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Appendix A- Glossary of Terms	
AC	Air Conditioning
ACH	Air Changes Per Hour
ADA	Americans with Disabilities Act
AFUE	Annual Fuel Utilization Efficiency
AHJ	Authority Housing Jurisdiction
AHU	Air Handling Unit
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ATC	Automatic Temperature Controls
AWT	Advanced Wastewater Treatment
BAS	Building Automation Systems
BoD	Basis of Design
BTU	British Thermal Units per Hour
BTUH	British Thermal Unit
cfm	cubic feet per minute
CHT	Champlain Housing Trust
CO2	Carbon Dioxide
Const Doc	Construction Documents Phase
COP	Coefficient of Performance
CxA	Cx Associates
D	Duplex
DB	Dry Bulb (referring to temperature)
DCW	Domestic Cold Water
DD	Design Development
DHW	Domestic Hot Water
DLC	Double-Loaded Corridor
DOAS	Dedicated Outdoor Air Systems
DOE	Department of Energy
DP/ dP	Differential Pressure
DX	Direct Expansion
EC Motors	Electrically Commutated Motors
ECMS	Environmental Control and Monitoring System
EER	Energy Efficiency Ratio
ERV	Energy Recovery Ventilation
ERW	Energy Recover Wheel
EVT	Efficiency Vermont
F	Farenheit
FPS	feet per second (velocity)
FPT	Fan-powered Terminal
GPM	Gallons per Minute flow rate
HRU	Heat Recovery Unit
HRV	Heating Recovery Ventilation
HSPF	Heating Seasonal Performance Factor
HVAC	Heating Ventilation and Air Conditioning
HVT	Housing Vermont

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HW	Hot Water
HWS	Hot Water Supply
HWST	Hot Water Supply Temperature
IESNA	Illuminating Engineering Society of North America
IPLV	Integrated Part Load Value
kW	kilowatts
kWh	kilowatts per hour
lb	pounds
LEED	Leadership in Energy and Environmental Design
Long Term	Long Term Affordable- no specified PUM target. It is the minimum cost of
	development for energy efficient envelope powered only with PV
low e	Low-emittance
LPD	Lighting Power Density
Ltg	Lighting
MBTU/MBH	One-Thousand BTUs
Mech Engr	Mechanical Engineer
MSOG	Mechanical System Optimization Guide
NABCEP	North American Board of Certified Energy Practitioners
NC	Normally Closed
Near Term	Near Term Affordable- defined as $75PUM for heat and DHW (maintained at 5% inflation)
NO	Normally Open
NOAA	National Oceanographic and Atmospheric Administration
NREL	National Renewable Energy Laboratory
O & M	Operations and Maintenance
OA	Outdoor Airflow
OPR	Owner's Project Requirements
OSA	Outside Air
PFI	Pellet Fuel Institute
PM	Preventive Maintenance
PSI	Pounds per Square Inch
PUM	Per Unit Monthly
PV	Photo Voltaic
RBES	Residential Building Energy Standards
RFP	Request for Proposal
RHEA	The Roadmap for Housing Energy Affordability
RPM	Revolutions Per Minute
R-Value	Measurement of insulation
SAT	Supply Air Temperature
SD	Schematic Design
SDHW	Solar Domestic Hot Water
SEER	Seasonal Energy Efficiency Ratio
SHGC	Solar Heat Gain Coefficient
Spec Dev	Specification Development (late Construction Documents Phase)
T	Townhouse
T&B	Test & Balance
TES	Thermal Energy Storage
TMY3	Typical Meteorological Year Version 3

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TRAV	Terminal Regulated Air Volume
TVSS	Transient Voltage Surge Surpressor
U-Factor	Overall heat transfer coefficient
UPS	Uninterruptable Power Supply
UV	Ultra-Violet Rays
VAV	Variable Air Volume
VFD	Variable Frequency Drive
VHCB	Vermont Housing and Conservation Board
VHFA	Vermont Housing Finance Agency
VOC	Volatile Organic Compounds

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Appendix B (part 1): Modeling/Sizing Inputs	
Parameter	**Modeled Value or Range**
General Parameters	*[Example information provided]*
Building Location	Burlington, VT
Builidng Type Calssification	Multifamily, Mixed Use Commercial, etc
Building Code Applied	VT Res Guildeline 2005
Weather Data Source / Type	NOAA TMY3, BTV
Analysis Tool/approach	
Building Dimensions	
Number of Floors Above Grade	2
Number of Floors Below Grade	1
Floor to Ceiling Height	8ft
Roof Configuration	Gabled, 25 degree pitch
Perimeter	200 ft
Surface Area	4000 sq-ft
Envelope	
Infiltration rate	0.1 ACH
Exterior Wall Assembly R-Value, Insulation Type	R-40, x" continuous polyiso + x" Batt
Attic Floor Assembly R-Value, Insulation Type	R-50 x" continuous polyiso + x" Batt
First Conditioned Floor is Above (Slab, Garage, Other)	Garage open to ambient conditions.
Slab Insulation (Below, above, slab edge, etc)	X" continuous R-14 below + 3" polyiso slab edge
Below Grade Wall Insulation	R-3, continuous polyeurethane, x"
Window Tabulation	Include types, assembly R values, shading coeff, orientation and quantity in separate table.
Door Tabulation	Include types, assembly R values, shading coeff, orientation and quantity in separate table.
Other Envelop Features	Address other features such as fixed exterior shading or shading by trees. Particularly important for cooling calcs.
Building Occupants	
Occupancy Schedule	Weekdays 5pm to 7am 100% Weekdays 7am - 3 PM 55% Weekdays 3PM - 5PM 75% Weekends & holidays 100%
Occupied Temperature Setpoint (winter, summer)	70/75F
Unoccupied Temperature Setpoint (winter, summer)	70/75F (no setback)
Total # of Units in Building	12
Average # of Occupants per Unit	3
Total Bedrooms in Building	20
Occupant types for DHW calculations	Senior, Family, Single Parent, Income Levels, Working, etc.

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Appendix B (part 1): Modeling/Sizing Inputs	
Parameter	**Modeled Value or Range**
Central Heating Plant Equipment	
Equipment Type	Condensing Boiler
Fuel Source	Oil
Equipment Efficiency	91% Efficient
Cooling Equipment	
Equipment Type	
Chilled Delivery Mode	
Equipment Efficiency (EER/COP)	
Number of Units	
DHW HP heating system	
ERV heating/cooling system	
Terminal Equipment	
Terminal Equipment Type	Baseboard
Capacity Rating	800 BTU/hr/sq-ft
Ventilation	
Ventilation rate dwelling	
Ventilation rate common areas	
Building Loads & Schedules	
Lighting Power Density - common areas	
Common area lighting schedule	
LPD dwelling units	
Dwelling unit lighting schedule	
Laundry loads & frequency	
Cooking	
Miscellaneous plug loads	

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Appendix B (part 2): Modeling/Sizing Outputs

Energy Use	Value	Units
Total Annual Space Heating Input Energy		MMBTU
Total Annual Space Cooling Input Energy [3]		Ton-Hrs
Total Annual Building Electrcal Energy		kWh/yr
Total Annual DHW Input Energy		
DHW Thermal Storage		
Peak Space Heating Load		MBTU/hr
Peak Heating Load from Ventilation		MBTU/hr
Space Heating Thermal Storage		
Boiler size and quantity		
Boiler and Thermal Storage peak hour capacity		MBTU/hr
Peak Space Cooling Load [3]		MBTU/hr
Energy Intensity		MBTU/sq-ft/yr
PUM Electrical Coss (current $ value) [1]		$/unit/month
PUM Fuel Costs (current $ Value) [2]		$/unit/month
PUM Electrical Costs (Yr. 15 @ 5% Esc) [2]		$/unit/month
PUM Fuel Costs (Yr. 15 @ 5% Esc)		$/unit/month

Notes:

[1[Per housing unit monthly expenses. Includes common areas.

[2] To calculate year 15 rough costs for 5% multiply current dollar fuel costs by 2.08, this is a rough approximation and does not include inflation

[3] For buildings with cooling model and report loads for ERV and for HRV to allow for comparison

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Appendix C: Owner's Project Requirements Example

The following document is a sample Owner's Project Requirements document for reference only. The values and requirements stated herein are for example purposes, except under the Energy Section, in which the language and numbers reflect the Roadmap to Energy Affordability requirements.

Owner & User Requirements – *describe the primary purpose, program and use of the project. Provide overarching goals relative to program needs, future expansion, flexibility, quality of materials, construction and operational costs.*

The Project is an affordable multi-family housing facility with 32 units including 3 units that meet ADA standards. The building design will use double loaded corridors and will not exceed 3 stories above grade. The building design shall encourage people to use the stairs rather than the elevator. Parking for 50 cars will be provided in an unheated below grade garage.

Site layout will provide safe access for students boarding school buses and for all parties using public transportation services to the site. Site lighting shall provide security while complying with Dark Skies guidelines. Roof lines, walkways and building entries shall be coordinated to minimize hazards from falling ice or snow.

The facility will be constructed to the standards of permanent affordability including:

- The building life is expected to be 100 years.
- Per Unit energy cost of $75/month in 2025
- Annual maintenance costs for building shell, interior upkeep and equipment preventive service shall not exceed: $ xx/sq ft/year average for 5 years and $yy/sq ft per year ten year average.
- Component life shall be in accordance with the following table:

Component	Expected Life	Notes
Roof	50 years	Roofing material shall be recyclable.
Siding	50 years	Refinishing of siding shall be required no more frequently than every 10 years at a cost not to exceed xx in current dollars.
Windows	30 years	Windows shall not require refinishing over their lifetime
Kitchen Cabinetry	30 years	Cabinetry shall not require refinishing over its lifetime
Appliances	15 years	
Interior doors and hardware	30 years	No refinishing
Interior wall and ceiling finishes	5 years	

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Interior floor finishes common areas	30 years	
Interior floor finishes apartments	15 years	
Central heating and domestic hot water equipment	20 years	
Central pumps	15 years	
In unit distribution of heat and ventilation (baseboards, diffusers, etc.)	15 years	No refinishing required, Owner should address cleaning expectations
Ventilation System	15 years	
Fixed lighting – lamp life	10,000 hours minimum	Spare lamps for in unit lighting shall be provided to ensure replacement lamps are available for 15 years.

The total budget for the project is $xxx including y% for soft costs.

Provide any specific budget limitations for building components or other budget detail that will assist the team specifying and constructing the building that most closely meets the owner's vision during the budgeting process.

Environmental and Sustainability Goals – *describe specific environmental requirements or goals*

The Project will not pursue a LEED rating. However, the following aspects of the design and construction shall be completed in compliance with the related LEED credit requirements as indicated in LEED 2009. Compliance with all LEED prerequisites is required for this project.

Owner selects specific areas that are priorities for the project and lists them here – suggested areas may include:

Sustainable Sites – site vegetation, low albedo roof, light pollution

Water Efficiency – reference flow values for plumbing fixtures below

Energy and Environment Credits - including energy performance (see energy goals set below)

Materials and resources – construction waste recycling, regional materials xx%

Indoor Environmental Quality – limit VOCs, include walk-off areas etc. (see indoor environmental goals below)

Energy Efficiency Goals – *describe overall project energy efficiency goals relative to the local energy code, ASHRAE etc. Describe any goals or requirements for building orientation, landscaping, façade, fenestration, envelop, roof and energy systems.*

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The building energy use for heating and ventilation shall not exceed 6 MBTU/sq-ft/year.

The Project shall be oriented with the long axis running east/west to control solar heat gain. Exterior shading shall be provided on the southern and western façades to minimize direct summer solar incidence. The building envelop shall be designed and constructed in accordance with the permanently affordable option described in the *Roadmap to Affordable Housing Version 1, 2011.* Building Envelop performance testing is required for this project. Testing shall be specified by the architect and performed by an approved testing entity and attended by the Owner's representative, architect and contractor responsible for building shell construction.

The building will be heated and have a mechanical ventilation system. In unit cooling is not included in the design. Building mechanical systems shall be designed and constructed in accordance with the *Mechanical Design Guide for Affordable Housing Version 1, 2011.* Mechanical system commissioning is required and shall be performed by an approved testing entity.

Appliances shall be Energy Star Rated and shall be rated at the highest efficiency level available. Refrigerators shall be Maytag xxx units. Appliances to be furnished to each unit include: Refrigerator – yyy ; dishwasher model yyy. Central laundry facilities shall be provided on each floor including yyy.

In unit lighting shall be linear or compact fluorescent and shall include at least one fixed lighting fixture in every room. Designers shall submit a schedule showing lighting wattage, lamp life, watts per square foot, average and minimum footcandle levels in each space as part of the Basis of Design documentation. Designers shall use IESNA as a guide; however IESNA footcandles should be considered the maximum to be provided by fixed lighting as occupants may provide supplemental lighting where needed. Common area lighting shall be automatically demand controlled and provide a minimal level of night lighting to ensure people are not walking into dark, unlit spaces at night. Use daylighting in common areas to minimize the use of electric lighting use during daytime hours.

Indoor Environmental Requirements – *For each program or area describe the intended use, anticipated occupancy, space environmental requirements, including lighting, temperature, humidity, acoustics, air quality and ventilation), desired adjustability of system controls, and accommodations for after-hours use.*

Common areas including the building main lobby, corridors and stairwells shall maintain a temperature of 72 degrees F in the winter. Summer temperatures shall not generally exceed xx – however, mechanical cooling is not to be included in the design. Shading and ventilation strategies shall be applied to minimize the impacts of hot days.

Dwelling units shall be designed to maintain a temperature of 70 degrees F in the winter. Summer temperatures shall not generally exceed xx – however, mechanical cooling is not to be included in the design. Shading and ventilation strategies shall be applied to minimize temperature rise on hot days.

Time to delivery of hot water to a bathroom sink shall not exceed 10 seconds.

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Equipment and system expectations – *Describe the level of quality, reliability, type, automation, flexibility and maintenance requirements for building systems other than those addressed in the Mechanical Guide, if any. When known, provide specific efficiency targets, desired technologies, or preferred manufacturers for building systems.*

Garage Ventilation System shall be variable speed controlled via carbon monoxide sensors to ensure air quality while limiting energy consumption.

Building occupants shall have individual thermostats controlling the temperature in the general living space and in the bedroom(s). The thermostats shall (not) be programmable type xxx. A thermostat operating guide shall be provided to occupants. Building occupant control of the ventilation system is (not) allowed. Building occupants are expected to have a low acceptance of difficult controls – controls shall be simple and readily understood.

Low flow devices shall be used with flow rates as follows: (EVT or HVT provide rates)

Kitchen Sink
Toilet
Shower
Bathroom sink

Documentation, Training and Operational Requirements

Project documentation shall be in electronic format and shall be used to develop as-built documents. Complete and accurate electronic as-built documents shall be provided to the Owner at the conclusion of construction.

Mechanical equipment maintenance will be provided by a third party service contractor. On site preventive maintenance shall be required no more frequently than once per year for equipment service and four times per year for filter changing.

Facility operation shall be fully automated. There will be no building operator assigned to this facility. Failure of critical equipment for heating and ventilation shall be alarmed to an external monitoring source.

Operator training shall be specified and provided as outlined in the attached training matrix.

Project will include remote monitoring of energy use via XXX system. Install meters on main electric service, hot water use and heating water use.

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Appendix D: Mechanical Systems Selection Matrix

Equipment Type	Example Equipment	Natural Gas Available			No Natural Gas Available		
		Duplex	Townhouse	Double-Loaded Corridor	Duplex	Townhouse	Double-Loaded Corridor
Fuel-Fired Central Plant Equipment	Weil McLain Ultra 3 UG-80, Buderus Logamax Plus GB142 (gas)& Logano GB125BE (oil)	Condensing Boiler W/OA Based Supply Water Temp Reset - 95%AFUE Gas		3-Condensing Boiler W/OA Based Supply Water Temp Reset - 95%AFUE Gas	Condensing Boiler W/OA Based Supply Water Temp Reset - 91%AFUE Oil		3-Condensing Boiler W/OA Based Supply Water Temp Reset - 91%AFUE Oil
	Froling P4 Pellet Boiler	Pellet Boiler 85% AFUE with TES.		3-Pellet Boilers 85% AFUE with TES.	Pellet Boiler 85% AFUE with TES.		3-Pellet Boilers 85% AFUE with TES.
Heat Pump Equipment	Daikin VRV III-S, Daikin VRV III, Mitsubishi City Multi			Senior Housing: Cooling req'd ASHP COP 3.5 EER 11.9			Senior Housing w/ Cooling ASHP COP 3.5 EER 11.9
Terminal Equipment	Heating: SlantFin,	Baseboard			Baseboard		
	ASHP	Dx Coils			Dx Coils		
Domestic Hot Water	AO Smith Vertex (gas direct); Triangle Tube (oil	Condensing DHW with Storage: 96% Thermal Efficiency			Indirect Fired:; 85% usable tank capacity; <0.5% losses		
	Bosch 2400ES	On Demand tankless: 82% Efficient					
		Solar preheat at 50% of load			Solar preheat at 50% of load		
Ventilation System	Fantech SH-704 & SHR-1504, Venmar HRV 600i	Energy recovery in each unit, without auxilliary heat, 70% Sensible Recovery			Energy recovery in each unit, without auxilliary heat, 70% Sensible Recovery		
	Semco ERV2000,			Cenral DOAS ERV and Heating Coil, 75% Sensible Recovery			Cenral DOAS ERV and Heating Coil, 75% Sensible Recovery

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Process Guide Flowchart

Phase / Activity	Developer	Owner	Arch	ME	CxA	O&M	Contractor
Development							
Establish project priorities to ensure long term affordability	X	X					
Establish project construction budget and operating costs	X	X					
Determine whether O&M will be in house or outsourced	X	X					
Budget for performance verification	X	X					
Document Owner's Project Requirements	X	X					
Design Team Selection & Contracting							
Include OPR, RHEA and MSOG with RFP	X	X					
Require team to provide examples of successful projects with energy/performance goals	X	X					
Include post occupancy verification requirements at 14 months.	X	X					
BoD to be submitted at SD and updated to reflect changes in project	X	X					
Include energy and other critical performance goals in the contract language	X	X					
Require that design documents be provided to the contractors in electronic format for as-built creation	X	X					
Require project specific O&M training plan and scope of materials to be delivered	X	X		X		X	
Team demonstrates experience with low energy approaches and integrated design			X	X			
Schematic Design							
Hire commissioning agent if included in scope	X	X			X	X	
Hold design charette to review OPR and clarify performance objectives	X	X	X	X	X	X	
Design team prepares BoD			X	X			
Begin modeling/sizing activities so that interactive effects can be considered			X	X			
Design review of BoD, Schematic drawings, modeling/sizing input documents	X	X			X		
Design Development							
Define operator training requirements	X	X				X	
100% DD model complete				X			
Modeling and load calc forms submitted				X			
BoD narrative updated			X	X			
Design review of updated BoD, DD drawings, modeling/sizing input and results documents	X	X			X	X	
Construction Documents							
Finalize design and details to ensure energy performance			X	X			
All team members discuss impacts of cost reduction measures and interactive effects	X	X	X	X	X	X	
If project energy goals are reduced modify contracts to reflect	X						
Project cost reduction efforts reflected in OPR and BoD as well as designs	X		X	X			
Modeling/sizing updated to reflect cost reductions in envelop				X			
Specifications require contractors to provide an accurate preventive maintenance matrix				X			
Specify requirement for electronic as-built documents and provide schedule for as-built submission and review during construction			X	X			
Contract ties payments to meeting documentation and training requirements as well as construction	X		X				X
Design review of BoD, CD drawings and specifications, sequences of operations, training and maintenance requirements	X	X			X	X	
Construction							
Commissioning of energy using systems where included					X		X
Independent performance testing of building envelop, particularly for infiltration	X		X				X
Operators are available and receive effective training				X	X	X	X
Verify as-built documentation	X		X	X	X	X	X
Preventive maintenance requirements are accurately documented in a matrix				X	X	X	X
Payments are tied to non-construction deliverables as well as construction	X	X	X		X		X
Post Occupancy							
Mechanism in place to maintain project as-built documents in accurate working and accesible order		X				X	
Occupant eduction regarding building performance		X					
Maintenance training at end of warranty period		X				X	X
Track building issues and energy use and report		X				X	
Post occupancy review of energy, maintenance and operations	X	X	X	X	X	X	X
Periodic recommissioning of systems		X			X	X	

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Appendix F: Sequences of Operation (Example)

The following sequences of operation are a sample. They are intended to act as a guide.

Duplex Units

Zone Temperature Control

Each duplex unit will have a single thermostat. Duplex units with two floors will have a thermostat for each floor. When a thermostat calls for heating, the respective heating hot water two position zone control valve (N.C., spring return) will open. When thermostat is satisfied, the zone valve closes.

Duplex with one modulating boiler and indirect DHW

When the system is off, with no zones calling for heating and indirect DHW heater setpoint satisfied, the zone valves are closed, primary HW pump is off, all boilers and associated circulator pumps are off.

The DHW recirculation pump may be on or off (based on its separate control system).

Upon call from a zone thermostat for heating, when zone valve end switch makes, the building primary heating HW pump runs.

When HW pump is on, and HWS temperature to building drops below setpoint, the boiler and its dedicated circulator operate. Boiler capacity modulates as required to maintain HWS temperature setpoint. When HWS temperature setpoint is satisfied, the boiler and its associated circulator stop.

When all zone valves close, primary pump stops, all boilers and associated circulators shut off.

HWS temperature setpoint shall be reset from 130F to 100F In proportion to outside air temperatures of 0F to 55F. Setpoint will be temporarily overridden to a warmer HWS setpoint upon domestic hot water priority call.

Indirect Domestic HW Control

When the water temperature within the indirect DHW tank drops below temperature setpoint, the dedicated indirect DHW circulator runs, and boiler and associated circulator run. The boiler modulates to maintain a water temperature setpoint of 180F. When indirect DHW tank temperature sensor is satisfied, boiler will shut off and the dedicated indirect DHW circulator stops.

DHW Recirculation Pump Control

When flow switch in common DHW pipe from DHW indirect heater to both duplex units indicates demand for DHW exists, the DHW recirc pump operates continuously for 30 seconds

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after the DHW flow switch indicates DHW demand has terminated. The DHWR circulator shall have a 15minute time delay before restart, even if a DHW demand from flow switch occurs.

Duplex Heat Recovery Ventilation

Each duplex unit HRV will be controlled separately.

The HRV will operate continuously at low speed. When bathroom light is turned on, HRV runs at full speed. When bathroom light is turned off, HRV runs at high speed until a time delay expires.

Large Multi Family Buildings

Zone Temperature Control

Each one bedroom unit will have a single thermostat. Units with two floors levels will have a thermostat for each floor. When a thermostat calls for heating, the respective heating hot water two position zone control valve (N.C., spring return) will open. When thermostat is satisfied, the zone valve closes.

Central Heating Plant Control (with multiple modulating boilers)

When the system is off, with no zones calling for heating, the zone valves are closed, primary HW pumps are off, and all boilers are off.

Upon call from a zone thermostat for heating, when a zone valve end switch makes, the building primary heating HW pump starts.

When heating HW distribution pump is on, when HWS temperature to building drops below setpoint, the lead boiler dedicated circulator starts and the boiler burner modulates to maintain HWS temperature setpoint. On further call, when lead boiler burner modulates to 90% position, the next boiler starts in the same manner. With two or more boilers operating, all operating boiler burners modulate in unison to maintain HWS temperature setpoint. When HWS temperature approaches HWS temperatures setpoint, all operating boiler burners modulate downward in unison. When the burners modulate to the minimum fire position, the last on boiler shuts off, and boilers continue modulate in unison. On further reduced call, the sequence continues in this manner until the HWS setpoint is satisfied, and all boilers shut off.

When all zone valves close, primary pump stops, all boilers shut off.

Alternate boiler sequencing to equalize run time of all boilers.

HWS temperature setpoint shall be reset from 130F to 100F In proportion to outside air temperatures of 0F to 55F.

The central heating plant is off whenever outside air temperatures are greater than 65F.

Heating HW Pump Control

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The two variable flow heating HW central distribution pumps, upon command to run, the lead pump starts and slowly ramps speed faster as required to maintain piping differential pressure (dP) control sensor (located in the remote 1/3 portion of piping distribution system) setpoint.

If a pump is commanded to run and fails to operate, the lag pump starts automatically.

Alternate lead/lag pump designation to equalize run time of pumps.

Direct Fired Domestic Hot Water Control

Two separate direct fired DHW tank heaters are piped in parallel. When the water temperature within direct fired DHW tanks drops below a 140F temperature setpoint (from internal factory installed temperature sensor/contacts), the unit fires. When the unit DHW temperature drops below setpoint (with a differential cut-in/cut-out to prevent short cycling), the firing stops.

DHW Recirculation Pump Control

When the temperature sensor in the DHWR return line in the most remote apartment of the system drops below 105F, the DHWR recirc pump runs until the temperature sensor rises to 115F. The pump runs a minimum ON time of at least 30 seconds (or longer if recommended by the manufacturer) to avoid short cycling.

Central Heat Recovery Ventilation (HRV) Control

When the HRV is off, the supply and exhaust fans are off, the two-position outside air and exhaust dampers close fully, the air to air plate heat exchanger by-pass damper is closed and the heating hot water reheat coil dedicated circulator is off.

The HRV runs continuously.

Upon command to run, the outside air and exhaust dampers open. When damper end switches indicate dampers are open, the supply fan end exhaust fans start.

The HRV supply air temperature (SAT) setpoint will be a constant 65F. When the SAT rises above the setpoint, the by-pass damper shall modulate towards open by by-passing air around the outside air side of the plate heat exchanger as required to maintain SAT setpoint.

Defrost Mode: When the temperature of the exhaust air leaving the heat exchanger drops to 35F, the by-pass damper shall modulate towards open by by-passing air around the outside air side of the plate heat exchanger as required to maintain exhaust air defrost temperature setpoint.

HRV control sequences described above are packaged factory installed controls.

HRV HW Reheat Coil Control: The HRV reheat coil dedicated variable speed circulator modulates speed as required to maintain supply air temperature discharge temperature setpoint of 65F. If central heating plant is disabled with outside air temperature lock-out, the HRV reheat coil controls are off.

Freeze Protection: If the temperature of the air leaving any portion of the reheat coils drops below 35F (as sensed by serpentine freezestat), the HRV goes to off mode, the reheat coil circulator goes to full speed. Reactivation of the freezestat occurs by manual reset.

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Appendix G: Basis of Design BoD (Example)

General - Mechanical

The building will be new construction of a 32,000 square foot, two story double loaded corridor multifamily housing located in South Burlington, VT. The building will contain 48 apartments, consisting of 24 one bedroom, 16 two bedroom and 8 three bedroom apartments. Occupancy type will be low income family.

Codes, Standards and Guidelines

Vermont Residential Building Energy Standards 2005

International Plumbing Code 2009, with VT Amendments

Vermont Public Building Code Requirements, 2009

ASHRAE Standard 62.2-2010, "Ventilation for Acceptable Air Quality"

ASHRAE Standard 90.2-2007, "Energy Efficient Design of Low-Rise Residential Buildings"

ASHRAE Handbook 2007 HVAC Applications, Chapter 49, "Service Water Heating"

MSOB Mechanical Optimization Guide

Load Calculations

Design conditions assumed for load calculations:

Winter: -11F w/ 15 Mph wind

Infiltration: 0.10 air changes per hour. (At winter design conditions)

Interior: 70F Relative humidity: N/A

Internal load assumptions: Heat gains from interior loads are excluded from design heating load sizing calculations.

Heating load safety factor: 5%

Boilers and Heating Water System

Each apartment will be an individual heating zone having one thermostat. Apartments having two stories will have two zones; upper and lower floors.

The design heating load for the building is calculated to be 208,000 Btuh. The heating load calculations are based on all zones calling for heat concurrently.

Central heating plant will consist of three natural gas boilers. Each boiler will be sized for 33% of design heating load.

Boilers will have the following features:

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Modulating burner capacity, capable of operating at 30% of rated maximum output capacity

Condensing type

95% AFUE efficiency

Minimum boiler entering water temperature of 50F (per manufacturer criteria)

Boiler minimum water flow rate of 25% of full design flow rate

Rated for ASME 50 PSI operation

Utilize 130F maximum heating hot water supply temperature

Specified boilers: Buderus Model Logamax Plus GB142 and Weil-McLain Ultra

Central heating plant will operate upon demand from any zone calling. Central heating will be locked out in summer whenever the outside air temperature exceeds 65F.

Boilers will operate in parallel so as to optimize combustion efficiency. Boilers will be staged sequentially such that when the boiler(s) capacity reaches 90%, the next boiler will fire, until all boilers are on; and all operating boilers will operate in unison at the same capacity.

The terminal heating equipment will utilize perimeter finned tube radiation. Terminal equipment will be selected to operate during design conditions with a heating hot water supply (HWS) temperature no hotter than 130F to optimize combustion efficiency by enhancing the condensing effect to reduce fuel consumption.

The HWS temperature setpoint will be reset from 130F to 100F reset proportionally based on outside air temperatures of 0F to 55F, again to optimize combustion efficiency.

Piping & Pumping

Two heating hot water pumps will be used; one operating at a time, with run time equalized over time automatically.

Heating HW will be variable flow. Pump capacity will be controlled by a piping differential pressure (dP) sensor located near the end of supply and return mains for pump variable speed/capacity control.

Terminal heating equipment within living units will be fitted with light commercial grade, two-port, and two position (non-modulating) control valves for durability. Control valves will be line sized (to minimize water friction) and will be normally closed, spring return closed.

The HRV hot water reheat coil will utilize a small ECM variable speed injection pump, so as to enhance part load operating efficiency by avoiding parasitic piping resistance from modulating control valves.

Minimum pump and system flow during low load conditions will be maintained by maintaining constant flow cabinet heaters at building entrances or at unit heaters (installed without control valves) and/or three port control valves installed at ends of long piping runs. Maintaining a limited volume of constant water flow at a few terminals will reduce first construction costs and eliminate the expense and complexity of differential by-pass valve assemblies.

Distribution piping configuration will be direct return.

Piping sizing will be based on a friction rate not to exceed 3 feet of head per 100 equivalent feet of piping.

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A pump sizing safety factor of 5% will be applied to pump head calculations, to account for uncertainties in piping construction.

A diversity factor of 90% (actual peak expected load vs. connected load) is applied to sizing the pump capacity.

Balance valves for variable water flow terminal equipment will be automatic, self contained pressure independent so as to ensure design flow to any terminal heating equipment, regardless of the system load. Manual balance valves will not be applied anywhere in the variable flow system. Pump discharge triple duty valves will be avoided because they add avoidable cost and impose permanent system resistance. Avoidance of manual balance valves will minimize the restriction (head loss) of balancing valves and circuit setters which impose a permanent resistance to water flow.

A Btu meter will monitor heating plant water flow and temperature difference (HWS and HWR) and totalize heating plant generated Btu's.

Controls

The boiler plant will have low water cut-off controls.

Boiler plant control will be fully automatic with manual override capability. A Tekmar® boiler plant controller will control the central heating plant.

The plant controls will have the following capabilities:

- Start/stop and control boiler burner firing capacity
- Assigns the lead boiler
- Assigns the lag boilers

The controls will have the capability to change:

- HWS temperature (HWST) setpoints
- HWS temperature reset parameters
- Water pumping pressure setpoints (via pump VFD's)

The control will monitor, via remote internet access, the following:

Boiler plant controller and all associated parameters (temperatures, boiler status, etc.)

Pump VFD and all associated parameters

Injection pumps

Heating plant Btu meter flow (gpm), HWS/HWR temperatures, and Btu totalization.

Domestic Hot Water

Domestic hot water sizing calculations are based on ASHRAE 2007 HVAC Applications Handbook, Chapter 49, "Service Water Heating".

Domestic water sizing is based on:

- 24 one bedroom apartments having 48 occupants
- 16 two bedroom apartment having 64 occupants

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- 8 three bedroom apartments having 48 occupants
- Total number of occupants for DHW load purposes: 160 occupants

Occupant usage classification: High use

Demographic classifications: High percentage of children, low income, on public assistance, families

Each apartment will have a kitchen dishwasher, one shower/bath combination per apartment. No clothes washing machines.

DHW peak demand calculations are based on the number of people.

Peak one hour DHW demand:

- 8.5 gallons per person
- 1,428 gallons total

Peak 15 minute DHW demand:

- 3.0 gallons per person
- 504 gallons total

Design one hour DHW demand: 1,428 gallons per hour

DHW entering water temperature: 45F

DHW tank storage temperature: 140F

DHW water delivery temperature: 120F (Using mixing valve)

DHW BTUH generation capacity: 1,130,000 BTUH

DHW Tank storage volume: two, heater/tank units, each having 80 gallons (Stored at 140F)

DHW recirculation flow rate: 8 gpm

Domestic hot water will be generated by direct fired domestic water heater/tank assemblies. The plant will utilize natural gas fired condensing water heaters. Water heater efficiency will vary based on entering water temperature. Efficiency will be rated for 96%.

A Btu meter will monitor solar DHW system performance in a manner similar to that described for the central heating plant. The DHW Btu meter will be connected to the building internet router to enable remote monitoring.

Solar DHW

Rooftop flat plate solar panels consisting of ### square feet of flat plate panel area will be used to preheat domestic hot water.

The solar preheat system will utilize a counter flow heat exchanger to transfer energy from the solar heating loop to the DHW preheat tanks.

DHW solar preheat tanks will be sized based on 2.0 gallons of storage per square foot of solar panel. Maximum pre heat tank storage temperatures will be 160F.

Solar system panels storage tank sizing is based on providing 50% of DHW load during the months of November, December, January, February; 100% of DHW load during all other months.

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A Btu meter will monitor solar DHW system performance in a manner similar to that described for the central heating plant.

The solar system controller and Btu meter will be connected to the building internet router to enable remote monitoring.

Ventilation

Ventilation calculations are based on The VT Residential Energy Guideline 2005.

Supply air ventilation to individual apartments will be provided on the basis of .05 cfm per square foot. Central corridors will be provided with ventilation at a rate of .05 cfm per square foot. Corridor will not have exhaust registers, so as to maintain a positive pressure relative to apartments, to help mitigate odor transfer from one apartment to another.

Ventilation will operate continuously. Exhaust volumes will match supply air volumes within apartments.

Total ventilation will be 1,650 cfm. Ventilation will be continuous.

Supply air to each apartment will be ducted and terminate in bedrooms. Exhaust air will be captured in bathrooms.

A manual volume damper in supply and exhaust duct runouts to each apartment will be provided to facilitate air balancing.

Heat Recovery Ventilation (HRV) Unit

Ventilation will be provided by a central HRV unit. The HRV unit will be an air to air plate type exchanger to avoid any odor cross contamination from exhaust side to fresh air side. Operation will be continuous and constant volume.

The HRV sizing will be as follows:

Outside Air Volume (100% OA): 1,650 cfm

Exhaust Air Volume: 1,650 cfm

The supply air temperature setpoint will be 65F (constant).

A heating hot water reheat coil will be provided to maintain supply air temperature setpoint when the HRV is not capable of discharging the supply air temperature setpoint and during defrost mode, when HRV recovery capacity is diminished. A low energy variable speed injection pump will be utilized for coil capacity control.

Factory packaged controls will be utilized.

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Appendix H: Design Review Example

Project	Example Project	**Reviewed by:**		**Review Date**	
Phase	**DD & CD Examples**	**Response by:**		**Response Date**	

Item	Ref	Reviewer Comments	Consultant Response	Status/Party
		Mechanical Review Comments		
1	DD 70% 23 22 23 2.1.B	Condensate receiver tanks: suggest deletion of galvanized steel for condensate tank construction. Galvanized lacks the long term durability of cast iron.	Galvanized steel will be deleted	Closed
2	MH-101	The general exhaust ductwork and return air ductwork are shown without volume dampers in major sub main duct runs. A volume damper in submains facilitates testing and balancing and significantly reduces the labor required for T&B. They also eliminate potential noise in the room from return/exhaust registers equipped with opposed blade volume dampers. Indicate volume dampers on return and exhaust sub main duct runs.	Added at main branches	Closed
3	MH-502	Detail 10, Preheat coil piping connections: The glycol supply and glycol return connections to the heating coil are shown reversed. The hot water supply should always connect to the leaving air aide of a coil. Revise detail so that the supply pipe connects to the air leaving side of the coil.	ok	Closed
4	MH-802	Detail 5, exhaust fan controls. Control sequences call for the exhaust fans to run continuously. The exhaust fan relieves heat gain in non occupied mechanical spaces and should be controlled by a thermostat. Indicate a thermostat on the plans for exhaust fans to be controlled by a thermostat. Where these exhaust fans are in rooms also served by a unit heater, suggest the use of a single thermostat instead of a separate ventilation/heating thermostat. The benefit of using a single thermostat for exhaust fan control and heating is that set point overlap is avoided and concurrent heating and ventilation permanently avoided.	Will show t-stats. Mech room fans which also have a unit heater in the space will have a single heating and cooling t-stat.	Closed
5	MP-103	The corridor heating water piping is shown with cold spring expansion loop. However, the expansion loop is shown penetrating a wall. When the pipe moves due to expansion, either the cold spring will be restricted from moving due to the wall or the pipe movement will damage the wall above the ceiling. Review the installed location of the cold spring expansion loop in reference to adjacent walls.	Not a wall there, only a counter	Closed
6	M-1.2	Typical Bathroom Exhaust: The exhaust register is shown to be installed over the sinks. Would the exhaust be more effective in removing shower vapor and odors if located in	We agree, will change.	Closed

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Item	Ref	Reviewer Comments	Consultant Response	Status/Party
		the adjacent shower/compartment?		
7	M-5.1	The drawing plans imply piping to finned tube radiation units will be downfeed. Should a manual drain valve be shown for downfeed FTR units?	We have a revised down feed FTR detail that will show a drain valve.	Closed
8	M-5.2	Boiler Plant Piping Diagram: Piping thermometers should be shown for boiler leaving water temperature, domestic water heater boiler water inlet and outlet to facilitate maintenance.	Thermometers will be added.	Closed
9	M-1.3	The laundry rooms call for 4 inch aluminum dryer vent duct. Suggest noting that sheet metal screws should not be used on dryer exhaust duct, due to build up of lint.	Will note in specifications.	Closed
10				
		Electrical Review Comments		
11	SD Elec Narrative	Vapor tight fixtures are intended for mechanical and electrical rooms. Is there a specific hazard in these spaces that requires this more expensive lighting approach? Most interior applications use open strip fixtures with reflectors in these types of spaces. The later approach will yield some first cost savings.	There is about a $10 difference between a heavy duty industrial strip versus the vapor tight. The benefit of less maintenance, better lamp performance (no dust build up) and ease of cleaning out weigh the cost difference.	Closed
12	SD Elec Narrative	In general it is helpful if the narrative includes the lighting design objectives and how the system will achieve those objectives. The design narrative should quantify target foot-candle, LPD and ambiance goals.	Will address.	Closed
13	SD Elec Narrative	Include reference electrical codes and standards	Will address	Closed
14	DD 70% EL-101	What are corridor FC levels? The Owner's Guide recommendations are 10FC day and 5 FC night. This implies two levels of lighting.	FC levels are designed for 10FC during the day and 5FC at night. There are two lighting circuits for this.	Closed
15	EL-101 Lighting Schedule	Fixture type I is specified with a 50W MH lamp – it is an under counter fixture – should be fluorescent.	Agree changing schedule	Closed
16	EL-101 elevator machine room	Since the basis of design is to use vapor tight fixtures in equipment rooms, should type M fixtures be specified in the elevator machine room?	Ok	Closed
17	16510 Ltg	LED fixture requirements are not specified. Recommend requiring listing by Efficiency Vermont as a minimum.	Efficiency Vermont requirements for LED lighting fixture was added to specifications.	Closed
18	16510 Ltg	3.4 Cleaning. Recommend adding the following phrase – electricians are responsible for final cleaning of fixtures after the completion of all project finish work. Fixtures shall be clean and in as new condition at the time of project turn-over.	Provisions for cleaning of lighting fixtures were added to specifications.	Closed
19	E1.1	Exit signs – add one at entrance door 100 and at laundry end of corridor 132 (otherwise	Exit signs at locations indicated were	Closed

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Item	Ref	Reviewer Comments	Consultant Response	Status/Party
		132 is showing only one egress path).	added to drawings.	
20	E1.2	Pumps P1 &2 – no disconnect shown. Verify that Div 15 is providing the code required disconnecting means.	Div. 15 is providing the required disconnecting means for pumps P1 & P2	Closed

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Appendix I: Training Requirements

Spec Section	Equipment / System	Total Hours	Type of Training	Timing [1]	Verified in Spec	Trainer	Trainer Organization	Verified Training Provided
			Miscellaneous Equipment					
142424	Hydraulic Elevators	4	System shut down, elevator recall, emergency proceedures, demonstrate elevator operation upon loss of power and any required reset upon restoration of power	TO				
213250	Fire Suppression	2	Overview of system, maintenance requirements and testing, location of tamper and flow switches and system valves	TO				
			Plumbing					
224100	Plumbing Piping	1	Review routing, access, placement of cleanouts, venting, roof drain locations - Building walk through with plans, review insulation levels	TO, 10 month post oc				
224400	Plumbing Fixtures	1	Review parts inventory, review equipment list	TO, 10				
	Well water system	1	location of well, pumps, valves, shut down proceedure	TO, 10				
	Septic system	1	tank location(s), maintenance requirements, mowing requirements	TO, 10 month post oc				
	Domestic Hot Water Heater	1	Equipment startup, trouble shooting and shut down proceedures, review preventive maintenance requirements as documented on the PM matrix, review spare parts	TO, 10 month post oc				
	Domestic Hot Water Pumps	1	Equipment startup, trouble shooting and shut down proceedures, controls, expected operation, potential problems with operation, review preventive maintenance requirements as documented on the PM matrix, review spare parts	TO, 10 month post oc				
			HVAC					
231700	Variable Frequency Drives	2-4	Location of equipment, equipment settings, normal operation, troubleshooting, start-up and shut down, expected operating ranges, diagnostics and programming	TO, 10 month post oc				
232600, 232800, 232900	Insulation	1	Review insulation levels on piping, equipment and ductwork. Identify source for replacement insulation if insulation is damaged during maintenance	TO, 10 month post oc				
235100, 235150, 235450	Hydronic piping, specialities & treatment	1	Walk through of piping system with plans and schematics, review strainer location, make-up water location, valves and water quality testing and maintenance requirements	TO, 10 month post oc				
235400	HVAC Pumps	1	Same as DHW pumps	TO, 10				
235580	Boilers	2	Start-up, shut down, trouble shooting, preventive maintenance, as documented in PM matrix, review spare parts	TO, 10 month post oc				
	Energy Recovery ventilator	2	Start-up, shut down, trouble shooting, preventive maintenance, as documented in PM matrix, review spare parts	TO, 10 month post oc				
	Controls	6	Programming, system concepts, overview of efficient system operations, expectations for system energy performance, diagnostics, troubleshooting, start-up, shut down, standard operation.	TO, 10 month post oc				
			Electrical					
	Electrical distribution system	3	Review service entry, service disconnects, meters, distribution panels, circuit breaker size and types, short circuit ratings and other protective devices, building ground system, preventive maintenance, reference schematic one line diagrams.	TO				
	Lighting and controls	2	review all fixture and lamp types installed, review replacement lamp inventory, training on control devices - what they are, how they work, what they control, verify correct operation, troubleshooting, replacement parts, preventive maintenance	TO, 10 month post oc				
	Fire Alarm & Carbon monoxide detection	2	Review system test documents, review system operation, alarm response, maintenance, testing and documentation	TO				

The following personnel shall attend all training unless otherwise noted. Training shall be scheduled at the convenience of the specified personnel.

Property Manager
Building Maintenance Personnel

Notes [1] Provide training either at TO - Turn over or at TO and at 10 months post occupancy as indicated

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Appendix J: Preventative Maintenance Sample Matrix						
	Equip: Central Air Handler w/ERW (Semco)	Frequency				Misc
		Day	Week	Month	Year	
No.	Tasks					
1.0	Visual exterior check out (sound, leaks, etc)		1			
2.0	Lubricate recovery wheel (ERW) rotor bearing.			6		
3.0	Check bearing set screws.			6		Also perform 1 month after startup.
4.0	Check sheave set screws.			6		Also perform 1 month after startup.
5.0	Check motor and gear reducer bolt tightness.			6		Also perform 1 month after startup.
6.0	Check for belt wear.			6		
7.0	Change filters			3		Also perform 1 month after startup.
8.0	Adjust ERW seals.			3		Also perform 1 month after startup.
9.0	Check for ERW rotor damage and flatness.			3		
10.0	Check ERW media tightness.			3		Also perform 1 month after startup.
11.0	Check/recalibrate temperature controller					
12.0	Check/clean VFD				1	
13.0	Clean motors, blow away dirt from vent fins, surfaces.			6		
14.0	Inspect connections. Look for frayed wiring loose connections.			6		
15.0	Check operating current fans and wheel.			6		
16.0	Check for vibration and for mounting bolt tightness.			6		
17.0	Lubricate motor bearings with lithium based grease.				1	
18.0	Inspect V-belts and drives. Repair as required.			1		
19.0	Inspect sheaves for burrs/dirt buildup, wear, alignment, set screw tightness.			1		
20.0	Check shafts and fan wheels for buildup, corrosion cracks. Clean/reapply coatings as required.			3		
21.0	Lubricate fan motors as recommended by motor manufacturer.				1	

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Appendix K: Fuel Price Comparison for Energy Affordability

Fuel	Units	BTU/unit	cost/unit 2011	cost/unit 2025	cost per MMBtu input 2011	cost per MMBtu input 2025	Affordable MMBtu/unit/ month	System Efficiency	Affordable average load MMBTU/ Unit/month	Load
wood pellets (hard, high quality)	ton	16,400,000	$230.00	$ 470.80	$14.02	$ 28.71	2.57	85%	2.18	heating only
Natrual Gas	therm	100,000	$1.58	$ 3.23	$15.80	$ 32.34	2.28	95%	2.16	heating only
Fuel Oil #2	gallons	138,200	$3.00	$ 6.14	$21.71	$ 44.43	1.66	91%	1.51	heating only
Propane	gallons	91,600	$3.00	$ 6.14	$32.75	$ 67.04	1.10	95%	1.04	heating only
Electricity	kWh	3,412	$0.14	$ 0.29	$41.03	$ 83.99	0.88	330%	2.90	cooling and heating

		PUM
Initial Year	2011	$ 36.00
Final Year	2025	$ 73.69
Escalation Rate Per Year:	5.25%	
# Years to escalate:	14	

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DLC

example sizing

40	units		
20	elderly	1.2	occupant per unit
20	family	2.8	occupant per unit
80			

OIL DHW Selection

Triangle Tube Smart	qty	continuous gph	continuous gpm	storage	effective storage	Buderus MBTUh input	Tank useful percent
120	1	145	2.42	119	101.15	121	85%
120	2	290	4.84	238	202.3	242	
120	3	252	4.2	357	303.45	210.00	
120	2	216	3.6	238	202.3	210	

occupants	time	use rate	gallons in period	period per hour	gallons per hour	avg gal/min	storage capacity at 85% useable)	capacity avail - storage + recovery: single by 121 MBh delivery	two by 242 MBh	three tanks served by two 105 mbh boilers	two tanks served by two 105 MBh boilers
80	5 min	0.7	56	12	672	11.2	66	101.15	226.5	324.45	220.3
	15 min	1.7	136	4	544	9.066667	160	137.45	274.9	366.45	256.3
	30 min	2.9	232	2	464	7.733333	273	173.75	347.5	429.45	310.3
	60 min	4.8	384	1	384	6.4	452	246.35	492.7	555.45	418.3
	2 hr	8	640	0.5	320	5.333333	753	391.55	783.1	807.45	634.3
	3 hr	11	880	0.333333	293.3333	4.888889	1035	536.75	1073.5	1059.45	850.3

water heating:		242	MBh
space heating:		208	MBh
space to dhw ratio		1.16	
Factor from ASHRAE Ap Chapt 49 fig 27		0.78	
Total boiler capacity		396.76	MBh
	4	105	MBh boilers
		available for DHW	
		210.00	boilers input to water heating tanks during peak heating

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Townhouse

example sizing

12 units

family 3.2 occupant per unit

38.4 occupants

OIL DHW Selection

Triangle Tube Smart	qty	continuous gph	continuous gpm	storage	effective storage	Buderus MBTUh input	Tank useful percent
120	1	126	2.1	120	102	105	85%

occupants	time	gallons per person	gallons in period	period per hour	gallons per hour	avg gal/min	storage capacity at 85% useable)	capacity avail: storage + recovery single 120 gallon w/ 105 MBh
38.4	5 min	0.7	26.88	12	322.56	5.376	31.6	102.0
	15 min	1.7	65.28	4	261.12	4.352	76.8	133.5
	30 min	2.9	111.36	2	222.72	3.712	131.0	165.0
	60 min	4.8	184.32	1	184.32	3.072	216.8	228.0
	2 hr	8	307.2	0.5	153.6	2.56	361.4	354.0
	3 hr	11	422.4	0.333	140.6592	2.34432	496.9	480.4

water heating:	105	space heating:	111
space to dhw ratio	0.946		
Factor from ASHRAE Ap Chapt 49 fig 27	0.75		
Total boiler capacity	189.75	MBh	
2x	94.875	MBh boilers	calc'd
2x	109	MBh	actual
	218	MBh Total	
	107	MBh available for DHW	

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Duplex
Family
4 occupants per unit

ASHRAE Applications Chapt 49 Table 5*

Oil	ASHRAE	Proposed
Storage (gal)	30	80
MBH input	70	50
1 hour draw/gallons	89	128
Recovery gph	59	60

* ASHRAE allows any combination that will meet the 89 gph max draw

OIL DHW Selection

Triangle Tube Smart	qty	continuous gph	continuous gpm	storage	effective storage	Buderus MBTUh input
80	1	60	1	80	68	50

Heating load	35.6	MBh
Buderus boiler input	85.6	MBh
Available for DHW	50	MBh

hourly capacity at peak load	hourly	cumulative
hour 1	128	128
hour 2	60	188
hour 3	60	248

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