Blank Paper to Passive

Empowering Early Feasibility Assessments

Agenda

- WHAT is a feasibility study?
- WHY conduct a feasibility study?
- WHEN to conduct the feasibility study
- WHAT projects benefit from a feasibility study?
- HOW to conduct a feasibility study

What is a Feasibility Study?

- Early assessment of a project’s ability to meet the Phius targets
- Compares a baseline case (ideally code), to a case that meets the Phius targets
- Drives design decisions
    - Identify areas of improvement early
- Establishes general target R-values / window performance / systems & efficiencies

fea·si·bil·i·ty stud·y

/ˌfēzəˈbilədē ˈstədē/

noun

an assessment of the practicality of a proposed plan or method.
"a feasibility study into the possibility of harnessing natural water power"

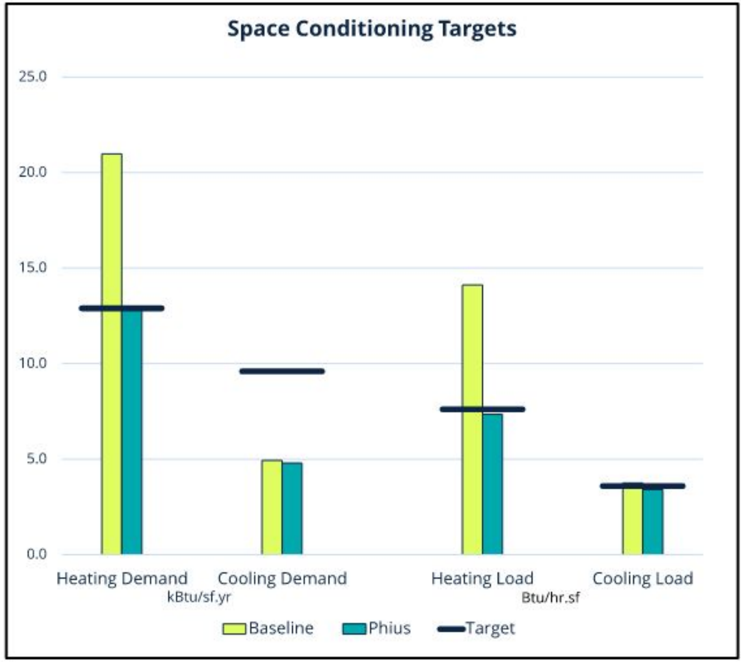
What is a Feasibility Study?

Feasibility Study Deliverables

- Completed WUFI file with two cases
  - Baseline case
    - Code (IECC 2021 or local requirements)
  - Phius-compliant case
    - With proposed design
- Comparison Report
  - Technical breakdown of the parameters of each case
- Feasibility Study Writeup
  - Notes, questions, and design recommendations for things that don’t appear in the comparison report

What is a Feasibility Study

Building Information	Baseline Case	Phius CORE 2021	Units
Building Address:			
Phius Climate Data Set:	Philadelphia International Airport PA		
Exterior Envelope Area:	5,264.95		ft²
Interior Conditioned Floor Area: (iCFA)	1,671.15		ft²
Window-to-Wall Ratio:	0.15		WWR
Number of Stories Above Grade:	3		
Number of Dwelling Units:	1		
Number of Bedrooms:	2		
Modeling Information			**Units**
Fuel Type:	Electricity		
Site-to-Source Energy Factor:	1.8*		
Exterior Envelope	**Baseline Case**	**Phius CORE 2021**	**Units**
Typical Roof:	48.5 / 0.02	48.5 / 0.02	R-value / U-value (effective)
Wall Type WX.1P - Uninsulated Party Walls:	3.4 / 0.24	3.4 / 0.24	R-value / U-value (effective)
Wall Type W1 - Third Floor:	26.1 / 0.037	32.2 / 0.03	R-value / U-value (effective)
Wall Type W1.F - Third Floor:	20.3 / 0.047	26.32 / 0.037	R-value / U-value (effective)
Wall Type W2A - Insulated Party Walls:	9.4 / 0.096	9.4 / 0.096	R-value / U-value (effective)
Wall Type W2 - Typ AG Walls:	23.2 / 0.041	33.0 / 0.030	R-value / U-value (effective)
Wall Type W3 - Insulated Basement Walls:	20.8 / 0.046	20.8 / 0.046	R-value / U-value (effective)
Existing Basement Slab:	Uninsulated	Uninsulated	R-value / U-value (effective)
Casement Windows(Alpen Zenith):	0.155 / 0.33	0.155 / 0.33	U-value / SHGC
Fixed Windows (Alpen Zenith):	0.149 / 0.33	0.149 / 0.33	U-value / SHGC
Glazed doors (Aplen Tyrol):	0.179 / 0.333	0.179 / 0.333	U-value / SHGC
Airtightness	**2021 IECC**	**Phius CORE 2021**	**Units**
Envelope Airtightness:	0.28	0.06	cfm50/ft² (envelope)
Lighting	**Baseline Case**	**Phius CORE 2021**	**Units**
Interior:	597		kWh/yr
Exterior:	36.7		kWh/yr
Appliances	**Baseline Case**	**Phius CORE 2021**	**Units**
Refrigerator:	445	445	kWh/yr
Dishwasher:	270	270	kWh/yr
Clothes Washer:	120 / 0.27	120 / 2.7	kWh/yr / MEF
Clothes Dryer:	5.79	5.79	kWh/yr / MEF
Miscellaneous Electric Loads	**Baseline Case**	**Phius CORE 2021**	**Units**
Total MELs:	1,657		kWh/yr



What is a Feasibility Study?

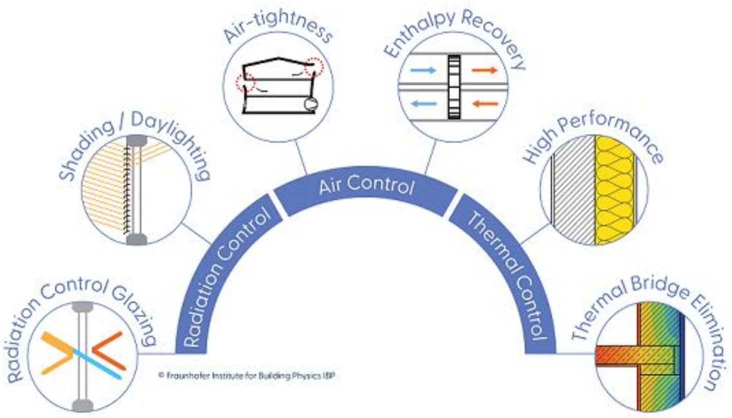
Additional Feasibility Study Deliverables

- Compare & Estimate
  - Energy Bills ($ & CO_2)
    - Don’t forget to include hookup fees!
  - Up-front Cost ($)
  - Return on Investment (ROI)
    - Include incentives gained
- Explain Qualitative Improvements
  - Comfort (quietness, no drafts etc..)
  - Indoor Air Quality
  - Durability
  - Resilience

Why conduct a Feasibility Study?

For the Client

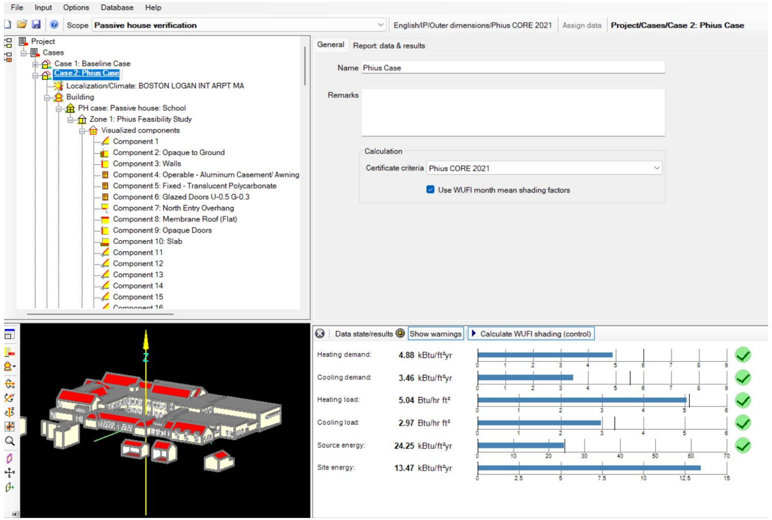
- Understand the benefits of a Phius project
  - Cost savings / low energy bills
- Understand the general differences between a code-built project vs a Phius project



Why conduct a Feasibility Study?

For the Design Team

- Establish design requirements to achieve certification
  - Wall / Roof / Slab target R-values
  - Window comfort / condensation requirements
  - Mechanical system types and performance
- Assess the impact of design decisions & tradeoffs
- Get a head-start on compiling documentation for certification
- Identify areas of improvement that can still be changed since this is happening early in the design process, like the envelope configuration (i.e. reducing surface area via more compact, simplified envelope)



Why conduct a Feasibility Study?

Incentives

- Mass Save
- Know of others?

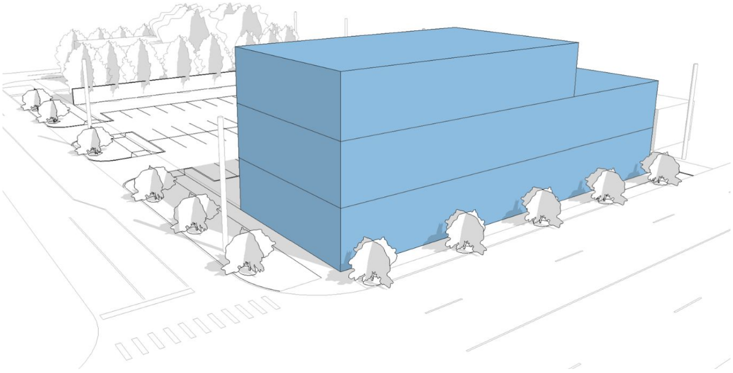
Pre-Construction Incentives

Incentive		Max. Value
Feasibility Study	Invoiced Feasibility costs up to	$5,000
Energy Modeling	75% of energy modeling costs	$500/unit, max.$20,000
Pre-Certification	$750/unit	N/A

- Projects must pre-certify (a.k.a. Design Certification through PHIUS or PHI) to qualify for full Passive House incentives
- Projects that do not pre-certify may participate in the Base or ENERGY STAR tiers.

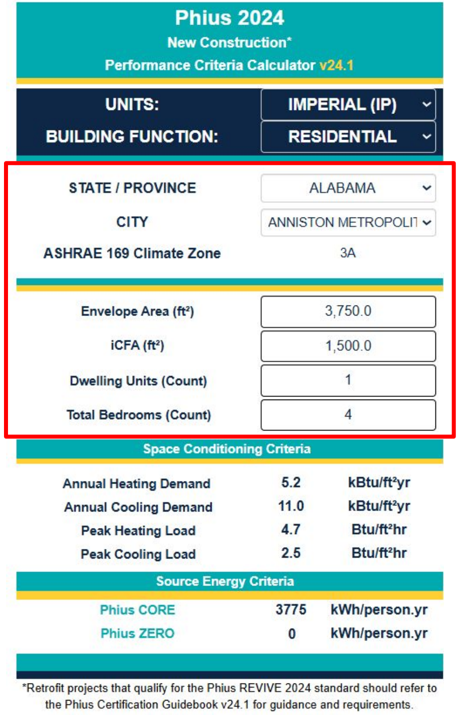
When to conduct a Feasibility Study?

- As early into the design process as possible when decisions are still flexible
- Some things do need to be known, like project geometry
  - Can still be schematic, but enough to get in the ballpark of the actual envelope area
- Not ideal if the project is already breaking ground or in CD phase



When to conduct a Feasibility Study?

- At a minimum, a project team could conduct a feasibility study with basic floor plans and overall building sections (or floor to floor heights) established
- Occupancy should also be (mostly) known
  - Residential: Number of dwelling units / number of bedrooms
  - Nonresidential: Design (max) occupancy
- In general, the minimum inputs required to calculate the project's specific performance criteria targets are needed to conduct the study



What projects benefit from a Feasibility Study?

- All projects could benefit from a feasibility study!
- Crucial for determining the likelihood of achieving certification before registering the project
- Avoid certification hang-ups that could have been caught during early design

Design to Model ✗

Model to Design ✓

How to conduct a Feasibility Study

Common Hang-Ups

- Since feasibility studies should be conducted during early design, there are many unknowns
- Can be intimidating to start a WUFI file with so little information
- R-values: design vs effective
    - Be wary of steel studs!
- When in doubt, be conservative

Exceptions:
Wood Framing Factor Method: Use this method for typical wood-frame assemblies with no exterior continuous insulation.

- Model 25% of the cavity as framing for 16" o.c. assemblies
- Model 15% of the cavity as framing for 24" o.c. assemblies

Metal Framing Deration Methods: Choose one method below whenever metal framing is used.
Simple Method:
33% x R-value/in of the cavity insulation for 16" o.c. assemblies
39% x R-value/in of the cavity insulation for 24" o.c. assemblies

ASHRAE Method:
Apply a deration to the insulation layer containing metal framing in accordance with ASHRAE 90.1 Table A.

How to conduct a Feasibility Study

Additional Common Hang-Ups

- Fuel Switching (natural gas systems vs electric systems)
- Not sure where to start on R-values?
  - Prescriptive Snapshot or Map
- Mechanical Ventilation Rates
  - Code (exhaust only)
  - Phius Minimums
  - Local Jurisdiction Minimums
- Thermal Bridging
  - Placeholders are Ok!

← PROVIDENCE

Climate Data
PROVIDENCE T F GREEN STATE AR

Climate Zone
4A

Maximum Window U-value (Btu/hr.sf.F)
0.18

Maximum SHGC
0.4

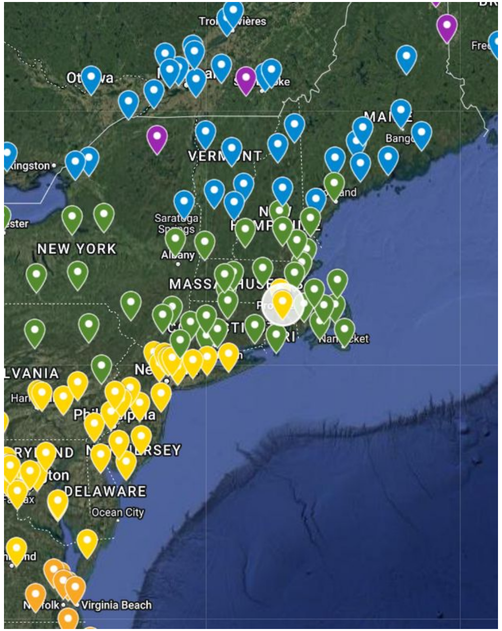
Minimum Projection Factor
NR

Minimum SRE for E/HRVs
0.79

Minimum TRE for E/HRVs
50%

Minimum Wall R-value
40

Minimum Roof R-value
71



Tips & Tricks for Feasibility Study Modeling: Geometry

Scenario: A project team wants to conduct a feasibility study with the following known parameters:

- Location: Providence, RI
- iCFA: 45,000 sf
- 60 1-bed units + some common spaces
- 3-stories
- 900 sf of commercial space at ground level
- Site oriented about east-west axis
- Target WWR: 0.3

Calculators

v4.0 - 2023.03

E/HRV Outside of the Thermal Envelope		
1	Climate Information	
	Country	State
	USA	MA
	Climate Location	
	BOSTON LOGAN INT ARPT	
2	Values for WUFI Passive.	
	Mechanical Room Temperature [°F]	40

v24.1.1 - 2024.07

Phius Water Pressure Booster Pump Estimator		Required inputs	Calculated cells
		Optional Inputs	Results
Results for WUFI Passive			
Energy demand (rated):	1136	W	
Period of Operation:	1.0	khr/yr	
Project Information			
Building Height:	47.50	ft	Water service to top-most water fixture.
Number of Dwelling Units:	75		
Optional Inputs with Default Assumptions			
Street Pressure:	30	psi	Default: 30
Pressure at fixture:	30	psi	Default: 30
Assumed friction losses:	10	psi	Default: 10
Pump Efficiency:	30%		Default: 30%
Motor Efficiency:	75%		Default: 75%
VFD Efficiency:	97%		Default 97%

Temperature Reduction Factor & Auxiliary Energy Calculator

Inputs		
Type of Phius Climate Data	Country	State
Typical	**USA**	**MA**
Phius Climate Location		
BOSTON LOGAN INT ARPT		
Semi-Conditioned Space Name	Setpoint Temp. (F)	
Freeze Protection (stair, bike, fire)	40	

Step 2: *Enter the* ***name of the semi-conditioned space****, as well as the planned* ***setpoint temperature*** *of the space in the cells above.*

Outputs for WUFI	
Attached Zones:	**Create New**
Name:	**Freeze Protection (stair, bike, fire)**
Type of attached zone:	**Unheated space**
Temperature difference reduction factor [-]	**0.80**

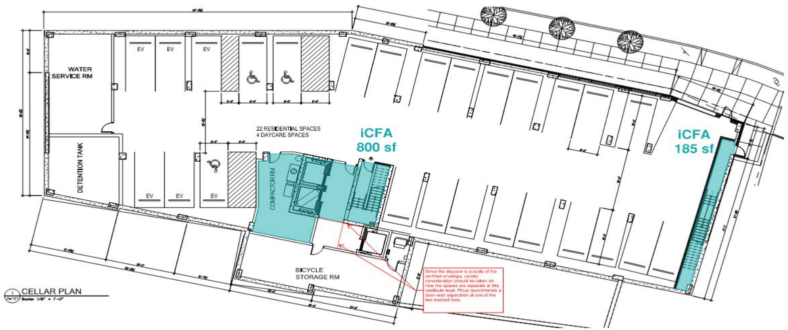
v24.1.1 - 2024.10

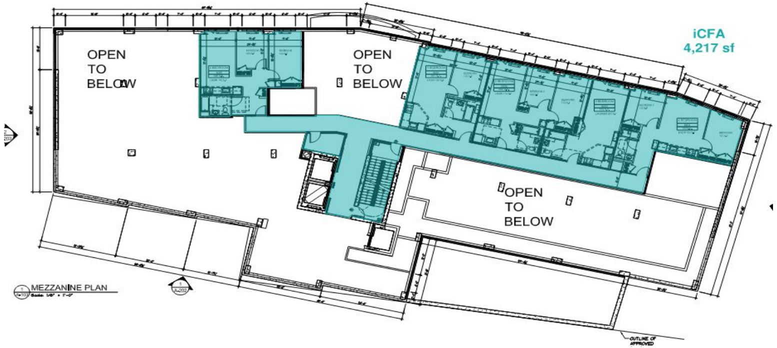
Phius - Auxilliary Energy Estimation Calculator

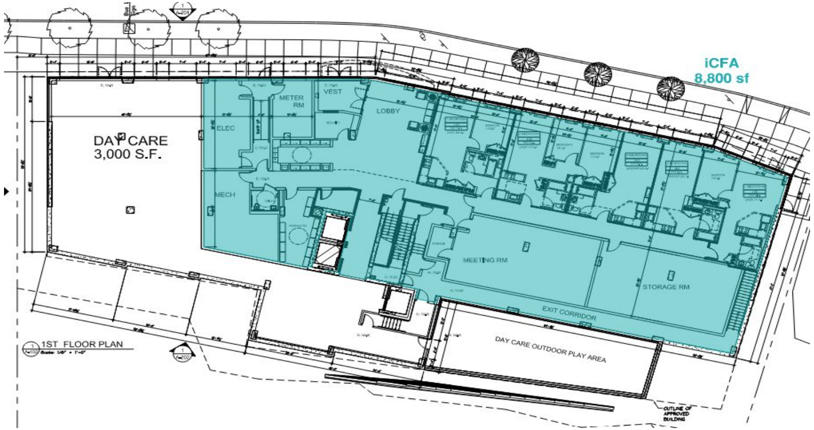
Component type	Connection	R-value	Surface area (sf)	U x A
Roof	**Ambient**	20	288	14.4
Floor	**Ground**	1	288	288.0
Wall	**Ambient**	9.9	1,440	145.5
				-
				-
				-
				-
				-
				-
				-

Outputs for WUFI	
Name:	**Freeze Protection (stair, bike, fire) Aux Energy**
Device Type:	**Other**
Quantity:	**1**
In conditioned space:	**UNCHECKED**
Energy demand for WUFI (W):	**970**
Period of Operation (khr/yr):	**1**

Total - Interior Conditioned Floor Area







Total - Interior Conditioned Floor Area

Interior Conditioned Floor Area (iCFA)

iCFA is the interior-dimension (drywall-to-drywall) projected floor area of the conditioned space that meets the following parameters:

- Interior spaces at least 7' in height, measured from the interior finished surfaces that comprise the thermal boundary of the building.
- Spaces that are visually open-to-below such as elevator shafts and true double-height spaces shall not be counted.
- Other than open-to-below, the projected floor area of all spaces within the building shall count toward the iCFA measurement, including stairs, interior walls, columns, built-in furniture, etc...

iCFA Summary

Cellar:	985 sf
1st:	8,800 sf
Mezzanine:	4,217 sf
2nd:	12,199 sf
3rd:	9,653 sf
4th:	12,199 sf
5th:	11,283 sf
Roof:	731 sf
Total:	60,067 sf

Where to Start with R-values

Baseline Case

- Most valuable - start with IECC minimum requirements
  - Chapter R402.2

CLIMATE ZONE	FENESTRATION *U*-FACTOR[b, i]	SKYLIGHT[b] *U*-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE[g]	MASS WALL *R*-VALUE[h]	FLOOR *R*-VALUE	BASEMENT[c,g] WALL *R*-VALUE	SLAB[d] *R*-VALUE & DEPTH	CRAWL SPACE[c,g] WALL *R*-VALUE
0	NR	0.75	0.25	30	13 or 0& 10ci	3/4	13	0	0	0
1	NR	0.75	0.25	30	13 or 0& 10ci	3/4	13	0	0	0
2	0.40	0.65	0.25	49	13 or 0& 10ci	4/6	13	0	0	0
3	.30	0.55	0.25	49	20 or 13& 5ci[h] or 0& 15ci[h]	8/13	19	5ci or 13[f]	10ci, 2 ft	5ci or 13[f]
4 except Marine	.30	0.55	0.40	60	30 or 20&5ci[h] or 13& 10ci[h] or 0&20ci[h]	8/13	19	10ci or 13	10ci, 4 ft	10ci or 13
5 and Marine 4	0.30[i]	0.55	0.40	60	30 or 20&5ci[h] or 13& 10ci[h] or 0&20ci[h]	13/17	30	15ci or 19 or 13& 5ci	10ci, 4 ft	15ci or 19 or 13& 5ci
6	0.30[i]	0.55	NR	60	30 or 20&5ci[h] or 13& 10ci[h] or 0&20ci[h]	15/20	30	15ci or 19 or 13& 5ci	10ci, 4 ft	15ci or 19 or 13& 5ci
7 and 8	0.30[i]	0.55	NR	60	30 or 20&5ci[h] or 13&10ci[h] or 0&20ci[h]	19/21	38	15ci or 19 or 13& 5ci	10ci, 4 ft	15ci or 19 or 13& 5ci

Modeling Feasibility Study Windows

- Windows have probably not been specified or selected at this point, so there wouldn't be any window data to use for WUFI
- To model whole-window performance based on IECC or Phius maximum requirements…

Example: A project team is in the early stages of design, and wants to model windows based on the maximum whole-window U-value to comply with the Window Comfort Requirements. They cannot exceed a whole-window U-value of 0.19 based on the tallest window in the project. To model this in WUFI, the team should enter the following:

- Glass U-value: 0.19
- SHGC: 0.15-0.4 (typ. whole-window range)
  - This can be adjusted as an intentional design decision to meet the performance criteria targets
- Frame width: 0.01"
- Frame U-value: 0.19
- Glazing-to-frame psi-value: 0 (included in whole window U-value)
- Psi-Installation: 0.03 (default)

This method "ignores" the frame inputs and calculates a whole-window U-value of 0.19. This is helpful when modeling for a feasibility study or before a final window selection has been made.

Where to Start with R-values

Phius Case

- Use the prescriptive climate map / prescriptive snapshot to over-estimate the required R-values for assemblies based on the project location
- Then, after the model is complete, insulation levels can be backed off

← PROVIDENCE

Climate Data
PROVIDENCE T F GREEN STATE AR

Climate Zone
4A

Maximum Window U-value (Btu/hr.sf.F)
0.18

Maximum SHGC
0.4

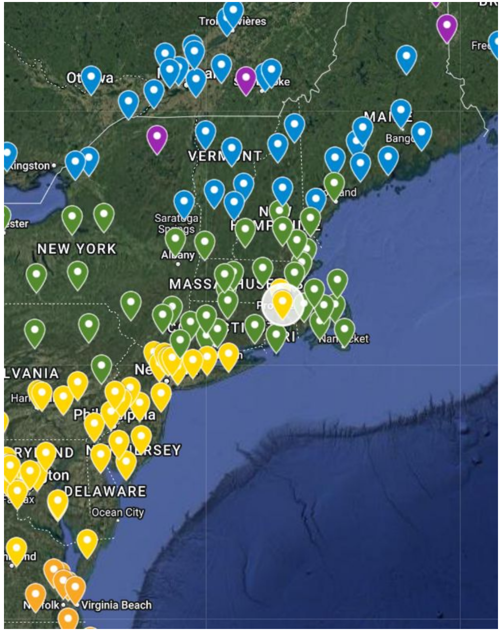
Minimum Projection Factor
NR

Minimum SRE for E/HRVs
0.79

Minimum TRE for E/HRVs
50%

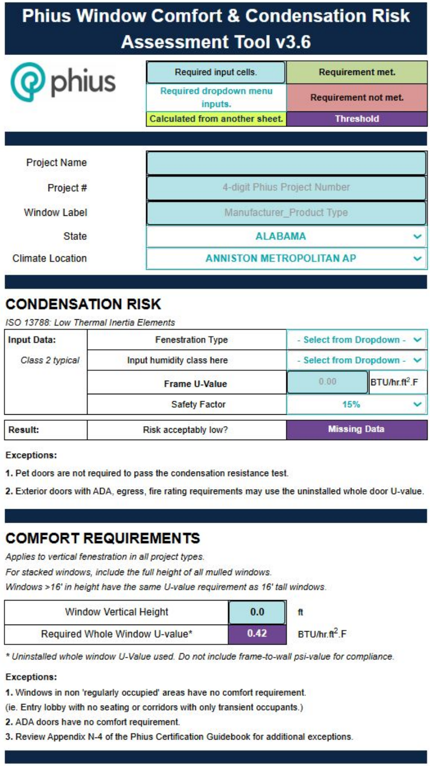
Minimum Wall R-value
40

Minimum Roof R-value
71



Window Comfort & Condensation Risk

- Window Comfort and Condensation v3.6
- Use the tallest window in the project to establish the worst-case whole-window U-value requirement for the Phius-compliant case
- If you have storefronts & “typical” windows, complete the assessment for both types



Phius Window Comfort & Condensation Risk Assessment Tool v3.6

phius

Required input cells.	Requirement met.
Required dropdown menu inputs.	Requirement not met.
Calculated from another sheet.	Threshold

Project Name	
Project #	4-digit Phius Project Number
Window Label	Manufacturer_Product Type
State	ALABAMA
Climate Location	ANNISTON METROPOLITAN AP

CONDENSATION RISK

ISO 13788: Low Thermal Inertia Elements

Input Data:	Fenestration Type	- Select from Dropdown -	
Class 2 typical	Input humidity class here	- Select from Dropdown -	
	Frame U-Value	0.00	BTU/hr.ft².F
	Safety Factor	15%	
Result:	Risk acceptably low?	Missing Data	

Exceptions:

1. Pet doors are not required to pass the condensation resistance test.
2. Exterior doors with ADA, egress, fire rating requirements may use the uninstalled whole door U-value.

COMFORT REQUIREMENTS

Applies to vertical fenestration in all project types.
For stacked windows, include the full height of all mulled windows.
Windows >16' in height have the same U-value requirement as 16' tall windows.

Window Vertical Height	0.0	ft
Required Whole Window U-value*	0.42	BTU/hr.ft².F

** Uninstalled whole window U-Value used. Do not include frame-to-wall psi-value for compliance.*

Exceptions:

1. Windows in non 'regularly occupied' areas have no comfort requirement.
(ie. Entry lobby with no seating or corridors with only transient occupants.)
2. ADA doors have no comfort requirement.
3. Review Appendix N-4 of the Phius Certification Guidebook for additional exceptions.

Does the Assembly need Derated?

- The following assembly characteristics would require a deration of the insulation layer affected
  - Wood / Steel studs
    - Easier to model wood studs directly in WUFI, but the 'deration' method can still be taken
    - Don't waste time trying to model steel studs in WUFI
  - Mechanically fastened continuous insulation layer
    - Unless recessed fasteners, or if fasteners are only used in the 'bottom' layer
    - Used to be only for CI $\geq$ 4", but is now required for all thicknesses (for Phius 2024)

I-3.1 Default Fastener Deration Values

Table I-3.1.0 Fastener Correction Derations		
Fastener Material	**Continuous Insulation Thickness**	**Deration Requirement**
Stainless Steel	<4"	Derate R/in by 10%
	≥4"	Derate R/in by 15%
Mild Steel	<4"	Derate R/in by 25%
	≥4"	Derate R/in by 35%
Plastic or Thermally Broken	No fastener correction required	
Aluminum	Fastener Correction Calculator required.	

Process Tips:
- Project teams may submit a project-specific Fastener Correction Calculator for certification compliance.
- The % deration should be applied to the R/in of the exterior rigid continuous insulation layer in the WUFI assembly.

Exceptions:
Wood Framing Factor Method: Use this method for typical wood-frame assemblies with no exterior continuous insulation.
- Model 25% of the cavity as framing for 16" o.c. assemblies
- Model 15% of the cavity as framing for 24" o.c. assemblies

Metal Framing Deration Methods: Choose one method below whenever metal framing is used.
Simple Method:
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39% x R-value/in of the cavity insulation for 24" o.c. assemblies

ASHRAE Method:
Apply a deration to the insulation layer containing metal framing in accordance with ASHRAE 90.1 Table A.

Internal Loads / Occupancy

Table 1.4.4.8.0 Dishwasher			
Water Connection	Reference Quantity	Energy Demand	Capacity[20]
DHW	PH case occupants	239 kWh/yr	Standard (12)

Table 1.4.4.8.1 Cooking			
Choice	Reference Quantity	When Applicable?	Energy Demand[21]
Electricity	PH case occupants	Coil	0.22 kWh/use
		Induction	0.20 kWh/use
Natural Gas		-	0.25 kWh/use

Table 1.4.4.8.2 Fridge / Freezer Combo			
Size (cu ft)	Reference Quantity	Energy Demand Reference	Energy Demand
<10	PH case Units or User Defined	Year	230 kWh/yr
15-20			451 kWh/yr
>20			699 kWh/yr

Table 1.4.4.8.3 Freezer		
Reference Quantity	Energy Demand Reference	Energy Demand
PH Case Units or User Defined	Year	394 kWh/yr

Table 1.4.4.8.4 Clothes Dryers			
Type	When Applicable?	Reference Quantity	CEF[22]
Condensation	Ventless	PH case occupants	2.68
	Heat Pump		5.85
Exhaust Air	Electric		3.93[23]
	Natural Gas[24]		3.48

Table 1.4.4.8.5 Clothes Washer				
Reference Quantity	Energy Demand	Utilization Factor	Capacity	MEF[25]
PH case occupants	110 kWh/yr	1	4.5 ft^3	3.13

Internal Loads / Occupancy

PHIUS+ MELS	Bedroooms	78	☑
PHIUS+ Interior lighting	PH case floor area		☑
PHIUS+ Exterior lighting	PH case floor area		☐

- Single family MELs + Lighting setup → WUFI Auto-calculates

User defined - Misc electric loads	User defined	1	☑
User defined - lighting	User defined	1	☑
User defined - lighting	User defined	1	☐

- Multifamily MELs + Lighting setup → MF Calculator

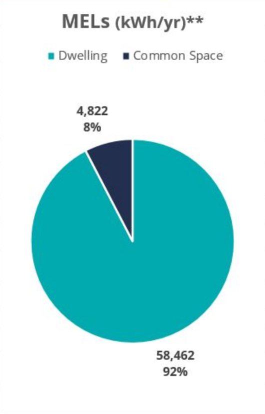
Multifamily Calculator

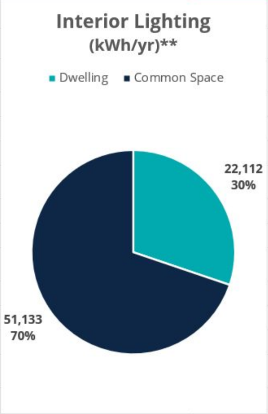
- Used for any project with 2 or more dwelling units!
- Used in the calculation of targets
- The $iCFA_{REF}$ should ALWAYS be less than the overall iCFA…why?

Phius Multi-Family Calculator	v24.0.1	Navigate to Definitions
Lighting & Plug Loads for WUFI Passive		
Number of Units	75	1
Design Occupancy	153	2
Number of Bedrooms	78	3
MEL_{DWELL} (kWh/yr)	58,462	4
Interior MEL_{YARD} (kWh/yr)	-	5
MEL_{COMM} (kWh/yr)	4,822	6
Total MEL (kWh/yr)	63,284	7
$LIGHTS_{INT,DWELL}$ (kWh/yr)	22,112	8
$LIGHTS_{INT,COMM}$ (kWh/yr)	51,133	9
Total $LIGHTS_{INT}$ (kWh/yr)	73,244	10
$LIGHTS_{EXT,DWELL}$ (kWh/yr)	1,904	11
$LIGHTS_{EXT,COMM}$ (kWh/yr)	-	12
$LIGHTS_{GAR}$ (kWh/yr)	1,500	13
Total $LIGHTS_{EXT}$ (kWh/yr)	3,404	14
Exterior MEL_{YARD} (kWh/yr)	-	15
$iCFA_{DWELL}$ (sf)	40,352	16
$iCFA_{COMM}$ (sf)	16,196	17
$iCFA_{REF}$ (sf)	56,548	18

Phius Notes/Instructions*

*Enter information | *Calculated values, do not override | *Results





*Commas are delineated in the calculated values for visual clarity, but no commas should be included when inputting values into WUFI Passive. The software treats commas as decimal points.
**Graphs above are for visualization purposes to help inform the designer, all WUFI entries should be taken from Column C to the left.

Dwelling Unit & Common Areas

$iCFA_{DWELL}$	The interior conditioned floor area of all the dwelling units. Since either the unit or floor method may be used, it may: - include or exclude the projected floor area of interior partition walls to common spaces, whichever approach is simpler to document. OR - include or exclude the projected floor area of interior partition walls within or between units, whichever approach is simpler to document.
$iCFA_{COMM}$	The interior conditioned floor area of common spaces, not including interior partition walls.
$iCFA_{REF}$	The sum of the **$iCFA_{DWELL}$** and **$iCFA_{COMM}$** to use as a reference for the total iCFA of the building. This value will likely be less than the iCFA of the whole building since interior partion walls may or may not be included in this calculation, but should be included in the whole building iCFA.

Dwelling Unit & Common Areas

CORRIDOR / STAIR
ELEVATOR
STORAGE / MECHANICAL
OFFICE
MULTIPURPOSE
COMMON BATHROOM
COMMON LAUNDRY
DWELLING UNIT

Mechanical Ventilation - Design airflow Rates

Baseline Case

- Probably most valuable to assume an exhaust-only system that complies with code requirements

Phius-Compliant Case

- Use the multifamily calculator as a guide for minimum dwelling unit ventilation requirements
  - If doing a single family project, use exhaust rooms to determine the minimum required ventilation (this should be familiar from CPHC training!)
- For common areas, assume: 0.06 cfm / sf (iCFA)

Total # of Units	75
Design Occupancy	153
Total # of Bedrooms	78
Total # of Bathrooms	75
Total $Supply_{DWELL}$ (cfm)	3,582
Total $Exhaust_{DWELL}$ (cfm)	3,582
$iCFA_{DWELL}$ (sf)	40,352

$iCFA_{DWELL}$ (sf)	40,352
$iCFA_{COMM}$ (sf)	16,196
$iCFA_{REF}$ (sf)	56,548

* 0.06 = 972 cfm

Mechanical Ventilation - Exhaust Devices

- Direct exhaust only, ducted straight to the outside
- Run time for range hood & dryers will be auto-calculated by WUFI, but flow rates do need defined
- Exhaust air flow rate defaults:
  - Use 220 cfm for dryers
  - Use 100 cfm for range hoods
  - Use 50 cfm for bath fans
    - 60 min/day = 21900 min/yr

Bathroom direct exhaust:

1. Assume 60 min / bathroom / day[27]
   - Exhaust volume flow rate [cfm]:
     → Sum total bathroom exhaust fans in the building
   - Run time per year [min]:
     → **(**365 days/yr ***** 60 min/day**) =** 21,900 minutes/yr

Name	Type	Exhaust volume flow rate [cfm]	Run time per year [min]	Run time per day [min]
Dryer	Exhaust dryer	220	n.def.	n.def.
Range hood	Exhaust range hood	100	n.def.	n.def.
Bathroom	Other exhaust appliances	50	21900	n.def.

Mechanical Systems

Documentation

- Early mechanical design is usually very schematic
  - Narratives identify the system type, design intent, and operation sequence
  - Schematic plans can provide information on distribution, equipment selection
  - Plant diagrams are most useful
- Identification of system type and match is most critical

About Systems in WUFI Passive

- WUFI is generally more focused on envelope than systems
- Having general ranges of efficiency and how to input in WUFI is most critical
- Remember: The building envelope (+E/HRV) set your passive space loads, and the systems sets the EUI / Source energy

About Efficiencies

- Following slides show the best estimate from Phius reviewing projects
- For baseline cases, if no specification, look at federal register

Incorporate Minimum Efficiency Requirements for Heating and Cooling Products into Federal Acquisition Documents

Boilers

The table below includes minimum efficiency requirements for the following FEMP-designated and ENERGY STAR-qualified covered product categories: boilers (commercial) and boilers (residential).

GAS- AND OIL-FIRED BOILERS: MINIMUM EFFICIENCY REQUIREMENTS

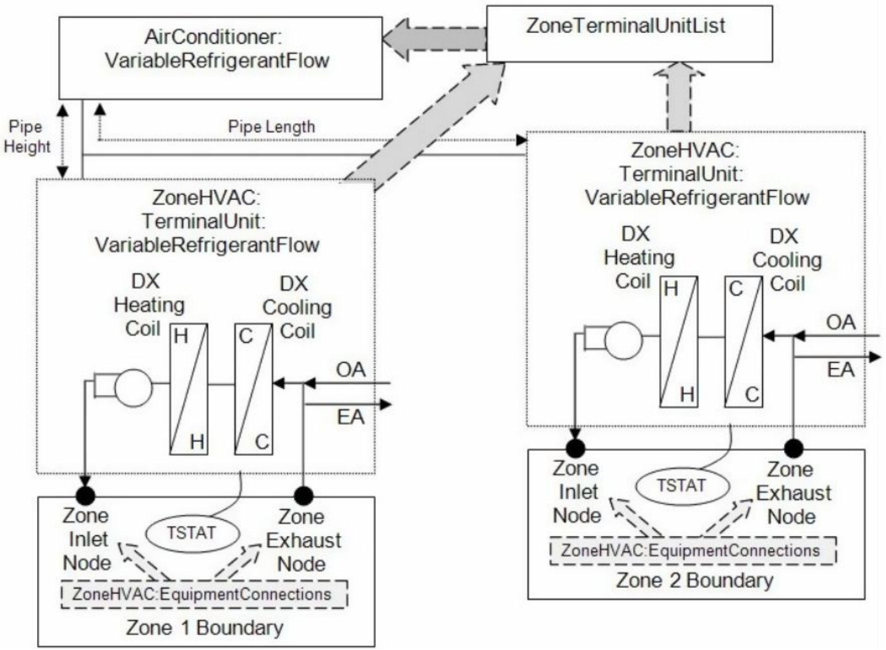
Equipment Type	Subcategory or Rating Condition	Size Category (Input)	Efficiency Metric	Minimum Efficiency
Boilers, hot water	Gas-fired	<300,000 Btu/h	AFUE[a]	90%
		≥300,000 Btu/h and ≤2,500,000 Btu/h	E_t[b]	94%
		>2,500,000 Btu/h and ≤10,000,000 Btu/h	E_c[d]	96%
		>10,000,000 Btu/h[d]	E_c	82%
	Oil-fired	<300,000 Btu/h	AFUE	87%
		≥300,000 Btu/h and ≤2,500,000 Btu/h	E_t	94%
		>2,500,000 Btu/h and ≤10,000,000 Btu/h	E_c	89%
		>10,000,000 Btu/h[d]	E_c	84%
	Gas-fired	<300,000 Btu/h	AFUE	90%
	Gas-fired (all, except natural draft)	≥300,000 Btu/h and ≤2,500,000 Btu/h	E_t	94%
		>2,500,000 Btu/h and ≤10,000,000 Btu/h	E_t	83%

Split Heat Pumps / VRF

- Most common system seen in project reviews
- Input as *Heat Pump:*
  - Heating COP 3
  - Cooling COP 4

or

- *Heat Pump Rated Monthly COP:*
  - Heating COP
    - 2.4 @ 17°F
    - 3.5 @ 47°F
  - Cooling COP 4



Ground Source WSHP

- More stable ground temps keep COPs consistent
- Input as *Heat Pump:*
  - Heating COP 3
  - Cooling COP 4
- Account for pumps by derating COP by ~5%

Or

- Include an Auxiliary Device
  - Assume ~7 tons/HP
  - Can be placed out of the thermal boundary

Heat Pumps in Series - WSHP

- Large format Electrification
- Input as *Heat Pump:*
    - Heating COP 2.25
    - Cooling COP 3.25
- Account for pumps by derating COP by ~5%

Or

- Include an Auxiliary Device
    - Assume ~7 tons/HP
    - Can be placed out of the thermal boundary

WSHP w/ Boiler and Cooling Tower

- Cold climates anyone?
- Input as *Heat Pump* with 80% coverage*:*
    - Heating COP 2.5
    - Cooling COP 3.25
- Input boiler as *User Defined* if gas or *Electric Resistance* w/20% coverage*.*
- Account for pumps and cooling tower by derating COP by ~10%

Or

- Include an Auxiliary Device
    - Assume ~7 tons/HP
    - Can be placed out of the thermal boundary

ASHP w/ Hydronic Fan Coils

- Large format Electrification
- Input as *Heat Pump:*
  - Heating COP 2.5
  - Cooling COP 3.5
- Account for pumps by derating COP by ~5%

Or

- Include an Auxiliary Device
  - Assume ~7 tons/HP
  - Can be placed out of the thermal boundary
  - May need to include fan energy as well

Combustion plus DX Cooling

- Input as *User Defined*:
  - Heating efficiency: 90% for furnace, 96% for boiler
- Input cooling as *Heat Pump:*
  - Cooling COP: 3.5

Ventilation

- If baseline system is not balanced:
  - *PH Case/Additional Data/ Type of ventilation system: Exhaust.*
- Balanced ventilation is a Phius program requirement
  - Input *Mechanical Ventilation Devices*
  - MF Calculator sizes flow rates
  - ERV: Sensible 0.75, Latent: 0.5
  - HRV: Sensible 0.8
  - Fan Power:
    - 1 W/cfm for small units
    - 1.5 W/cfm for DOAS
    - 2+ W/cfm for high rise

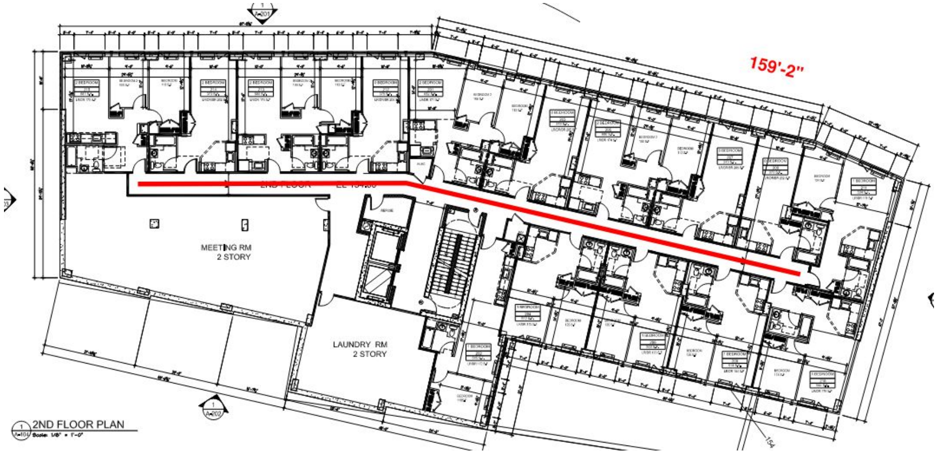
Distribution - Domestic Hot Water

Keep it Simple & Conservative!

- Recirculation likely?
- How many stories?
- How many risers?
- How long are the double-loaded corridors?

stories x # risers x 10’ (or so)
= Vertical Recirc Pipe lengths

stories x length of the corridor
= Horizontal Recirc Pipe lengths



Distribution - Domestic Hot Water

Keep it Simple & Conservative!

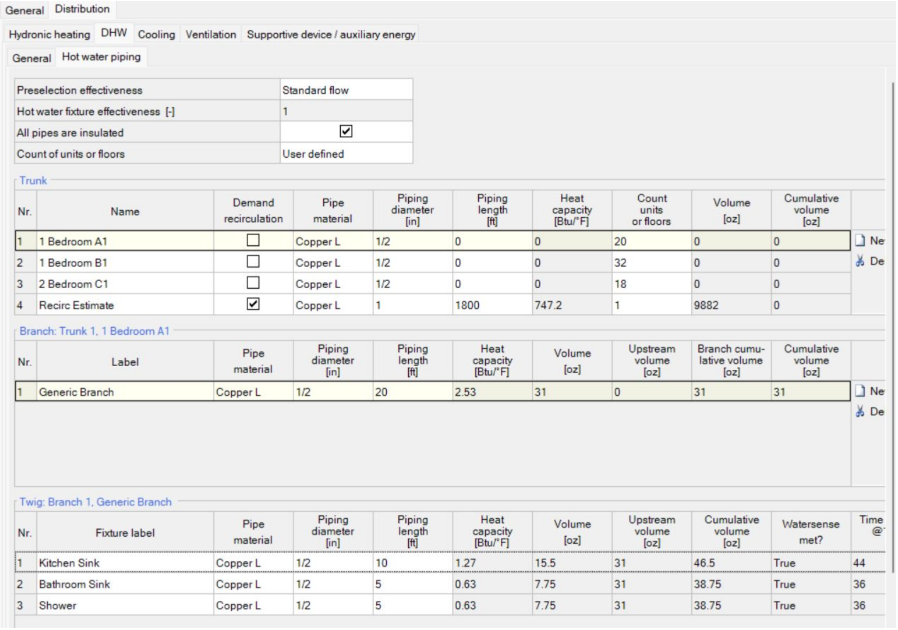
- How many dwelling units?
- How many dwelling units types?
- How many bathrooms?

Use the Multifamily Calculator to help you

Trunks: Input one line per dwelling unit type.

Branches: Input one line to connect to the twigs.

Twigs: One line per fixture type: kitchen sink, lavatory faucet, tub/shower.



Preselection effectiveness	Standard flow
Hot water fixture effectiveness [-]	1
All pipes are insulated	☑
Count of units or floors	User defined

Trunk

Nr.	Name	Demand recirculation	Pipe material	Piping diameter [in]	Piping length [ft]	Heat capacity [Btu/°F]	Count units or floors	Volume [oz]	Cumulative volume [oz]
1	1 Bedroom A1	☐	Copper L	1/2	0	0	20	0	0
2	1 Bedroom B1	☐	Copper L	1/2	0	0	32	0	0
3	2 Bedroom C1	☐	Copper L	1/2	0	0	18	0	0
4	Recirc Estimate	☑	Copper L	1	1800	747.2	1	9882	0

Branch: Trunk 1, 1 Bedroom A1

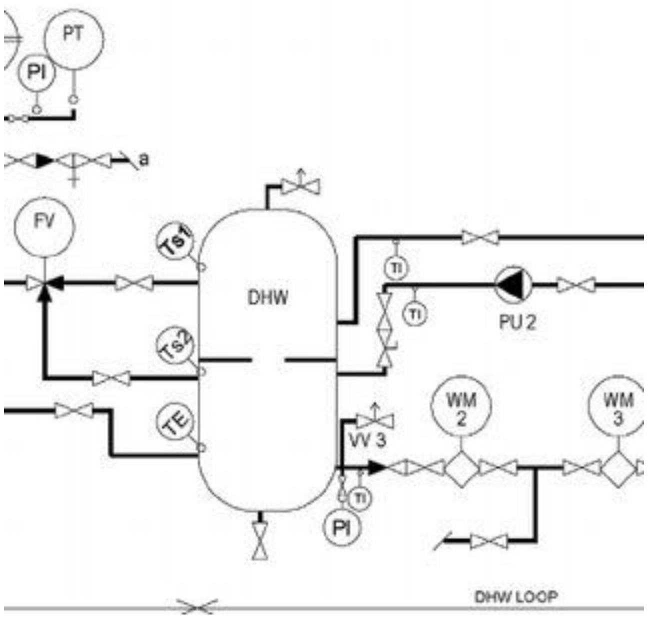
Nr.	Label	Pipe material	Piping diameter [in]	Piping length [ft]	Heat capacity [Btu/°F]	Volume [oz]	Upstream volume [oz]	Branch cumu-lative volume [oz]	Cumulative volume [oz]
1	Generic Branch	Copper L	1/2	20	2.53	31	0	31	31

Twig: Branch 1, Generic Branch

Nr.	Fixture label	Pipe material	Piping diameter [in]	Piping length [ft]	Heat capacity [Btu/°F]	Volume [oz]	Upstream volume [oz]	Cumulative volume [oz]	Watersense met?	Time @
1	Kitchen Sink	Copper L	1/2	10	1.27	15.5	31	46.5	True	44
2	Bathroom Sink	Copper L	1/2	5	0.63	7.75	31	38.75	True	36
3	Shower	Copper L	1/2	5	0.63	7.75	31	38.75	True	36

DHW Plant

- Distribution and and demands set the loads, plant equipment sets the EUI
- In larger buildings, electrification has been difficult
- Can be centralized, semi centralized, or decentralized
- Include recirculation pumps in the *Aux Energy*



Gas Water Heater

- Boiler + storage tank or unitary
- Set as *User Defined* device
  - Efficiency: 90-95%
- Include *Water Storage*
  - Specific total losses: 8 Btu/hr °F

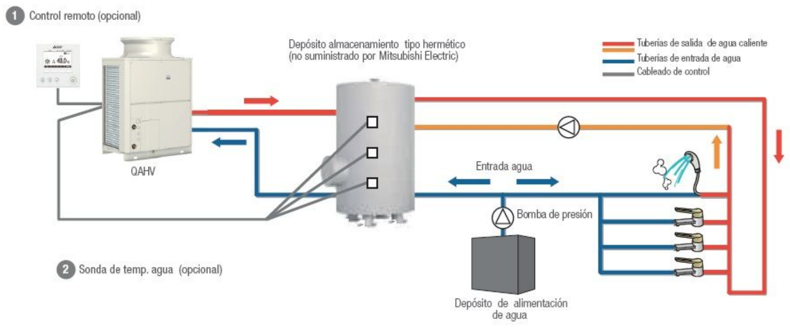
Electric Water Heater

- Boiler + storage tank or unitary
- Set as *Electric Resistance* device
- Include *Water Storage*
  - Specific total losses: 8 Btu/hr °F

Heat Pump Water Heater

- Unitary only
- Set as *HPWH Inside* device
  - COP / Performance Ratio
  - Match Heating COP
  - EF: 2.35
- **Do not** include *Water Storage*

Split Heat Pump Water Heater



- CO_2 or Split
- Set as *Heat Pump*
  - COP: 3 for CO_2, 2 for R-410A / 32, etc
- Include *Water Storage*
  - Specific total losses: 8 Btu/hr °F
- If swing tank is present, assume 20% coverage by *Electric Resistence*