Sustainable Architecture in California

Meeting the Urbanization Challenge
Smart City Solutions from Austria and California

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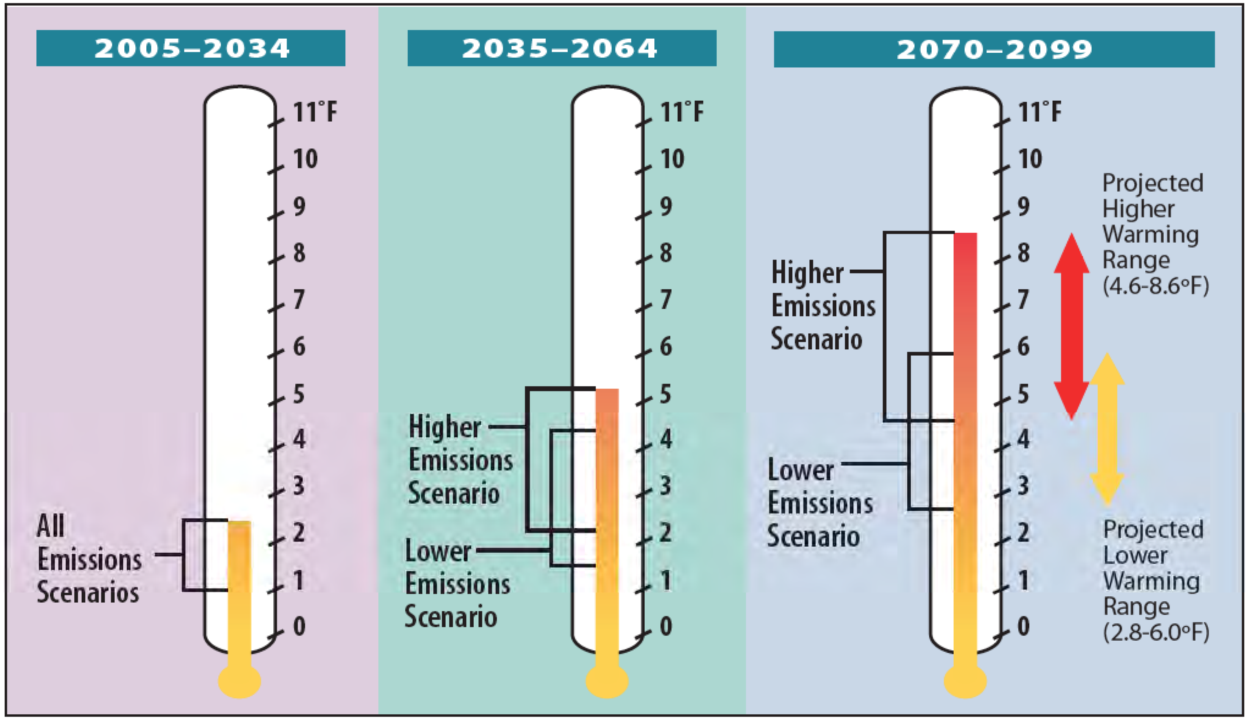
October 11, 2013, Los Angeles, CA

USC University of Southern California

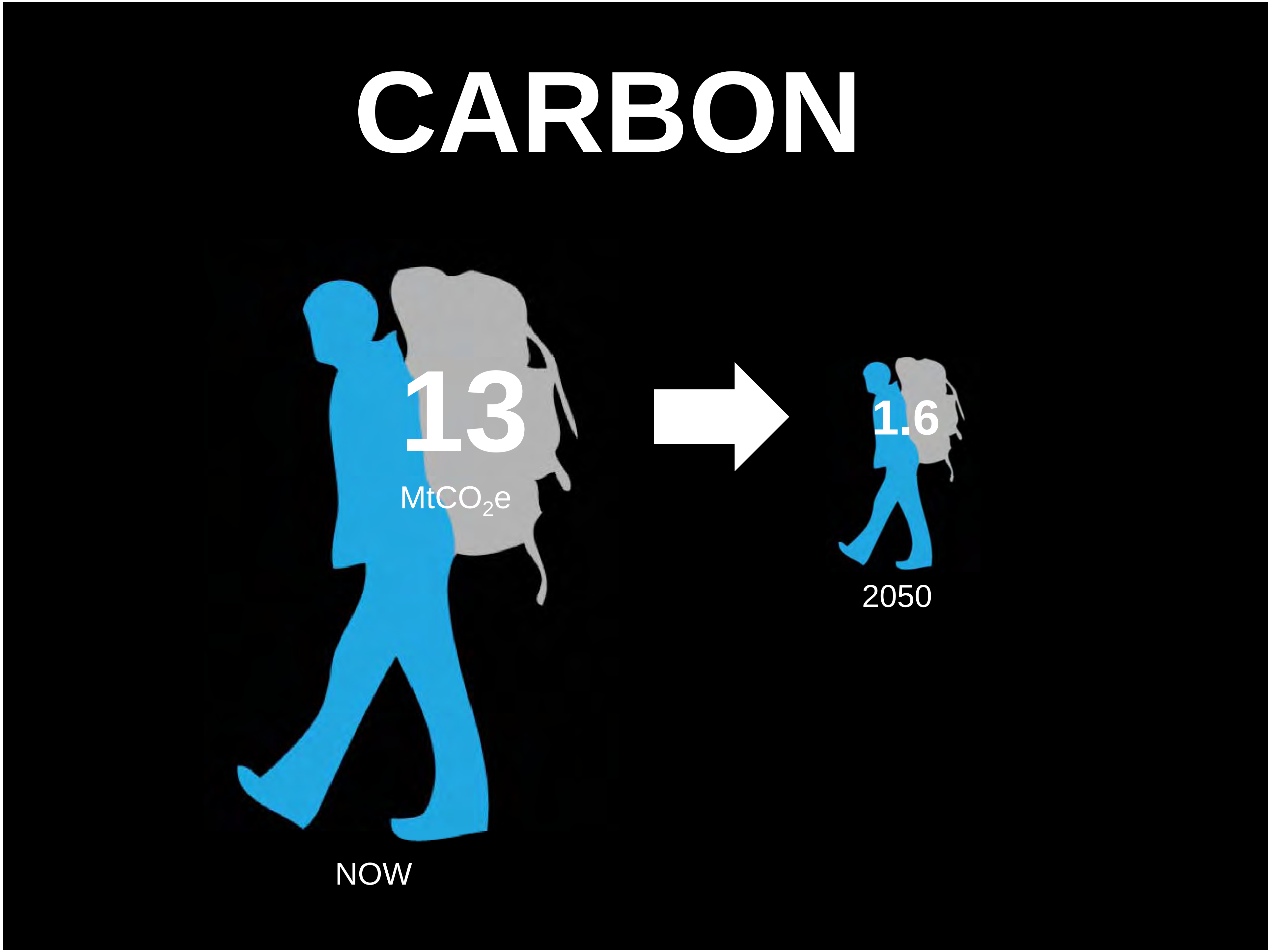

51 Million
2050
Currently ~37 Million
2x
Current Energy Demand

Projected Average Temperatures in California



California is expected to experience dramatically warmer temperatures during this century. The figure shows projected increases in statewide annual temperatures for three 30-year periods. Ranges for each emissions scenario represent results from state-of-the-art climate models.


60%
80%
“Cut global emissions by 60 to 80%
PCC 2007)


CARBON
13
MtCO2e
1.6
NOW
2050

BOLD

1. Reduce GHG emissi… 1990 levels)
2. Net Zero Residential by 2…
3. Net Zero commercial by **2030**…
4. Retrofit existing buildings to **80%**… ficient

WE ARE BUILDING DESIGNERS!

1. Buildings and Climate Systems
   - Global Warming, Urban heat island
2. Buildings and Transit Systems
   - Transit energy intensity
3. Buildings and Energy Systems
   - 77% of Electricity demand (+ Peak demand)
4. Buildings and Ecological Systems
   - Water, Childhood development, Biophilia, Biodiversity, Food
5. Buildings and Public Space
   - Connection, Comfort, Social engagement

“Net – Zero”
Energy used
Energy generated
Annual
ARCHITECTURE AT ZERO :: 2012

ENERGY

- Base load reduction
  - CA commercial buildings consume *67,077 GWh annually. Of this, interior lighting (29%), cooling (%15), and ventilation (12%) represent the largest, second-largest, and forth-largest loads respectively, and when combined amount to over half of all electricity consumed (56%).

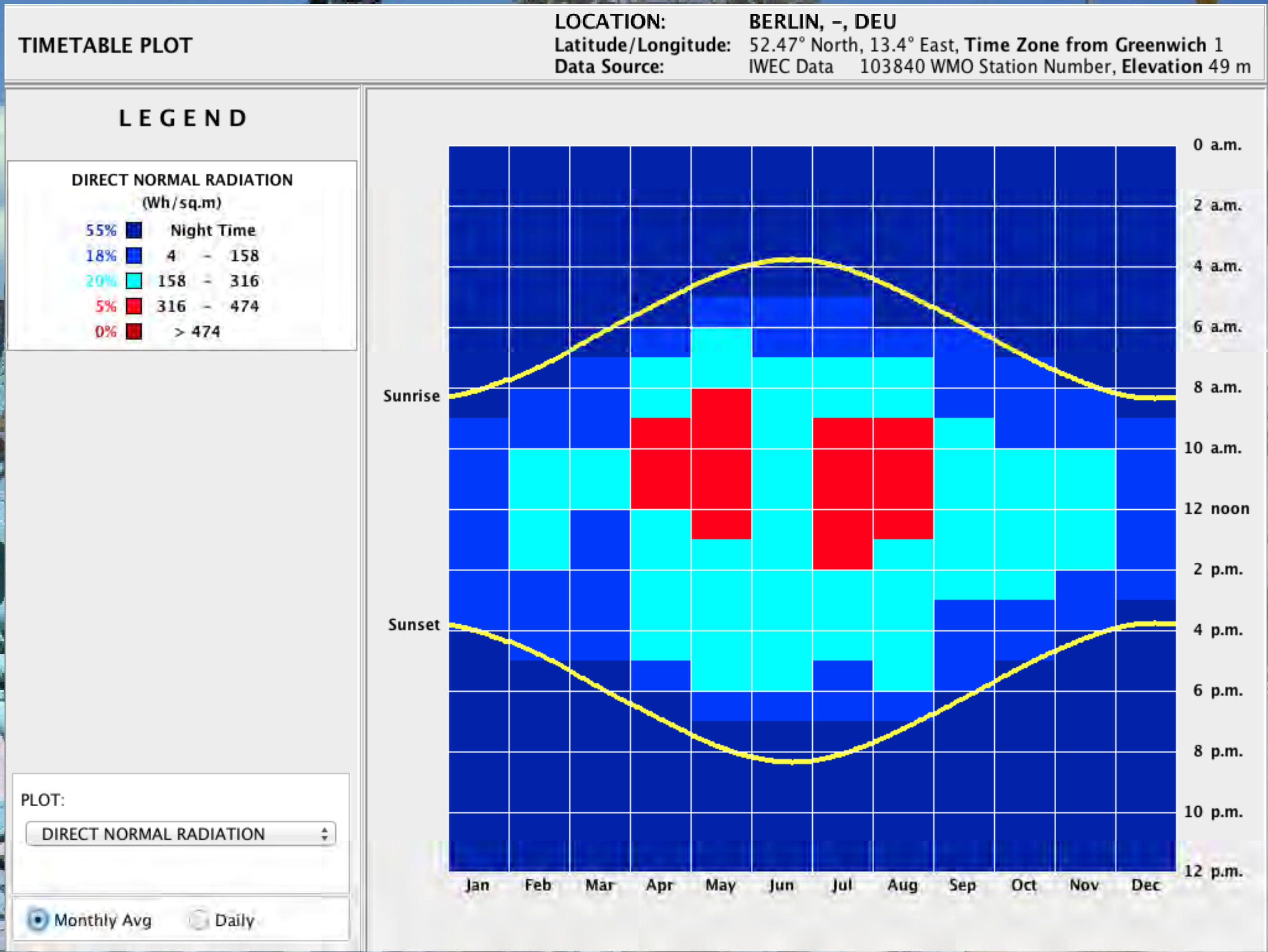
- Peak load reduction
  - Of the statewide peak load, the building sector accounts for about 73%.
  - California's highest peak demand was 52,863 megawatts and is growing at about 2.4 percent per year, roughly the equivalent of three new 500-megawatt power plants.

ENERGY

25% of national energy demand met with renewables

50% at peak production (+ weekend demand)

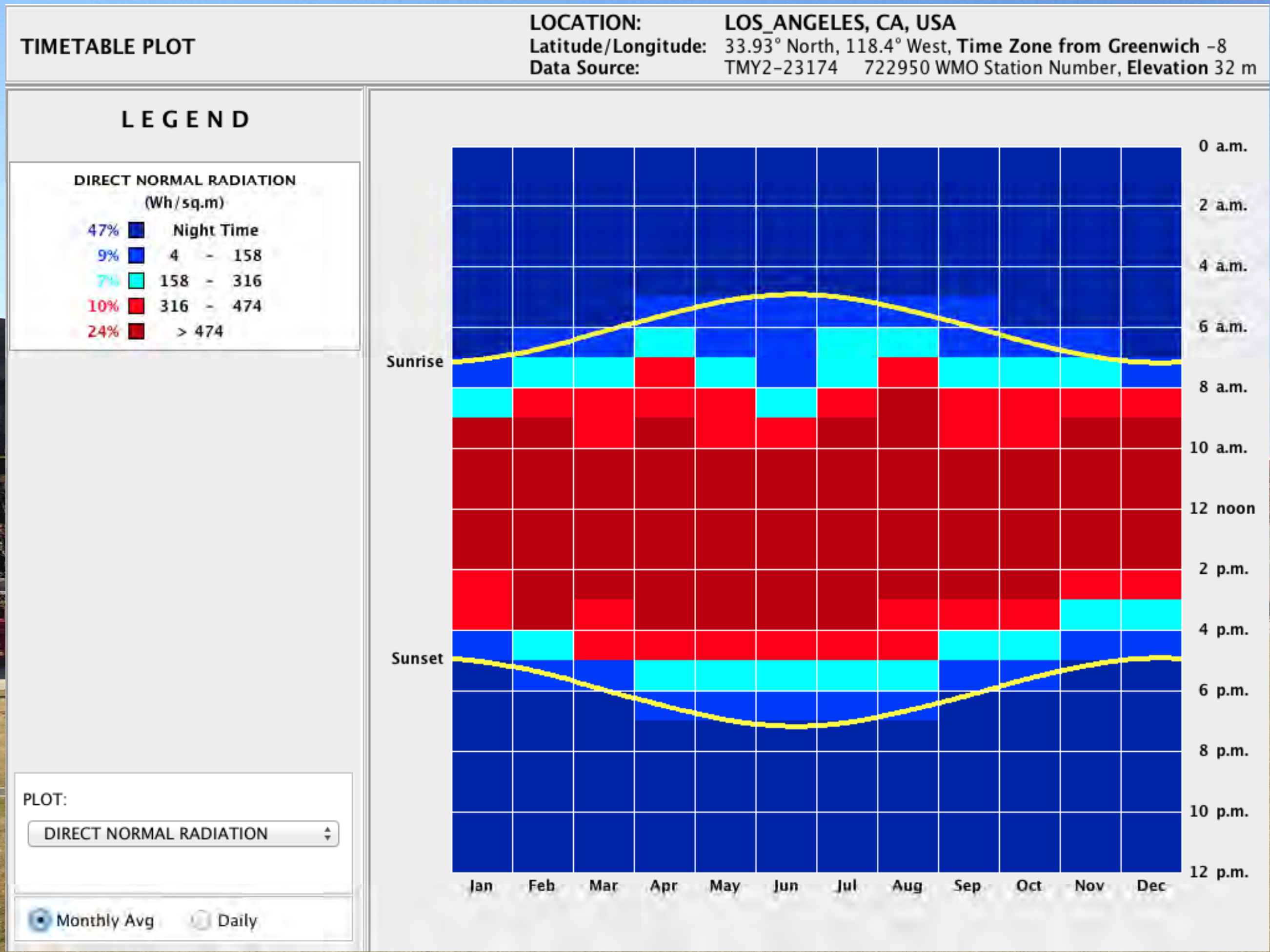
ENERGY



TIMETABLE PLOT
LOCATION: BERLIN, -, DEU
Latitude/Longitude: 52.47° North, 13.4° East, Time Zone from Greenwich 1
Data Source: IWEC Data 103840 WMO Station Number, Elevation 49 m
LEGEND
DIRECT NORMAL RADIATION
(Wh/sq.m)
55% Night Time
18% 4 - 158
20% 158 - 316
5% 316 - 474
0% > 474
PLOT:
DIRECT NORMAL RADIATION
Monthly Avg
Daily
Sunrise
Sunset
0 a.m.
2 a.m.
4 a.m.
6 a.m.
8 a.m.
10 a.m.
12 noon
2 p.m.
4 p.m.
6 p.m.
8 p.m.
10 p.m.
12 p.m.
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec


LOS ANGELES

LOS ANGELES


TIMETABLE PLOT
LOCATION: LOS_ANGELES, CA, USA
Latitude/Longitude: 33.93° North, 118.4° West, Time Zone from Greenwich -8
Data Source: TMY2-23174 722950 WMO Station Number, Elevation 32 m
LEGEND
DIRECT NORMAL RADIATION
(Wh/sq.m)
47% Night Time
9% 4 - 158
7% 158 - 316
10% 316 - 474
24% > 474
PLOT:
DIRECT NORMAL RADIATION
Monthly Avg
Daily
Sunrise
Sunset
0 a.m.
2 a.m.
4 a.m.
6 a.m.
8 a.m.
10 a.m.
12 noon
2 p.m.
4 p.m.
6 p.m.
8 p.m.
10 p.m.
12 p.m.
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

~29,000 MW PEAK Demand (within the ISO Grid)

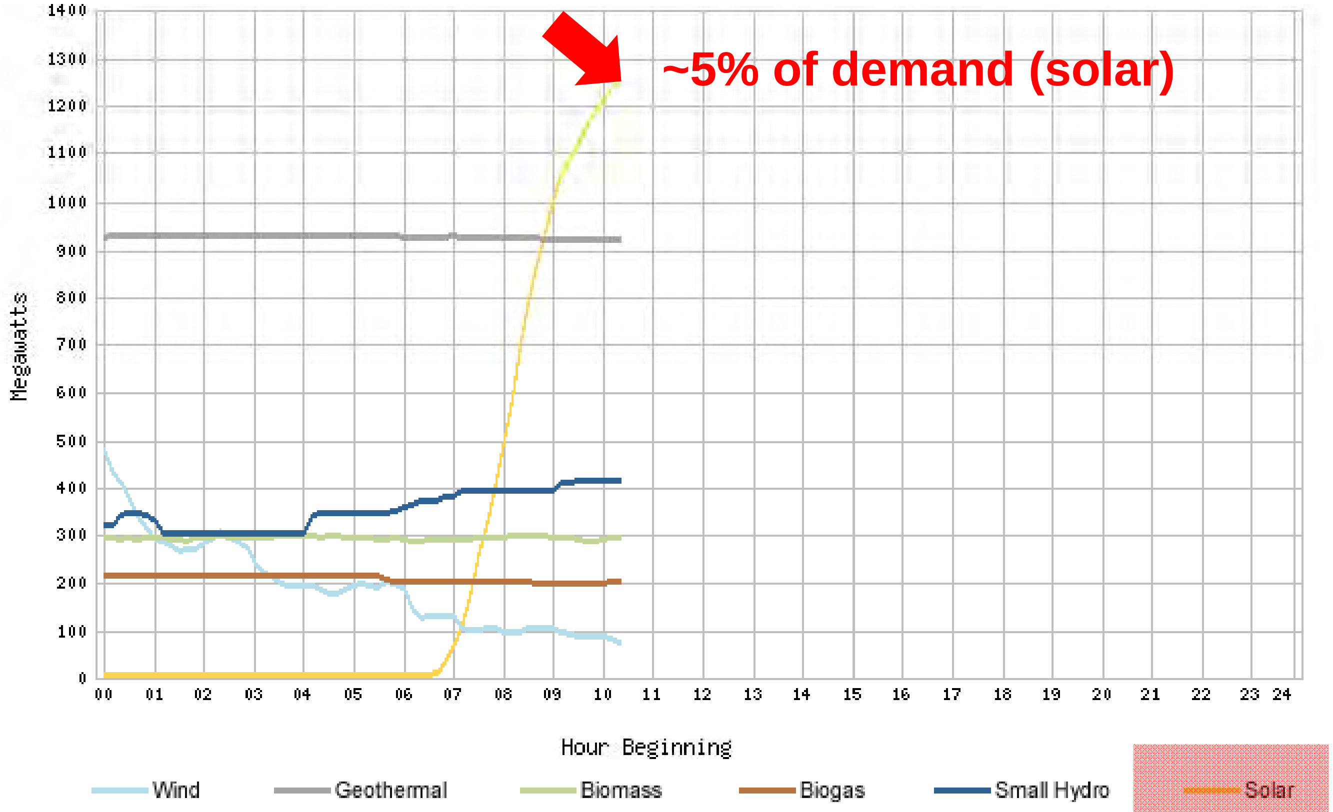
Renewables

Graph shows aggregated output from renewables connected to the ISO grid.

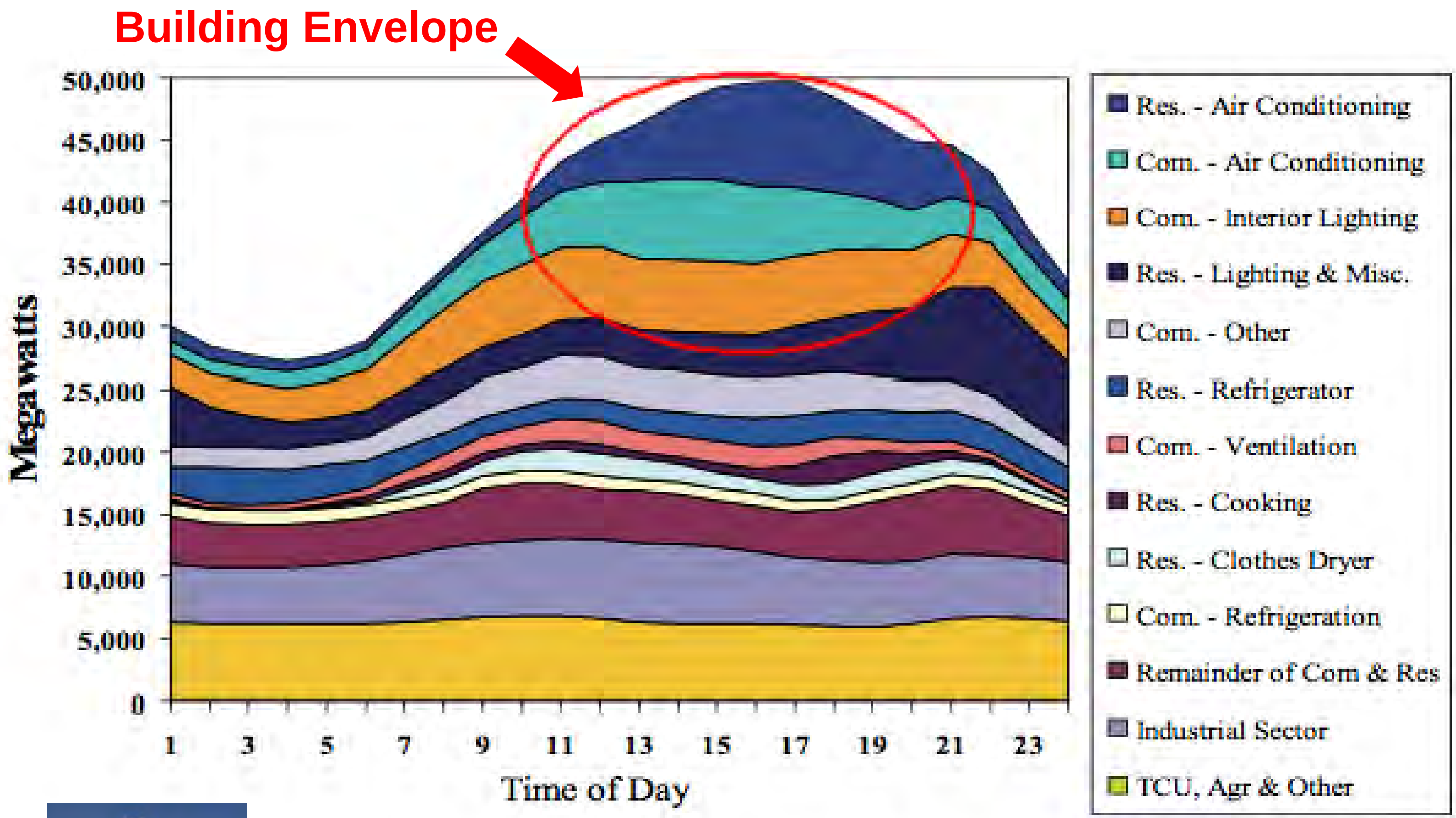
Current Renewables
3144.63 MW

Renewables Watch

The Renewables Watch provides actual renewable energy production within the ISO Grid.
Click here to view yesterday's output.



CA Electricity Demand Curve

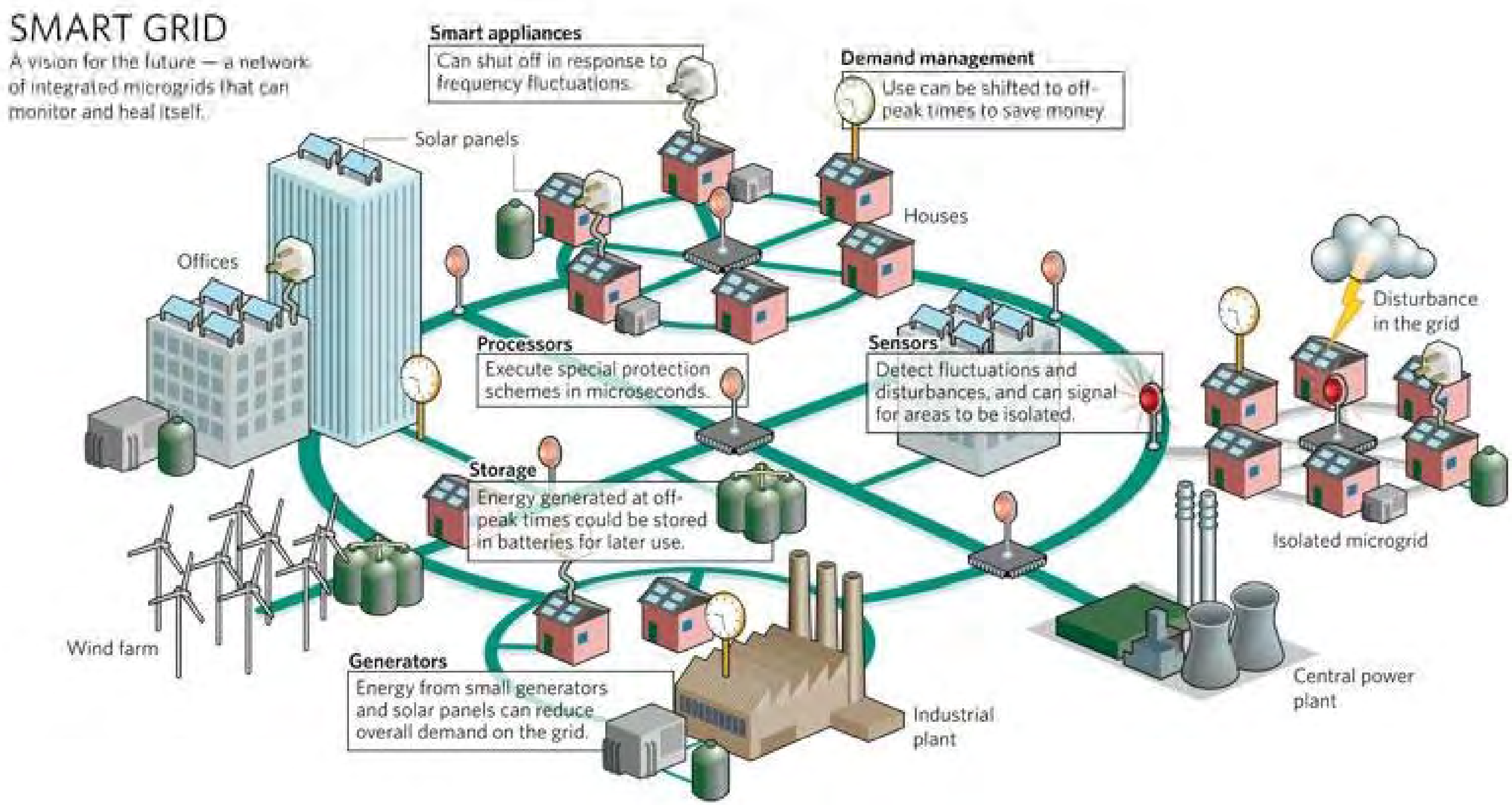


~=500 MW

Source: Pacific Gas and Electric (PG&E)

What is a Smart Grid?

Smart Grid describes advanced information-based utility technologies to improve reliability, security, and efficiency



Strategies for Solving the Problem

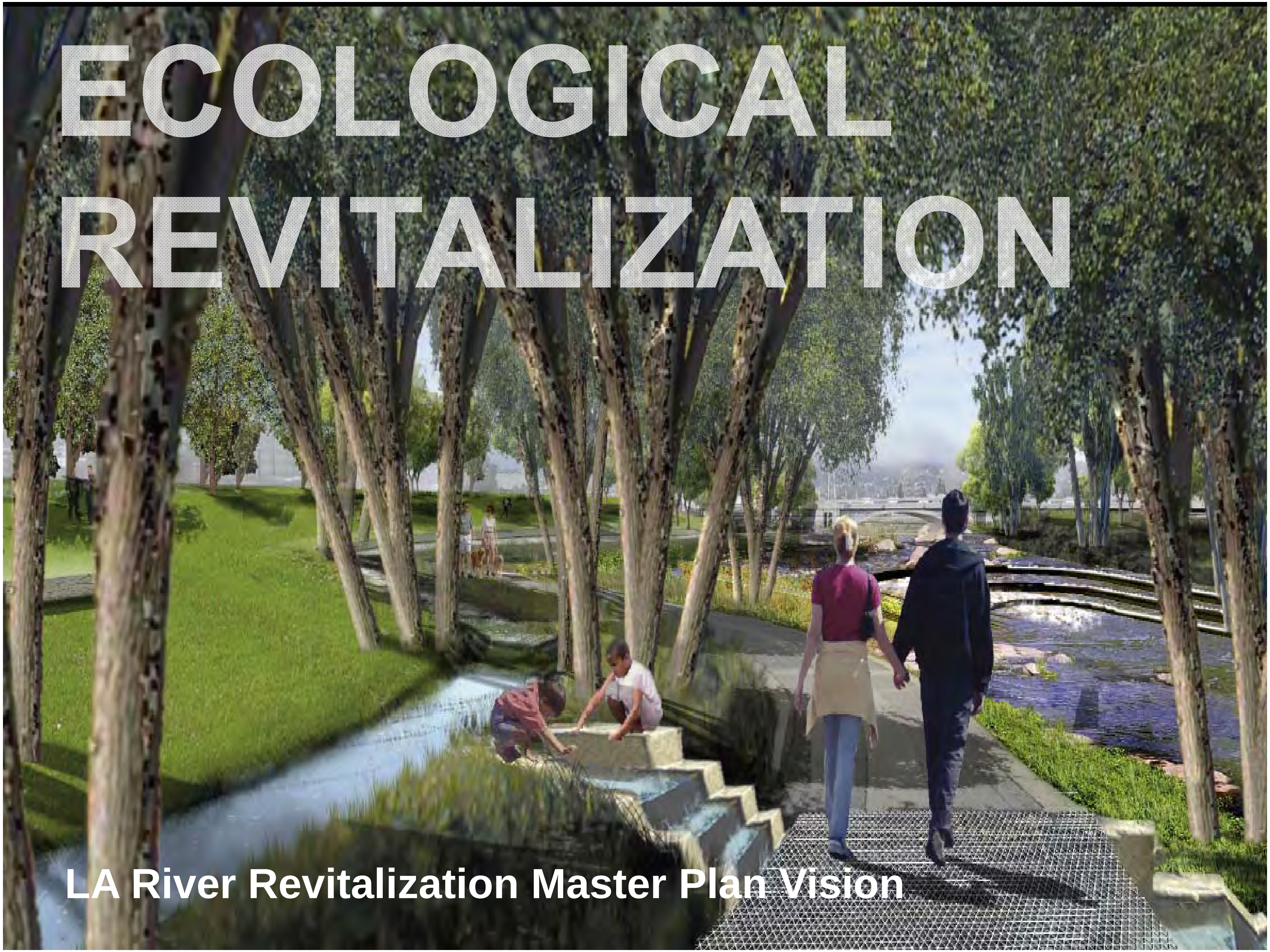
1. Manipulation of the thermal zone
   The California Energy Commission estimates a 1 to 3 percent energy savings for each degree the thermostat is set above 72°F.

2. Demand controlled ventilation
   Up to 20% cooling energy savings.

3. Appropriate electrical lighting intensity and scheduling in perimeter zones

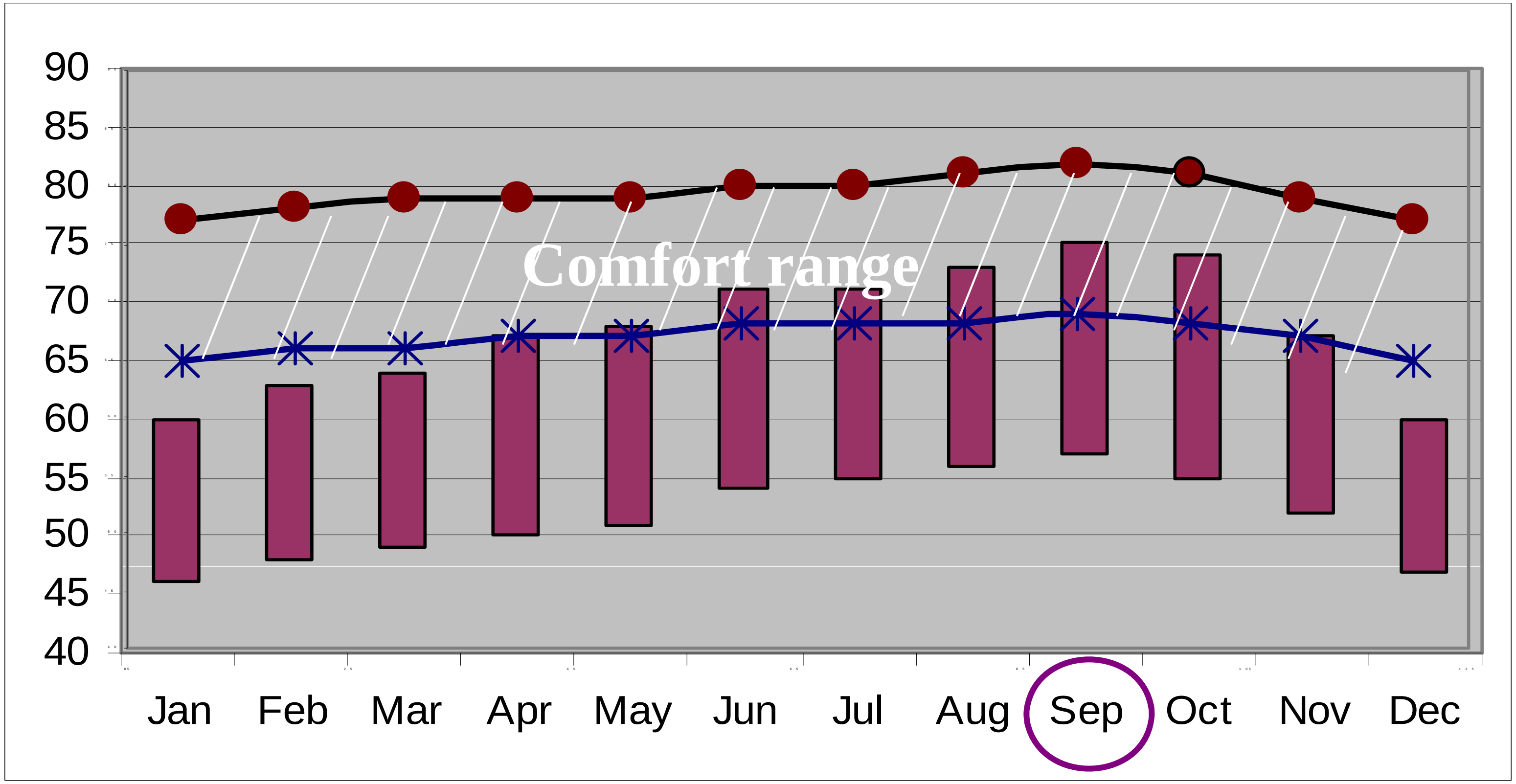

DE-SEALING

ECOLOGICAL REVITALIZATION

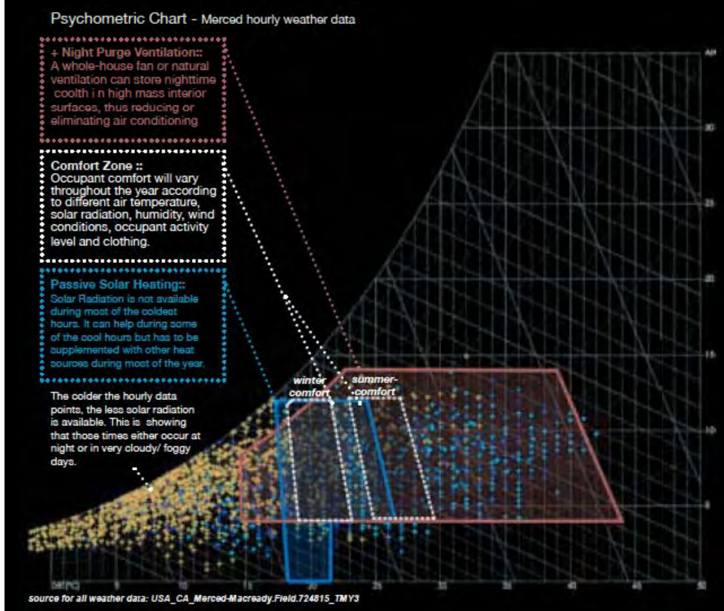


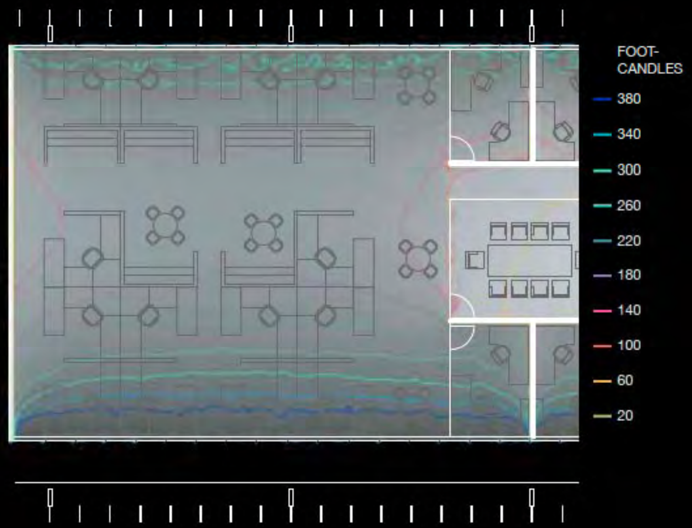
LA River Revitalization Master Plan Vision

Passive Cooling: SF Bay Climate

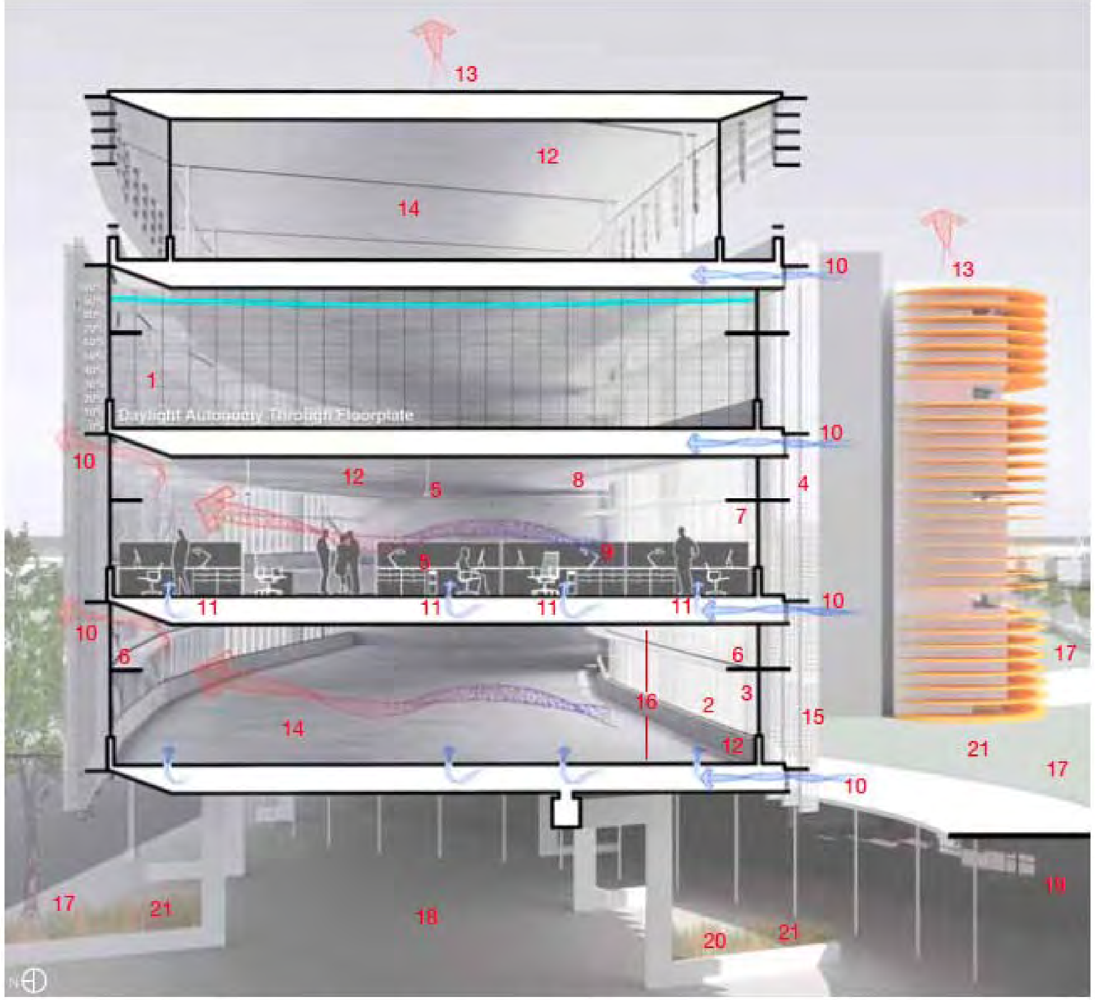


Need internal pickup of less than 7°F to stay within the target zone!





TYPICAL BAY WITH ISO-LUX ILLUMINANCE CONTOURS
1/16 = 1 -0 :: March 21 12:00pm, Clear Skies - *Radiance* Simulation



HIGH PERFORMANCE BUILDING

1. 82% Window-to-wall ratio and high ceilings yield 90% daylight autonomy
2. Spectrally selective glazing
3. Thermally broken frames
4. Exterior PV integrated shading fins
5. Lights and receptacles to use DC to avoid transformer losses
6. Light shelves
7. Interior glare control shades
8. Electric light daylight controls
9. Low wattage LED task lights

MIXED MODE CONDITIONING

10. Natural ventilation during swing seasons through operable windows or outdoor supply through floor plenum, exhaust through core and high windows
11. Personal environmental management at workstations
12. Radiant ceiling and perimeter for ambient heating and cooling
13. Naturally ventilated bathroom, stair cores, and central core

LONG-SPAN EXOSKELETON

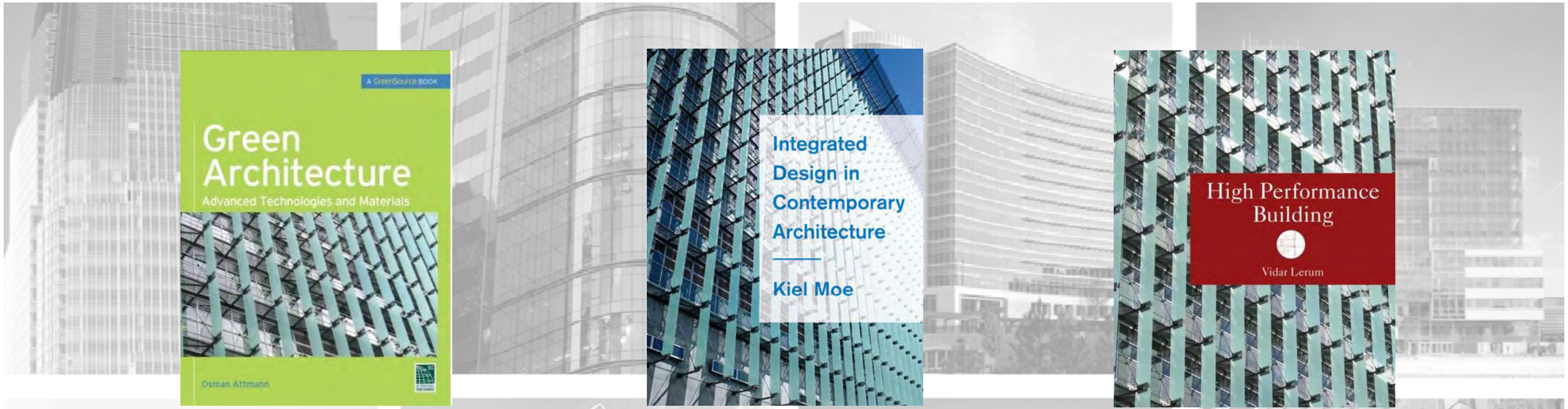
14. Column free space
15. Exterior fins supported by primary structure
16. 15' floor to floor heights

GROUND FLOOR

17. Fountains, green roof, and landscape pre-cool ambient air
18. Wide pedestrian plaza arcade provides shade and shelter at street edge
19. Deep overhang shades ground floor window walls along with strategic frit locations
20. Drought-tolerant landscaping
21. Graywater re-use for irrigation and fountains

Images: Loisos Ubbelohde

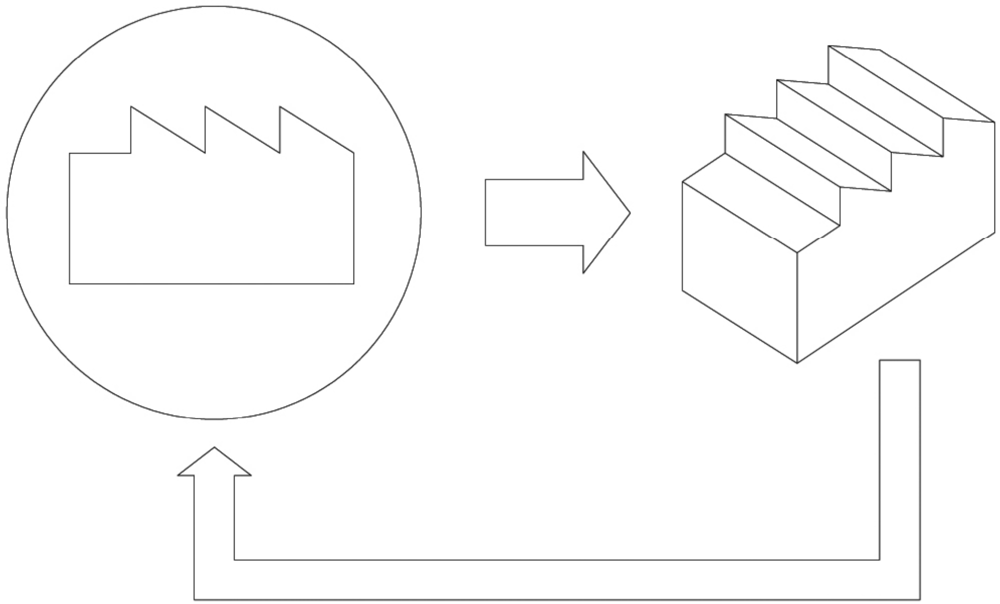

Green!
The New York Times



"Transparent skins provide access to daylight, and natural daylight is one of the leading drivers today of architectural design—green or otherwise."
(Environmental Building News, 2010)

"In our whole career, we are going to produce two dozen, three dozen buildings, we don't make that much effect on the world, but, if it's seen as a prototype, that spins off more kind-of ideas like that, then you realize that it actually has huge huge potential."
(Thom Mayne, Principal, Morphosis)


Smart?
The New York Times



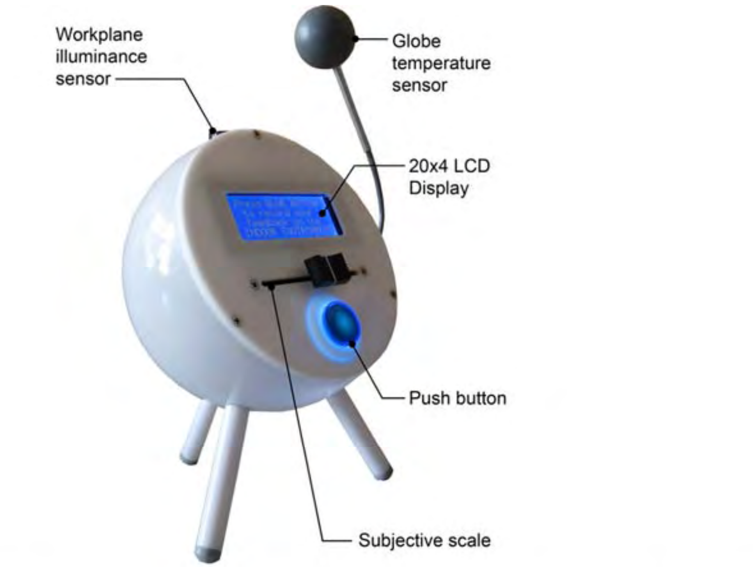
Feedback Loop

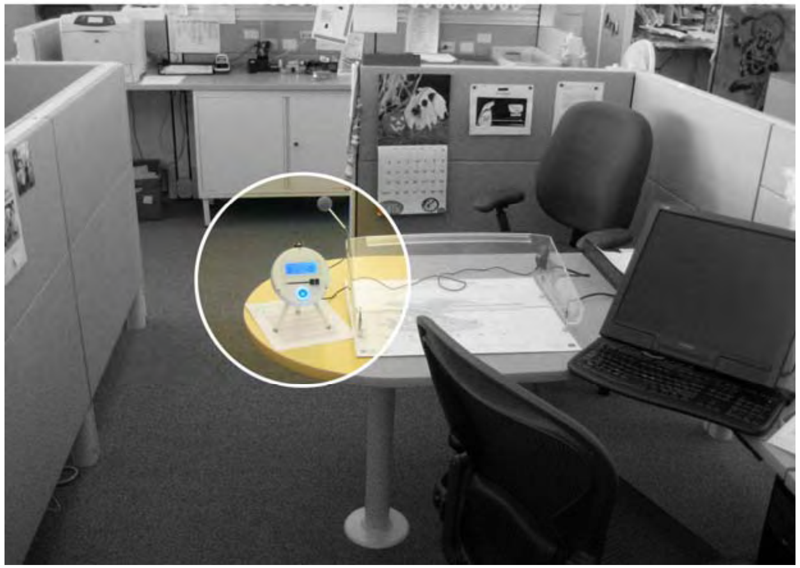
Energy

Comfort

Behavior

PROOF OF PERFORMANCE

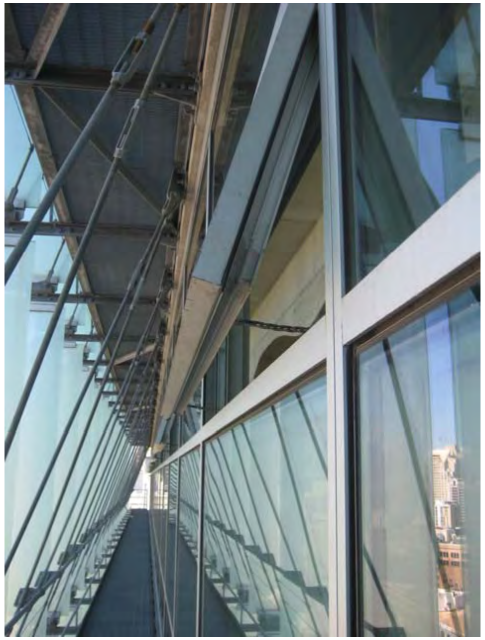


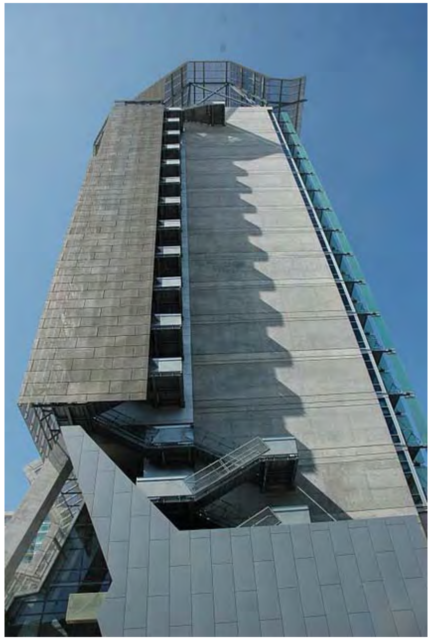


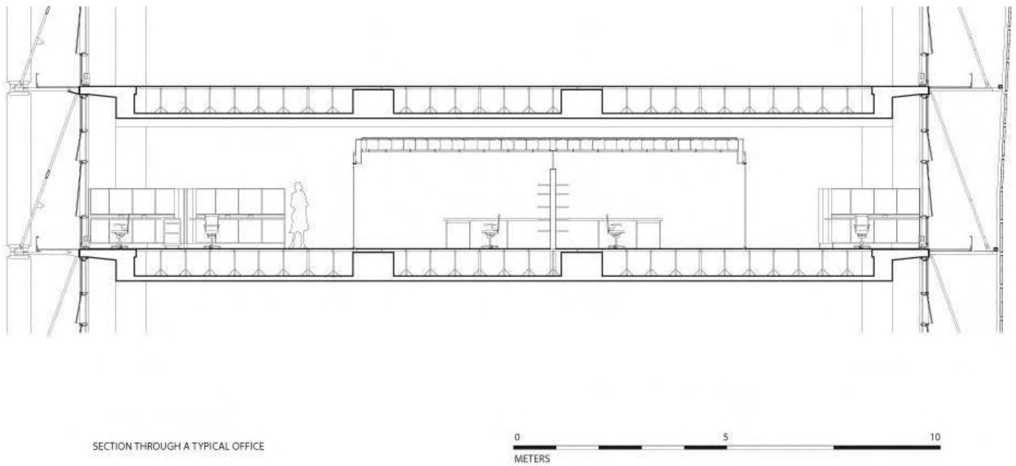
Push
Device responds to user at any time to record feedback

Pull
Device interrupts user to request feedback

Ambient
Device signals request for feedback without interrupting user

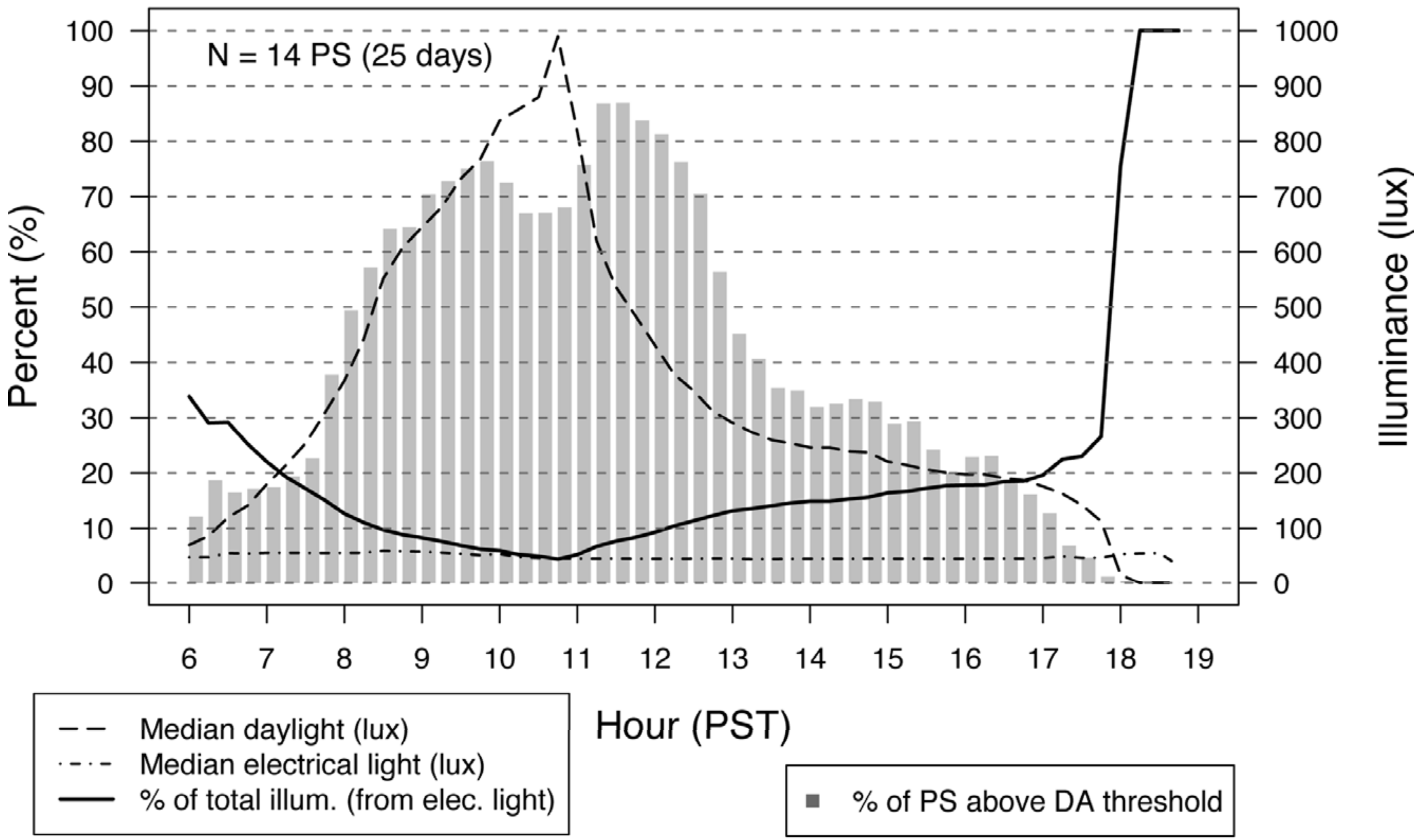


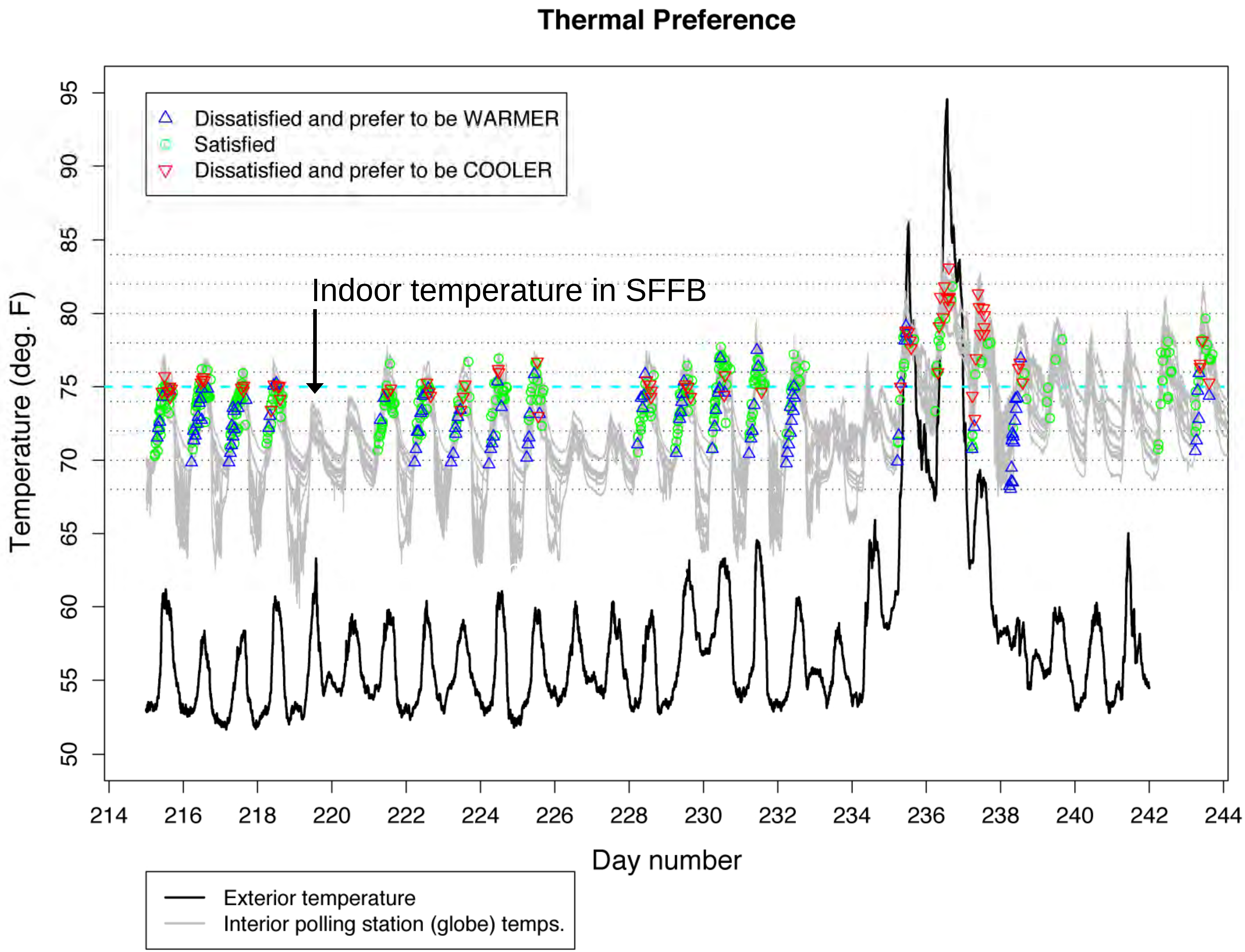


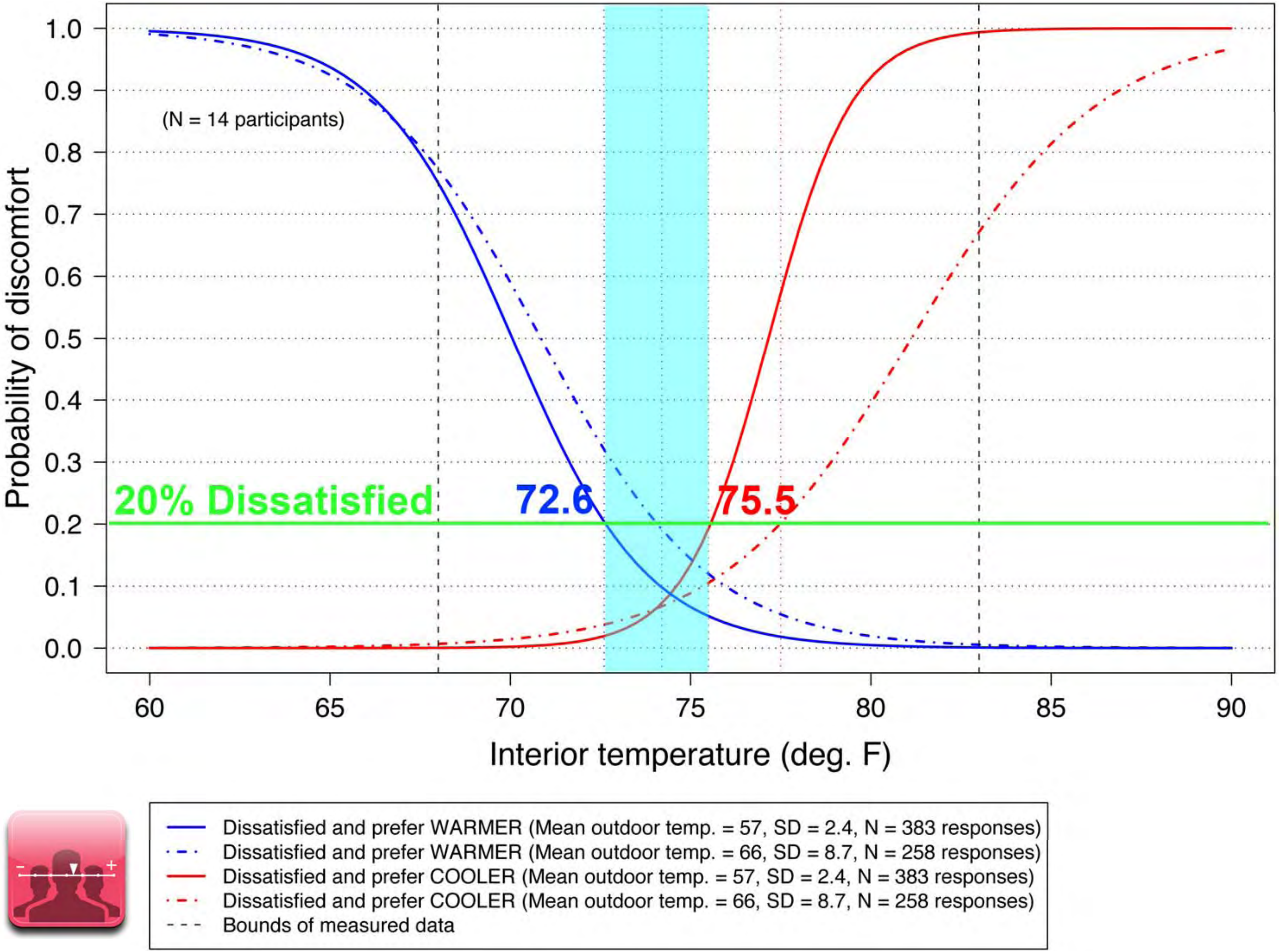


SECTION THROUGH A TYPICAL OFFICE

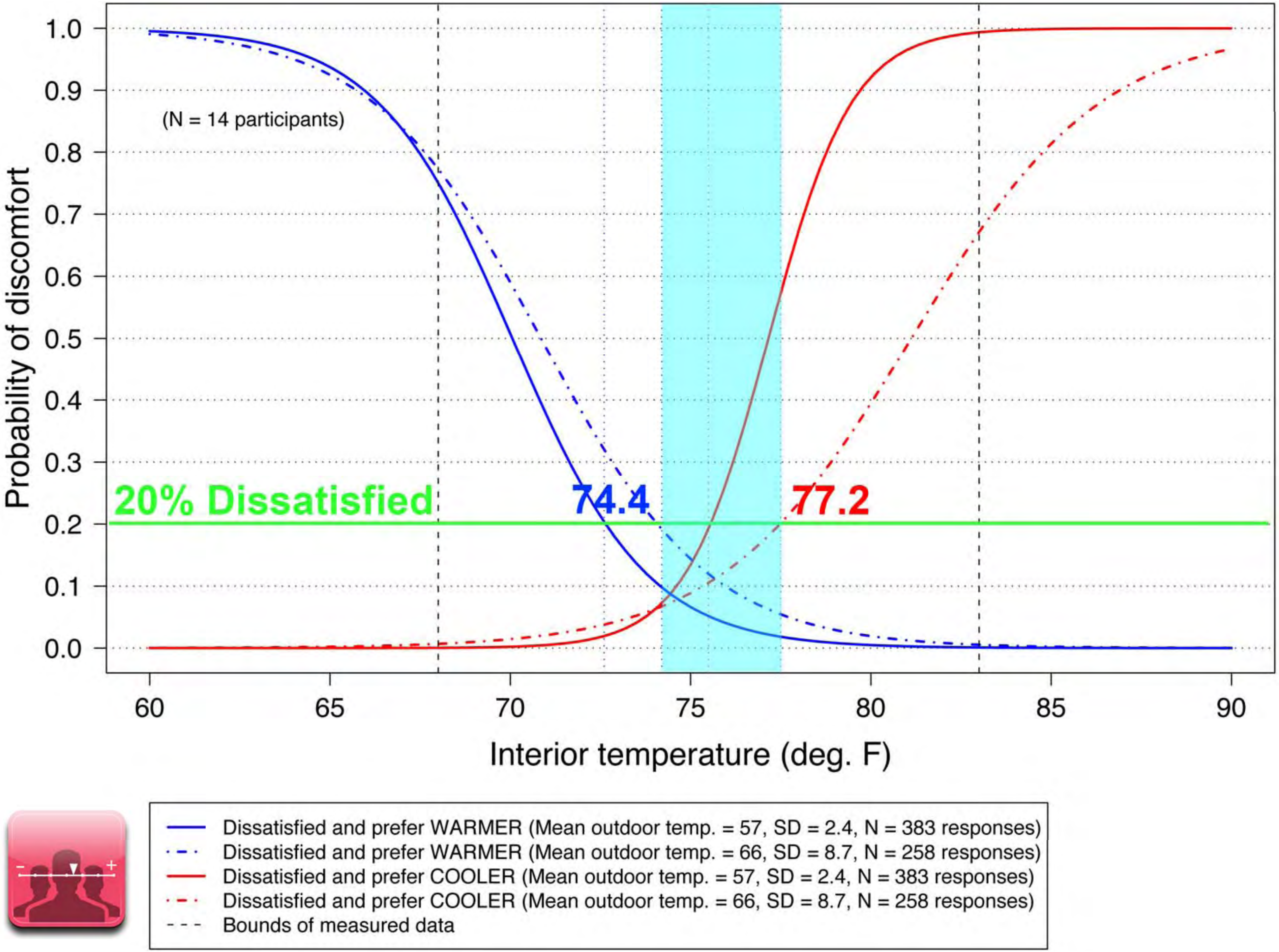
SE Perimeter Zone D.A.




Thermal Preference
Dissatisfied and prefer to be WARMER
Satisfied
Dissatisfied and prefer to be COOLER
Indoor temperature in SFFB
Temperature (deg. F)
95
90
85
80
75
70
65
60
55
50
214
216
218
220
222
224
226
228
230
232
234
236
238
240
242
244
Day number
Exterior temperature
Interior polling station (globe) temps.



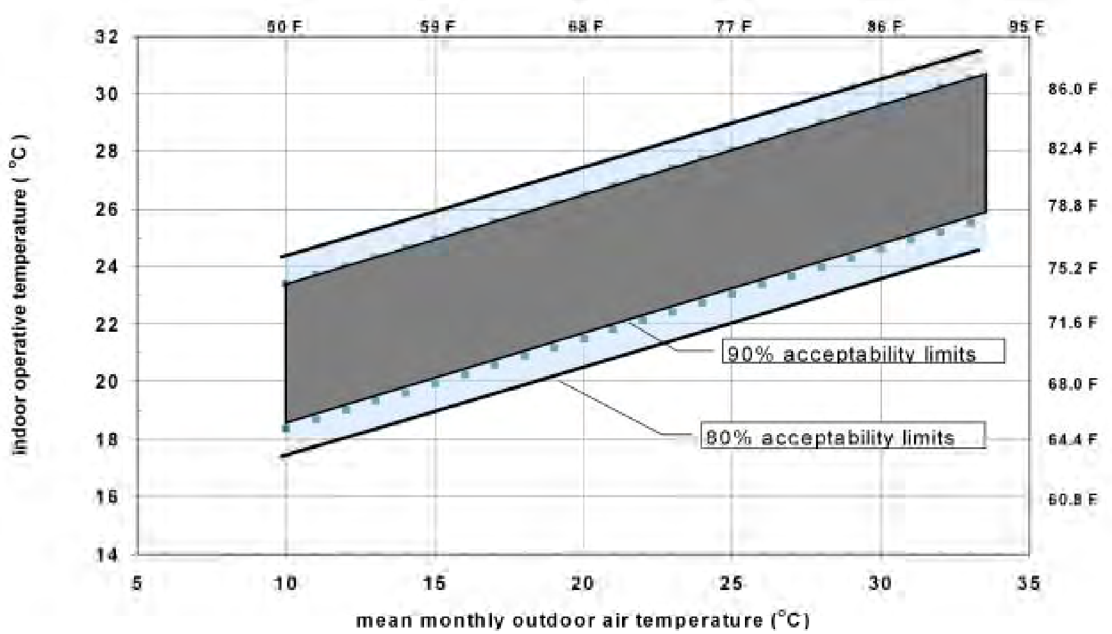
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Probability of discomfort
(N = 14 participants)
20% Dissatisfied
72.6
75.5
60
65
70
75
80
85
90
Interior temperature (deg. F)
Dissatisfied and prefer WARMER (Mean outdoor temp. = 57, SD = 2.4, N = 383 responses)
Dissatisfied and prefer WARMER (Mean outdoor temp. = 66, SD = 8.7, N = 258 responses)
Dissatisfied and prefer COOLER (Mean outdoor temp. = 57, SD = 2.4, N = 383 responses)
Dissatisfied and prefer COOLER (Mean outdoor temp. = 66, SD = 8.7, N = 258 responses)
Bounds of measured data



1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Probability of discomfort
(N = 14 participants)
20% Dissatisfied
74.4
77.2
60
65
70
75
80
85
90
Interior temperature (deg. F)
Dissatisfied and prefer WARMER (Mean outdoor temp. = 57, SD = 2.4, N = 383 responses)
Dissatisfied and prefer WARMER (Mean outdoor temp. = 66, SD = 8.7, N = 258 responses)
Dissatisfied and prefer COOLER (Mean outdoor temp. = 57, SD = 2.4, N = 383 responses)
Dissatisfied and prefer COOLER (Mean outdoor temp. = 66, SD = 8.7, N = 258 responses)
Bounds of measured data

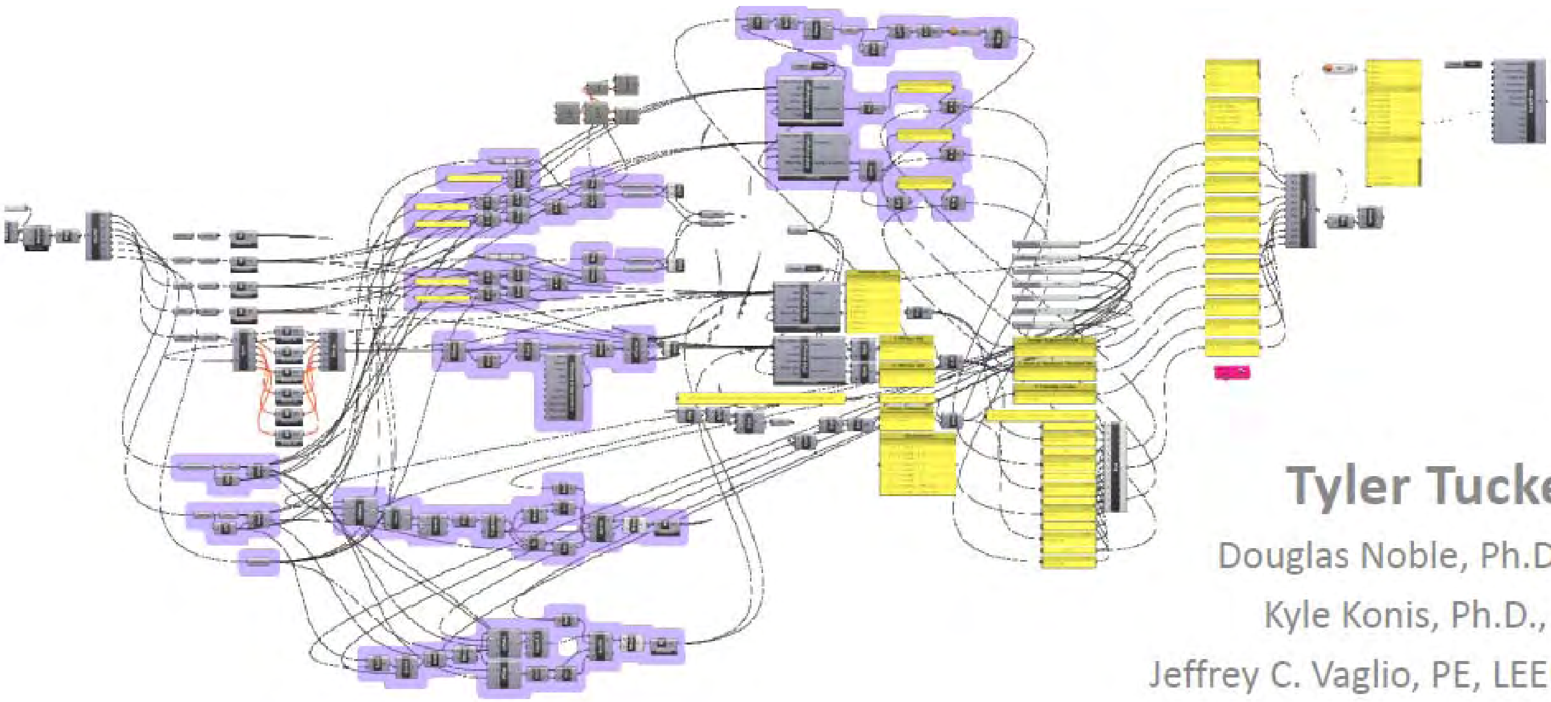
Feedback: thermal comfort

Thermal comfort range shifts in response to outdoor weather conditions, however acceptability range (i.e. “target zone”) much narrower than assumed



Adaptive thermal comfort model (after Brager and DeDear)

Performative Shading Design: Parametric Based Measurement of Shading System Configuration Effectiveness and Trends



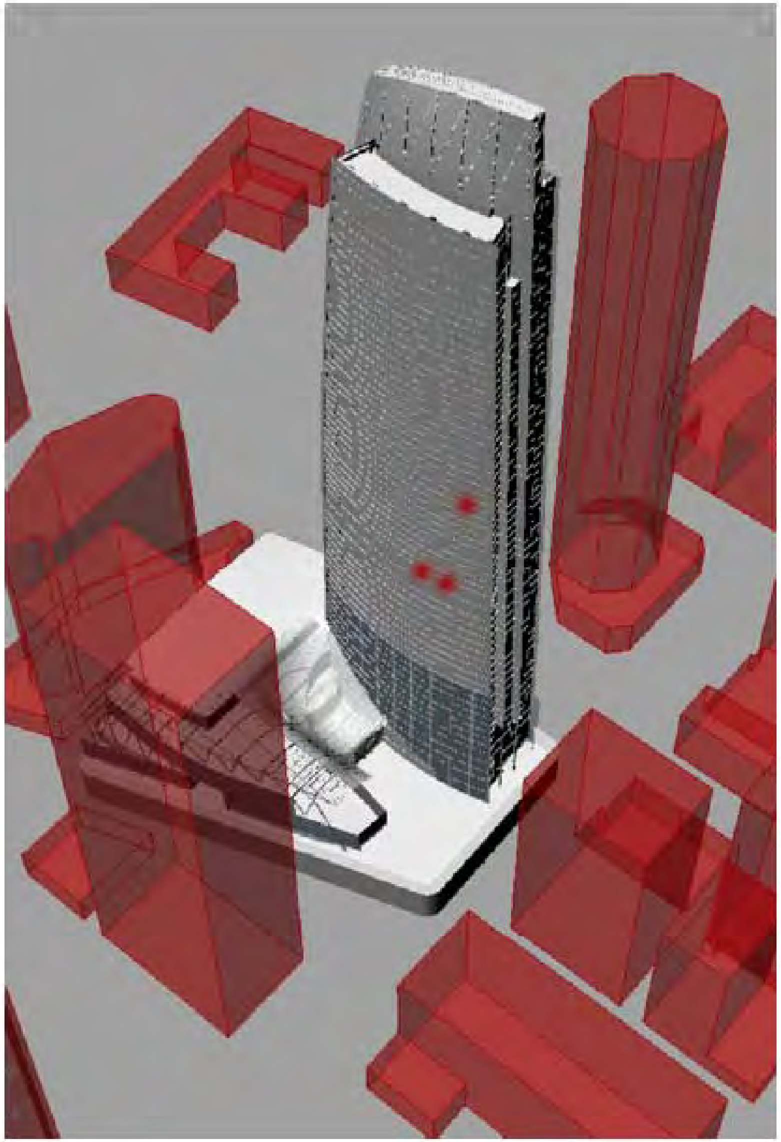
Tyler Tucker

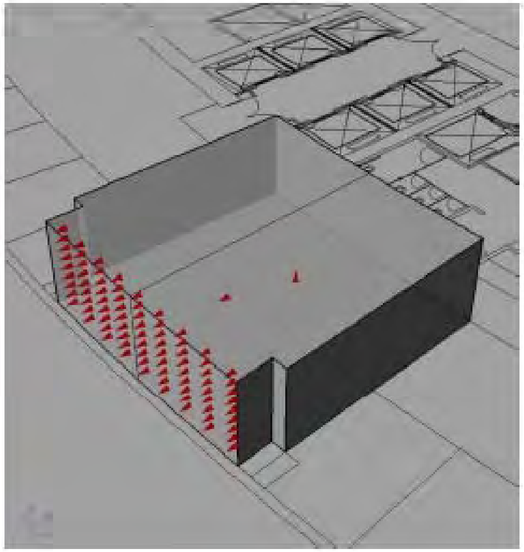
Douglas Noble, Ph.D., FAIA

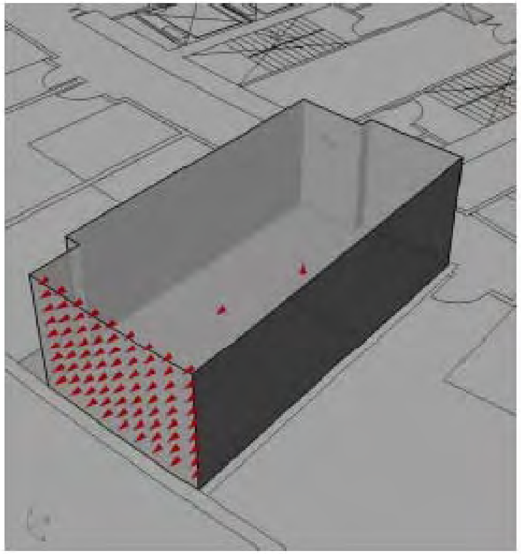
Kyle Konis, Ph.D., AIA

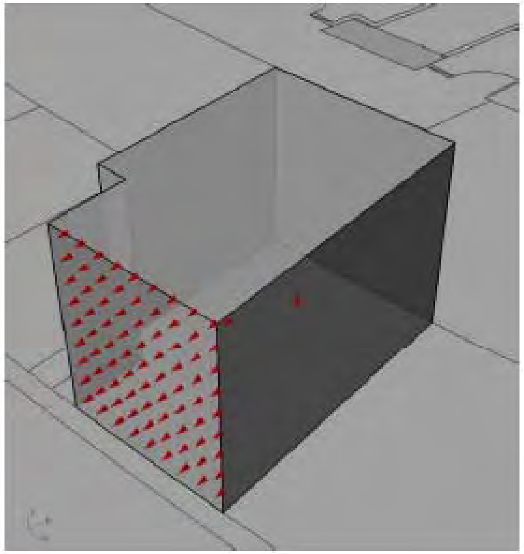
Jeffrey C. Vaglio, PE, LEED AP BD+C

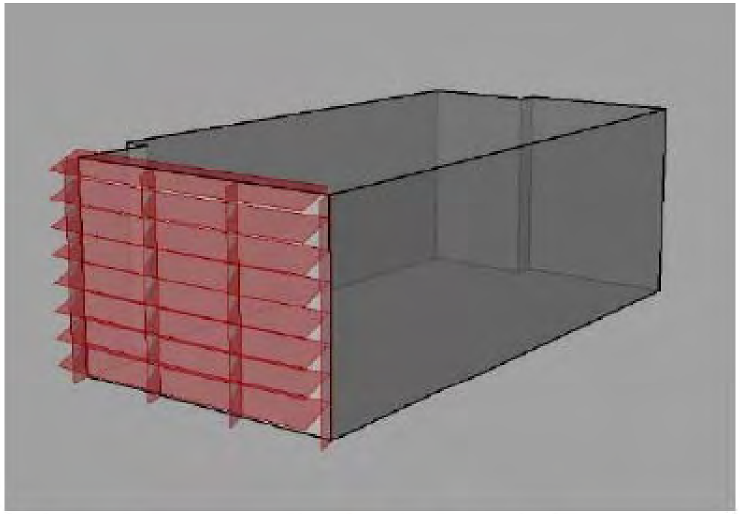
- 81 radiation sensors
- 1 horizontal illuminance sensor
- 1 vertical eye level illuminance sensor

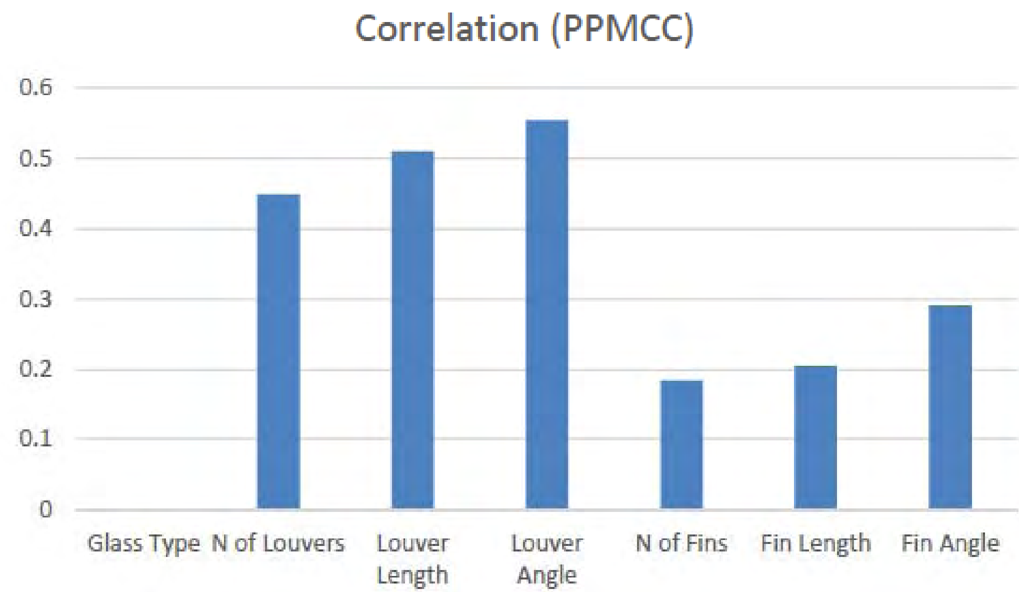








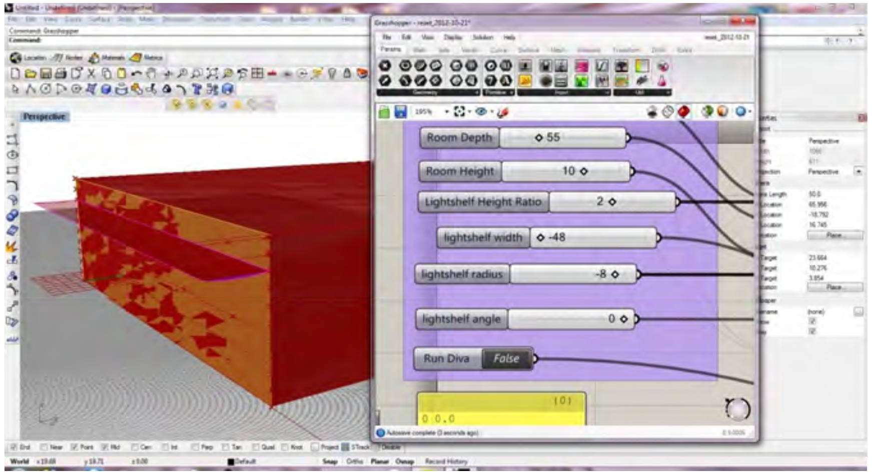


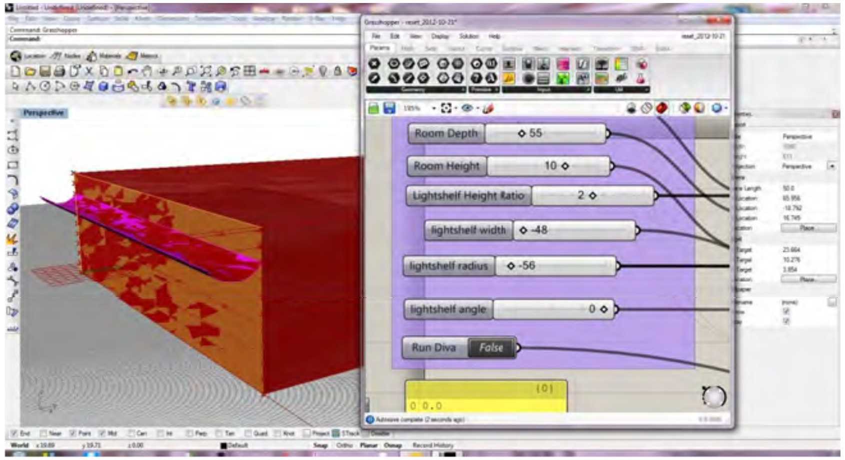


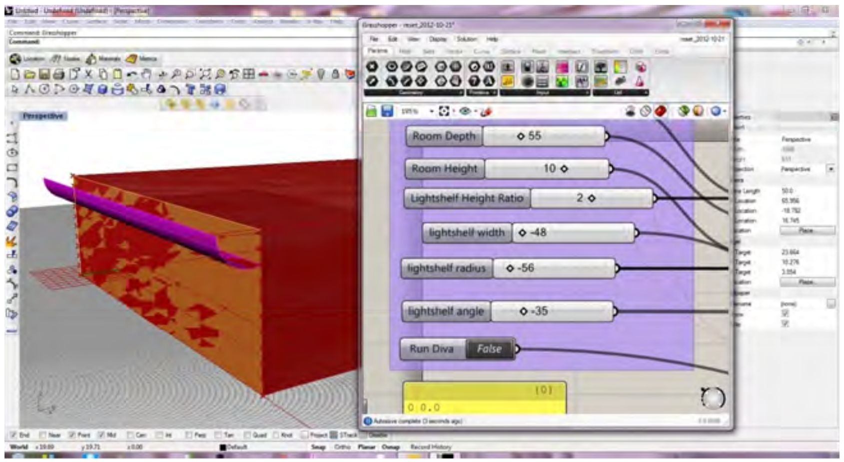
Glass Type	# of Louve	Louver Ler	Louver An	# of Fins	Fin Length	Fin Angle	Average R	% Hours o	% Probabil	Fitness	#
1	8	20	-24	4	15	-21	170.7407	6	0.276946	-0.75234	975
1	8	20	-24	4	15	-21	170.7407	6	0.276946	-0.75234	976
1	8	21	-27	4	15	-21	165.3333	5	0.275346	-0.75283	751
1	8	21	-27	4	15	-21	165.3333	5	0.275346	-0.75283	752
1	7	20	-27	5	15	-21	176.9877	7	0.278266	-0.75375	901
1	8	20	-24	4	15	-21	171.6049	6	0.276946	-0.75529	1100
1	8	20	-24	4	15	-21	171.6049	6	0.276946	-0.75529	1101
1	8	20	-27	5	16	-18	166.8519	5	0.27548	-0.75847	829
1	8	20	-27	5	16	-18	166.8519	5	0.27548	-0.75847	830
1	7	19	-24	4	17	-18	183.1358	8	0.281187	-0.76028	832
1	7	21	-27	3	15	-21	179.9753	7	0.277289	-0.76063	918
1	8	20	-24	5	19	-15	167.8519	5	0.275502	-0.76196	505
1	8	20	-24	5	19	-15	167.8519	5	0.275502	-0.76196	506
1	8	20	-24	3	15	-18	174.2593	6	0.276339	-0.76228	869
1	8	20	-24	3	15	-18	174.2593	6	0.276339	0.76228	870
1	8	23	-30	4	15	-18	157.037	3	0.273049	-0.76549	590
1	8	23	-30	4	15	-21	157.2469	3	0.272848	-0.76552	703
1	8	21	-30	4	16	-21	163.1358	4	0.274719	-0.76759	1015
1	7	20	-30	5	16	-12	175.358	6	0.277033	-0.76839	543
1	8	20	-30	3	15	-21	170.5556	5	0.274814	-0.76885	985

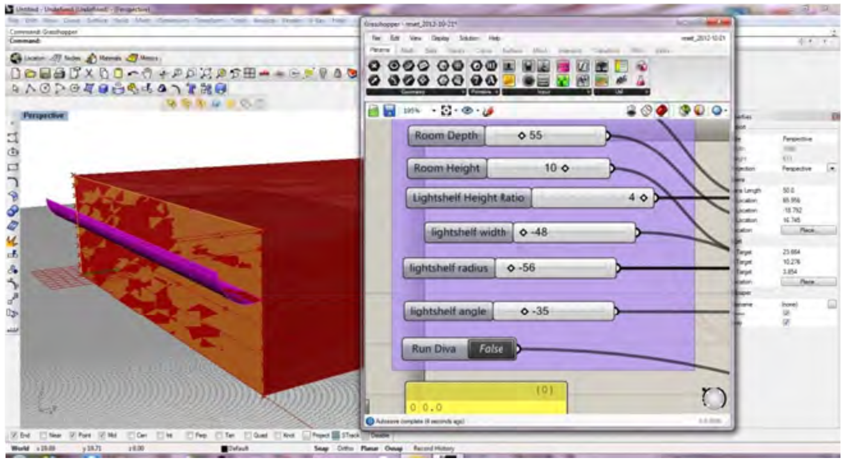
Parametric Modeling and Performance Optimization of an Anidolic Light Shelf

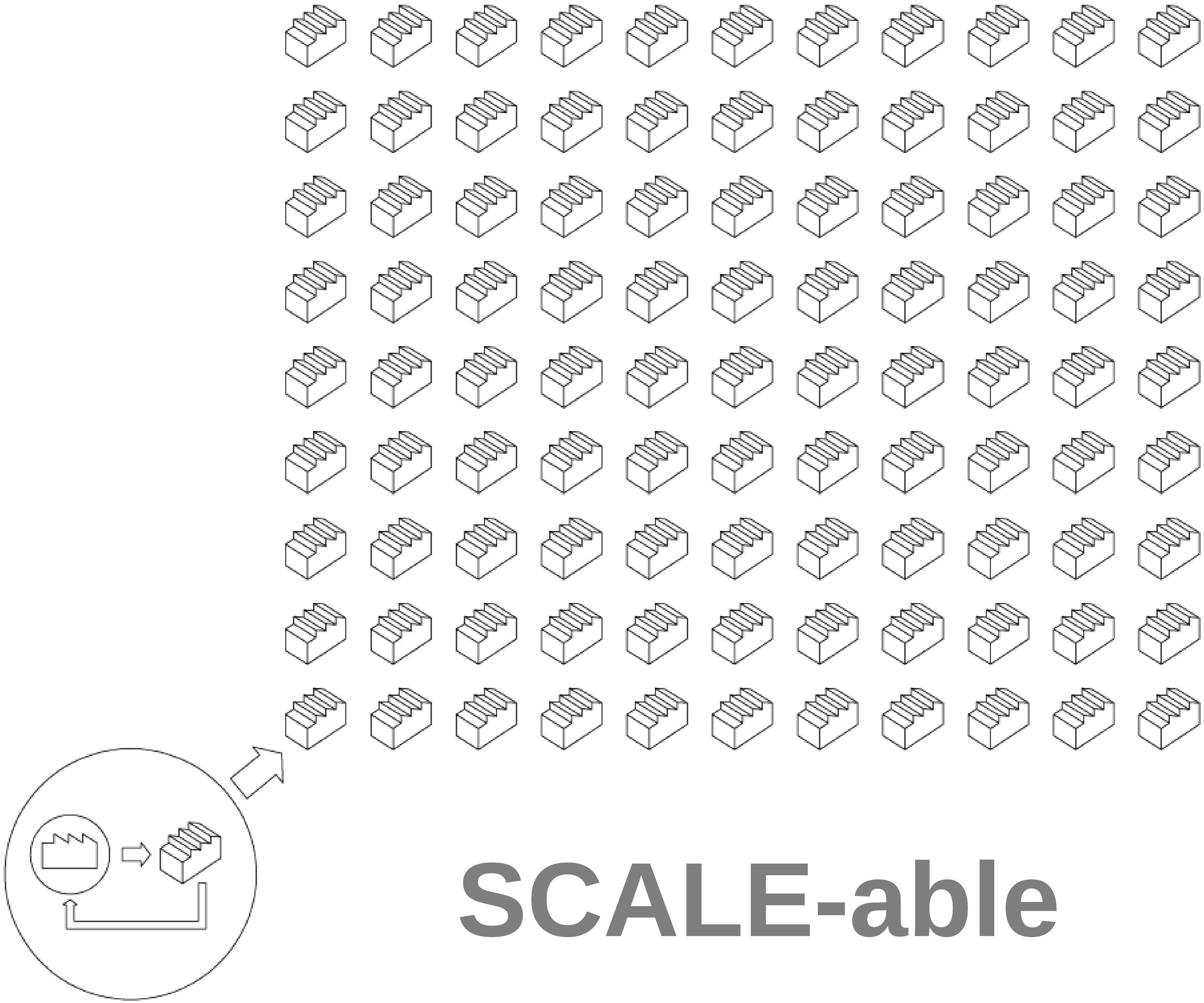
Yue Liu, Kyle Konis, Ph.D, Doug Noble, AIA





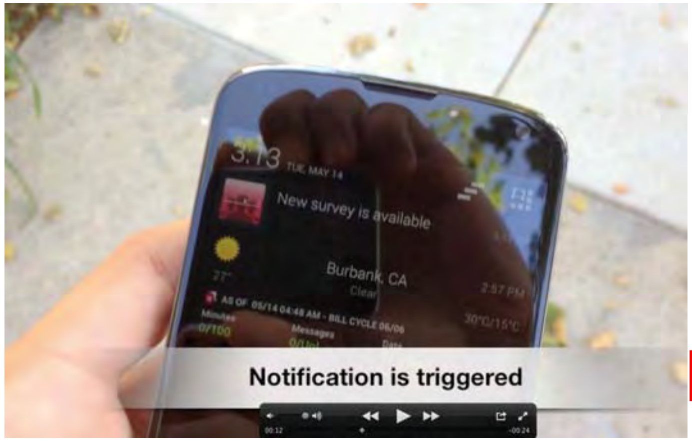


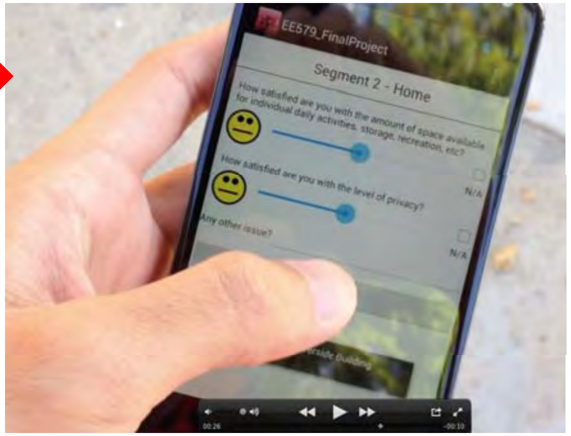




SCALE-able

Location-aware Mobile Survey Mechanism

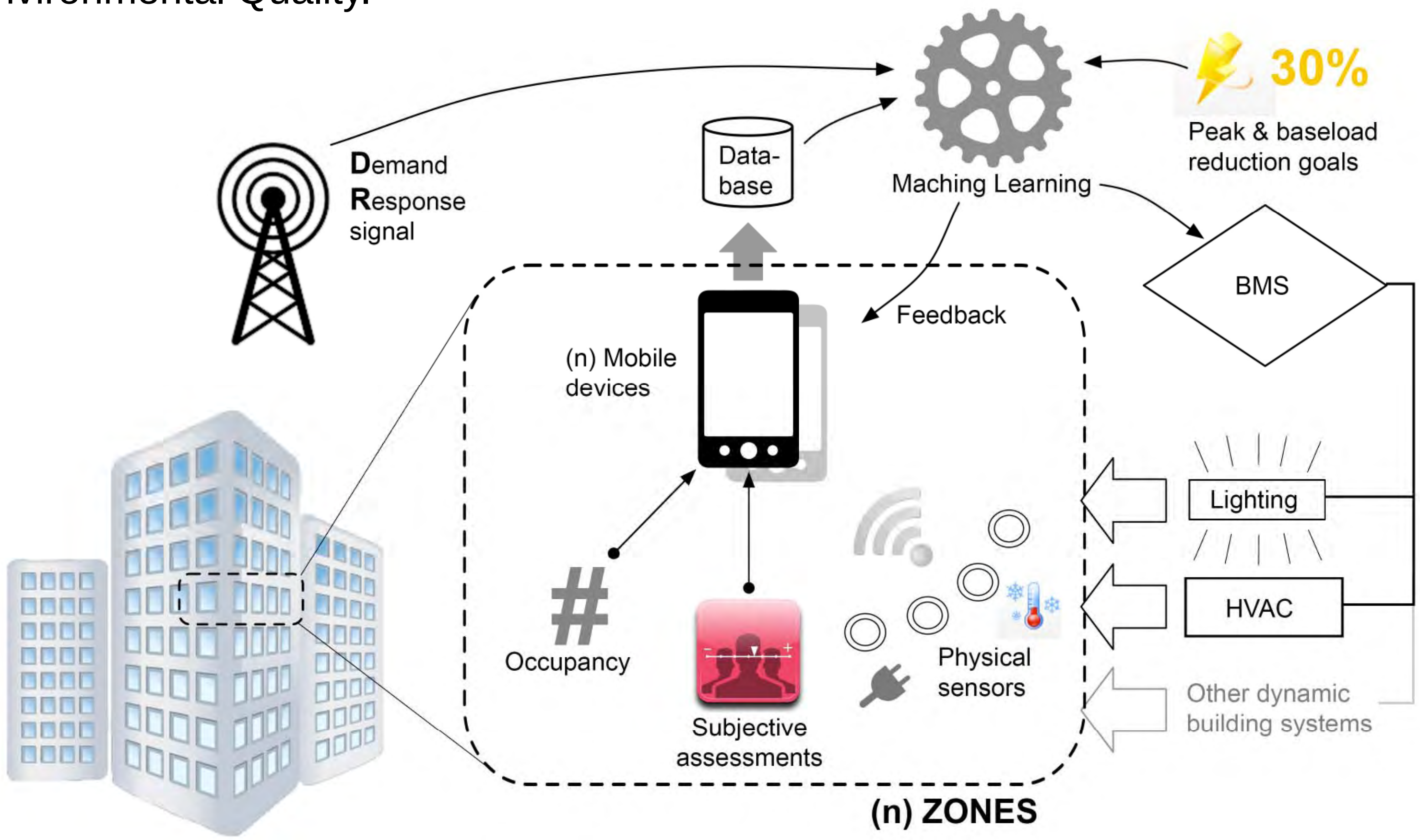




Subjective Feedback

The Building Occupant Mobile Gateway

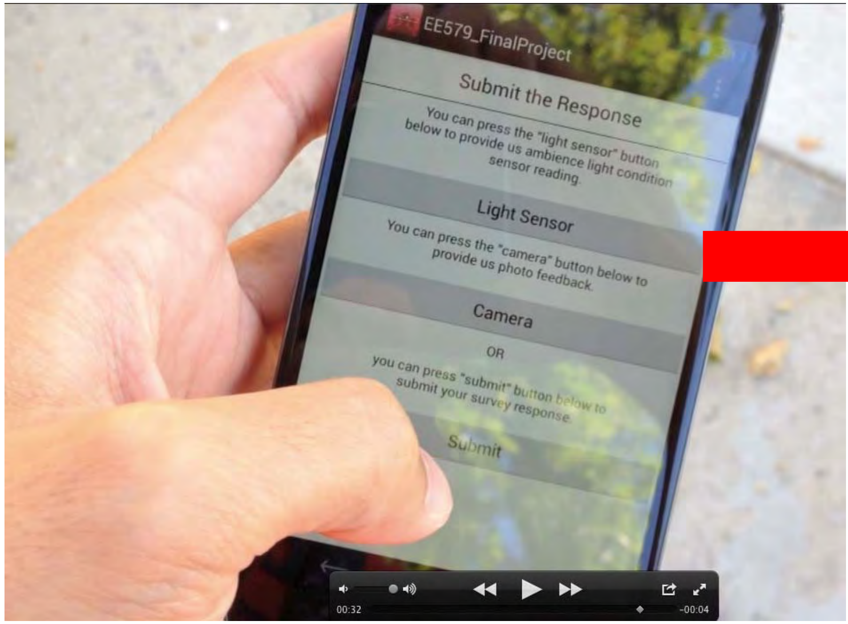
A Framework and Enabling Technology for Occupant-Aware Building Energy Optimization and Enhanced Measurement and Verification of Indoor Environmental Quality.

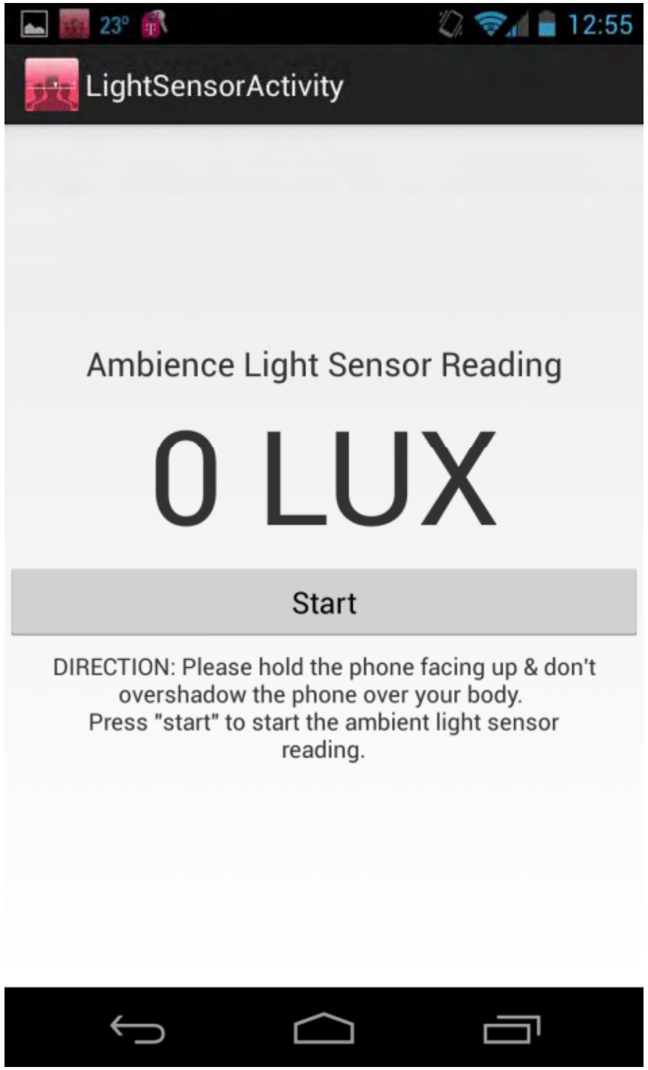


PI: Kyle Konis, AIA, Ph.D
Assistant Professor, USC Department of Architecture

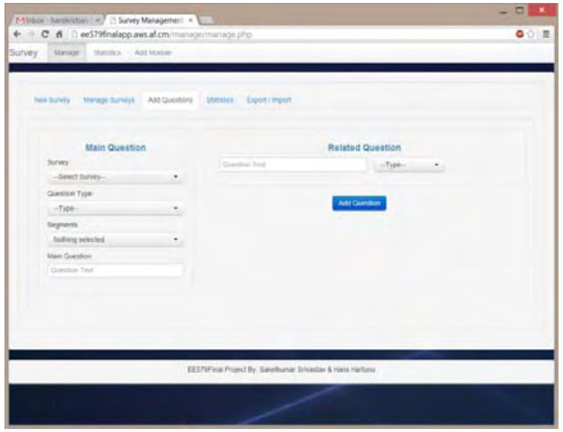
Co-Investigator: Murali Annavaram, Ph.D
Associate Professor, USC Viterbi School of Engineering

(Integrate Onboard Sensors)

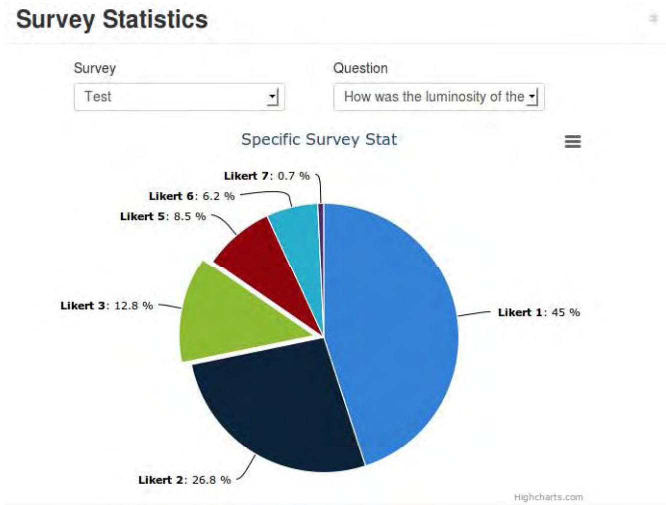




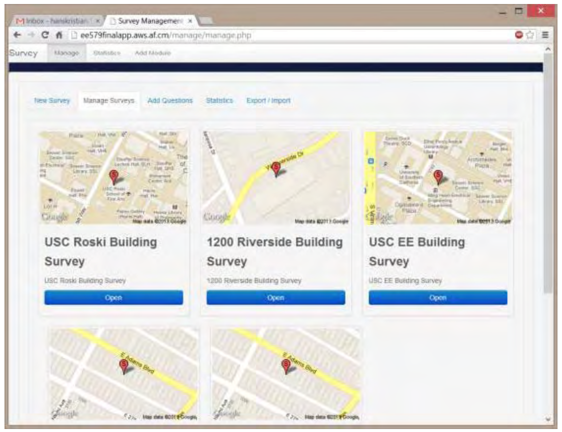
FLEXIBLE: Backend Management Console



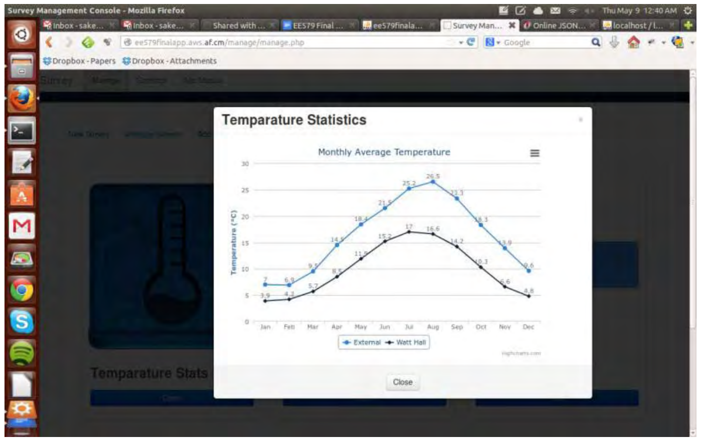
Custom Surveys



Survey Statistics



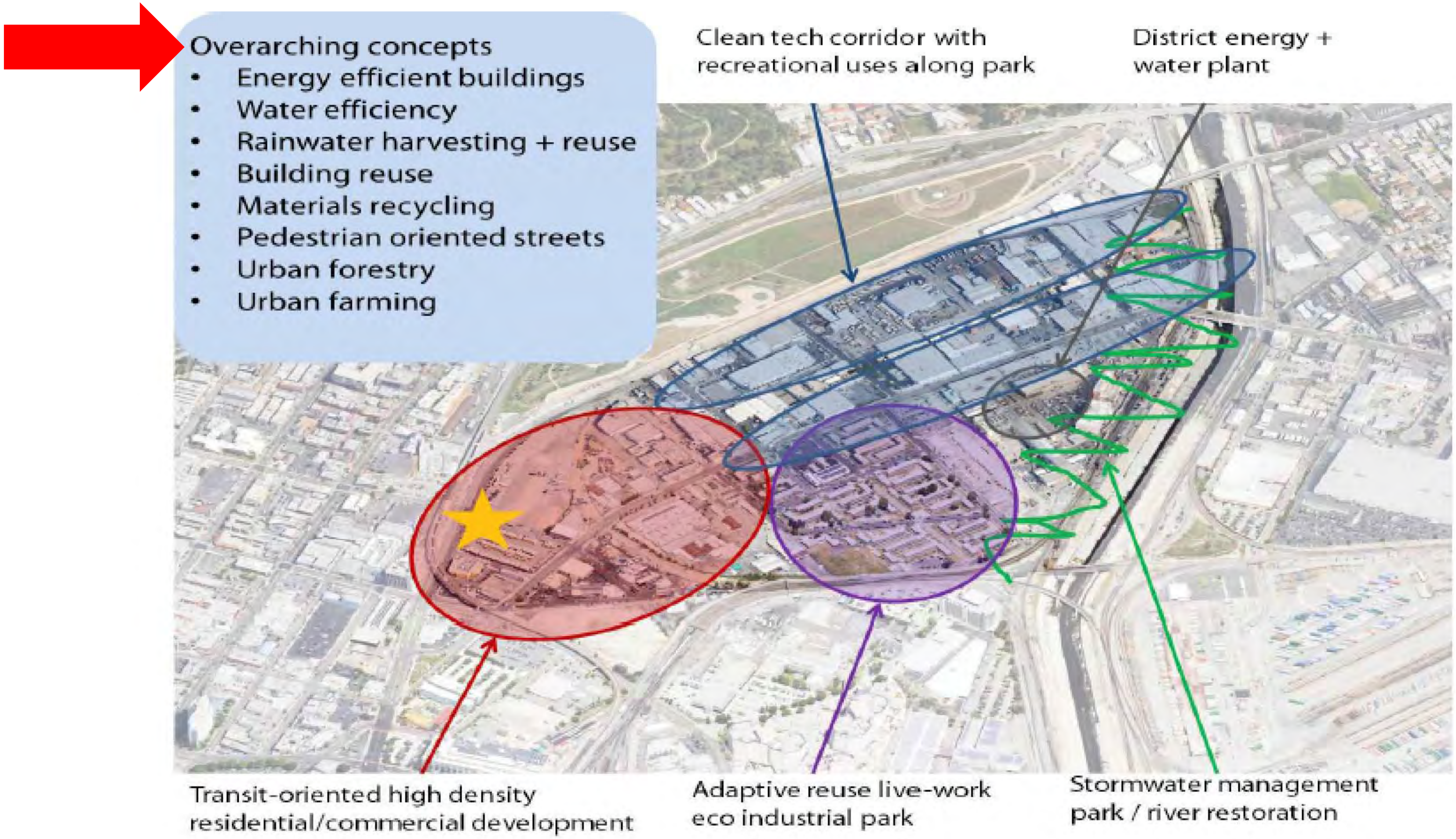
Survey Management




District Scale

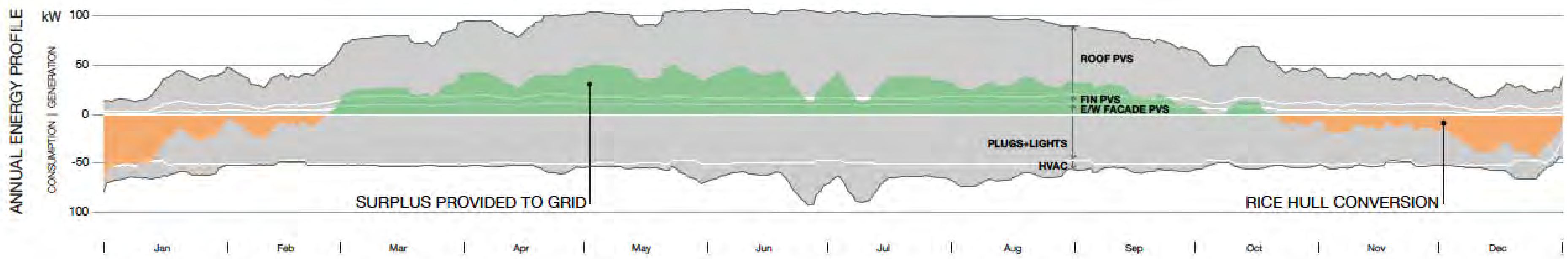
CONCEPT

The proposed SDP enhances the CASP plan by building in policies for equitable development, integrating river revitalization, and developing district energy, water and recycling systems to complement high performance building requirements.

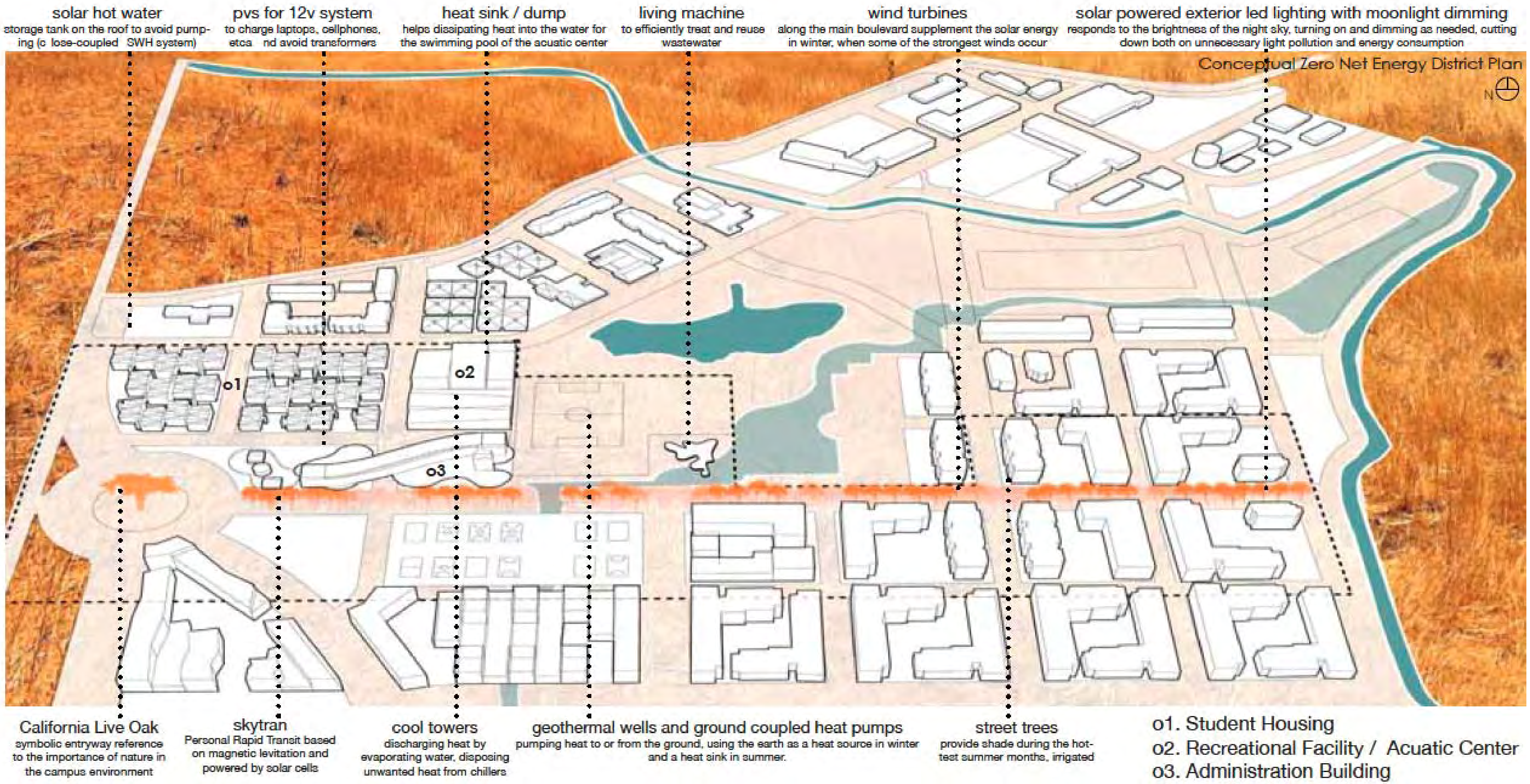


Concept Diagram; Source: background from Google Earth, diagram by S. Mendler

Faculty: Kyle Konis
Team: Sandra Mendler, Yingjun Hu, Sara Hrynik



Images: Loisos Ubbelohde



THANK YOU

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