NEW ECOLOGY
Community-Based Sustainable Development

Sustainability Strategic Plan

Riverside Station Mixed-Use Redevelopment

Newton, MA
June 9, 2020

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PROJECT SUSTAINABILITY GOALS

The Riverside Station Mixed-Use Redevelopment project (the "Riverside Development") presents a unique and generational opportunity to transform the sprawling automobile parking lot located at the Riverside MBTA multi-modal transit terminal. The proposed project will create a compact, walkable, and transit-oriented development that will create a new energy-efficient neighborhood. It will also substantially improve and reduce the impacts to the surrounding environment created by the existing parking facility by reducing the amount of paved areas and incorporating green infrastructure as recommended in the City of Newton's *Climate Change Vulnerability Assessment and Action Plan*. By creating a mixed use community adjacent to multiple modes of transit, the project will reduce the automobile dependency of both new residents and commercial tenants.

In addition to both minimizing environmental impact and improving access to transit, indoor environmental air quality and occupant comfort are at the core of the community vision adopted by the design team for the Riverside Development. To implement these broad sustainability principles, the project will incorporate the Green Newton *Green Building Principles* including minimizing building operating energy by methods that include Passive House design principles, minimizing embodied carbon, incorporating all-electric mechanical systems, and minimizing the carbon footprint for transportation. These standards dovetail with the 30-year roadmap identified in the *Citizens Climate Action Plan*, which also has a specific focus on encouraging the transition to electric vehicles (EVs). Mark Development understands the importance of a holistic, integrated design approach in achieving such ambitious goals, and has assembled a design team that has the experience and expertise necessary to realize this vision.

Mark Development is committed to be a leader in sustainability in the Newton community and pledges the following commitments for the Riverside Development:

1. Passive House design principles for the residential portions of the project, including certification of three residential buildings.
2. Electrification of the residential portions of the project to reduce fossil fuel dependence.
3. Embodied Carbon analysis guiding material selection.
4. Solar PV serving a portion of the common area load for the Passive House certified buildings and Solar Ready design for all building roofs. The parking garage will pursue solar installation through the MBTA.
5. Rainwater Reuse for Irrigation and substantial Green Stormwater Infrastructure
6. Electric Vehicle Charging stations for 10% of the project parking spaces[1] and provisions for future Electric Bus charging

Refer to Riverside Commitments Summary Table for building-by-building sustainability commitments.

[1] The quantity of EV charging stations within the MBTA parking spaces are to be determined by the MBTA

RIVERSIDE REDEVELOPMENT SUSTAINBILITY FEATURES

PASSIVE HOUSE DESIGN PRINCIPLES

The United Nations International Panel on Climate Change (IPCC) released a report in 2018 that clearly stated that eliminating greenhouse gas production by 2050 is needed in order to avoid catastrophic effects of climate change. As outlined in the Newton Citizens Climate Action Plan, the Newton Citizens Commission on Energy (NCCE) agrees with the IPCC and urges Newton developers to achieve these climate goals through Passive House design.

The Passive House building standard represents the future of building energy efficiency by encompassing stringent energy usage intensity thresholds combined with field performance testing to validate overall building performance. The Passive House Institute U.S. (PHIUS) is the main third-party certifying organization for Passive House buildings.

PHIUS's mission statement clearly defines the goals of the standard, which are directly aligned with the IPCC goals: "To develop and promote North American passive building standards, practices, and certifications for buildings, professionals, and products to create structures that are durable, resilient, comfortable, healthy, and super energy efficient."

The Riverside Development has made the commitment to design and build the residential portion of the buildings using Passive House Design Principles. These principles will include:

- High performing thermal envelope with continuous insulation
- Airtight construction with low air change rates
- Balanced mechanical ventilation systems for improved indoor air quality and comfort
- High performance windows and doors to manage solar energy and minimize leakage

The project team will conduct Passive House feasibility studies including energy modeling for the residential use portions of all residential buildings. The team has committed to achieving certification for the residential use portions of three of the residential buildings.

ELECTRIFICATION

As outlined in the Carbon Free Boston Summary Report 2019, "Achieving carbon neutrality will require Boston's buildings to be highly efficient and to move away from fossil fuel use for heating and other services. New buildings can be built to the highest possible performance standards, while avoiding the lock-in of fossil fuels." The impact of building design on the total greenhouse gas emissions in Boston is identified further in the report, "The GHG emissions from the use of electricity, heating oil, natural gas, and steam in Boston's buildings account for more than two-thirds of the city's total emissions."

Passive House design principles achieve the objective of reducing building energy usage intensity relative to code-compliant buildings. However, to minimize dependence on carbon fuel sources and corresponding GHG emissions, these buildings need to switch to all-electric design where feasible. Due to higher energy costs for electricity relative to natural gas, many projects face an innate challenge to overcome this imbalance to construct feasible projects. When Passive House design principles are coupled with electric heating, cooling, and domestic hot water generation, the impact of energy usage is reduced in overall life-cycle cost, thereby increasing project feasibility.

The Riverside Development has made the commitment to design and build the residential portion of the residential buildings with all-electric-sourced heating and cooling systems (heat pumps, variable refrigerant flow systems, etc.) in addition to electric domestic hot water generation, where practicable, based on space type and utility metering. In addition, the Riverside Development will explore the feasibility of electrification for the hotel and office buildings.

EMBODIED CARBON

As project operational energy consumption is reduced through Passive House design principles and other sustainability measures, the carbon emissions occurring during the construction phase become more prominent in the overall building life-cycle emissions.

To further understand these impacts, a preliminary embodied carbon analysis was performed to evaluate various envelope wall assemblies implemented for a previous project constructed by Mark Development. New Ecology, Inc. (NEI) examined the thermal performance of numerous wall assemblies in conjunction with embodied carbon to compare the impact of various construction materials.

The Riverside Development will continue to evaluate material selection during the design phase and consider both embodied carbon and thermal performance during the wall assembly selection process. High performance wall assemblies with low embodied carbon and high thermal performance will be identified and evaluated for use during individual building design.

SOLAR PV INSTALLATION AND SOLAR READY DESIGN

The Riverside Development team recognizes the promise of energy independence and reduced carbon emissions, through renewable energy sources such as solar PV panels. While the reduction of energy use realized by Passive House design and construction is the primary driver of reduced carbon emissions for the project, renewable power generation on-site is a visible measure that everyone can understand. For this reason, the project will install rooftop solar PV panels on portions of the residential building roofs to offset 25% of the common area energy use for the Passive House certified buildings. Additionally, and more importantly, the team has encouraged the MBTA to pursue a solar PV installation over the parking garage. The MBTA has agreed to solicit interest from solar PV vendors through a Request for Proposal (RFP) process. If this RFP is successful, it will result in the generation of a significant amount of on-site electricity generation and will be visible to the general public.

The Riverside Development team will further build on the positive impacts of the efficiency described above by incorporating electrical, structural, and other design elements that make all buildings "solar ready" for renewable energy systems. Solar Ready design means that the project team will engage in a roof mapping exercise during individual building design to identify roof areas suited to renewable energy system integration, and that those areas of the roof will have the structural capability to carry the dead load and uplift loads of a renewable energy system. In addition, Solar Ready areas of the roof will be free and clear of any mechanical systems or plumbing penetrations, which are a major contributor to reduced potential in terms of system size and production. All required electrical chases from the roof into the electrical room will be included in the design and construction of the building, and space will be left free and clear in mechanical rooms for locating inverters. Roofs will use high solar reflectance index materials as well to mitigate heat island impacts and significantly lower ground surface temperatures relative to the current site conditions.

SITE DESIGN AND WATER REUSE

By the Riverside Development's very nature, it will present a substantial environmental benefit to both its immediate surroundings and the area as a whole. Located adjacent to the Charles River, the reduction of impacts from stormwater runoff are of key importance. The existing parking facilities at both the Riverside Terminal and the adjacent Hotel Indigo represent over 10 acres of asphalt pavement that contribute substantial amounts of stormwater runoff directly into the Charles River, which is essentially untreated. By relocating and consolidating the parking into a single strucutre, automobiles will be parked where they are protected from the elements, and the salt, sand, and petroleum contamination associated with open-air parking will be drastically reduced.

The Riverside Development's site is currently a heat island hot spot, registering higher temperatures than the surrounding neighborhood due to the high percentage of impervious asphalt surface. The redeveloped site will provide more pervious green space and replace large sections of asphalt with buildings with high solar reflectance roofs, reducing the heat island effect. In recent urban climate preparedness studies, large buildings with white roofs and pocket parks resulted in the most significant heat island reductions relative to other land cover types such as asphalt parking areas or low-density asphalt shingle-roofed houses (https://www.cambridgema.gov/CDD/Projects/Climate/~/media/A3977AB1B6AB47D7BEE02AE4D0B1410B.ashx).

The proposed redevelopment of the site will incorporate several Low Impact Development (LID) measures to promote the treatment and return of groundwater to the subsurface aquifer. Portions of the lower roof areas that are visible to residential tenants may include planted "green roof" systems. A "green roof" contains live plants in a lightweight soil medium that is designed to retain precipitation. The water is then absorbed by the plants and returned to the air through transpiration. This process removes dissolved contaminants including phosphorus, when the roof is designed as a passive system that is not fertilized or watered. Phosphorus is a particular contaminant of concern in the Charles River watershed, of which the project site is a part. Additionally, on-street parking areas will be paved with pervious pavement to collect and infiltrate the "first flush" of stormwater from the streets before they reach the closed drainage collection system. The project will also include a subsurface stormwater retention and infiltration system designed to treat and retain stormwater within the site, further improving the water quality in the watershed and reducing the strain on the municipal drainage system.

A portion of the retained stormwater (cleaner roof drainage) will be utilized for site irrigation to reduce outdoor water consumption for the site.

LEED NEIGHBORHOOD DEVELOPMENT

The Riverside Development will follow LEED Neighborhood Development (ND) design strategies to integrate ten buildings into one cohesive site. Sidewalks, intersections, perimeter landscaping, and the main façade will welcome the community members and visitors based on LEED design criteria strategies. Landscaping and site improvements will further emphasize the social and environmental priorities of this project. Outdoor spaces will be designed to encourage social engagement, turf will be minimized on the project, and plantings will be drought tolerant and appropriate for the microclimates specific to each planting area.

To determine the feasibility of LEED ND certification, Mark Development completed an evaluation exercise to review the site design including a LEED ND scorecard checklist. It was determined that receiving LEED ND certification was achievable in practice as many of the credit requirements have already been incorporated into the site design. Due to the extensive certification cost to pursue LEED ND, the team opted to follow the design strategies listed below without pursing certification.

The following LEED Neighborhood Development credit design strategies will guide the site design and construction:

Smart Location & Linkage

- Smart Location
- Wetland and Water Body Conservation
- Agricultural Land Conservation
- Floodplain Avoidance
- Preferred Locations
- Access to Quality Transit
- Bicycle Facilities
- Site Design for Habitat or Wetland and Water Body Conservation

Neighborhood Pattern & Design

- Walkable Streets
- Compact Design
- Connected and Open Community
- Mixed-Use Neighborhoods
- Access to Civic & Public Space
- Access to Recreation Facilities

Green Infrastructure & Buildings

- Minimum Building Energy Performance
- Indoor Water Use Reduction
- Construction Activity Pollution Prevention
- Rainwater Management
- Heat Island Reduction

ELECTRIC VEHICLE CHARGING STATIONS

As outlined in the Carbon Free Boston Summary Report 2019, electric vehicle infrastructure needs to be drastically improved to meet the cities goals. "*Any remaining cars and trucks driving into and around Boston in 2050—including ride-hailing services—must run on low- or zero-GHG fuel or electricity. The City, region, and Commonwealth, along with utilities and other private sector partners, must help accelerate an affordable market transformation toward electric vehicles. Programs to support electric vehicle purchases and to build out local and regional electric vehicle infrastructure will help make EVs a more economic, convenient, and accessible solution.*"

Riverside Development residential and commercial tenants, visitors, and the community alike will desire access to EV charging parking spaces for both convenience and climate change mitigation. Mark Development understands that provisions for electric vehicle charging stations need to be implemented during construction to avoid extensive costs of upgrading the electrical infrastructure at a future date. Therefore, Mark Development is planning to implement EV charging parking spots at the Riverside Development for at least 10% of the project parking spaces, to be located in preferred locations for various users. This does not include the MBTA parking spaces. However, it is anticipated that the MBTA will choose to include a significant quantity of EV charging spaces as well.

In addition, Mark Development is committing to an additional 10% of parking spaces to be electric vehicle-ready to allow simple conversion to EV parking spots in the future. And provisions will be made such that the site is ready for potential future electric MBTA bus charging infrastructure.

TRANSPORTATION

It is expected that by its design, the project will exhibit a substantial reduction in demand for automobile use with many residents opting to forgo car ownership altogether and office tenants reverse-commuting from the Boston area. The site boasts extreme proximity to the adjacent light rail Riverside Terminal, which makes the site an appealing candidate for a development of this scale. In addition to the light rail facility, several bus and shuttle lines will reward residents, hotel guests, and commercial employees with easy, affordable, and clean transportation methods to the surrounding communities, downtown Boston, and even New York City.

The Riverside Development is planned as a full-service neighborhood and will include a variety of amenities including restaurants, retail spaces, and other services. This will ultimately mitigate the need for site occupants to depart the Riverside Development. A new connection to the surrounding Charles River Reservation will afford residents and employees access to acres of parks, trails, cross country skiing, golf, and other recreational opportunities all without the need for an automobile.

In addition, the design team will employ a Transportation Demand Management (TDM) plan including short term and long-term bike parking, Zip Car availability on the property, and designated spots and charging stations for low emitting vehicles and electric cars (and financial incentives for use of public transit by residents).

Bicycle Facilities

The Riverside Development includes 942 bicycle parking spaces throughout the site and buildings available for the various users, including residents, office tenants, retail and hotel employees, visitors and MBTA commuters. 854 of these spaces will be located in secure and weather protected locations including interior bike rooms and bike cages.

Residential bicycle use shall be encouraged throughout the development through the provision of 610 safe, convenient, covered, and secure long term bicycle parking areas. This amounts to more bicycle storage facilities than residential units in the development, resulting in a bicycle parking to residential unit ratio of 1.05.

In addition to interior bicycle parking spaces, bicycle racks will be provided at a minimum of one per approximately 200 linear feet of sidewalk edge at all retail frontages to promote community bicycle travel. Additionally, a well-lit bicycle rack will be provided adjacent to each major entrance to office and residential buildings at the nearest advantageous location (no further than 75').

MECHANICAL SYSTEMS

Mechanical systems selected and sized to meet the minimal heating and cooling loads and ensure comfort will complement the advanced building envelopes incorporated in the design. The design team has performed a life cycle cost analysis of the preliminary design for the first residential building to facilitate informed decision-making around envelope design and mechanical system selection. This analysis provides a more holistic view of the implications of the performance, operating cost, and carbon impacts of options under consideration.

The life cycle cost analysis includes all-electric systems (heat pump and VRF) compared against natural gas-based hydronic systems. This evaluation informed preliminary mechanical system design options and allowed the MEP consultants to understand the design principles early in the design stage.

The design team included Massachusetts incentive programs during the life cycle cost analysis that support installing VRF and air-source heat pump systems for mixed use buildings.

Low flow, high performance fixtures that meet or exceed the EPA WaterSense standards will also be integrated to reduce water and energy use while maintaining tenant comfort.

LIGHTING AND ELECTRICITY

Appliances will be top performers in function, design, energy, and water efficiency. Electrical load will be reduced through smart lighting design that takes full advantage of the efficient, reliable, and attractive LED fixtures and lighting controls that are now available.

INDOOR AIR QUALITY

Of equally important consideration are the indoor air quality impacts of our approach. Mark Development is committed to providing individuals and families with a living environment that enhances their lives and health. Mark Development will accomplish this through two methods: ventilation and material selection. Ventilation systems will be designed to provide fresh supply air directly to each apartment. Toxins and contaminants will be minimized through careful specification of low VOC and no added urea formaldehyde materials.

TRAINING, TESTING, AND VERIFICATION

Managing the transition from modeled performance to achieving real world performance is a main focus for this project. A series of on-site trainings, inspections, testing, and continuous feedback to the team will be the primary tools used to ensure designed and modeled approaches translate to performance achievement.

As part of this process, the Riverside Development team will:

- Hold a pre-construction trades training focused on trade specific best practices around performance-based construction;
- Review submittals for greening compliance;
- Conduct testing and inspections by certified HERS raters and PHIUS verifiers that include:
    - Foundation insulation inspections
    - Insulation and air barrier inspections
    - Mock-up level duct leakage and compartmentalization testing
    - Final duct leakage testing
    - Final compartmentalization testing
    - Flow testing on water use fixtures
- Train and educate the buildings operations staff on the green features of the building and how to operate and maintain them; and
- Train and educate the residents of the buildings on the green features and how to minimize environmental footprint.

FUNDAMENTAL COMMISSIONING

Fundamental commissioning provides another critical layer of oversight that will be integrated into the Riverside Development. Heating, cooling, ventilation, domestic hot water, lighting, and other mechanical systems will be submitted to performance testing and verification process to ensure proper installation and operations. As part of this process, a certified commissioning agent will:

- Develop and implement a commissioning plan
- Verify installation and performance of systems to be commissioned
- Provide a summary commissioning report to the building owner

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Riverside Redevelopment - Sustainability Commitments Summary

Building+B 4:E9	Building Type			Secondary Use		Newton Ordinance Sustainability Pathway		Construction Standards	Electrification	Embodied Carbon	Electric Vehicle Chargers	Electric Vehicle Ready	Solar PV Source Energy**	Solar PV Ready
[#]	[Type]	[Units]	[sf]	[Type]	[sf]	[12.4.A.1 - LEED Gold Certifiable]	[12.4.A.2 - Passive House]*	[-]	[Yes/No]	[-]	[%]	[%]	[Y/N]	[Y/N]
1	Office	0	243,387	-	-	Silver Certifiable	-	Market Standards	Explore Electrification	Guiding Material Selection	-	-	No	Yes
2	Hotel	150	77,300	-	-	Silver Certifiable	-	Market Standards	Explore Electrification	Guiding Material Selection	-	-	No	Yes
3	Residential	137	153,683	-	-	Certifiable	Explore Certification	Passive House Principles	Yes	Guiding Material Selection	-	-	No	Yes
4	Residential	107	122,810	Retail	3,792	Certifiable	Explore Certification	Passive House Principles	Yes	Guiding Material Selection	-	-	No	Yes
5	Residential	50	57,200	-	-	Certifiable	Explore Certification	Passive House Principles	Yes	Guiding Material Selection	-	-	No	Yes
6	Residential	57	65,135	Retail	6,886	Certifiable	Explore Certification	Passive House Principles	Yes	Guiding Material Selection	-	-	No	Yes
7	Residential	46	54,265	Retail	7,785	Certifiable	Certification	Passive House Principles	Yes	Guiding Material Selection	-	-	Yes	Yes
8	Residential	76	62,146	Retail	3,218	Certifiable	Certification	Passive House Principles	Yes	Guiding Material Selection	-	-	Yes	Yes
9	Residential	44	42,330	Retail	21,561	Certifiable	Explore Certification	Passive House Principles	Yes	Guiding Material Selection	-	-	No	Yes
10	Residential	100	96,002	-	-	Certifiable	Explore Certification	Passive House Principles	Yes	Guiding Material Selection	-	-	No	Yes
Garage	Garage	1971 Spots***	-	-	-	N/A	N/A	-	-	-	10%	10%	MBTA RFP	Yes

*One additional residential building will be certified.
**One additional residential building will have a 25% of the common area load as solar PV.
***1000 of the 2011 parking spots on the site are owned by MBTA. It is anticipated that the MBTA will choose to include EV charging spaces as well.

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Riverside Station Development
Mark Development LLC
Newton, MA

This memorandum intends to clarify and define the concept of 'Passive House Principles' for the residential buildings that will not pursue Passive House Certification within the Riverside Station Development. Below is an outline of the criteria that these buildings will be required to meet. Additionally, a table is attached to compare various design and construction parameters between a code compliant, Passive House Principles and Passive House Certified building.

Passive House Principles Design:

1. **High performing thermal envelope with continuous insulation**
   - Minimizes thermal bridges throughout entire building envelope assembly mitigating cold spots and potential for condensation.
   - 1" of exterior insulation for wall assemblies with thermal break attachment system to minimize thermal bridges (wood furring strips). Given the thermal bridging of conventional commercial cladding attachments (reducing the effective R-value of exterior insulation 50-80%) this thermal bridge-free 1" of insulation will be more effective than 2" of insulation with conventional z-girts.

2. **Airtight construction with low air change rates**
   - New Ecology has achieved 2ACH for whole building blower door test through attentiveness on design detailing, on-site quality control, and testing in otherwise conventional construction. It is expected that this level of tightness will be achieved on the Passive House Principles buildings through our oversight, testing and verification.
   - A high quality air barrier will be used. Tyvek type stapled air barrier will not be implemented.
   - These buildings will be LEED Gold Certifiable and will need to achieve LEED v4 Enhanced Compartmentalization credit air tightness of 0.15cfm/sf.
   - New Ecology expects to achieve air infiltration rates of 0.33cfm50/sf of envelope for a whole building blower door test.

3. **Balanced mechanical ventilation systems for improved indoor air quality and comfort**
   - Passive House Certified and Passive House Principles buildings will have same mechanical systems design.
   - Continuous operation of central ERV results in high indoor air quality for occupants. Centralized approach reduces the quantity of 'holes' in the building that

are needed for decentralized unit level ERVs or non-ERV type systems drastically improving air tightness and reducing locations of potential water penetration.
- Fully electric heating, cooling and domestic hot water eliminate site generated carbon emissions.
- Ventilation, heating and cooling strategies are above and beyond code requirements. Code does not require balanced energy recovery ventilation.

4. **High performance windows and doors to manage solar energy and minimize leakage**
   - Windows will be ENERGY STAR certified. This is above and beyond code requirement.

Testing and Verification

The following testing and verification procedures will occur for 'Passive House Principles' buildings in the Riverside Station Development.

1. **Compartmentalization (unit blower door):**
   - NEI will perform multiple plan and spec reviews identifying air leakage detail improvements and requirements.
   - NEI will ensure architect will include dedicated compartmentalization and air sealing drawings to accurately and concisely cover scope.
   - NEI will perform a green contractor training session with GC to review the requirements of air-tightness early on in construction.
   - Project will follow LEED v4 Enhanced Compartmentalization protocol testing with defined sample size to meet 0.15cfm/sf.
   - Project will implement a mock-up mid-point testing procedure to address any leakage challenges early in the construction phase.
   - A certified HERS Rater (who will also likely be a Certified Passive House Rater) will perform the compartmentalization testing.

2. **Whole Building Blower Door:**
   - An NEI Certified Passive House Consultant (CPHC) will be immersed in the design and construction process.
   - NEI will visually inspect envelope and air barrier installation to ensure air tightness requirements are met.
   - NEI will perform multiple plan and spec reviews identifying air leakage detail improvements and requirements.
   - NEI will perform a green contractor training session with GC to review the requirements of air-tightness early on in construction.
   - NEI will perform a whole building blower door mid-point test to identify location or air leakage that can be remedied.
   - NEI will perform a final whole building blower door to meet 2ACH.
   - A Certified Passive House Rater (who will also likely be a certified HERS rater) will perform the whole building blower door test.

		Code Compliant	Passive House Principles	Passive House Certified
Envelope - Window	[Btu/hr.sf.F]	U-0.45	U-0.28	U-0.22
Envelope - Wall	[R-value]	No requirement, modelled at: R-18	R-18 (1" continuous insulation)	R-28 (2" continuous insulation)
Envelope - Roof	[R-value]	No requirement, modelled at: R-30	R-30	R-70
Envelope - Slab	[R-value]	No requirement, modelled at: R-10 (only for 2ft)	R-10 (continuous for whole slab)	R-10 (continuous for whole slab)
Site Energy Use Intensity	[kBtu/sf/yr]	46.9*	22.6**	18.1**
Source Energy Use Intensity	[kWh/person/yr]	13,323*	6,420	5150
Site Emissions	[mtCO2e]	237***	0	0
Whole Building Infiltration	[cfm50/sf]	No requirement, typical: 0.99-1.65	0.33	0.06
	[ACH50]	No requirement, typical: 6-10 ACH50 common	2	0.36
Compartmentalization (Unit)	[cfm/sf]	No requirement	0.15	0.15
Testing & Verification	[-]	No requirements	• Whole building blower door testing • Unit blower door testing • Unit duct tightness testing	• Whole building blower door testing • Unit blower door testing • Unit duct tightness testing • PHIUS verification
All Electric	[yes/no]	No	Yes	Yes
Heating & Cooling	[-]	Gas fired, DX cooling, in-unit combustion hot water heater	Mini-split air source heat pump	Mini-split air source heat pump
Ventilation	[-]	No ERV, back of unit outside air duct per unit, bathroom & kitchen exhaust	Central ERV	Central ERV
Domestic Hot Water	[-]	Gas fired combustion in-unit hot water heater	Electric storage	Electric storage

*From PNNL *Estimated Energy Use Intensity by Building Type – Standard ASHRAE 90.1-2013* table.
**Modeled results; does not include thermal bridge calculations.
***ENERGY STAR, NEWE 74.94kg/Mbtu CO2 Emissions Equivalent

Table 1: Comparison of design and construction parameters between a code compliant, passive hose principles and passive hose certified building