

NET-ZERO IIT



Illinois Institute of Technology



U.S. Department of Energy Race to ZERO
2016 Student Design Competition

PROJECT SUMMARY

Location: Chicago, IL

Area: 2,280 sq. ft/unit (4 units total)

4 bedrooms, 2 bathrooms, and 2 stories per unit

Wall Insulation = R-56

(Cavity insulation + continuous insulation)

Foundation Insulation = R-50

Roof Insulation = R-63

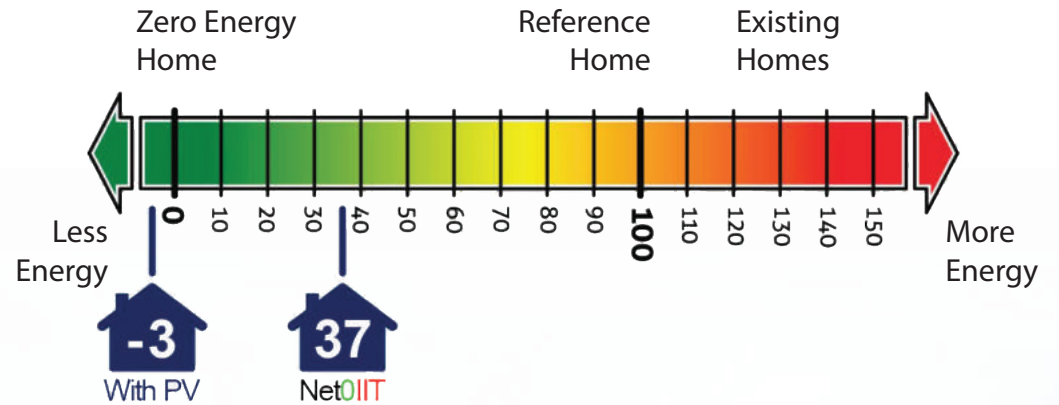
Window Performance = U-0.17 SHGC: 0.27

HVAC = SEER 22 and HSPF 10.0

mini-split heat pump

Estimated monthly energy cost

\$58/unit w/o PV; \$4/unit w/ PV



Design

Energy
Analysis

Envelope
Durability

IAQ

HVAC

Lighting
Water Heating

Financial
Analysis

Design



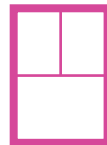
PROJECT SITE



SITE PLAN



ELEVATIONS



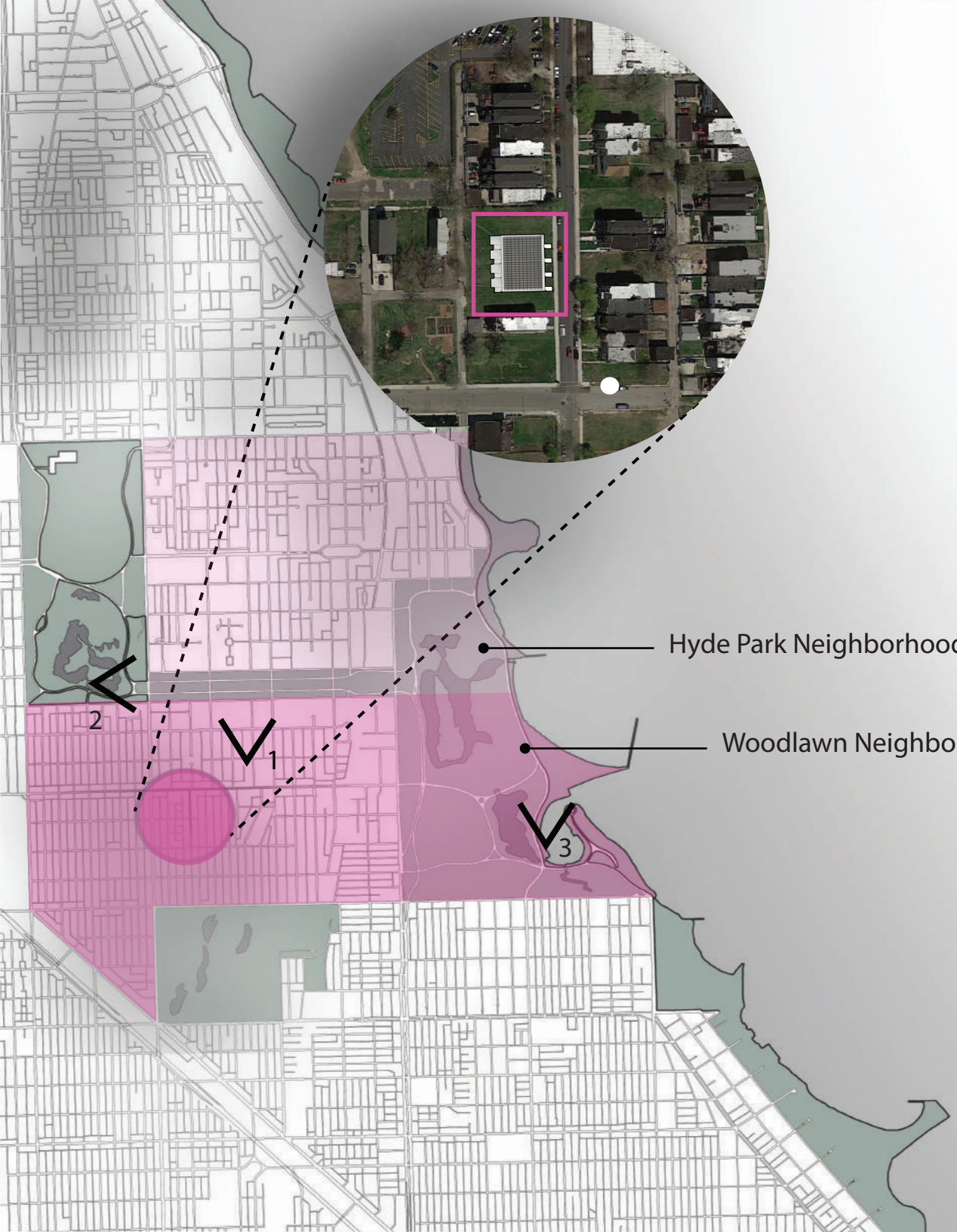
FLOOR PLANS



SECTION



Project



1 University of Chicago



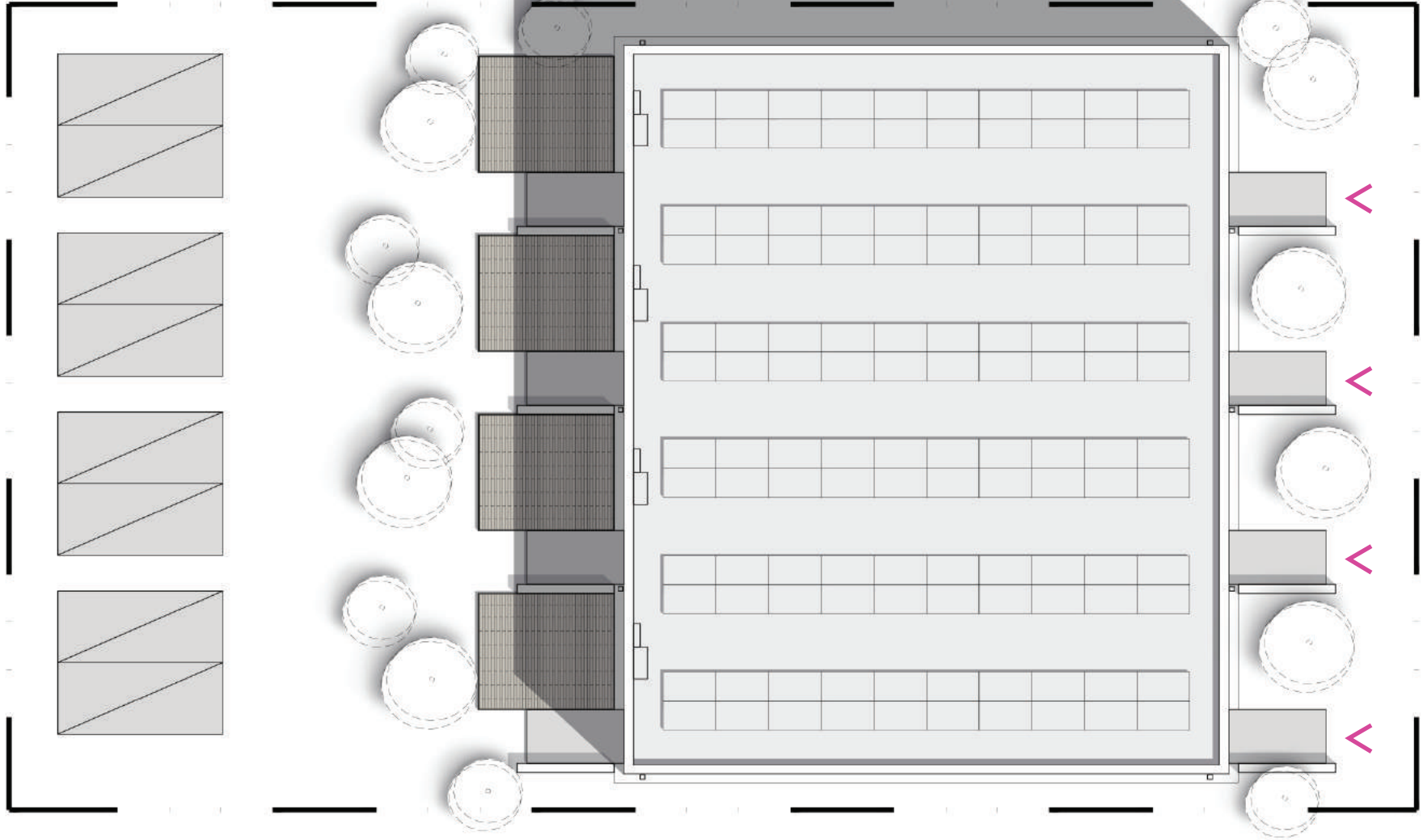
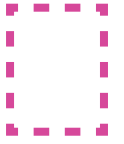
2 Midway Plaisance



3 Jackson Park

Hyde Park Neighborhood

Woodlawn Neighborhood



0 2' 5' 10' 20' 40'



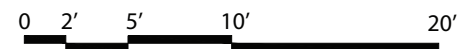
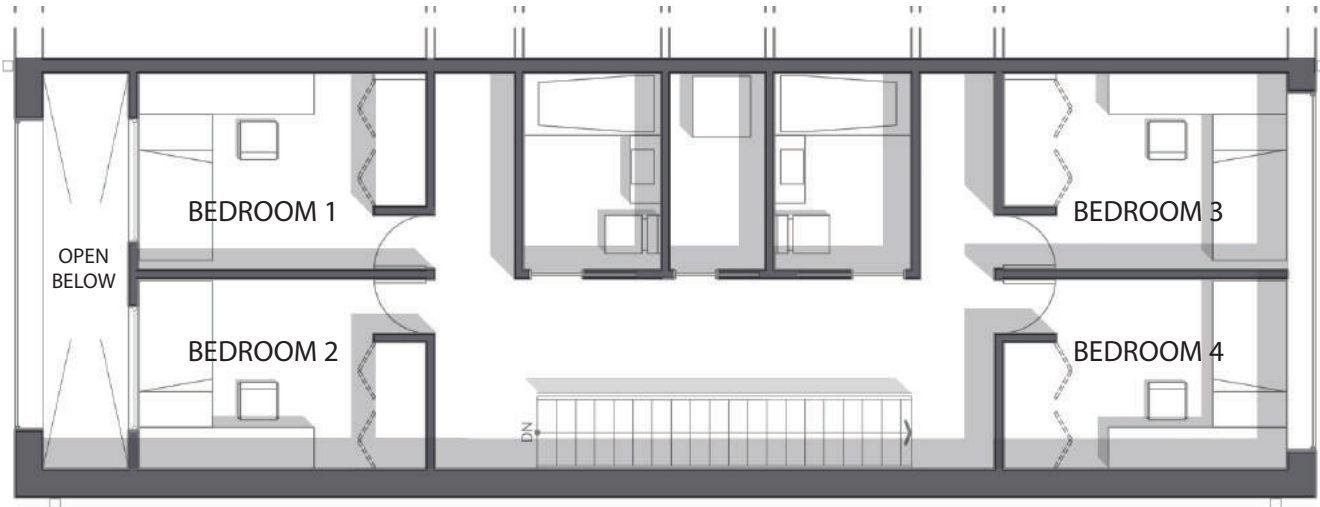
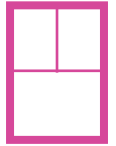
0 2' 5' 10' 20'

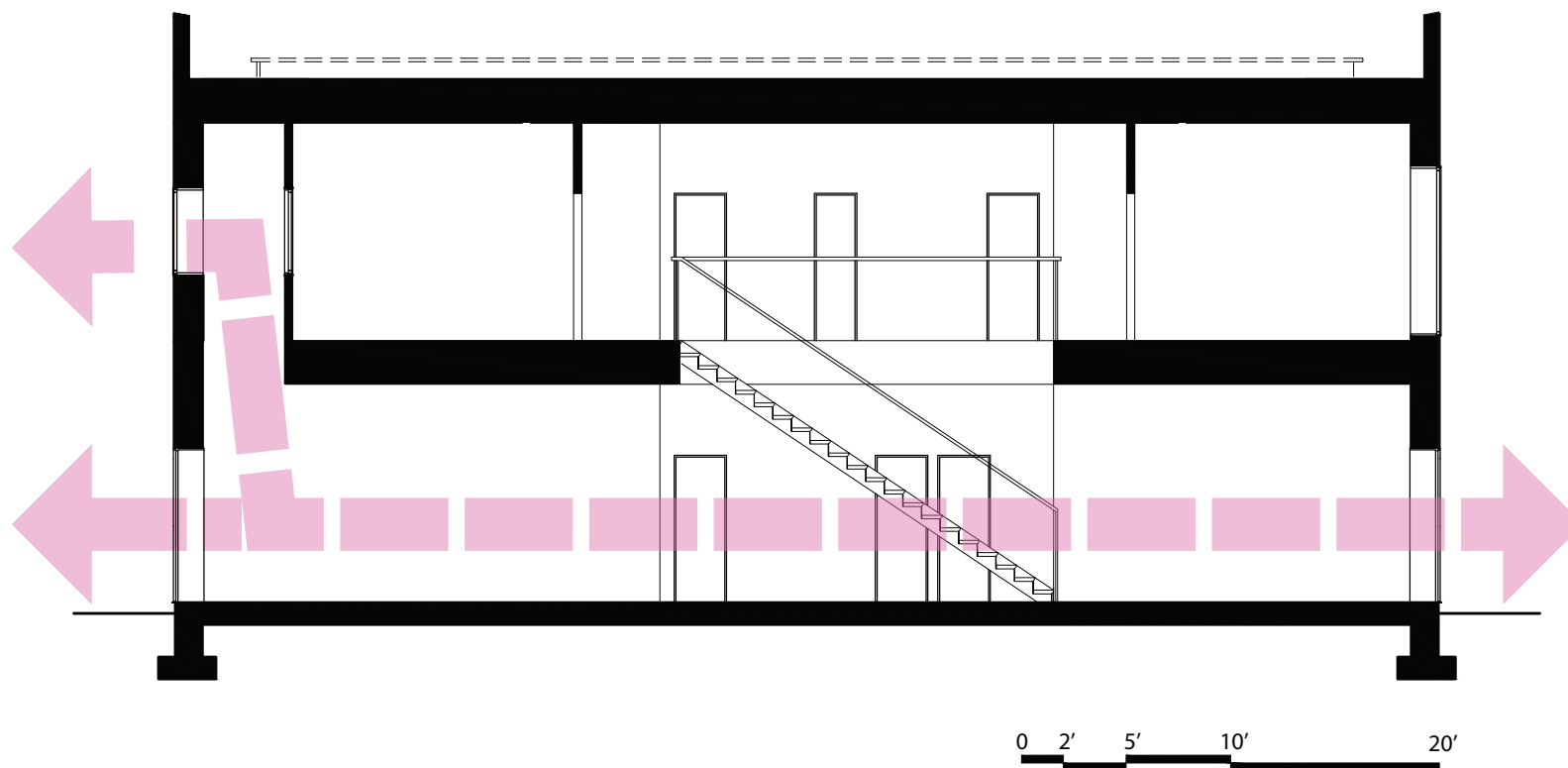


S Drexel ave



S Maryland ave





Energy Analysis

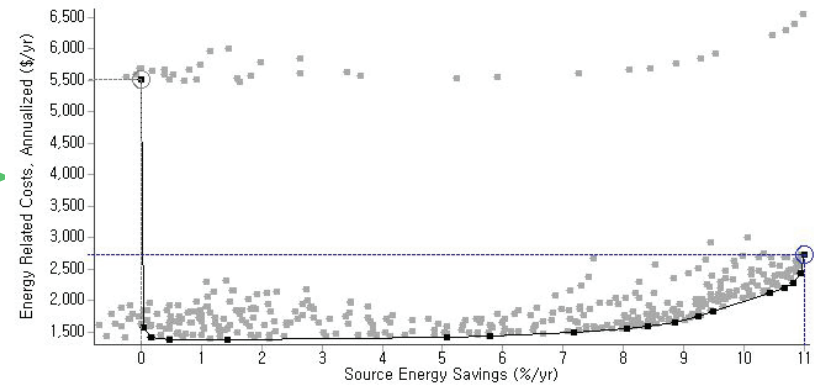
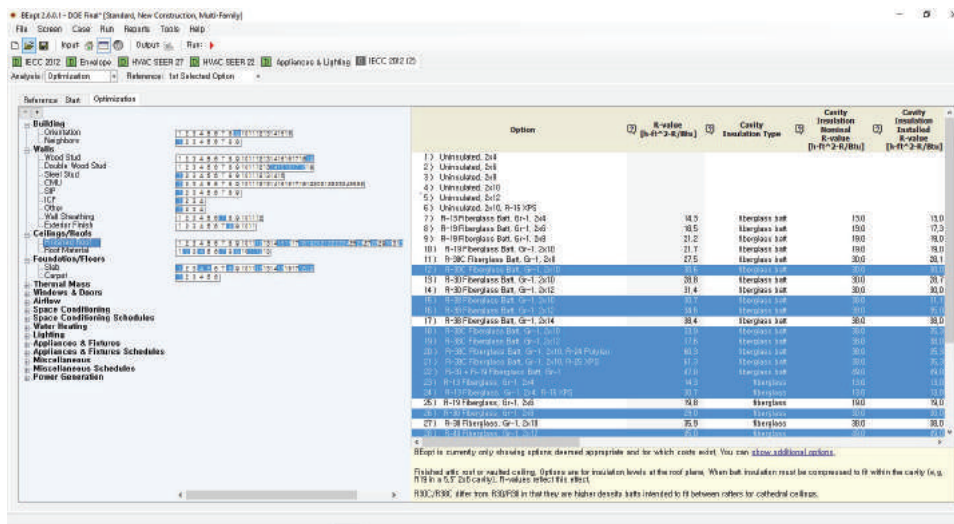
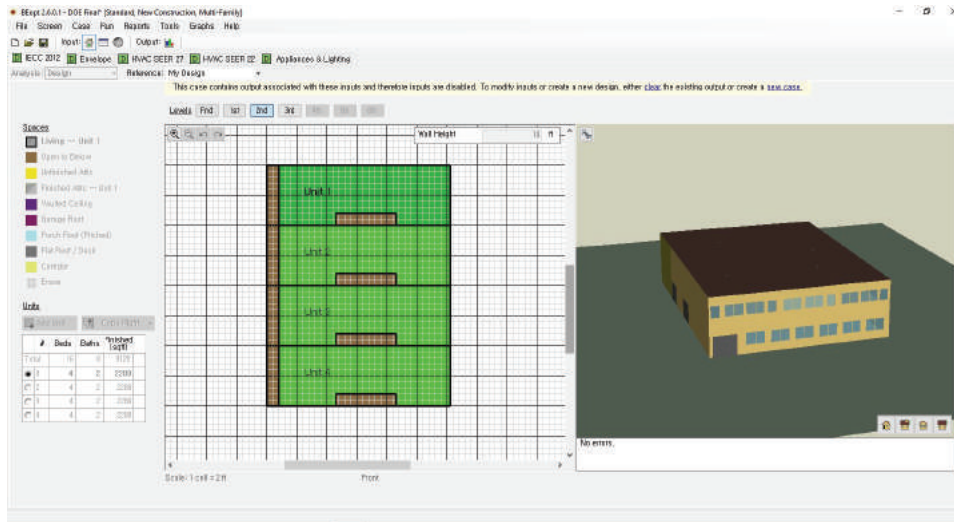


REDUCE ENERGY USE

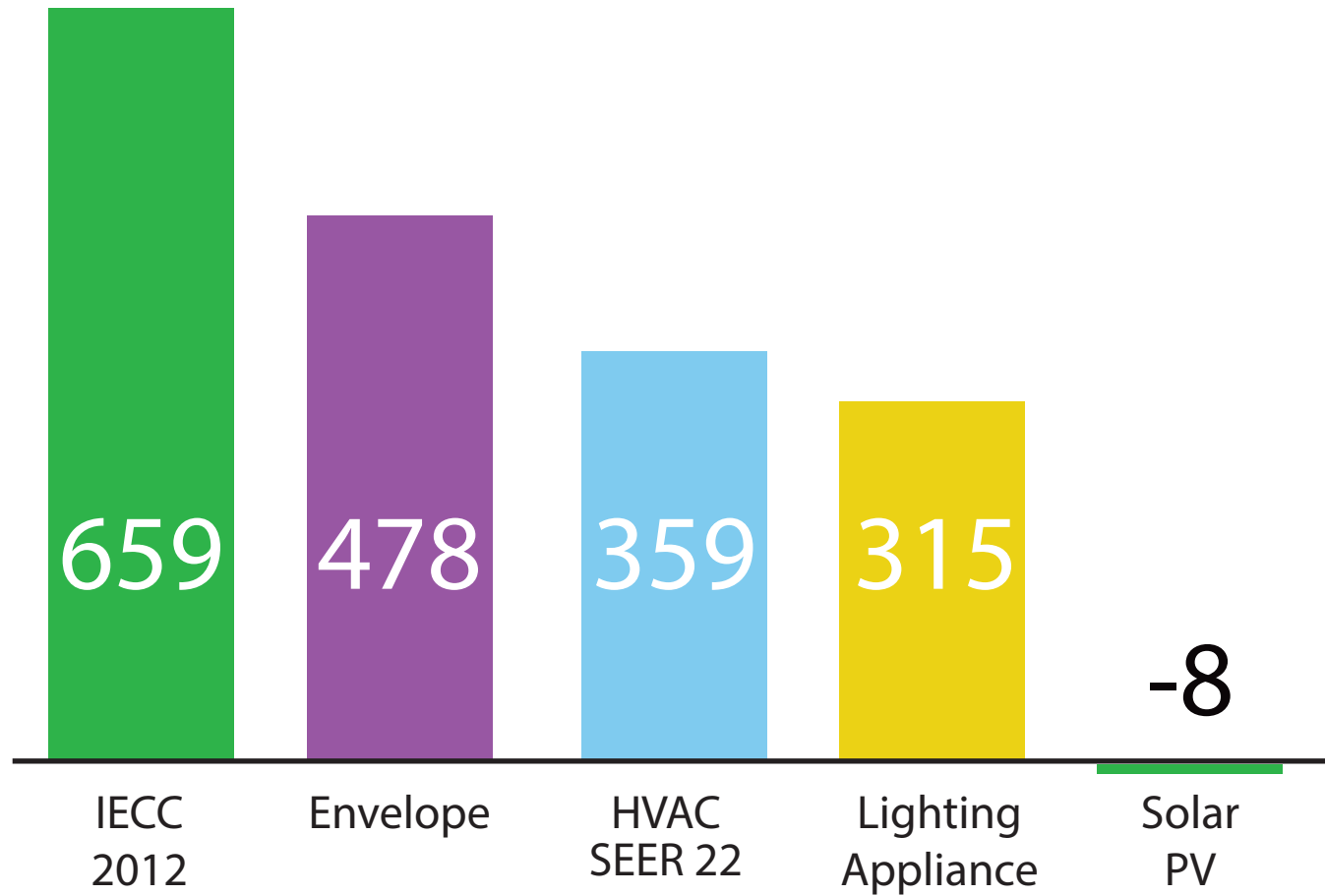


SOLAR PV

BEOPT ENERGY MODELING IN OPTIMIZATION MODE



ENERGY ANALYSIS RESULTS FROM BEOPT AND ENERGY PLUS



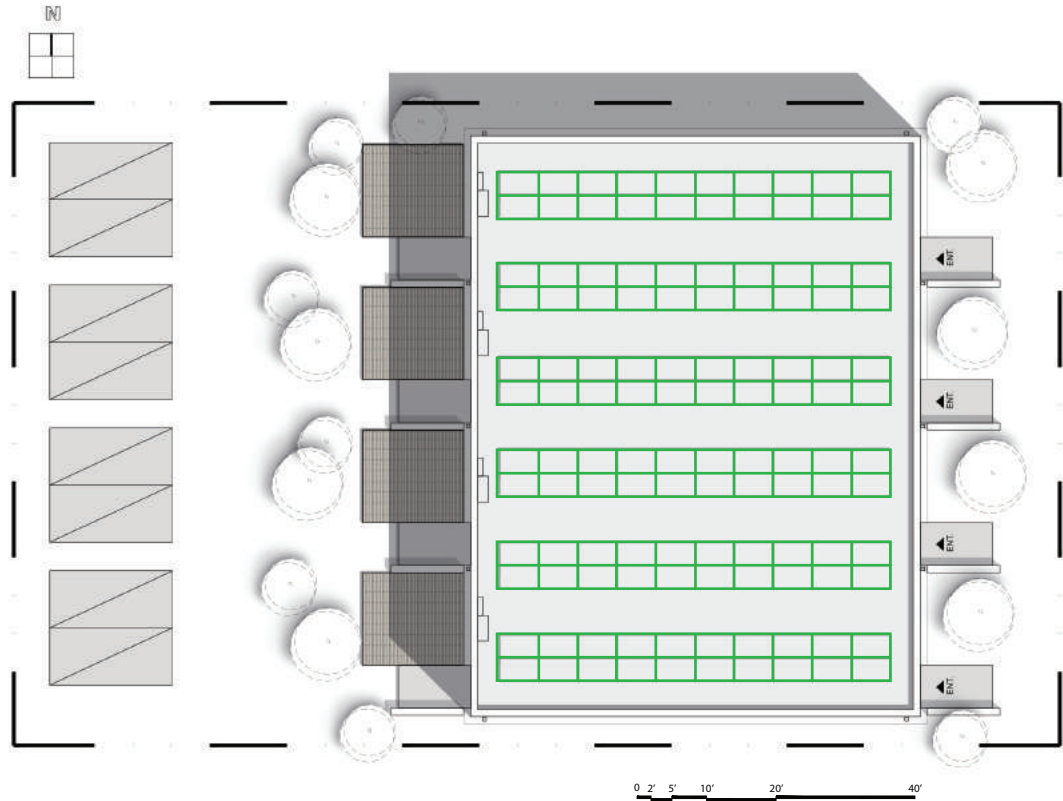
Unit: MMBTU/yr

PHOTOVOLTAIC (PV) SYSTEMS

323
MMBtu/yr



Month	AC Energy (MMBtu/yr)
Jan	13
Feb	17
Mar	26
Apr	33
May	41
Jun	42
Jul	43
Aug	35
Sep	28
Oct	21
Nov	13
Dec	10
Total	323



Area: 4,049 sf
 Module efficiency: 22%
 Inverter efficiency: 96%
 DC system size: 82 kW

Envelope Durability



REDUCE ENERGY LOSS



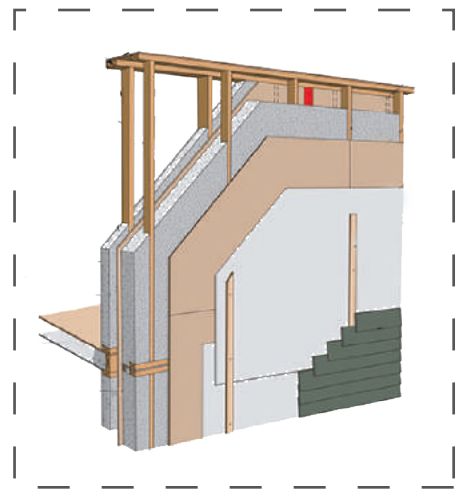
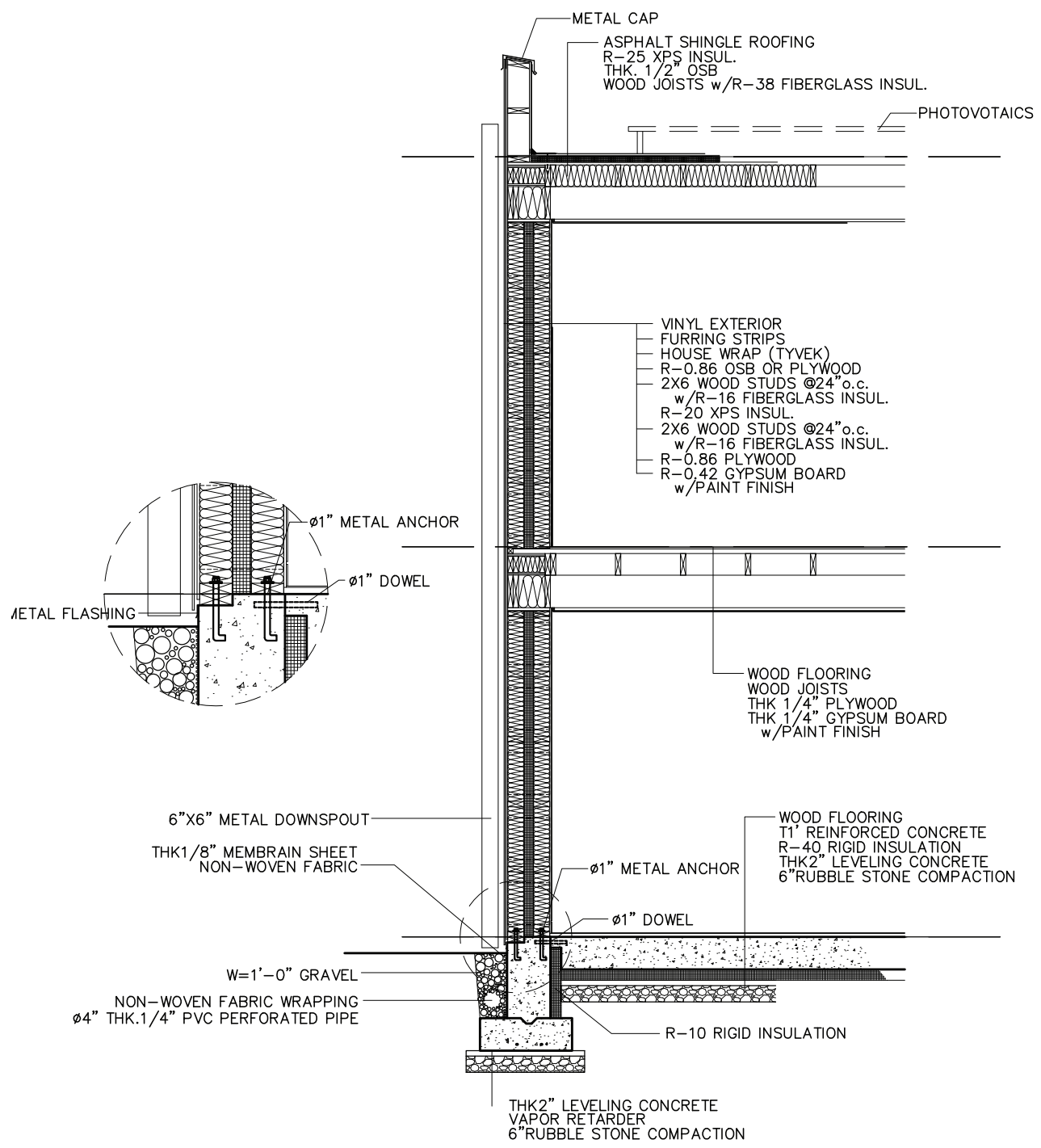
REDUCE UTILITY BILLS



CONSTRUCTABILITY



AVOID MOISTURE PROBLEMS



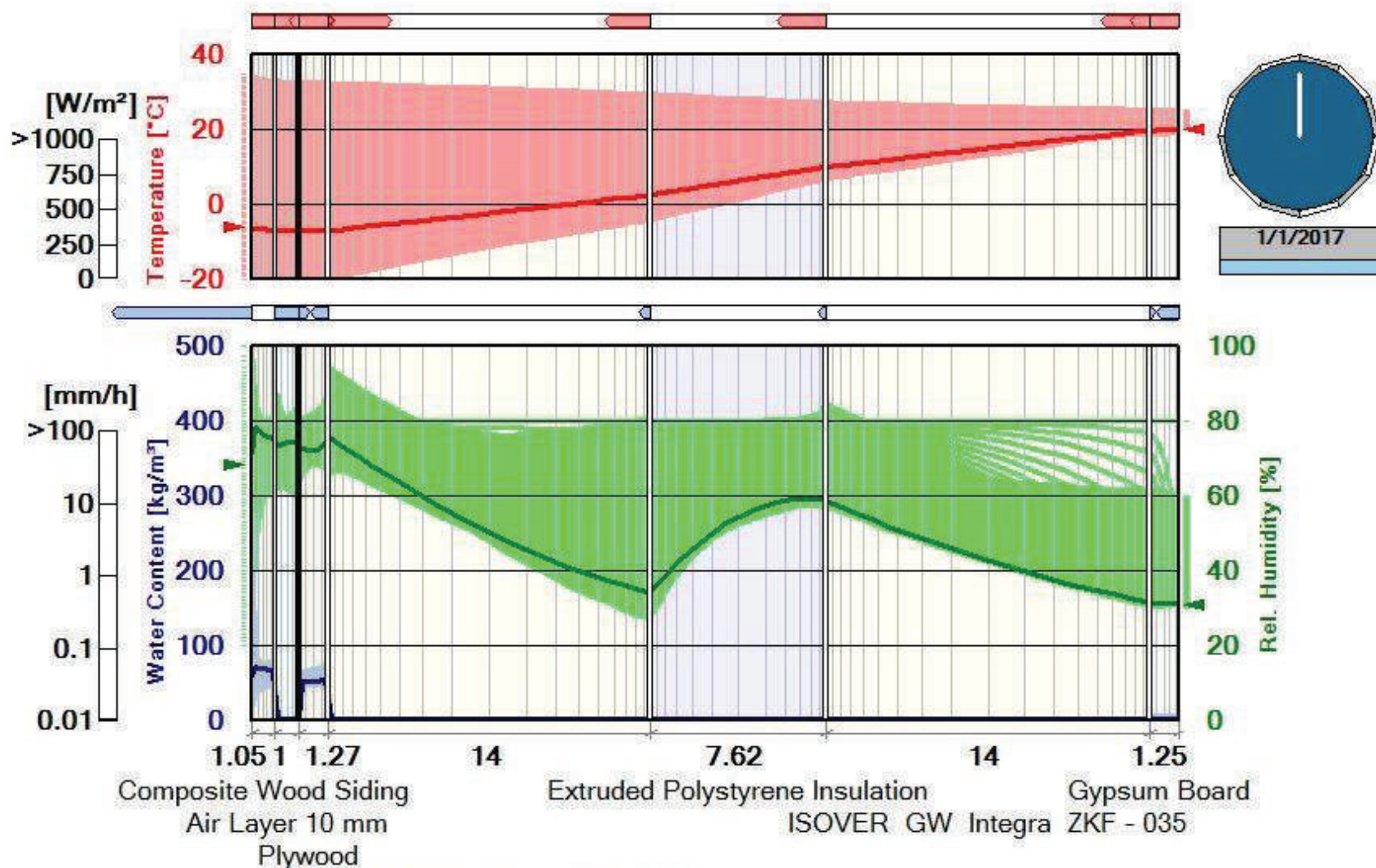
source: www.buildingscience.com



HYGROTHERMAL ANALYSIS

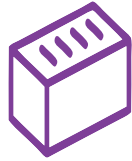
Location: Chicago, IL; cold year

WUFI

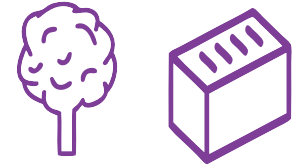




FRESH AIR



FINISH MATERIALS



PAINTING

Non-emitting VOC paint



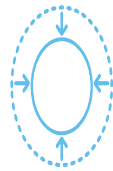
FURNITURE

Meeting CARB requirements

HARDWOOD FLOORING

Oak-natural Finish
Meeting CARB requirements
Low formaldehyde emissions

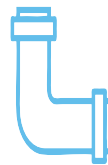
HVAC



PROPER EQUIPMENT SIZING



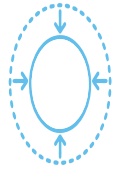
ENERGY-STAR EQUIPMENT



MINIMIZED DUCTWORK



PROVIDE THERMAL COMFORT



HEATING AND COOLING LOADS

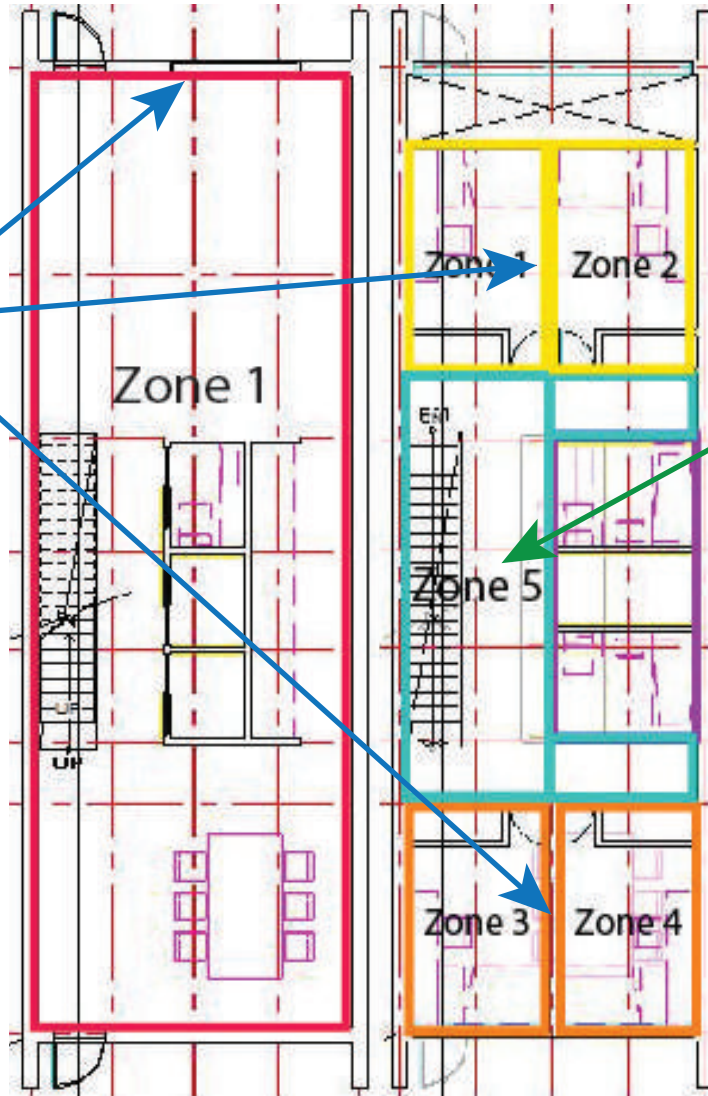
Unit	Cooling load (tons)	Heating load (kBtu/yr)
1	1	27
2	1	18
3	1	18
4	2	35
Total	5	98



ADVANTAGES OF AN AIR-SOURCE MINI-PLIT HEAT PUMP

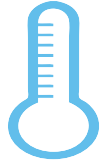


SPECIFYING THE MINI-SPLIT HEAT PUMP SYSTEM



Outdoor model	RAS-12EAV-UL	38GHQG36-3
Max # of zones	1	5
Cooling cap. range (tons)	0.2 ~ 1.2	0.7 ~ 3.0
SEER	23	21
Heating capacity (kBtu/h)	3 ~ 19	8.8 ~ 44.3
HSPF	10.0	10.2
Airflow (cfm)	406/438	4,531

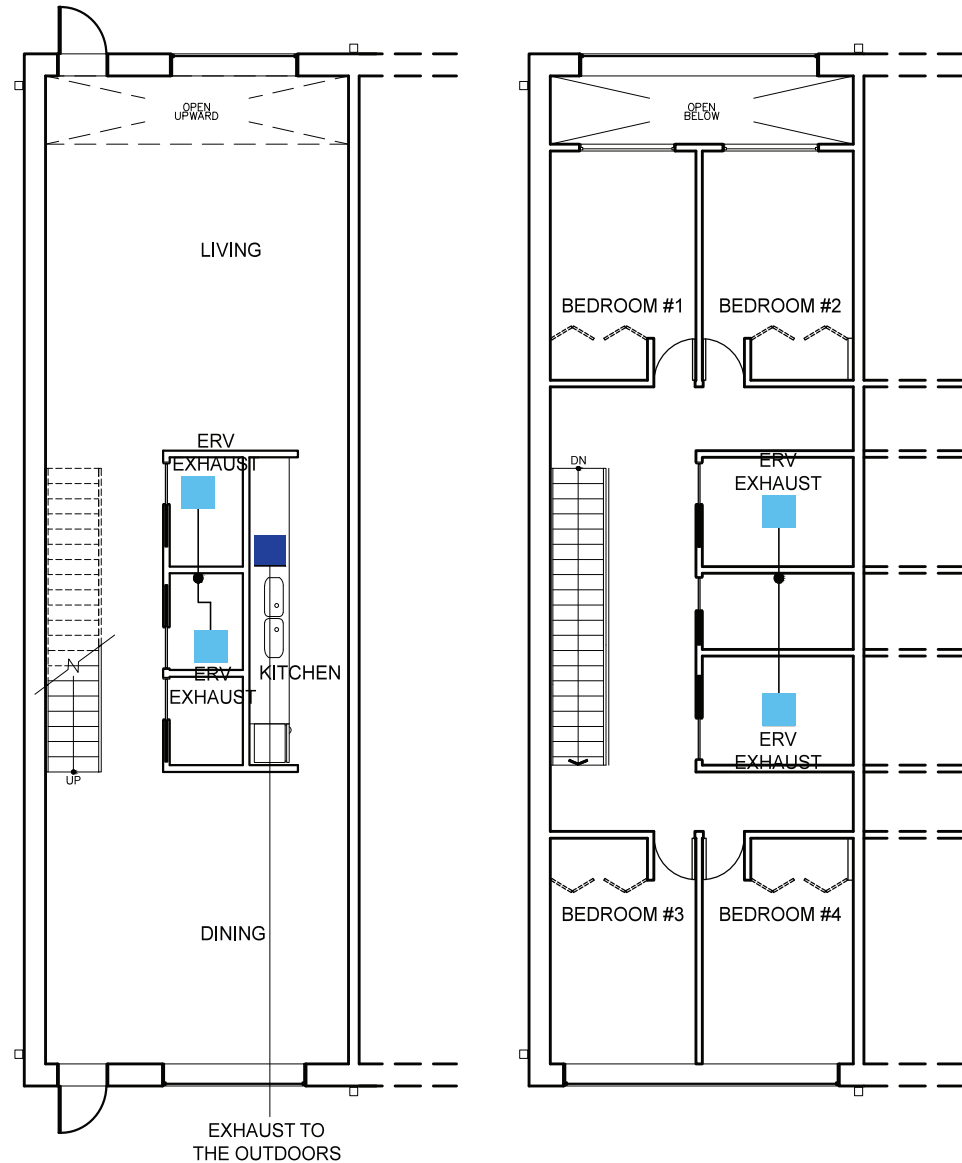
MECHANICAL VENTILATION



- Achieve up to 92 cfm (61 cfm is required)
- MERV 13 particle filter
- CO2 occupancy sensor



Zehnder comfoAir 160 ERV



Exhaust and vent

Lighting
Water Heating



PROVIDE SUFFICIENT LIGHTING



REDUCE ENERGY CONSUMPTION



ENERGY-STAR EQUIPMENT

ENERGY STAR REQUIREMENT



Energy Star Requirement



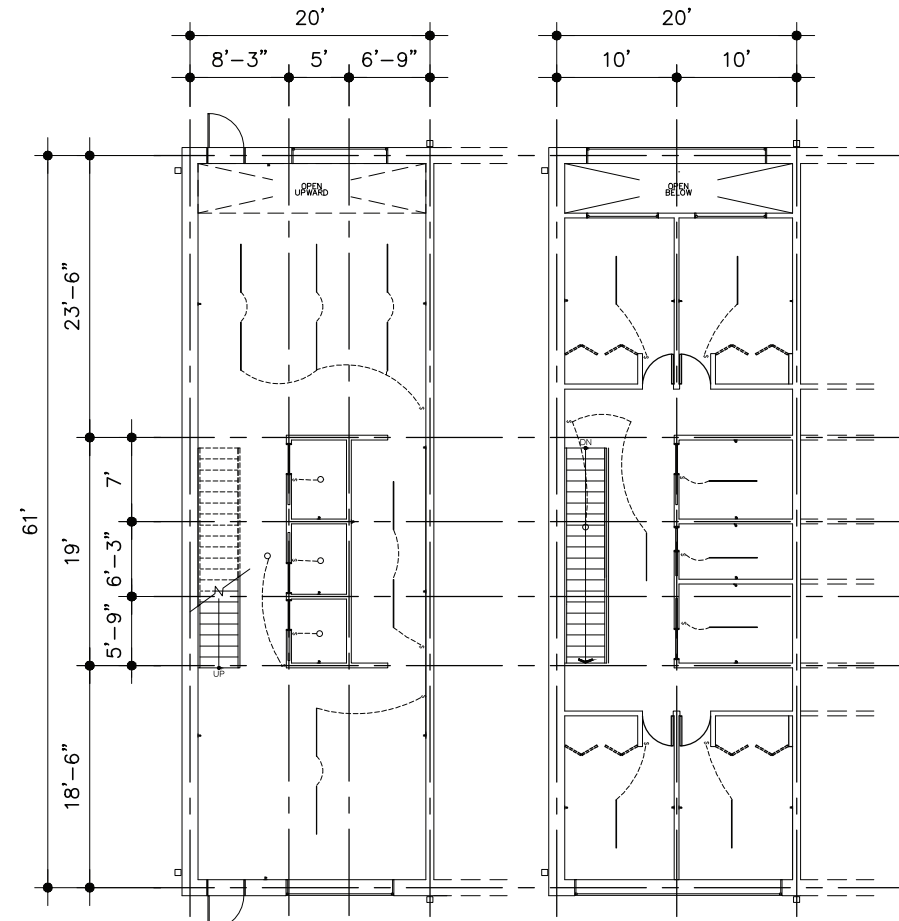
	Energy Star Requirement	Incandescent	CFL
Min Color Rendering Index	80	80	82
Min Luminous Efficacy (lm/W)	55	84	103
Min Lifetime (hrs)	25,000	25,000	40,000
Min Light Output (lm)	800	800	1500

LIGHTING DESIGN

5
MMBtu/yr



Room	Area (sq)	Illuminance (lm/sq)	Lumens / room (lm/sq)	Lumens of bulb (lm)	Number of bulbs (ea)	Watts (W)	Usage (hrs/day)	Number of rooms (ea)	Net Energy consumption (kWh/yr)
Dining	342	10	3420	1500	2	14.5	10	1	106
Kitchen	116	20	2320	1500	2	14.5	10	1	106
Living	434	20	8680	1500	6	14.5	15	1	476
Bedroom	100	20	2000	1500	2	14.5	10	4	423
Corridor (1st floor)	76	5	380	800	1	9.5	15	1	52
Bathroom	61	20	1220	1500	1	14.5	5	2	53
Storage (1st floor)	82	5	410	800	1	9.5	2	1	7
Stairway	70	5	350	800	1	9.5	15	1	52
Corridor (2nd floor)	250	5	1250	1500	1	14.5	15	1	79
Closet	43	5	215	800	1	9.5	2	1	7



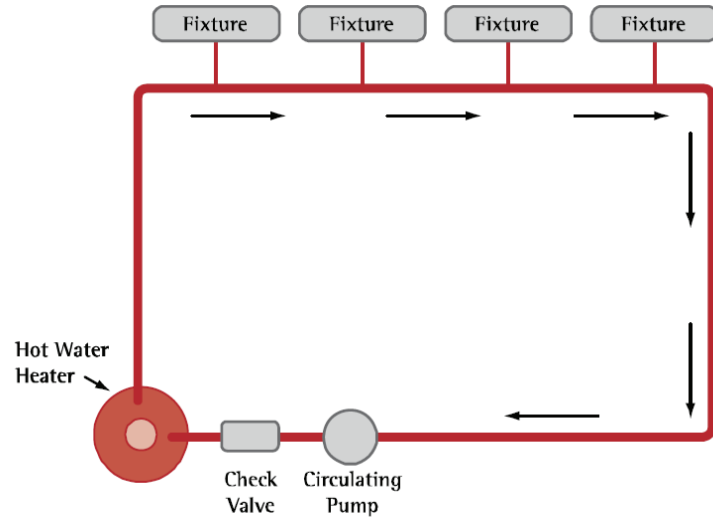
◦ Duplex Convenience Outlet
◦ GFCI Duplex Outlet

Total 1362
Net Energy in MMBTU/yr 5






DOMESTIC HOT WATER

Demand-initiated recirculation system



Rheem water heater 50 gal

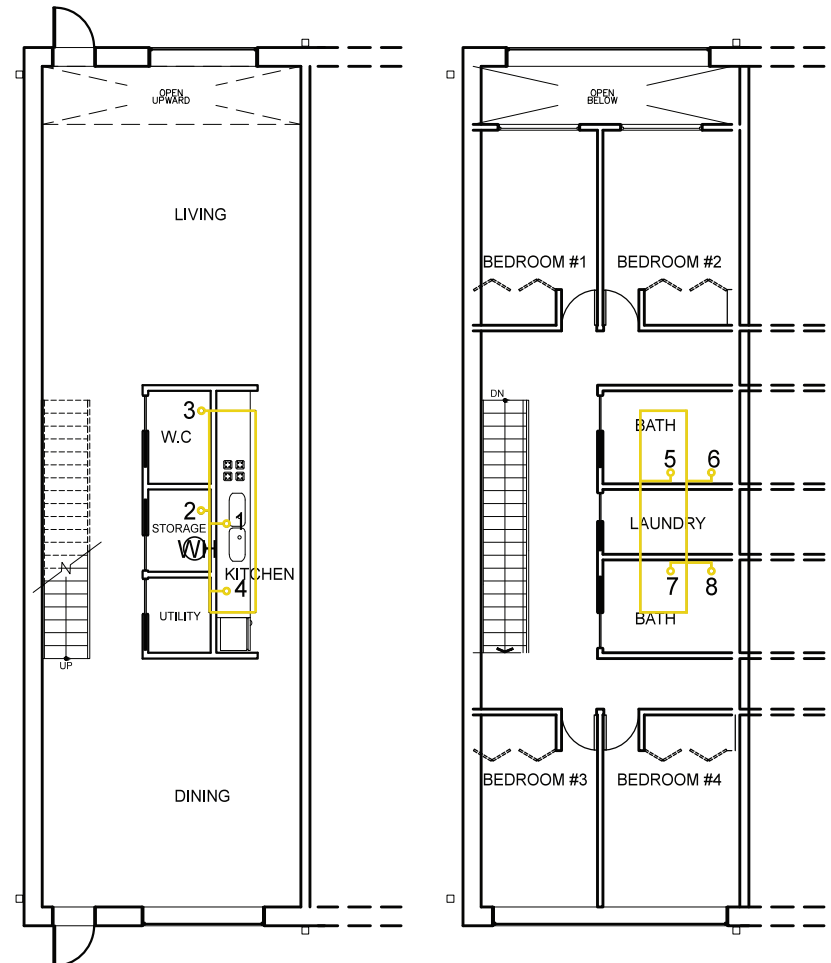


FIXTURES	SPECIFICATIONS	CERTIFICATION	GPM	PRICE (\$)
Kitchen faucet		Watersense	2.2	180
Lavatory faucet		Watersense	1.5	55
Dishwasher		Watersense	2.0	35

HOT WATER DELIVERY SYSTEM CALCULATIONS



Fixture	Pipe segment	Pipe diam. [in]	Water capacity [oz/ft]	Pipe length [ft]	Water volume [gal]
1st floor Kitchen sink	Drop from loop	1/2	1.89	1.75	0.026
	1	1/2	1.89	1.06	0.016
Total hot Water Volume [gal]					0.041
Hot Water Wait Time [sec]					1.132
1st floor Washing Machine	Drop from loop	1/2	1.89	0.93	0.014
	2	1/2	1.89	0.38	0.006
Total hot Water Volume [gal]					0.019
1st floor Lavatory sink	Drop from loop	1/2	1.89	7.1	0.105
	3	1/2	1.89	0.38	0.006
Total hot Water Volume [gal]					0.110
Hot Water Wait Time [sec]					4.418
1st floor Dish-washer	Drop from loop	1/2	1.89	26	0.384
	4	1/2	1.89	1.06	0.016
Total hot Water Volume [gal]					0.400
2nd floor Lavatory sink	Drop from loop	1/2	1.89	4.78	0.071
	5	1/2	1.89	2.56	0.038
Total hot Water Volume [gal]					0.108
Hot Water Wait Time [sec]					4.335
2nd floor Shower	Drop from loop	1/2	1.89	13.38	0.198
	6	1/2	1.89	2.2	0.032
Total hot Water Volume [gal]					0.230
Hot Water Wait Time [sec]					6.901
2nd floor Lavatory sink	Drop from loop	1/2	1.89	5.78	0.085
	7	1/2	1.89	1.57	0.023
Total hot Water Volume [gal]					0.109
Hot Water Wait Time [sec]					4.341
2nd floor Shower	Drop from loop	1/2	1.89	5.78	0.085
	8	1/2	1.89	2.2	0.032
Total hot Water Volume [gal]					0.118
Hot Water Wait Time [sec]					3.535



Financial Analysis



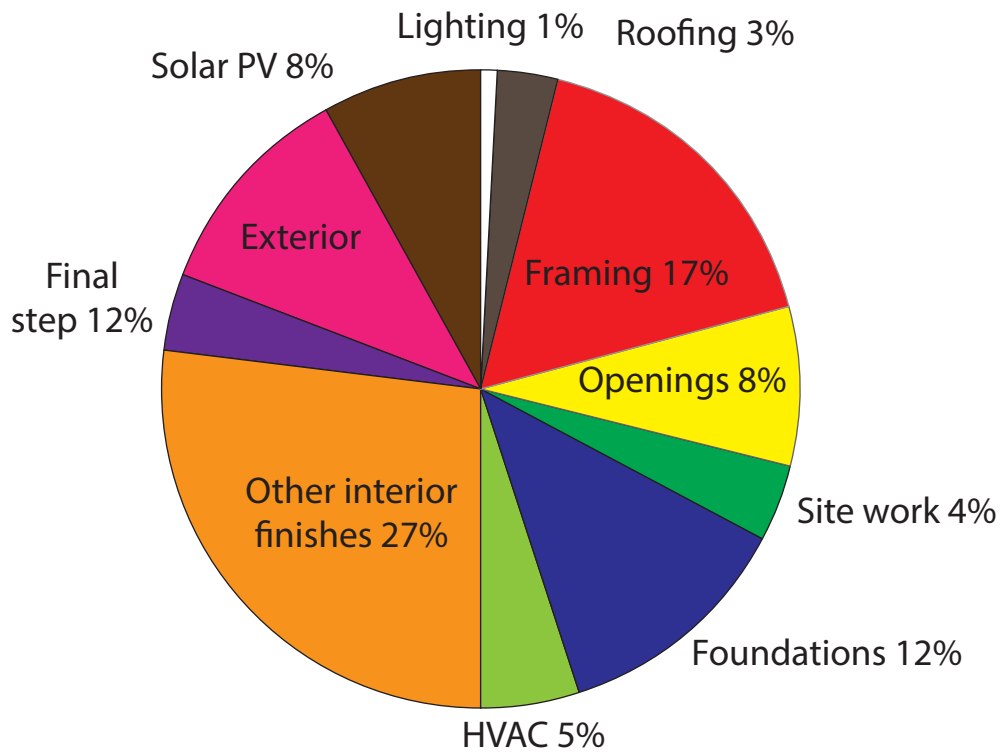
CONSTRUCTION COST



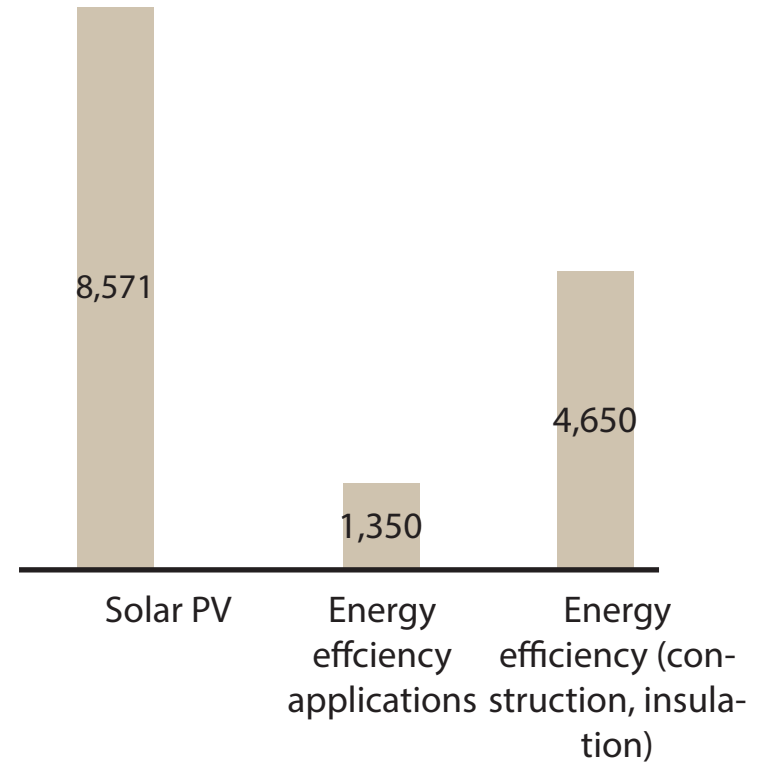
FINANCIAL ANALYSIS



CONSTRUCTION COST BREAKDOWN



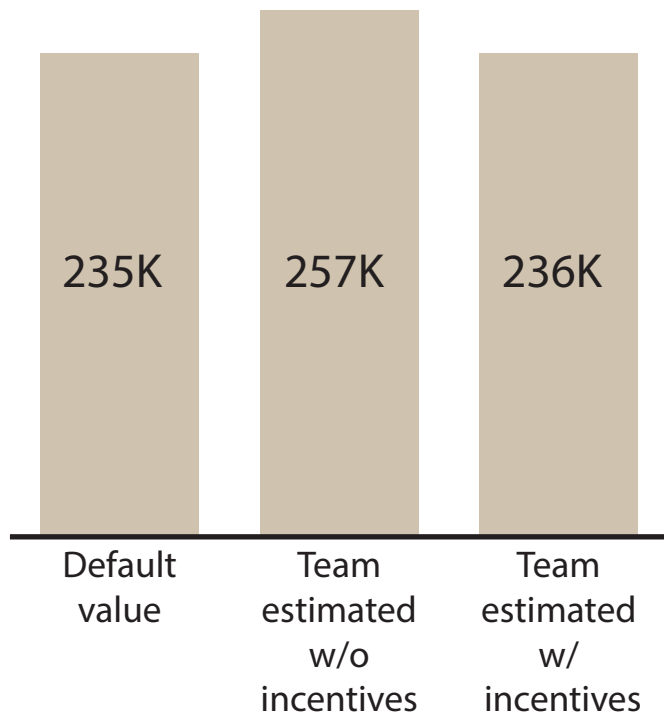
TOTAL INCENTIVES



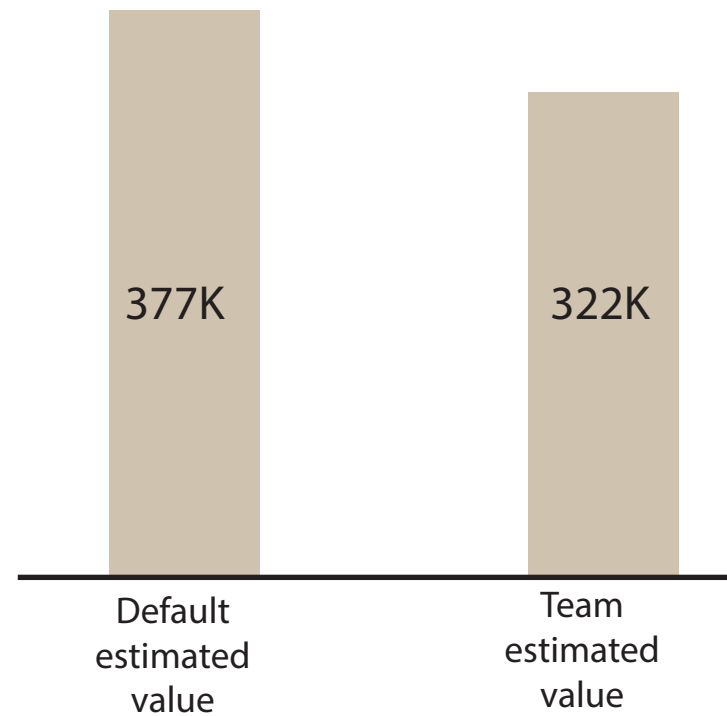
Unit: USD (\$)



CONSTRUCTION COST



SALE PRICE



Unit: USD (\$)

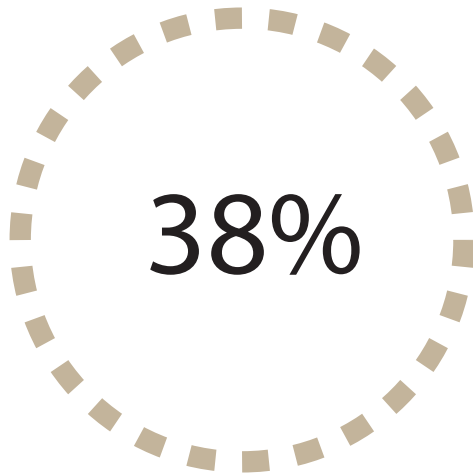


LOAN BREAKDOWN

Annual interest rate	3.5%
Years	30
Payments per year	12
Number of payments	360
Down payment	\$ 104,000
Principle amount	\$ 244,000
Monthly payment	\$ 1,093

DEBT TO INCOME RATIO

Monthly household Debt	\$ 30
Operations and maintenance costs	\$ 196
Monthly utility costs	\$ 22
Property tax	\$ 541
Insurance	\$ 65
Mortgage payment	\$ 1,093
Calculated debt to income ratio	38%



DEBT TO INCOME RATIO



PAYBACK PERIOD FOR SOLAR PV