BUILDING ENERGY 15

MARCH 3-5, 2015 AT THE SEAPORT WORLD TRADE CENTER

AIA Provider: Northeast Sustainable Energy Association

Provider Number: G338

Applying Passive House Principles to 160 Units of Affordable Housing – Lessons Learned

Hank Keating, AIA, VP Design and Construction, Trinity Financial, Inc.
James Petersen, P.E., Principal, Petersen Engineering, Inc.
Lauren Baumann, VP, New Ecology, Inc.

March 5 ,2015 (Thursday), 8:30am - 10:00am

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Course Description

Fairfax Gardens was a 150 unit dilapidated public housing development in Taunton, MA. The THA selected Trinity Financial to be the developer, owner and operator of a 160 unit replacement program on two sites. The Hope VI Program requires a very competitive funding application that includes strong sustainability incentives measured using LEED and/or Enterprise Green community checklist criteria. The Fairfax Gardens funding application was successful in part because it committed to very aggressive energy conservation measures. To meet these commitments, the development team had to work collaboratively through the design process to develop systems and details that would produce one of the most energy efficient affordable housing developments in the country. Emphasis was put on simplicity for operation and maintenance, affordability, constructability at scale, dependability, and very low energy bills for residents. In addition, the project had to negotiate the myriad of regulations governing allowable rents and utility charges.

Learning Objectives

At the end of the this course, participants will be able to:

1. How do you integrate passive house-type ECMs such as double-stud walls, super-insulation, super air-sealing, and heat recovery ventilation into 160 units of affordable housing?
2. What are the primary technical and construction factors that influence details and systems selection?
3. What are the primary code and funding agency regulations that influence systems selection and utility billing?
4. How do you train tenants to accept and properly use new building components such as mini-splits, HRVs, awning windows, condensing dryers, etc.?


POLICE
NO TRESPASSING ON
TAUNTON HOUSING AUTHORITY
PROPERTY

Fairfax Gardens Hope VI

Taunton, MA

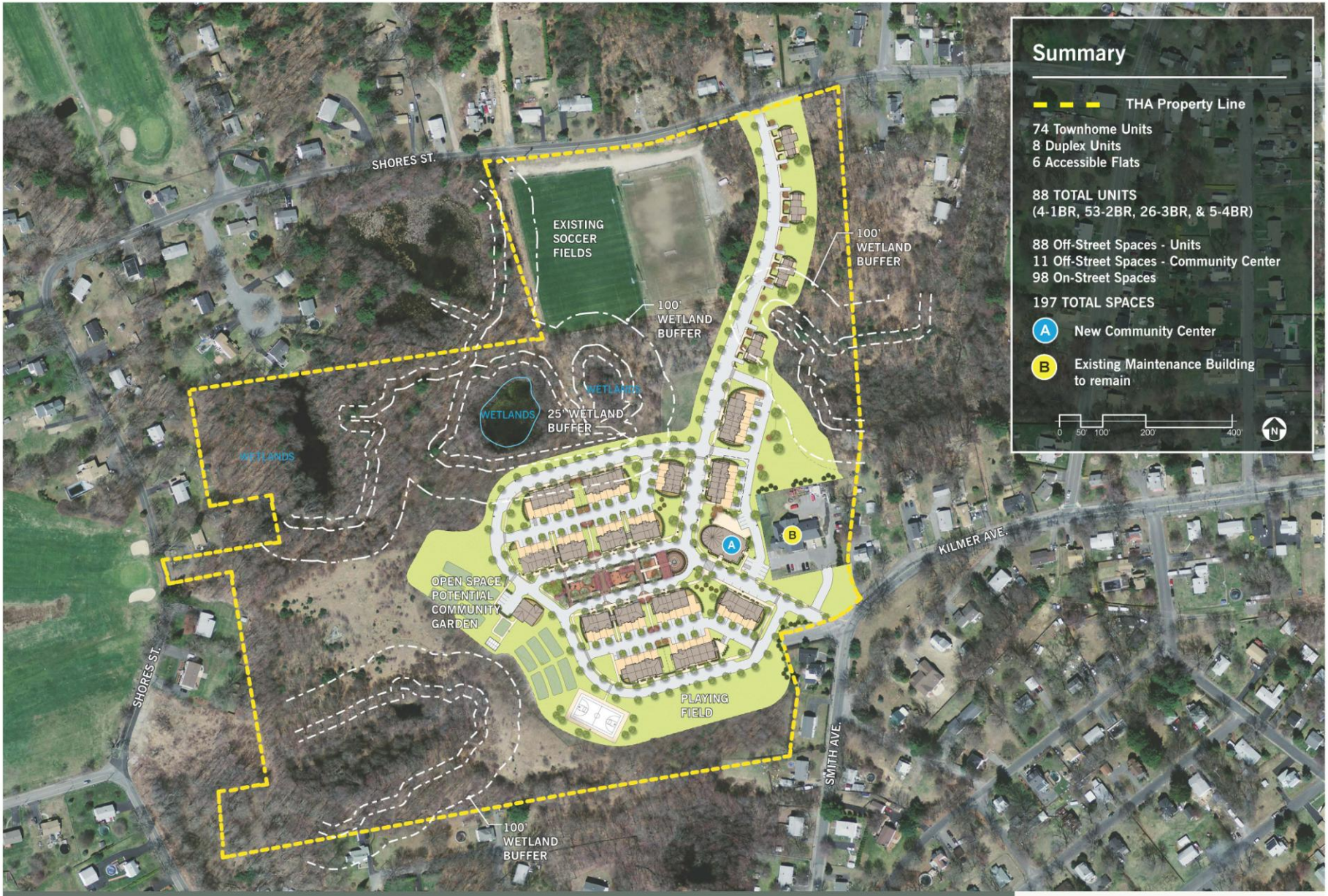
Existing Conditions

February 1, 2012

DEVELOPER : Trinity Financial

ARCHITECT : The Architectural Team

tat | the architectural team



Fairfax Gardens Hope VI

Taunton, MA

Context Site Plan

February 1, 2012

DEVELOPER : Trinity Financial

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Off-Site Parcel 6A - 2

Taunton, MA

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Summary

A 54 Units
(41-1BR & 13-2BR)
Community Room & Management Space
2 & 3-Stories

B 8 Town Homes
(2-3BR, & 6-2BR)
2 & 3 -Stories

C 5 Town Homes
(2-3BR & 3-2BR)
2 & 3 -Stories

D 5 Town Homes
(1-3BR & 4-2BR)
2 -Stories

72 TOTAL UNITS
(41-1BR, 26-2BR, & 5-3BR)

97 TOTAL SPACES(1.3 Spaces per Unit)
47 Potential Future Spaces

Off-Site Parcel 6A - 2

Taunton, MA

Site Plan

February 1, 2011

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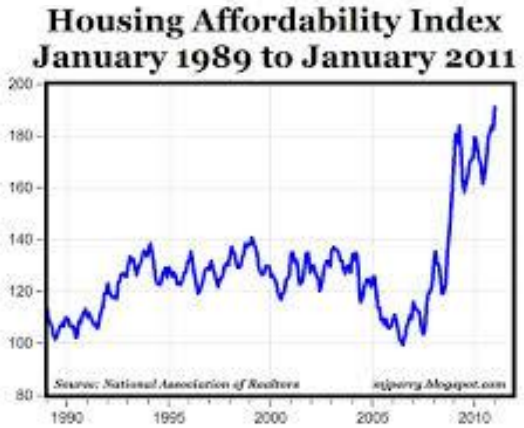
Enterprise green communities®



- The program is tailored to affordable housing
- This is not a 3rd-party certification
- There are no hard costs associated with registration, review, and certification from Enterprise

Enterprise green communities®

- HUD funding requirement

- Must score high to be competitive – need to commit to many of the “optional” criteria

Enterprise Criteria

Energy Use Reduction

- Meet Energy Star standards (mandatory)
- Energy Star appliances (mandatory)
- 80% Energy Star qualified fixtures (mandatory)
- Install daylight sensors for outdoor lighting (mandatory)
- 65 or less HERS score (15 optional points)
- Install renewable energy source to provide at least 10% of the project's estimated electricity demand (15 optional points)
- Design to accommodate installation of PV in the future (2 optional points)

Enterprise Criteria

Ventilation

- Energy Star-labeled bathroom fans that exhaust to the outdoors and are connected to a light switch and are equipped with a humidistat sensor or timer, *or* operate continuously (mandatory)
- Install power vented fans or range hoods that exhaust to the exterior (mandatory)
- Install a ventilation system for the dwelling unit, providing adequate fresh air per ASHRAE 62.1/62.2 (mandatory)
- Clothes dryers must be exhausted directly to the outdoors (mandatory)

Integrated Design Process

Kick-Off Charrette

- Performance-oriented developer
- Trinity had assembled a skilled *and* motivated team
- Performance ***not*** Certification
- Team could quickly orient around opportunities and important areas to focus

Charrette Discussion

Energy Feature Funding

High level Energy Star Certification assumed

- Push for HERS rating around 30 w/o renewables
- Often rebates help subsidize this certification process and offset some of the capital costs
- Columbia Gas/Municipal Electric Co. – NEED to design with Gas! How much?

Charrette Discussion

Building Envelope

Double-Stud Wall Construction

- One structural wall, one non-structural wall to provide a deep cavity for more insulation.
- TAT had done early stage design of the buildings to allow for a 13-14 inch wall, which should be sufficient to accommodate a double stud wall or passive house design.
- A consensus was reached that all building types would use the same type of construction

Charrette Discussion

Building Envelope

Roof

- NEI suggested a hot roof strategy with spray foam
- Mechanical systems can be confidently downsized if spray foam is being relied on as the air barrier
- Late VE of spray foam and impacts? Team felt confident that this was not likely given that other fundamental design decisions would have been made assuming the hot roof
- Switch from a dry sprinkler system to a wet system if a hot roof is used

Charrette Discussion

Building Envelope

Exterior Envelope/Air Sealing

- NEI recommended an unofficial goal of under 1 ACH but a goal of 1.5 ACH in the spec to allow for some wiggle room

Glazing

- Energy Star compliant windows with a U-value of at least 0.3

Charrette Discussion

Mechanical Systems

Utilities and Metering

- All electric systems?
  - Rebate implications
  - Cost of Fuel

- Tenant paid bills – “Skin in the game” and allowance interplay

Charrette Discussion

Mechanical Systems

Heating and Cooling

- Townhome: Mini-split ducted fan coils
- Apartment building: Two-pipe changeover system with ducted fan coils

Charrette Discussions

Mechanical Systems

Domestic Hot Water – tough nut to crack

- After pre-tempering at central location, warm water would then go to the apartments to be brought up to the hot water temperature with the individual electric water heaters

- This would substantially lower distribution heat losses and would keep a portion of the DHW production costs on the tenant

Charrette Discussion

Mechanical Systems

Domestic Hot Water

Solar thermal

- Cheaper capital cost than PV
- Reduce DHW costs which tend to become a larger proportion of total energy cost when the heating load is reduced in a tight, efficient building
- Could be included in the project scope and easily be VE'd out down the line if the budget doesn't allow for it

Solar thermal tied into a gas boiler, coupled with electric hot water heaters in the units

Charrette Discussion

Mechanical Systems

Ventilation

- In Townhome buildings, individual heat recovery ventilators (HRVs)
- In Apartment building, centralized ERVs
- Bathroom exhaust would feed into the ERV system
- Kitchens would be intermittent & exhaust directly to outdoors

Commissioning

Trinity is very interested in commissioning

Charrette Discussion

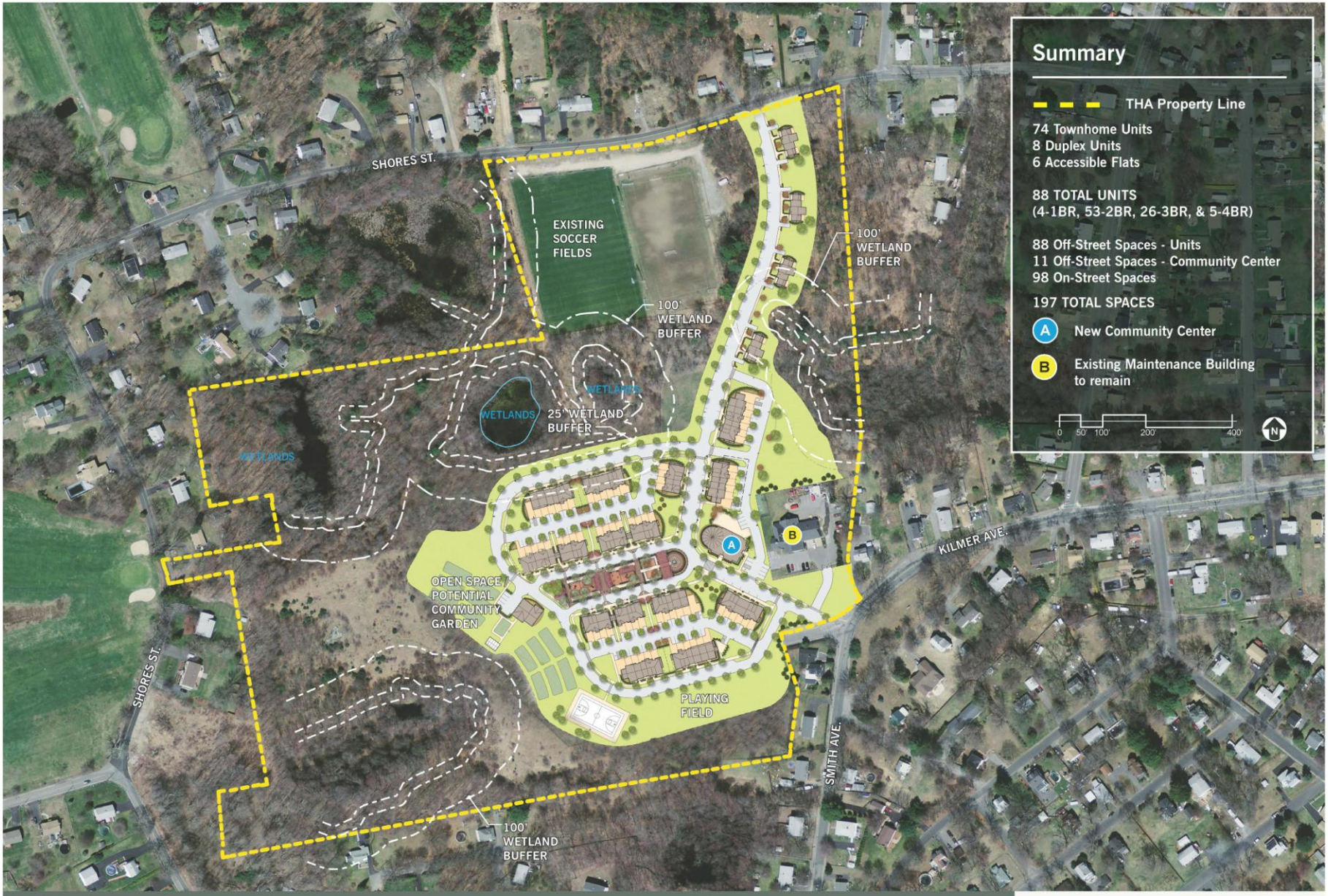
Electrical Load

Interior Lighting

- The project team agreed to go with screw-in to minimize complications
- Trinity poses the idea of coupling this strategy with tenant education and potentially providing a stock of the efficient bulbs for the tenants to buy directly from management

Appliances

- Energy Star



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Off-Site Parcel 6A - 2

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Fairfax Gardens Hope VI

Taunton, MA

Site Plan Detail

February 1, 2012

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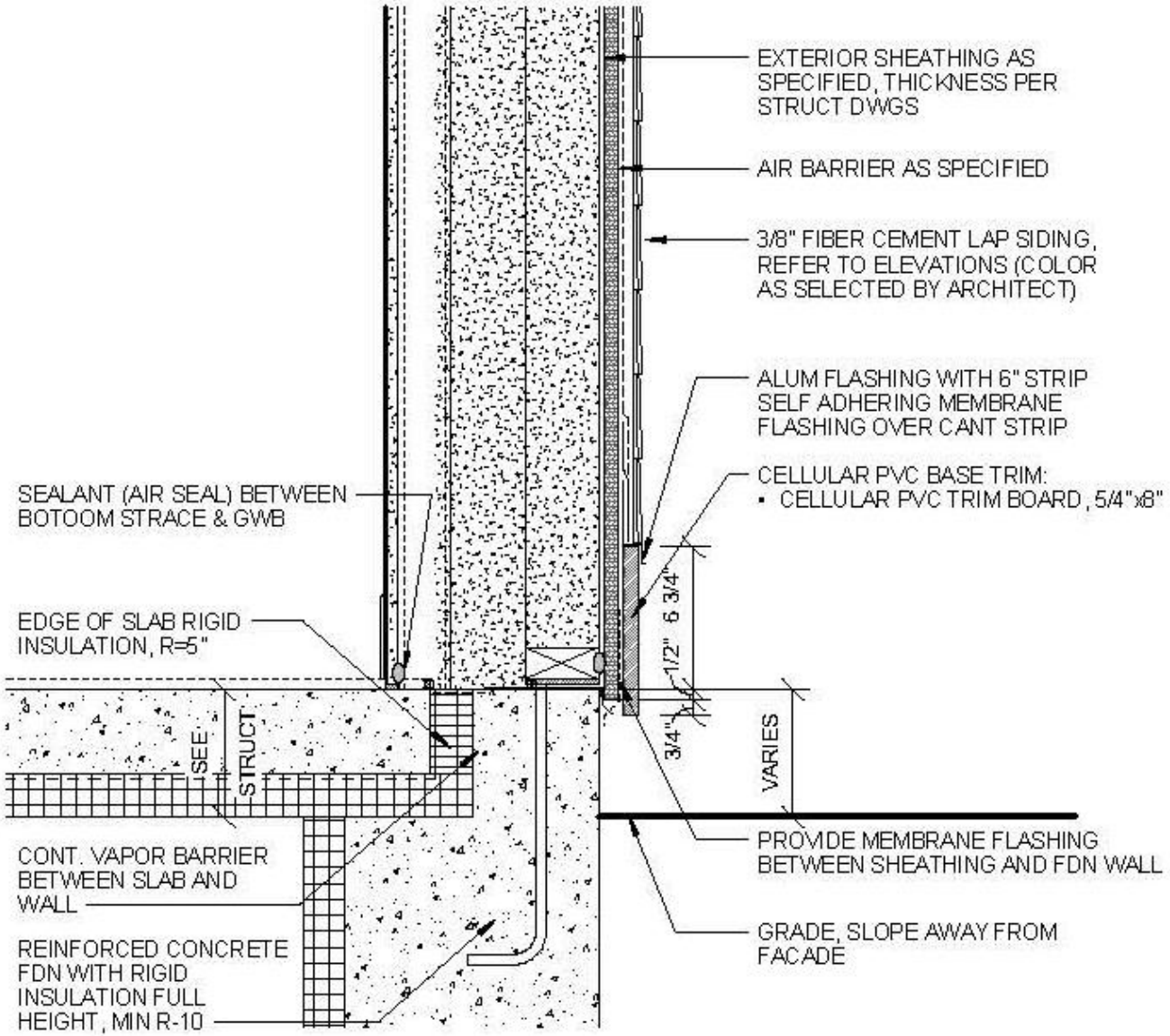
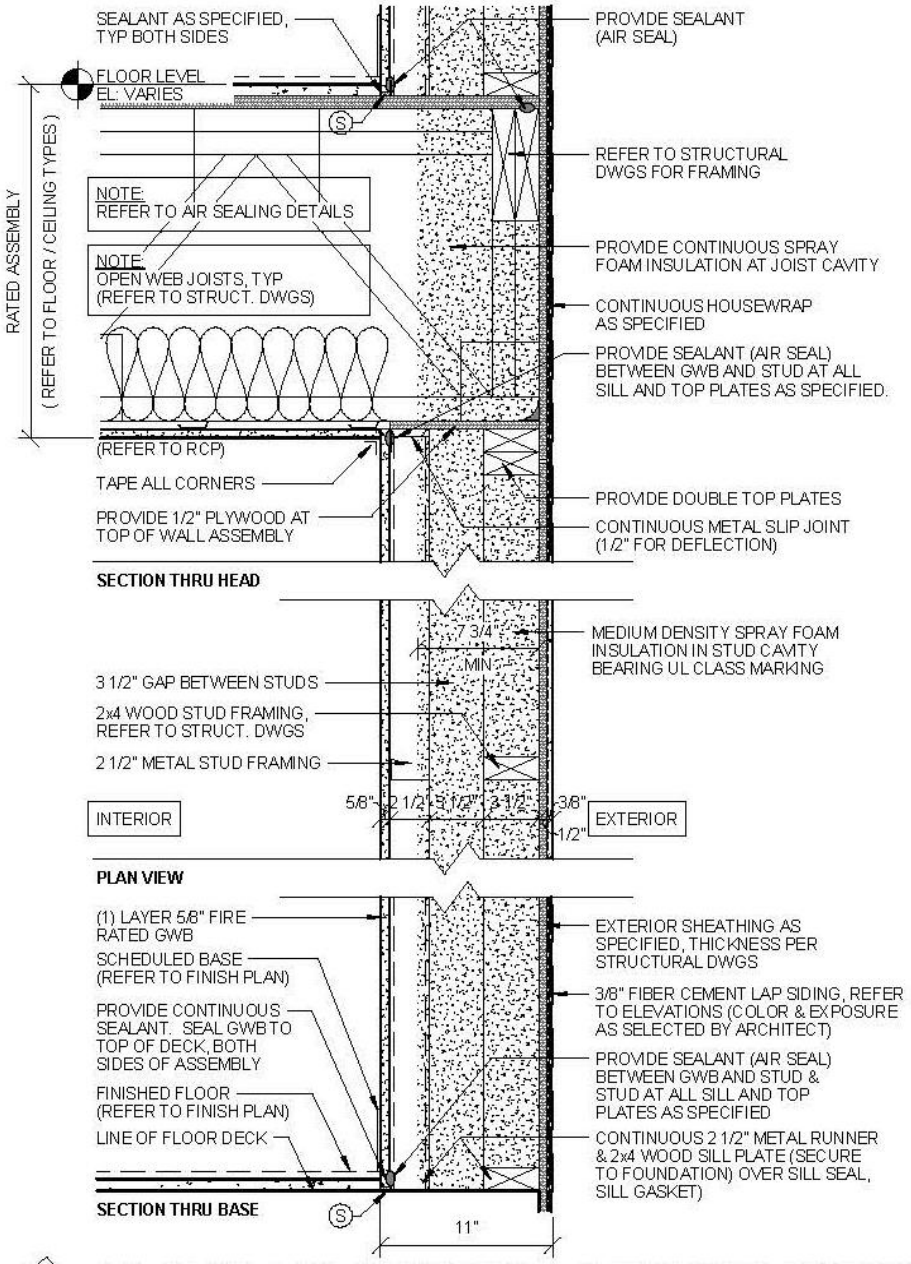
Wall Assemblies

- Hardie Siding
- GreenGuard Raindrop Housewrap
- OSB Sheathing
- 2x4 Wood Stud (Structural)
- 7.5” Demilec APX open cell, spray applied semi-rigid polyurethane foam
- 2-1/2” metal stud
- 5/8” sheetrock interior wall
- Overall wall thickness 12”
- 2” Foamular 250 EPS thermal break between interior slab and exterior foundation wall



10 **CONST DTL - SECTION - TYPICAL SILL**

Scale : 1 1/2" = 1'-0"

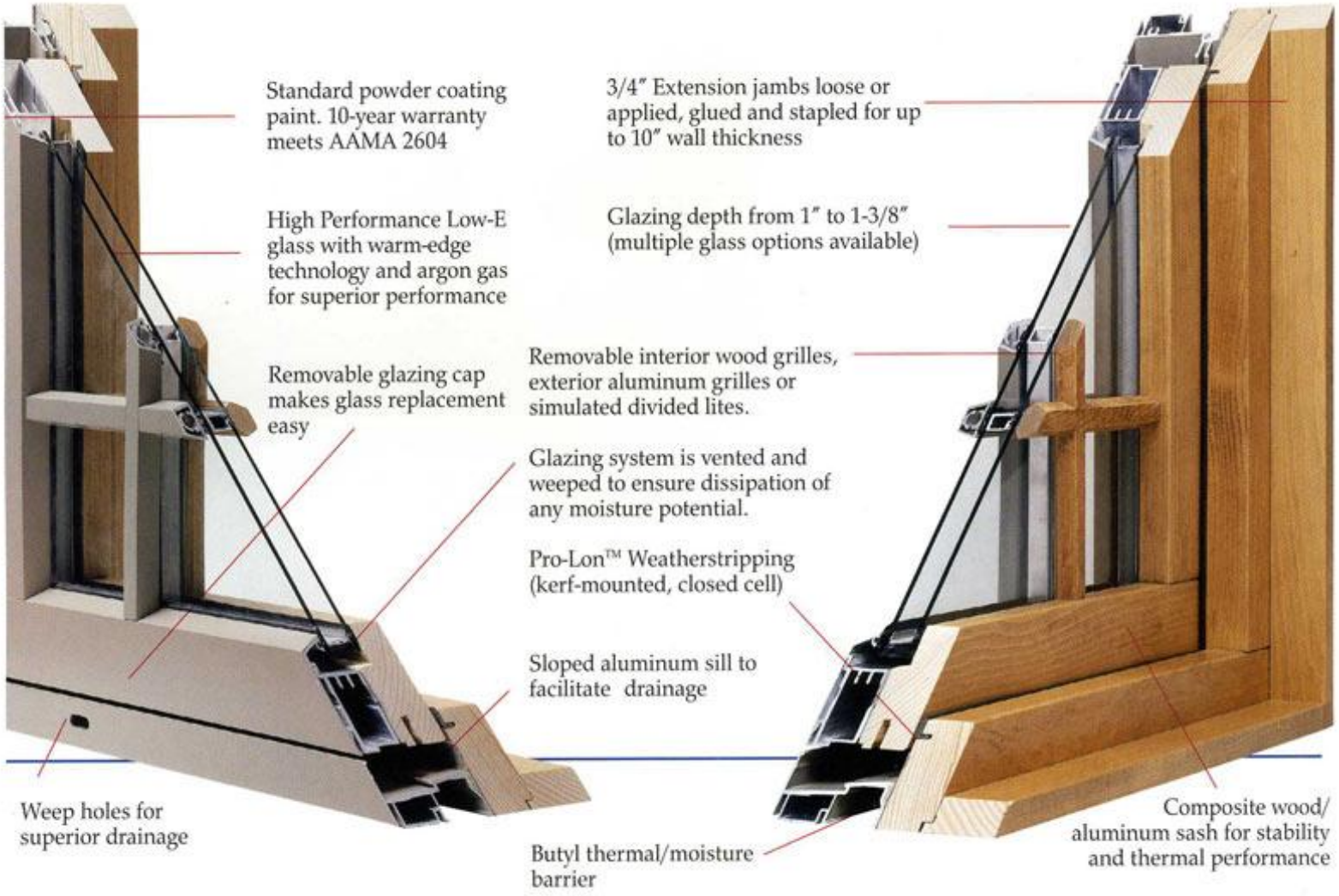


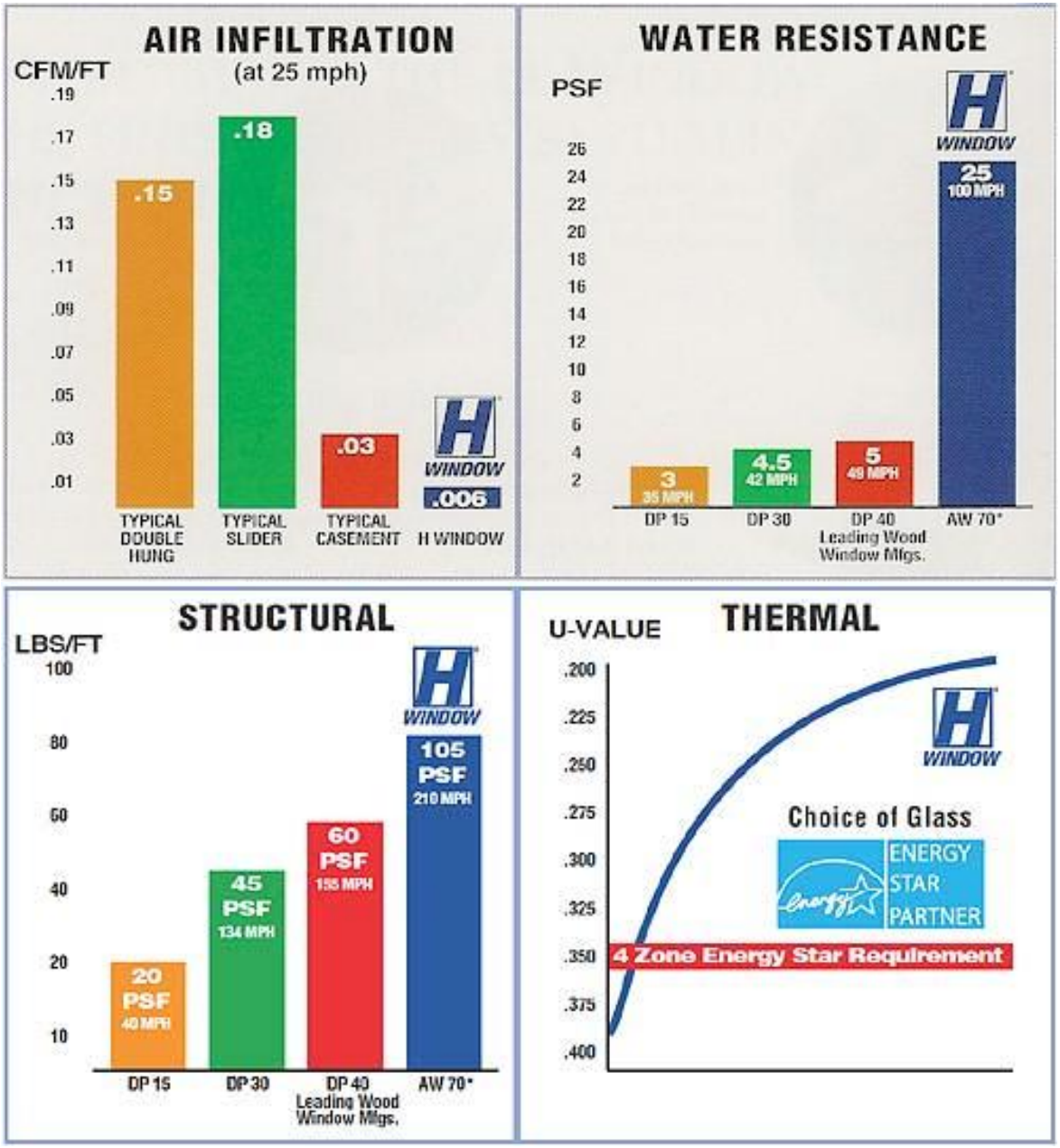
E4A

E4A - BLDGS B,C,D - LOAD-BEARING, TYPICAL FIBER CEMENT SIDING

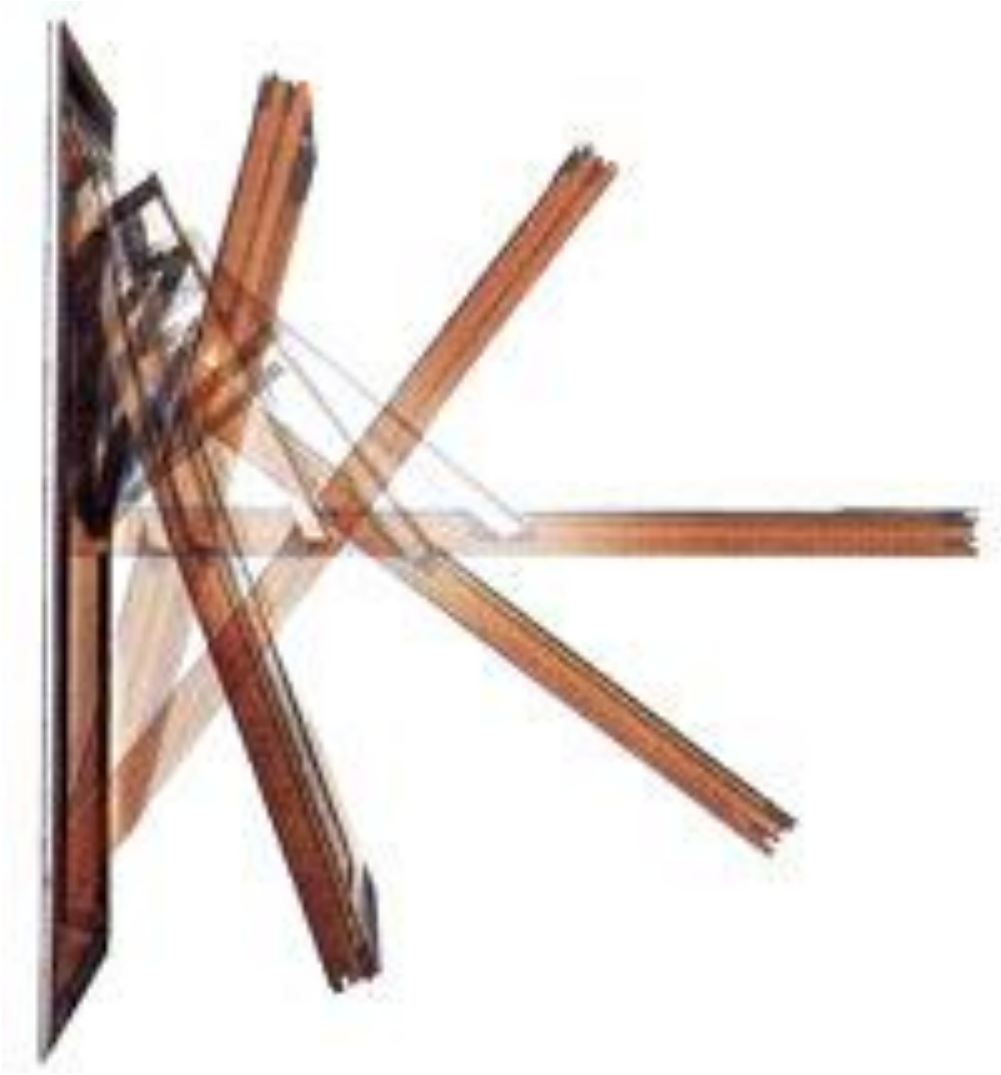
Scale : 1 1/2" = 1'-0"

H Windows


Standard powder coating paint. 10-year warranty meets AAMA 2604
High Performance Low-E glass with warm-edge technology and argon gas for superior performance
Removable glazing cap makes glass replacement easy
Weep holes for superior drainage
3/4″ Extension jambs loose or applied, glued and stapled for up to 10″ wall thickness
Glazing depth from 1″ to 1-3/8″ (multiple glass options available)
Removable interior wood grilles, exterior aluminum grilles or simulated divided lites.
Glazing system is vented and weeped to ensure dissipation of any moisture potential.
Pro-Lon™ Weatherstripping (kerf-mounted, closed cell)
Sloped aluminum sill to facilitate drainage
Butyl thermal/moisture barrier
Composite wood/ aluminum sash for stability and thermal performance


AIR INFILTRATION
CFM/FT
(at 25 mph)
.19
.17
.15
.13
.11
.09
.07
.05
.03
.01
.15
.18
.03
WINDOW
.006
TYPICAL DOUBLE HUNG
TYPICAL SLIDER
TYPICAL CASEMENT
H WINDOW
WATER RESISTANCE
PSF
26
24
22
20
18
16
14
12
10
8
6
4
2
WINDOW
25
100 MPH
3
35 MPH
4.5
42 MPH
5
49 MPH
DP 15
DP 30
DP 40
Leading Wood Window Mfgs.
AW 70*
STRUCTURAL
LBS/FT
100
80
60
40
20
10
WINDOW
105 PSF
210 MPH
60 PSF
155 MPH
45 PSF
134 MPH
20 PSF
40 MPH
DP 15
DP 30
DP 40
Leading Wood Window Mfgs.
AW 70*
THERMAL
U-VALUE
.200
.225
.250
.275
.300
.325
.350
.375
.400
WINDOW
Choice of Glass
ENERGY STAR PARTNER
4 Zone Energy Star Requirement

H Windows

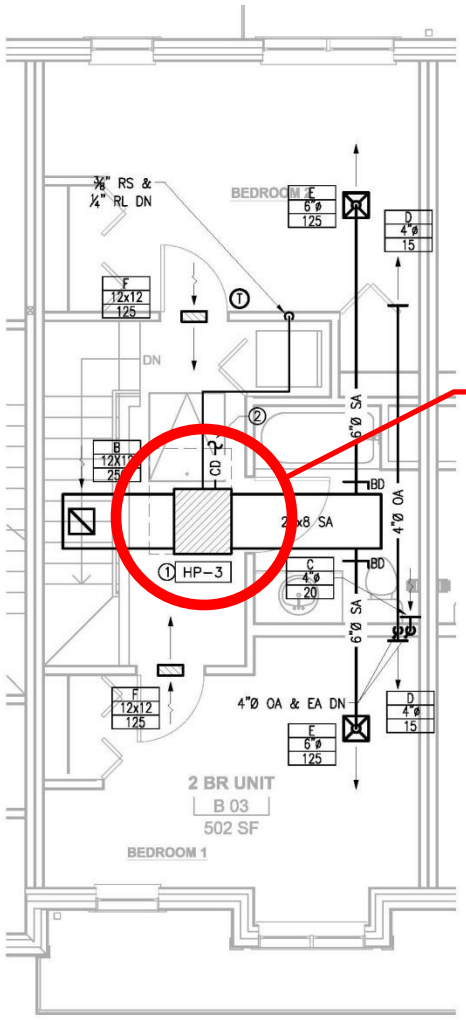


Townhome/Duplex

Heating & Cooling (Townhome/Duplex)

- Air-Source Heat Pump (ASHP)
  - Individual ASHP System at each Unit for both Heating and Cooling
    - 1 Wall Cassette Ductless Style Indoor Unit for 1st Floor Living/Dining Area
    - 1 Horizontal Ducted Style Indoor Unit for 2nd/3rd Floor Bedrooms with Brief Ductwork for Air Distribution
    - 1 Outdoor Unit

Typical Townhome Unit Plan



Outdoor Unit

Horizontal Ducted

Wall Cassette

5 HVAC TYPICAL 2BR UNIT 2ND FLOOR PLAN
SCALE: 1/4" = 1'-0"
UNIT B-03 SHOWN

4 HVAC TYPICAL 2BR UNIT 1ST FLOOR PLAN
SCALE: 1/4" = 1'-0"
UNIT B-03 SHOWN

Wall Cassette Indoor Unit

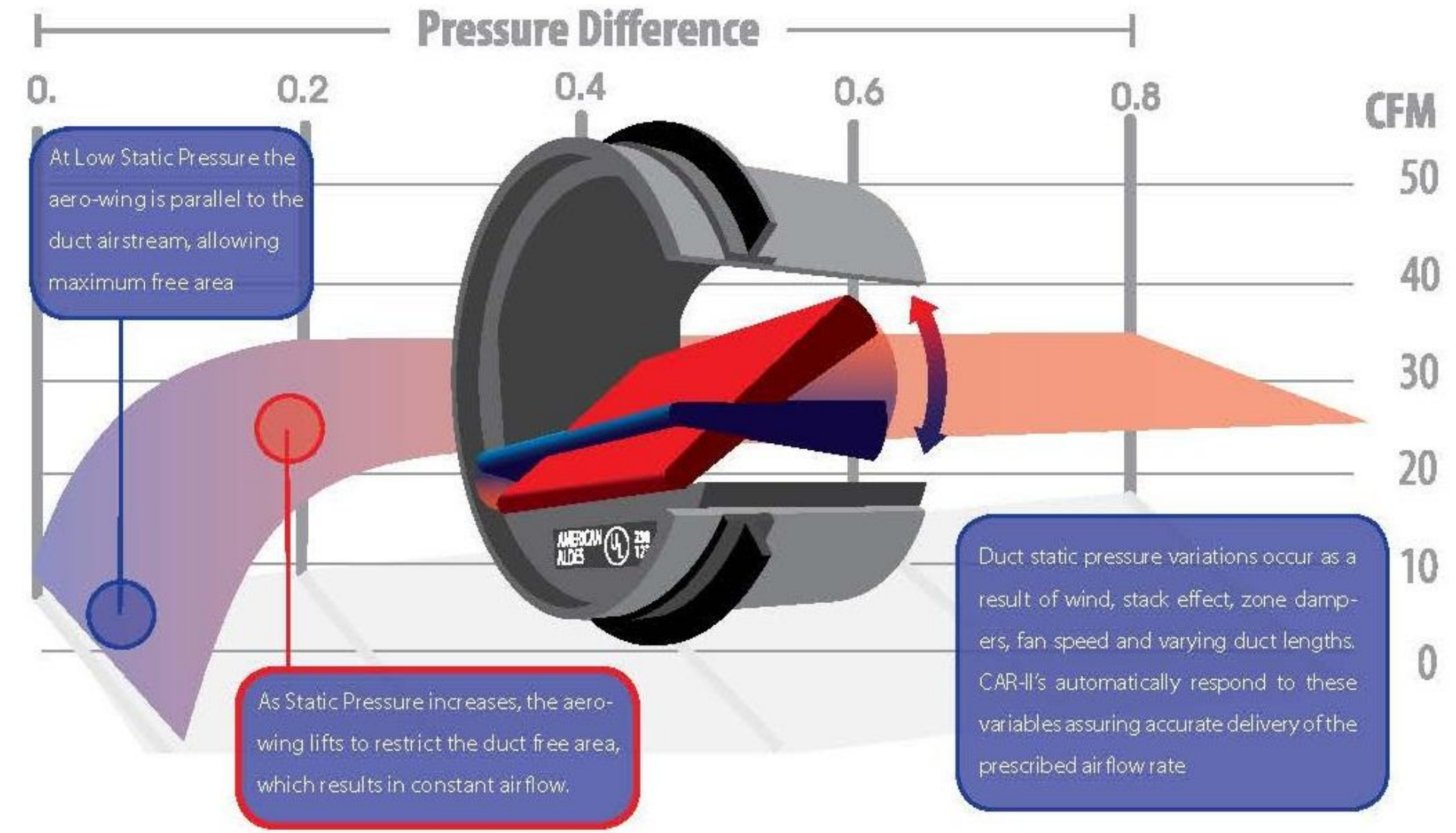
Horizontal Ducted Indoor Unit

Outdoor Unit

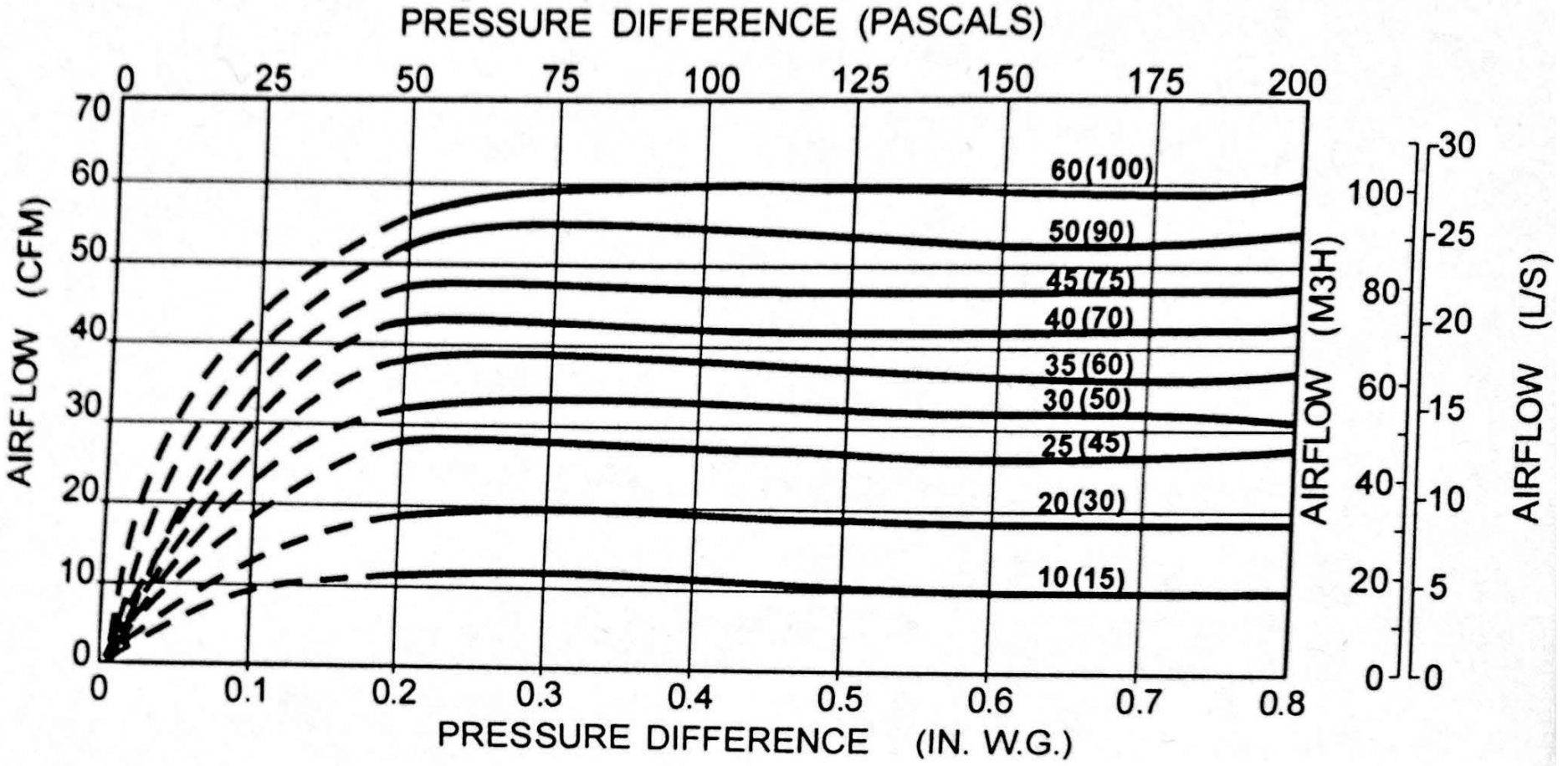
Ventilation (Townhome/Duplex)

- Local HRVs at each Unit
  - Complete Ductwork System for OA & EA Distribution within Unit
    - Separate (Decoupled) from Heating and Cooling System
    - Located Next to Exterior Wall to Minimize Length of Ductwork Connections to the Outdoor
  - OA Grille with Integral CAR Damper at each Living Area and Each Bedroom
  - EA Grille with Integral CAR Damper at Each Kitchen and Each Bathroom
    - Re-Circ. Range Hood
- Condensing Dryer at Each Unit to Eliminate the need of Wall Penetration required for Traditional Ducted Dryer

HOW THE CAR-II WORKS



Courtesy of American Aldes


PRESSURE DIFFERENCE (PASCALS)
0
25
50
75
100
125
150
175
200
AIRFLOW (CFM)
70
60
50
40
30
20
10
0
60(100)
50(90)
45(75)
40(70)
35(60)
30(50)
25(45)
20(30)
10(15)
AIRFLOW (M3H)
100
80
60
40
20
0
AIRFLOW (L/S)
30
25
20
15
10
5
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
PRESSURE DIFFERENCE (IN. W.G.)

Balancing with CAR Dampers

- Field balancing not possible. Can be confusing for the Balancing Contractor.
- Accurately measuring low airflow rates not possible with conventional measuring equipment.

Low-Tech Airflow Verification

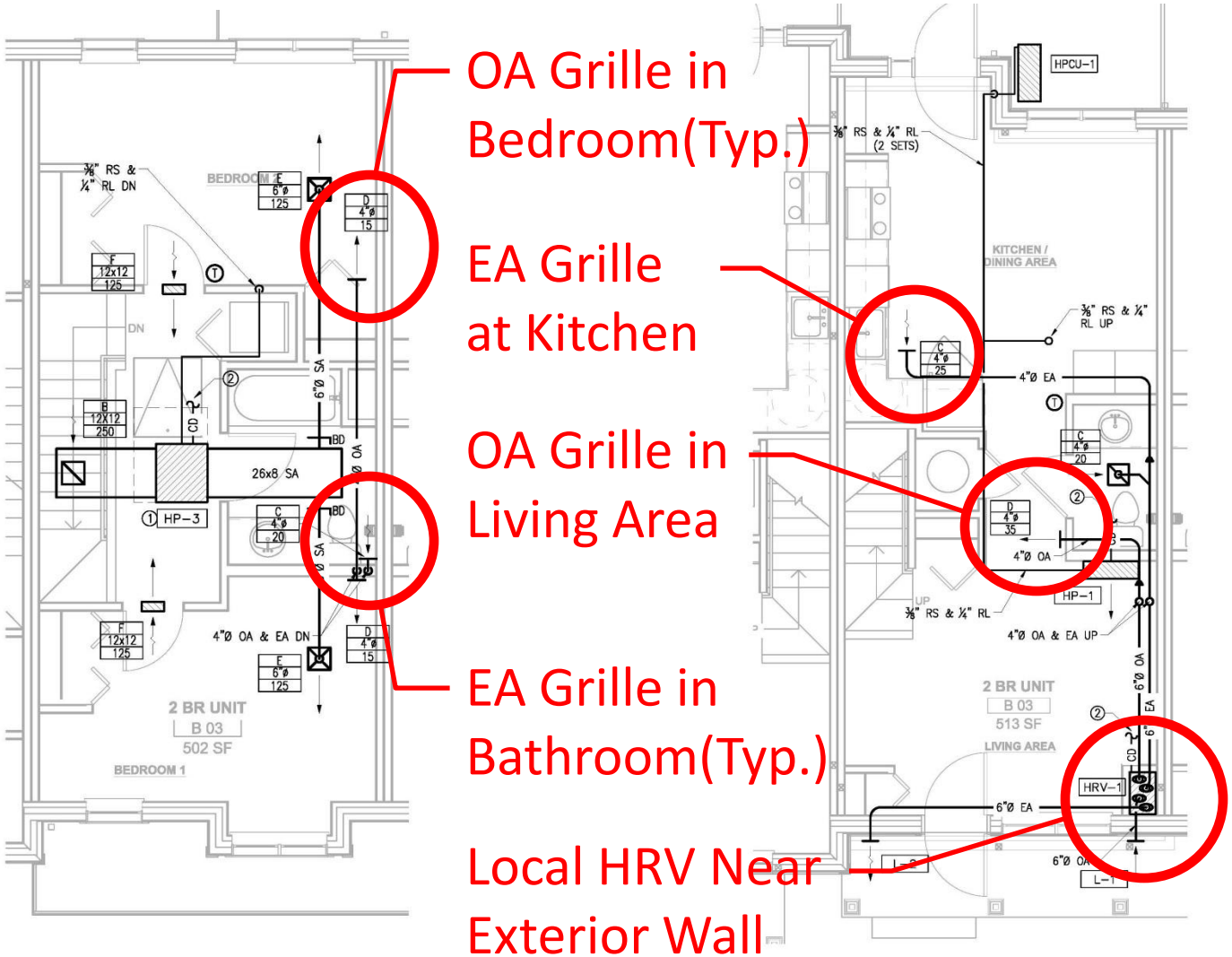
Trash-Bag-Fill-Time to CFM Conversion

$$\left(\frac{gal}{sec}\right)\left(\frac{ft^3}{gal}\right)\left(\frac{sec}{min}\right) = CFM$$

$$\left(\frac{30}{time\ in\ sec}\right)\left(\frac{1}{7.48}\right)\left(\frac{60}{1}\right) = CFM$$

$$\frac{241}{time\ in\ sec} = CFM$$

Typical Townhome Unit Plan



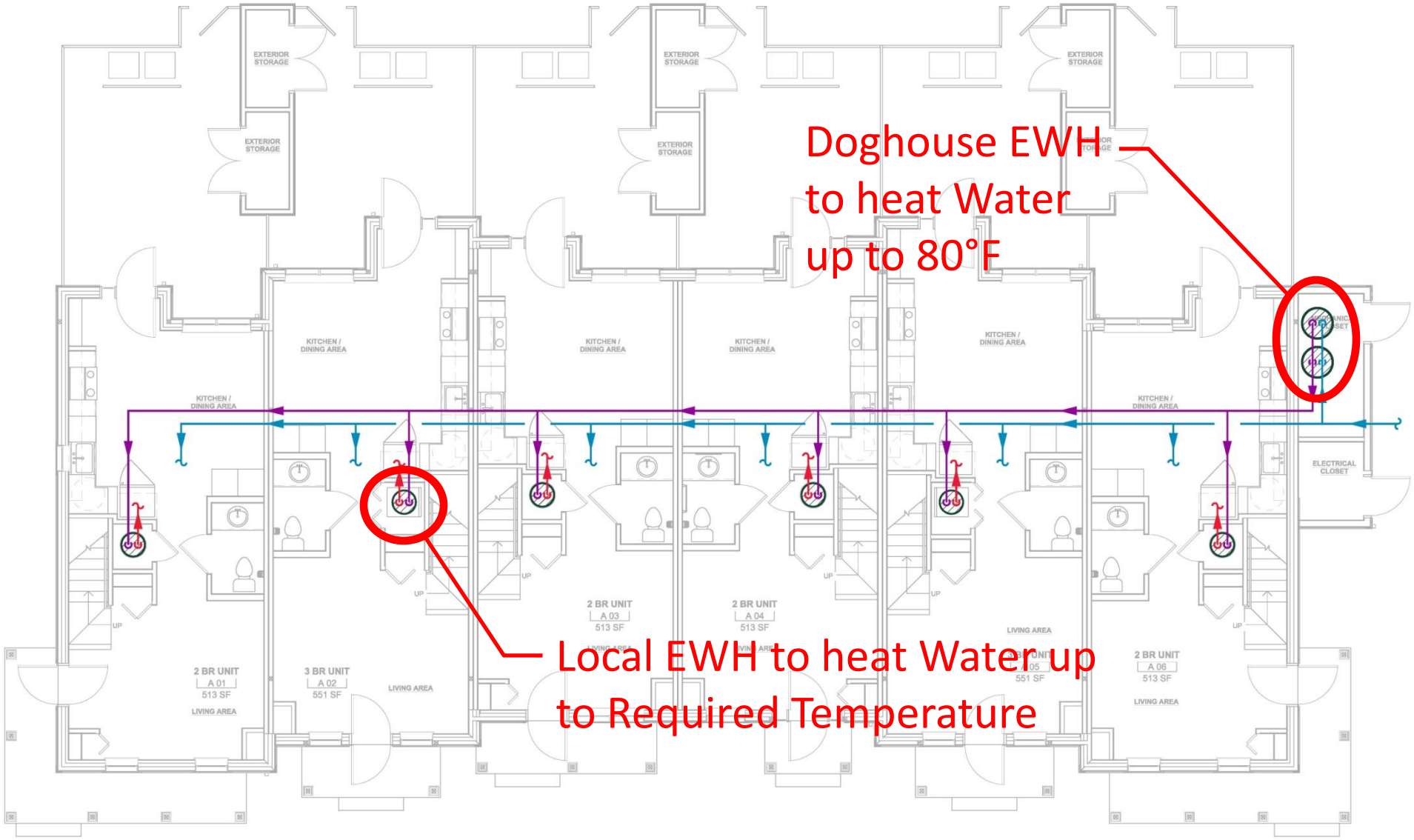
5 HVAC TYPICAL 2BR UNIT 2ND FLOOR PLAN
SCALE: 1/4" = 1'-0" UNIT B-03 SHOWN

4 HVAC TYPICAL 2BR UNIT 1ST FLOOR PLAN
SCALE: 1/4" = 1'-0" UNIT B-03 SHOWN

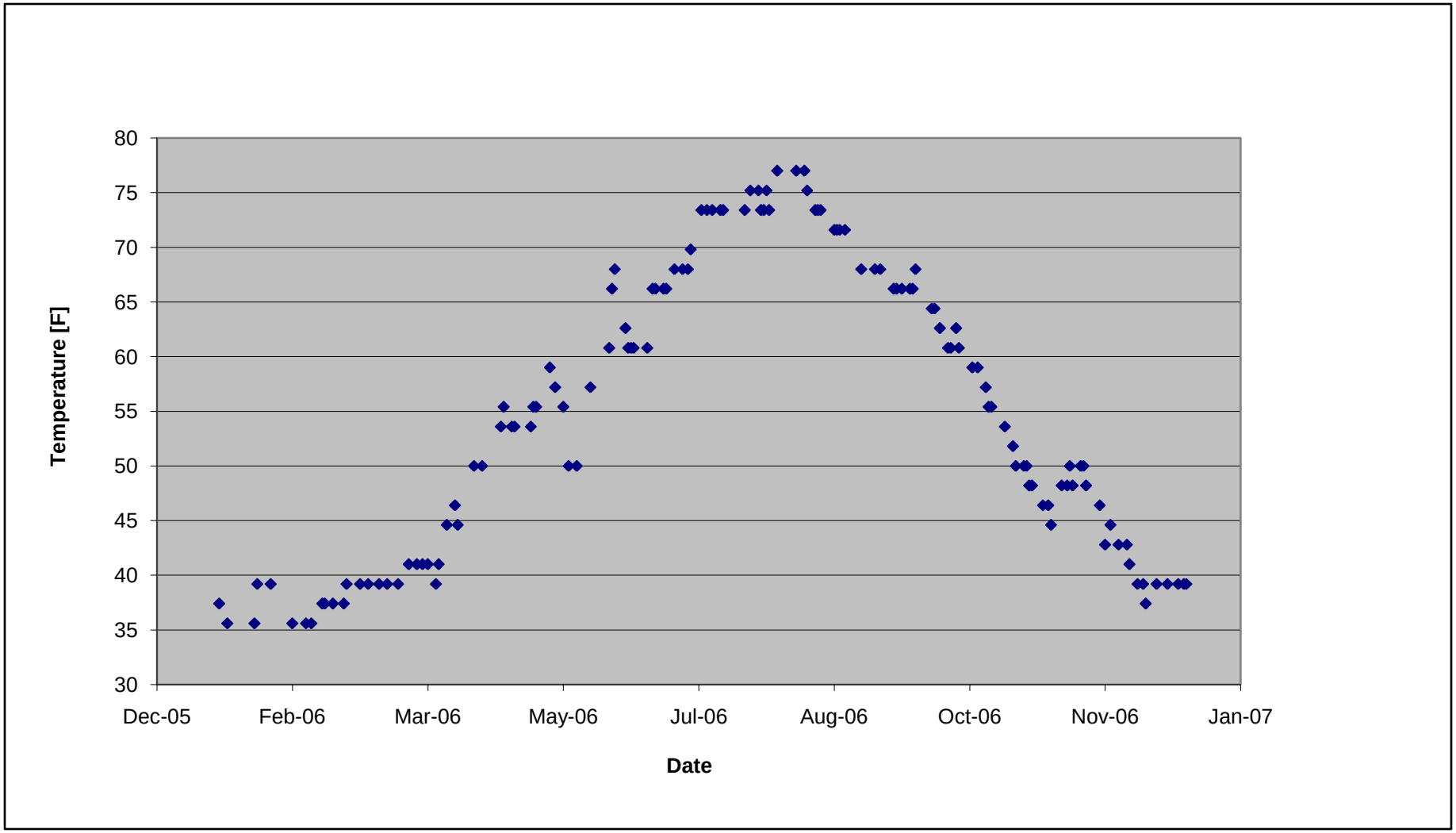
DHW (Townhome/Duplex)

- Central Electric Water Heater at Doghouse
  - "Pre-Temper" DCW Supply to Each Unit to 70-80°F
- Localized "2nd Stage" EWH at Each Unit
  - Provide Heating of the 80°F water to required DHW Temperature (130°F at tank, 107°F at shower)
- Eliminate the Need of DHW Re-Circ System as the "Pre-Tempered" Water distribution piping is not hot.
- Solar Thermal Ready

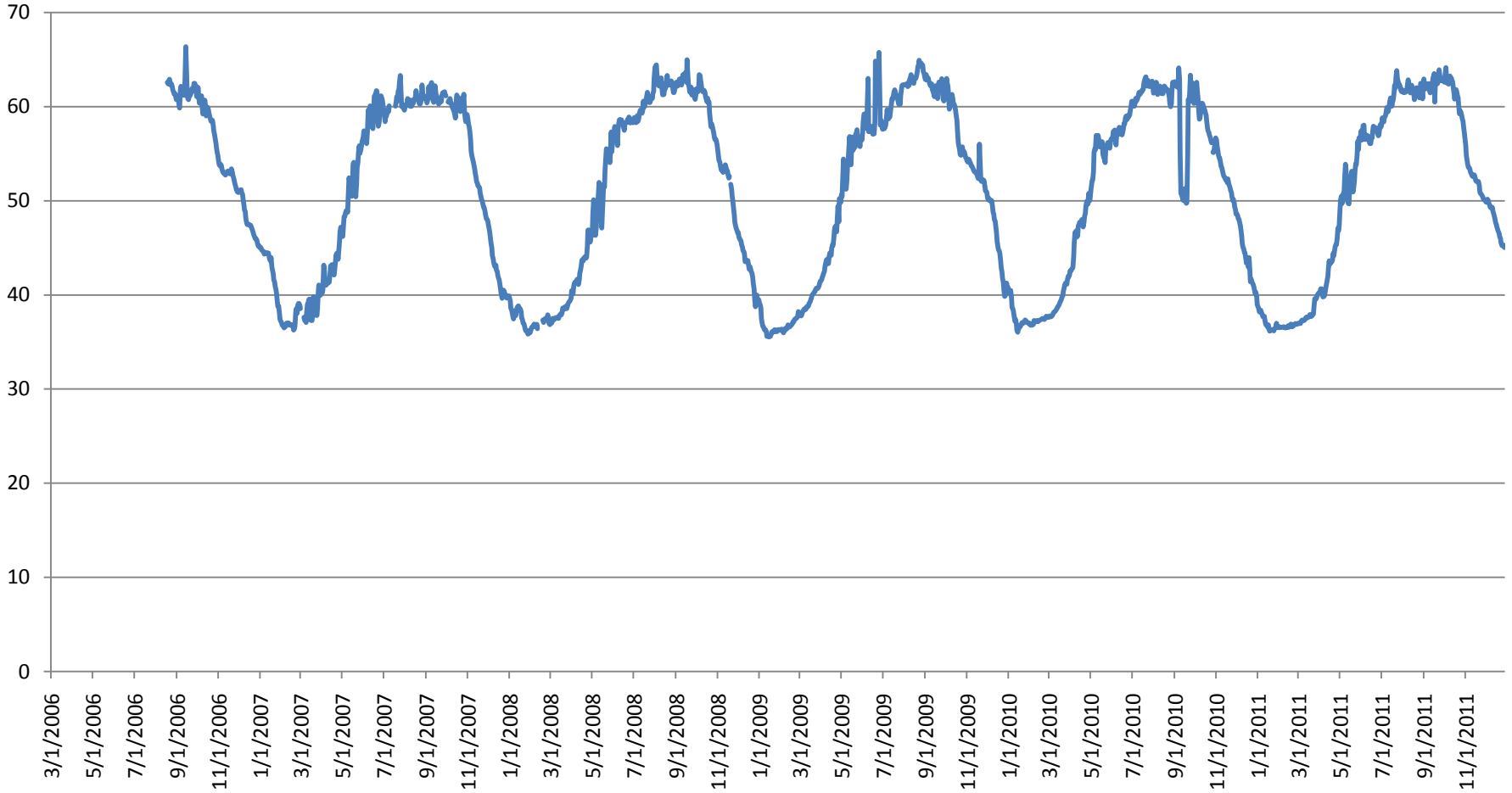
Townhome/Duplex DHW Distribution



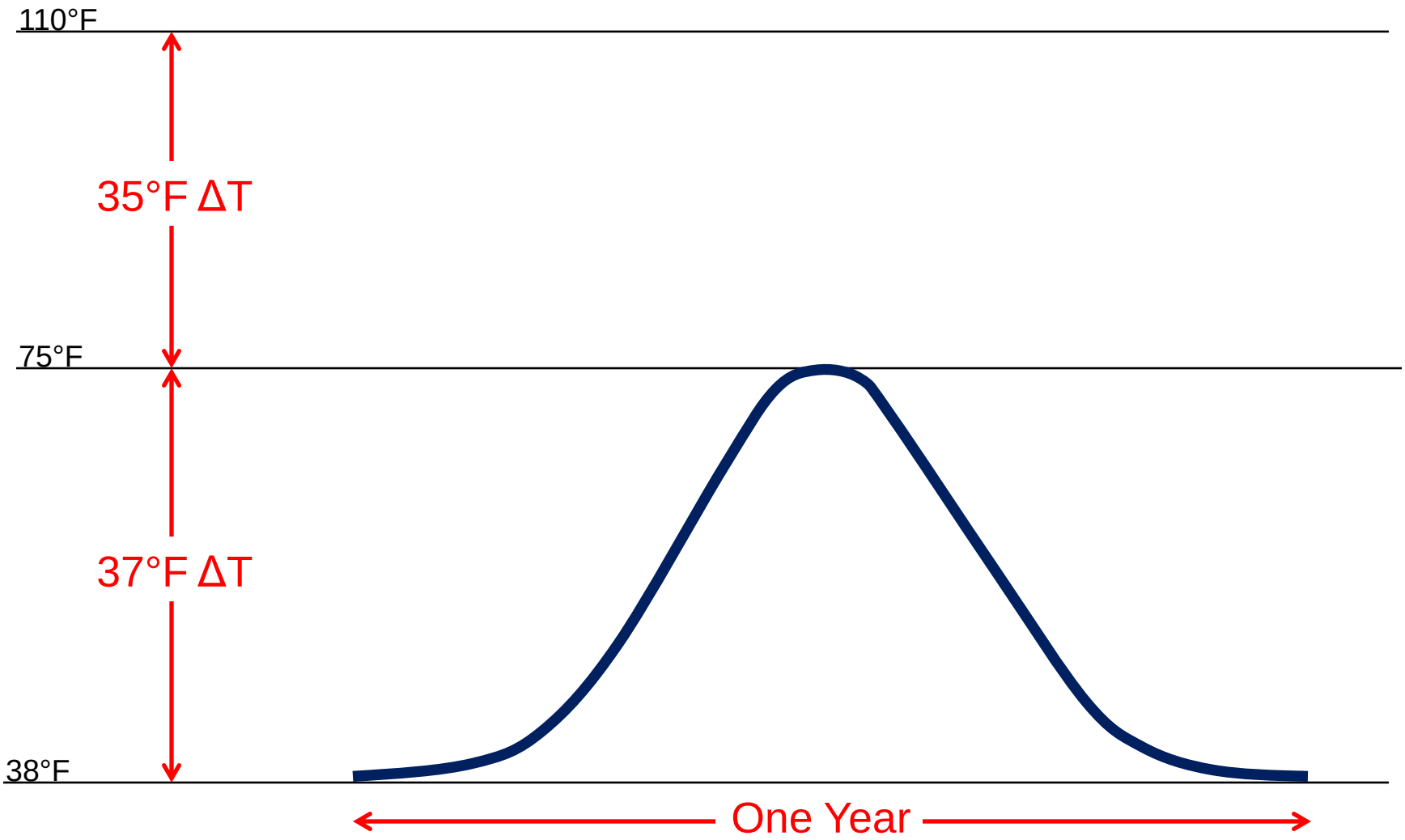
Portsmouth NH Cold Water Supply Temperature – 2006



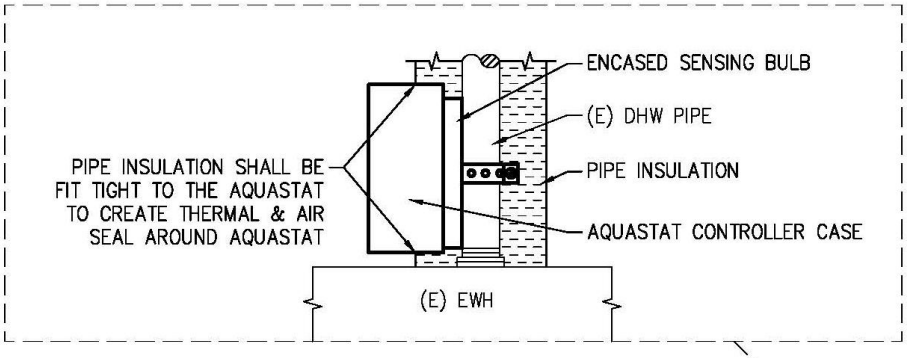
Massachusetts Municipal Cold Water Supply Temperature – 2006 to 2011



Annual Cold Water Supply Temperature

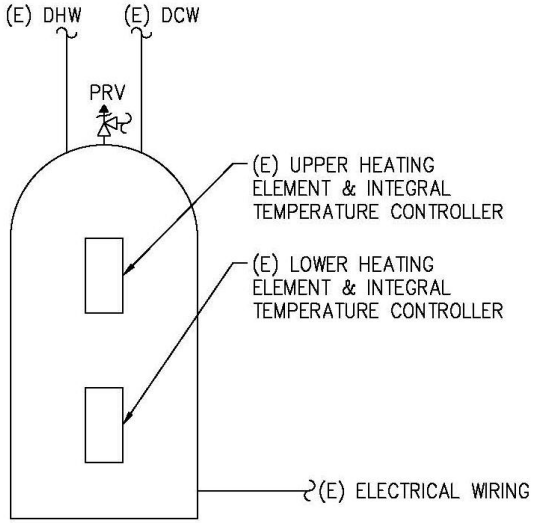


Equipment Limitations

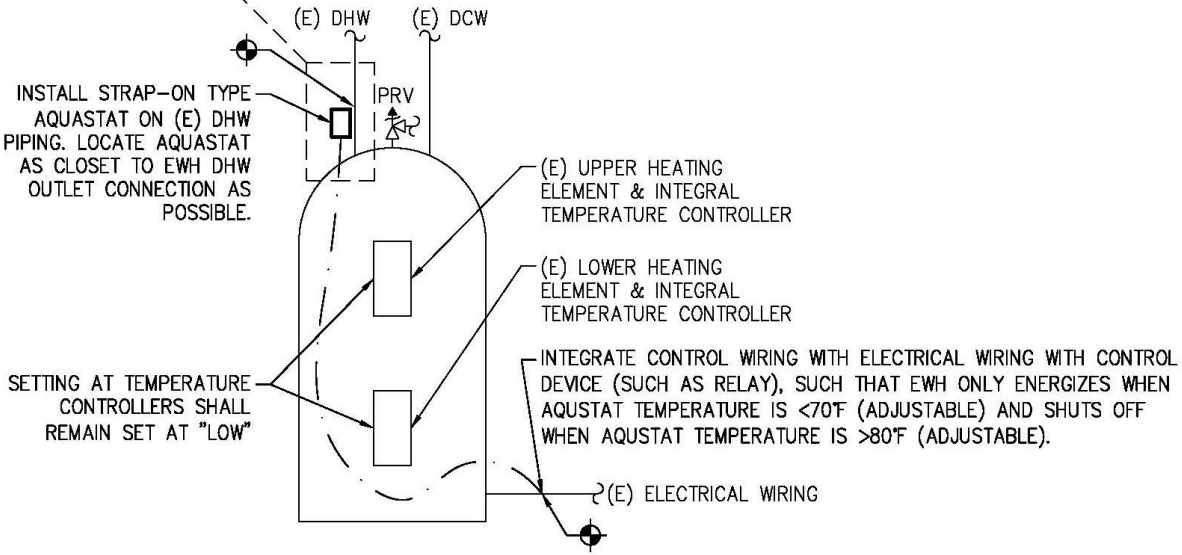


SUMMARY OF WORK:

1. LEAVE ALL CONTROLS BY MANUFACTURER AS IS.
2. INSTALL NEW AUQASTAT AND CONTROLS AS NECESSARY WITH A WIDE TEMPERATURE RANGE THAT WILL ALLOW THE TANK TEMPERATURE TO BE SET AT 75℉±5℉ (AQUASTATS WITH RANGES FROM 60℉ TO 200℉ ARE READILY AVAILABLE.
3. MODIFICATIONS TO THE HOT WATER SUPPLY PIPING SHALL BE MADE (SUCH AS PROVIDING STRAIGHT SECTION OF PIPING) TO PERMIT THE INSTALLATION OF THE AQUASTAT AT THE DHW OUTLET CONNECTION OF WATER HEATER. CARE NEEDS TO BE TAKEN TO AVOID SWEATING COPPER PIPING TOO CLOSE (APPROX. NO CLOSER THAN 6") TO THE WATER HEATER CONNECTION IN ORDER TO NOT OVERHEAT THE TANK LINER.
4. CONFIGURE THE AQUASTAT AND CONTROLS TO INTERRUPT POWER TO THE WATER HEATER THE MAINTAIN A CONSTANT TANK TEMPERATURE OF 75℉±5℉.
5. SUBMIT FOR REVIEW CONTROLS AND METHODS FOR ACHIEVING STEPS 1 THROUGH 3.
6. PRIOR TO CONVERTING ALL TANKS, CONVERT ONE TANK OVER TO THE NEW CONTROL METHOD AND CONFIRM PROPER OPERATION WITH OWNER.



EXISTING INSTALLATION



RETROFIT INSTALLATION

Mechanical Doghouse

Apartment Building

Heating & Cooling (Apt. Bldg.)

- 2-Pipe Seasonal Change-Over System
  - Central Boiler Plant
  - Central Chiller Plant
  - 2-Pipe Valance Units at apartments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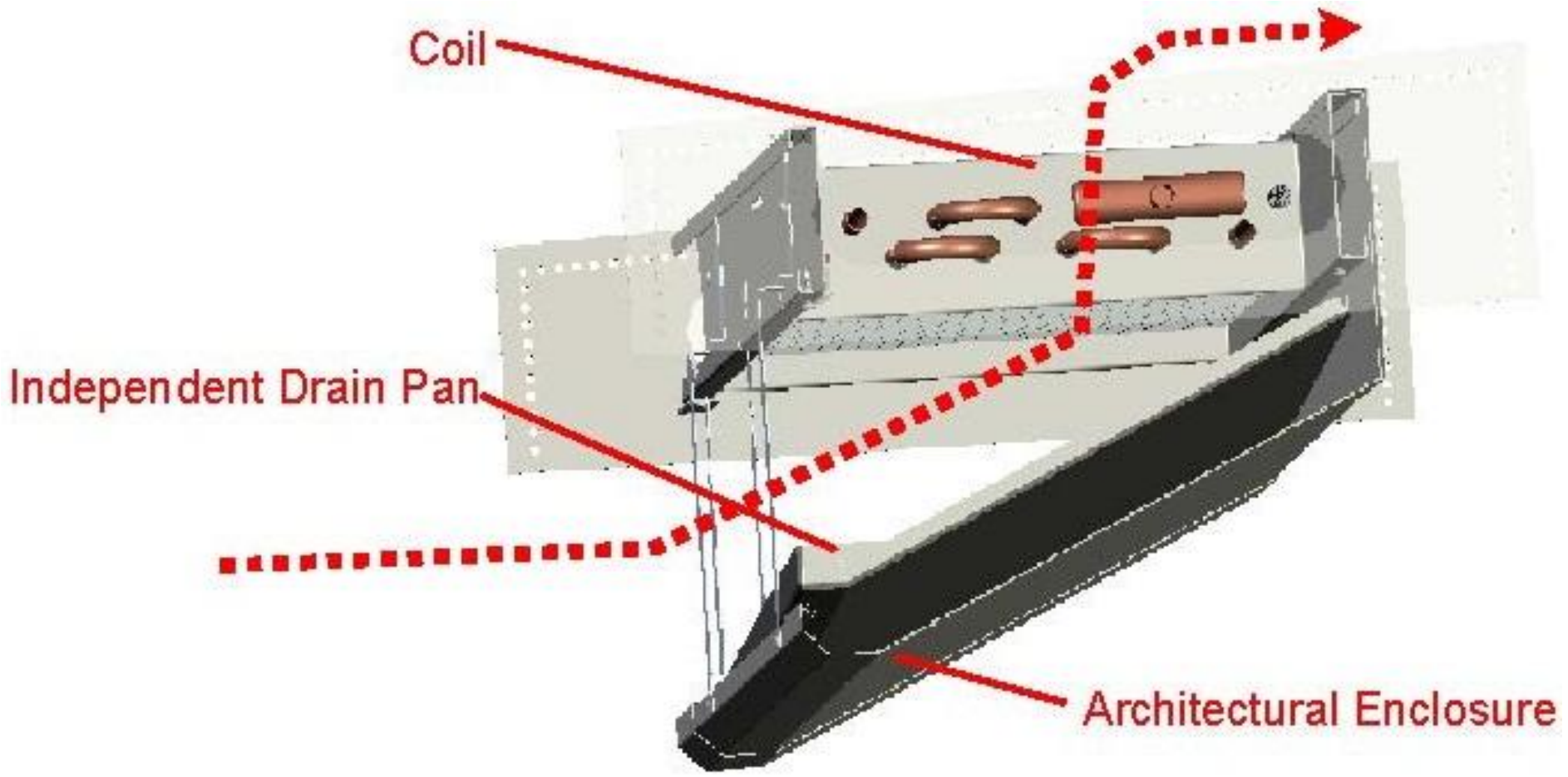
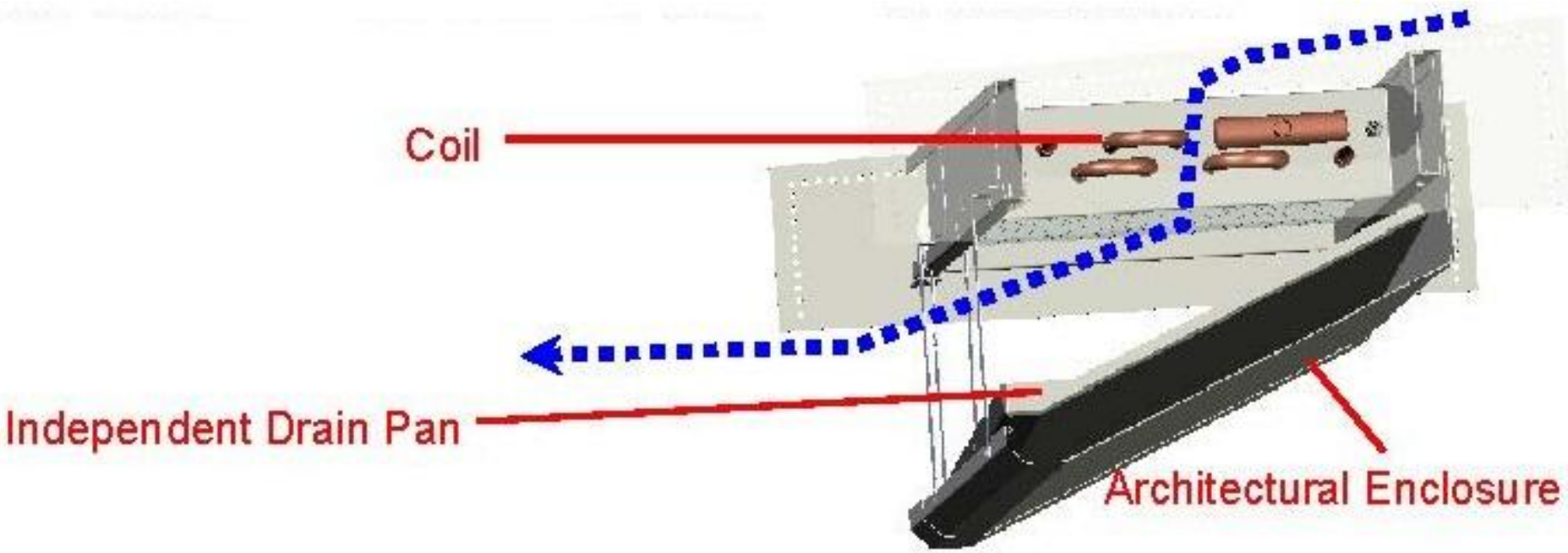
Heating Mode



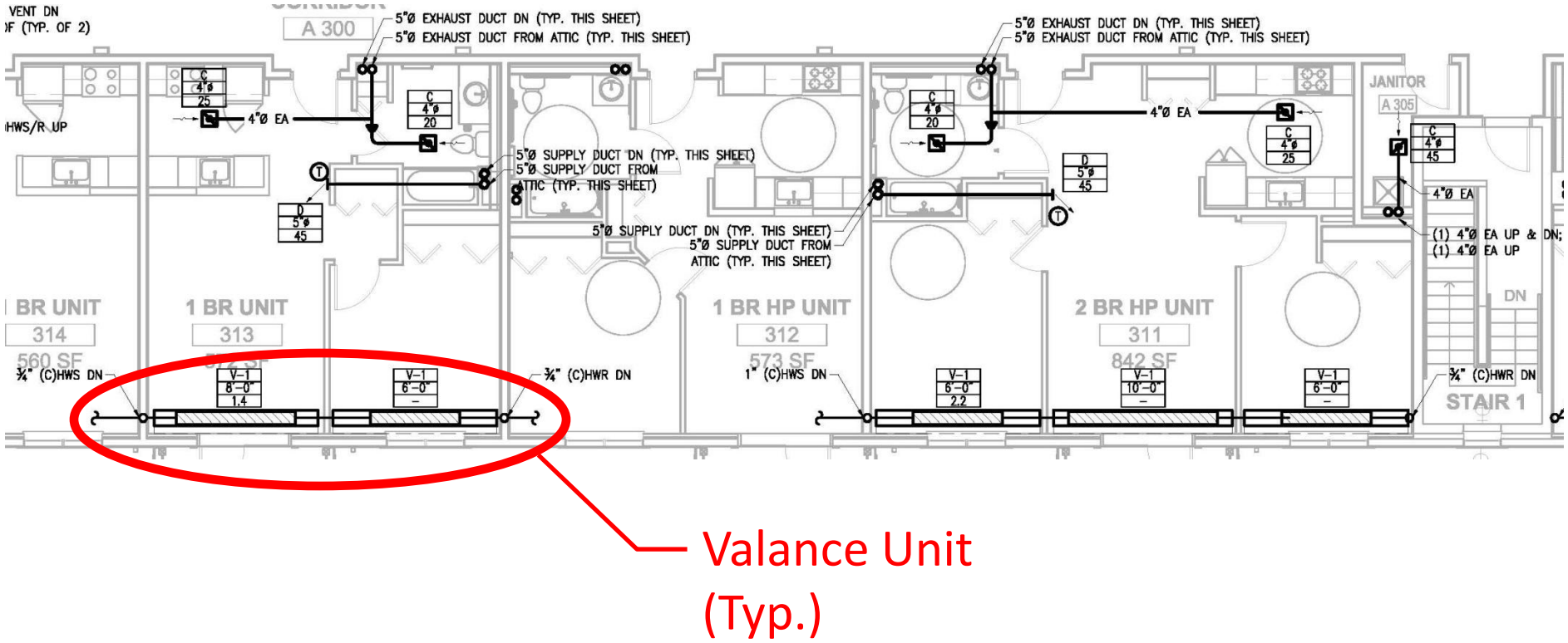
Courtesy of SIGMA Corporation

Cooling Mode



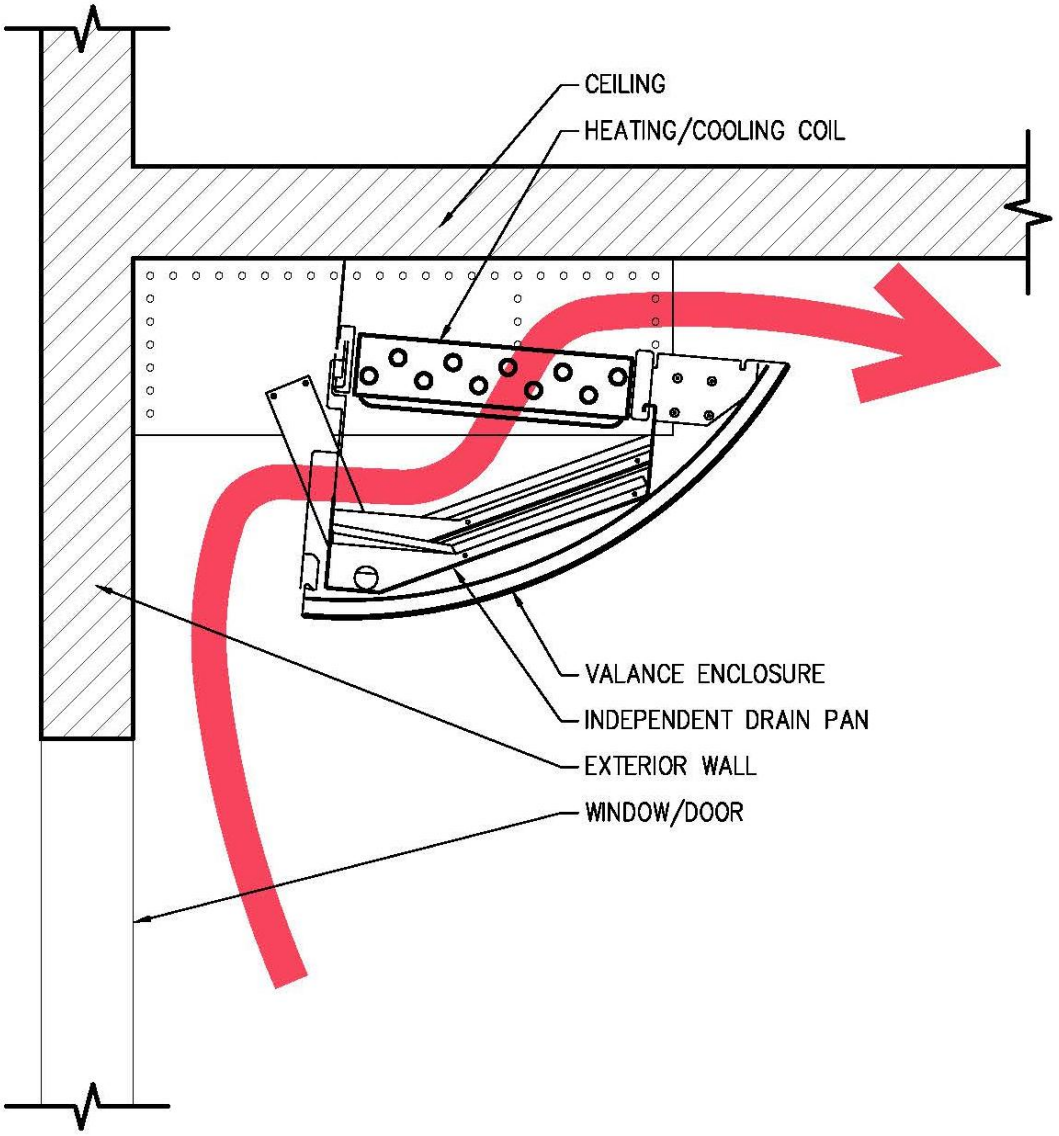
Courtesy of SIGMA Corporation

Typical Apt. Bldg. Unit Plan



Valance Unit
(Typ.)

Valance Section (Heating)

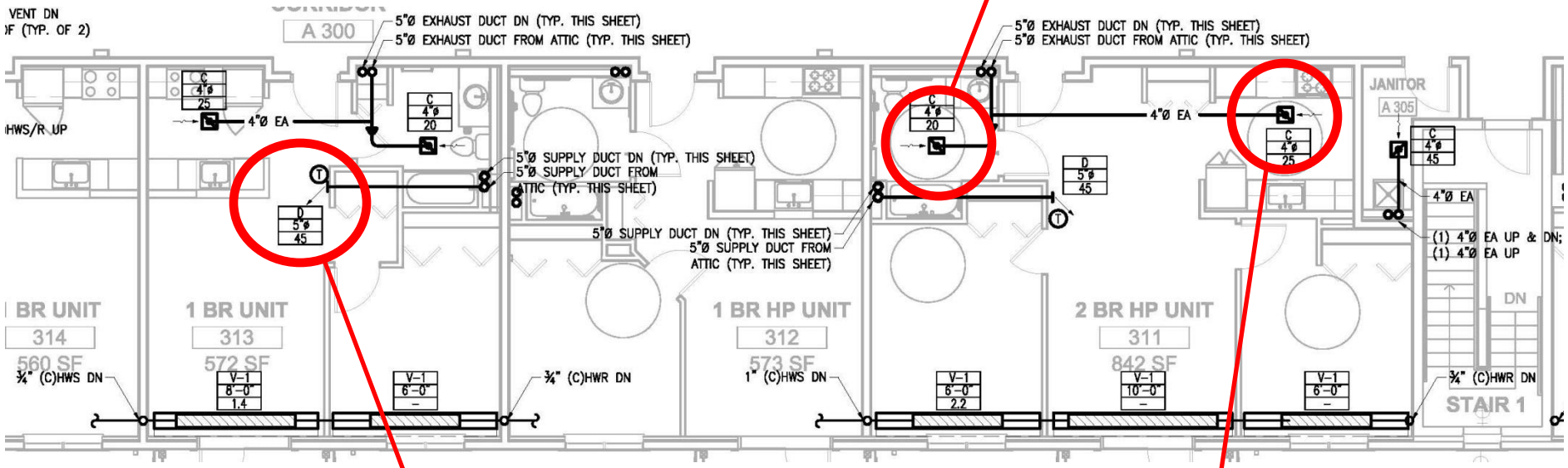


Valance Unit Installed (without Enclosure)

Ventilation (Apartment Bldg.)

- Central DOAS System
  - OA Supply to Space Treated to Neutral Conditions
    - Heat and Cooling Coil Connected to Central Heating and Cooling Plants
  - Complete Ductwork System for OA & EA Distribution throughout Building
    - Separate (Decoupled) from Heating and Cooling System
  - OA Grille with Integral CAR Damper at each Living Area
  - EA Grille with Integral CAR Damper at each Kitchen and Bathroom
    - Re-Circ. Range Hood

Typical Apt. Bldg. Unit Plan



EA Grille in Bathroom (Typ.)

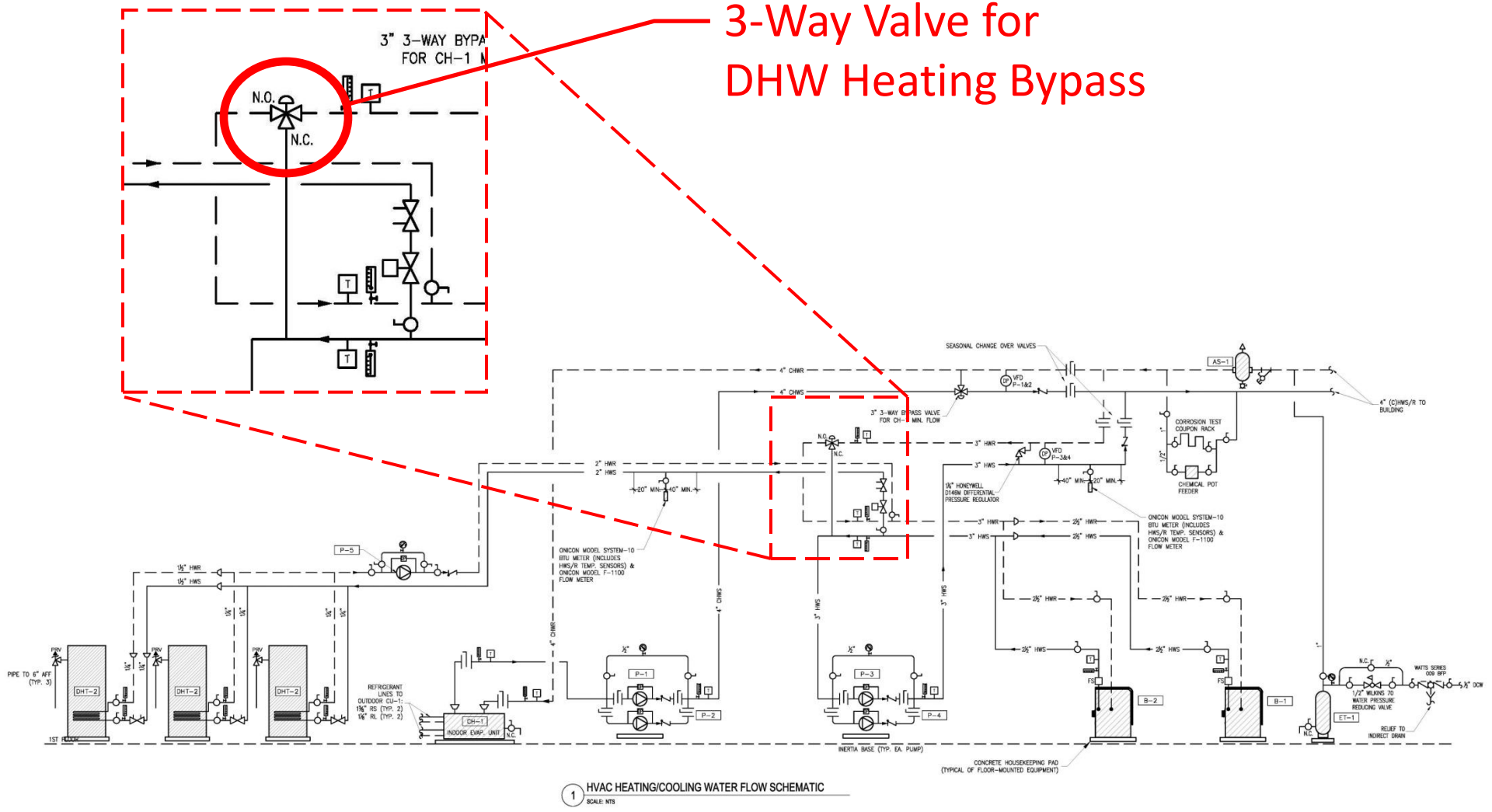
OA Grille in Living Area (Typ.)

EA Grille at Kitchen (Typ.)

DHW (Apartment Building)

- Central Indirect Water Heaters/Tanks
  - Connected to the Central Boiler Plan
  - DHW Re-Circ System
  - DHW does not overheat the main loop
  - Solar Thermal Ready

DHW (Apartment Building)



Home Energy Rating Certificate

501-511 Ferris Lane
Taunton, MA 02780

5 Stars Plus
Confirmed
HERS Index: 53

Registry ID	**018931889**
Rating Number	
Certified Energy Rater	William D'Arrigo
Rating Date	1/22/2014
Rating Ordered For	Taunton Housing Authority

General Information

Conditioned Area	7747 sq. ft.	House Type	Multi-family, whole building
Conditioned Volume	76164 cubic ft.	Foundation	Slab
Bedrooms	14		

Mechanical Systems Features

Air-source heat pump:	Electric, Htg: 9.3 HSPF. Clg: 17.5 SEER.
Air-source heat pump:	Electric, Htg: 10.0 HSPF. Clg: 15.0 SEER.
Water Heating:	Conventional, Electric, 0.94 EF, 40.0 Gal.
Duct Leakage to Outside	0.06 CFM25.
Ventilation System	Balanced: HRV, 371 cfm, 156.0 watts.
Programmable Thermostat	Heat=Yes; Cool=Yes

Building Shell Features

Ceiling Flat	N/A	Slab	R-10.0 Edge, R-10.0 Under
Sealed Attic	N/A	Exposed Floor	R-30.0
Vaulted Ceiling	R-42.0	Window Type	U: 0.33, SHGC: 0.15
Above Grade Walls	R-34.9	Infiltration Rate	Htg: 0.76 Clg: 0.76 ACH50
Foundation Walls	N/A	Method	Blower door test

Lights and Appliance Features

Percent Interior Lighting	100.00	Range/Oven Fuel	Electric
Percent Exterior Lighting	100.00	Clothes Dryer Fuel	Electric
Refrigerator (kWh/yr)	415.00	Clothes Dryer EF	3.01
Dishwasher Energy Factor	0.78	Ceiling Fan (cfm/Watt)	0.00

Estimated Annual Energy Cost

Use	MMBtu	Cost	Percent
Heating	22.8	$722	11%
Cooling	7.1	$223	3%
Hot Water	64.8	$2054	31%
Lights/Appliances	95.3	$3021	46%
Photovoltaics	-0.0	$-0	-0%
Service Charges		$580	9%
Total	**190.0**	**$6600**	**100%**

Criteria

This home meets or exceeds the minimum criteria for the following:
2009 International Energy Conservation Code
Massachusetts Stretch Code*
* Compliance with criteria for this program is determined by the rater.

Conservation Services Group
50 Washington Street
Westborough MA 01581
508-836-9500

The Home Energy Rating Standard Disclosure for this home is available from the rating provider.
REM/Rate - Residential Energy Analysis and Rating Software v14.3
This information does not constitute any warranty of energy cost or savings.

Home Energy Rating Certificate

801 and 803 Fairground Avenue
Taunton, MA 02780

5 Stars Plus
Confirmed
HERS Index: 52

Registry ID	**480081816**
Rating Number	
Certified Energy Rater	William D'Arrigo
Rating Date	9/23/2013
Rating Ordered For	Taunton Housing Authority

Estimated Annual Energy Cost

Use	MMBtu	Cost	Percent
Heating	13.2	$416	16%
Cooling	2.9	$92	4%
Hot Water	23.8	$753	30%
Lights/Appliances	34.4	$1090	43%
Photovoltaics	-0.0	$-0	-0%
Service Charges		$193	8%
Total	**74.2**	**$2544**	**100%**

Criteria

This home meets or exceeds the minimum criteria for the following:

General Information

Conditioned Area	3012 sq. ft.	House Type	Multi-family, whole building
Conditioned Volume	30522 cubic ft.	Foundation	Slab
Bedrooms	6		

Mechanical Systems Features

Air-source heat pump:	Electric, Htg: 9.3 HSPF. Clg: 17.5 SEER.
Air-source heat pump:	Electric, Htg: 10.0 HSPF. Clg: 15.0 SEER.
Water Heating:	Conventional, Electric, 0.94 EF, 40.0 Gal.
Duct Leakage to Outside	17.47 CFM25.
Ventilation System	Balanced: HRV, 160 cfm, 54.0 watts.
Programmable Thermostat	Heat=Yes; Cool=Yes

Building Shell Features

Ceiling Flat	N/A	Slab	R-10.0 Edge, R-10.0 Under
Sealed Attic	N/A	Exposed Floor	R-30.0
Vaulted Ceiling	R-42.0	Window Type	U: 0.33, SHGC: 0.15
Above Grade Walls	R-34.9	Infiltration Rate	Htg: 0.73 Clg: 0.73 ACH50
Foundation Walls	N/A	Method	Blower door test

Lights and Appliance Features

Percent Interior Lighting	100.00	Range/Oven Fuel	Electric
Percent Exterior Lighting	100.00	Clothes Dryer Fuel	Electric
Refrigerator (kWh/yr)	415.00	Clothes Dryer EF	3.01
Dishwasher Energy Factor	0.78	Ceiling Fan (cfm/Watt)	0.00

Conservation Services Group
50 Washington Street
Westborough MA 01581
508-836-9500

The Home Energy Rating Standard Disclosure for this home is available from the rating provider.

REM/Rate - Residential Energy Analysis and Rating Software v14.3

This information does not constitute any warranty of energy cost or savings.

HERS INDEX

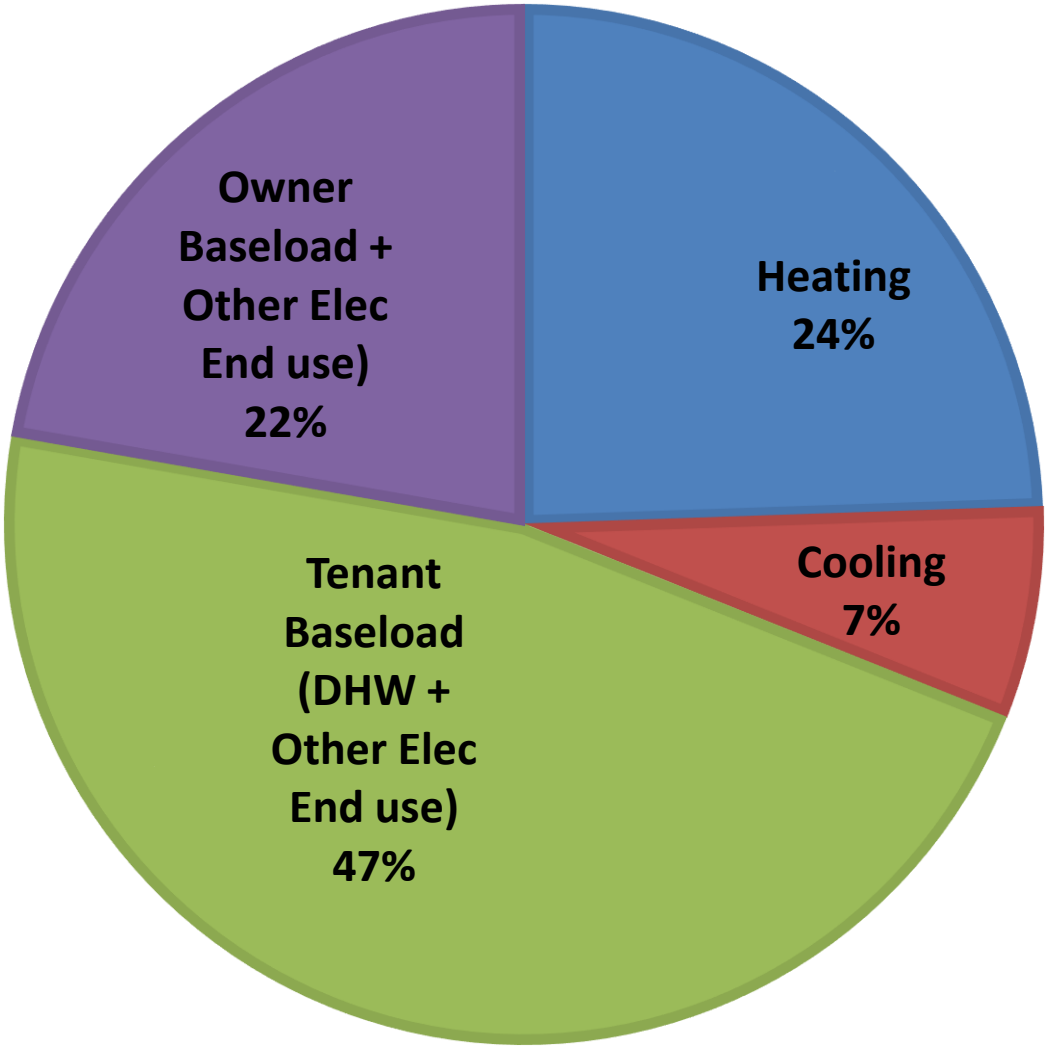
Building	HERS Index
A: 100-110 Fairground Ave.	56
B: 101-113 Ferris Lane	56
C: 401-411 Derby Court	55
D: 201-211 Ferris Lane	57
E: 301-315 Derby Court	58
F: 101-115 Derby Court	59
G: 201-217 Derby Court	54
H: 501-511 Ferris Lane	53
I: 401-413 Ferris Lane	53
J: 300-306 Fairground Ave.	53
K: 201-211 Fairground Ave.	54
L: 401-411 Fairground Ave.	53
M: 501 & 503 Fairground Ave.	52
N: 601 & 603 Fairground Ave.	52
O: 701 & 703 Fairground Ave.	52
P: 801 & 803 Fairground Ave.	52

Measured Air Leakage

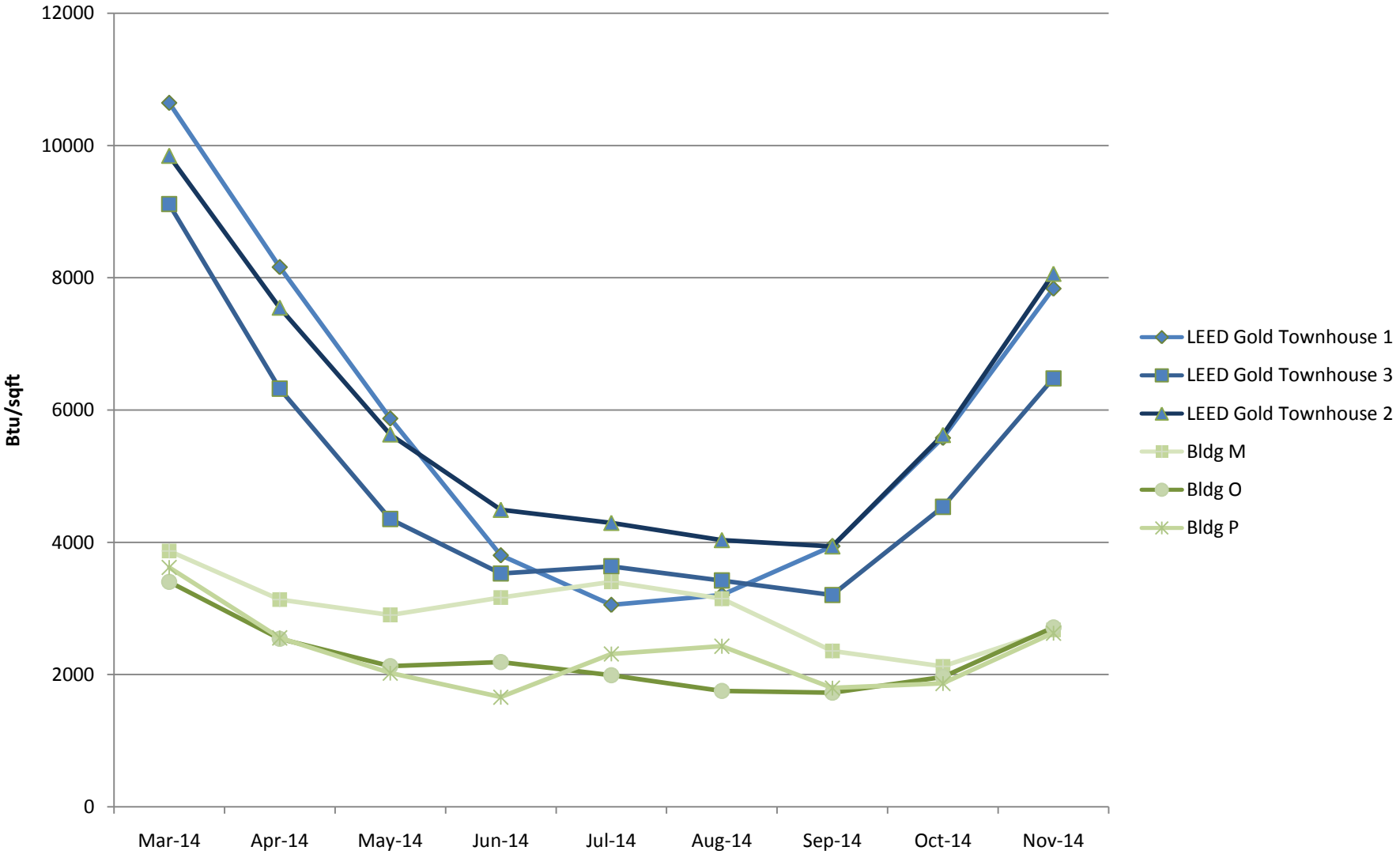
(Passive House Standard 0.6 ACH 50)

Building	Gross SF	Measured WB Air Leakage (ACH 50)
A: 100-110 Fairground Ave.	7913	0.85
B: 101-113 Ferris Lane	9718	1.05
C: 401-411 Derby Court	7875	0.94
D: 201-211 Ferris Lane	7077	0.88
E: 301-315 Derby Court	11080	0.95
F: 101-115 Derby Court	11080	1.34
G: 201-217 Derby Court	12323	**0.58**
H: 501-511 Ferris Lane	7931	0.76
I: 401-413 Ferris Lane	8962	0.85
J: 300-306 Fairground Ave.	5687	0.67
K: 201-211 Fairground Ave.	7074	0.8
L: 401-411 Fairground Ave.	9665	0.84
M: 501 & 503 Fairground Ave.	2925	**0.52**
N: 601 & 603 Fairground Ave.	2925	**0.54**
O: 701 & 703 Fairground Ave.	2925	0.70
P: 801 & 803 Fairground Ave.	2925	0.73

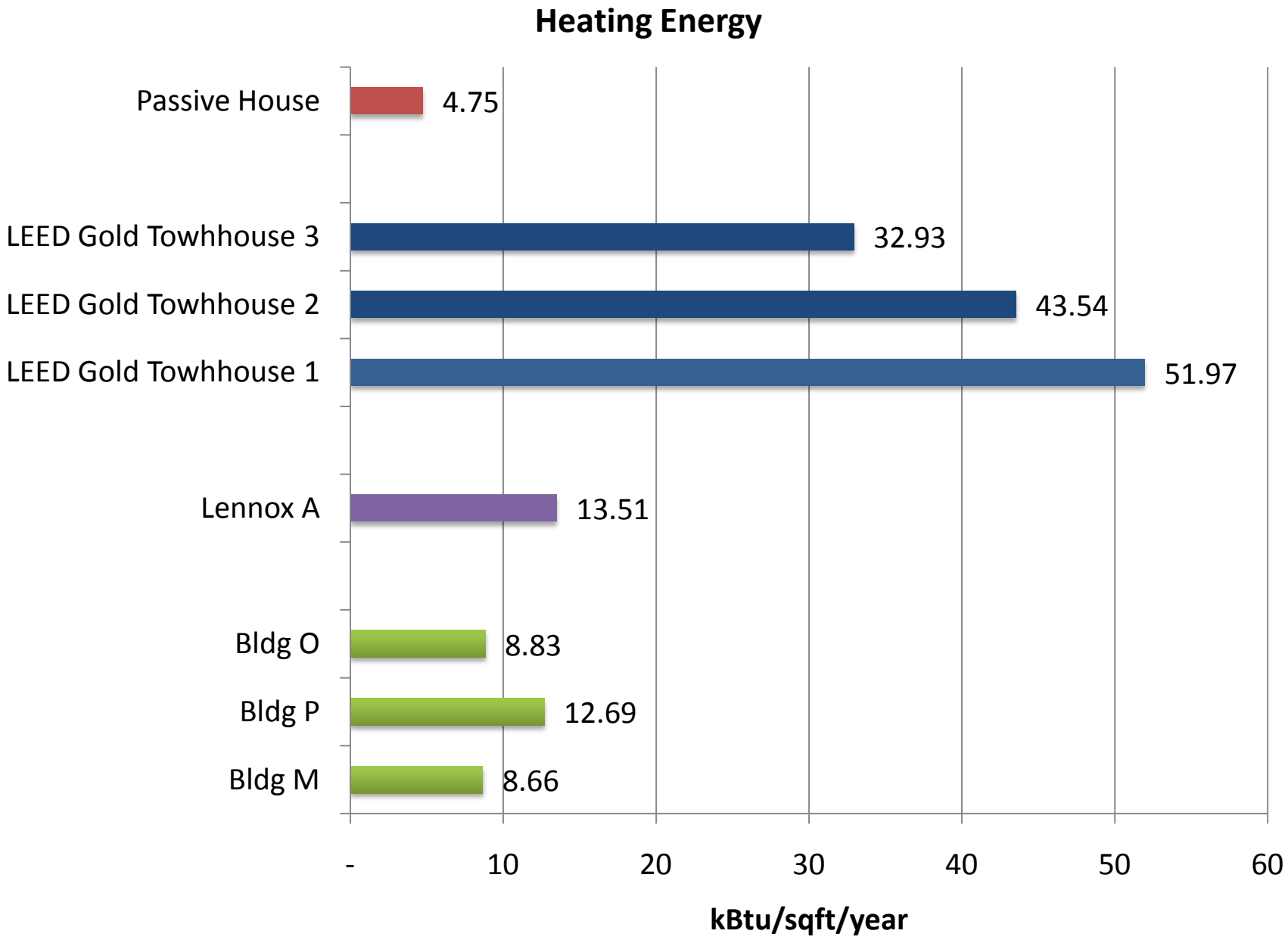
Building P - Total Energy Use



Benchmarking Total Energy Use



Comparing Benchmarks



Lennox A

- Setpoint: 60 degrees F
- Heating: 2.76 Btu/sqft/HDD
- Hot water: 15,495 Btu/bedroom/day

- Natural gas use: 19 kBtu/sqft/year
- Benchmark (buildings in MA, built after 2000, low-income residence, gas use includes heat and hot water): 58 kBtu/sqft/year

Energy Cost/Month/Unit

$/Month	Petersen Pre-Design Estimate	Allowance	Projected (Median)
Apartment Building (1BR unit)	25	36	
Apartment Building (2BR unit)	31	48	
Townhome Building (2BR unit)	82	154	94 (n=3)
Townhome Building (3BR unit)	102	191	
Townhome Building (4BR unit)	109	232	129 (n=3)

How do you train tenants to accept and properly use new buildings components such as mini-splits, HRVs, awning windows, condensing dryers, etc?

- Commissioning
- 5-year Utility Tracking & Performance Evaluation

- Paybacks? ROI?
- Benefits of ECMs go to tenants, not developer

HARD Cost per Unit

- Bid Results: $35,000/Unit Higher than Budget
- Required Significant VE WITHOUT reducing ECMs except:
  - Eliminate solar DHW
  - Simplify facades
  - Simplify structural details
  - Simplify fencing and sheds
  - Reduce trim detail
  - Reduce landscaping
  - Reduce quantity of dormers and windows

FINAL Cost per Unit

- $309,000/Unit → $261/GSF
  - Comparable to our other stick-built projects
- Includes premiums for
  - Davis Bacon Wages Rates
  - Significant union participation
  - Section 3 Hiring
  - MBE / WBE Hiring
  - Local Hiring
  - Two sites

Thank You!

This concludes The American Institute of Architects
Continuing Education Systems Course

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