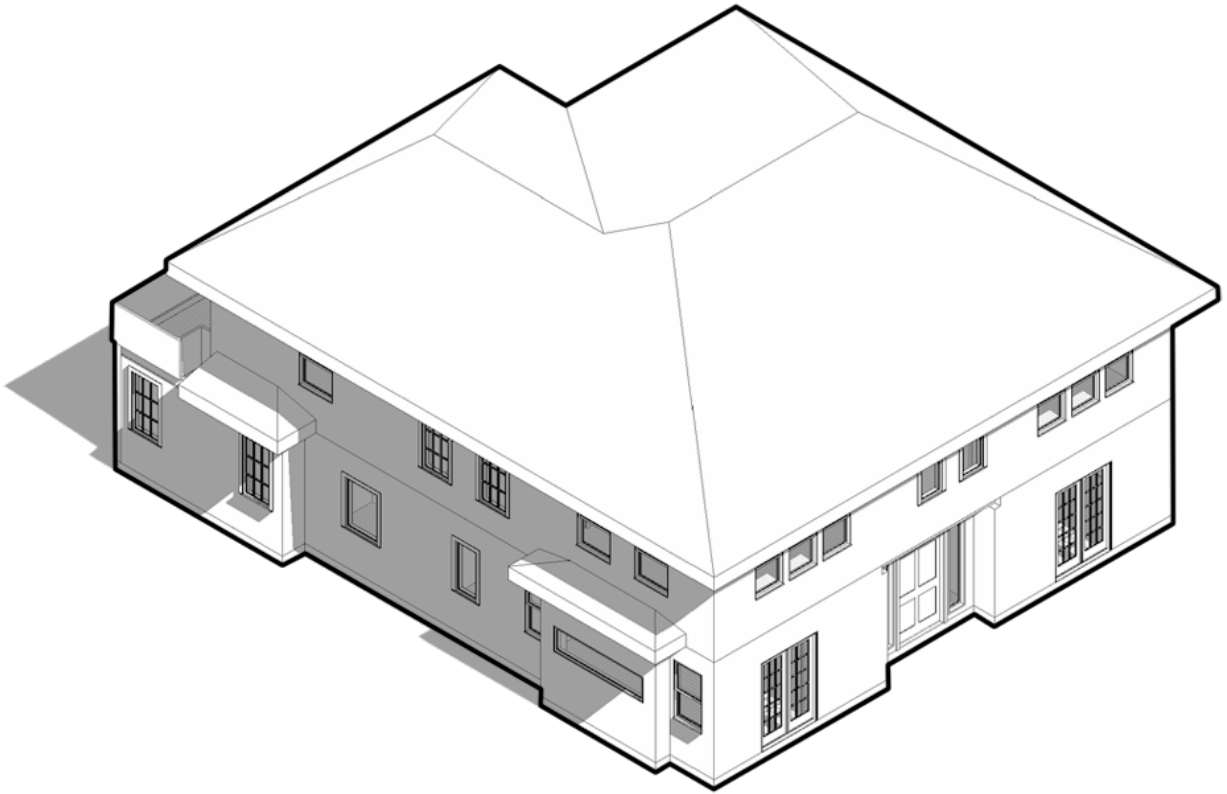
Team Negawatt

Berkeley
UNIVERSITY OF CALIFORNIA



Carlos Duarte

Priya Gandhi

Antony Kim

Jared Landsman

Luis Santos

Sara Tepfer

Taoning Wang

UC BERKELEY ENVIRONMENTAL DESIGN

CBE
CENTER FOR THE BUILT ENVIRONMENT

Broader context

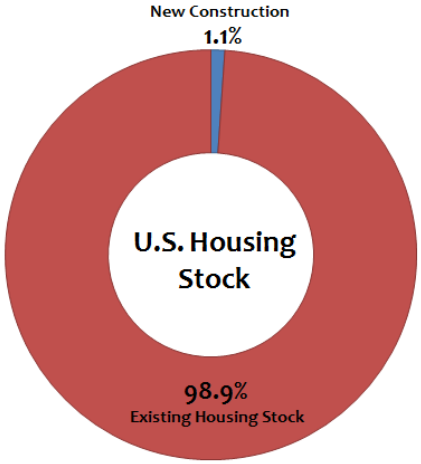
The Economist

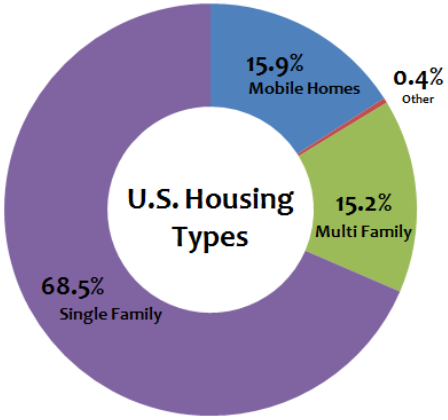
Urban land

Space and the city

Poor land use in the world's greatest cities carries a huge cost

Apr 4th 2015 | From the print edition



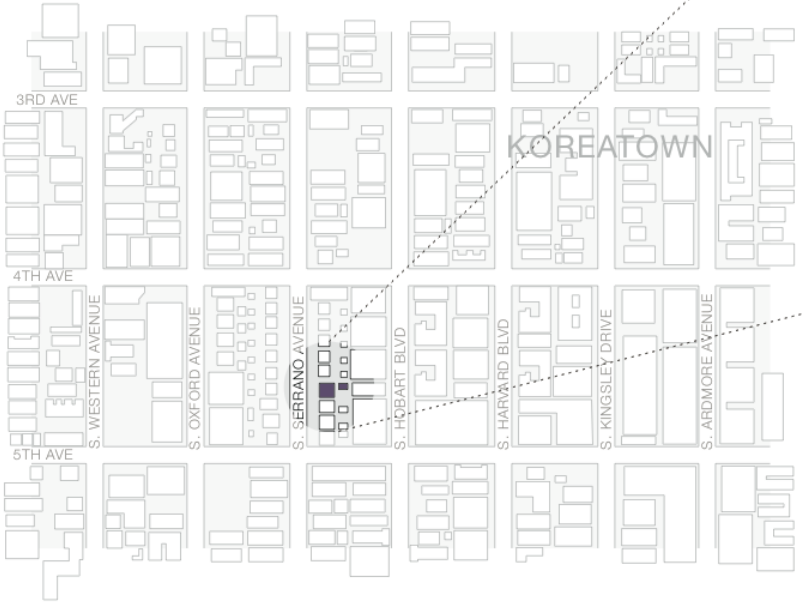


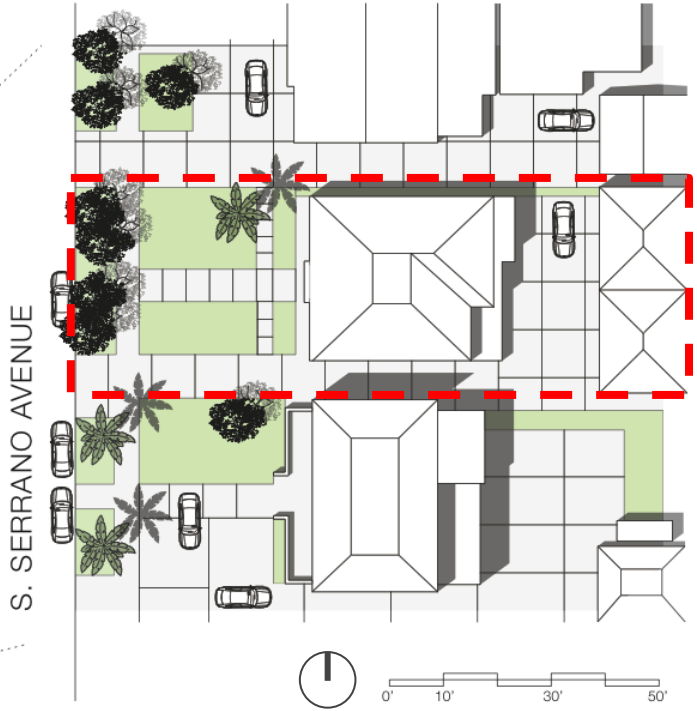
Selected site

Los Angeles, CA (Koreatown District)

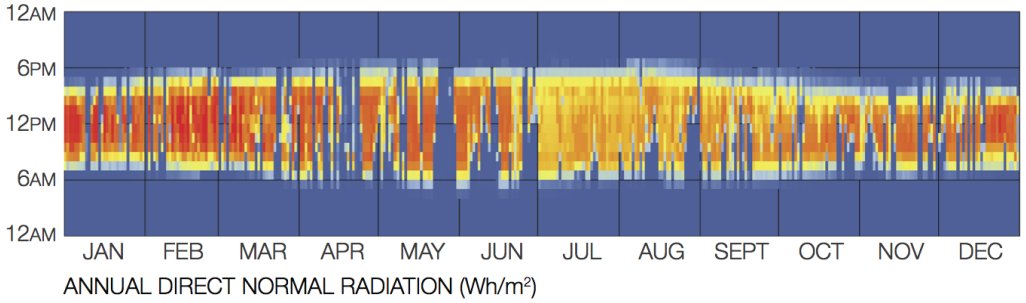
Built in 1916 & Designated a Historical Monument in 1998

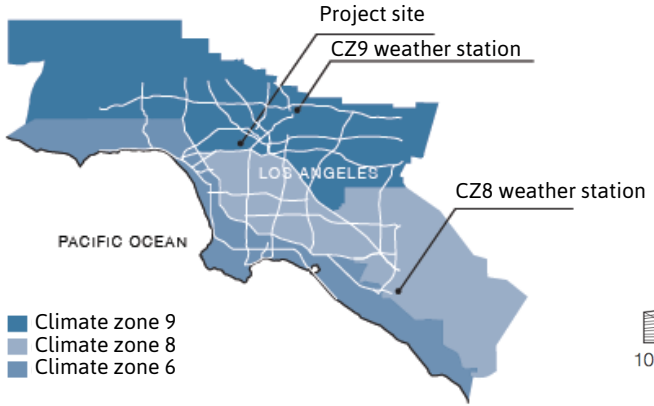
3450 ft^2 Single Family Dwelling

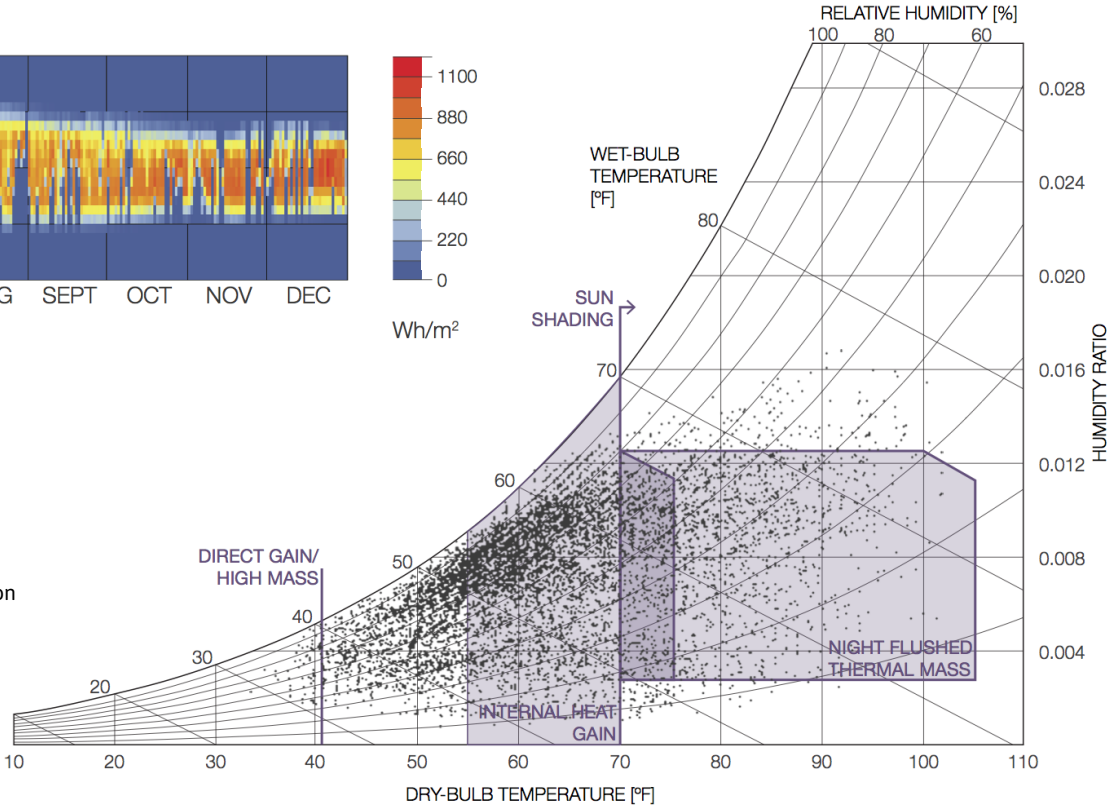




Climate


12AM
6PM
12PM
6AM
12AM
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
DEC
ANNUAL DIRECT NORMAL RADIATION (Wh/m²)
1100
880
660
440
220
0
Wh/m²


Project site
CZ9 weather station
CZ8 weather station
LOS ANGELES
PACIFIC OCEAN
Climate zone 9
Climate zone 8
Climate zone 6


RELATIVE HUMIDITY [%]
100
80
60
WET-BULB TEMPERATURE [°F]
80
70
60
50
40
30
20
SUN SHADING
DIRECT GAIN/ HIGH MASS
NIGHT FLUSHED THERMAL MASS
INTERNAL HEAT GAIN
10
20
30
40
50
60
70
80
90
100
110
DRY-BULB TEMPERATURE [°F]
0.028
0.024
0.020
0.016
0.012
0.008
0.004
HUMIDITY RATIO

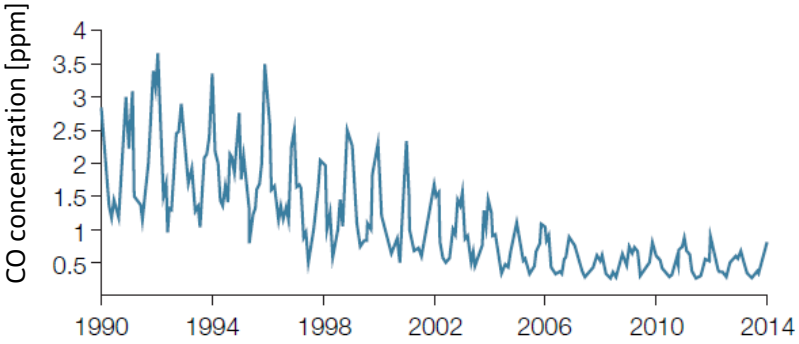
Design Goals

- Increase urban density
- Rehab an existing building
- Maintain historical preservation status
- Zero Net Energy (ZNE)
- First address energy efficiency and after energy production

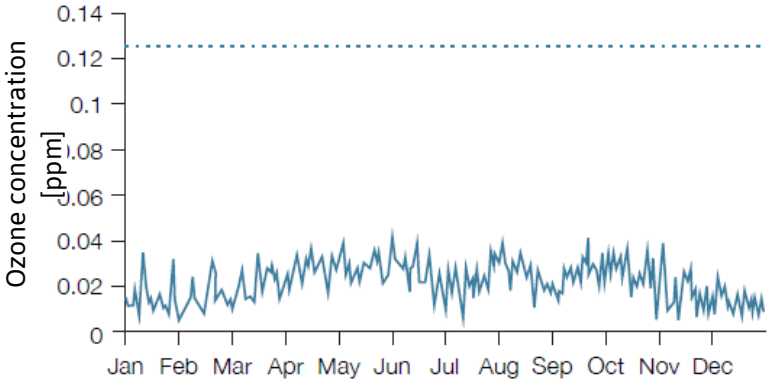
Air quality

- Downward trend in almost all criteria pollutant concentrations over last 20 years
- Almost all criteria pollutants concentrations below “moderate” AQI during 2013
- PM 2.5 only pollutant of concern for design → MERV 12 filtration

1990-2013 Carbon monoxide (CO) concentrations

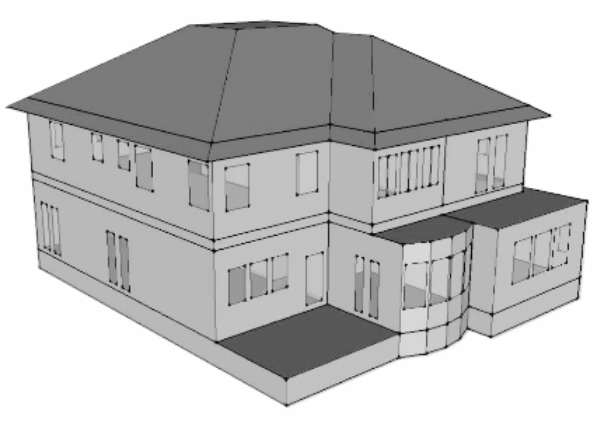


2013 Daily average ozone concentration



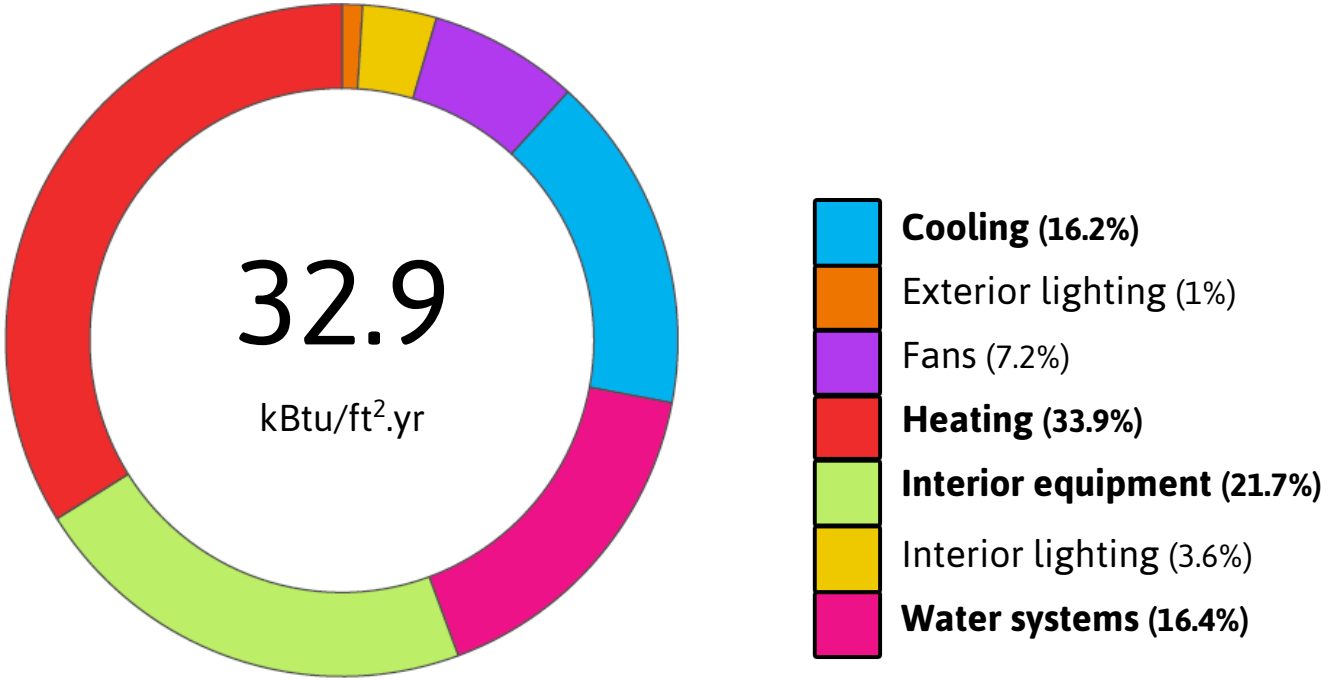
Energy modeling as a design driver

- Simulation engine: EnergyPlus
- Baseline inputs
  - No insulation in walls and ceiling
  - Single pane windows
  - High infiltration rates (~ 1 ACH)
  - Typical residential equipment and operation
- General outputs
  - End-use energy consumption
  - Peak cooling and heating



Energy modeling as a design driver

Baseline



Design strategies

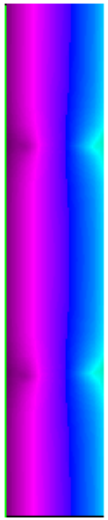
- Heating:
  - Increase of insulation + thermal bridging correction
  - Window replacement
  - Infiltration rate reduction
  - Personal heaters
- Cooling:
  - Increase of insulation + thermal bridging correction
  - Windows replacement
  - Radiant barriers in roof
  - Natural ventilation - operable windows
  - Thermal mass + night flush
  - Dynamic blind system
  - Fans
- Lighting:
  - Daylighting
  - Electric Lighting

Design strategies

- Heating:
  - Increase of insulation + thermal bridging correction
  - Window replacement
  - Infiltration rate reduction
  - Personal heaters (CBE low-energy heaters - recommendation for occupancy)
- Cooling:
  - Increase of insulation + thermal bridging correction
  - Windows replacement
  - Radiant barriers in roof
  - Natural ventilation - operable windows (code compliance & air quality concerns)
  - Thermal mass + night flush
  - Dynamic blind system (not commonly used by the users)
  - Fans (recommendation for occupancy)
- Lighting:
  - Daylighting
  - Electric Lighting

Envelope

Existing Wall

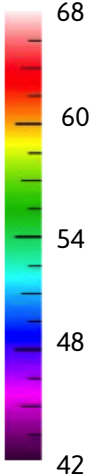


R-Value
3.3 hr-ft^2-°F/Btu

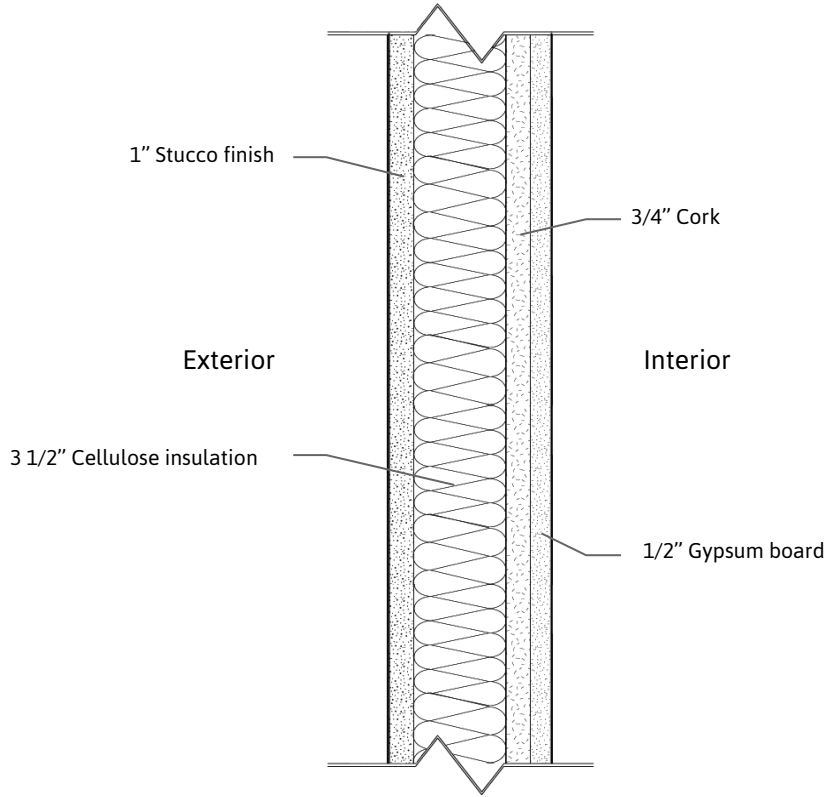
Design Wall

R-Value
18.3 hr-ft^2-°F/Btu

Temperature (°F)



Design Wall
(detail)



Envelope

Existing Window

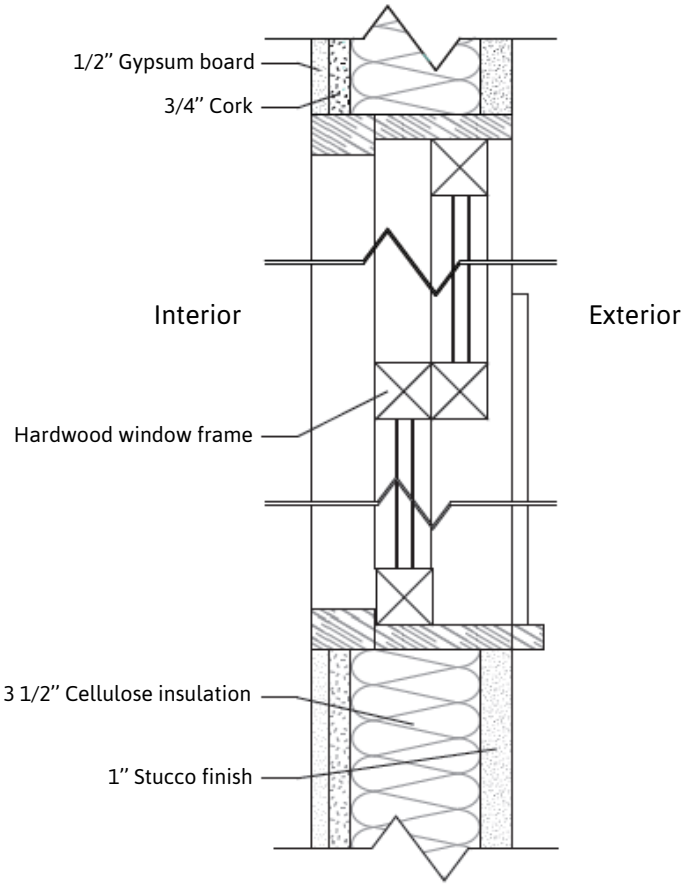
U-factor: 0.34 Btu/hr-ft^2-°F
SHGC: 0.77
VT: 0.86

Design Window

U-factor: 0.15 Btu/hr-ft^2-°F
SHGC: 0.38
VT: 0.68

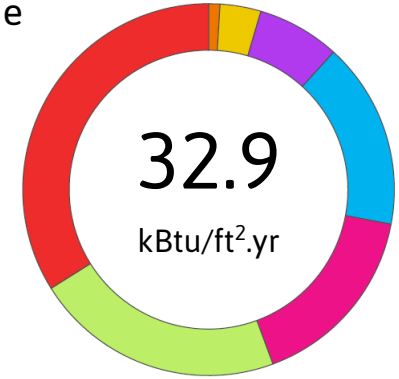
Temperature (°F)

Design Window (detail)

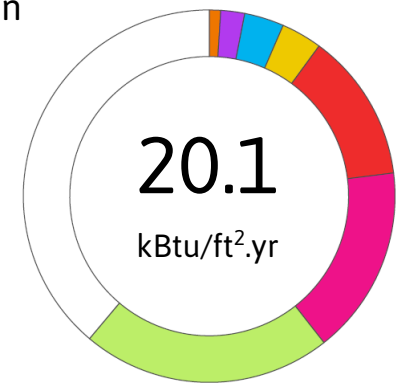


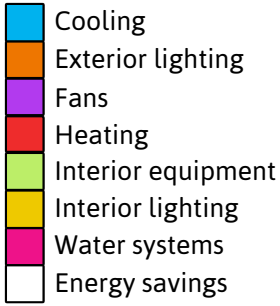
Envelope

Baseline

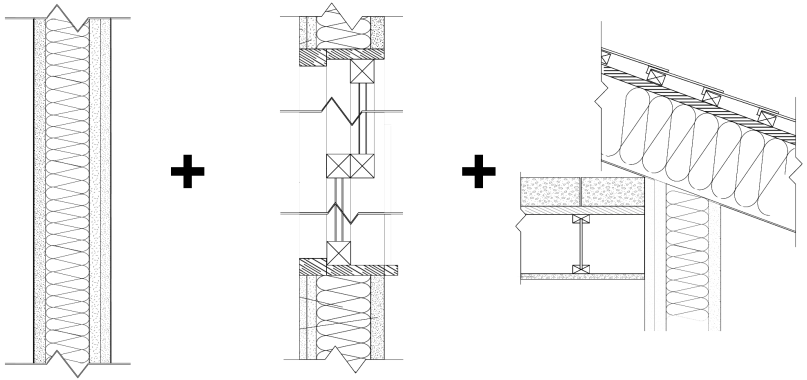


Solution





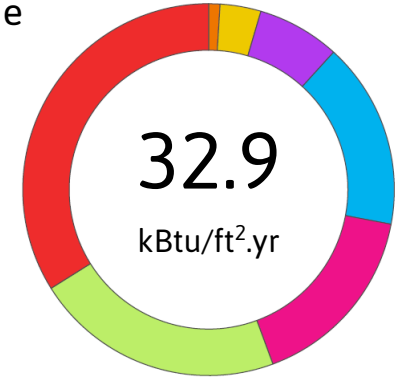
- Alteration in wall, window, roof, and floor constructions
  - Increased R-value
  - Reduced infiltration
  - Compliance with IECC
- Reduction in EUI of 39%



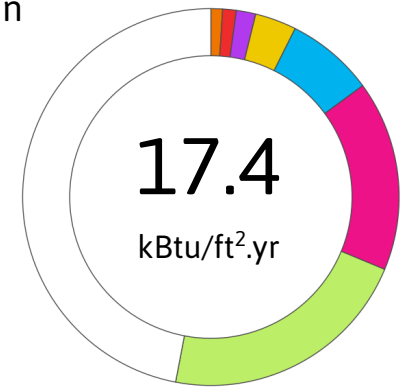
Design ext. wall + Design window + Design roof

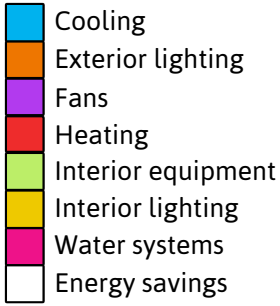
Reduced infiltration rate

Baseline



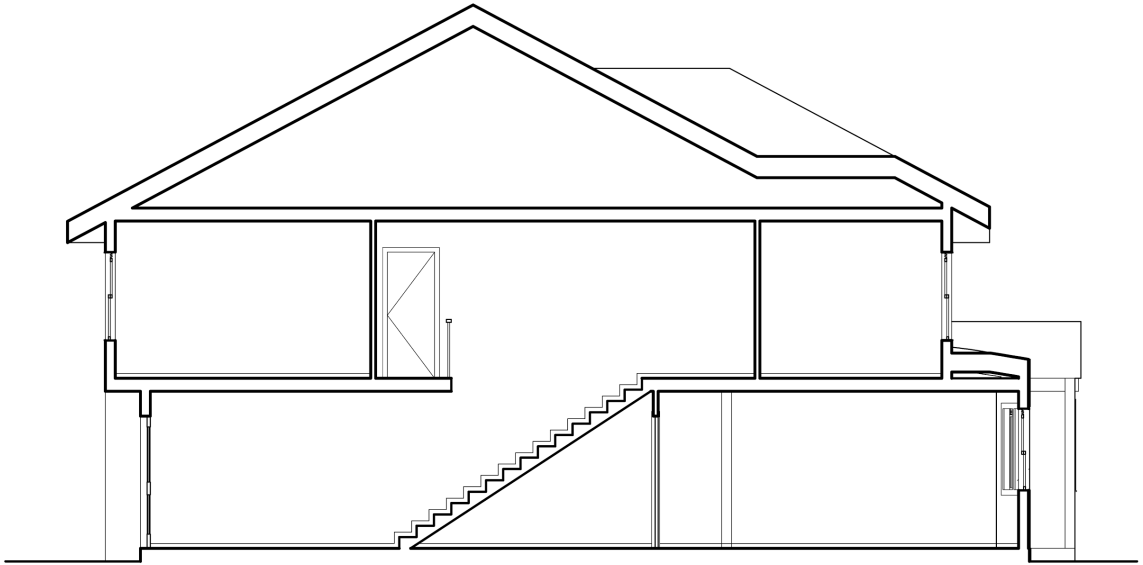
Solution





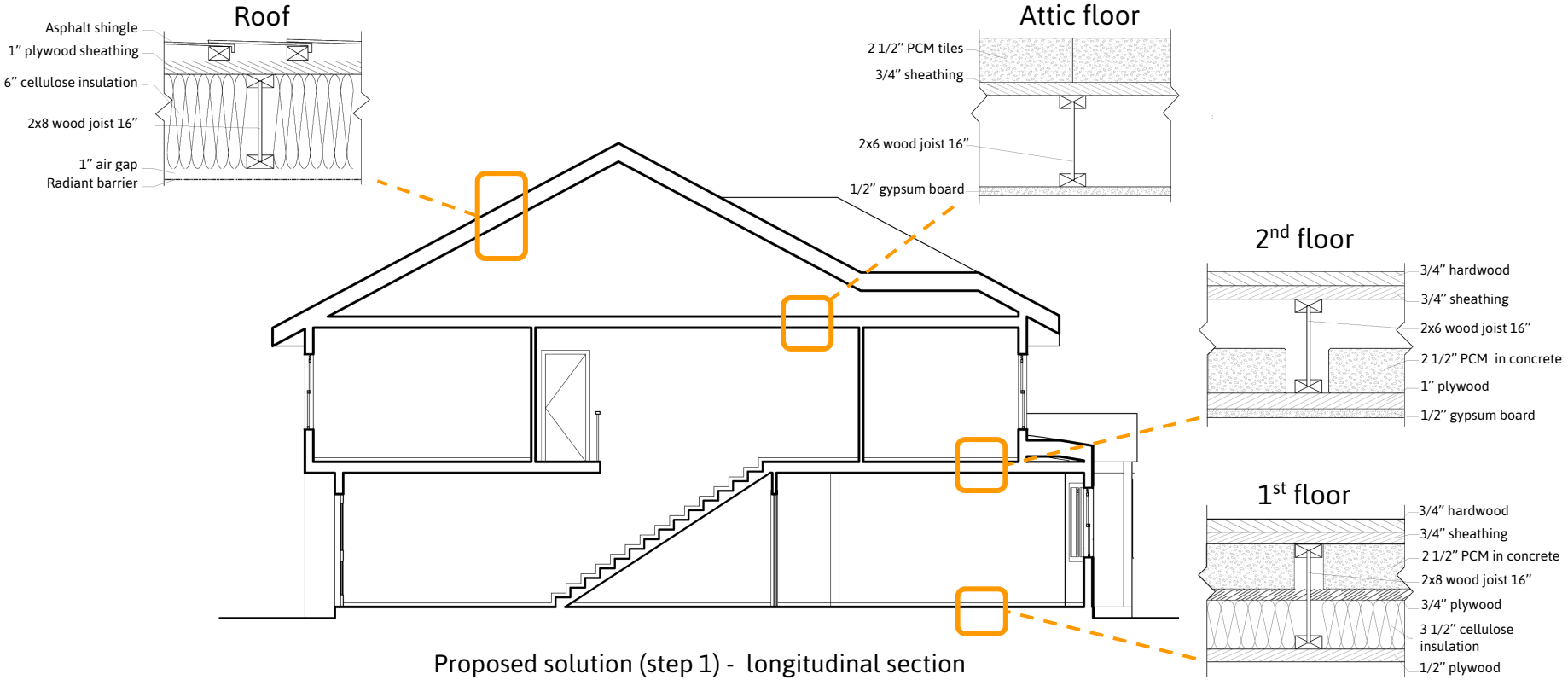
- Cumulative strategies:
  … + reduced infiltration rate
- Infiltration rate reduced from 1 ACH to 0.3 ACH (possible with the alteration of the envelope)
- Reduction in EUI of 47%

Ventilation and cooling scheme



Existing building - longitudinal section

Ventilation and cooling scheme

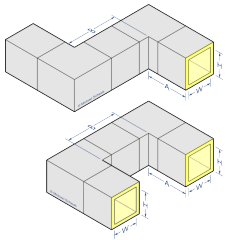


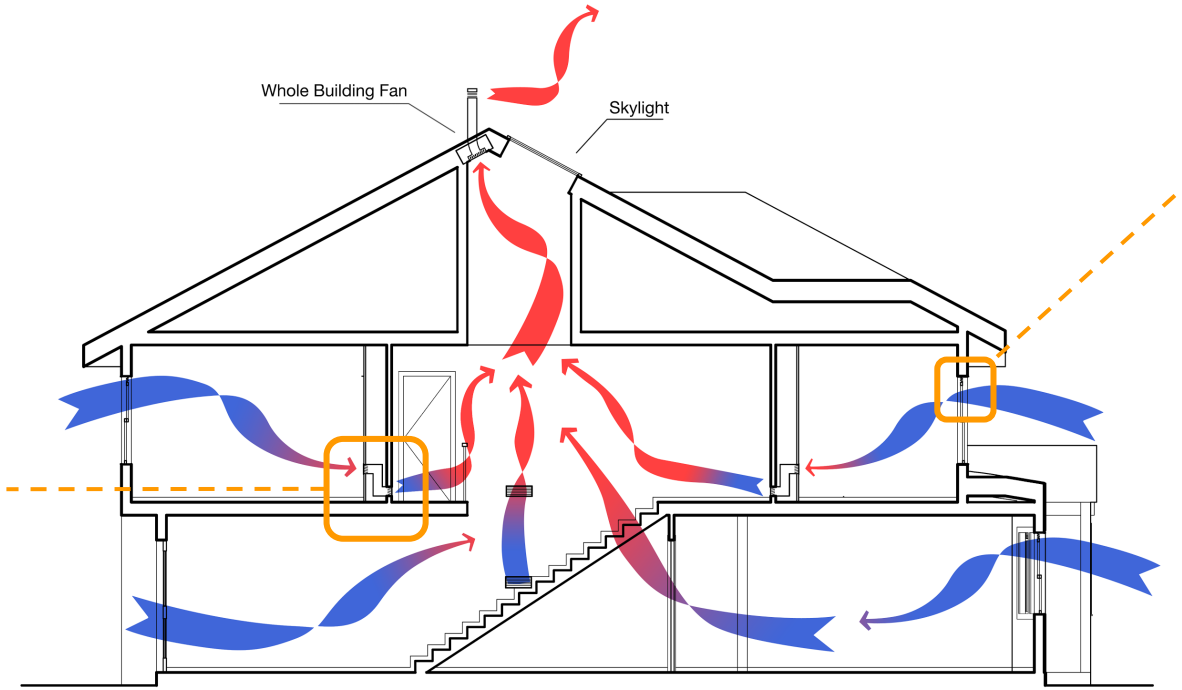
Proposed solution (step 1) - longitudinal section

Ventilation and cooling scheme

Window vent

Z-duct

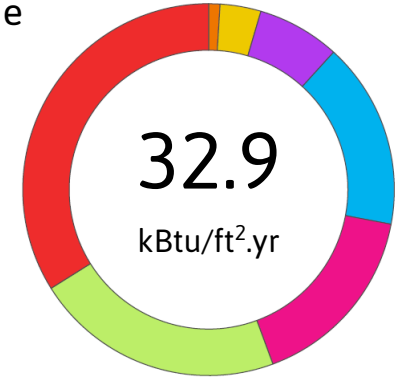




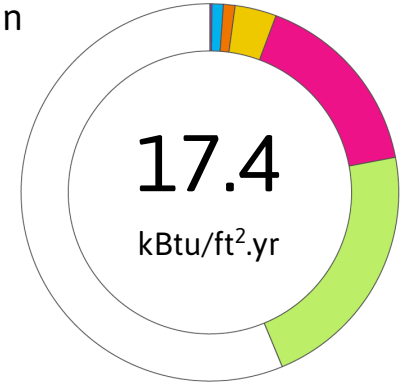
Proposed solution (step 2) - longitudinal section

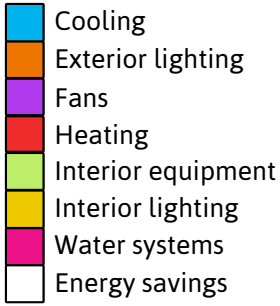
Thermal mass + night flush

Baseline



Solution





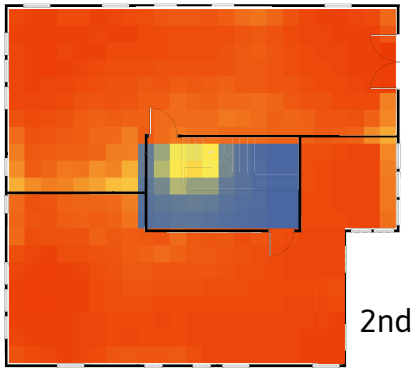
- Cumulative strategies:
  - … + thermal mass and night flush +
  - expanded set points
- Night Flush + expanded set points:

	Minimum temp. [°F]	**Maximum temp. [°F]**
Typical Thermostat setpoints	64.4	73.4
Thermostat	60	84
Vent when indoor	64.4	73.4
Vent when outdoor	55	78

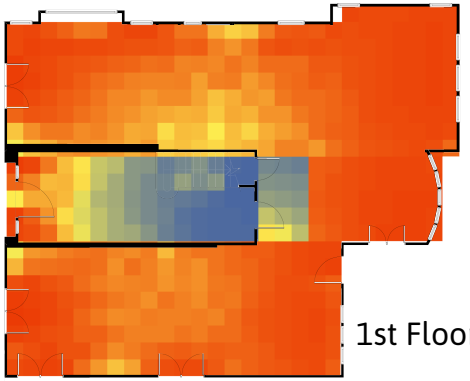
- Reduction in EUI of 56%

Daylighting

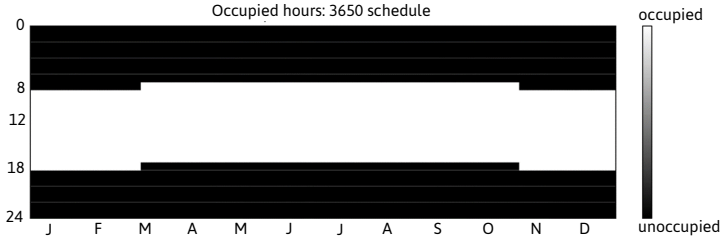
Daylight Autonomy 300 lux (DA_{300lux}): % of annual daytime hours that a given point in a space is above 300 lux in an occupied schedule



2nd Floor



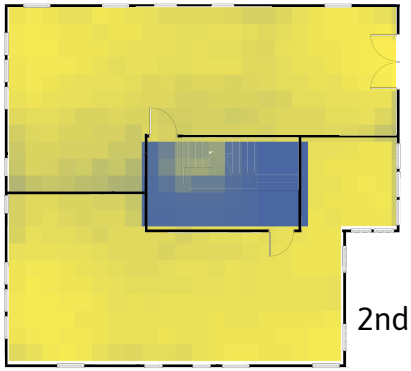
1st Floor



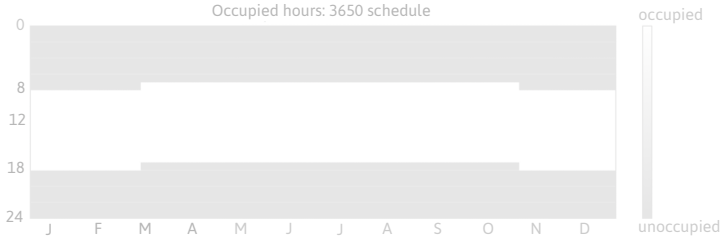
Daylighting

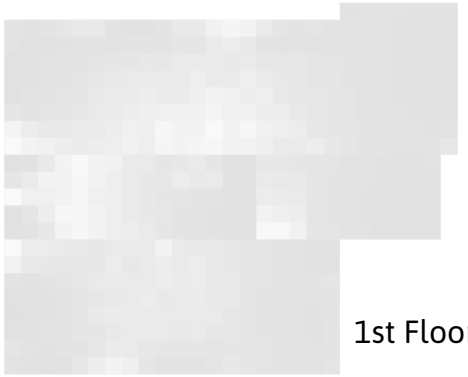
Daylight Autonomy 300 lux (DA_{300lux}): % of annual daytime hours that a given point in a space is above 300 lux in an occupied schedule

2nd Floor

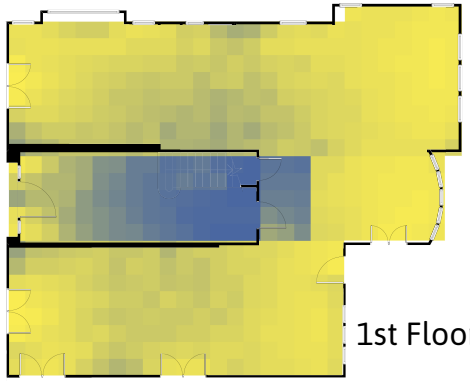


2nd Floor

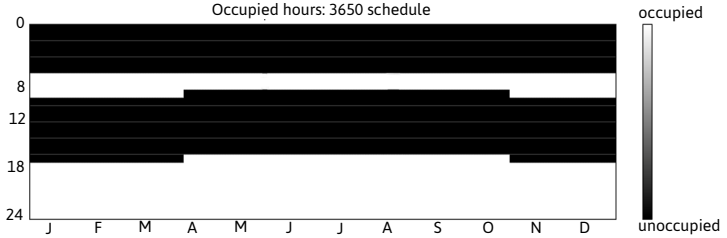




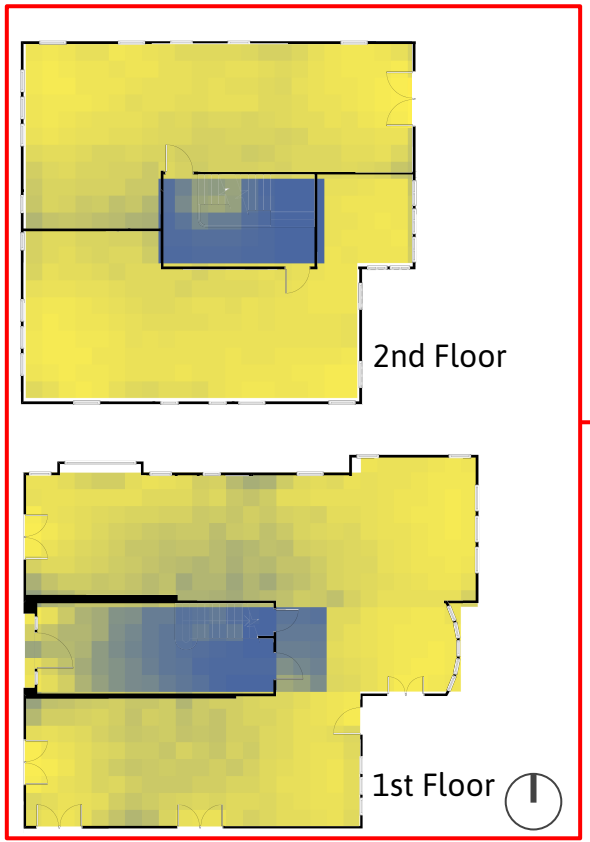
1st Floor



1st Floor



Lighting



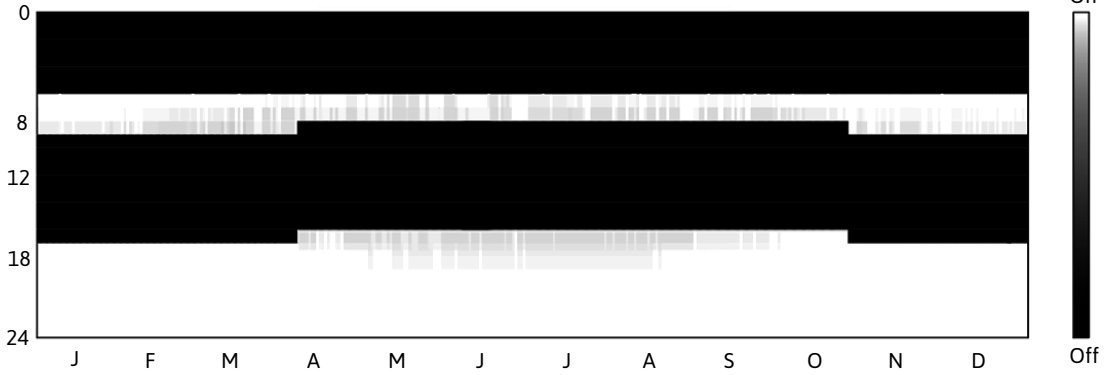
DA300lux

0% 100%

Compact Fluorescent Lights (CFL)

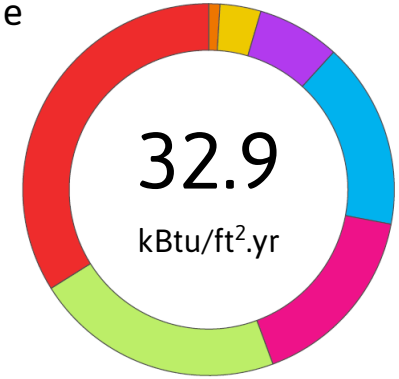
Light Emitting Diode (LED)

LPD schedule

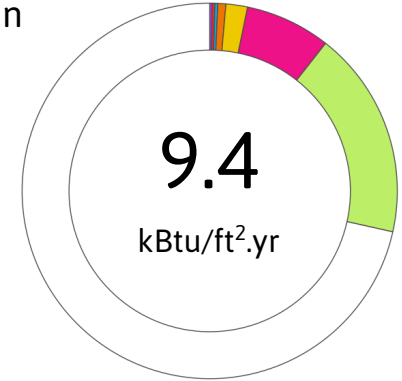


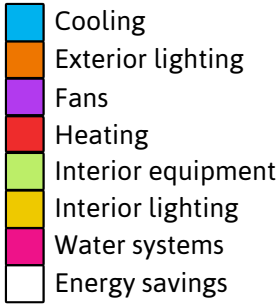
Lighting + appliances

Baseline



Solution

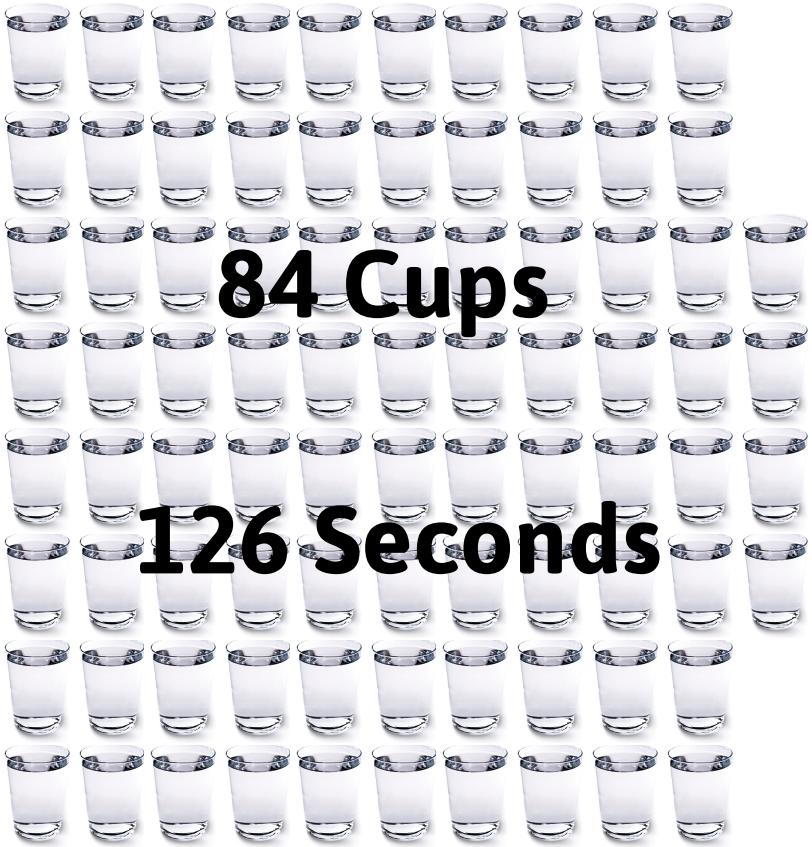




- Cumulative strategies:
  … + Lighting (LED + LPD schedule) + Energy Star equipment
- From Energy Star reports it was assumed that by using Energy Star products interior equipment would be 20% more efficient
- Final EUI a **71.5% reduction**

Appliances

Domestic Hot Water



84 Cups

126 Seconds

vs

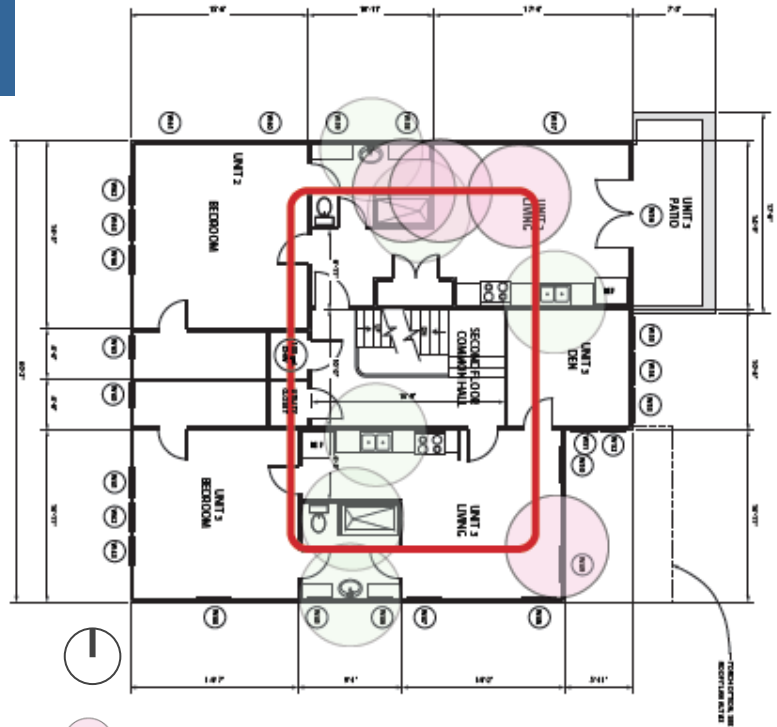
1 Cup

2.5 Seconds

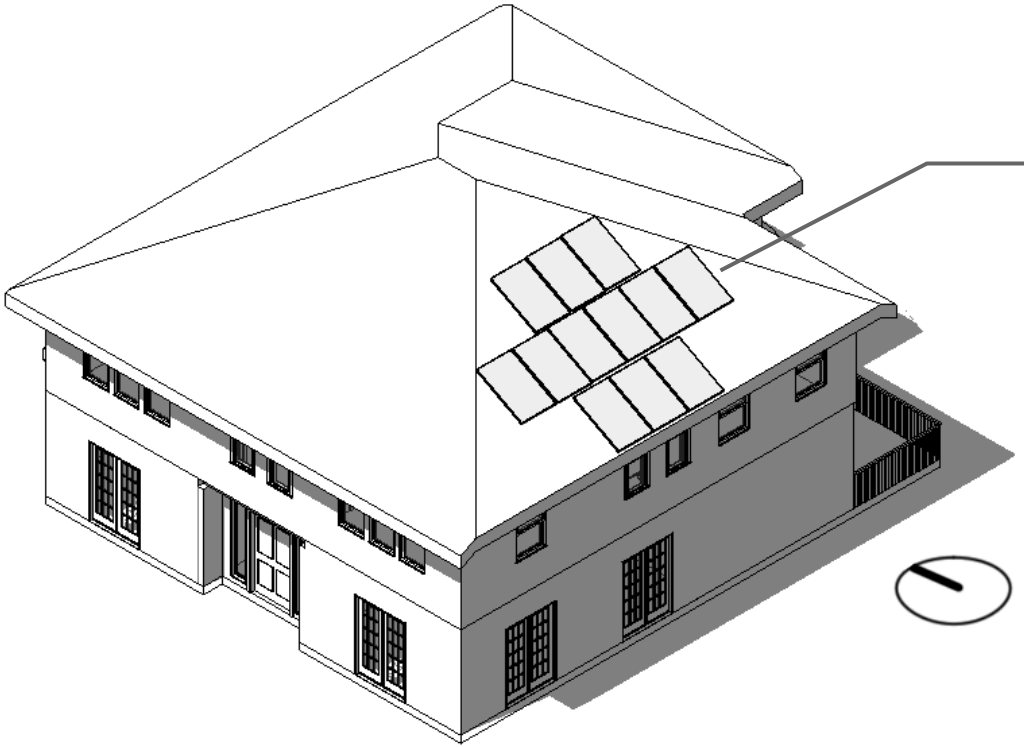
Domestic Hot Water

Demand Initiated Recirculating System

- Step 1: map out POUs
- Step 2: Main loop placement & sizing of recirc pump
- Step 3: size fixtures and connection lines



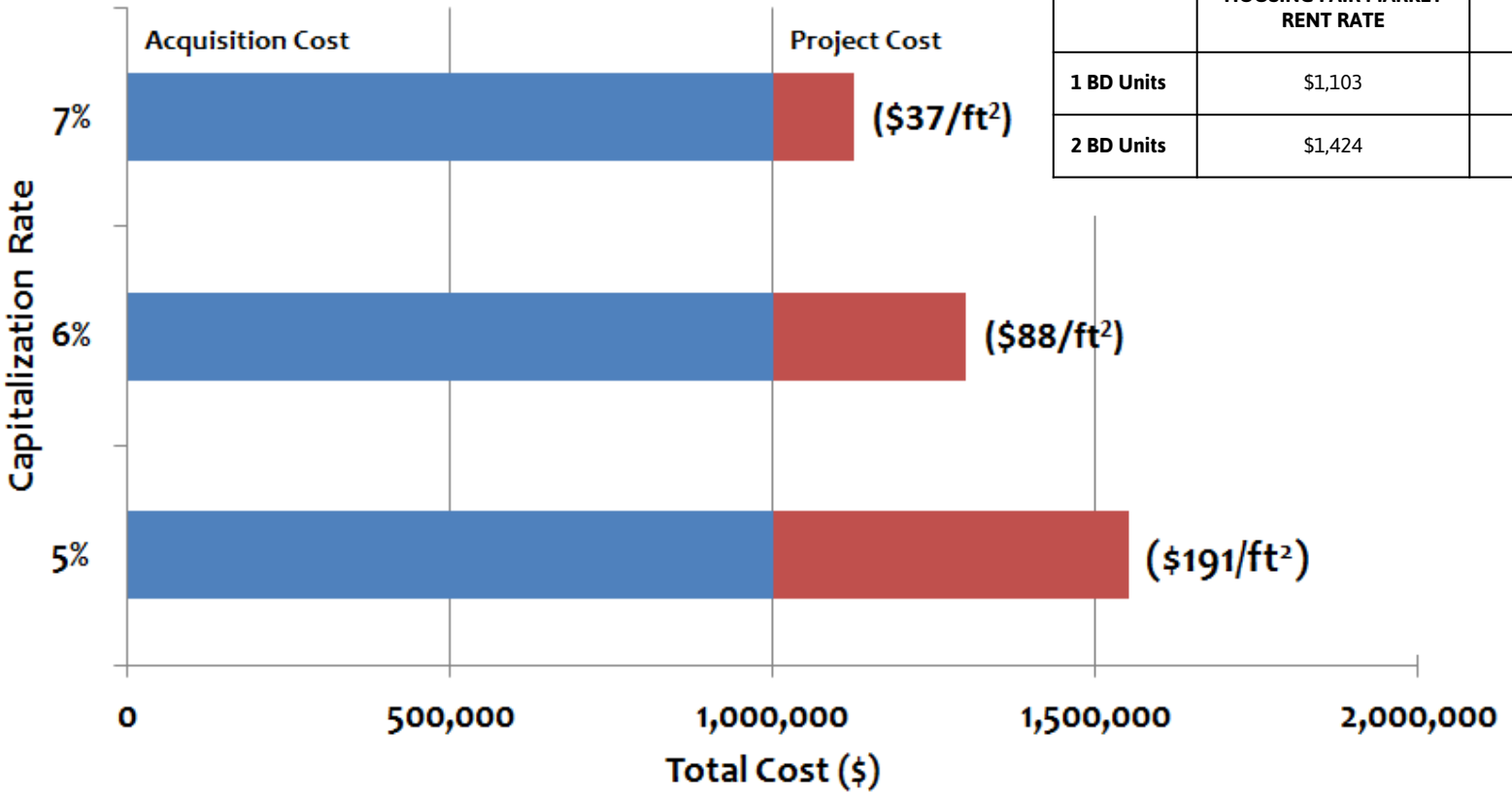
Solar PV



South facing roof
Array size: 10.5 kW
Energy Generation Intensity: 12.6 kBtu/ft^2.yr

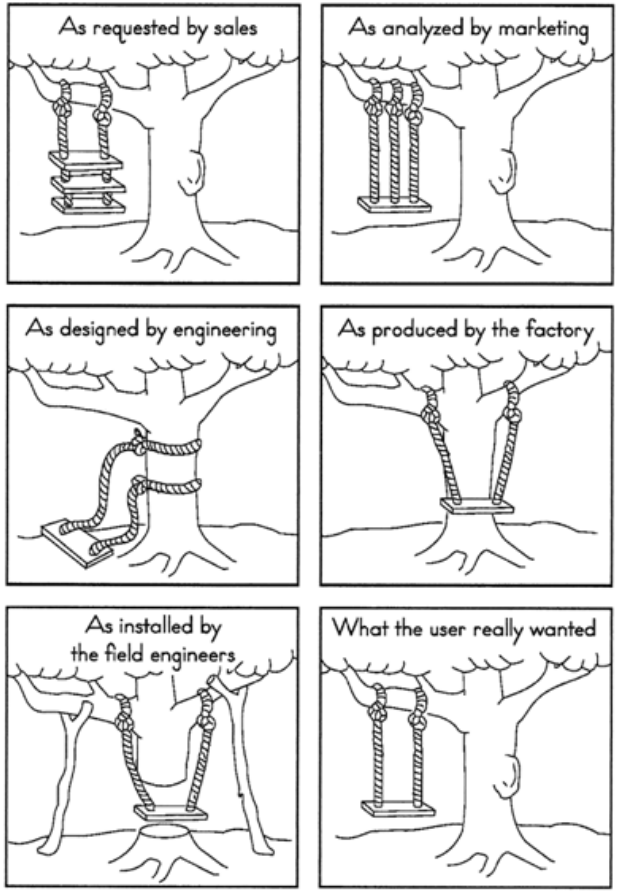
Financial analysis

	2014 HUD AFFORDABLE HOUSING FAIR MARKET RENT RATE	MARKET RATE KOREATOWN SEGMENT
1 BD Units	$1,103	$2,128
2 BD Units	$1,424	$4,200



Conclusions

- Existing Buildings is the Future of High-Performance Housing
- Increasing Density Multiples Performance
- User Needs is Central to Design Process
- Passive & Semi-Passive Design Strategies are integral in achieving ZNE
- It is possible to achieve ZNE even with requirements of historic preservation
- Energy modeling can be a driver for design



Source: Don Kite, *Parts Pups*, Nov. 1971, and *Reader's Digest*, October 1973.

Extra Slides

Air quality

Indoor air pollutant source control

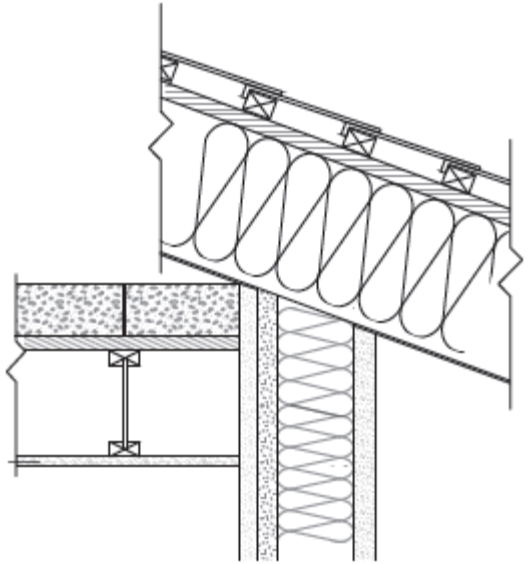
- Low-emitting finishes and furnishings
- No indoor combustion
- Exhaust fans in all bathrooms, kitchens
- Entry mats at all primary entrances
- No smoking in building or on property

Protection from outdoor sources

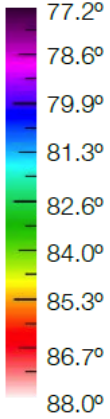
- Seal potential pest entry points
- Weatherstripping on doors, windows
- Seal penetrations, chases between units
- Low radon potential

Envelope

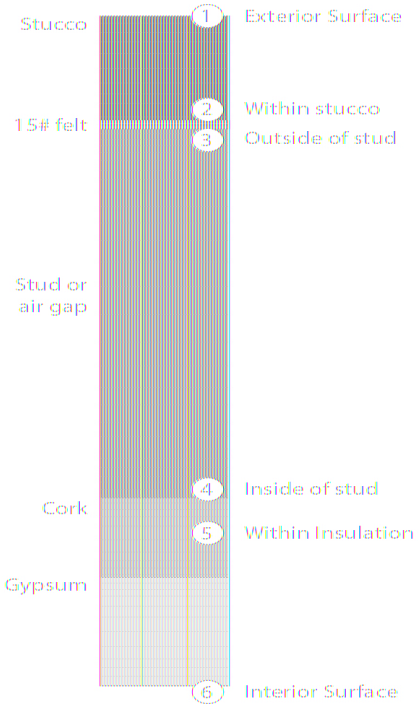
Roof Design

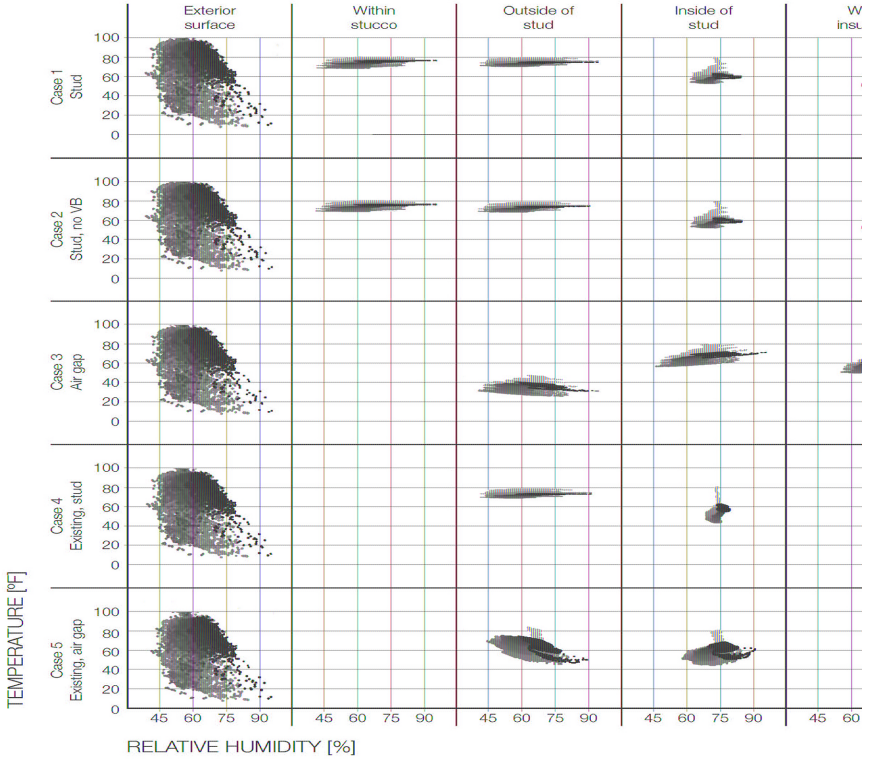


Roof/Wall Section Detail



Envelope


Stucco
15# felt
Stud or air gap
Cork
Gypsum
1 Exterior Surface
2 Within stucco
3 Outside of stud
4 Inside of stud
5 Within Insulation
6 Interior Surface


Exterior surface
Within stucco
Outside of stud
Inside of stud
Case 1 Stud
Case 2 Stud, no VB
Case 3 Air gap
Case 4 Existing, stud
Case 5 Existing, air gap
TEMPERATURE [°F]
RELATIVE HUMIDITY [%]