The Lafayette

Buildings of Excellence Early Design Support

Rendering by C2 Design Group

Selecting Efficient All-Electric Mechanical Systems

The Lafayette
Schenectady, NY

Owner: Rosenblum Group

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1. Executive Summary

Overview of Investigation

This report was created as part of NYSERDA's Early Design Support program which aims to assist design firms in integrating carbon-neutral features into the initial stages of multifamily building projects. The program seeks to create buildings that are not only clean and resilient but also aesthetically pleasing and functional, providing occupants with healthy, safe, comfortable, and resilient living spaces. By offering direct funding to design firms, the initiative encourages the design of projects that achieve carbon-neutral performance, demonstrate cost-effectiveness, and serve as scalable models for future sustainable building designs.

This report was prepared by Sustainable Comfort, Inc, the primary energy consultant, with assistance from ownership and design team members. It is geared toward a professional audience of developers, architects, as well as general contractors and mechanical and plumbing engineers. The goal is to communicate findings of early design studies from the Lafayette project, in a format that can be accessed by other teams to support their sustainable development of multifamily projects through scalability and replicability.

The team studied various mechanical system options to provide a replicable low carbon building, including comparing a ground source heat pump system with multiple packaged air source heat pump systems. The building envelope was reviewed to provide above code performance and Energy Star Multifamily New Construction Compliance. To reduce peak demand, the team evaluated different smart thermostat options with demand response capabilities. The non-energy co-benefits and passive survivability of high-performance design was also researched.

Outcomes and Recommendations

NYSERDA's Early Design Support funding provided a valuable opportunity to research and further understand the design decisions related to achieving a high-performing, sustainable, healthy space that helps build a strong community. The project has achieved the goal of creating an all-electric building design that reduces embodied carbon and provides a comfortable and resilient space for residents at an affordable price.

Through the detailed mechanical system study, the team found that a simplified packaged mechanical system approach with integrated Energy Recovery Ventilation (ERV) provides efficient overall performance and a lower initial cost compared to ground source heat pump systems, offering a replicable approach to building electrification while maintaining individual tenant comfort and control. Paired with smart demand response thermostats and an efficient envelope, the simplified mechanical approach can be a replicable system throughout the region for decarbonizing multifamily housing.

The following pages show a summary of the overall study findings and recommendations in a simplified case study format. The Appendix provides a mechanical system selection guide to assist others in selecting the right all-electric system for future housing projects.

The Lafayette
Schenectady, NY

Image: C2

Owner: Rosenblum Group | Location: Schenectady, NY

The Lafayette, a 64-unit market-rate multifamily housing project, contains a mix of studio, one-bedroom, and two-bedroom apartments. The five-story project features a ground level parking garage with residential units above, to efficiently maximize development of the half acre lot. Throughout the duration of the integrated design process, the team set an energy road map that valued efficient all-electric systems, efficient envelope and mechanicals achieving an Energy Rating Index (ERI) 25% better than Energy Star Multifamily New Construction to reduce operating costs, individual systems to allow for tenant paid utilities with simple tenant controls, and cost effective first cost and overall operating costs to allow for a market rate apartment building in a downtown location. This abbreviated case study highlights outcomes of the mechanical selection and architectural detailing to achieve an efficient carbon neutral ready building.

NYSERDA Support

Through the use of NYSERDA Buildings of Excellence Early Design Support, the project has compared several mechanical systems including geothermal and air source heat pumps options, and utilized an integrated design process to design an energy efficient building. The project has received the Buildings of Excellence Demonstration Award, as well as other programs detailed below:

- Buildings of Excellence Demonstration: $1,000,000
- Early Design Support: $250,000
- New Construction-Housing: $160,000
- NY-Sun: TBD

NEW YORK STATE | Buildings of Excellence Award Winner

Learn more about this study by checking out the full NYSERDA Early Stage Design Report here:
https://www.nyserda.ny.gov/All-Programs/Multifamily-Buildings-of-Excellence/Early-Design-Support-Program

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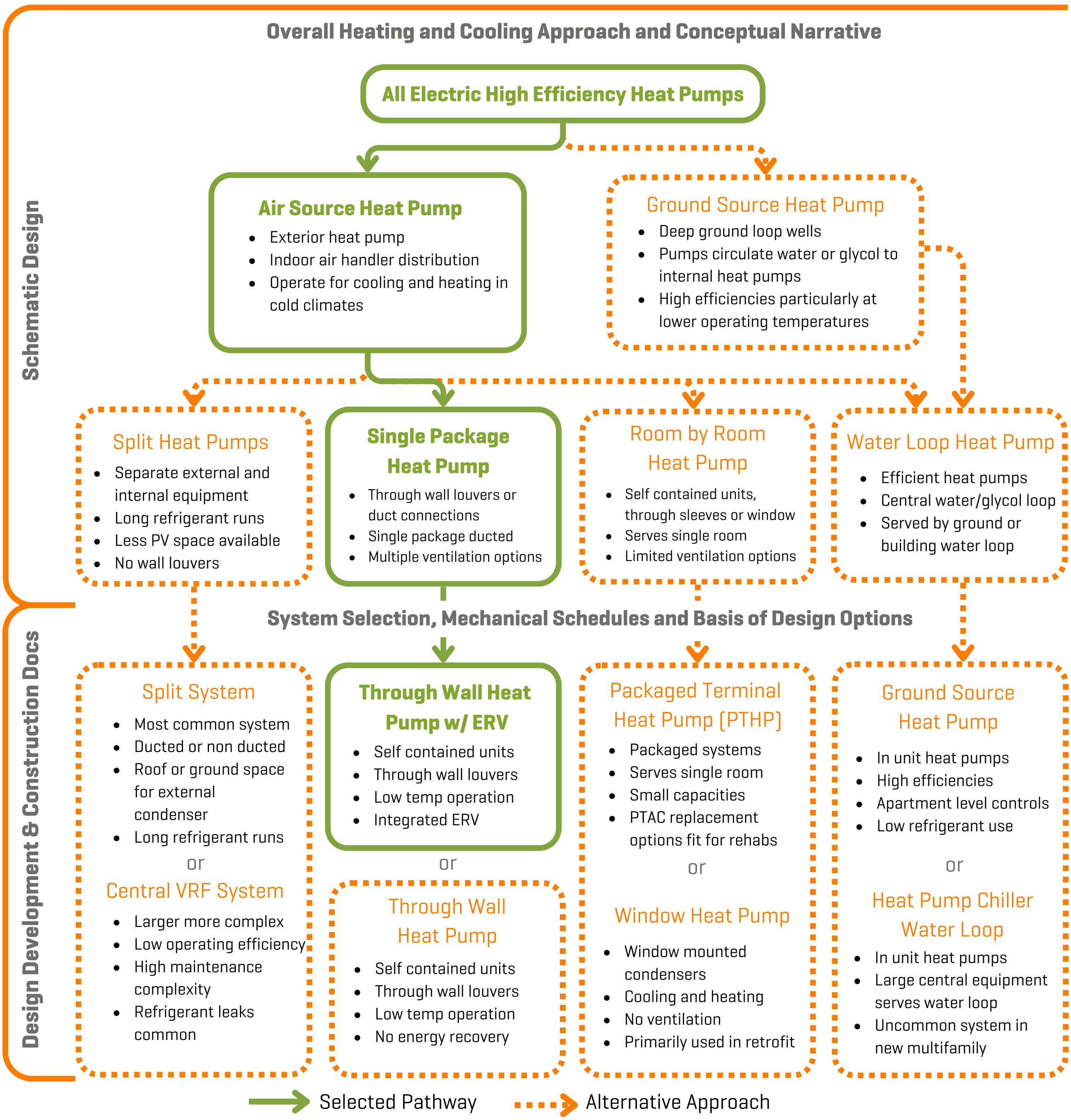
Mechanical System Selection Guide

Selection of the type of mechanical system is essential to guide early design to achieve a high-performance building. The NYSERDA Early-Stage Design Study included the creation of a guide to assist in the selection of mechanical systems in the early Schematic Design stage. The study compared each systems potential features and benefits, including detailed cost comparisons of candidate systems, to select an appropriate mechanical system for the project. Below is a summary of the major features and selection criteria for the selected system and alternatives. Full mechanical selection guide to assist future projects can be found here: www.greenrater.com/mechanicalselectionguide



GSHP vs. ASHP Cost Comparison

The team compared the cost of a ground source heat pump (GSHP), a packaged through wall heat pump (Friedrich VRP System), and a packaged through wall heat pump with integrated ERV (FreshCo Fresh Pak). Using pricing from early 2024, the three were compared for their overall operating efficiency, initial cost including incentives and tax credits, and consistency in building operation and determined the packaged system with integrated ERV provided the ideal balance of efficiency and lower initial cost.

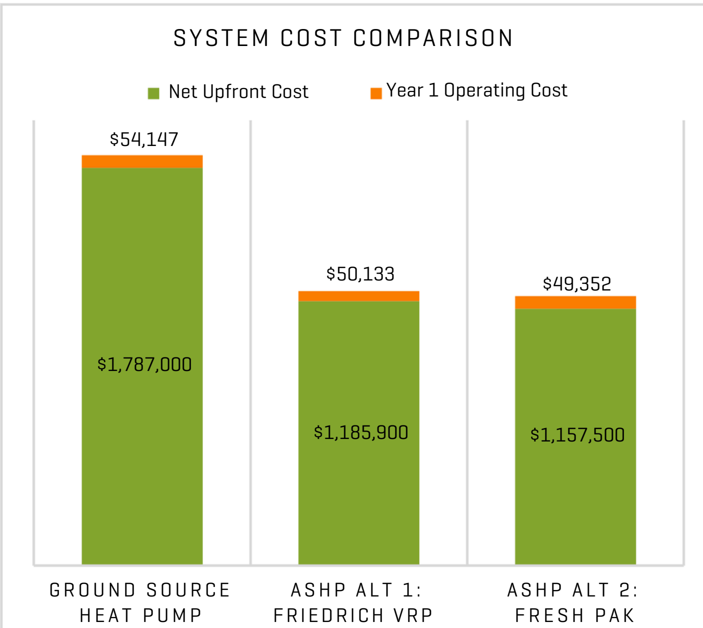


Fig: Initial Cost Comparison - 2024 Costs

Packaged Heat Pump w/ ERV

Due to the lower overall lifetime cost including initial cost and operating cost, the team selected the through wall packaged heat pump with integrated ERV's. There are multiple systems of this type including the FirstCo Fresh Pak EPE and Ice Air 8SPXC-ERV systems. The pros of these systems include a single package with ERV included for efficient overall performance, low refrigerant use and low leakage potential. The cons include being newer systems to the market, can have lower rated efficiencies than split systems, and include wall penetrations that should be detailed with care to prevent air leakage.

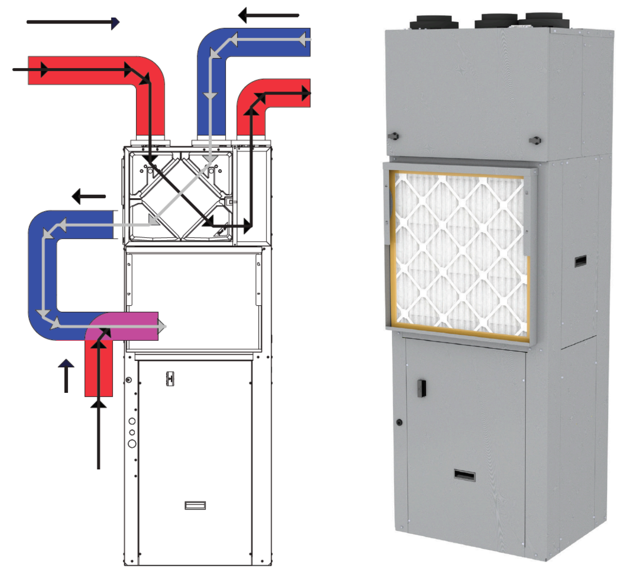


Fig: Integrated System Layout: Image Courtesy of Fresh Pak

Energy Modeling Comparison Results

Once the system was selected, during Design Development the FirstCo Fresh Pak and Ice Air systems were compared for overall building efficiency, first cost, and cost of operation. The Ice Air system has a rough cost of $6,790 per system, with the FreshPak at $9,142 per system. The Ice Air provides better efficiencies at lower temperatures and lower initial costs and is the current preferred system. Final system selection will occur at start of construction.

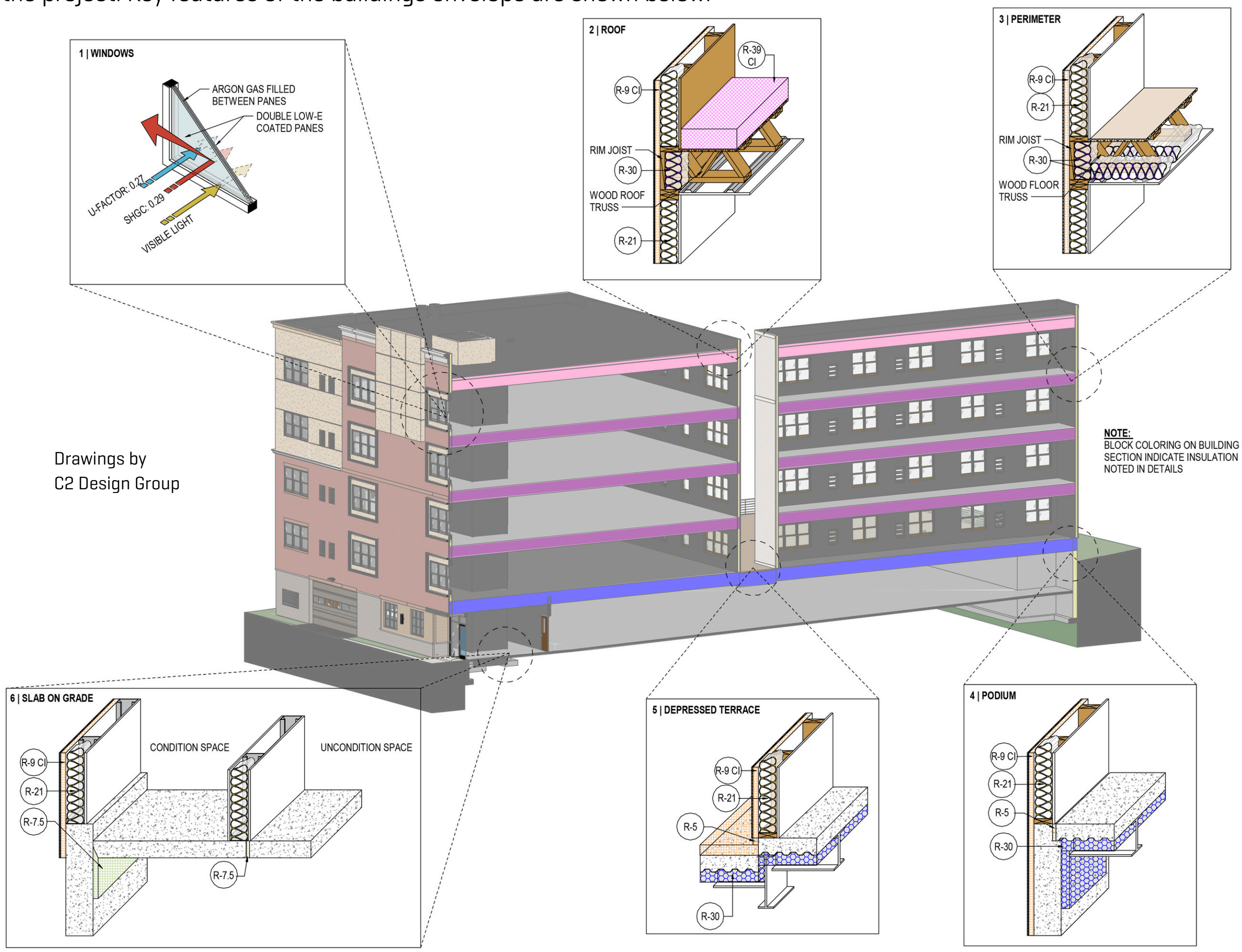
Ice Air 8SPXC-ERV Systems				
HERS RESULTS		ENERGY STAR HERS RESULTS		
UNIT MODELED	HERS INDEX (POST-PV)	HERS INDEX (PRE-PV)	ENERGY STAR MFV1.1 TARGET INDEX	% BETTER THAN ENERGY STAR
Studio Small	18	43	66	35%
Studio Large	18	42	66	36%
1Bed Small	21	43	68	37%
1 Bed Large	21	41	65	37%
2Bed	10	40	57	30%
UTILITY BILL SUMMARY				
	ELECTRIC USAGE (KWH/ YR)	SOLAR SIZE (KW)	SOLAR KWH PRODUCED	YEARLY UTILITY BILLS
Apartments	358, 456	164	173, 740	$ 56, 983

First Co Fresh Pak EPE Systems				
HERS RESULTS		ENERGY STAR HERS RESULTS		
UNIT MODELED	HERS INDEX (POST-PV)	HERS INDEX (PRE-PV)	ENERGY STAR MFV1.1 TARGET INDEX	% BETTER THAN ENERGY STAR
Studio Small	17	42	65	35%
Studio Large	18	42	65	35%
1Bed Small	20	43	66	35%
1 Bed Large	23	43	64	33%
2Bed	12	42	56	25%
UTILITY BILL SUMMARY				
	ELECTRIC USAGE (KWH/ YR)	SOLAR SIZE (KW)	SOLAR KWH PRODUCED	YEARLY UTILITY BILLS
Apartments	360, 518	164	173, 740	$ 57, 354

Fig: Energy Modeling Comparison Fresh Pak vs. Ice Air Systems

Architectural Detailing

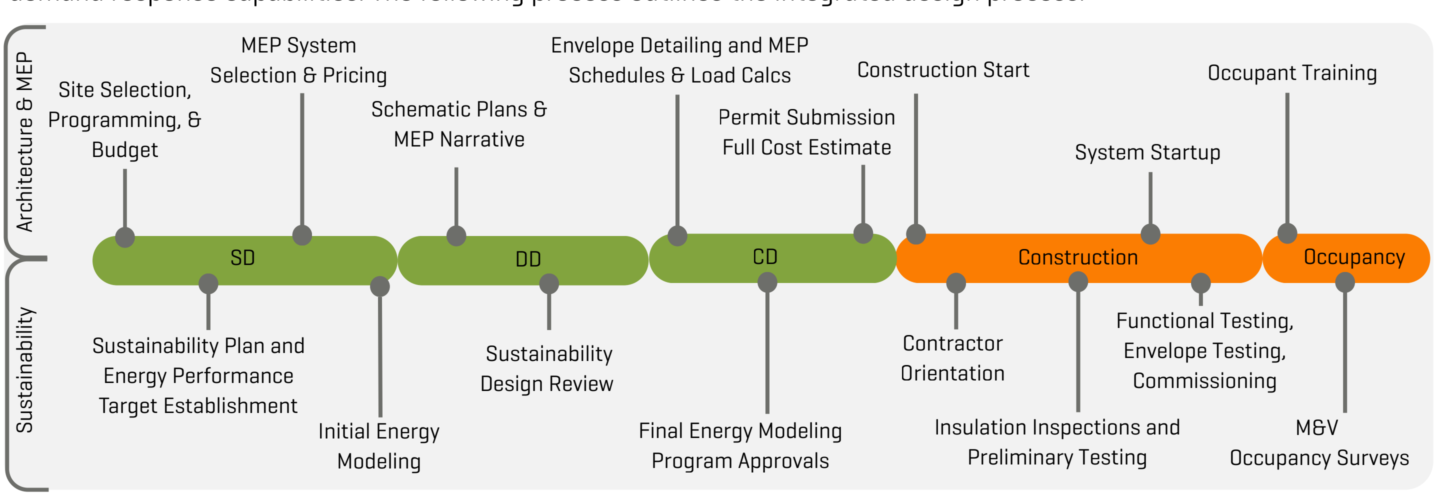
To achieve the goals of the energy road map established for the project, the design team provided details to achieve 35% better than the ERI of the Energy Star Multifamily New Construction Program which was identified as one of the primary efficiency goal of the project. Key features of the buildings envelope are shown below:



Drawings by
C2 Design Group

Integrated Design Process

The Lafayette project underwent an integrated design process to achieve a high-performance design. The benefits of this process include fully vetted and coordinated plans including energy modeling to assess performance, fully integrated energy efficient design, early cost comparisons, and innovative features such as solar PV inclusion and demand response capabilities. The following process outlines the integrated design process:



2. About the Project

Building Rendering by C2 Design Group

The Lafayette, a 64-unit market-rate multifamily housing project, contains a mix of studio, one-bedroom, and two-bedroom apartments. The five-story project features a ground level parking garage with residential units above, to efficiently maximize development of the half acre lot.

The proposed location, 31 Lafayette Street in Schenectady, NY, contains an existing office building. The downtown site on the corner of Lafayette and Liberty Streets, is within walking distance of restaurants, shops, entertainment venues and nightlife, local universities, and other transportation access points and features a very walkable Walk Score rating of 89/100.

Throughout the duration of the integrated design process, the team has focused on decisions that will provide an efficient, comfortable, and durable building with cost increases being reserved for items with the largest benefit and payback. The project's efficient mechanical systems and optimized thermal envelope will help reduce residents' utility bills. The building has been designed to reduce operating costs to the owner and add value to the tenants with the building's overall sustainable lifestyle and amenities.

Site Plan by C2 Design Group

In addition to being awarded funding for research through NYSERDA's Early Design Support Program, the project was selected as a winner in Round Three of New York State's Buildings of Excellence (BOE) Demonstration Competition for the design of a clean and resilient multifamily building. The goals of the NYSERDA BOE program for the Lafayette project are, to develop a cutting-edge design that elevates living space comfort and indoor air quality, to provide substantial savings on utility and maintenance expenses for building owner and/or residents, and use these savings to help finance the building long-term, and to serve as a model for the industry beyond New York to follow in encouraging energy efficiency.

3. Meet the Team

Owner / Developer

Primary Energy Consultant

Architect

Mechanical Engineer

Owner / Developer

The project is being developed by the Rosenblum Group of Albany. With over 35 years of expertise in real estate development, property management, and construction, the Rosenblum Group offers a single-source solution for a wide range of property-related needs. Leveraging its broad cross-sectional knowledge, the company provides services including facility management, property maintenance, tenant relations, construction services, lease management, and real estate development, all with a commitment to cost-effective, sustainable solutions. Each partnership begins with a thorough understanding of the client's background, daily operations, and long-term vision, fostering strong relationships and laying the groundwork for meeting goals and delivering superior results.

Energy Efficiency and NYSERDA Primary Energy Consultant

In collaboration with NYSERDA, Sustainable Comfort, Inc. (SCI) has provided early design support services, taken the lead facilitation role of the integrated design process, and facilitated this report in support of NYSERDA's BOE Early Design Support Program. SCI is an energy efficiency consulting, construction, development, and property management firm with expertise in multifamily housing. As qualified green consultants and raters, SCI focuses on a collaborative approach to energy-efficient design and construction by providing early-stage energy modeling and design reviews, utility incentive support, construction inspections and testing, and green program compliance and certifications.

Architecture

C2 Design Group provides full-service architecture, interior design, and planning for residential, commercial, government, education, and retail. From conceptual design through to final construction, our work follows a process-driven approach with a foundation built upon collaboration and communication with our clients. Our end goal is to always exceed our client's expectations, building more than just the spaces in which they inhabit, but also lasting relationships. C2 is also committed to the principles of sustainable design. Our staff of architects consists of LEED Accredited Professionals who recognize the importance of incorporating sustainable ideologies into our work. We believe that all design should be elevated with sustainable elements.

Mechanical Engineer

Alderson Engineering is a full-service MEP/FP consulting engineering firm serving clients across 20+ states for the past three decades. Led by partners Neal Babcock and Drew McFadden, our firm's strength is our combination of youth and technology integrated with experience and wisdom. We pride ourselves in providing "Client First" service no matter the project size. The team atmosphere is the foundation of our firm and is extended to the relationships we develop with each client. It is always our goal to deliver our design on schedule and on budget and to make the process an enjoyable one for the entire project team.

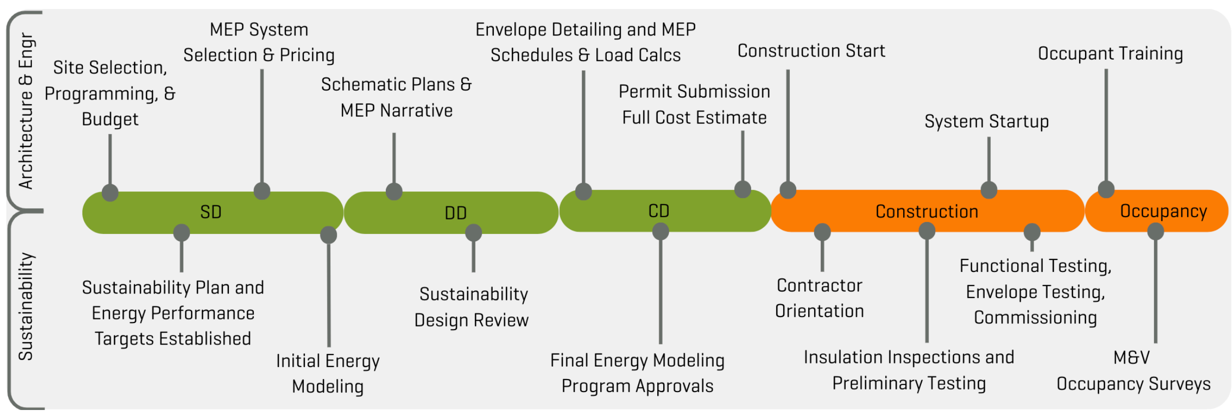
NYSERDA Early Design Support

Through the funding provided by NYSERDA's Early Design Support Program, the team was able to research various mechanical system options and assemble findings within this report to be utilized by other multifamily design teams. The team at NYSERDA provided helpful feedback and guidance for the report. SCI served as design partner in this process.

Integrated Design Process

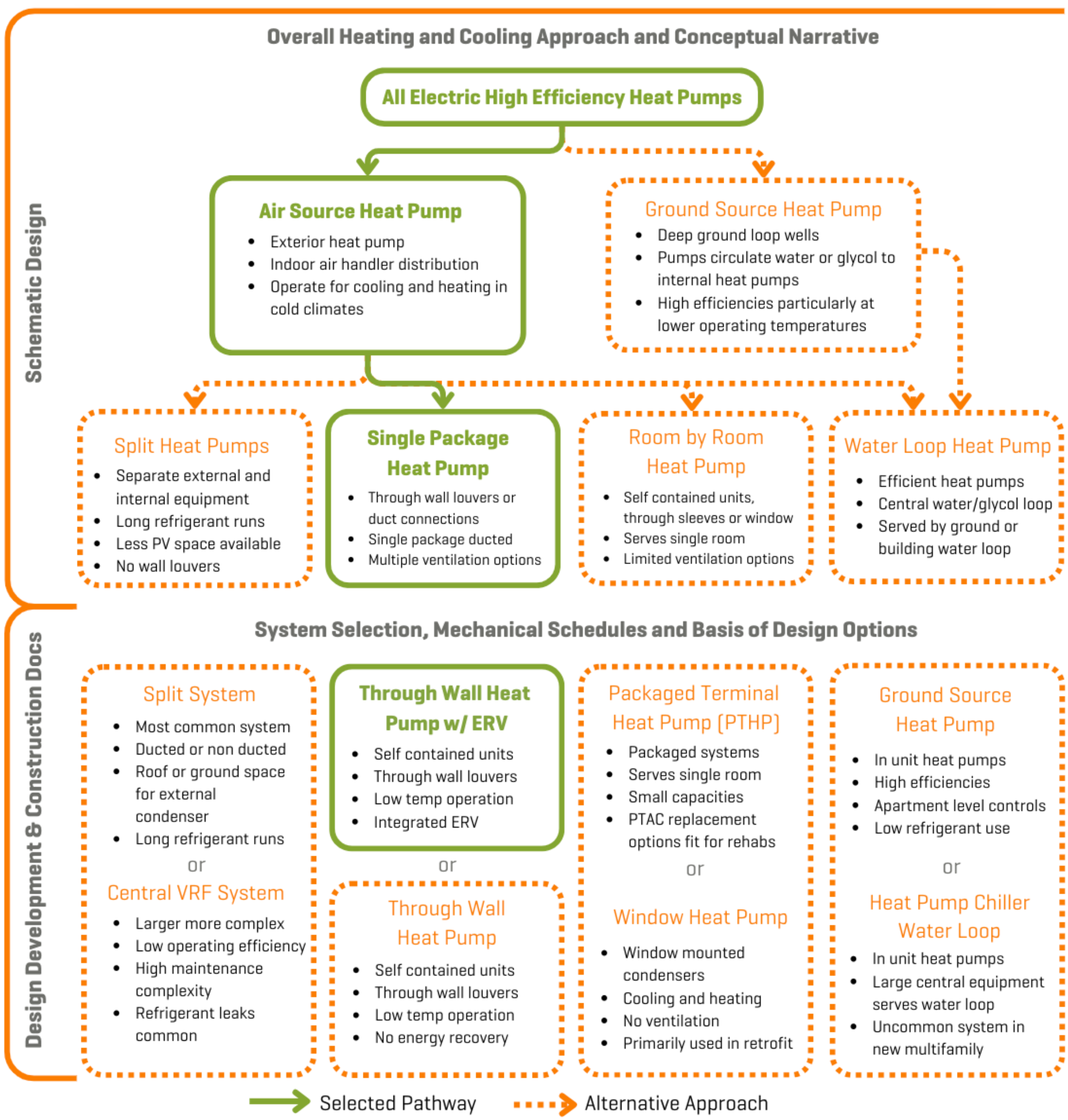
The team used the collaborative integrated design approach to make exterior envelope, mechanical, electrical, and plumbing selections. Having key project stakeholders – owner, architect, engineer, and consultants – work together from the earlier stages of the project resulted in coordinated, high-performance solutions. By integrating expertise and decision-making early, the approach helped optimize efficiency, reduce conflicts, enhance sustainability, and create cohesive designs that meet functional, aesthetic, and budgetary objectives. C2 provided architectural drawings at each major stage, Alderson Engineering provided MEP system options, and multiple designs and equipment selections including geothermal, and various packaged heat pump systems including Friedrich VRP, FirstCo Fresh Pak, and Ice Air systems. Sustainable Comfort provided energy modeling, and design reviews against all major energy efficiency programs. At each stage preliminary pricing was sought for major design decisions such as mechanical system selection. The integrated process is detailed below to show how these stages interact and relate to the overall project timeline.

Figure 1: Integrated Design Process



4. Mechanical System Study

The team has engaged in a study of the potential mechanical system options to achieve carbon neutral ready operational performance. The team started with the Schematic Design decisions to create a conceptual plan, followed by the actual system selections in Design Development. Each stage will be reviewed in detail throughout this section of the report, including the considerations and factors as to why each major decision was made. The appendix includes a full mechanical selection guide for use on future projects outline recommendations, pros, and cons of each system shown below.



Schematic Design: Energy Road Map

In Schematic Design the team sets major design goals and energy efficiency standards to set the goals of the overall project. The project team set values to help guide the decision-making process on the project including mechanical systems selection. Major criteria include:

- All-Electric building design – elimination of fossil fuels to meet state climate goals
- Efficient and cost-effective building envelope and insulation to keep costs down
- Small unit sizes to match the needs of the downtown market
- Simple systems controllable at the unit level to give tenants control and align costs to tenants.
- Cost effective installation to allow a market rate housing project to be financeable in a downtown market.

To set the goals for energy efficiency the team identified the NYSERDA New Construction – Housing program, Buildings of Excellence Programs, and utilized Energy Star Multifamily New Construction Program to set and compare benchmarks. At each stage including Schematic Design and Design Development, the team has used energy modeling using Ekotrope software to review key decisions based on overall cost effectiveness.

Energy Star Multifamily New Construction Criteria

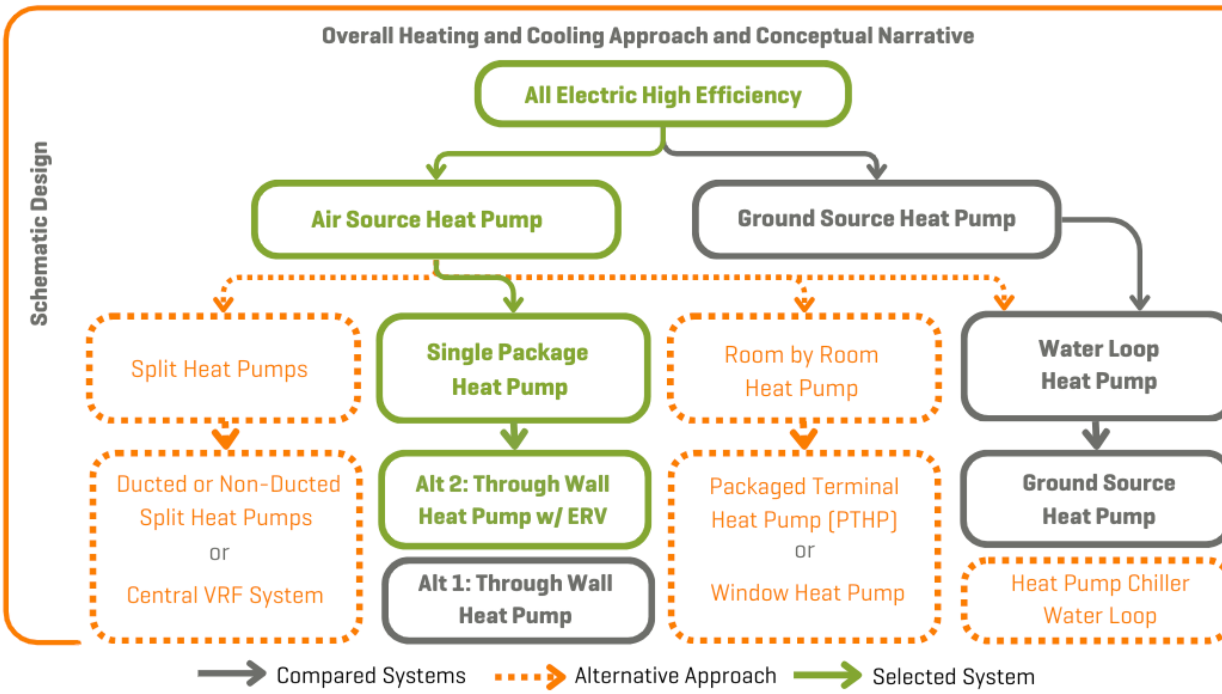
The use of the Energy Star Multifamily New Construction Program utilizes the following key energy efficiency criteria and process throughout design and construction:

- HERS Energy Modeling that meets the Energy Rating Index (ERI) Targets set by Energy Star
- Design Checklists
  - The HVAC Design Report (Completed by the Mechanical Engineer)
  - The Rater Design Report (Completed by Sustainable Comfort HERS Rater)
- Construction Checklists
  - The Rater Field Checklist (Completed by Sustainable Comfort HERS Rater)
  - The HVAC Functional Testing Checklist (If applicable, completed by the HVAC Contractor and/or Functional Testing Agent)
  - The Energy Star Multi Family Workbook (Completed by Sustainable Comfort HERS Rater)
  - The Water Management System Builders Requirements (Responsibility of the Builder)

Schematic Design: Conceptual Mechanical System Comparison

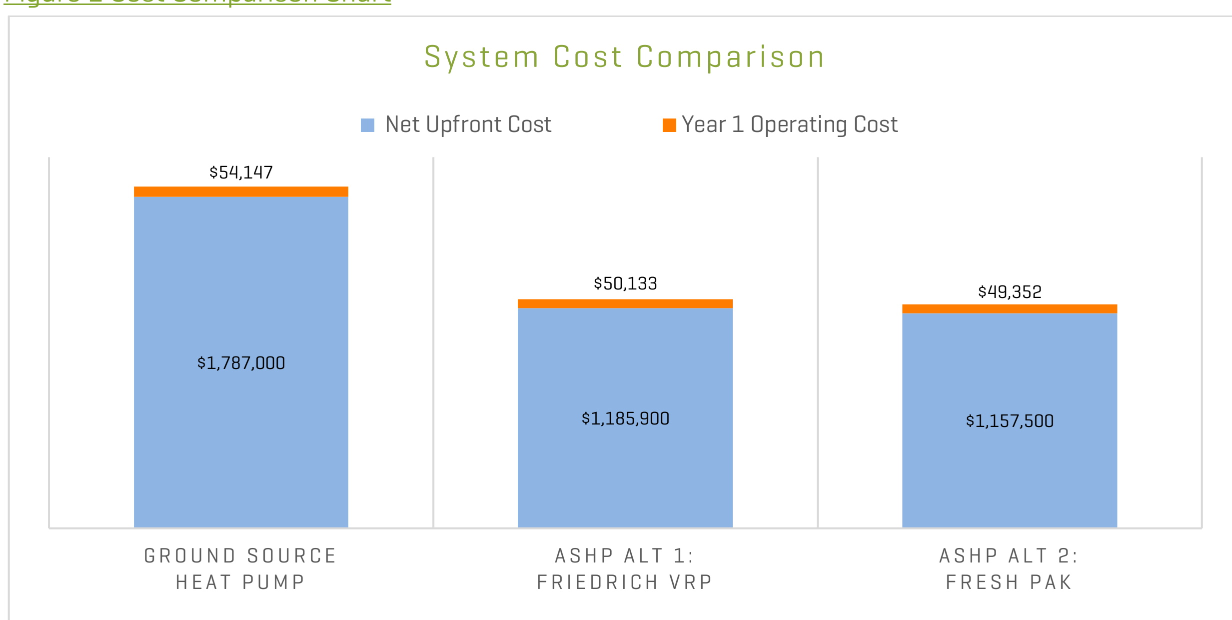
In Schematic Design the team laid out all potential mechanical systems to achieve the overall project goals. To achieve maximum efficiency the team valued maximizing roof space to use for available solar PV production, minimizing refrigerant runs to minimize leakage, individual apartment mechanical and hot water systems, and maximizing apartment efficiency.

The first major decision of providing Air Source Heat Pumps or Ground Source Heat Pumps was explored from various standpoints to help determine which direction to take the design. The team quickly ruled out some options discussed later in "Alternate Mechanical Systems" section and ultimately did a deeper comparison of a Geothermal Ground Source Heat Pump (GSHP), a Packaged Through Wall Heat Pump (Friedrich VRP System), and a Packaged Through Wall Heat Pump with Integrated ERV (FreshCo Fresh Pak). Using pricing from early 2024, the three main mechanical system selections (GSHP, Friedrich VRP, and Fresh Pak) were compared for their overall operating efficiency, first cost including incentives and tax credits, and operating costs.



During the review it was determined the Fresh Pak (ASHP Alt 2) system would be the best system to pursue for the project. The system minimizes refrigerants compared to split systems due to the packaged heating/cooling elements, as well as increases overall building efficiency using an integrated ERV as a part of the single packaged system.

Figure 2 Cost Comparison Chart



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Cost/Benefit Analysis

The full analysis of the cost breakdown is shown in the figures below. The ground source heat pump systems come at a large premium in both upfront cost and operating cost taking maintenance into account and are therefore not recommended for the project. It would be recommended where developers are able to maximize tax credits and rebates, and underwrite full energy efficiency savings.

Figure 3 Cost/Benefit Analysis Table

System Cost Comparison				
Upfront Costs	Ground Source Heat Pump	ASHP Alt 1: Friedrich VRP	ASHP Alt 2: Fresh Pak	Difference GSHP vs. Alt 2
HVAC Cost [1]	$1,850,000	$1,200,000	$1,175,000	($675,000)
Geothermal Well Cost [2]	$880,000	$0	$0	($880,000)
HVAC Tax Credit [3]	($629,000)	$0	$0	$629,000
Geothermal Well Tax Credit [3]	($299,000)	$0	$0	$299,000
CleanHeat Incentive [4]	($15,000)	($14,100)	($17,500)	($2,500)
Net Upfront Cost	**$1,787,000**	**$1,185,900**	**$1,157,500**	**($629,500)**
Year 1 HVAC Costs				
Year 1 Energy Cost [6]	$33,147	$35,133	$28,352	($4,795)
Year 1 Maintenance Cost [5]	$21,000	$15,000	$21,000	
Total Year 1 Operating Cost	**$54,147**	**$50,133**	**$49,352**	**($4,795)**

Cost Footnotes

[1] The cost of the 'HVAC Cost' portion for the GSHP system was determined as $25/square foot based on estimates provided by Brightcore energy and independently verified by Rosenblum Group through other contractors. The cost of equipment for the alternative air source systems was determined via quotes from Family Danz Mechanical with both the Friedrich VRP system and FreshPak system compared and determined to be comparable in cost.

[2] The cost of the (24) geothermal boreholes were determined in consultation with Brightcore energy through an integrated process where Brightcore and Alderson worked in tandem to refine the well design and estimate costs of the system.

[3] The GSHP system would be eligible for a federal Investment Tax Credit. For purposes of this analysis, it is assumed that the credit would include a 30% base credit plus a 10% domestic content credit for a total 40% ITC. Given that the credit is non-refundable, may only be applied against tax liabilities within a 5-year period, and would be well over $1MM, the developer would need to 'sell' the credit on the open market to maximize its benefit to the project. Such sales have historically resulted in a benefit of 85-90 cents on the dollar. Accordingly, the ITC reflected in the table above has been reduced by 15%. This analysis was conducted in 2024; tax law changes and risk of potential termination or adjustment was not factored into the economic analysis.

[4] The Clean Heat Incentive is estimated as this incentive is calculated on a custom basis for all projects this size. Final incentives will be sought for the final HVAC system selection.

[5] The geothermal system maintenance cost is shown to be a little higher due to maintenance of the water/well loop - pumps, controls, and water chemistry plus an incrementally higher cost for the techs who would invariably be working on the (more complex) geothermal system. The in-unit equipment of each system is comparable between a water source heat pump and packaged terminal heat pump system. The Fresh Pak system will include extra filter replacements due to the in-unit ERV.

[6] The annual energy cost of the ASHP Alternative systems compared to the geothermal water source system was produced using a whole building energy simulation from Alderson Engineering. Energy costs were based on a blended rate of 17 cents/KWh and have been summarized below. These cost comparisons are HVAC costs only.

Figure 4 Energy Modeling Operating Cost Results by Alderson

Year 1 Electric Operating Costs			
Component	Ground Source Heat Pump	ASHP Alt 1: Friedrich VRP	ASHP Alt 2: Fresh Pak
Air System Fans	$ 5,256	$ 3,486	$ 10,982
Cooling	$ 6,889	$ 11,550	$ 7,855
Heating	$ 17,405	$ 20,420	$ 9,516
Pumps	$ 3,598	$ -	$ -
Heat Rejection Fans	$ -	$ -	$ -
HVAC Sub-Total	**$ 33,148**	**$ 35,456**	**$ 28,353**

Ground Source Heat Pump Option

The Ground Source Heat Pump (GSHP) option is detailed in this section. The GSHP option was initially identified to achieve the energy efficiency goals of the project while minimizing exterior equipment and maximizing tax credits to achieve carbon neutral ready attributes. Through the exploration it was determined the high up-front cost was insurmountable in this location compared to alternative packaged systems.

Alderson Engineering provided a geothermal system design to receive pricing from HVAC contractors and geothermal well drillers. The Ground Source Heat Pump (GSHP) system would consist of 24 wells (6 circuits of 4 wells) to be drilled to a depth of 495 feet, and would be separated by 20 feet from the adjacent well(s), and will operate between 40°F and 90°F. The geothermal system is sized with enough capacity to avoid the need of supplemental boilers or cooling tower systems. Other characteristics include:

1. The boreholes would be located beneath the building with the manifold located in a mechanical room at the ground level.
2. The ground-source fluid would be 25% propylene glycol with corrosion inhibitors.
3. The geothermal loop would enter the building (2" supply and return lines) into the mechanical room, where the two ground water pumps will be located.
4. A duplex pump system for a variable primary configuration would distribute condenser water to all the indoor heat pumps (which would be in a mechanical closet within each apartment) and then send it back to the wells.

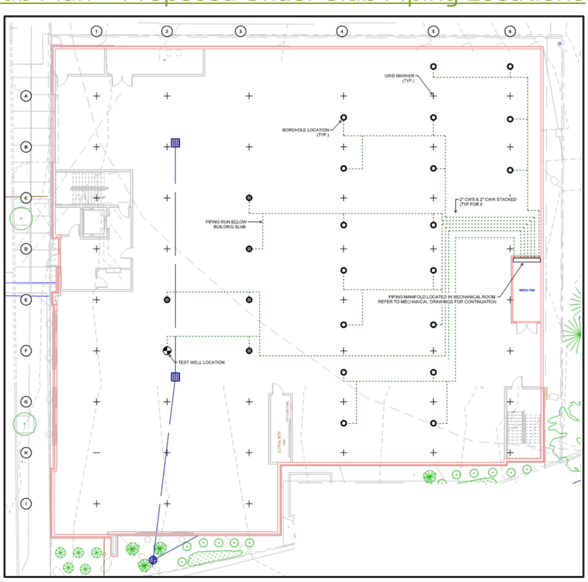
Between the beginning of 2023 to early 2024, the pricing of this system showed large increases in cost. The geothermal design was refined due to overall costs, and alternative air source heat pump design options were considered which have shown to be more cost-effective. The cost increases in the geothermal system are due in large measure to inflationary impacts on materials and equipment costs, uncertainty about soil conditions that could drastically impact well drilling costs, and labor costs to a somewhat lesser extent.

The entire building, apartments and common areas, would be ventilated and exhausted via a common Energy Recovery Unit (ERU) on the roof. The common ERU includes air-cooled DX cooling, heat pump heating with backup electric heat, and hot gas reheat dehumidification. The upfront cost of this system is still relatively high as compared to the ASHP systems studied.

Figure 5 Geothermal System Schedule

Geothermal System Schedule	
Geothermal Boreholes	
Number of Boreholes	24
Borehole Depth (ft)	495
# Borehole Circuits	6
# Boreholes per Circuit	4
Grout Mixture Type	Thermally Enhanced Bentonite
Grout Min Thermal Conductivity	1.20 BTU/hr-ft-F
Geothermal Pipe Size	
Loop Size (in)	1.25"
Branch Size (in)	2"
Manifold Size (in)	6"
Minimum Cover Depth (in)	60"
Fluid information	
Fluid	Propylene Glycol (25% by volume)
Flow (GPM)	140
Field Press Drop to Blg	50 FT HD
Max Entering Water Temp	90F
Min Entering Water Temp	40F

Figure 5 Geothermal Sub Slab Plan – Proposed Under Slab Piping Locations



ASHP Alternative 1: Friedrich VRP System

The first alternative explored consists of vertical packaged terminal heat pumps (VTHP) with auxiliary electric heat. These units are in a mechanical closet adjacent to an exterior wall and include a louver to the exterior. Mechanical ventilation is introduced into the apartment through the VTHP's, while the apartments are exhausted via a common ERU on the roof of the building.

The benefits of these systems include their lower up-front costs and ease of installation by reducing long refrigerant runs and maintaining equipment within the building. These systems are common in multifamily housing, and the heat pump systems provide all electric performance. However, since these systems penetrate the exterior wall, they break the air and weather barrier of the building leading to more attention needed on detailing and typically have lower efficiencies due to smaller coil sizes. Due to the inefficient ventilation options, Friedrich was not selected vs. the Fresh Pak with included Energy Recovery Ventilation.

For the Alternative 1 design, the common ERU includes air-cooled heat pump cooling and heating (with backup electric heat), and hot gas reheat dehumidification. In addition to exhausting the apartments, the ERU will provide mechanical ventilation & conditioning in the common corridors.

The VTHP basis of design is a Friedrich Variable Refrigerant Packaged (VRP) Heat Pump system, which uses a variable-speed compressor that allows for precise control of the amount of refrigerant flowing to the indoor units. This flexibility enables the system to match the heating or cooling demands of different zones within a building. The VRP system can modulate the refrigerant flow to precisely meet the heating or cooling needs of the building. This can result in reduced energy consumption compared to traditional HVAC systems. The proposed unit selections for this project as listed in table below.

Figure 6 Friedrich Vertical Heat Pump Schedule

Vertical Heat Pump Schedule (VHP)			
Unit Designation (Indoor Unit)	**VHP-1**	**VHP-2**	**VHP-2H**
Basis of Design	Friedrich	Friedrich	Friedrich
Model Number	VRP12K	VRP24K	VRP24K
Nominal Tons	1	2	2
Supply Fan CFM	370	480	620
External Static Pressure (in. wc.)	0.25	0.25	0.3
Outside Air CFM	70	70	70
Unit Dimensions (L x W x H)(in.)	26" x 25" x 52"	26" x 25" x 62"	26" x 25" x 62"
Operating Weight (lbs.)	215	255	255
Location	Enclosure	Enclosure	Enclosure
Service	Dwelling Unit	Dwelling Unit	Dwelling Unit
Refrigerant	R-410A	R-410A	R-410A
Cooling			
Condenser EAT °F (DB/RH)	95/40	95/40	95/40
Total / Sensible Capacity (MBH)	11.5 / 8.5	23.4 / 17.3	23.4 / 17.3
ARI EER / SEER	10.4 / 15.1	8.0 / 13.7	8.0 / 13.7
Heating			
Type	Air Source HP	Air Source HP	Air Source HP
Capacity @ 47°F / 17°F (MBH	11.2 / 17.1	21.0 / 14.3	21.0 / 14.3
COP @ 47°F (310/380)	3.1	3.4	3.4
Auxiliary Heat Type	Electric	Electric	Electric
Auxiliary Heat Capacity (kW)	2.4	3.5	5.6

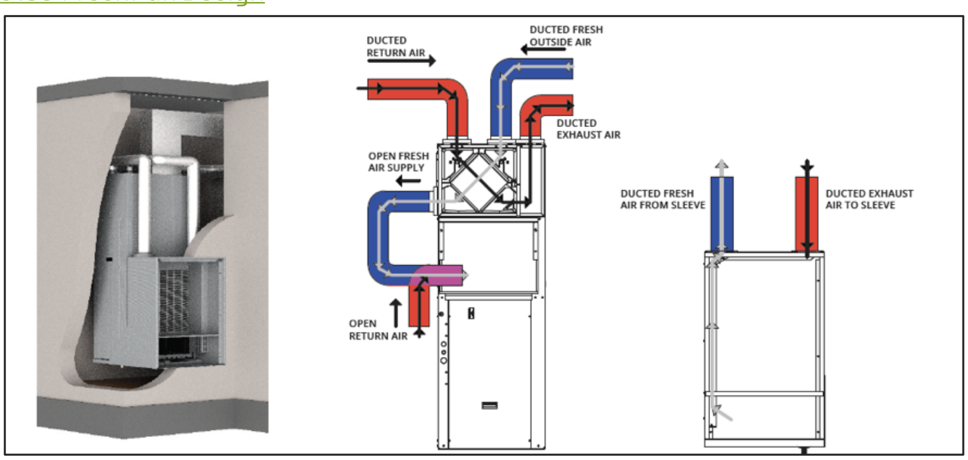
Figure 7 Friedrich Sizing Options

ASHP Alternative 2: Fresh Pak or Alternative

In Schematic Design, Alderson Engineering also explored the use of FirstCo's FreshPak product shown in Figure 8. The product is a Single Packaged Vertical Unit, like the VTHP, with DX Cooling and Heat Pump (with electric backup). The FreshPak units include a fully integrated ERV, which would eliminate the need for a common ERU on the roof to service the apartments. The cooling and heating capacities are comparable to the VTHP system (Friedrich VRP) so the schedules and unit sizes can match the Friedrich system design. The team worked with the manufacturer to gather all relevant performance data and other information to decide whether to utilize this unit as it is a newly manufactured system. These systems provide similar benefits to the Alternative 1, while providing integrated Energy Recovery Ventilation (ERV's).

Due to the superior ventilation quality produced through the integrated ERV and subsequent savings on common area ventilation ductwork and equipment, the team selected this option and plans to further pursue the design of the Fresh Pak system. Later in the design development stage, the team was introduced to a packaged unit manufactured by Ice Air that is like the FreshPak in sizing and capabilities. With similar features, pricing, and dimensions both these systems are explored in the Design Development section of this report to expand on final selection criteria.

Figure 8 FirstCo FreshPak Design



Schematic Design: Energy Modeling Comparisons

In addition to the custom cost comparison between the 3 systems proposed above, the impact on the HERS Rating energy modeling was assessed. The below energy modeling was conducted in early Schematic Design to assess the GSHP Option, the Alternative 1 Friedrich System, and the Alternative 2: Fresh Pak System.

The HERS modeling reinforces the decision from the detailed cost/benefit analysis and shows comparable overall HERS Ratings between the GSHP System and Alternative 2 Fresh Pak System. Due to the significantly lower first cost the Alternative 2 was selected. The Alternative 1 Friedrich System shows higher HERS results and therefore higher energy use and does not fully meet the energy efficiency goals of the project.

Figure 9 Schematic Energy Modeling Summaries

Ground Source Heat Pump System				
UNIT TYPE	UNIT MODELED	HERS INDEX (PRE-PV)	ENERGY STAR MFV1.1 TARGET INDEX	% BETTER THAN ENERGY STAR
1 Bed Lrg	203	45	66	32%
2 Bed Sml	206	42	65	35%
1 Bed Sml 5th	502	47	67	30%
2 Bed End 5th	511	44	62	29%

Alternative 1: Friedrich System				
UNIT TYPE	UNIT MODELED	HERS INDEX (PRE-PV)	ENERGY STAR MFV1.1 TARGET INDEX	% BETTER THAN ENERGY STAR
Studio Sml	214	45	65	31%
1 Bed Lrg	206	55	61	10%
2 Bed	205	51	63	19%
Studio Lrg 5th	502	52	63	17%
1 Bed Sml 5th	511	63	63	0%
2 Bed 5th	505	57	55	-4%

Alternative 2: Fresh Pak System				
UNIT TYPE	UNIT MODELED	HERS INDEX (PRE-PV)	ENERGY STAR MFV1.1 TARGET INDEX	% BETTER THAN ENERGY STAR
Studio Sml	214	41	65	37%
1 Bed Lrg	206	42	67	37%
2 Bed	205	43	70	39%
Studio Lrg 5th	502	44	64	31%
1 Bed Sml 5th	511	46	68	32%
2 Bed 5th	505	45	57	21%

Schematic Design: Hot Water Heating Options

The hot water system will include individual air source hot water heating systems, which reduces the cooling load in the summer while providing tenants with lower operating cost for hot water. Air source heat pumps will be individually provided for each tenant instead of a centralized system. This has the benefit of allowing the tenants to pay for their own hot water use and incentivize efficient use of hot water. The inclusion of WaterSense low flow fixtures will also help to minimize hot water use. The heat pump hot water heater basis of design is the Rheem PROPH50 which provides a UEF-3.5 and an annual operating cost estimated at $110/year. These systems are readily available, with units available off the shelf at $1,700/unit with an estimated $109,000 in equipment cost for the hot water heaters in the building. These systems will add to the heating load of the building which is offset by the efficient heat pump systems and will provide free cooling to the building in the summer months.

Image by Rheem

Hot Water Price Comparisons

To assist in selecting the hot water option, the team also priced out in 2023 other air source heat pump alternatives, particularly a few options for central air source heat pump DHW plants. To upgrade to a central plant, the building would also need the addition of a central distribution system with pumps, piping, and insulation to move the hot water from the central system to each unit. The alternative central equipment priced included:

- Mitsubishi QAHV was priced to include 1) 500-gallon storage tank, 1) 175-gallon storage tank, 1) 150-gallon electric swing tank, and 2-QAHV outdoor CO2 condensing units. List pricing for equipment for this system was provided by Mitsubishi at $250,000. (not selected)
- Lync by Watts Aegis A was priced to include 1 Aegis 500, 1 heat exchanger, 2) 500-gallon storage tanks and mixing valve for a total budget cost of $260,000. This system is an outdoor CO2 based condensing unit with glycol piped to large storage tanks. (not selected)
- LG Hydrokit K3 was priced to include 1 VRF outdoor unit, 3 Hydrokit K3 systems with associated pumps, and storage tanks for a total system price of $111,000. This is the most cost-effective alternative system, however, is still estimated to cost more for installation, with the potential maintenance costs and space needs of the larger central plant system. (not selected)

Schematic Design: Energy Recovery Ventilation Options

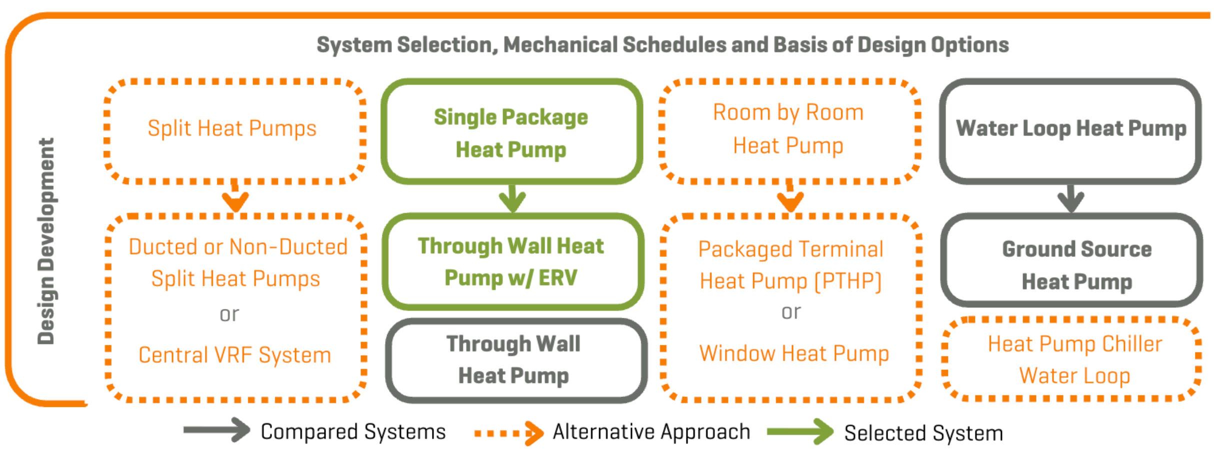
The Energy Recovery Ventilation (ERV) systems were a large consideration in the final mechanical system selection of the project. Each mechanical system was explored inclusive of how the systems provide mechanical ventilation, and the overall efficiency and cost of the types of ventilation systems being provided with each system.

The major ventilation systems explored included central ERV system with the GSHP system, unitary ERV in unit, and the packaged HVAC systems with integrated ERV. The Fresh Pak was selected to maximize the fresh air to each apartment using a dedicated ERV. This keeps the ductwork contained to each unit and reduces construction costs which provide energy recovery.

The alternative Friedrich VRP system did not include any energy recovery ventilation for the apartments as the fresh air option for that system only includes a fresh air intake fan as a part of the packaged system. This can increase energy use of the overall system. The geothermal alternative relied on a large central Dedicated Outdoor Air System (DOAS) unit for ventilation for all apartments including exhaust from each unit and supply ventilation.

Schematic Design: Alternative Mechanical Systems Explored

The following systems were also explored for heating and cooling beyond the Ground Source Heat Pump and Alternative Air Source Heat Pump System and fall into 4 categories: Split Heat Pumps, Packaged Heat Pumps with Integrated ERV's, Packaged Heat Pumps, and Water Loop Heat Pumps. Ultimately the Packaged Heat Pump with Integrated ERV was selected for the project due to no exterior equipment, no field installed refrigerant runs, and integrated ERV's. In Design Development the exact manufacturer and basis of design selection was reviewed, which occurs later in the report between the FirstCo Fresh Pak and Ice Air SPXC.



Split Heat Pump Options

Split heat pump systems were explored and are standard systems to electrify heating and cooling however were not selected due to the need for roof space for exterior condensers and long refrigerant runs within the building which can be prone to leaks. Studies have shown refrigerant leaks total 1-3% of total system charge and contribute greatly to global warming and are particularly prone in field applied systems. The roof space needed for condensers would reduce overall PV capacity by roughly 40% for this building and reduce the overall solar PV system from 154 kW to roughly 90 kW and reduce solar production accordingly.

Ducted or Non-Ducted Split Heat Pumps

Mini Split Heat Pump systems were explored but were dismissed due to the increase in refrigerant lines to run through the building leading to potential refrigerant leakage. Estimates have shown up to 3% refrigerant leakage per year due to field connections. The limited site plan would also limit the condenser locations to the roof and would reduce the availability of roof space for future solar PV inclusion. Therefore, the packaged systems were preferable from a maintenance and operations standpoint.

Split Heat Pump Pros:

- Known and readily available systems
- Highest available efficiencies for ASHP
- Can operate at low temps without backup heat
- Ducted or non-ducted options available

Split Heat Pump Cons

- Exterior space needed for condensers
- Roof mounted condensers reduce space for PV
- Long refrigerant runs increase chance of leaks
- No included ventilation

Image by Mitsubishi

Variable Refrigerant Flow (VRF) System

The VRF systems were not heavily explored for this building configuration due to the large number of refrigerant lines that it would take to serve the building and the project team's desire to minimize refrigerant use. The VRF systems are also more complicated to maintain, needing specialized knowledge and skill beyond the typical building maintenance techs. Since each apartment is tied together any outage would impact multiple units and wings of the building rather than single apartments. Recent NYSERDA studies have shown VRF to operate below rated efficiencies and come with a high first cost of installation.

VRF Pros

- Less exterior equipment w/ larger capacity
- Can provide domestic hot water
- Use where exterior space constraints exist

VRF Cons

- High up-front installation cost
- Long refrigerant runs in building
- Complex maintenance requirements
- Lower operating efficiencies found in multiple studies of real-world performance.

Image by Mitsubishi

Image Courtesy of Mitsubishi

Packaged Heat Pump Options

These systems provide self-contained heat pump systems and are connected to the exterior via louvers with ductwork connections to be able to serve a single apartment. There are multiple options for ventilation including integrated ERV's or supply only ventilation depending on manufacturer and equipment type. System options include:

Through Wall Heat Pumps w/ ERV (Ex. FirstCo Fresh Pak or Ice Air SPXC-ERV)

As previously discussed, the FirstCo Fresh Pak offers several benefits to the overall design. It allows for a decentralized ventilation & exhaust system throughout the building, high efficiency heating & cooling, and energy recovery local to each apartment. Of the two packaged products with Integral ERV of which we reviewed, the FirstCo equipment contains higher capacities and better overall efficiencies at standard temperatures than Ice Air. Though at lower ambient temperatures (5°F), the capacities are significantly derated and will require the electric heat to activate frequently. The unit has an overall higher electrical load than its counterparts and will require a larger electrical breaker & feeders as a result.

The Ice Air SPXC ERV offers nearly Identical options and similar performance as the FirstCo Fresh Pak. However, the overall capacities and efficiencies at standard ambient temperatures are slightly inferior. Where the Ice Air product does have an advantage over FirstCo's is in low temperature conditions. At 5°F ambient conditions, the Ice Air SPXC ERV benefits from nearly double the heating capacity as the Fresh Pak (using Heat Pump alone). Because of the larger capacities at low ambient temperatures, there is less likelihood that the electric auxiliary heat will be required, allowing for lower electrical loads at the apartments and in the building.

Packaged w/ ERV Pros:

- Lower first cost installation than other systems, including 36% lower than the GSHP system explored for the project.
- Single package for heating, cooling
- No refrigerant runs or exterior condensers

Packaged w/ ERV Cons

- Ventilation provided through supply, no energy recovery
- Typically, lower operating efficiencies that split systems
- Backup electric resistance can increase operating cost
- Wall penetrations introduce potential thermal bridging or air leakage, not recommended for Passive House.

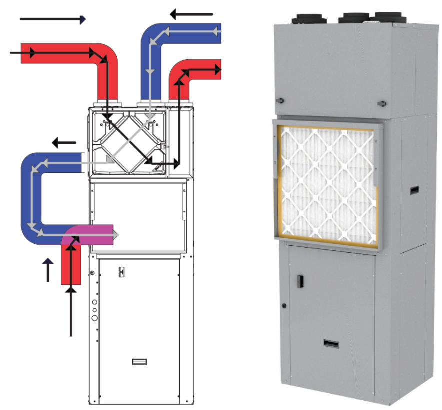


Image by Fresh Pak

Through Wall Heat Pump (Ex. Friedrich VRP System or Magic Pak)

Friedrich VRP systems provide through the wall packaged heating and cooling via cold climate heat pumps. The unit features a fresh air option without energy recovery and typically is designed with backup electric resistance heating. These systems reduce the need for external condensers and eliminate refrigerant runs in the building.

The Friedrich VRP system was explored as an alternative and rejected due to the continued need to provide a central energy recovery system in the building, and the potential low operating efficiencies of the system. To meet a similar design as the FirstCo Fresh Pak or Ice Air SPXC ERV, the VRP could be paired with a separate, third party, ERV. However, this would require additional controls and could complicate the sequence of operations.

MagicPak offers a unit very similar to the Friedrich VRP, however it was not heavily explored due to the lack of an integral ERV. If the team had chosen to continue with the Friedrich VRP this option would have been studied in more detail. Like the Friedrich VRP, the MagicPak could be paired with a separate, third-party, ERV. However, adding additional components to the system and controls seem unnecessary.

Image by Friedrich

Packaged no ERV Pros:

- Lower first cost installation than other systems

- Single package for heating, cooling
- No refrigerant runs or exterior condensers

Packaged no ERV Cons

- Ventilation provided through supply, no energy recovery
- Typically, lower operating efficiencies that split systems
- Backup electric resistance can increase operating cost
- Wall penetrations introduce potential thermal bridging or air leakage, not recommended for Passive House.

Room by Room Heat Pumps

There are packaged heat pump systems that serve single rooms such as packaged terminal heat pump systems (PTHP) or window heat pumps which provide the convenience of through the wall systems while serving a single space at a time. These unitary systems serve the room they are in and do not contain duct systems to other spaces. The team preferred the single packaged approach to providing heating, cooling, and ventilation at the unit level and did not want room by room equipment, or window units hanging outside each apartment visually. Specific PTHP and window unit types include:

Package Terminal Heat Pump (PTHP) (Ephoca All in One System)

Early in Design Development stage, another alternate packaged system included the MINOTAIR PENTACARE-V12 unit. This unit includes heat pump cooling and heating (with electric backup heat), dehumidification, and integral ventilation/exhaust fans. This system would eliminate the need for a common ERU on the roof.

The MINOTAIR system is limited in its capacity, as it only comes in one size (3/4 ton). Based on our calculations, it would not be sufficient to meet the apartment's loads alone and would be dependent on electric backup heat, which would be less efficient than the basis of design's heat pump heating. For the MINOTAIR system to be feasible, significant upgrades would be required to the building's envelope, resulting in added costs. The unit's footprint roughly 41" wide requires a wider mechanical space than the Friedrich VRP or Fresh Pak, so teams should determine whether the MINOTAIR system is an option early on in design to leave sufficient space for the system.

Early in the design the team reviewed the AIO system from Ephoca. Like MINOTARI'S PENTACARE, it is a compact 12"x25" packaged Air Source Heat Pump system with electric auxiliary heat. It has the additional feature of having an Integral ERV, which would provide added efficiencies and pre-treat the incoming outside air by recovering heat from the bathroom exhaust air. However, like the MINOTAIR product, the equipment Is limited to 1-Ton capacity, which is not sufficient to meet most of the apartments' loads, based on our calculations.

Due to limitations on manufacturing due to both Minotair and Ephoca being small international manufacturer's, the availability of each unit should be checked if considering.

PTHP Pros

- Integrated heating, cooling, and ventilation
- No exterior louvers, only duct connections to outside.
- Saves space on exterior for PV
- No refrigerant runs
- Potential use in Passive House buildings

PTHP Cons

- Smaller capacity units
- Difficult balancing airflows
- Custom systems require specialty knowledge

Image by Ephoca

Window Heat Pump (Ex. Gradient or Midea)

The Gradient 120V Window Heat Pump provides an easy to install packaged heat pump which installs in minutes within any single or double hung window. It operates off a 120V outlet to stay within existing building electrical constraints and provides a condensate free operation through atomization of condensate. The unit provides cooling and heating in all temperature ranges. In a typical apartment each exterior bedroom and living room would get a unit allowing independent room temperature controls.

While this unit provides great features and benefits for retrofits, the application in new construction is a more difficult case to make primarily due to the visual impact of the exterior condensers that are left hanging off the building at each window location. New construction projects are typically subject to more stringent site plan and planning board reviews and approvals where building aesthetics are a major decision-making factor. The team was not interested in exploring this option due to aesthetics for this project.

Window HP Pros

- Installs within an hour in each apartment
- No interior demolition needed to install
- 120V outlet capable
- No condensate dripping
- Energy savings compared to existing systems such as central steam

Window HP Cons

- Limited new construction applications
- Visually adds window unit at each room
- No ventilation options available

Image by Gradient

Water Loop Heat Pump Options

The most common water loop system in multifamily apartments are geothermal wells with a water source heat pump located in each apartment providing heating and cooling for the building by running a central water loop with either glycol or water distribution. However, there are instances where the central loop can also be served by a chiller boiler combination or central air source heat pump system.

Ground Source Heat Pumps

Ground Source Heat Pumps offer high operating efficiencies, however come with much larger first costs due to well drilling and central pumps with in-unit water source heat pumps. Due to higher first cost, these systems should be considered on projects that can maximize any federal tax credits, grants, and incentives or need reduced loads.

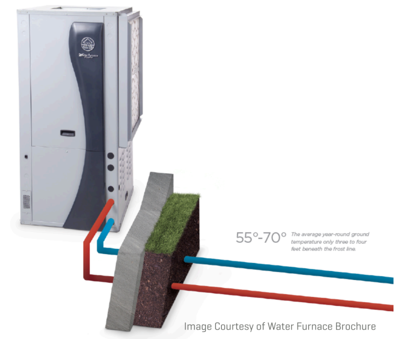


Image by Water Furnace

GSHP Pros:

- Highest operating efficiencies
- Can lower building peak electrical load
- Maximize tax credits, grants, and incentives

GSHP Cons

- Highest first cost
- More complex equipment to commission and maintain

Water Loop Heat (WLHP) Pumps

When not using a ground source loop, it is possible to still use a building water loop to serve in unit water source heat pumps. This option is typically done with a central chiller and boiler heating and cooling the loop. To serve the loop with full Air Source heat Pumps is a newer technology and the team did not consider the central loop option due to the high cost of the unitary heat pumps and central systems.

Image by Climate Master

WLHP Pros

- Large central equipment creates hot and cold water for the building
- In unit uses same water source heat pumps
- No refrigerant runs

WLHP Cons

- Uncommon system in multifamily due to limited or expensive heat pump chiller options
- Central heat pump and in unit heat pump needed to maintain and operate efficiently
- Central water piping needed in building

Design Development: Mechanical System Selection

In Design Development the basis of design and alternative systems were explored. The team selected the Packaged Heat Pump with Integrated ERV with the FirstCo Fresh Pak System initially identified as the basis of design. In Design Development, a secondary manufacturer Ice Air was identified and the systems compared. The systems were compared based on the following features:

- Operating capabilities: Similar capabilities
- Capacities: Similar capacities with higher capacity at lower temps for Ice Air Unit
- Efficiency: Higher efficiencies for Ice Air unit
- Size and space considerations: Similar space considerations
- Installation Costs: Lower first cost estimated for Ice Air unit, as shown in Figure 10 below, the initial quotes show $6,790 per unit for Ice Air and $9,142 for FreshPak Systems.

Led by Alderson Engineering, the two systems were explored with manufacturer input and assessment against the overall goals of the project. The specifications and schedules were created for each proposed system and how they would be able to work within the building design. Based on the analysis, the Ice Air system offers higher heating capacities at lower temperatures and slightly higher efficiency while offering lower first cost installation.

The final decision on mechanical systems will not be made until closer to final design due to the rapidly changing market and availability of these packaged systems with integrated Energy Recovery. Any new systems will continue to be explored for viability, cost, and efficiency. Below are the specifications between the two systems.

Figure 10 Fresh Pak vs. Ice Air Specifications

	FirstCo Fresh Pak			Ice Air SPXC w/ ERV		
Unit Type	**Studio**	**1 Bedroom**	**2 Bedroom**	**Studio**	**1 Bedroom**	**2 Bedroom**
Model #	EPE18	EPE18	EPE24	8SPXC18-ERV	8SPXC18-ERV	8SPXC24-ERV
Cooling Capacity (Btu/hr)	17.7	17.7	24.6	16.8	16.8	24
Sensible Capacity (Btu/hr)	14.2	14.2	20.7	13.9	13.9	18.8
SEER2	11.9	11.9	11.9	13.4	13.4	14.3
Heating Capacity @ 47F (Btu/hr)	16.5	16.5	21	15.2	15.2	21
Heating Capacity @ 5F (Btu/hr)	6.4	6.4	8.5	10.3	10.3	16.2
HSPF2	6.3	6.3	6.3	6.7	6.7	7.8
Backup Resistance Size (kW)	3	3	5	5	5	5
ERV Fresh Air (CFM)	35	40	60	35	40	60
ERV Wattage (W)						
ERV Efficiency	60.6%	60.6%	60.6%	60.6%	60.6%	60.6%
Refrigerant	R-32	R-32	R-32	R-32	R-32	R-32
Inside Clearance	36"W x 32"D			31"W x 31"D or 35.5"W x 24"D		

Each system was priced based on a per system pricing comparison provided by each manufacturer. Final pricing contingent of a full HVAC Contractor estimate of full system costs, however the Ice Air system shows a lower unit cost at initial comparison.

Figure 11 Fresh Pak vs. Ice Air Cost Comparison

Ice Air	
Item	**Cost**
VPHP-1	$ 6,100
VPHP-1.5	$ 6,500
VPHP-2	$ 7,560
+5kW Elec Heater (each)	$ 165
+Shipping (each)	$ 125
*includes Chassis, Louvered Panel, Plenum, Louver	
Rough Cost per VPHP	$ 6,790

FirstCo FreshPak	
Item	**Cost**
VPHP-1	N/A
VPHP-1.5	$ 7,176
VPHP-2	$ 7,385
+Louver (Custom Color)	$ 898
+Louvered Panel (each)	$ 382
+Wall Sleeve Ports (each)	$ 561
+ Shipping (total)	$ 6,000
Includes Chassis, Plenum, Electric Heaters	
Rough Cost per VPHP	$ 9,142

Design Development Stage: Energy Modeling

At the Design Development stage, we revisited our HERS Rating energy modeling to assess the differences between the Ice Air and Fresh Pak Systems. The tables below show the HERS summary and utility usage of the two systems which shows slightly lower energy use with the Ice Air 8SPXC-ERV system modeled, and roughly equivalent HERS Scores between the two systems modeled. Due to the lower first cost and higher efficiency and capacity at low temperatures the Ice Air System performance is preferred and recommended. Shown below are the energy modeling results and technical specifications used in the energy modeling.

Figure 12: Summary of HERS Scores – Fresh Pak and Ice Air Systems

Ice Air 8SPXC-ERV Systems				
HERS RESULTS		ENERGY STAR HERS RESULTS		
UNIT MODELED	HERS INDEX (POST-PV)	HERS INDEX (PRE-PV)	ENERGY STAR MFV1.1 TARGET INDEX	% BETTER THAN ENERGY STAR
514	18	43	66	35%
502	18	42	66	36%
511	21	43	68	37%
506	21	41	65	37%
505	10	40	57	30%
UTILITY BILL SUMMARY				
	ELECTRIC USAGE (KWH/YR)	SOLAR SIZE (KW)	SOLAR KWH PRODUCED	YEARLY UTILITY BILLS
Apartments	358,456	164	173,740	$ 56,983

First Co Fresh Pak EPE Systems				
HERS RESULTS		ENERGY STAR HERS RESULTS		
UNIT MODELED	HERS INDEX (POST-PV)	HERS INDEX (PRE-PV)	ENERGY STAR MFV1.1 TARGET INDEX	% BETTER THAN ENERGY STAR
514	17	42	65	35%
502	18	42	65	35%
511	20	43	66	35%
506	23	43	64	33%
505	12	42	56	25%
UTILITY BILL SUMMARY				
	ELECTRIC USAGE (KWH/YR)	SOLAR SIZE (KW)	SOLAR KWH PRODUCED	YEARLY UTILITY BILLS
Apartments	360,518	164	173,740	$ 57,354

SUSTAINABLE COMFORT

Figure 13: Ekotrope Energy Modeling Inputs

BASIC PROJECT INFORMATION			
PROJECT NAME	The Lafayette	TOTAL # UNITS	64
ADDRESS	31 Lafayette St, Schenectady	TOTAL # BEDROOMS	68
MODELING DATE	2024.01.17		

ENVELOPE CONSTRUCTIONS	INSULATION			OTHER	Drawing Ref:
	Type	Continuous	Cavity	Framing Size/Spacing, other Notes	
Exterior Walls	Zip-R/Batt	R-9	R-21	Zip R-9 + 2x6 Wd, 16" o.c. w/ Batt	A600
Slab Insulation - Lobby's, Stairwells	Rigid	R-10	N/A	R-10 Under-Slab	A600
Podium Insulation	CCSF	R-30	N/A	Continuous from ceiling to exterior walls	A601
Parking Garage	Unconditioned	N/A	N/A	Parking garage outside thermal boundary	A600
Roof	Rigid	R-39	N/A	Polyiso rigid insulation above roof deck	A105
Rim/Band Joists	Zip-R/Batt	R-9	R-30	Zip R-9 + WD Floor truss, 24" o.c. w/ Batt	A600

FENESTRATION	Type	U-value	SHGC	Drawing Ref
Windows	Single Hung, Vinyl	0.27	0.29	A900

FRESH PAK -MECHANICAL VENTILATION								
Type	Location	Bedrooms	Hours/Day	Watts	Sound	Rate	Efficiency	Drawing Ref
ERV - VHP-1.5	Packaged Heat Pump	Studio/1 BR	24	10	TBD	40	70%	M500 / Submittal
ERV - VHP-2	Packaged Heat Pump	1 BR/2 BR	24	12	TBD	50	70%	M500 / Submittal

FRESH PAK - APARTMENT HEAT PUMP SYSTEMS		Cooling		Heating			Fan		
Heat Pump Type	Model #	Efficiency	Capacity kBtu	Efficiency	Capacity kBtu	Backup	Flow	Wattage	AHRI #
VHP-1.5	EPE18**B	11.9 SEER2	11.9	6.3 HSPF2	16.5	0 Degrees	600	120	M500 / 213683696
VHP-2	EPE24**B	11.9 SEER2	23.4	6.3 HSPF2	22.4	0 Degrees	800	160	M500 / 213683697

DIRECT HOT WATER HEATING						
Type	Model #	Fuel	Tank Size	Recovery Eff	EF	Drawing Ref
Individual	REH2H50S10	Heat Pump	50 Gallon	406	3.44	P500

PERFORMANCE TESTING			Drawing Ref
Proposed Unit Infiltration	0.3	CFM50 per sf of enclosure	Energy Star MFNC V1.1
Proposed Total Duct Leakage	6	CFM25 per 100sf	Energy Star MFNC V1.1
HVAC Design Reports	Tolerances Met		Energy Star MFNC V1.1
HVAC Grading Included - Dwelling Unit	Yes	Grade I fan flow, wattage, and refrigerant charge	Energy Star MFNC V1.1
Common Area Functional Testing	Yes, Sections 1-5	Grade I fan flow, wattage, and refrigerant charge	Energy Star MFNC V1.1
Central Ventilation Leakage Testing (For Apartments)	No	Grade I fan flow, wattage, and refrigerant charge	Energy Star MFNC V1.1

Solar System						
Solar System	Location	Capacity	DeRate	Orientation	Tilt	Drawing Ref
Roof Mounted	Roof	173kW	0.77	180 degrees	35 deg	Estimate

APPLIANCES					
Type	Model #	Energy Use	Energy Star?	Fuel	Drawing Ref
Refrigerator	FFHT2045VS	385 kWh/yr	Yes	Electric	Proposed or Similar
Dishwasher	FFCD2413US	270 kWh/yr	Yes	Electric	Proposed or Similar
Clothes Dryer	FLCE7523AW	3.73 CEF	No	Electric	Proposed or Similar
Clothes Washer	FLCE7523AW	175 kWh/yr	No	Electric	Proposed or Similar
Range/Oven	FFEF3054TS	Standard		Electric	Proposed or Similar

LIGHTING				
Type	Type	% High Eff	Energy Star?	Drawing Ref
All Lighting	LED	100	Yes	E500

PLUMBING FIXTURES				
Type	Model #	Flow Rate	WaterSense?	Drawing Ref
Toilets	K-3999	1.28	Yes	P500
Showerheads	T14464	1.75	Yes	P500
Lav Faucets	573LF-MPU-PP	1	Yes	P500
Kitchen Faucets	18SB.9301800T	1.5	N/A	P500

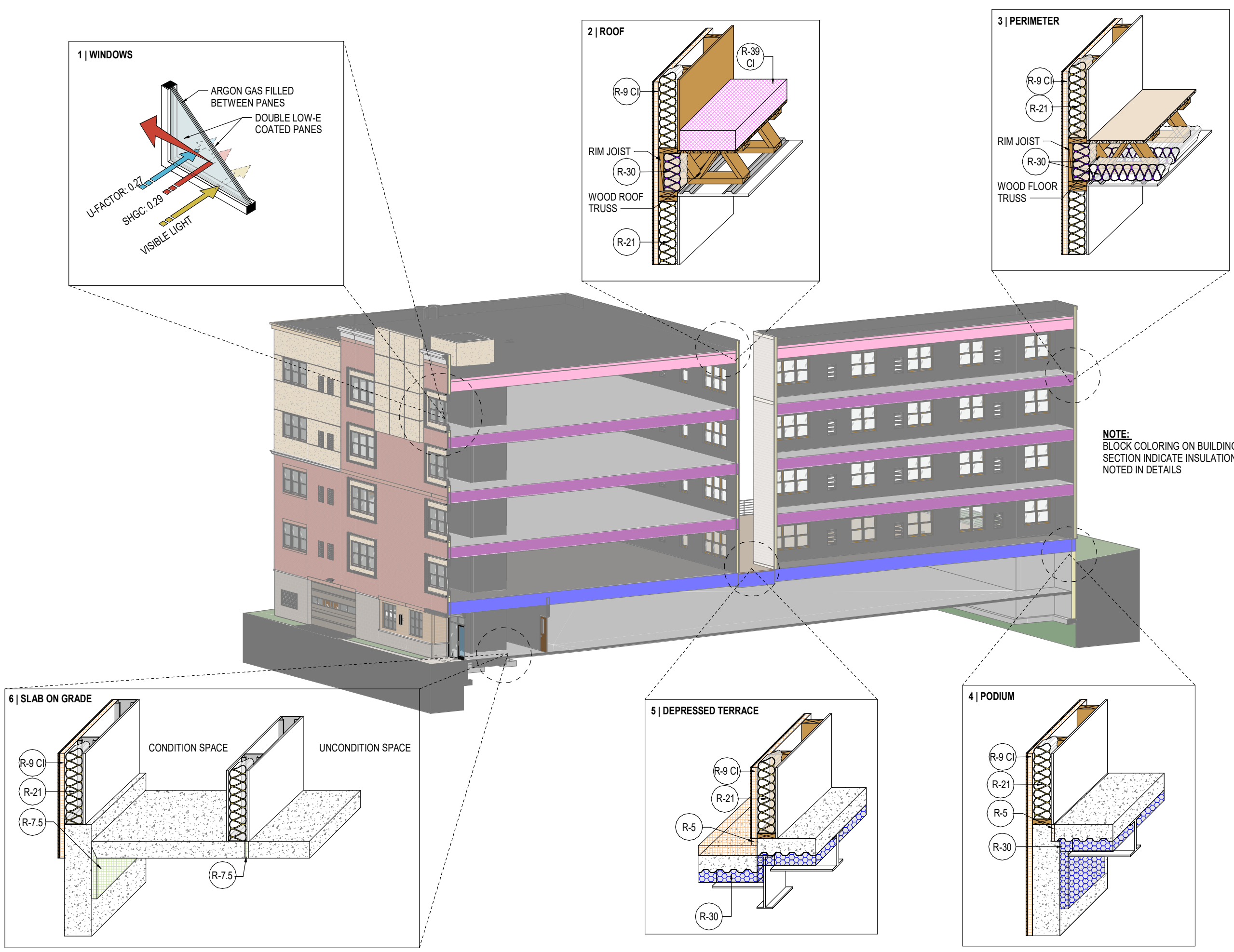
(shaded cell) Assumptions or not found in plans

5. Carbon Neutral-Ready Research

Exterior Envelope Considerations

Additional insulation around the building envelope was included in the design to allow for an energy efficient building and provide passive survivability to the residents. The insulation levels were determined based on the original energy goals of the project established in the energy road map. The team targeted Energy Star Multifamily New Construction program to set a guideline for an energy efficient envelope design and to achieve energy modeling >25% better than the ERI index established by the Energy Star program. SCI conducted a design review to identify exact insulation levels to comply with the Energy Star program. The details below show the primary features that go into an advanced envelope to meet the Energy Star Multifamily New Construction program.

Figure 14: Envelope Detailing – Drawings by C2 Design Group



To summarize the insulation levels to achieve Energy Star targets, the design includes R-10 around the foundation walls under the slab for 24" around the perimeter, R-30 spray foam on the elevated concrete deck continues down to the perimeter walls to ensure a complete insulated deck (and reduce thermal bridging at edge of slab) from the garage space to the residential space. The usage of R-9 Zip-R sheathing around the exterior walls in addition to the R-21 insulation in the cavity of the walls provides continuous insulation to the wall assembly above code requirement per Table C402.1.3 of the 2020 Energy Conservation Construction Code of New York State. The roof insulation is R-39 minimum at the lowest point of roof, which is R-9 above the requirement per Table C4021.3 2020 Energy Conservation Construction Code of New York State.

Sheathing and R-9 continuous insulation run past the roof trusses up the parapet wall to prevent thermal breaks at the attic area. This exceeds the requirement of R-3 in the 2020 NYS Stretch Energy Code. The zip sheathing system provides a continuous air barrier system around the perimeter of the building. All joints are to be sealed with required flashing tape as well as around all penetrations.

Energy star rated window systems with low-e glazing have been included in the design of the building. Pella 250 Series provides a 0.27 u-factor and 0.29 SHGC for double pane, clear glazing. This glazing specification exceeds the requirements of 0.38 u-factor and 0.38 SHGC per table C402.4 2020 Energy Conservation Construction Code of New York State. All windows will be fully flashed and caulked around the perimeter to prevent air leakage. This window also exceeds the requirements in the 2020 NYS Stretch Energy Code, which requires a 0.36 U-factor and 0.38 SHGC.

These features have contributed to low loads for the apartments and small systems that have been sized to match the loads, as shown in the figure below from the Energy Star HVAC Design Report.

Figure 15: Heating and Cooling Loads and Equipment Sizing

Unit Loads and Equipment Sizing			
Unit Type	**Studio - Unit 202**	**1BR - Unit 206**	**2 BR - Unit 205**
Number of occupants used in loads:	2	2	3
Total occupant gains (Btuh):	900	900	1350
Conditioned floor area used in loads:	570	770	1145
Window area used in loads:	45	75	135
Predominant window SHGC used in loads:	0.38	0.38	0.38
Infiltration (ACH / ACH50 / CFM) used in loads:	0.25 ACH	0.25 ACH	0.25 ACH
Mechanical ventilation (CFM) used in loads:	35	40	60
Non-occupant Internal gains used in loads (Btuh):	1830	2530	3600
Door orientation (N, NE, E, SE, S, SW, W, NW):	W	SE	SW
Cooling Load and Equipment Sizing			
Sensible Heat Gain At Design Conditions (kBtuh):	8.0	11.1	17.5
Latent Heat Gain At Design Conditions (kBtuh):	1.5	1.8	3.0
Total Heat Gain at Design Conditions (kBtuh):	9.0	12.9	20.5
Ice Air Model Number	8SPXC18-ERV	8SPXC18-ERV	8SPXC24-ERV
Cooling Capacity (kBtu/hr)	16.8	16.8	24
Sensible Capacity (kBtu/hr)	13.9	13.9	18.8
Cooling Sizing %	187%	130%	117%
Sizing Recommendation	Low Load <25kBtu	90-130%	90-130%
Heating Load and Equipment Sizing			
Total Heat Loss at 4.7F Design Conditions (kBtuh):	5.9	9.1	14.4
Ice Air Model Number	8SPXC18-ERV	8SPXC18-ERV	8SPXC24-ERV
Heating Capacity (kBtu/hr) at 5F	10.3	10.3	16.2
Heating Sizing %	175%	113%	113%
Sizing Recommendation	100-140%	100-140%	100-140%

Demand Response and Virtual Power Plants

With the selected Air Source Heat Pump mechanical system, one feature that warrants additional attention is the overall peak demand of the building and impact on the grid. A ground source heat pump system can reduce overall peak loads due to the more consistent underground temperature. By comparing the Ekotrope modeling between a ground source heat pump system with central ERV and the unitary Fresh Pak with integrated ERV we see the Fresh Pak system has a higher peak summer and winter demand. The summer peak is increased by 3%, and the winter peak is increased by 38% compared to the ground source heat pump. Since the current electric grid peaks in the summer, the building will not add substantially to the peak, however exploration of how new buildings can reduce the winter peaks when electrically heated buildings see higher electric spikes, and when solar PV production is at its lowest will be important for future grid considerations.

With the help of NYSERDA's Early Design Support funding, the team was able to research mechanical control systems, EnergeX and Embue, and evaluate each system's demand response capabilities. Demand response is the practice of adjusting a building's energy use in response to signals from the electric grid – such as high demand periods, grid strain, or time-of-use pricing – so that energy consumption is reduced, shifted, or temporarily delayed. For the Lafayette project this can reduce peak demand charges and potentially lower operating costs while offering flexibility to the grid. The team started by researching smart thermostat options that can integrate into a demand response program and interviewed 2 products include Embue and EnergeX.

Embue – Peak Loan Management and Virtual Power Plant

Increasingly, when a building uses energy is becoming as important as how much energy it uses in total throughout the year. By managing the peak load, i.e. the maximum electricity used each day or each month, a building can reduce energy costs and even be paid at times when the electric grid is under stress such as on a hot summer day. Peak Load Management (PLM) is part of a broader, even more valuable strategy, called Virtual Power Plant.

A Virtual Power Plant (VPP) is a network of distributed energy resources (DERs) such as rooftop solar panels, electric vehicle chargers, batteries, thermostats and other building controls that are all connected and coordinated through a central software platform. When networked together, these small-scale devices function like a single, in-building power plant that can dynamically respond to grid demands by adjusting energy usage or feeding power back into the system. This approach enhances grid stability, optimizes energy distribution, and facilitates the integration of renewable energy sources. VPPs also allow building owners to participate in energy markets, selling excess power back to the grid to enhance revenue.

embue™

Image by Embue

To implement a VPP and PLM, a building must install power monitoring within the building to understand all areas of energy use, including electrical distribution, central equipment, individual apartments and common areas. Properties use power monitoring to collect data and analytics to identify trends, anomalies and areas of improvement. It is best to integrate smart building controls at the earliest design stage to ensure products are compatible, and to maximize demand response capability and controls.

Smart building controls that manage all major electricity consuming, producing or storage systems -- both in-apartment and central equipment -- to shape energy usage and consumption. Today, AI-driven systems, such as Embue, operate to analyze real-time data and historical patterns, dynamically adjust HVAC and building systems to improve energy efficiency, comfort and to feed predictive maintenance. This software can also obtain and store weather data to predict how buildings will operate under different conditions using digital twin technology.

These systems then connect to the grid to respond to requests to reduce peak electricity load and, optionally, sell energy into the grid through a marketplace. Both forms of interaction generate new revenue streams by selling energy back to utility companies during times of peak use and receive incentives for reducing peak demand.

Embue estimates a 64-unit multifamily building will be able to generate between $1,000 and $3,000 per year from the grid in this location based on current demand response programs available. A typical installation runs between $350-$500 for an apartment, taking the place of the existing thermostat, with a yearly subscription fee of $41/apt/year to support ongoing controls and operation.

Integrating solar panels into a VPP strategy is highly beneficial. Grid stress often occurs at times when solar production is high. VPP software can use solar energy to satisfy some of the cooling load in a building and reduce net electricity demand. Including BESS and solar with HVAC control could generate over $10,000 per year for the building.

The Lafayette team met with Embue to explore options on the building which included individual thermostats for each apartment which come with the potential for occupancy sensors and/or window open/close sensors to prevent the equipment from operating when windows are open. The software can handle demand response by only cycling on certain pieces of equipment at a time, such as operating the building in 3 sections where only 2/3 of the building heat pumps are operating at any given time to control the peaks. Using integrated strategies that can also link with EV charging demand response options can provide a building that is interactive with the grid.

EnergeX

Another option for demand control via equipment scheduling and linking with utility demand response programming is the EnergeX system utilizes a Wi-Fi smart thermostat that not only monitors interior temperature, but exterior conditions as well. The thermostat uses an open platform that integrates with commonly used building access applications, and all building thermostats can be controlled on a single dashboard by the building's property management team. Within the dashboard the management team can give the dwelling unit occupant control over temperature settings but set maximum and minimum temperature setpoints and control vacant units remotely. The system has both "event" and "scheduling" options to allow the management team to adjust the thermostats during a single grid-strain event or during hours of peak demand pricing. With a cost of around $130/thermostat the price is reasonable for the capabilities.

Final thermostat selection has not been made at design development stage.

Additional Carbon Emissions Reductions

There are additional high performance attributes that contribute to a low carbon building, including:

- Refrigerant Reduction: The project aims to reduce refrigerant lines, particularly those with field installed connections to reduce refrigerant leak potential. Refrigerant lines can leak an average of 1-3% per year. Self-contained HVAC equipment is less prone to leakage.
- Low Global Warming Potential Materials:
  - Concrete Selection: Lightweight concrete and fly ash are currently being evaluated to reduce the amount of concrete required without affecting strength and to reduce the transportation delivery costs. Concrete used for the slab on metal deck (elevated slab) is designed using a lightweight concrete system to reduce the amount of concrete needed.
  - The pre-manufactured wall framing will use 26% less wood than traditional framing techniques.
  - The Zip Wall system that will be utilized for framing utilizes lumber that is FSC certified and utilizes a lower GWP rigid insulation than other similar rigid insulations.
- Renewable Energy: The project will include solar rooftop PV system to offset building energy use and will fill as much available roof space as possible. Packaged HVAC systems allow more space for roof mounted PV panels.

Non-Energy benefits

Included in the original project energy road map there were certain features that contribute to owner and resident health and wellness that go beyond energy use. Those features are best to be considered as early as possible to make sure they are integrated into the building program. The project includes features and benefits beyond energy reduction, including:

- EPA Indoor AirPLUS Certification: By pursuing EPA Indoor AirPlus, the team will include additional low carbon material selections and design elements to enhance the comfort, health, and quality of the building. In addition, interior finishes will contain low VOC's for both the materials and all adhesives required. Using a third-party program such as the EPA is a recommended guide for projects looking to value the indoor air quality while utilizing national metrics and guides to the design and construction team, as they can also be used for incentives.
- Non-smoking: To reduce exposure to harmful airborne contaminants, the Lafayette building will be strictly non-smoking. No smoking is permitted anywhere on the premises including in apartments, common areas, and support offices, or within proximity of any exterior doorways. The non-smoking policy will be enforced by default provisions in the lease, including escalation documentation and penalties that could include lease termination. Particularly in buildings with tight envelopes and energy recovery ventilation, implementing smoke-free buildings is critical to the entire building air quality and is a recommended measure for all projects.

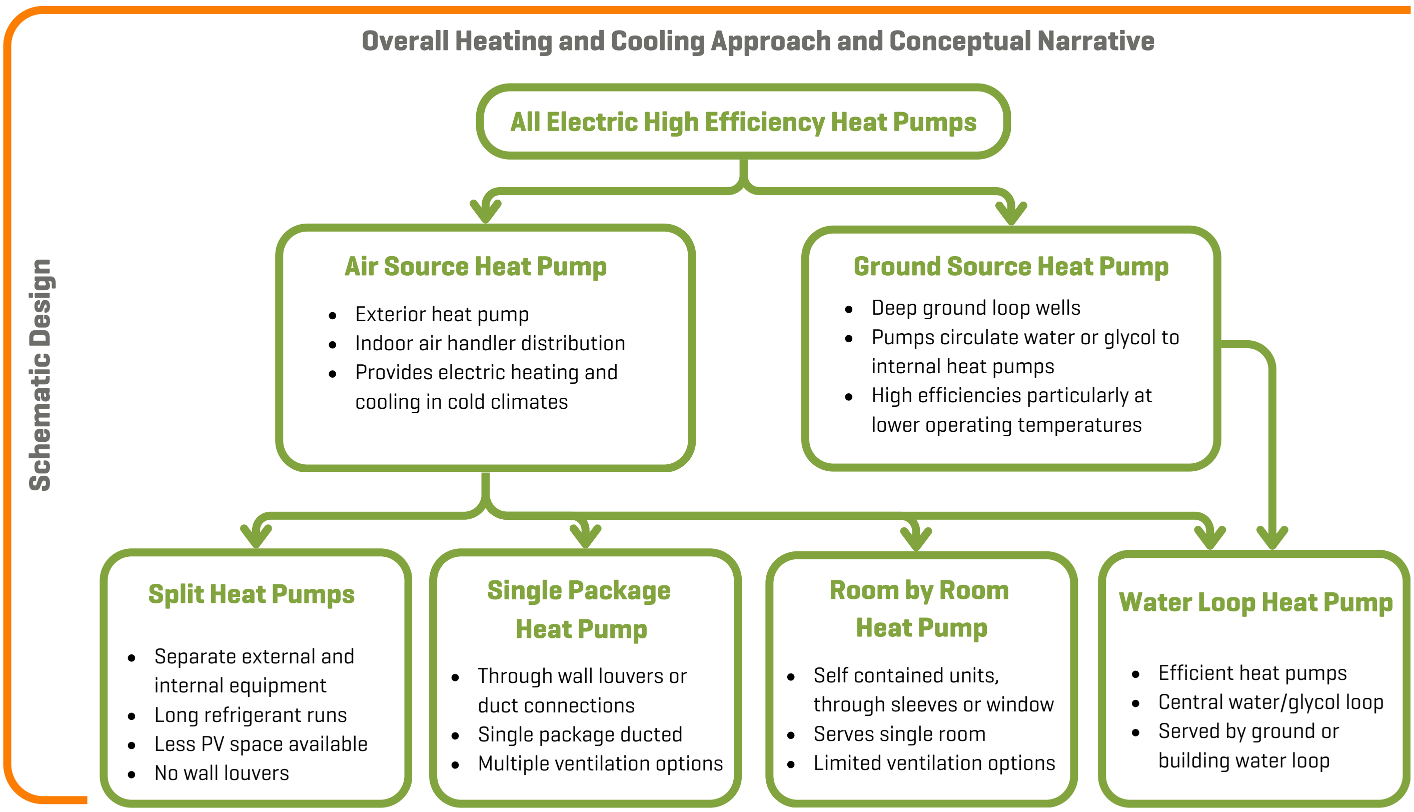
- On Site Gym Access: The fitness center will include all professional grade equipment: two treadmills, an elliptical, a stationary exercise bike, a double weight stack machine, a sit-up bench, resistance training equipment (TRX straps), and medicine balls are currently expected. Tenants will be able to access the gym 24/7 with the use of a key fob. Rosenblum Group typically hires a professional gym consultant to assist with the equipment selection and layout. This feature is unique to this project and provides an amenity valued in the market.
- Passive Survivability: The project will maintain comfortable and safe thermal conditions for residents through high efficiency heating, cooling, and ventilation equipment complimented by airtight compartmentalization measures to allow tenants better control of their apartment conditions, resulting in less conditioned air escaping through open windows and a healthier environment. The project is targeting additional insulation levels and air tightness to increase the building's ability to maintain temperature and other critical conditions during power outages or other extreme events like massive snowstorms. This benefit is a feature of the advanced energy goals and indoor air quality of the project.
- Co-Working space: The co-working space provides the ability to work on site and not have to utilize transportation which can contribute to lower overall emissions. The co-working space can be utilized as a gathering place during emergency weather events to provide information and support to the residents. This feature is unique to this project and provides an amenity valued in the market.

Appendix A: Mechanical System Selection Tear Sheet

Mechanical Selection Guide

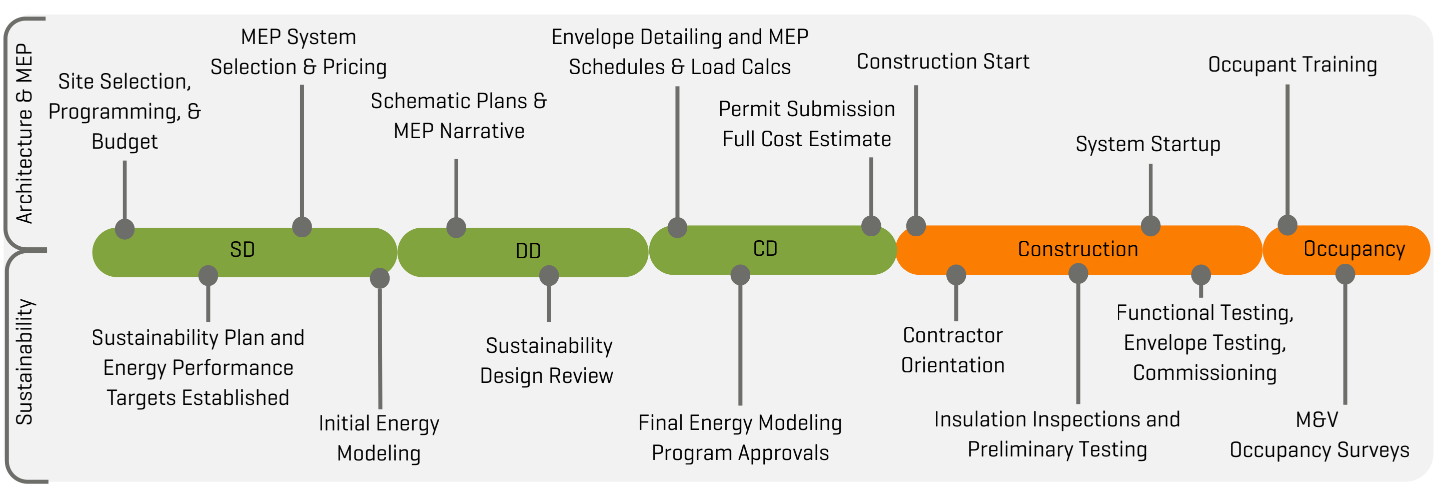
October 2025

The following guide provides mechanical selection options and recommendations based on Sustainable Comfort's experience in high-performance all electric multifamily housing projects across the Northeast. These systems are suggested for new construction multifamily projects, or renovations that include envelope upgrades. Systems should be selected for overall performance and reliability, initial installation cost, ability to provide and integrate with ventilation systems, ease of maintenance and replacement, and energy efficiency.



Integrated Design Process

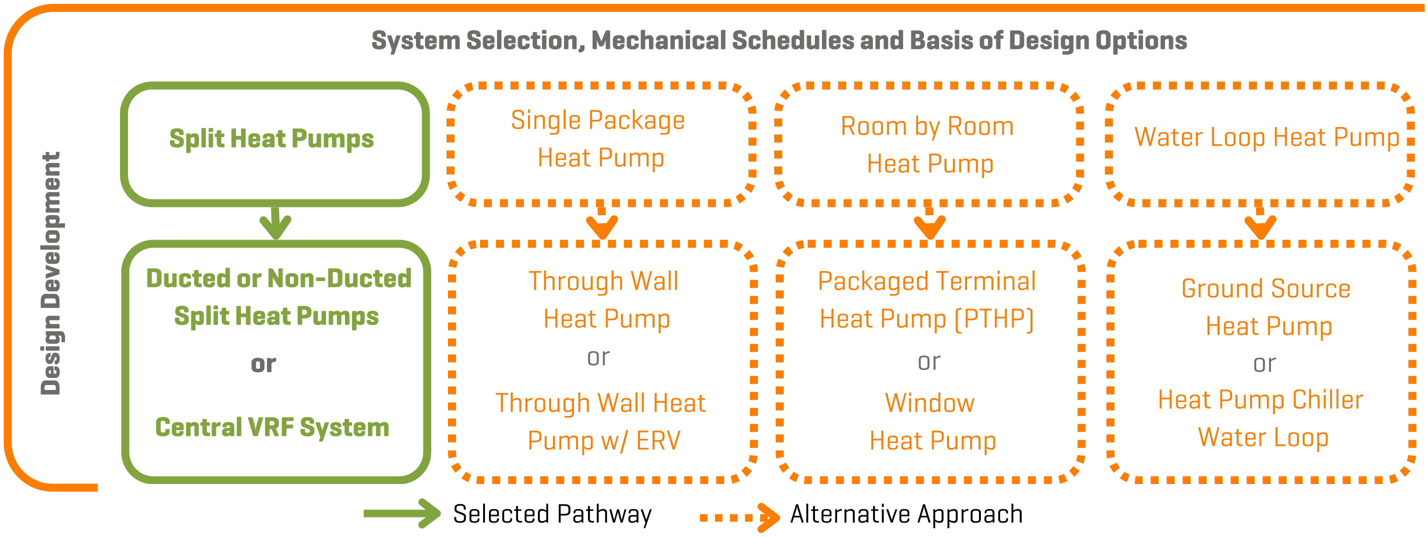
Selection of the mechanical systems is recommended in early schematic design, as features such as overall building efficiency, site plan and exterior visual impact can influence early architectural planning. Once options are determined, Sustainable Comfort can run initial energy modeling to estimate potential energy costs to provide feedback on decisions.



This guide was created in collaboration with NYSERDA Early Stage Design Support Program.

SUSTAINABLE COMFORT

Split Heat Pumps



Ducted or Non-Ducted Split Heat Pumps

Recommendations: Works well in most applications, especially for low rise with adequate roof, ground, or balcony space for condensers. Common system with available maintenance options. Suggest selecting a cold climate heat pump from the NEEP Cold Climate Database https://ashp.neep.org/

Pros:

- Known and readily available systems - Most common
- Highest available efficiencies for ASHP
- Can operate at low temps without backup heat
- Ducted or non-ducted options available

Cons

- Exterior space needed for condensers
- Roof mounted condensers reduce space for PV
- Long refrigerant runs increase chance of leaks
- No included ventilation

Image Courtesy of Mitsubishi

Image Courtesy of Mitsubishi

Central VRF System

Recommendations: Recommend avoiding for HVAC due to complexity and cost of installation, additional maintenance, and based on recent studies showing lower operating efficiencies.

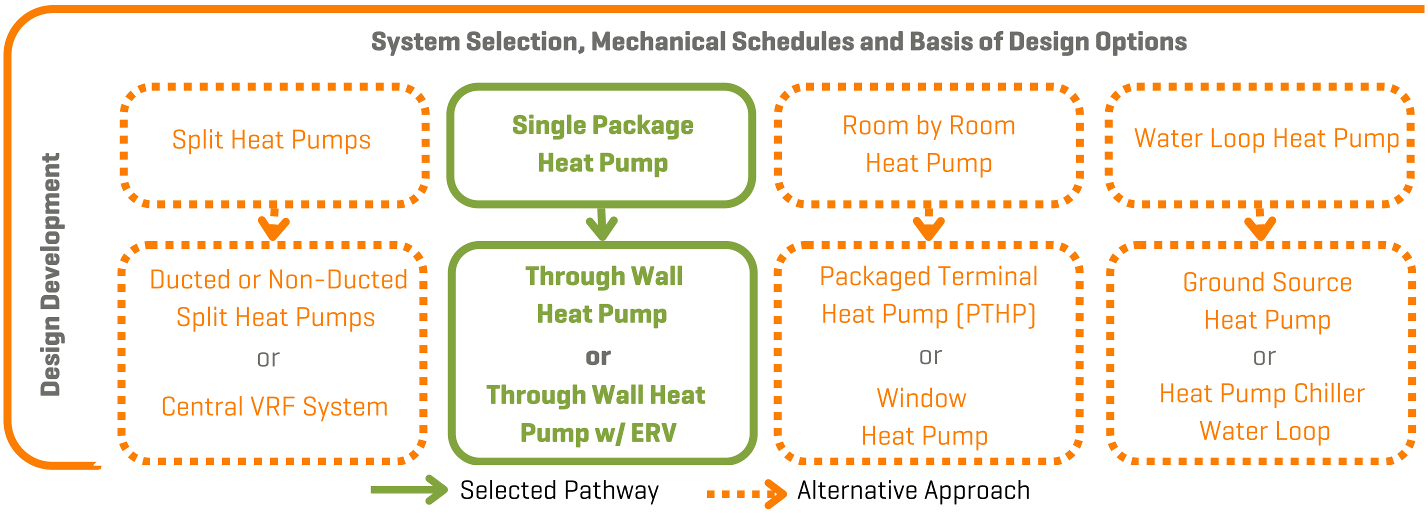
Pros

- Less exterior equipment w/ larger capacity
- Can be used to create hot water for use in systems such as domestic hot water
- Use where exterior space constraints exist
- Heat recovery systems available to reduce energy use

Cons

- High up front installation cost
- Long refrigerant runs in building
- Complex maintenance requirements
- Lower operating efficiencies found in multiple studies of real world performance.

Single Package Heat Pump



Through Wall Heat Pump (Ex. Friedrich VRP, Magic Pak)

<u>Recommendations</u>: Through wall packaged heat pump with supply only ventilation. Used when low cost, single equipment preferred or limited exterior space.

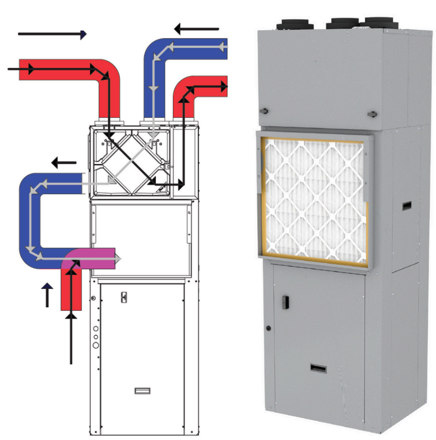
Pros:

- Lower initial installation cost compared to other systems
- Single package for heating, cooling
- No refrigerant runs or exterior condensers

Cons

- Ventilation provided through supply, no energy recovery at specific non-adjustable flow rates
- Typically lower operating efficiencies than split systems
- Backup electric resistance can increase operating cost
- Wall penetrations introduce thermal bridging and air leakage, not recommended for passive building

Image Courtesy of Freidrich



Images Courtesy of Fresh Pak

Image Courtesy of Epocha

Through Wall Heat Pump w/ ERV (Ex. Fresh Pak HP, Ice Air SPXC-ERV, Ephoca All-in-One Vertical Stack)

<u>Recommendations</u>: Through wall packaged heat pump with integrated ERV. Used when single equipment with integrated ERV preferred over separate ventilation systems, no refrigerant runs or exterior condensers, however lower operating efficiencies that split heat pumps.

Pros:

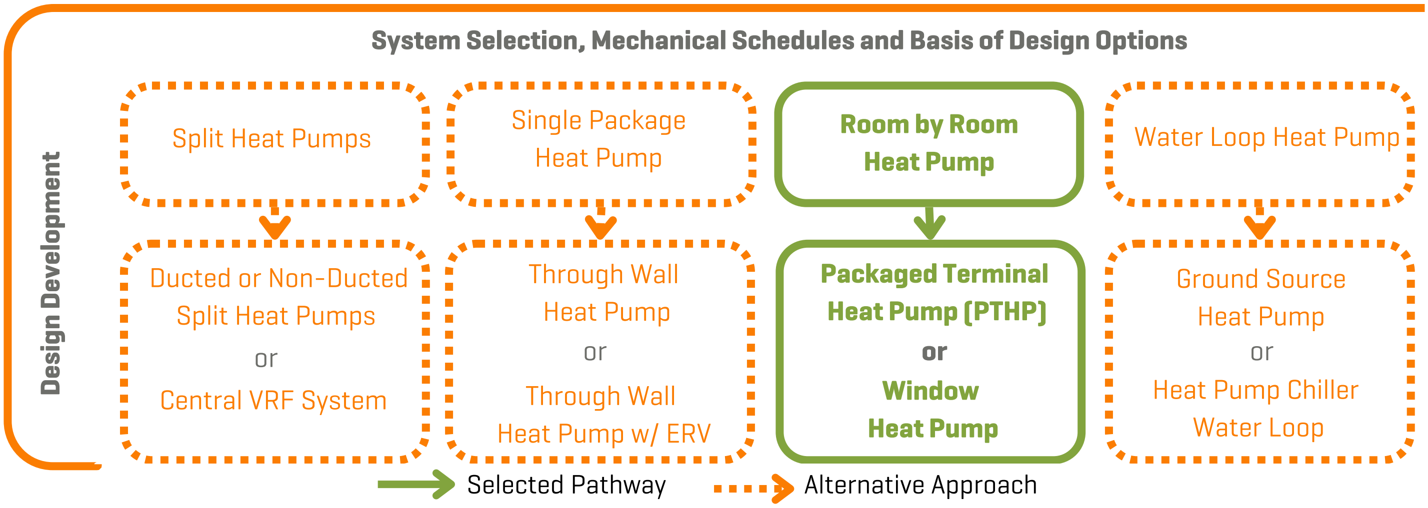
- Single package for heating, cooling, and ventilation
- Attached ERV provides efficient ventilation performance
- Same manufacturers typically provide options with and without ERV options

Cons

- Newer systems with new market entries
- Typically lower operating efficiencies that split systems
- Wall penetrations introduce thermal bridging and air leakage, not recommended for passive building

SUSTAINABLE COMFORT

Room by Room Heat Pump



Packaged Terminal Heat Pump (PTHP) (Ex. Ephoca All-in-One)

<u>Recommendations:</u> Fully packaged heat pumps with optional ERV module via wall penetrations. Works in rehab and new construction with PTAC replacement capability. Come with ERV modules, or single package serving single rooms.

Pros

- Integrated heating, cooling, and ventilation option
- Duct connections to outside lead to PTAC replacement options and use in rehabs
- No outdoor unit saves space on exterior for PV
- No refrigerant runs
- Potential use in passive buildings

Cons

- Smaller capacity units
- Lower efficiencies than split systems
- Custom systems require specialty knowledge

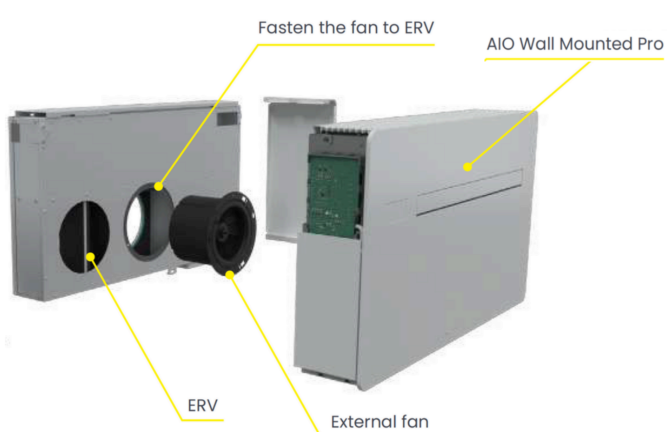


Image Courtesy of Ephoca

Image Courtesy of Gradient

Window Heat Pump (Ex. Gradient, Midea, Ephoca)

<u>Recommendations:</u> Great for moderate rehab electrification projects where single window unit can replace all other heating and cooling.

Pros

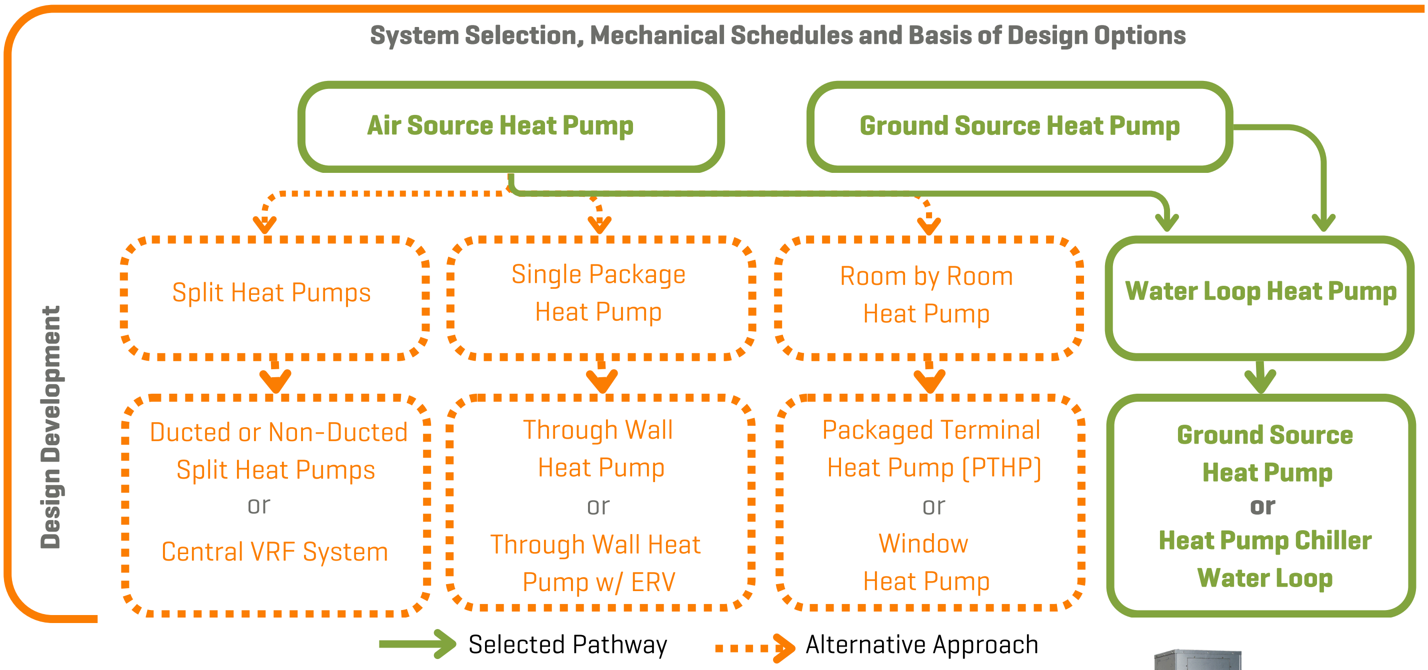
- Installs within an hour in each apartment
- No interior demolition needed to install
- 120V outlet capable
- Atomized condensate to eliminate dripping
- Energy savings compared to existing systems such as central steam

Cons

- Limited new construction applications
- Visually adds window unit at each room
- No ventilation options available

SUSTAINABLE COMFORT

Water Source Heat Pump



Ground Source Heat Pump

<u>Recommendations</u>: Ground source heat pumps served by a central ground water loop offer high operating efficiencies, however come with much larger initial costs due to well drilling and central pumps and water loop piping with in unit ground source heat pumps. Consider if you can maximize any federal tax credits, grants, and incentives or need reduced loads.

Pros:

- Highest operating efficiencies
- Can lower overall peak load on building electrical
- Maximize tax credits, grants, and incentives

Cons

- Highest initial installation cost
- More complex system to commission and maintain

Image Courtesy of Climate Master

Heat Pump Chiller Water Loop

<u>Recommendations:</u> When not using a ground source loop, it is possible to still use a building water loop to serve in unit water source heat pumps. Consider when low space constraints for condensers. The central loop would be served by a heat pump chiller to provide all electric central systems to serve the building water loop.

Pros

- Large central equipment creates hot and cold water for the building water loop
- In unit water source heat pumps
- No refrigerant runs

Cons

- Less common system in multifamily housing
- Central heat pump and in unit heat pump needed to maintain and operate efficiently
- Central water piping needed in building

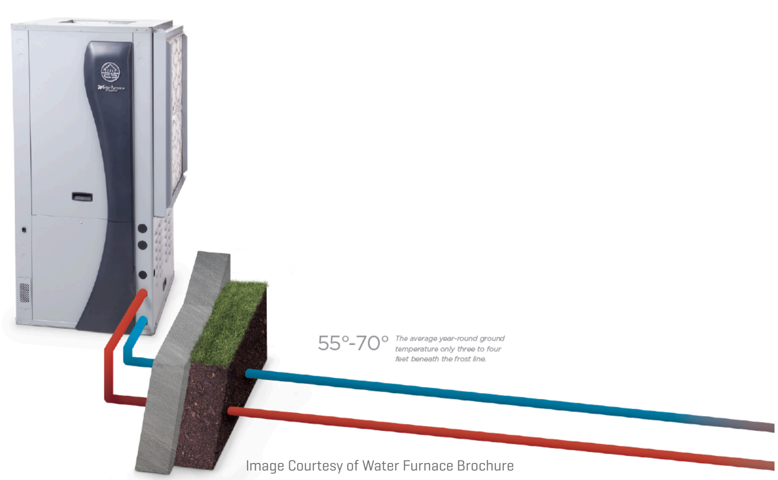


Image Courtesy of Water Furnace Brochure