case 2 (Plot plantation)  Case 3 (Road plantation)  Case 4 (Road plantation)

Case 5 (Combination plantation)  Case 6 (Combination plantation)  Case 7 (Combination plantation)  Case 8 (Combination plantation)
Technical inputs for **Town Planning Scheme for Gujarat**

<table>
<thead>
<tr>
<th>Street Hierarchy</th>
<th>Obstruction angle 50°, H/W ratio 1.2</th>
<th>Obstruction angle 60°, H/W ratio 1.7</th>
<th>Obstruction angle 70°, H/W ratio 2.6</th>
<th>Obstruction angle 80°, H/W ratio 5.7</th>
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<td>N-S</td>
<td>74% shaded</td>
<td>81% shaded</td>
<td>87% shaded</td>
<td>94% shaded</td>
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<tr>
<td>E-W</td>
<td>52% shaded</td>
<td>61% shaded</td>
<td>71% shaded</td>
<td>82% shaded</td>
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<tr>
<td>NW-SE</td>
<td>68% shaded</td>
<td>76% shaded</td>
<td>84% shaded</td>
<td>93% shaded</td>
</tr>
</tbody>
</table>

Source: Kanika Agrawal, CEPT University

### Incident Solar radiation received on street

11 December 2012, Rajan Rawal at GRIHA, Bangalore
Technical inputs for Town Planning Scheme for Gujarat

Design development – Mutual Shading Shade and radiation analysis: Resultant built mass models Diagrammatic representation

Source: Kanika Agrawal, CEPT University
Understanding Vernacular Architecture: Window Configurations

Source: Mihir Vakharia, CEPT University
Understanding Vernacular Architecture: Daylight Performance of Trellis: Lattice ‘Jali’

Source: Dharmesh Gandhi, CEPT University
Adaptive Thermal Comfort Model for India: On Going Work

ASHRAE 55 Adaptive thermal comfort model

Five Climate Zone

Air-conditioned – Mixed Mode and Naturally ventilated Buildings

Winter – Summer – Monsoon

Indian benchmark - International Benchmark

9000 Occupants across five climate zones
Near Net Zero Energy Building

A Living Laboratory
Net / Near Zero Energy Building – A Living Laboratory
ASHRAE 55 thermal comfort based on the mean monthly temperature for Ahmedabad, India

Source: Built Ecology,
Net / Near Zero Energy Building – A Living Laboratory

Daylighting Parameters Cloud Cover

Direct Solar Radiation

Sunpath Diagram

Source: ECOIII, The Weidt group, CEPT University
Net / Near Zero Energy Building – A Living Laboratory
Sun Control Analysis South Facing Clerestory

**Base Case**
No light shelf (70 deg cut-off)

**Option 1**
500 light shelf (39 deg cut-off)

**Option 2**
800 light shelf (30 deg cut-off)

Source: ECOIII, The Weidt group, CEPT University
Net / Near Zero Energy Building – A Living Laboratory

Illuminance of floor plan under clear sky Basement level

With 67% VT on East & West

Reduced VT helps reduce high contrast/glare near windows

With 33% VT on East & West

Source: ECOIII, The Weidt group, CEPT University
Net / Near Zero Energy Building – A Living Laboratory

Continuous Daylight Autonomy (300 lux) on Work Plane Basement level

Reduced VLT decreases DA by about 10% throughout

Source: ECOIII, The Weidt group, CEPT University
Reduced VLT increases UDI(<100) by about 6% throughout

Source: ECOIII, The Weidt group, CEPT University
Net / Near Zero Energy Building – A Living Laboratory

Useful Daylight Index (>2000) on Work Plane Basement level

Reduced VT reduced UDI (>2000) by UP TO 30%!

Source: ECOIII, The Weidt group, CEPT University
Net / Near Zero Energy Building – A Living Laboratory

Luminance views under clear sky I Floor

With glass partition wall

With opaque partition wall

Source: ECOIII, The Weidt group, CEPT University

11 December 2012, Rajan Rawal at GRIHA, Bangalore
Net / Near Zero Energy Building – A Living Laboratory
Integrated Disciplines: Progress Images

Source: London Info, CEPT University
Net / Near Zero Energy Building – A Living Laboratory
Integrated Disciplines: Progress Images

Source: London Info, CEPT University
Net / Near Zero Energy Building – A Living Laboratory

Thermal Comfort Analysis: Velocity Contours

Velocity Contours: at 0.5 meter height

Velocity Contours: at 1.2 meter height

Source: Mecharts, & CEPT University
Thermal Comfort Analysis: Predicted mean Vote and Percentage People Dissatisfied

PMV at 1.0 meter height

PPD at 1.0 meter height

Source: Mecharts, & CEPT University
When you can measure what you are speaking about, and express it in numbers, you know something about it, but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind.

**Lord William Thomson Kelvin**
THANK YOU

rajanrawal@cept.ac.in