Testing Form and Function

Through WUFI Feasibility Studies

phiuscon
NEW YORK 2021

ICON ARCHITECTURE

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Overview:

1. WHAT IS A FEASIBILITY STUDY?
2. MODEL INPUTS
3. REPRESENTING THE RESULTS
4. LEARNING FROM THE ANALYSIS
5. CASE STUDIES

Overview:

1. WHAT IS A FEASIBILITY STUDY?
    - 1a. Purpose & Scope
        - Incentives from MassSave
    - 1b. ICON's Experience
2. MODEL INPUTS
3. REPRESENTING THE RESULTS
4. LEARNING FROM THE ANALYSIS
5. CASE STUDIES

1a. INCENTIVES

WHAT IS A FEASIBILITY STUDY?

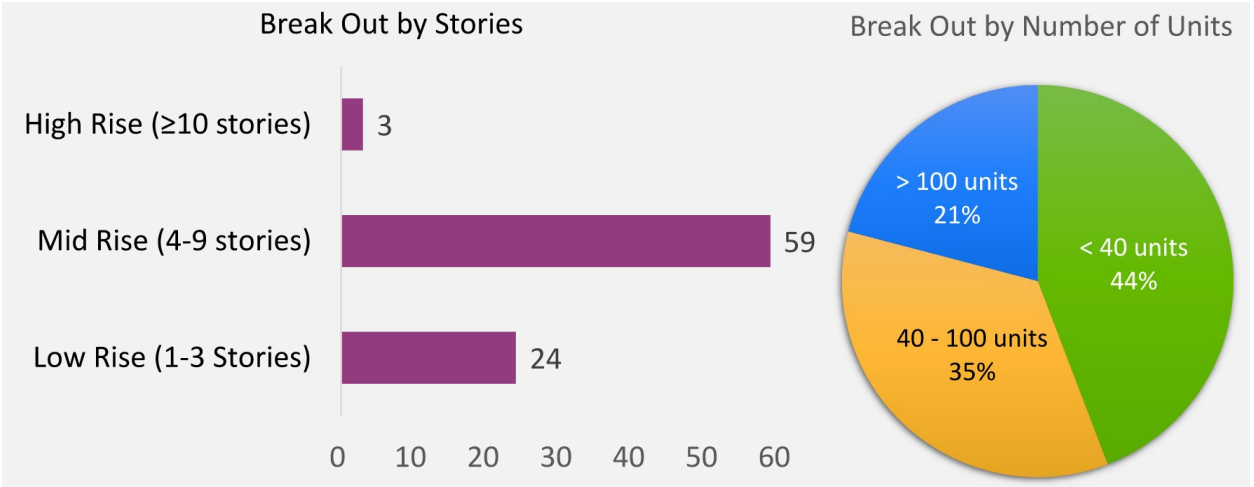
- Identify Passive House standards
- Mechanical system strategies
- Thermal bridging strategies
- Envelope assemblies
- Team Charrette

Passive House Incentive Structure for Multi-Family Buildings
(5 units or more)

Incentive Timing	Activity	Incentive Amount	Max. Incentive
Pre-Construction	Feasibility Study	100% of Feasibility costs	$5,000
	Energy Modeling	75% of Energy Model costs	$500/unit, max. $20,000
	Pre-Certification	$500/unit	N/A
Post-Construction	Certification	$2,500/unit	
	Net Performance Bonus	$0.75/kWh	
		$7.50/therm	

Average Project:
- 73 Units
- 85,000 SF

All construction types:
- Steel frame
- Wood Frame
- Podium



Stats & Graphics Provided by Mass Save

1b. ICON EXPERIENCE

PASSIVE HOUSE PROJECTS & FEASIBILITY STUDIES

1b. ICON EXPERIENCE

PASSIVE HOUSE PROJECTS & FEASIBILITY STUDIES

THE DISTILLERY: 2018

PEABODY: UNDER-CONSTRUCTION

3 HAWKINS STREET: UNDER-CONSTRUCTION

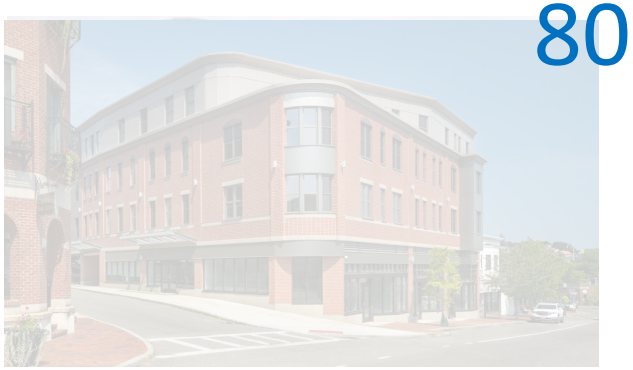
MULTI-FAMILY HOUSING PROJECTS

FINCH CAMBRIDGE: 2020

LEAVITT: UNDER-CONSTRUCTION

555 MERRIMACK: CONSTURCTION STARTING 2022

RANGING FROM 21 TO 98 UNITS



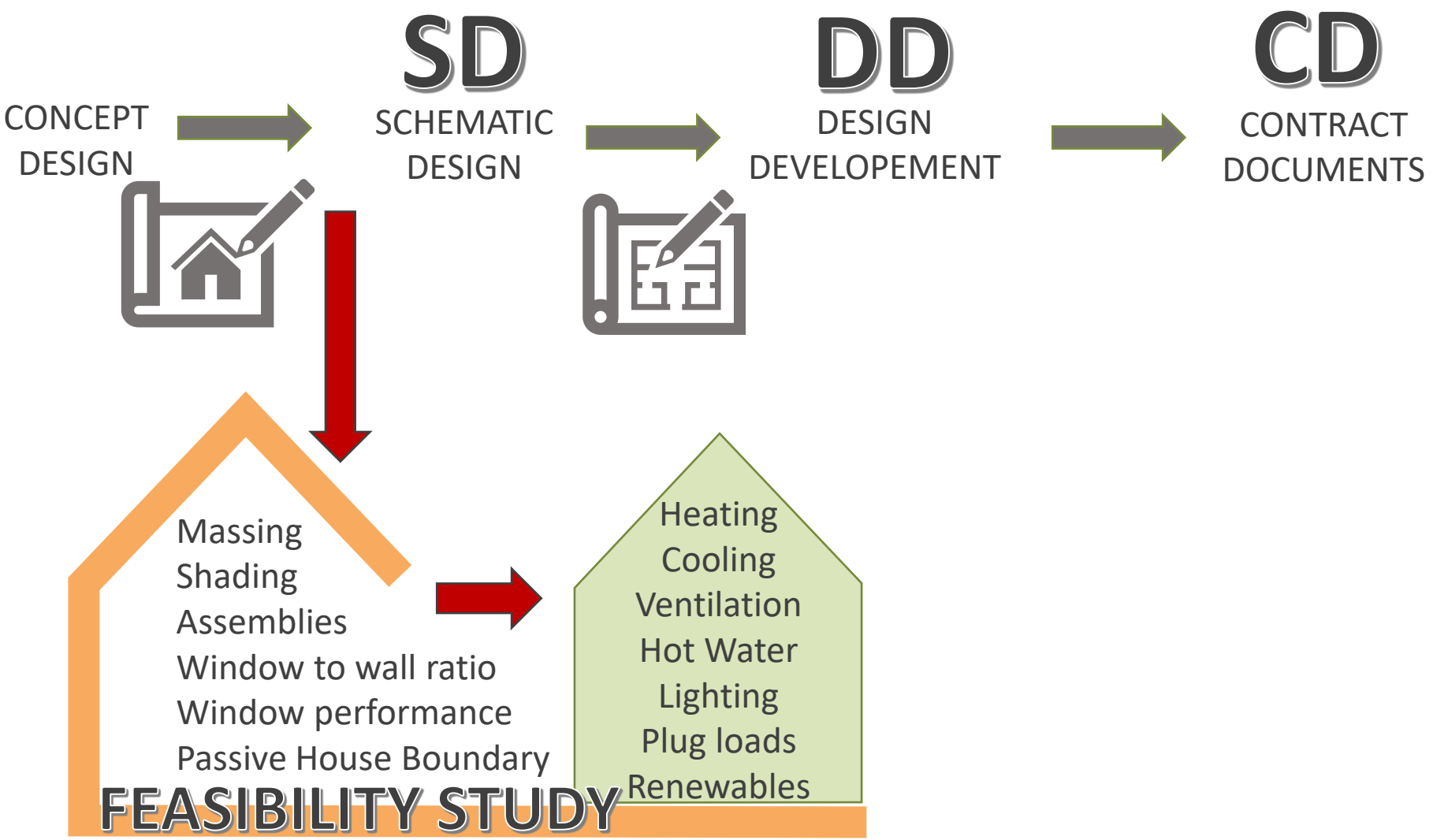
HARBOR VILLAGE: 2021

RIVERDALE: UNDER-CONSTRUCTION

SIMON FIREMAN EXPANSION: IN PERMITTING

80% ARE AFFORDABLE HOUSING

PASSIVE HOUSE PROJECTS & FEASIBILITY STUDIES



Overview:

1. WHAT IS A FEASIBILITY STUDY?
2. MODEL INPUTS
    - 2a. What's important?
    - 2b. Project Specifics
    - 2c. Building Mass/ Geometry
    - 2d. Assemblies
    - 2e. Windows
    - 2f. Systems
3. REPRESENTING THE RESULTS
4. LEARNING FROM THE ANALYSIS
5. CASE STUDIES

2a. DETERMINING WHATS IMPORTANT

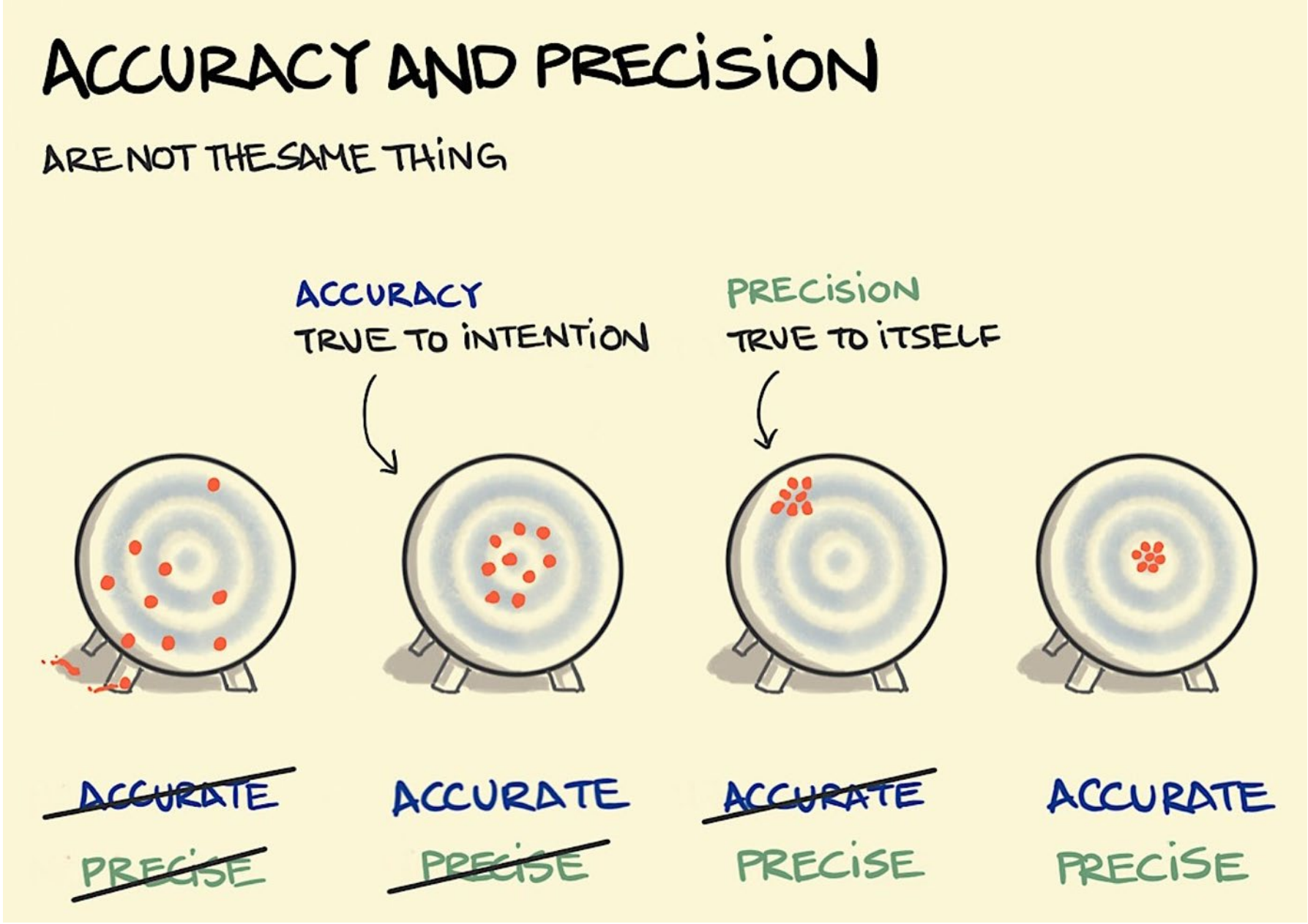
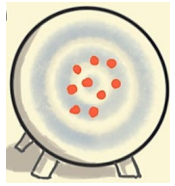


Image: Sketchplanations.com

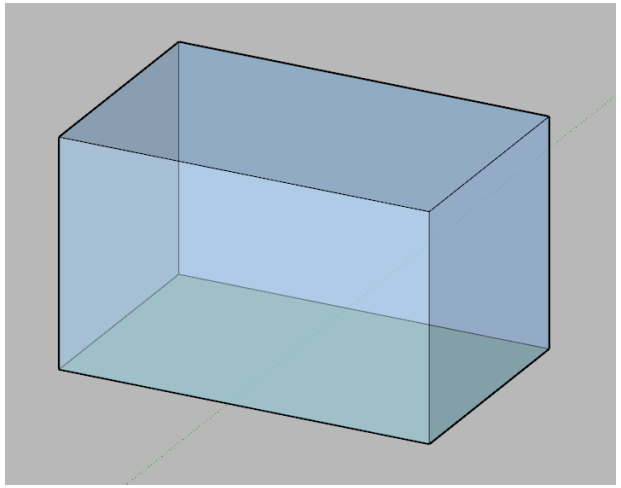
2b. PROJECT SPECIFICS

MODEL INPUTS



ACCURACY

ACCURACY & PRECISION



phius 2021
Performance Criteria Calculator v2

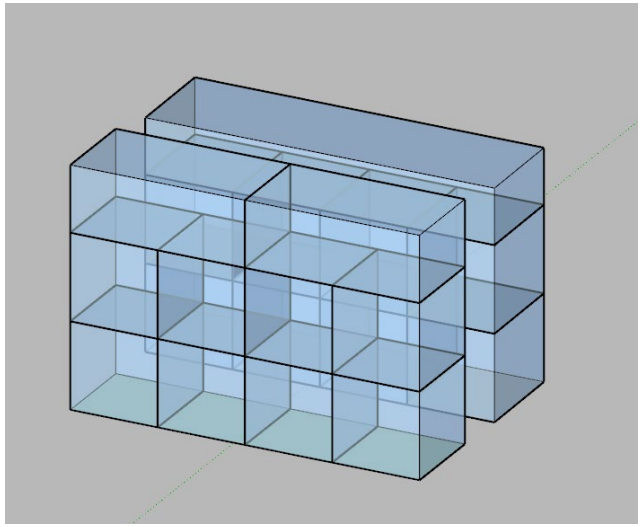
UNITS:	IMPERIAL (IP)
BUILDING FUNCTION:	RESIDENTIAL
PROJECT TYPE:	NEW CONSTRUCTION
STATE/ PROVINCE	MASSACHUSETTS
CITY	BOSTON LOGAN INT ARPT
Envelope Area (ft²)	15,000
iCFA (ft²)	20,000
Dwelling Units (Count)	18
Total Bedrooms (Count)	30

Space Conditioning Criteria

Annual Heating Demand	4.6	kBtu/ft²yr
Annual Cooling Demand	7.7	kBtu/ft²yr
Peak Heating Load	4.2	Btu/ft²hr
Peak Cooling Load	3.3	Btu/ft²hr

Source Energy Criteria

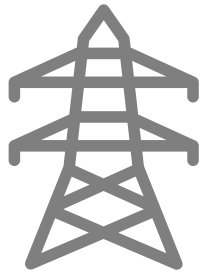
phius CORE	4650	kWh/person.yr



PHIUS+ 2018 versus phius 2021

= Updated TARGETS

EV Charging



Future Electrification, Updated Conversion Factor

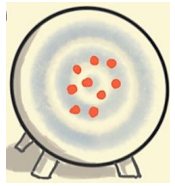
Domestic Hot Water

Timeline:

November 9 - December 7, 2020: Public comment period
March 1, 2021: PHIUS 2021 Full Release
March 1 - December 31, 2021: PHIUS+ 2018 and phius 2021 Submission Overlap
December 31, 2021: PHIUS+ 2018 ends

January 1, 2022*: All new project under phius 2021

2c. BUILDING MASS / GEOMETRY



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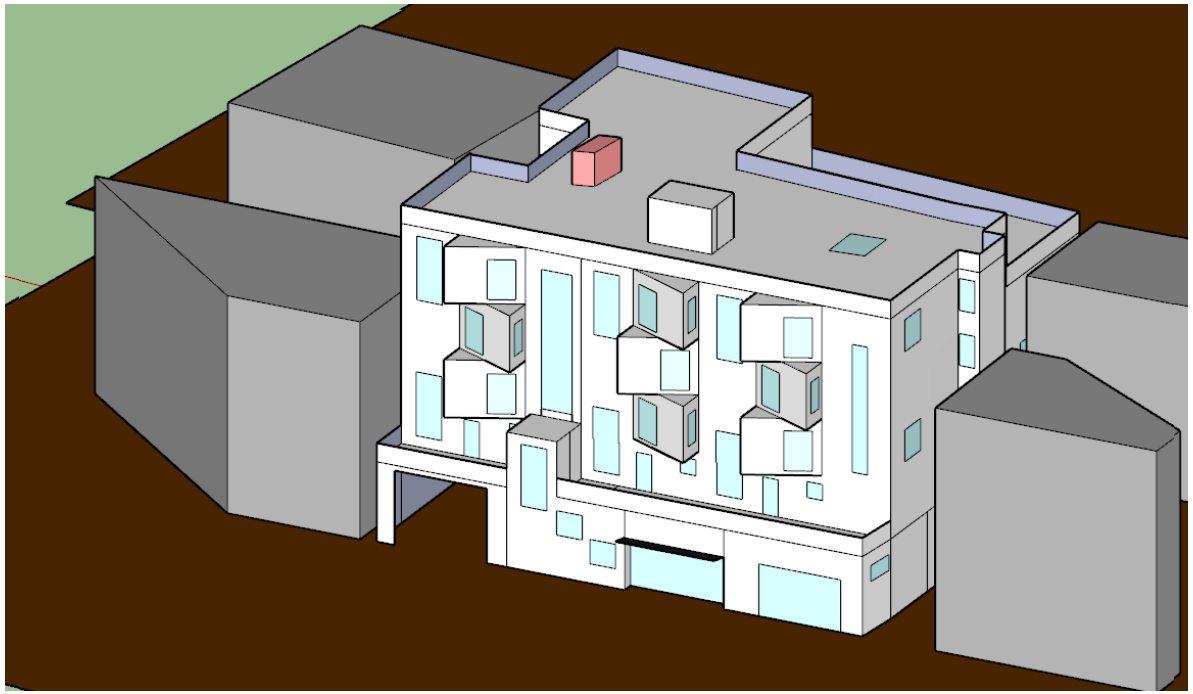
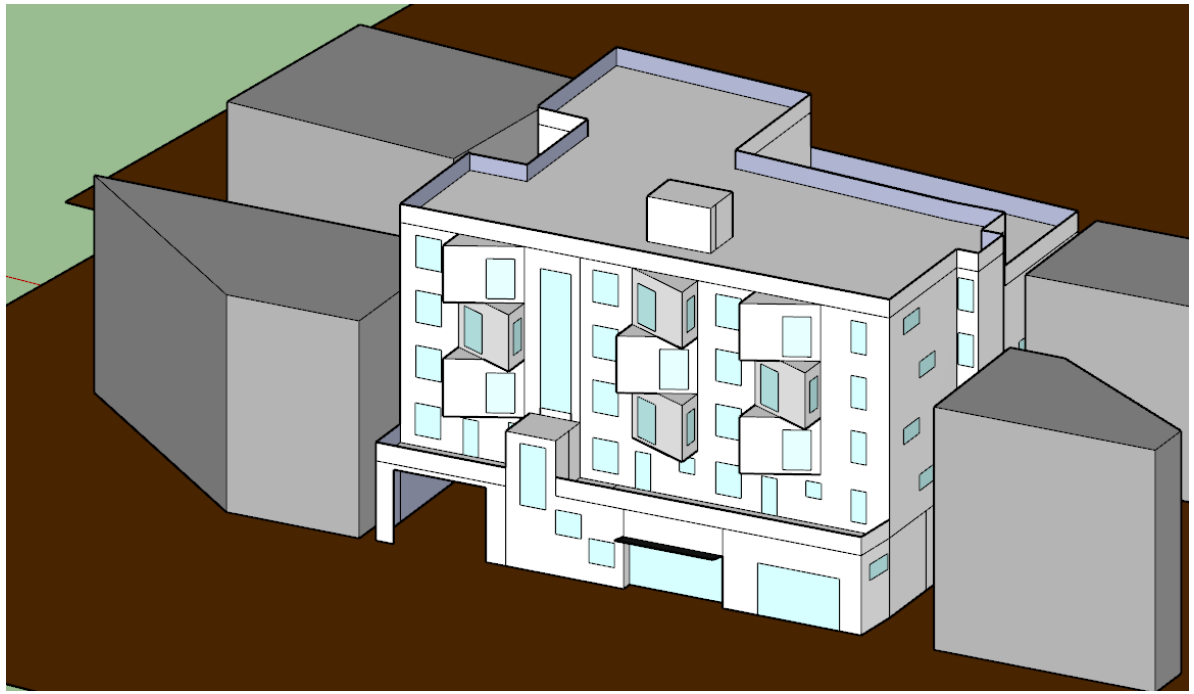


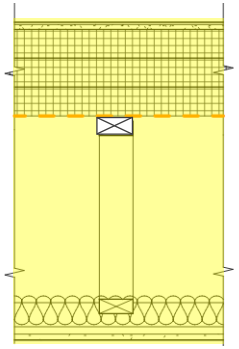
ACCURACY & PRECISION



2d. ASSEMBLIES

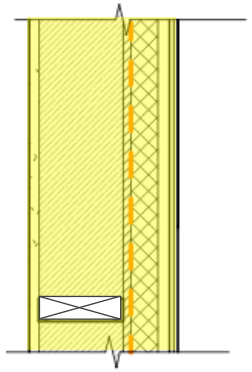
ACCURACY

ROOF



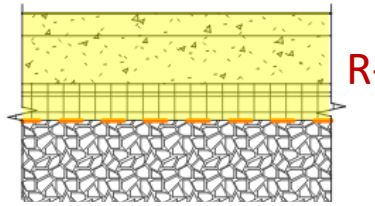
R-50

WALLS



R-32

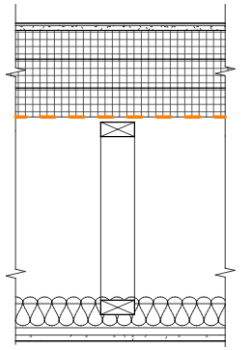
SLAB



R-10

ACCURACY & PRECISION

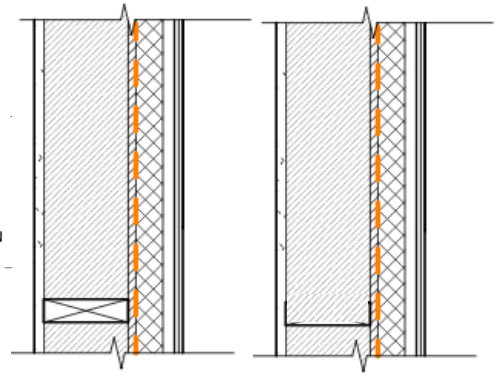
ROOF



TYPICAL ROOF ASSEMBLY (TOP TO BOTTOM)
VB CONSTRUCTION - NO RATING NEEDED
- MEMBRANE ROOFING SYSTEM
- OVERLAYMENT BOARD
- TAPERED RIGID INSULATION (R-30 MIN) 1/4"/FT SLOPE TO DRAIN
- EXT. GRADE SHEATHING (SEE STRUC. DWGS.) ALL JOINTS TAPED TO CREATE CONTINUOUS AIR BARRIER
- SPRAY FOAM UNDERSIDE OF SHEATHING AT PENETRATIONS
- OPEN WEB WOOD TRUSS (SEE STRUCT. DWGS)
- 3" ACOUSTIC BATT INSULATION
- RESILIENT CHANNELS @ 12" O.C. (TYP.)
- 5/8" TYPE 'C' GWB

R-50

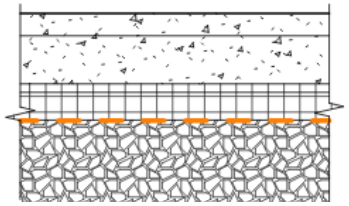
WALLS



TYPE VB- FIBER CEMENT PANEL ASSEMBLY ON WOOD STUD (OUT TO IN)
- FIBER CEMENT PANEL
- 3/4" X 3" PT FURRING BATTENS FOR RAIN SCREEN ATTACHMENT
- 2" CONTINUOUS RIGID INSULATION
- COMMERCIAL GRADE CONTINUOUS VAPOR PERMEABLE AIR BARRIER
- 1/2" EXTERIOR SHEATHING (SEE STRUCT.)
- 2x6 WOOD STUDS @ 16" O.C. (SEE STRUCT. DWGS)
- FILL CAVITY WITH DENSE PACKED DRY APPLIED CELLULOSE INSULATION (R-21 MIN.)
- FILL GAPS IN WOOD PANELS 1/4" & LARGER WITH SPRAY FOAM/ GASKETING
- (1) LAYER 5/8" GWB

R-32

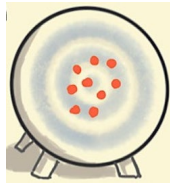
SLAB



TYP. CONC. SLAB-ON-GRADE WITH INSULATION (TOP TO BOTTOM)
- STRUCTURAL SLAB (SEE STRUCT. DWGS)
- 15 MIL. POLYETHYLENE VAPOR BARRIER TAPE JOINTS & PENETRATIONS
- 4" RIGID INSULATION, MIN R-10
- COMPACTED CRUSHED STONE (SEE STRUCT. DWGS)
- FILTER FABRIC
- STRUCTURAL FILL

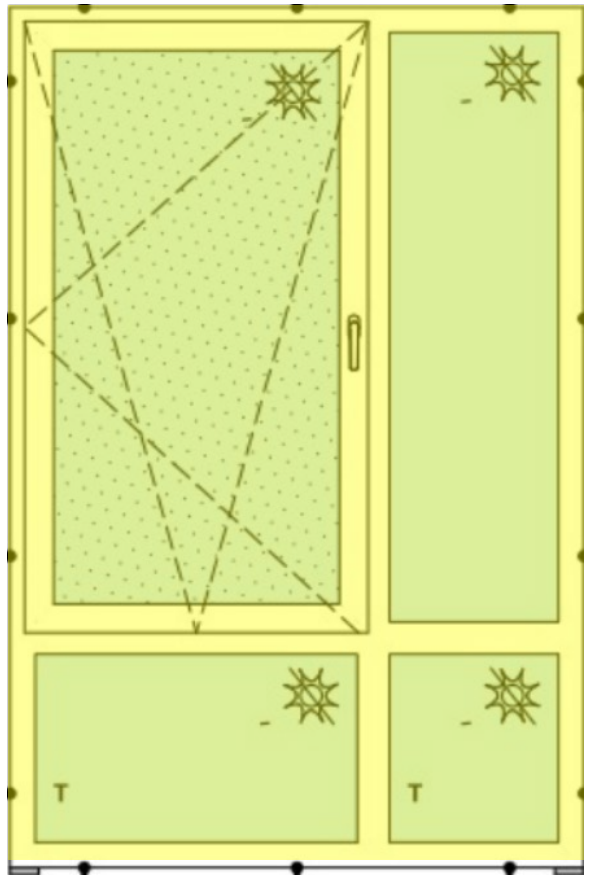
R-10

2e. WINDOWS



ACCURACY

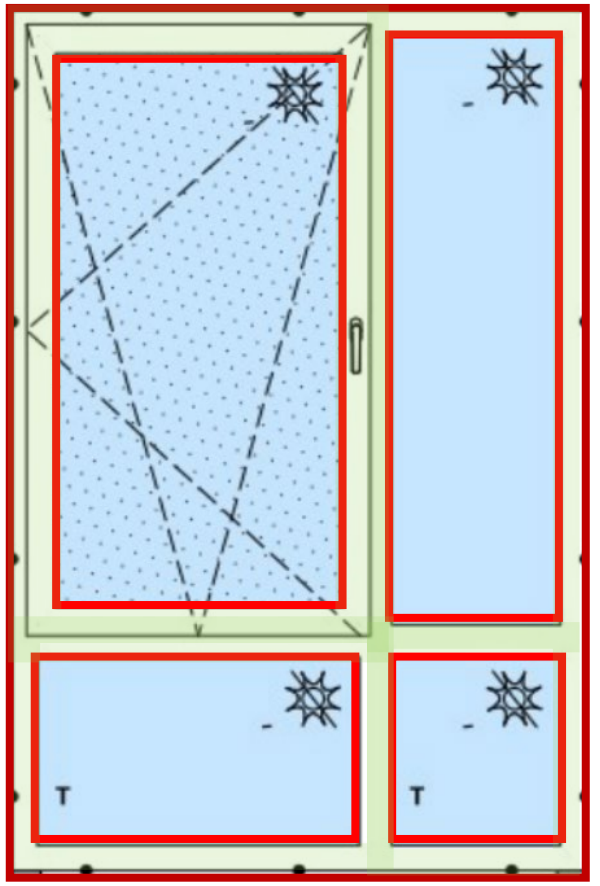
Whole Window Model



U-0.14

ACCURACY & PRECISION

Component Model

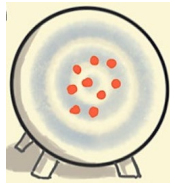


U-glazing
U-frame
Psi – glazing to frame
Psi f- frame to wall

U-0.14

2f. SYSTEMS

MODEL INPUTS

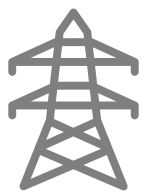


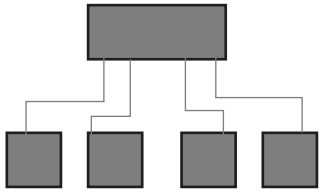
ACCURACY

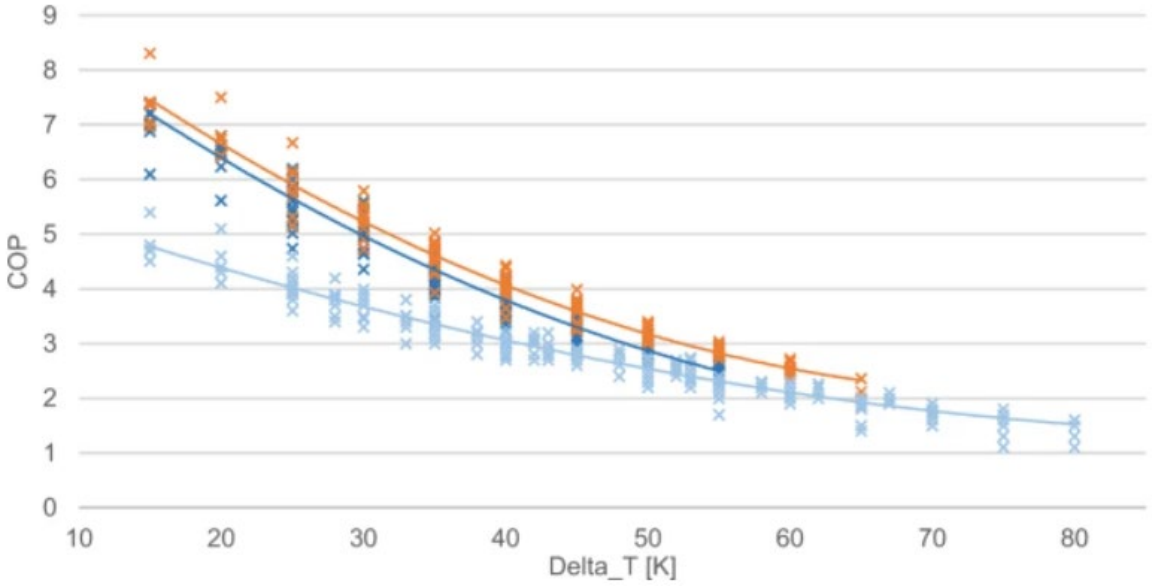
HVAC

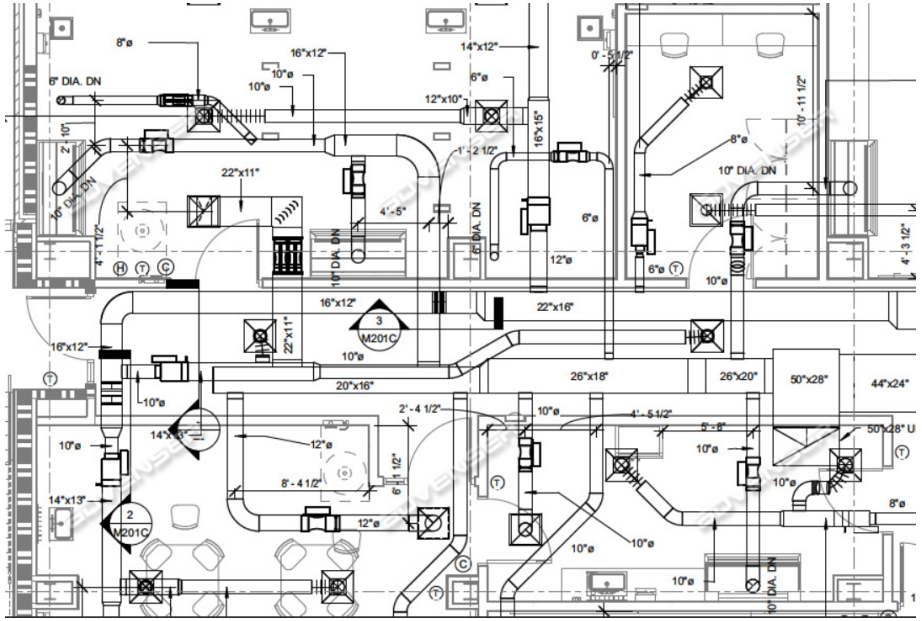
ACCURACY & PRECISION

ELECTRIC CENTRALIZED







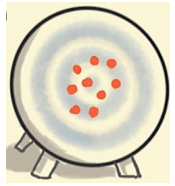


SYSTEM TYPE, RANGE OF PERFORMANCE

EXACT DISTRIBUTION & EQUIPMENT

2f. SYSTEMS

MODEL INPUTS

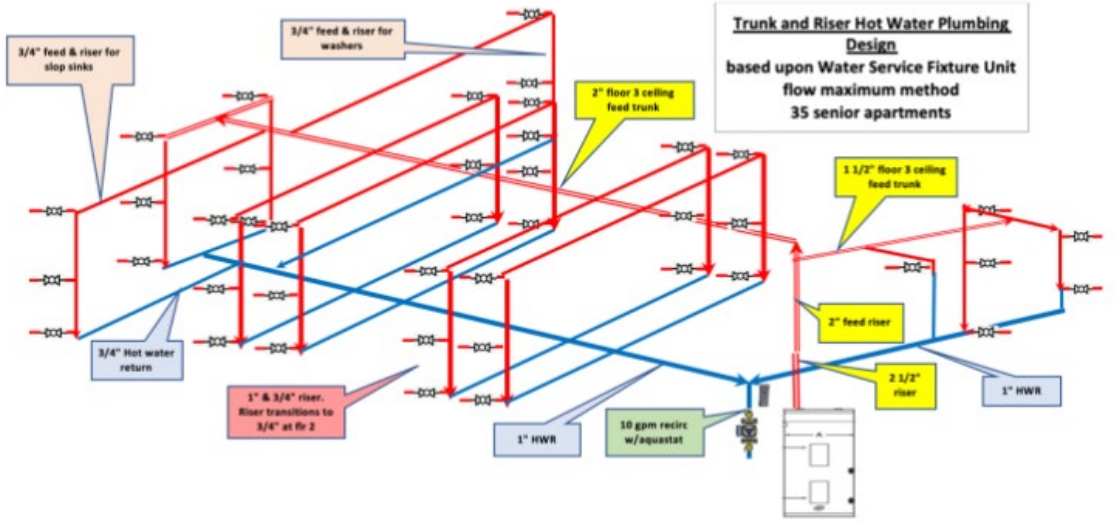


ACCURACY

PLUMBING

ACCURACY & PRECISION

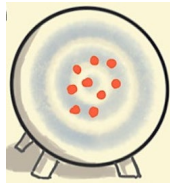
SIMPLIFIED CALCULATIONS BASED ON FIXTURE/UNIT COUNT



EXACT DISTRIBUTION

2f. SYSTEMS

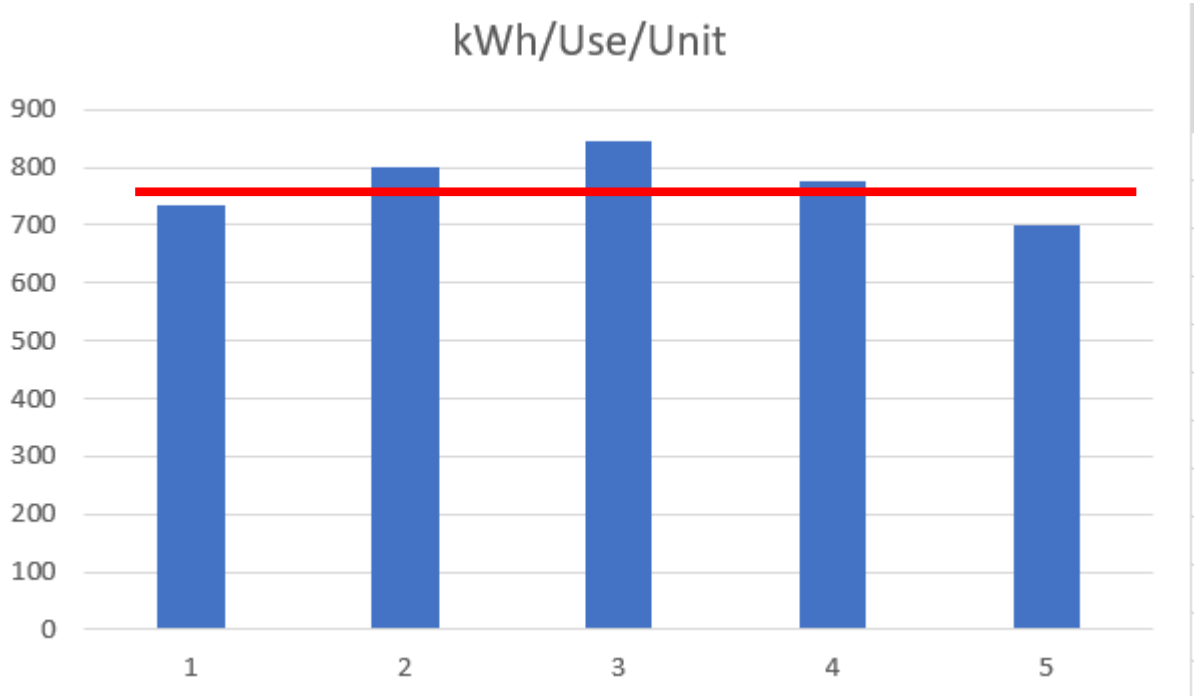
MODEL INPUTS



ACCURACY

ELEC LOADS

ACCURACY & PRECISION



RULES OF THUMB & DEFAULT VALUES

BASED ON PAST FEASBILITY STUDIES AND BUILT PROJECTS

WUFI-Passive / PHPP Entries	
Lighting & Plug Loads	
Number of Units	0
Input the total number of dwelling units under PH Case>General in WUFI Passive. In PHPP, input on the Verification sheet.	
Design Occupancy	0
Input the Number of Occupants on the Inner Loads/Occupancy tab in WUFI Passive. In PHPP, input on the Verification sheet.	
Number of Bedrooms	0
Input the Number of Bedrooms on the Inner Loads/Occupancy tab in WUFI Passive.	
iCFA (ft^2)	0
Input in WUFI Passive under Zone 1	
MEL (kWh/yr)	0
Input the kWh/yr as 'User Defined' entry on the Inner Loads/Occupancy tab in WUFI Passive. In PHPP, add as 'Other' entry in Electricity sheet.	
$LIGHTS_{INT}$ (kWh/yr)	0
Input the kWh/yr as 'User Defined' entry on the Inner Loads/Occupancy tab in WUFI Passive. In PHPP, add as 'Other' entry in Electricity sheet.	
$LIGHTS_{EXT}$ (kWh/yr)	0
Input the kWh/yr as 'User Defined' entry on the Inner Loads/Occupancy tab in WUFI Passive. In PHPP, add as 'Other' entry in Electricity sheet. Be sure to assign as outside the envelope.	
$LIGHTS_{GAR}$ (kWh/yr)*	0
Input the kWh/yr as 'User Defined' entry on the Inner Loads/Occupancy tab in WUFI Passive. In PHPP, add as 'Other' entry in Electricity sheet. Be sure to assign as outside the envelope.	

Overview:

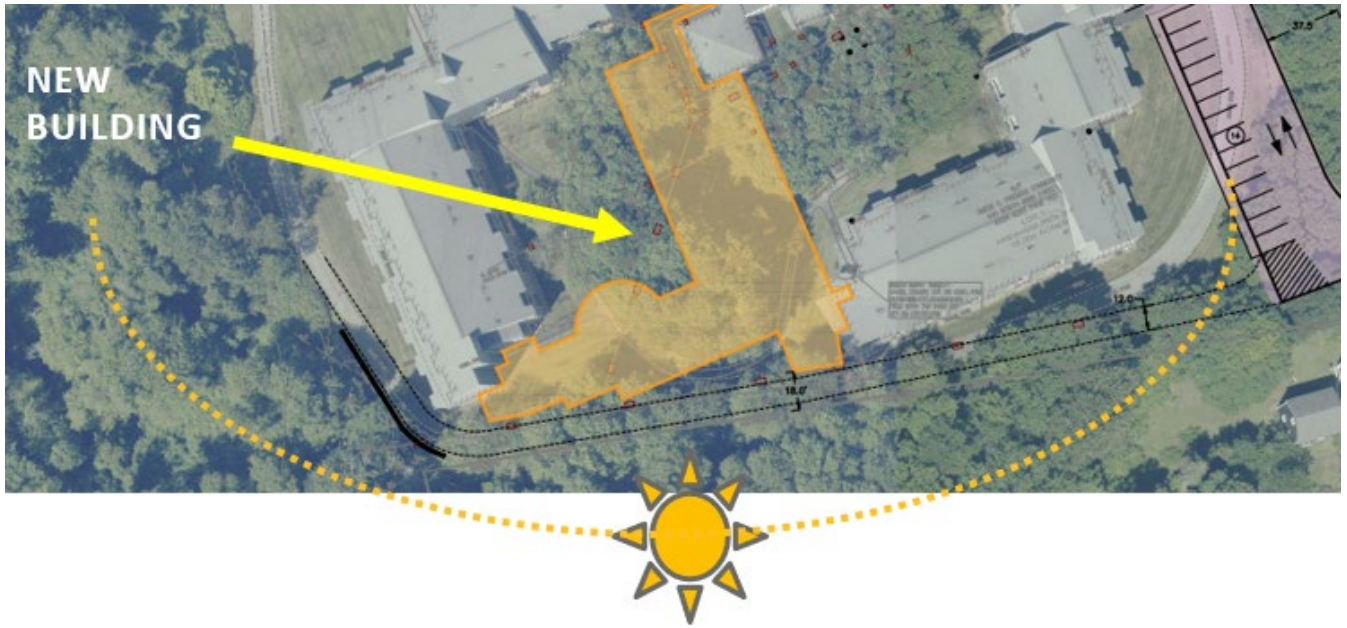
1. WHAT IS A FEASIBILITY STUDY?
2. INPUTS
3. REPRESENTING THE RESULTS
    - 3a. Start with the basics
    - 3b. Be Clear on Expectations
    - 3c. Report Card
    - 3d. Baseline to Passive House
    - 3e. Paths to Certification

LEARNING FROM THE ANALYSIS

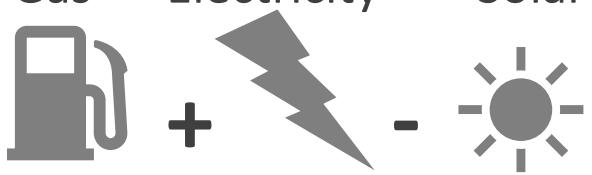
CASE STUDIES

3a. START WITH THE BASICS

REPRESENT THE RESULTS



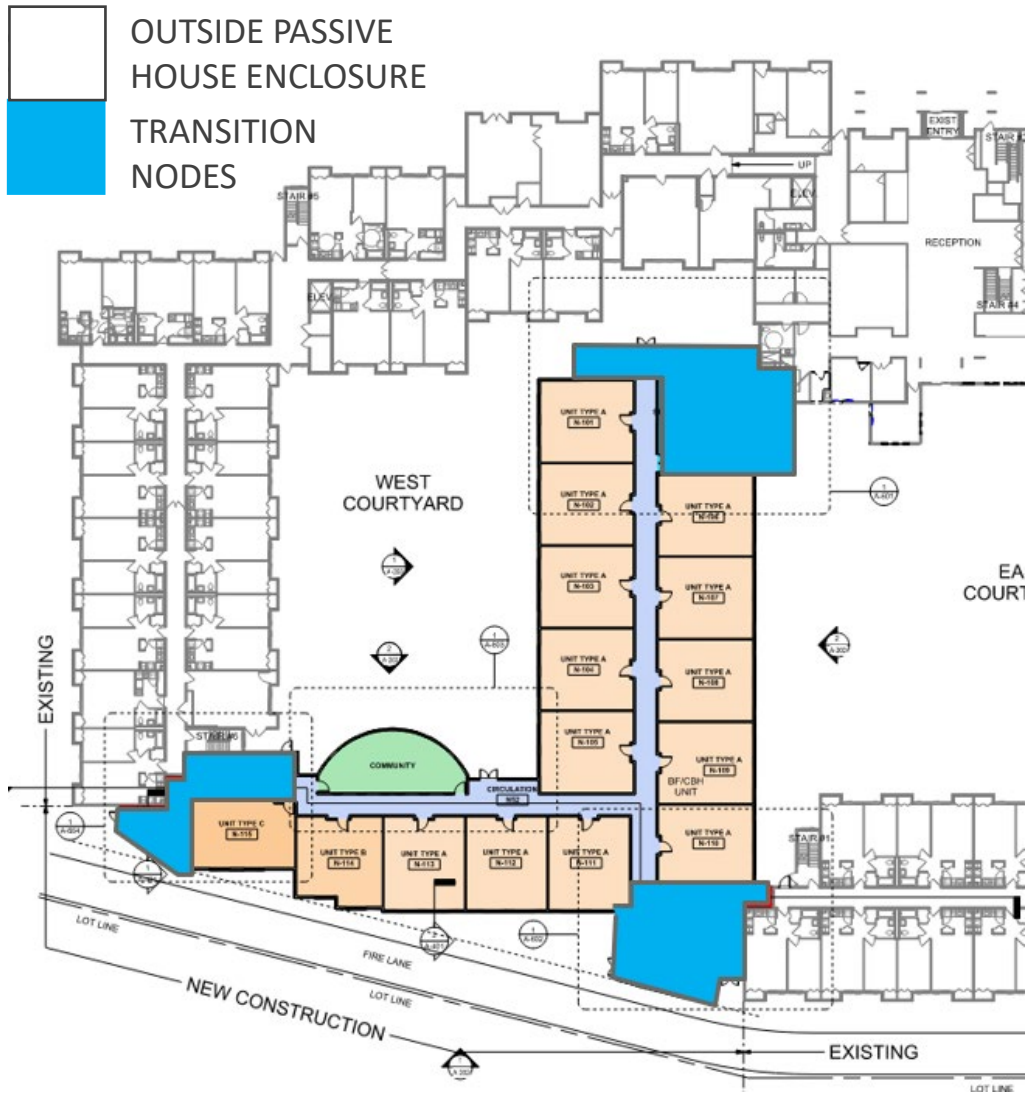
Gas Electricity Solar



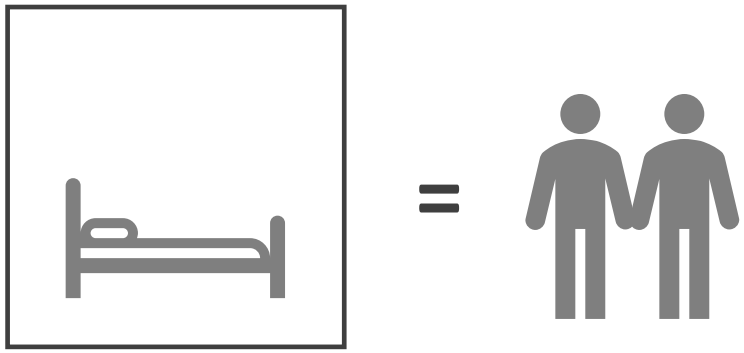
Gross SF

= **EUI**

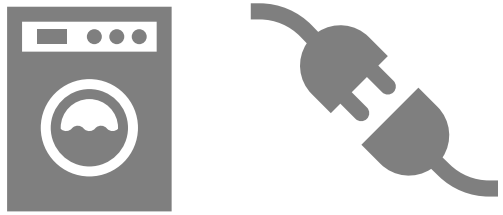
Energy Use Intensity
kBTU/SF/yr



3a. START WITH THE BASICS



1 Bedroom = 2 people



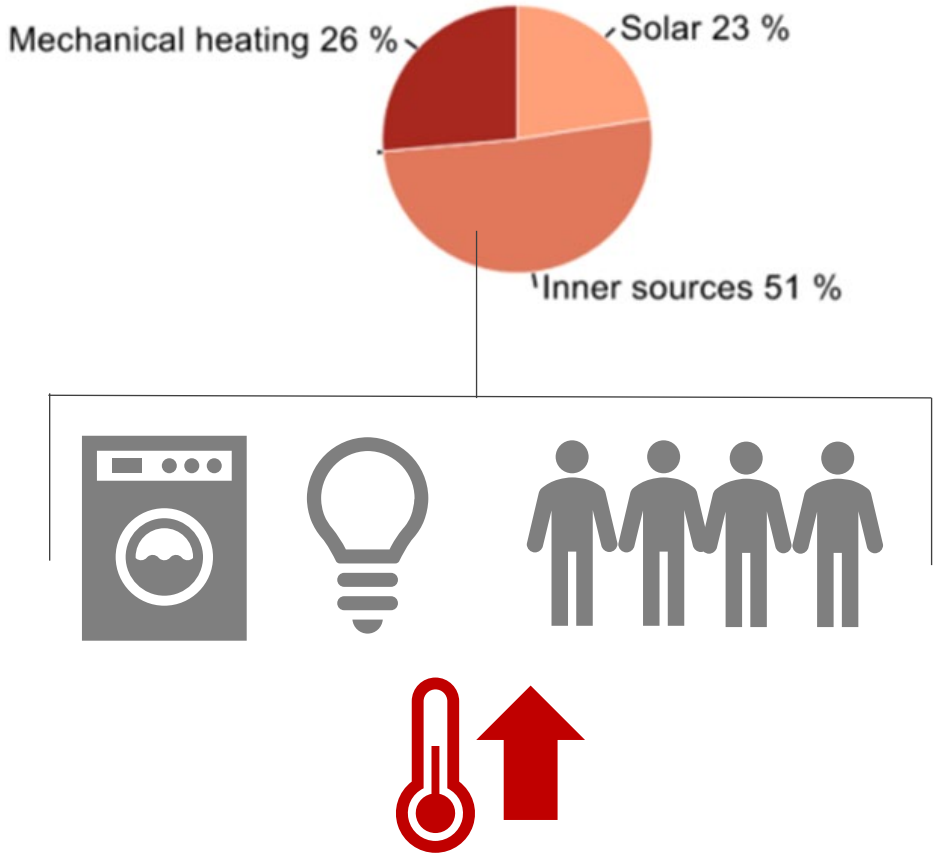
Default appliance and plug loads

Default water usage per person

3b. EXPECTATIONS

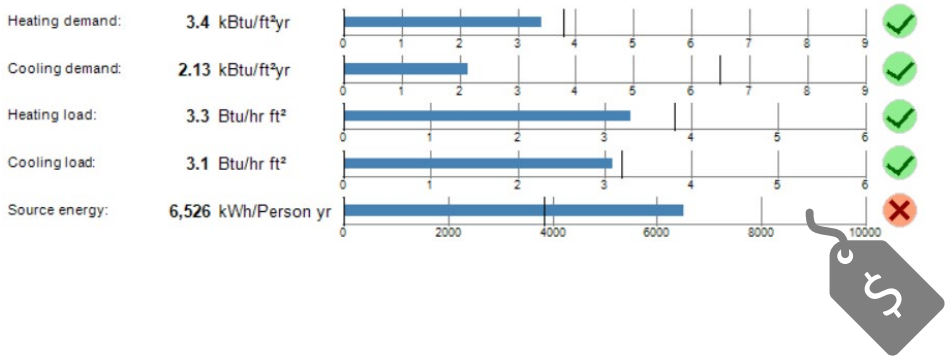
REPRESENT THE RESULTS

High Internal Loads



Renewable Energy Needed

Model results ≠ Utility Bill



3c. REPORT CARD

REPRESENT THE RESULTS

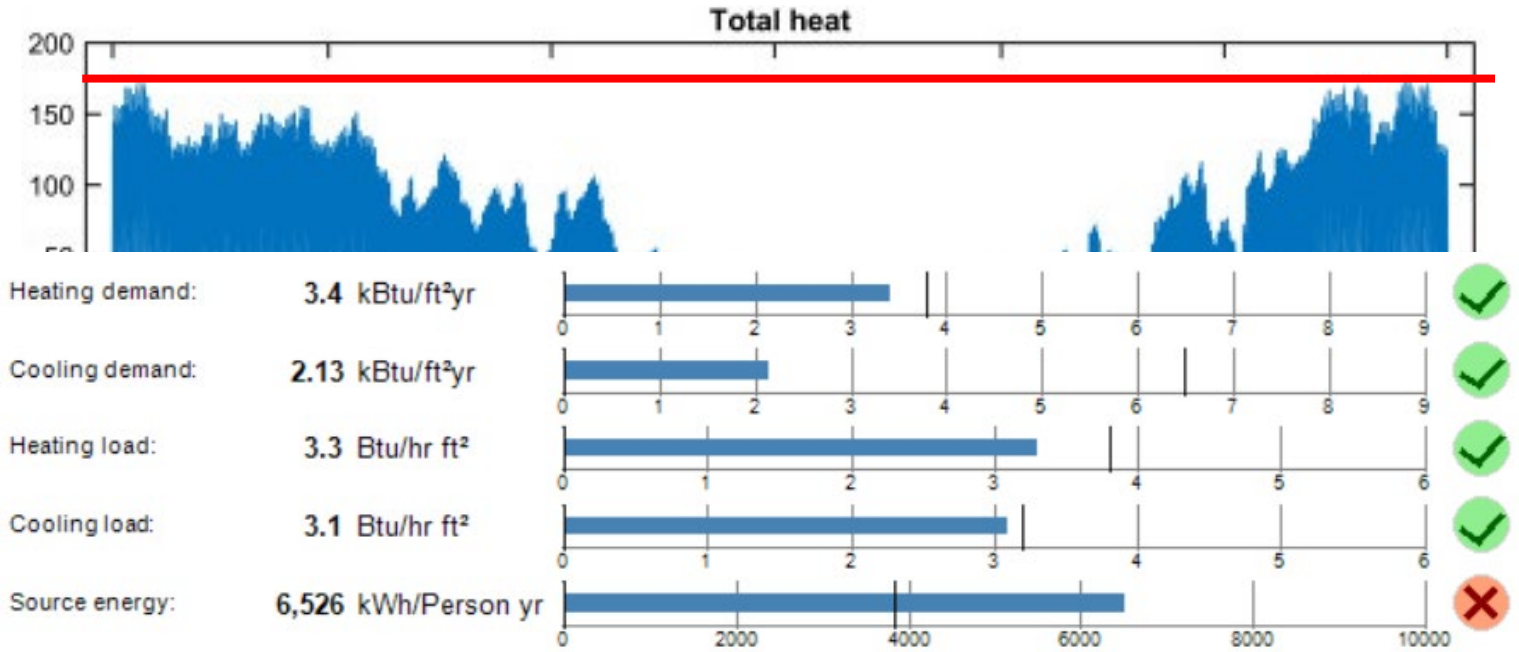
Thresholds:

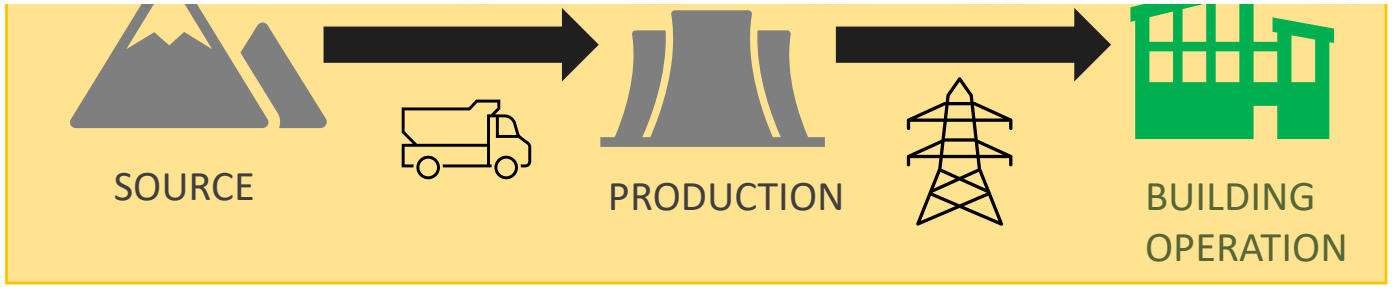
Heating/Cooling Demand

Heating/Cooling Load

Source Energy

Site Energy





3c. REPORT CARD

REPRESENT THE RESULTS

Goal = lowering consumption - Measured in kBTU/SF/year at site and source

Tenets of Passive House that lead to reduction

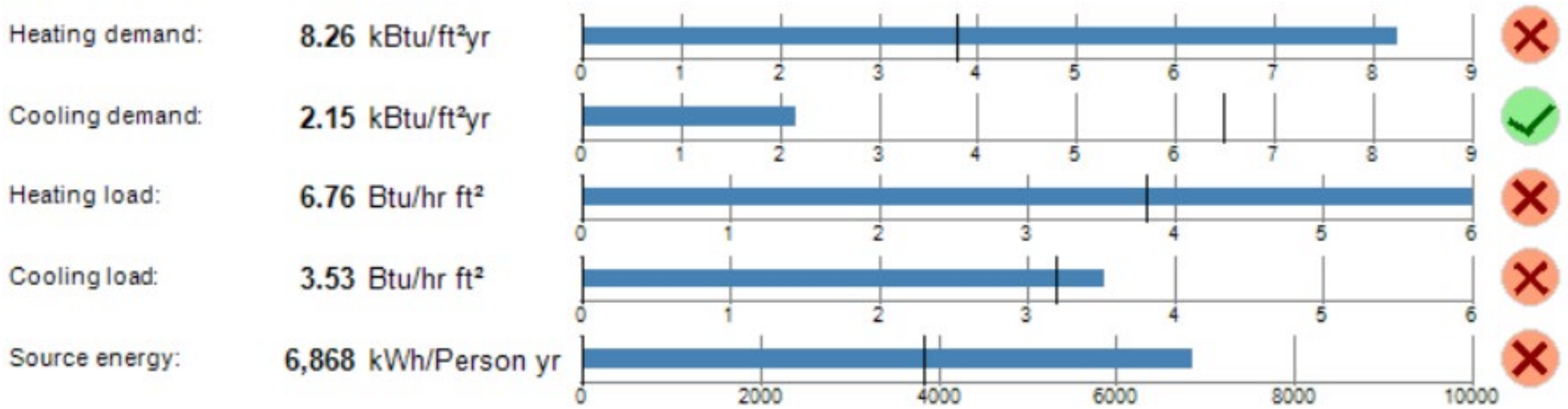
AIRTIGHT	Eliminate infiltration Test results
THERMAL CONTROL	Minimize Loss/Gain Optimized Window Performance
MECHANICAL SYSTEMS	Right Sized Balanced Ventilation
OTHER LOADS	Plug loads/lighting/appliances Renewable Energy

3d. BASELINE TO PASSIVE HOUSE

REPRESENT THE RESULTS

BASELINE CASE

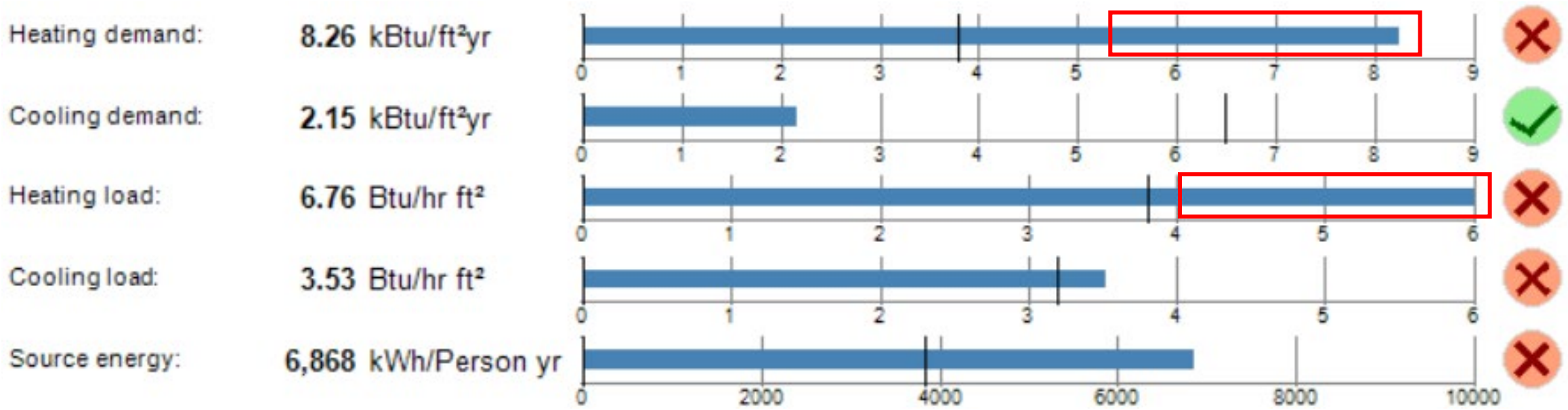
Infiltration = 0.25 cfm/ft3 (Code)
Double Glazed Windows, u- 0.27 (Energy Star)
No Continuous insulation, no shading, no solar



3d. BASELINE TO PASSIVE HOUSE

REPRESENT THE RESULTS

START WITH INFILTRATION

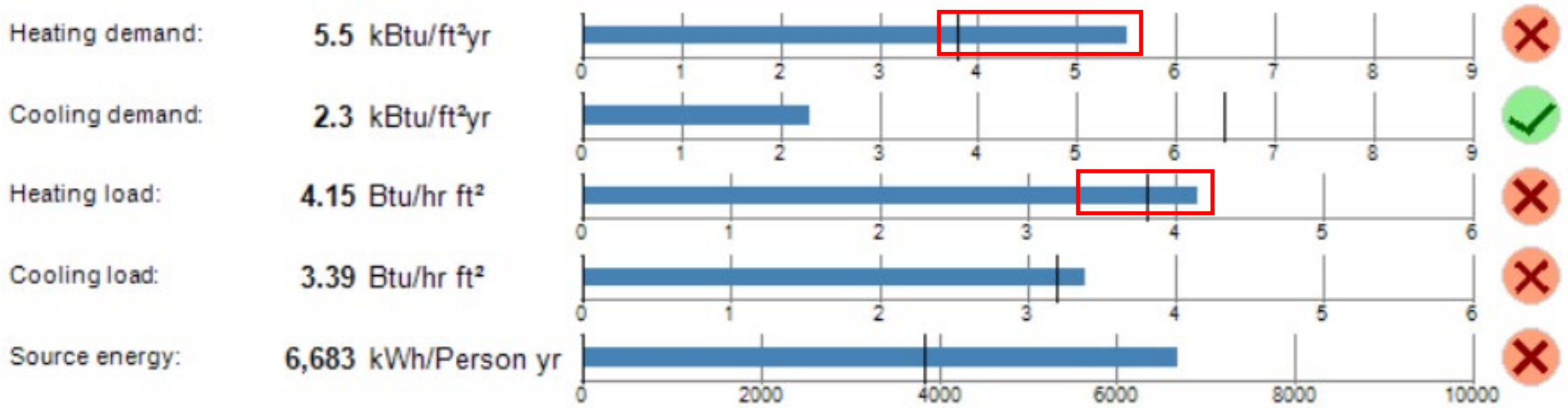


UPGRADE Passive House threshold of 0.05 cfm/ft3

3d. BASELINE TO PASSIVE HOUSE

REPRESENT THE RESULTS

IMPROVE WINDOWS

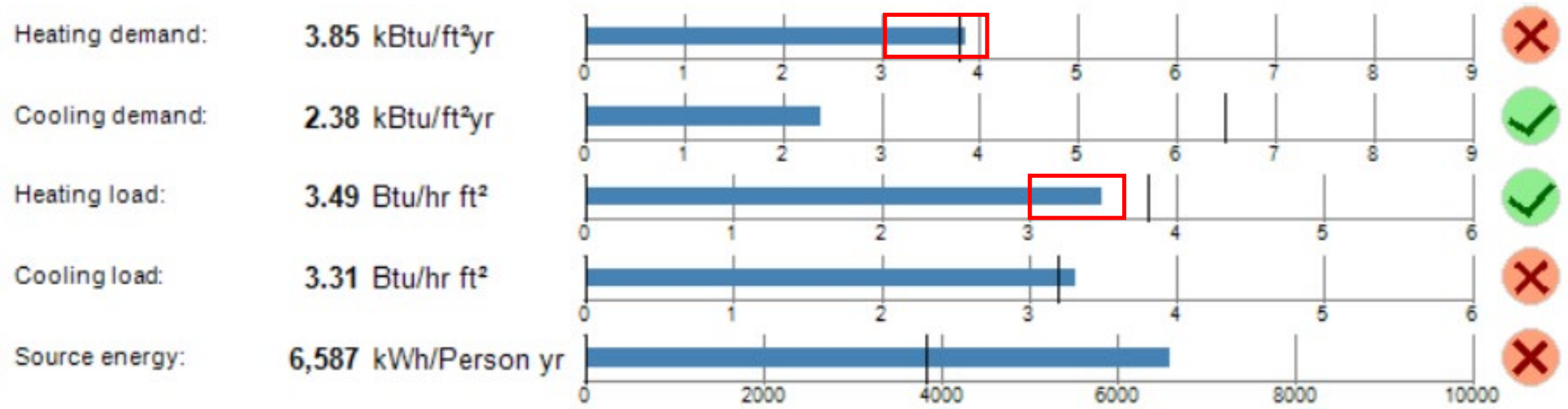


UPGRADE Triple Glazed, u-0.18

3d. BASELINE TO PASSIVE HOUSE

REPRESENT THE RESULTS

CONTINUOUS INSULATION

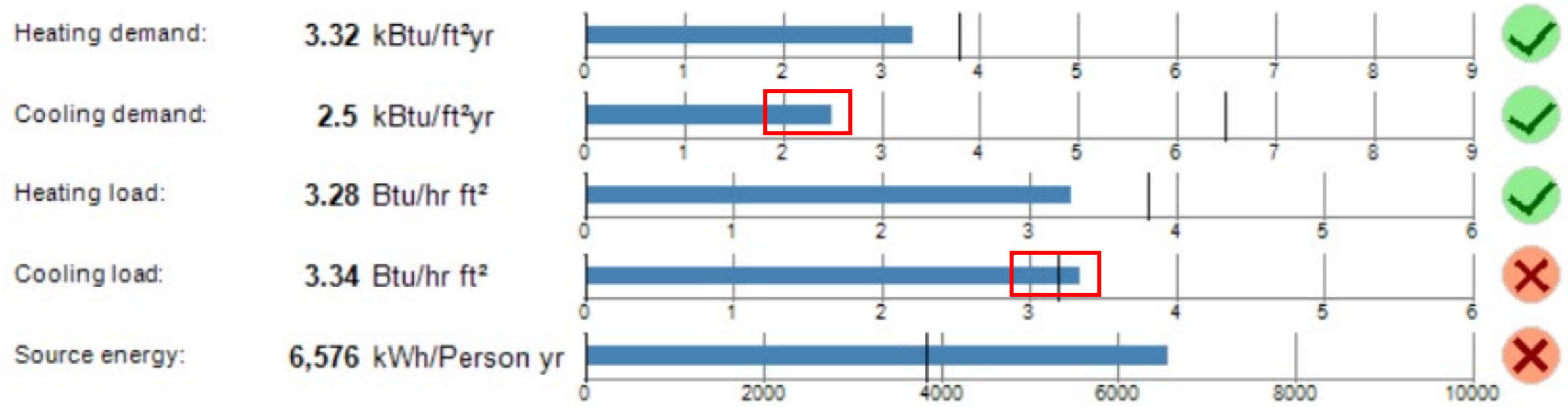


UPGRADE Adding 2” Continuous insulation at Exterior Walls

3d. BASELINE TO PASSIVE HOUSE

REPRESENT THE RESULTS

SHADING

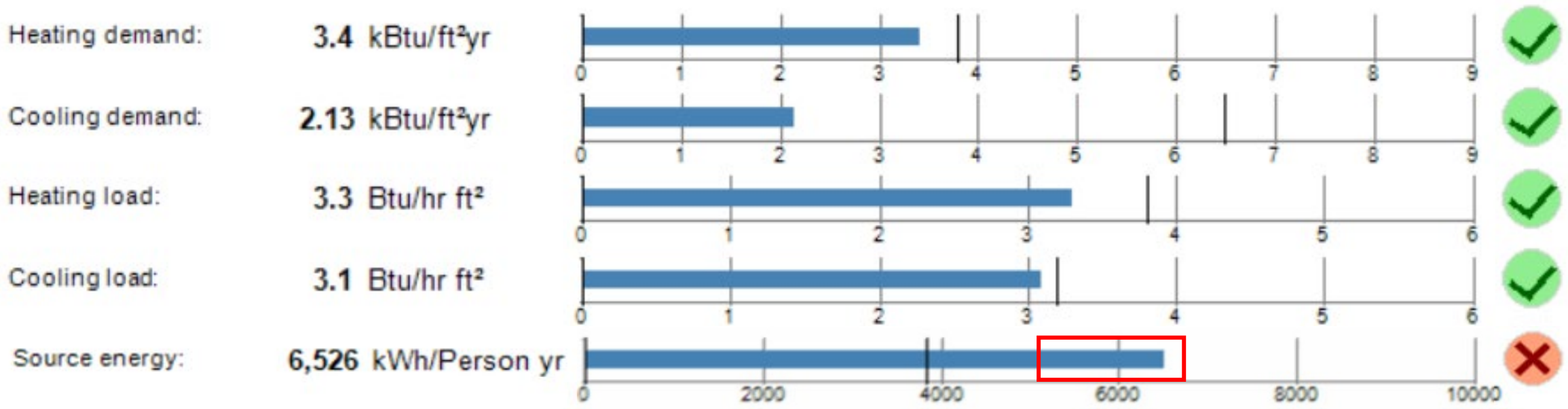


UPGRADE Add Shading at South & West Exterior Walls

3d. BASELINE TO PASSIVE HOUSE

REPRESENT THE RESULTS

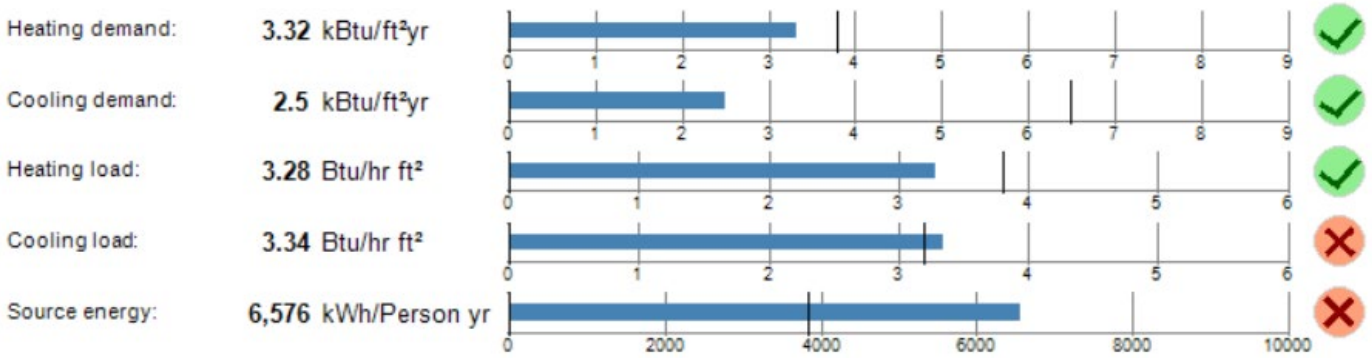
SOLAR PV



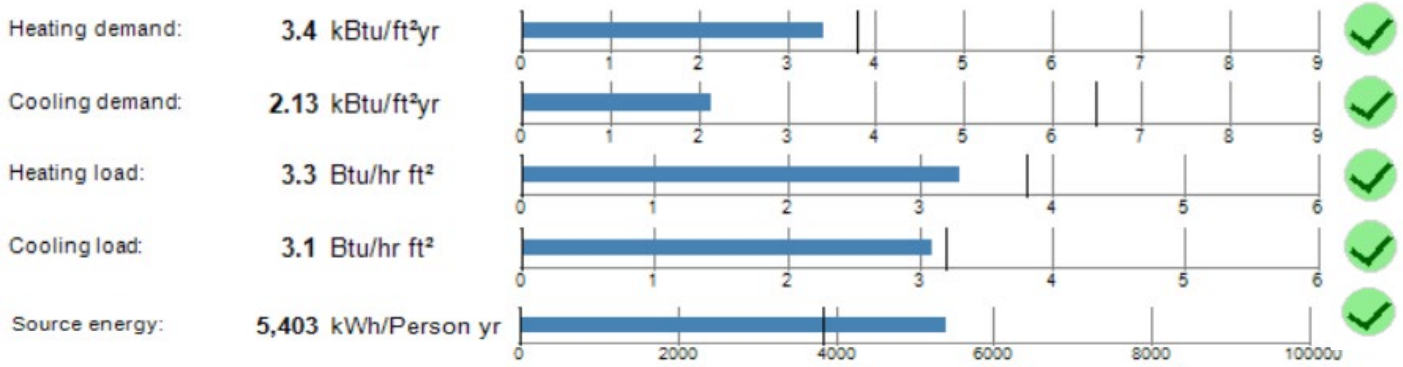
UPGRADE Adding PV at Roof

3e. PATHS TO CERTIFICATION

REPRESENT THE RESULTS



+ Shading + PV
OR
+ Lower SHGC + Geothermal



Show what it takes to get to a passing model

Overview:

1. WHAT IS A FEASIBILITY STUDY?
2. MODEL INPUTS
3. REPRESENTING THE RESULTS
4. LEARNING FROM THE ANALYSIS
    - 4a. Biggest Impacts
    - 4b. Impacts On Systems
5. CASE STUDIES

4a. BIGGEST IMPACTS

AIR INFILTRATION — No model inputs affect this

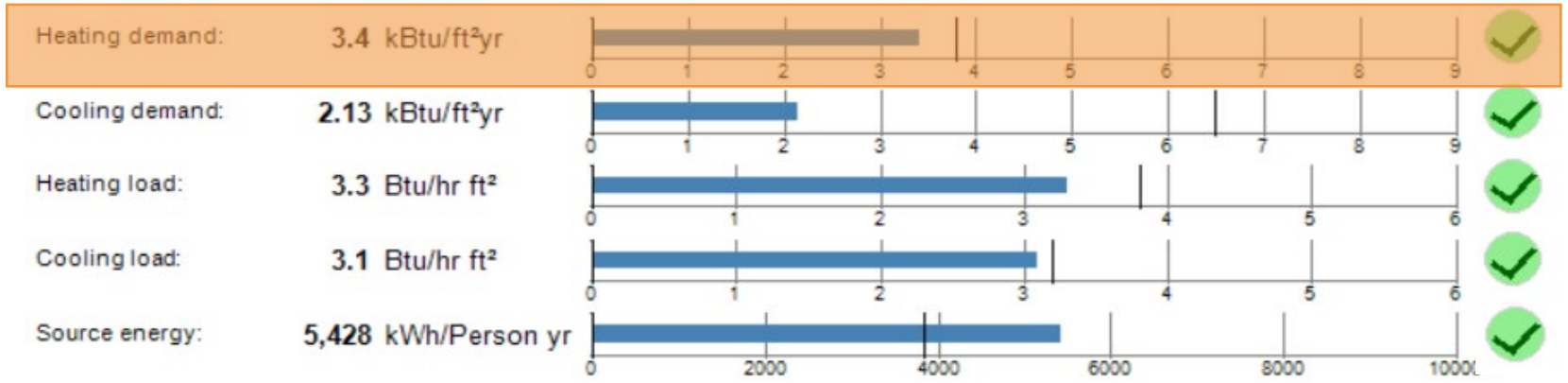
WINDOWS & CONTINUOUS INSULATION

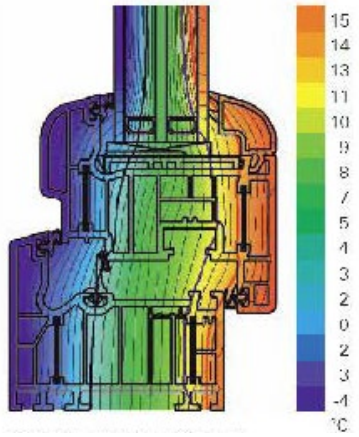
SYSTEMS : DHW & ERV Efficiency

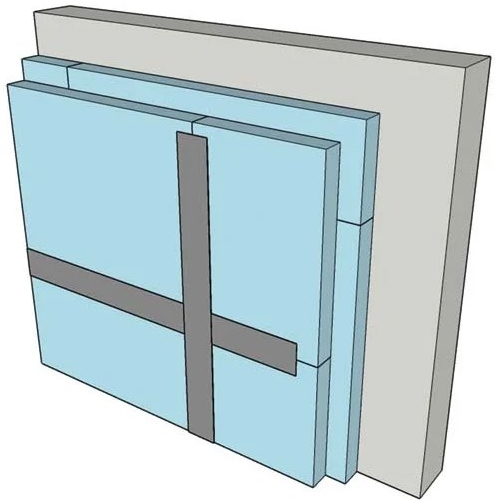
LOADS, SHADING, PV

4a. BIGGEST IMPACTS

Use R-values and U-values to change HEATING DEMAND

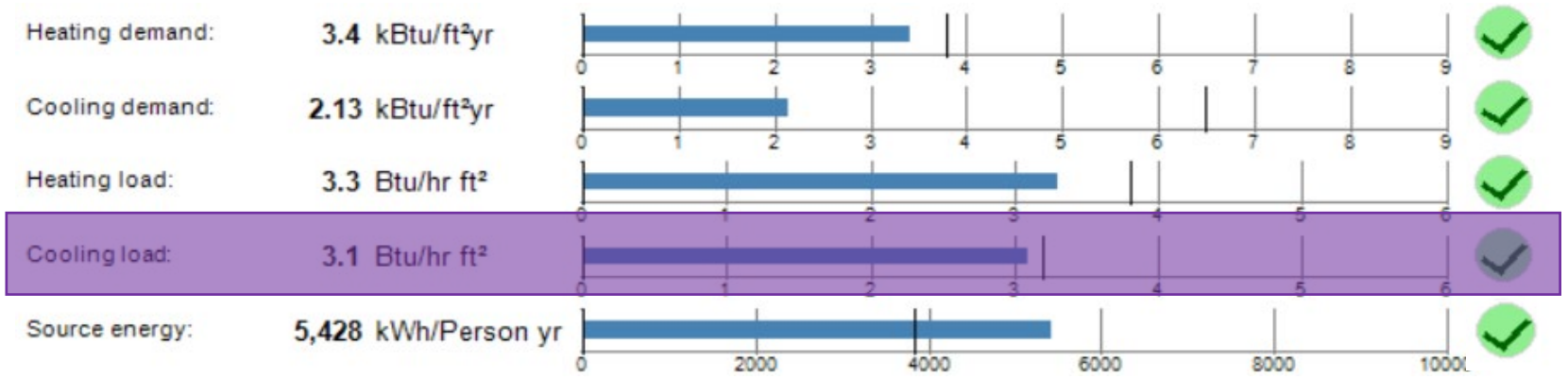






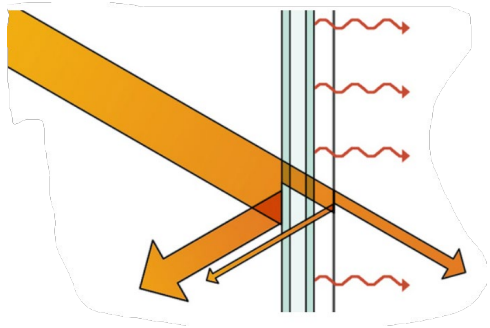
4a. BIGGEST IMPACTS

Use **exterior shading** to control **COOLING LOAD**



Contextual Shading

Blinds at windows



Window Properties

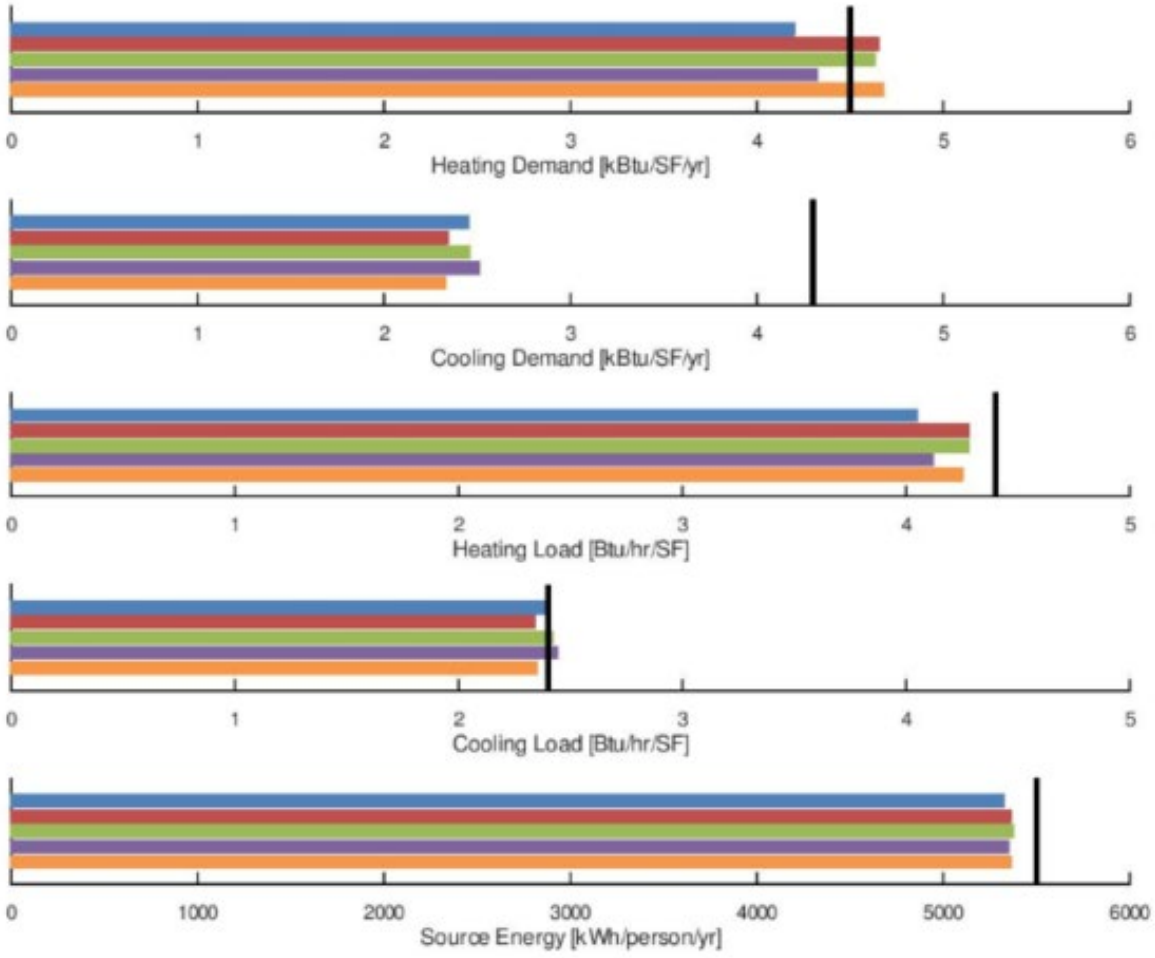
4a. BIGGEST IMPACTS

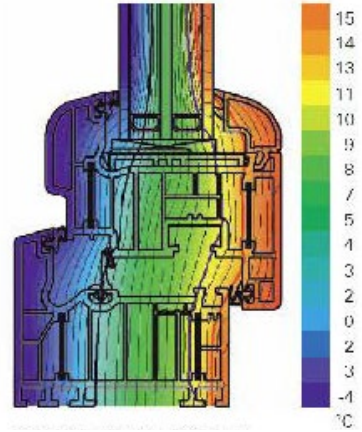
LEARNING FROM ANALYSIS

WINDOW INPUTS

HEATING DEMAND

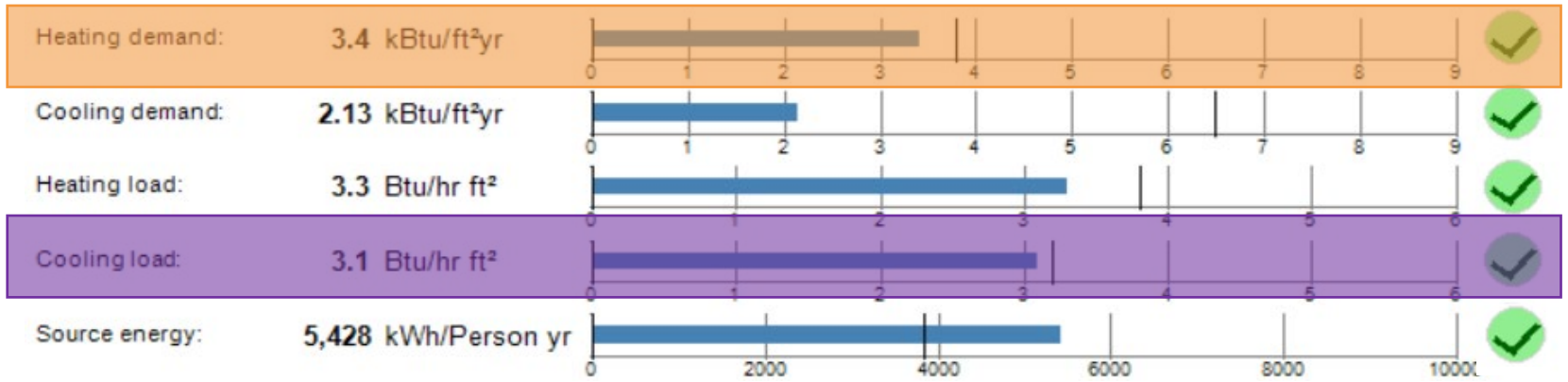
COOLING LOAD





Window	S1	S2	V1	V2*	V3	V4*
SHGC_c [-]	0.300	0.510	0.345	0.500	0.260	0.510
U_g	0.094	0.100	0.105	0.105	0.123	0.123
U_f (fixed)	0.194	0.194	0.195	0.195	0.195	0.195
U_f (operable)	0.206	0.206	0.220	0.220	0.220	0.220
Ψ_spacer (fixed)	0.0154	0.0143	0.0173	0.0173	0.0173	0.0173
Ψ_spacer (operable)	0.0166	0.0147	0.0173	0.0173	0.0173	0.0173

4a. BIGGEST IMPACTS



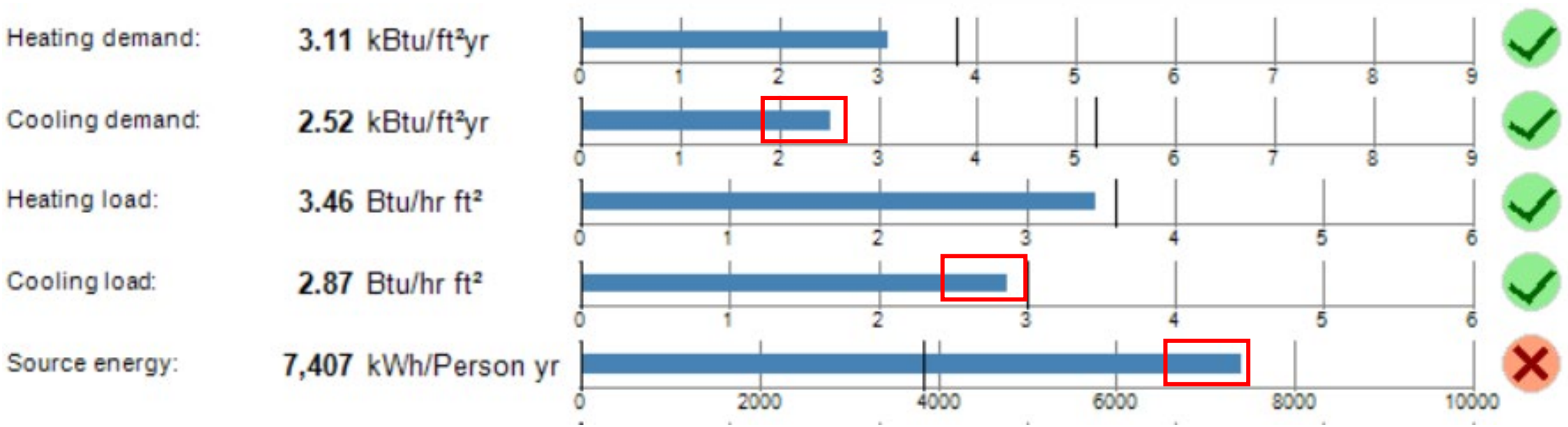
HEATING DEMAND AND COOLING LOAD are pinned against each other, finding the balance can be challenging

4b. IMPACT ON SYSTEMS

LEARNING FROM ANALYSIS

Domestic hot water system selection, scheme and insulation

BASE - DECENTRALIZED



UPGRADE TO CENTRALIZED SYSTEM

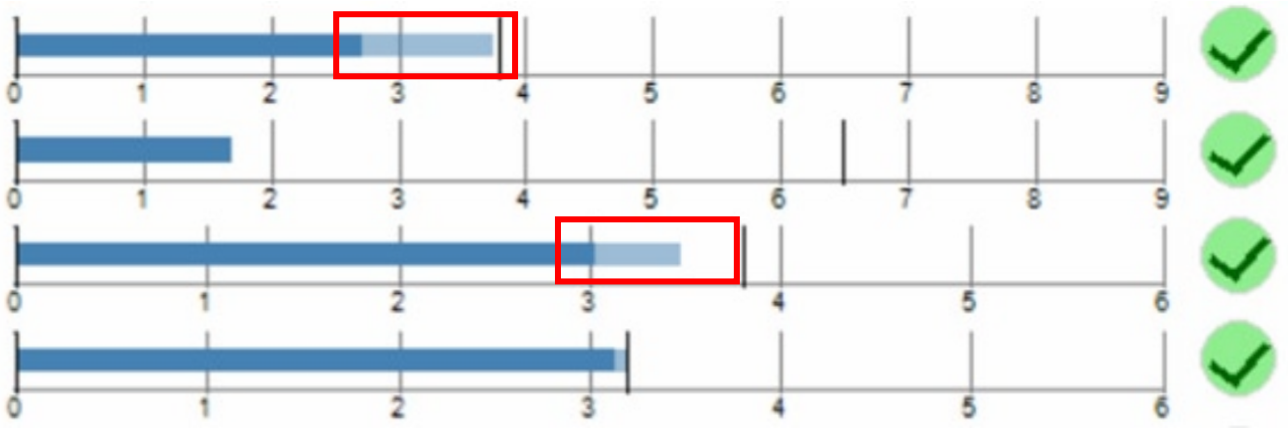
Central Hot Water reduces cooling demand and load & overall energy

4b. IMPACT ON SYSTEMS

LEARNING FROM ANALYSIS

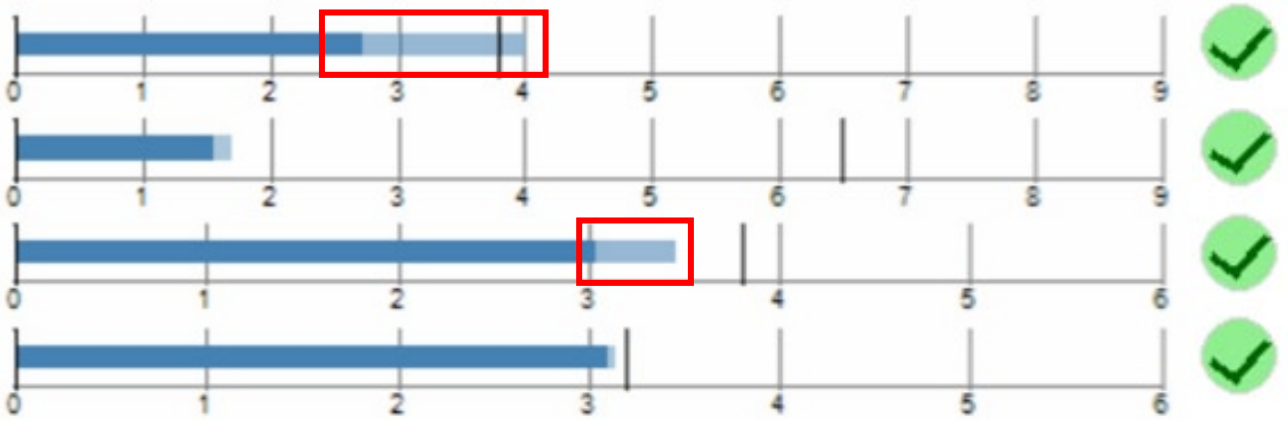
ERV EFFICIENCY

Heating demand:	**2.71** kBtu/ft²yr
Cooling demand:	**1.69** kBtu/ft²yr
Heating load:	**3.03** Btu/hr ft²
Cooling load:	**3.14** Btu/hr ft²



LAUNDRY TYPE & EFFICIENCY

Heating demand:	**2.71** kBtu/ft²yr
Cooling demand:	**1.69** kBtu/ft²yr
Heating load:	**3.03** Btu/hr ft²
Cooling load:	**3.14** Btu/hr ft²



Overview:

1. WHAT IS A FEASIBILITY STUDY?
2 MODEL INPUTS
3. REPRESENTING THE RESULTS
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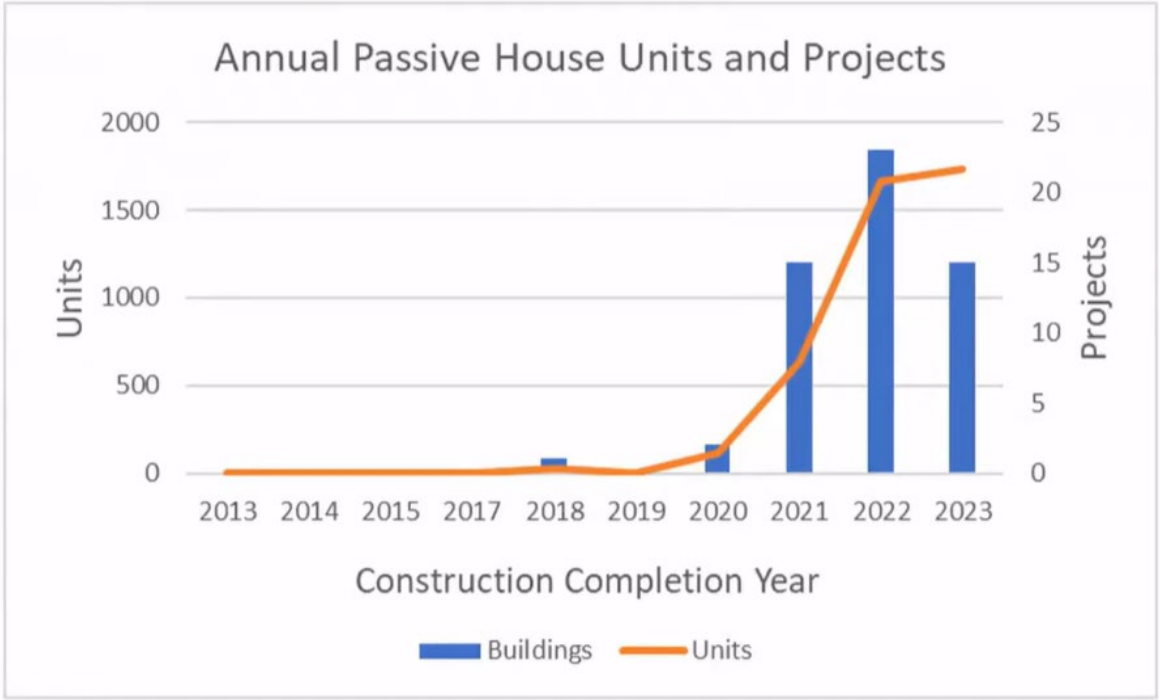
5. CASE STUDIES
    - 5a. Incentive Trends
    - 5b. Case Study Trends
    - 5c. Case Study after Feasibility

5a. INCENTIVE TRENDS

- 86 buildings enrolled projected to complete through 2026
- Over 5,000 units
- Over 5.5 million GSF
- Projects located throughout the Commonwealth
- Projects include both market-rate and low income



(1) Certified in 2018: The Distillery

2021 snapshot:
- 10 Certified
- 17 Pre-Certified

Stats & Graphics Provided by Mass Save

5b. CASE STUDY TRENDS

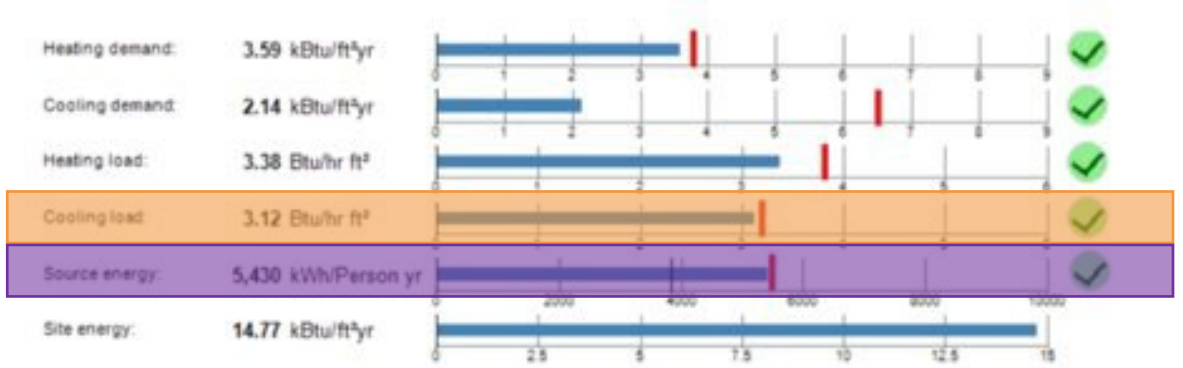
Cooling load

&

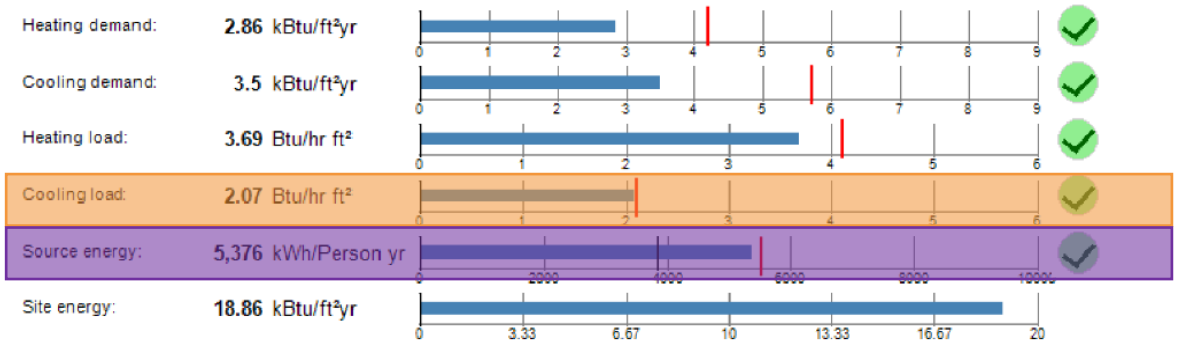
Source energy

are the hardest to meet

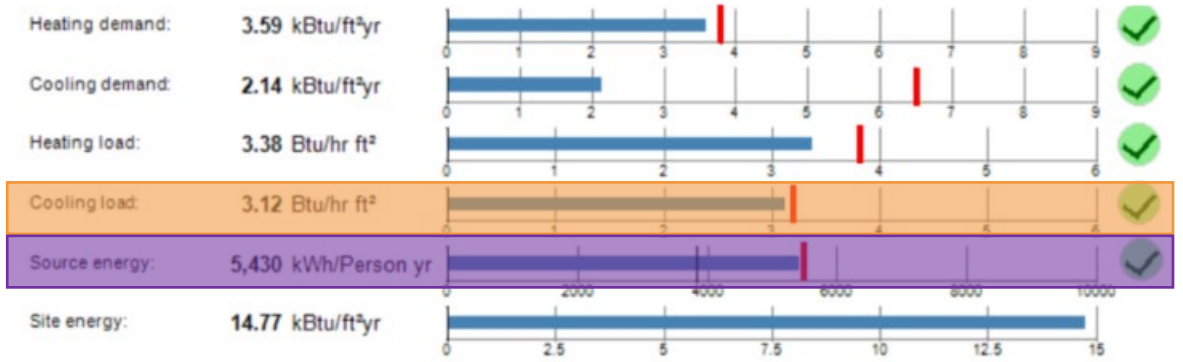
WUFI Results:



WUFI Results:



WUFI Results:

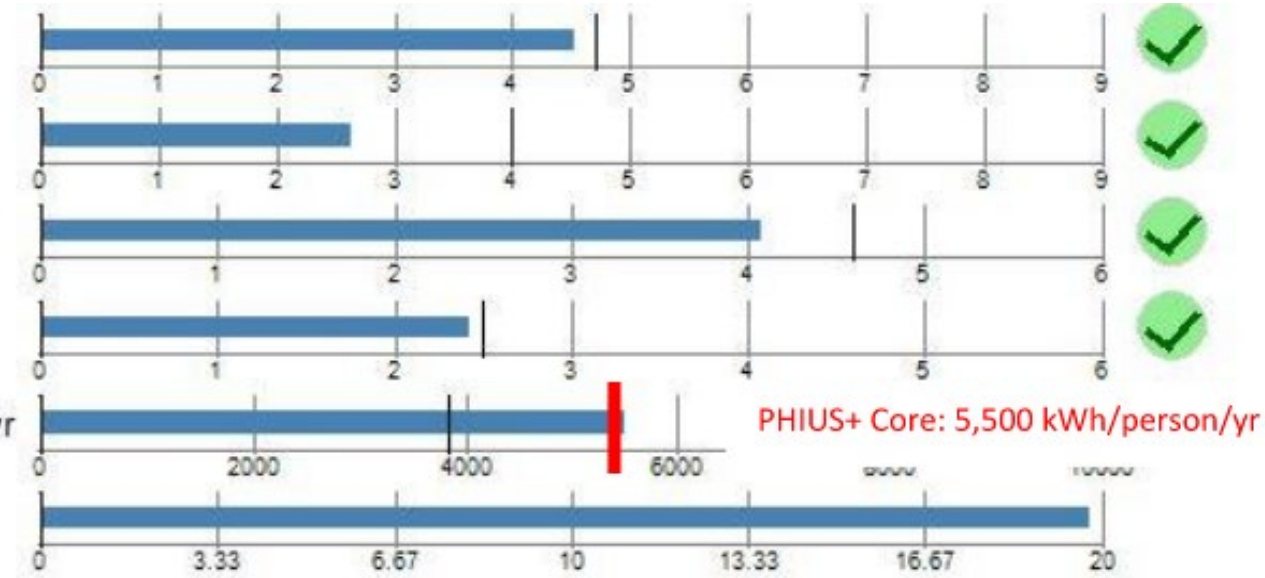


5c. CASE STUDY

Peabody St

21-unit, 5-story building with 43 bedrooms and 64 occupants in Climate Zone 5A

Heating demand:	**4.52** kBtu/ft²yr
Cooling demand:	**2.64** kBtu/ft²yr
Heating load:	**4.07** Btu/hr ft²
Cooling load:	**2.42** Btu/hr ft²
Source energy:	**5,503** kWh/Person yr
Site energy:	**19.76** kBtu/ft²yr



5c. CASE STUDY

Peabody St

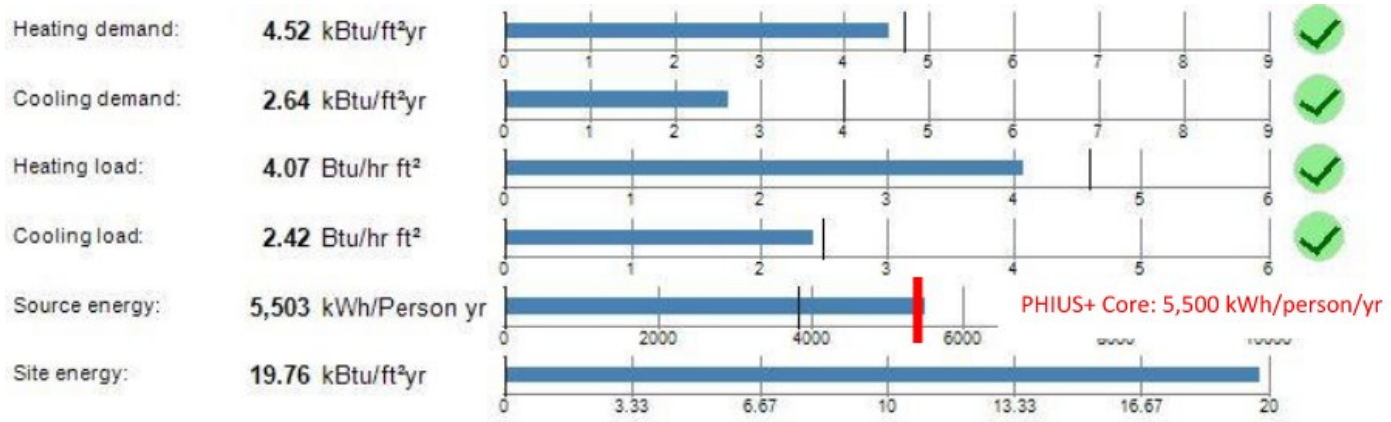
Assemblies:
- Infiltration 0.06 CFM/SF @ 50 Pa
- Slab on Grade: R-10
- Wood-Framed Walls: R-32 (2.5” Continuous insulation)
- Roof: R-47
- uPVC-Frame Windows: U-0.2
- SHGC: 0.5

Central ERV

VRF Heat pumps
COP of 3.53, Centralized condensers

Central Gas-fired water heaters
(2) 119-gallon tanks stored at 140°F

- DHW Distribution:
o 120°F design flow with 18-hours/day recirc
o Length of circulation pipes: 1,500 ft
o Heat loss coefficient per pipe: 0.09 BTU/(hr ft °F)



5c. CASE STUDY : AFTER FEASIBILITY

Peabody St: What's changed since the study

Assemblies:
- Infiltration 0.06 CFM/SF @ 50 Pa
- Slab on Grade: R-10
- Wood-Framed Walls: R-30 (2” Continuous insulation)
- Roof: R-64
- uPVC-Frame Windows: U-0.1425
- SHGC: 0.5

- iCFA decreased by 5%
- Updated WWR
- Revised modeling of perimeter insulation
- Reduced lighting and plug loads based on multifamily calculator
- Added ERV for common space
- 10 kw PV on roof

Central ERV

VRF Heat pumps
COP of 3.53, Centralized condensers

Central Gas-fired water heaters
(2) 119-gallon tanks stored at 140°F

- DHW Distribution:
o 120°F design flow with 18-hours/day recirc
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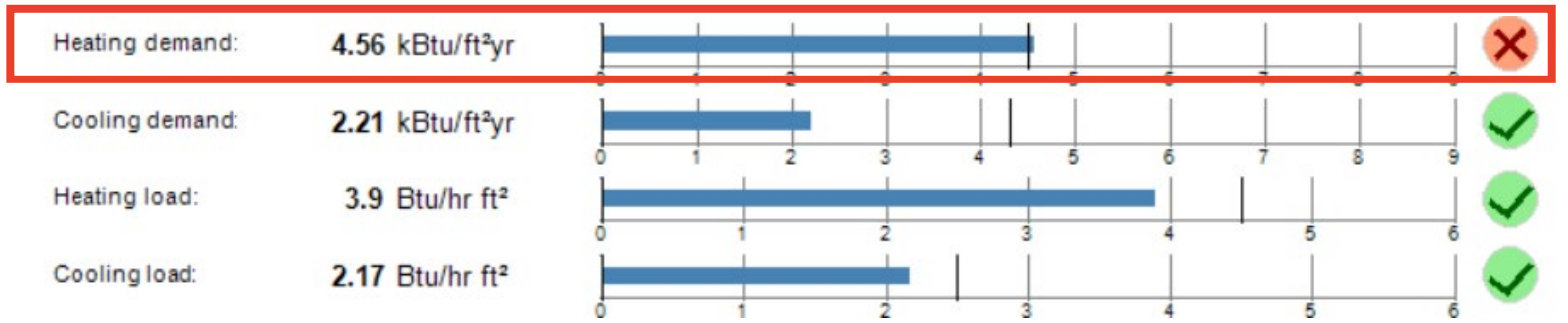
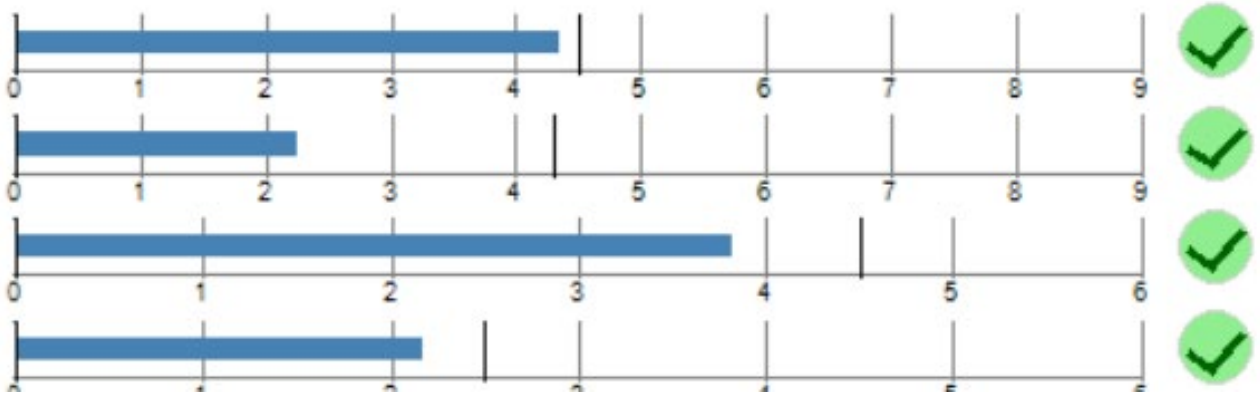


5c. CASE STUDY : AFTER FEASIBILITY

Peabody St : Updated Results

- Reduced foundation perimeter thermal bridge psi-value based on THERM calculations.
- Reduced window installation psi-values & U-values based on manufacturer documents and THERM calculations.
- Increased polyiso insulation thickness at roof
- Updated (increased) refrigerator and dishwasher energy usage.

Heating demand:	**4.36** kBtu/ft²yr
Cooling demand:	**2.24** kBtu/ft²yr
Heating load:	**3.82** Btu/hr ft²
Cooling load:	**2.16** Btu/hr ft²



MAINTAIN MINIMUM 10% BUFFER DURING FEASIBILITY STUDY

KEY TAKE AWAYS:

MODEL INPUTS:

- Focus on Accuracy, not Precision

REPRESENTING THE RESULTS

- Start with the basics, explain the metrics and assumptions
- Compare to a baseline and show improvement of each intervention

LEARNING FROM THE ANALYSIS

- Envelope/Shading are Heating Demand & Cooling Load drivers
- Focus on DHW and ERV

CASE STUDIES:

- Maintain min 10% buffer from targets for refinement during Pre-Certification

Questions?

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gaitcheson@iconarch.com