

Whole Homes

ENGS 44: Group 1



Personas

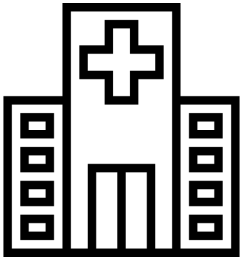
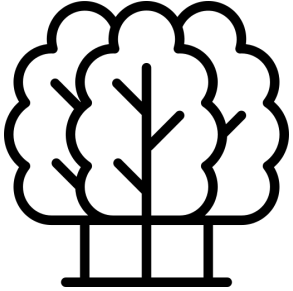
Young professionals (20's and 30's years old)

Singles and couples (no families)

Working weird and long hours

Value healthy living if able to be added to existing busy schedules

Building layout conducive to small nudges toward healthy living



Values of a Healthy Lifestyle

Holistically Healthy

Creating a Sense of Place



Values



Spiritual: Inviting and centrally located Green Space



Physical: healthy eating & exercise (2.5 hours of heart pumping/week)



Emotional/Mental: Need 8-9 hours of sleep. Looking for stress reduction



Environmental: welcoming and sustainable housing

Values



Financial: Two unit types (One for Affordable studios / One for couples)



Occupational: Easy access and visibility to the Rail Trail for everyone & a bike room with a pump



Social: Space in units to host friends and social spaces on first floor



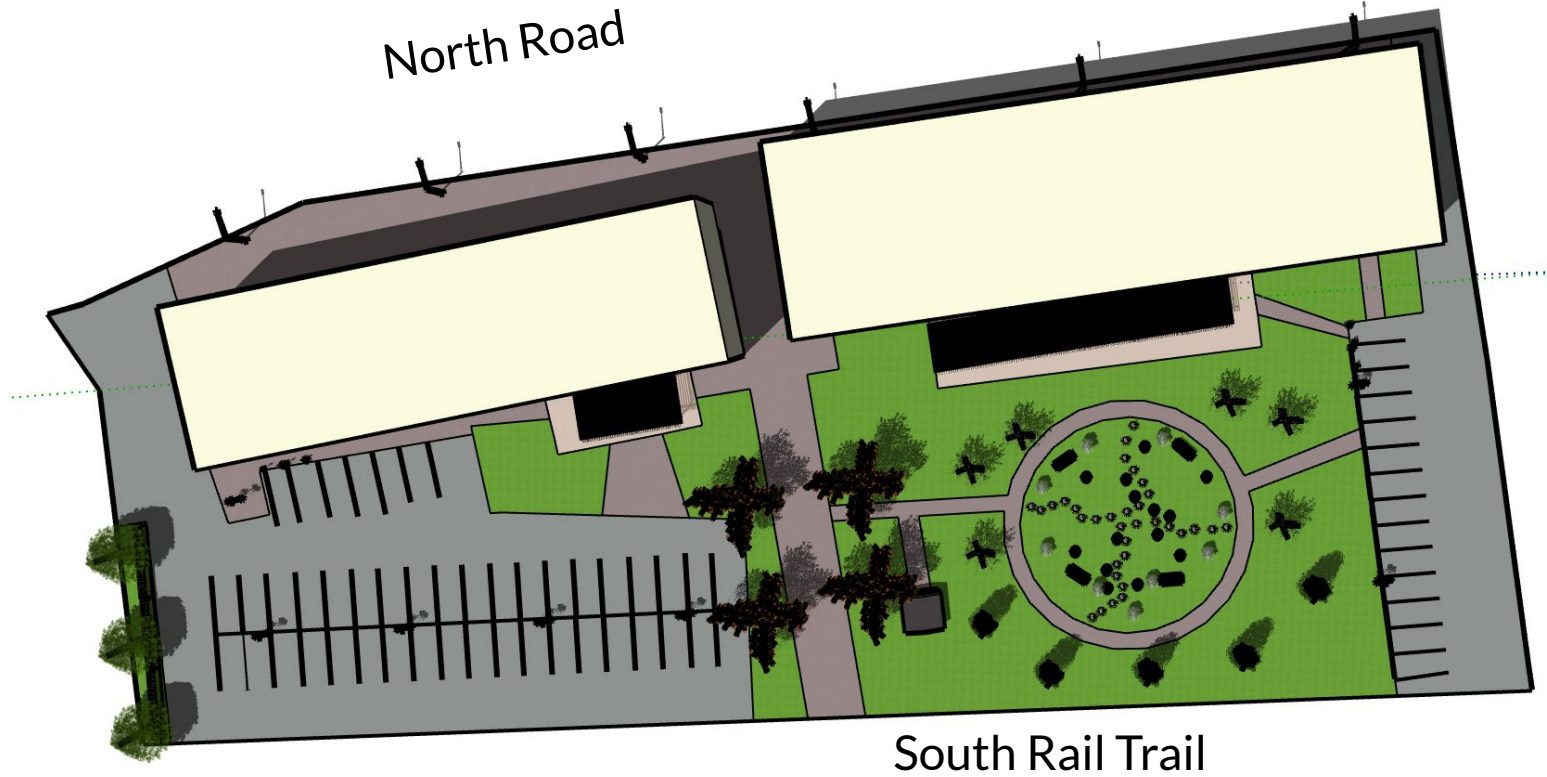
Intellectual: Using available resources around them to expand knowledge, improve skills, and create potential for sharing with others

Inspiration

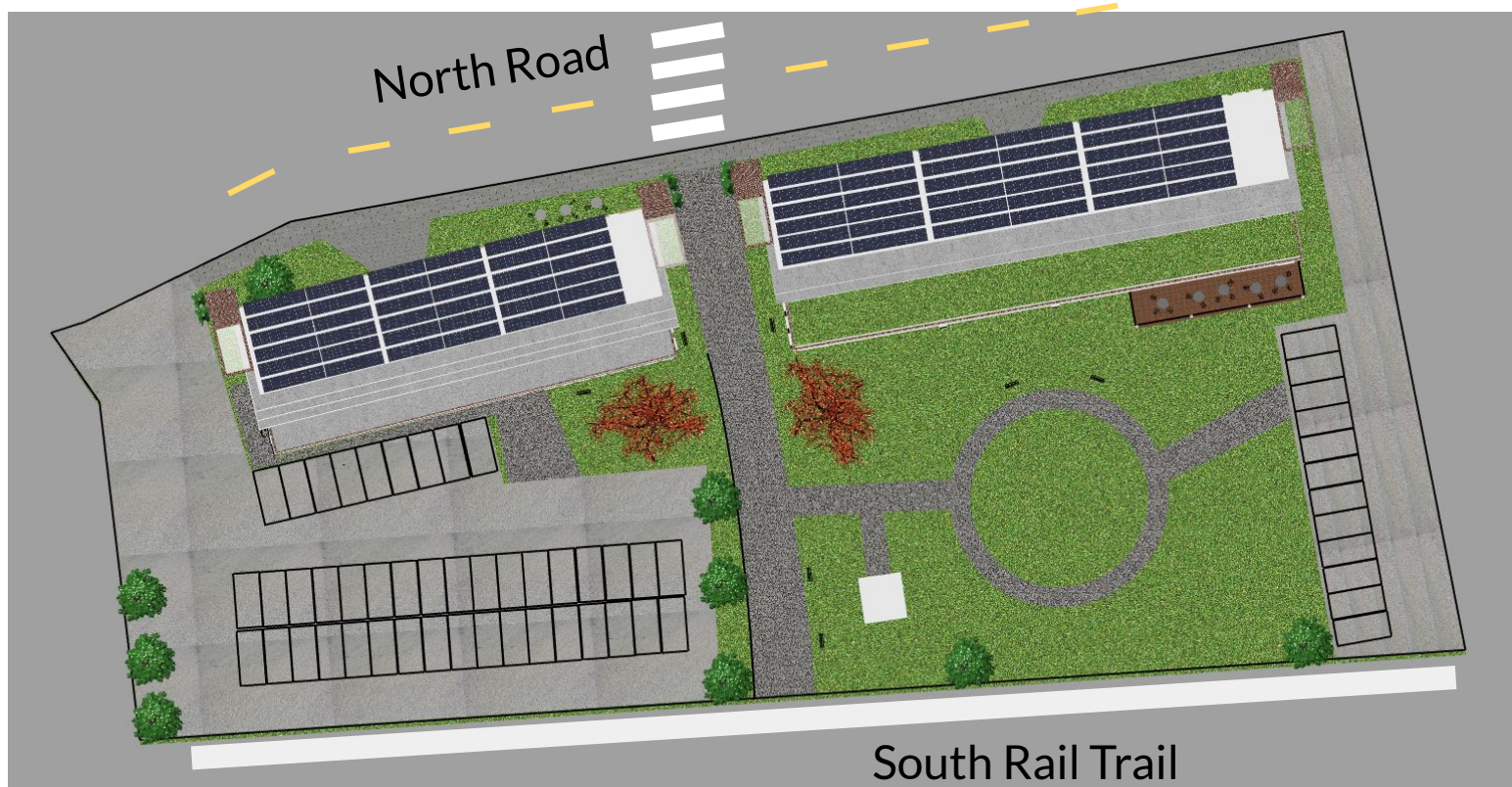


Inspired by architecture in Hanover & Lebanon and converted mill buildings

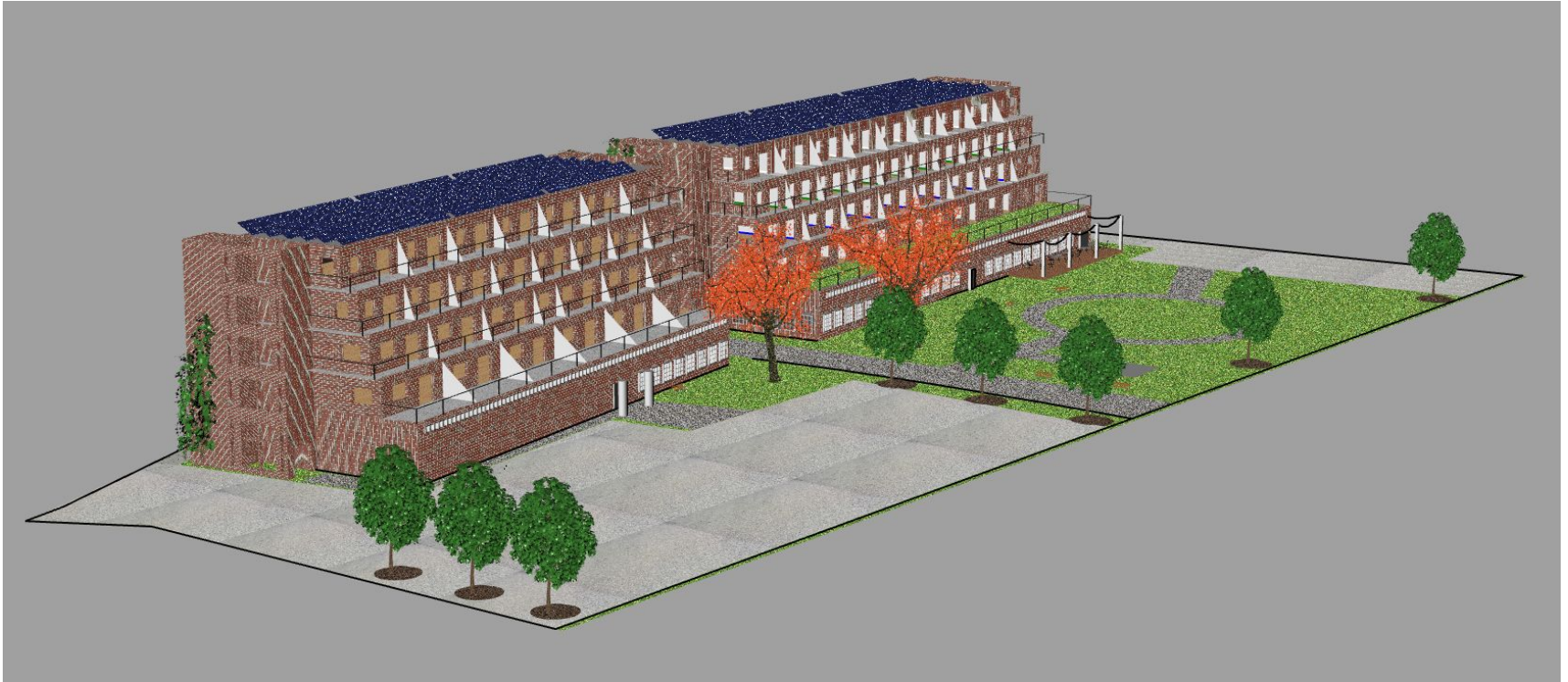
Layout



Layout



Layout - cascading



Layout



Layout



Layout



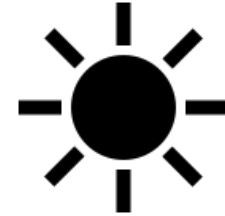
Building overview



61 Total Units



60 Parking Spots



215,760 kWh
Produced Yearly
from Solar



34 Studios



27 One
Bedroom



84 Estimated
Residents

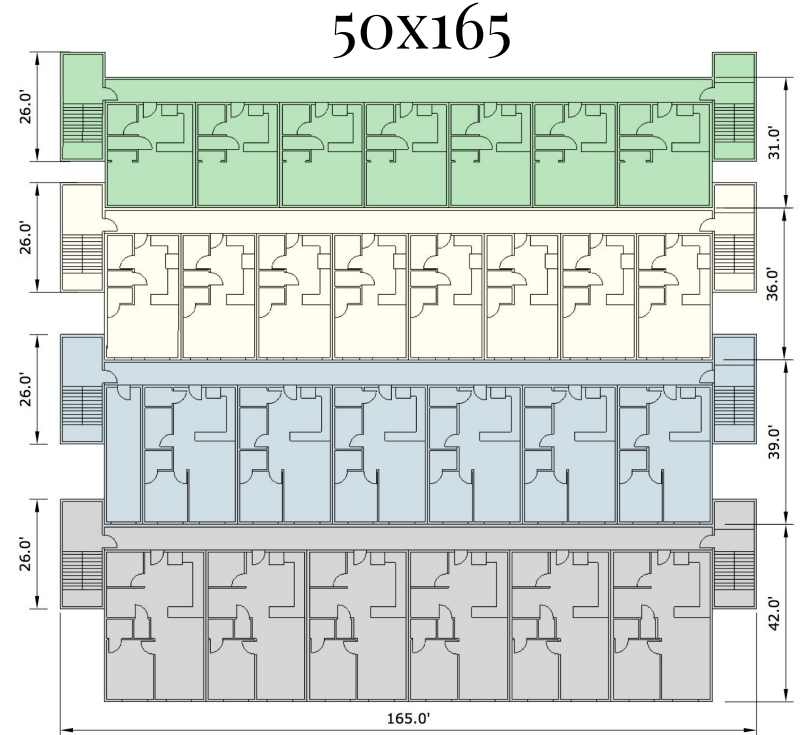
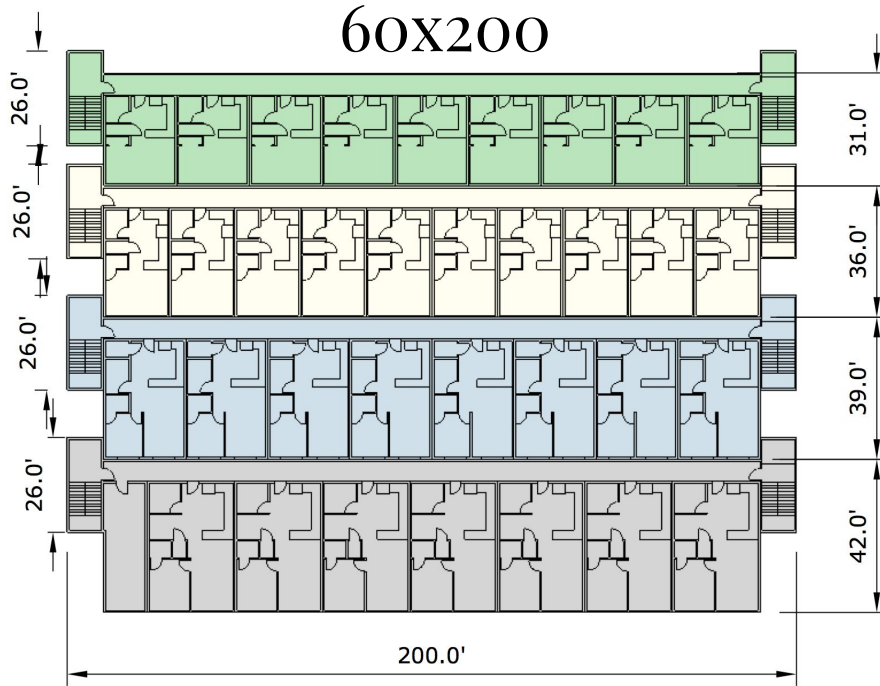


612,279 kWh
Yearly Electrical
Consumption

Residential Space

Residential Floor Plan

- 2nd Floor
- 4th Floor
- 3rd Floor
- 5th Floor



Interior Values



Emotional/Mental: all spaces incorporate a calming, neutral color palette and sleep-promoting elements such as healthy light bulbs and opaque shades



Spiritual: Spa-like elements incorporated into bathroom to create zen space, clear sightlines make small spaces feel bigger



Physical: Fridges with filtered water, kitchen with ample space for food preparation

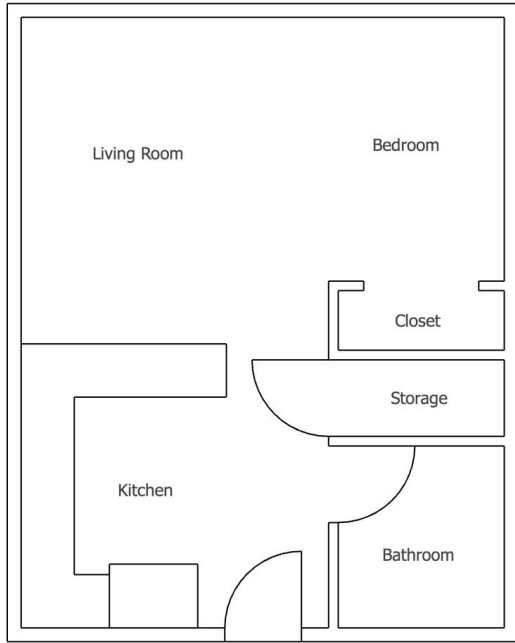


Social: ample space to have friends over on weekends

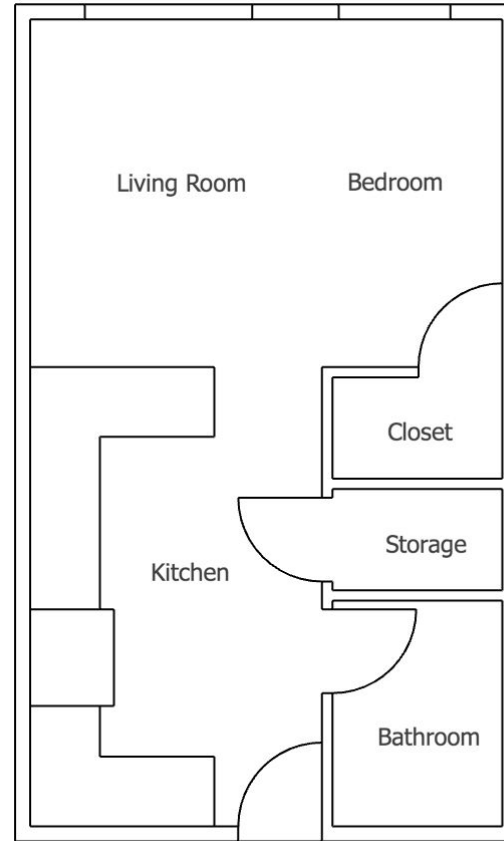


Environmental: clean air, exposure to natural light

Studio Layouts

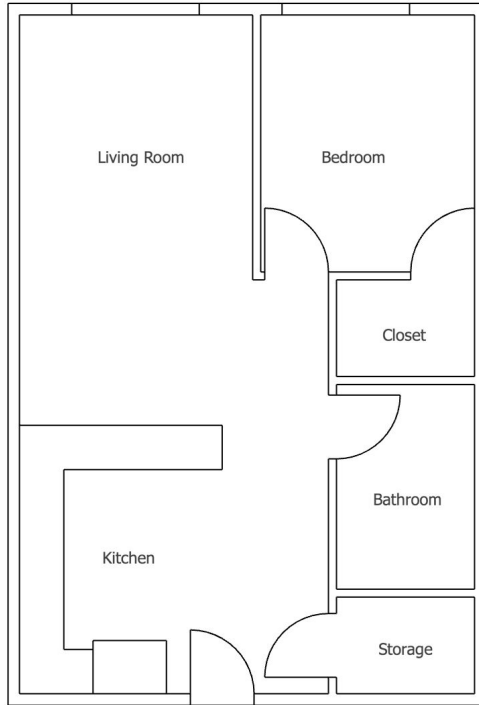


20X25

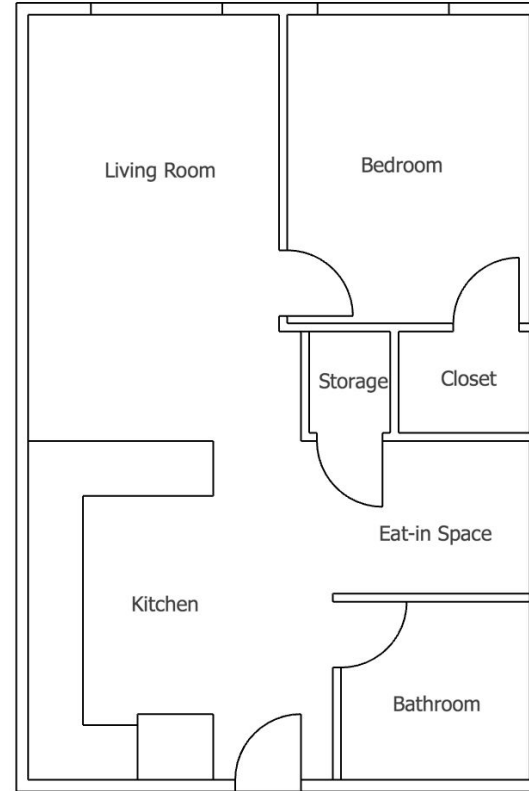


18X30

1 BR Layouts

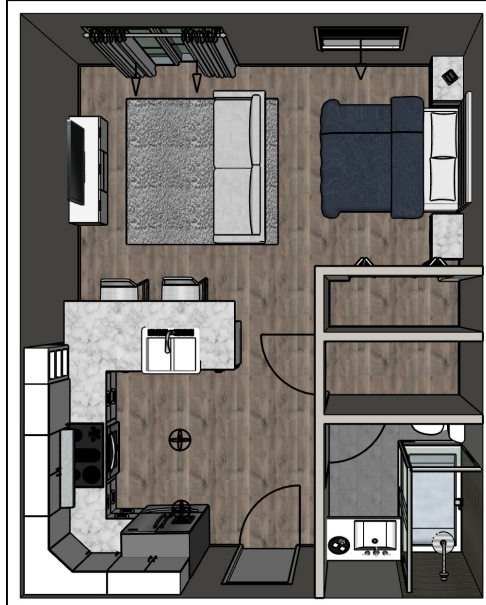


22.5X33



24X36

Smallest Studio vs Smallest 1 BR



Studio Example Space



Commercial Space

Commercial Units

Building 1

Sit-Down Cafe

- About 3,813 ft²
- Inspiration: KAF
- To-go and sit-down options
- Mid-range price
- Bar area

Workout Space

- About 4560 ft²
- Large floor space
- Weekend classes (i.e. Yoga or TRX)
- Basic exercise equipment for easily accessible workouts

Community Lounge Space

- About 1406 ft²
- Comfortable seating area
- Promotes **community / social interaction**

Commercial Units

Building 2

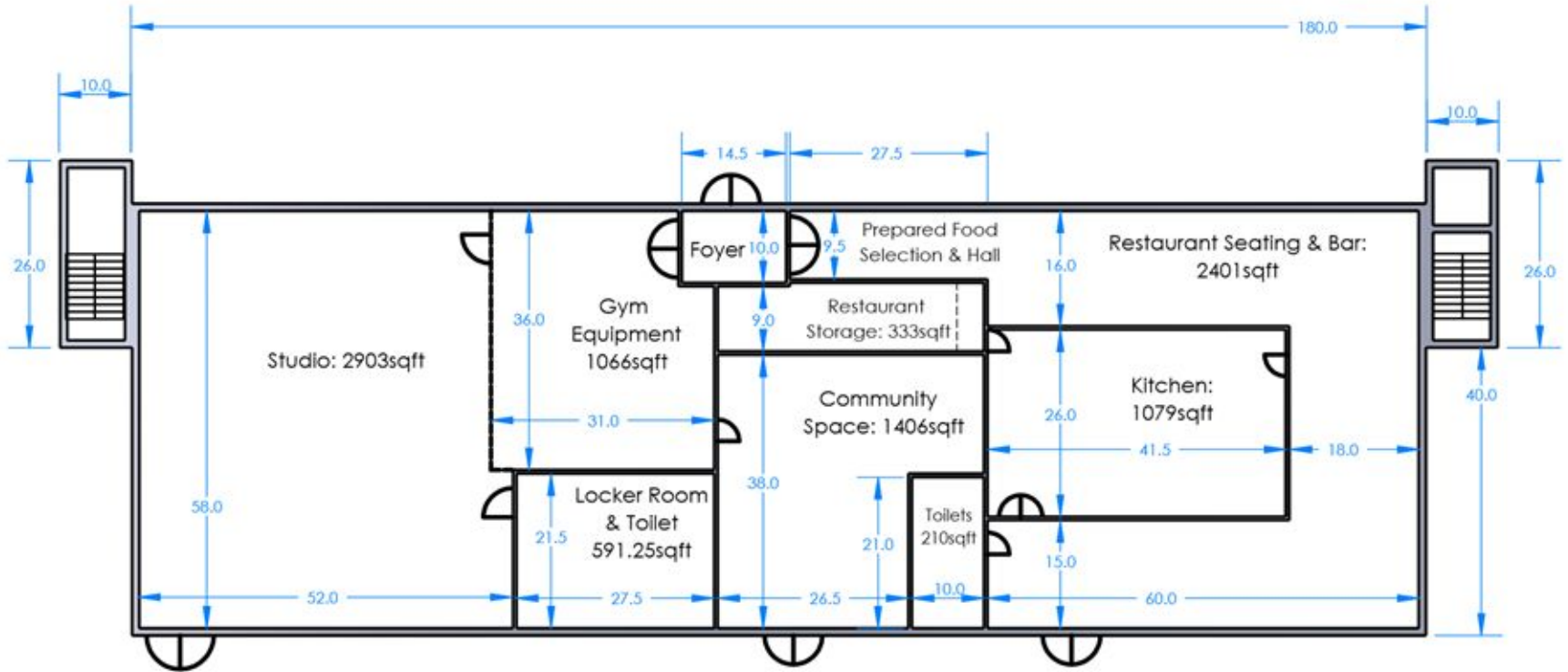
Bike Room / Shared Sporting & Outdoors Equipment Closet

- About 896 ft²
- **Bike Room**
 - Strategic placement of the bike room encourages biking rather than driving
- **Outdoors equipment closet**
 - Shared outdoors equipment for tenants to use
- Promotes **physical well-being**

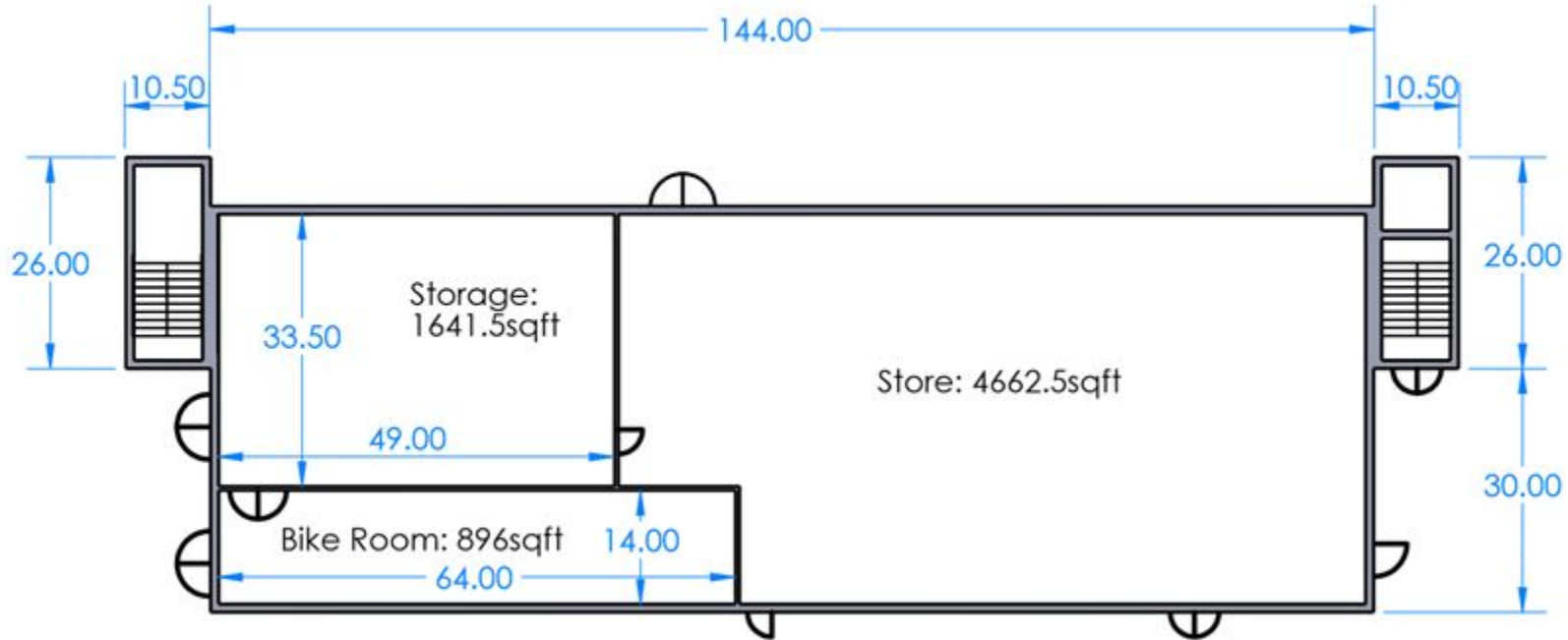
Health Food Store

- About 6,303 ft²
- No nearby grocery stores
- Focused on **local & fresh produce** (i.e. COOP)
- Has some prepared food
 - Chopped salads
 - Soups
 - Juices / Smoothies

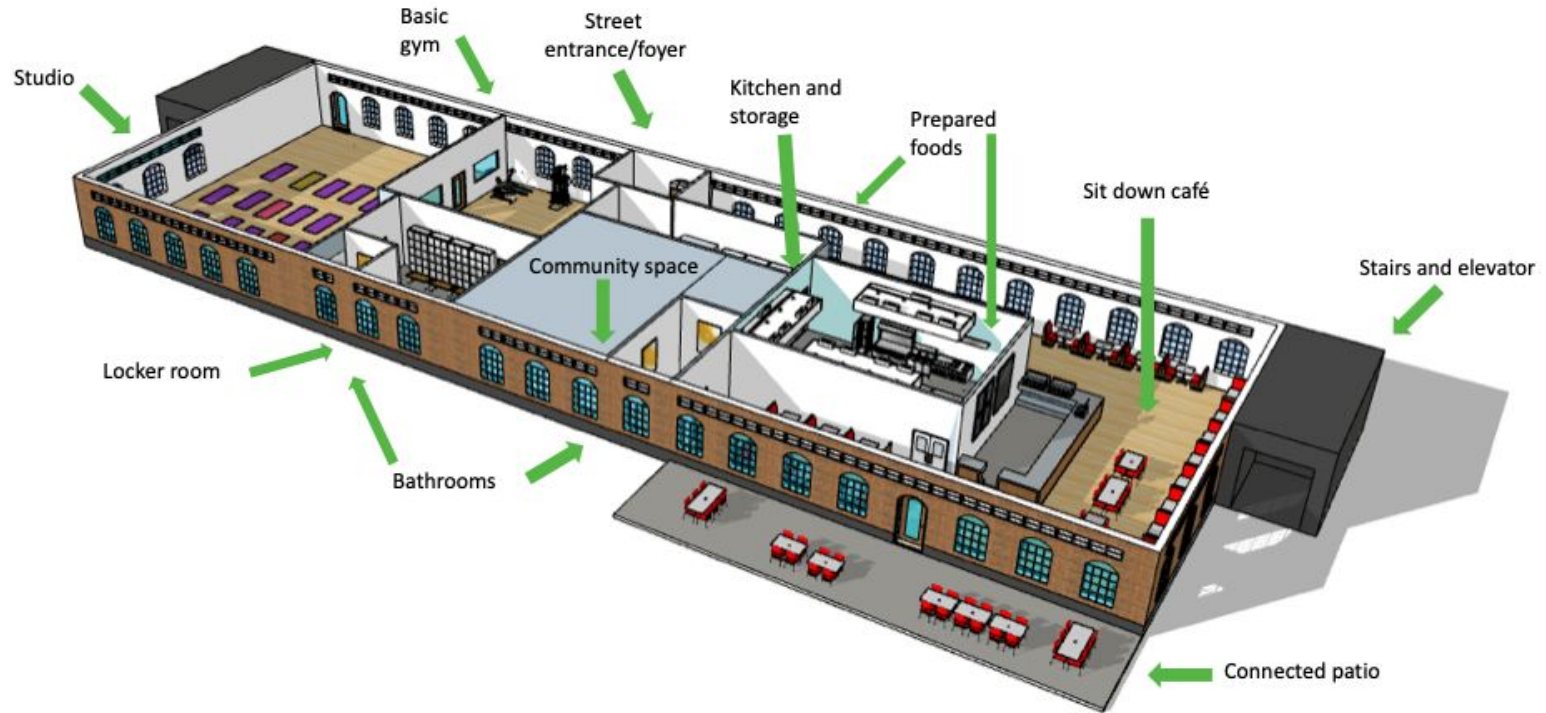
Building 1 Commercial Layout



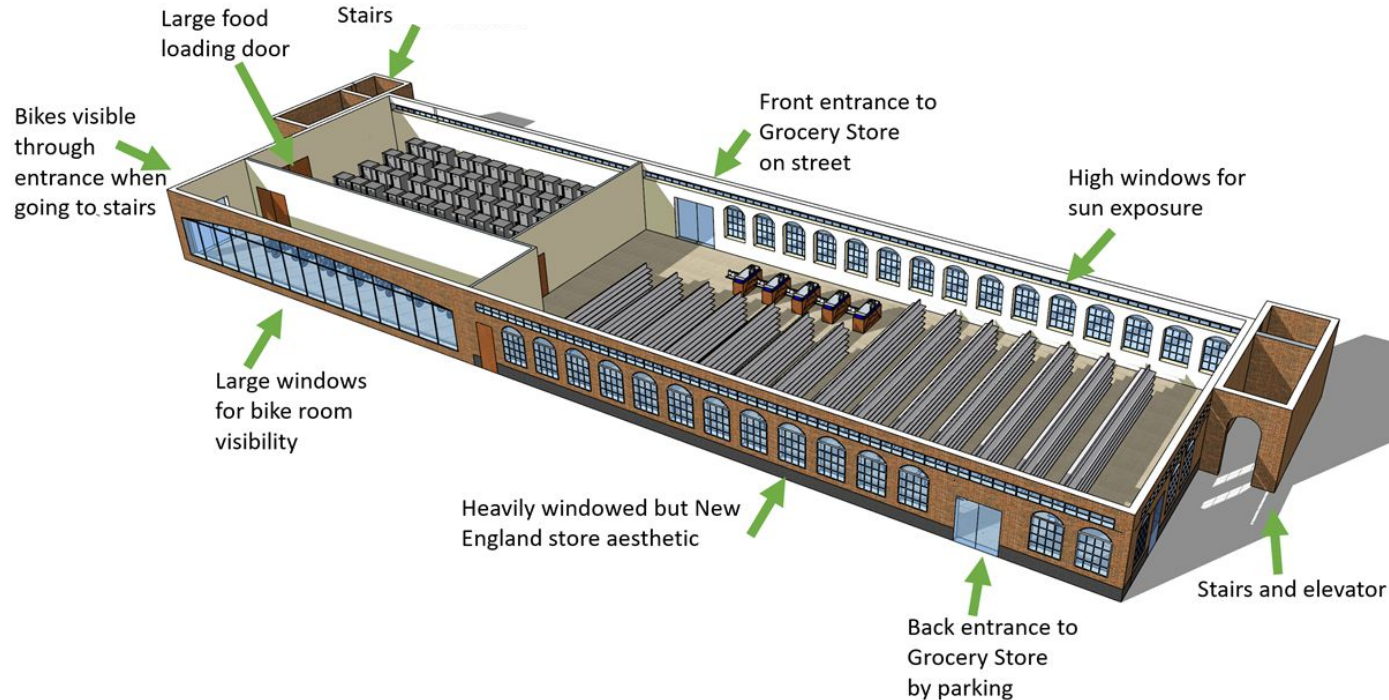
Building 2 Commercial Layout



Building 1 Commercial Key Features



Building 2 Commercial Key Features



Health Food Store

- No nearby grocery store
- **Reinforces healthy lifestyle**
 - Fresh and local produce, conveniently located to tenants, to encourage cooking at home
 - Healthy prepared foods to dissuade customers with limited time from eating fast food
 - Provides tenants with the option to cook or pick up convenient, healthy to-go options
 - **Promotes healthy eating habits**



Sit-Down Cafe

- To go options available for customers with limited time
- Made-to-order food available
 - Promotes a good atmosphere
 - Brings in customers (Both tenants and non-tenants) to provide a social space
 - Promotes **social well being** through having a low stress, social environment

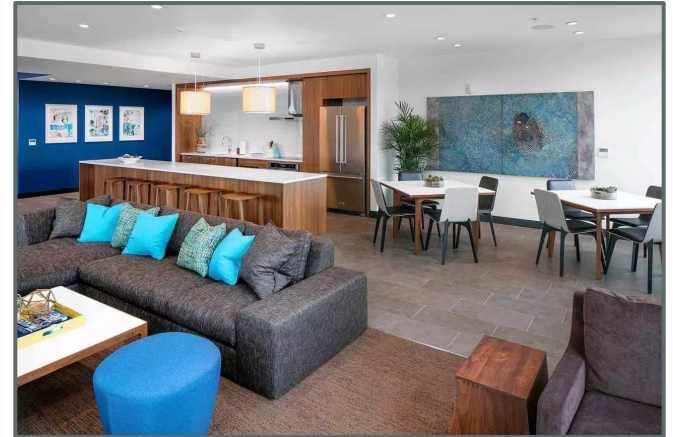


Workout Space

- **Studio space**
 - Provides a multipurpose space that allows for a variety of different workouts (i.e. Yoga, HIIT, TRX...etc.)
 - Classes can be hosted that will cater to the tenants
- **Basic exercise equipment**
 - Basic exercise room is fast becoming a staple for apartment complexes
 - Supplement the studio space
 - Provides an option for a busy individual who does not necessarily exercise regularly or does not have the time to commit to a gym membership
- Promotes **physical well-being**

Community Lounge

- Provides open space for tenants of the building to interact
- Encourages the community atmosphere
- Promotes **social well-being**



Bike Room / Shared Sporting & Outdoors Equipment Closet

- **Shared Sporting & Outdoors Equipment Closet**
 - Provides tenants of the building with sporting and outdoors equipment they would not have because they are not permanent residents.
 - XC Skis, Snowshoes, Hiking Poles, & Tents
 - Maps of trails in the region
 - Encourages going outdoors and the **emotional/mental** well-being of the tenants.
 - Promotes **physical** well-being of the tenants.
- **Bike Room**
 - Strategic of the bike room encourages biking rather than driving
 - Promotes **physical** well-being of tenants

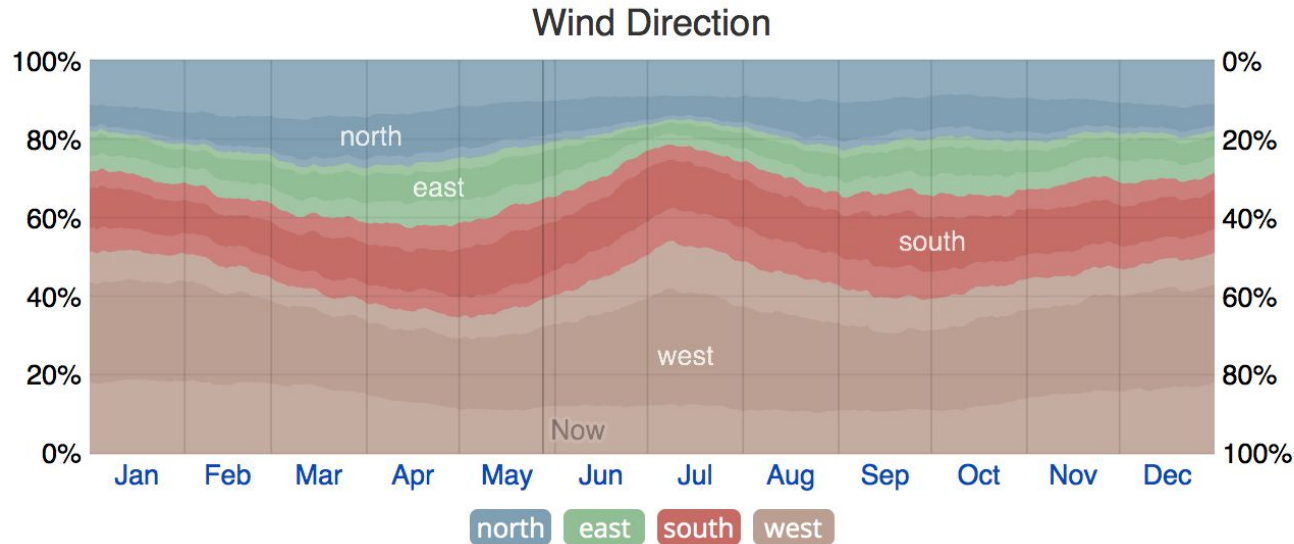


Landscaping

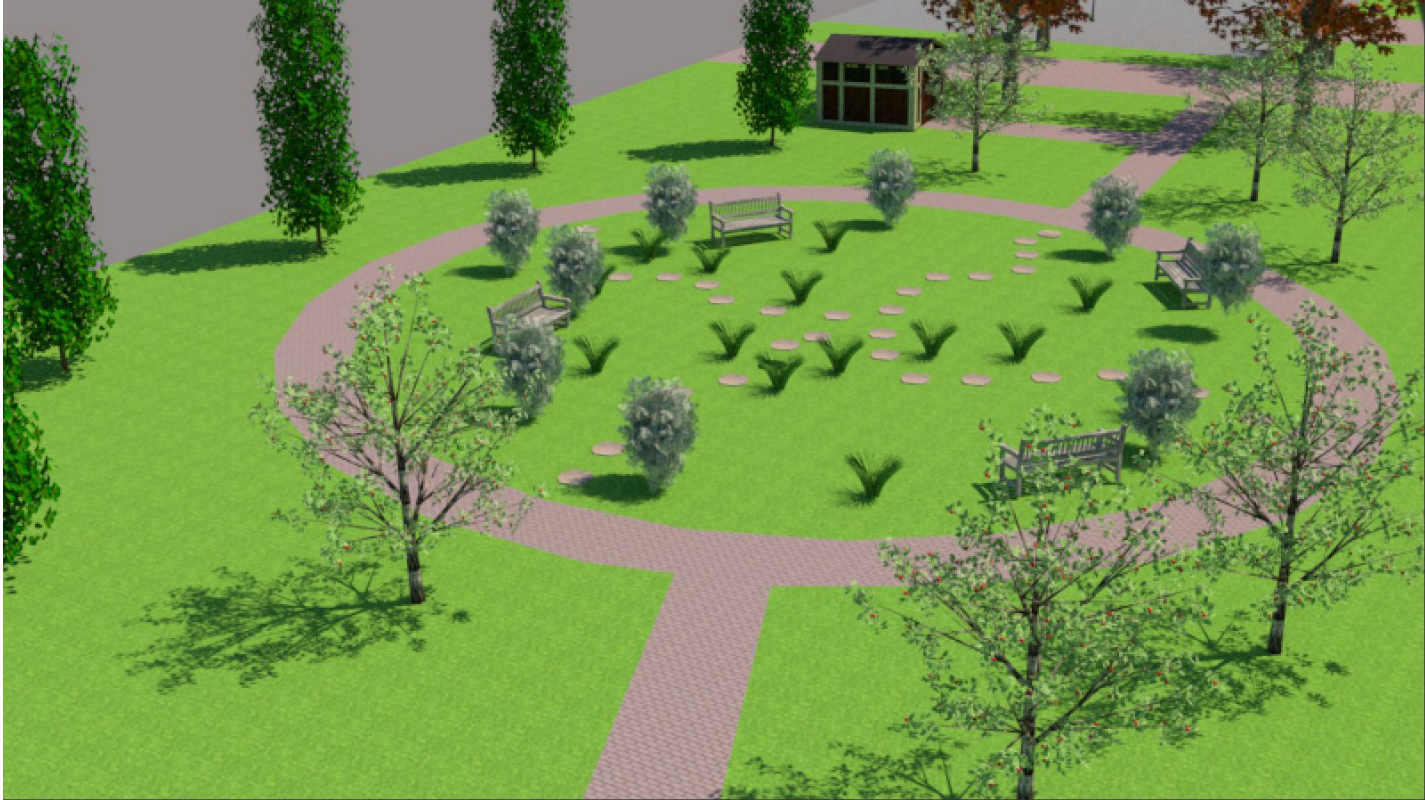


Wind Shielding

- Evergreen trees in the West corner of parking lot provide a wind break



Green Space and Micro-Green Breaks



Rain Garden



Vaccinium angustifolium
Lowbush blueberry



Panicum virgatum
Switchgrass or Panic grass



Symphyotrichum
(formerly Aster)
novi-belgii
New York American-
aster



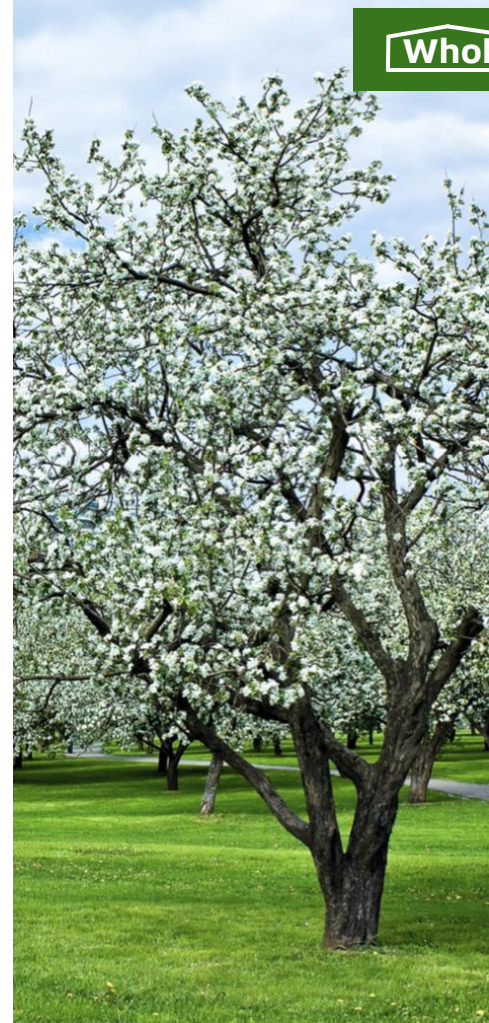
Iris versicolor
Blue iris or Blue flag



Eutrochium (formerly
Eupatorium)
purpureum
Sweet Joe Pye weed

Trees

- **Environmental Health:** native tree species
 - White Spruce
 - American Hornbeam
 - Red Maple
 - Hawthorn
- **Physical Health:** fruiting trees
 - Crimson Gold apple tree
 - Liberty apple tree

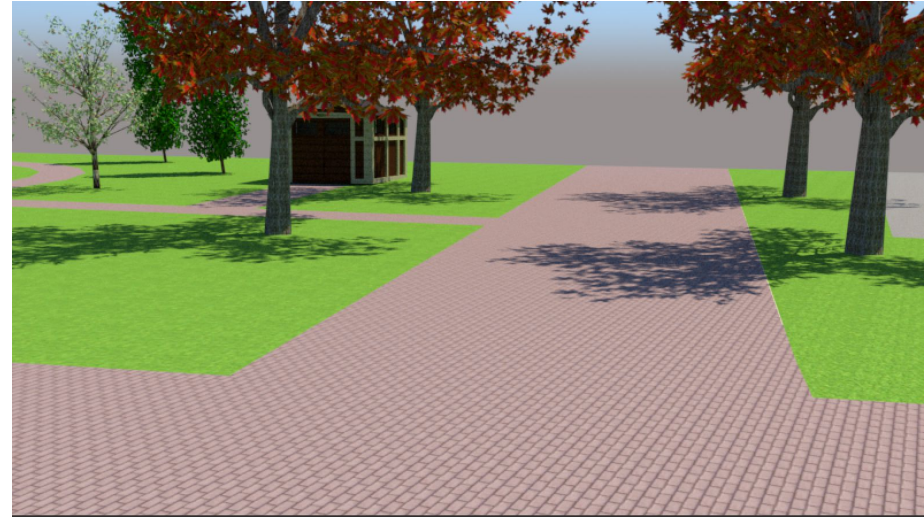


Stormwater Management

- Less than 30 cm of soil before bedrock
- Soil type: Inceptisols
- Land Cover: 54% impervious (~45,000 ft²), 46% permeable (38,000ft²)

Stormwater Calculations	
Water Quality Volume	3800 ft ³
Soil Void Space	33 %
Soil Depth	1 ft
Infiltration Rate	0 in/hr
Ponding Depth	0 in
Green Stormwater Infrastructure	6000 ft ²

Engagement with Rail Trail



Energy Analysis

Deliberate Energy Choices

- Electrification
 - Better for the **environment**
 - Protects residents from **financial** uncertainties
- Tight sealed envelope with green materials
 - Maintaining comfortable temperature and humidity
 - Better air quality because of better building materials
- Mechanical Ventilation (unit HRV systems)
 - Necessary for good air quality without natural infiltration
 - Lower utility bill because of heat exchange with exhaust air
- Triple pane, Argon filled, Low-E windows
 - Allows for large windows without huge heat losses
 - Economically worthwhile for a new construction project

Energy Analysis: Electrify Everything

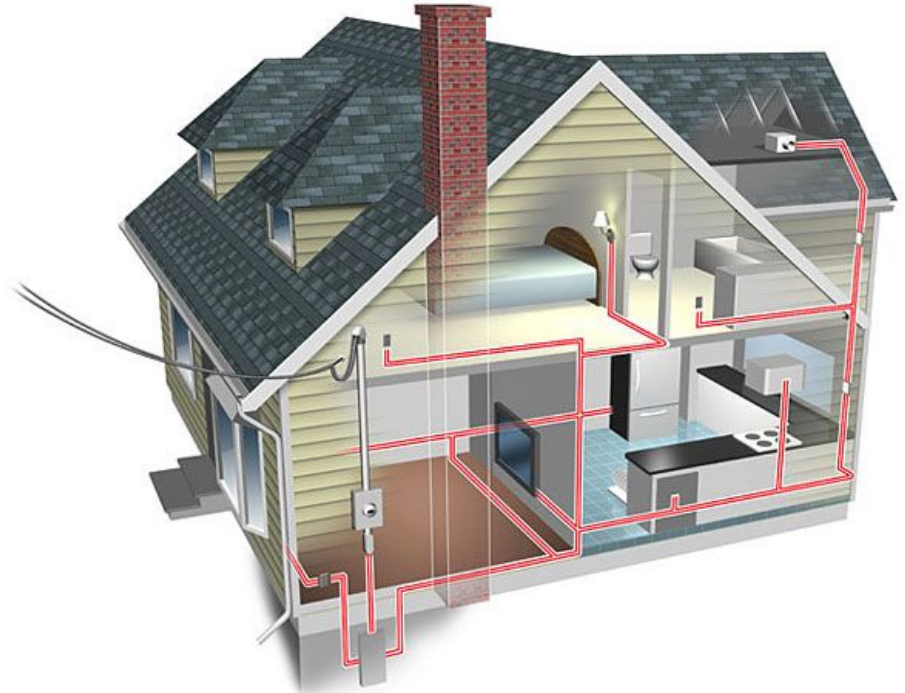
Residential Units

Environmental: cleaner air quality and less emissions

Intellectual: plaques to learn about sustainability in the building

Financial: An efficient building decreases utility bills

Advances in Heat Pump technology have made it possible in Cold Climates.



How to Electrify Everything

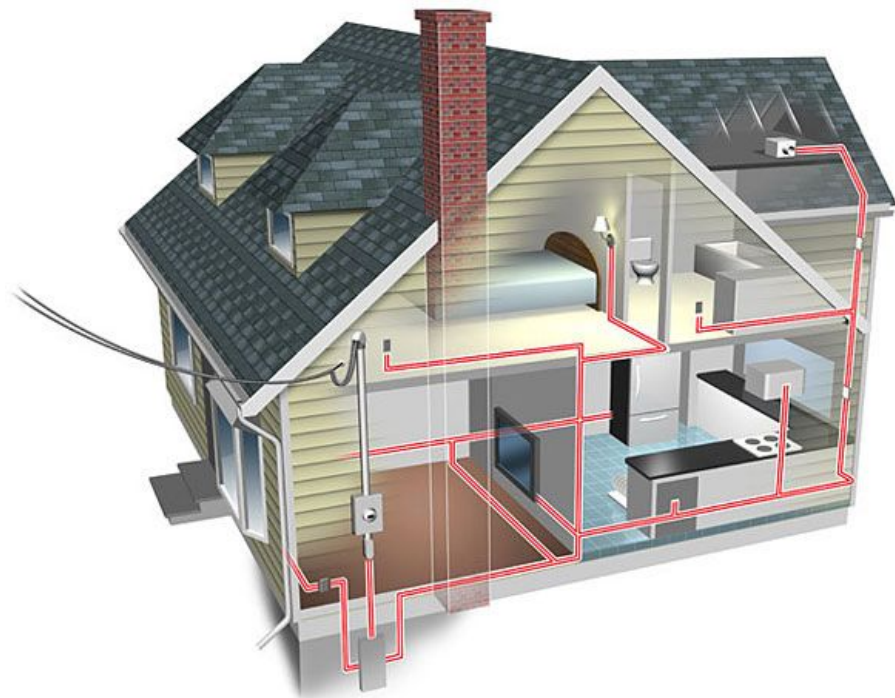
Heat Pumps

HVAC

Water Heaters

All-electric washers and dryers

All-electric kitchen range and oven



Heat Pump Sizing

Heating Load 6,000 BTUh

Cooling Load 4,000 BTUh

Mitsubishi Hyper Heat Pump System

Ducted or Wall-Mounted

100% Heating Capacity at 5°F, less than 1% of the time

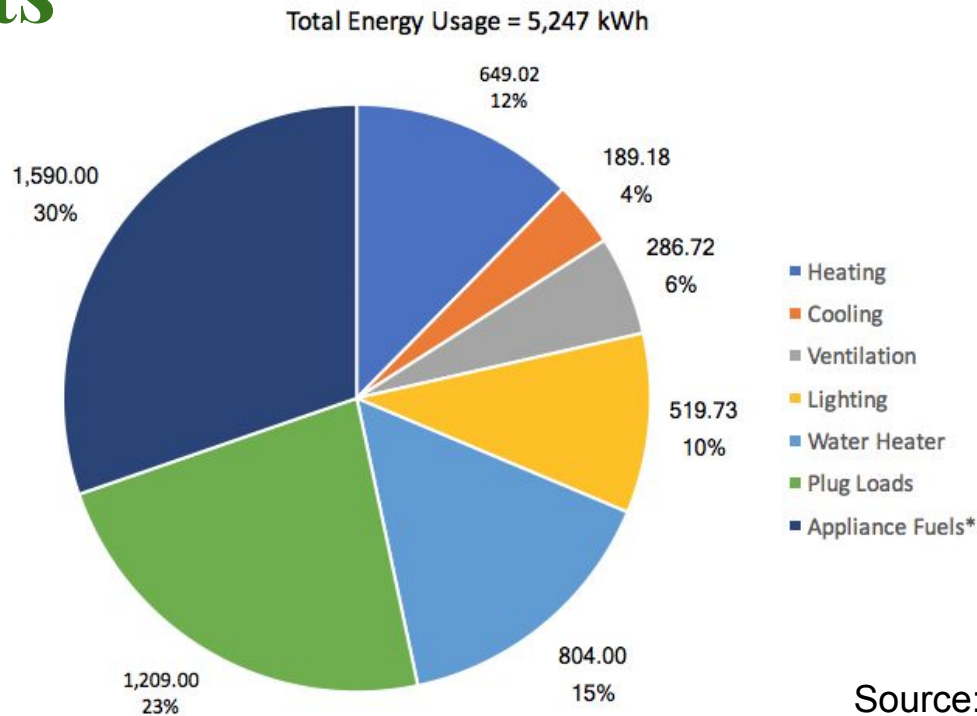
Performance down to -13°F, less than 0.1% of the time



Energy Consumption per square foot (EUI)

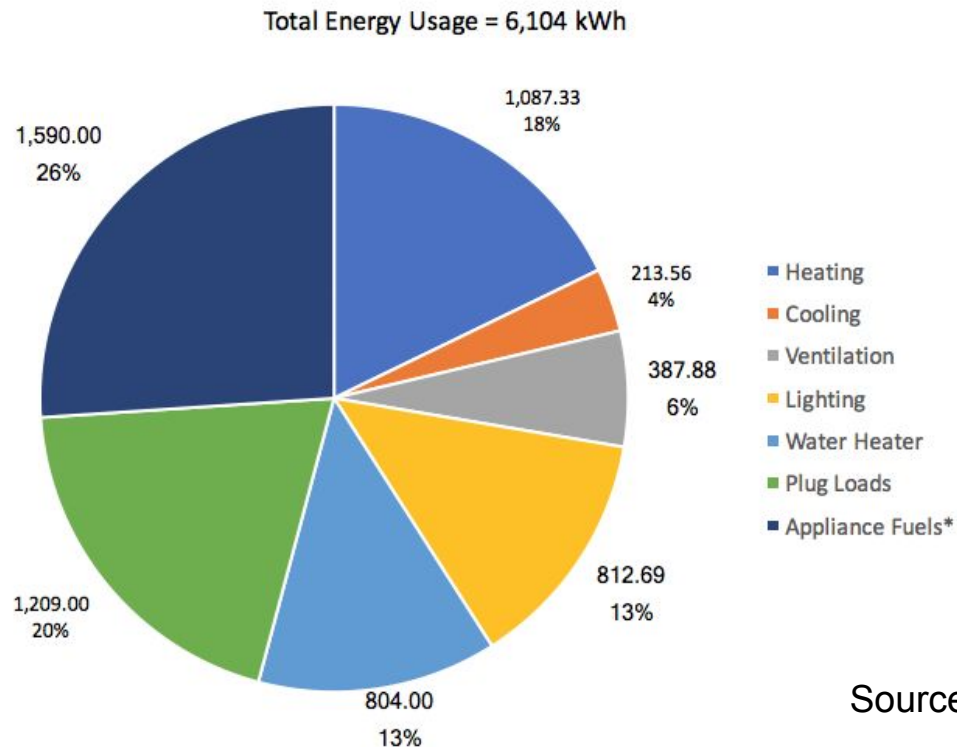
Space	Building EUI	Energy Star EUI
Building 1 residences	7.9 kWh/ft ²	17.46 kWh/ft ²
Building 2 residences	7.8 kWh/ft ²	17.46 kWh/ft ²
Grocery	21.3 kWh/ft ²	57.44 kWh/ft ²
Restaurant	18.56 kWh/ft ²	38.30 kWh/ft ²
Studio	5.25 kWh/ft ²	16.44 kWh/ft ²
Whole Building*	8.47 kWh/ft ²	11.75 kWh/ft ²

Annual Energy Breakdown for Individual Studio Units



Source: HEED calculations

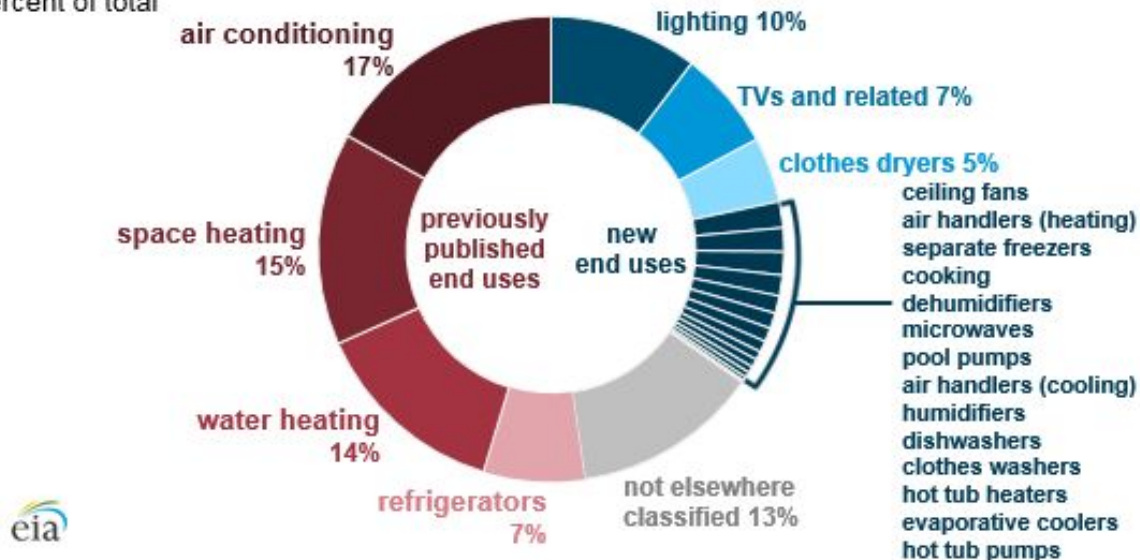
Annual Energy Breakdown for 1 Bedroom Unit



Source: HEED calculations

Annual Energy Breakdown for Average American Home

Residential electricity consumption by end use, 2015
percent of total



Source: EIA

Grocery Store Energy Efficiency

Environmental: make use of waste heat from refrigerator compressors

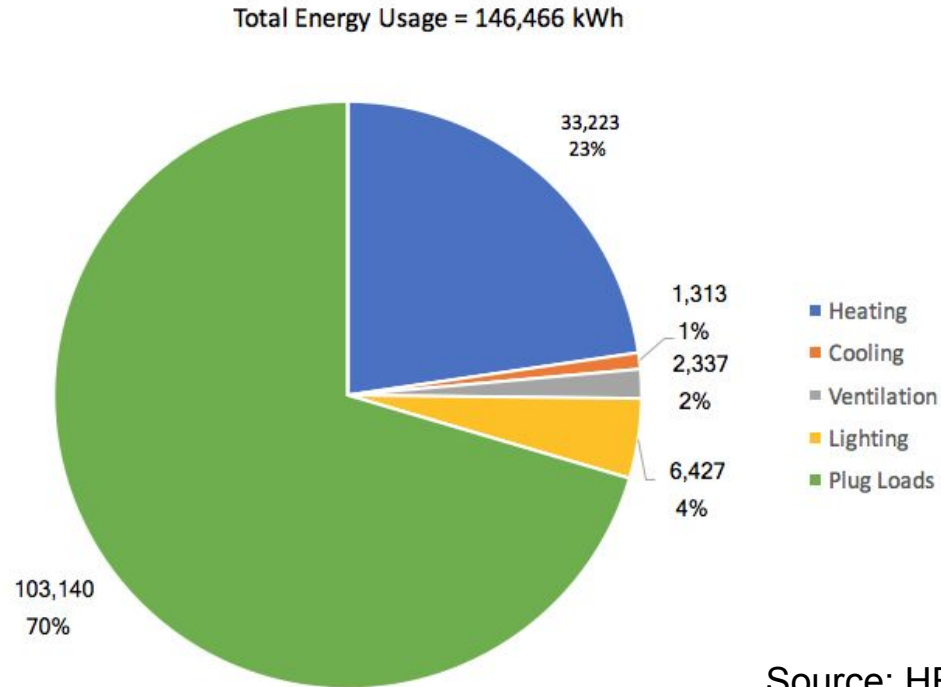
Financial: save on electricity through efficiency measures

NREL's Grocery Store 50% Energy Savings Report

- 7% Higher Capital Costs
- 14% Lower 5 year Life Cycle Cost



Energy Breakdown for Grocery Store



Restaurant Energy Efficiency

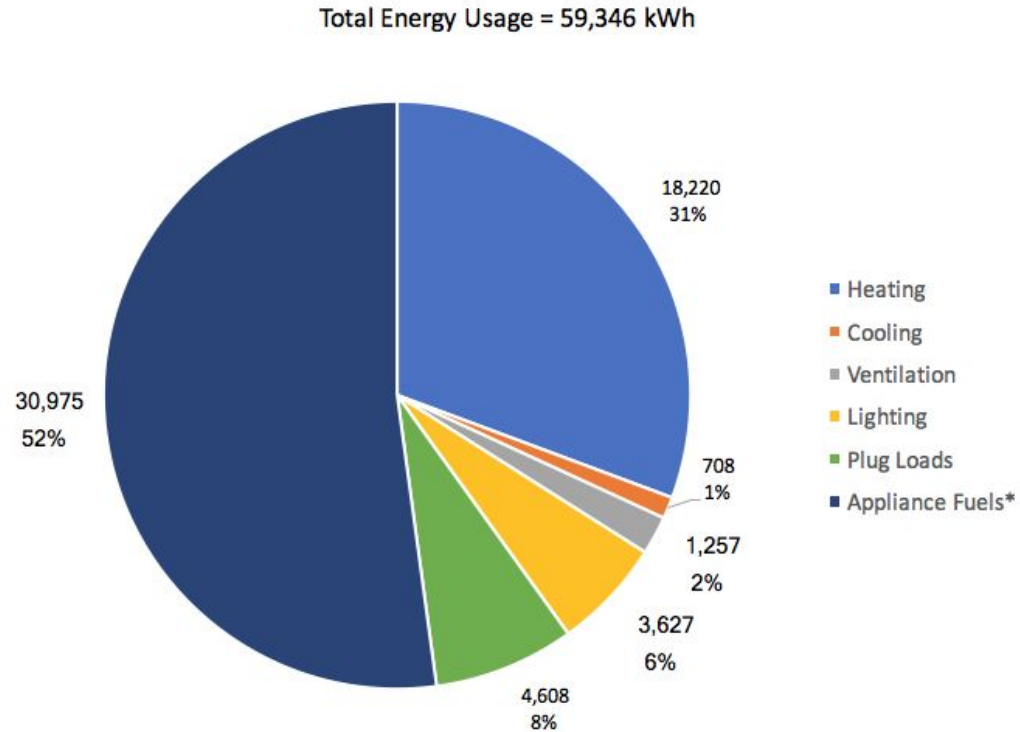
Environmental: Efficient appliances and recycling food and cooking oil waste.

Financial: save on electricity through efficiency measures.

Only unelectrified aspect of the building design, commercial gas burners are ubiquitous in the restaurant industry. Fuel of choice is propane because natural gas is not available.

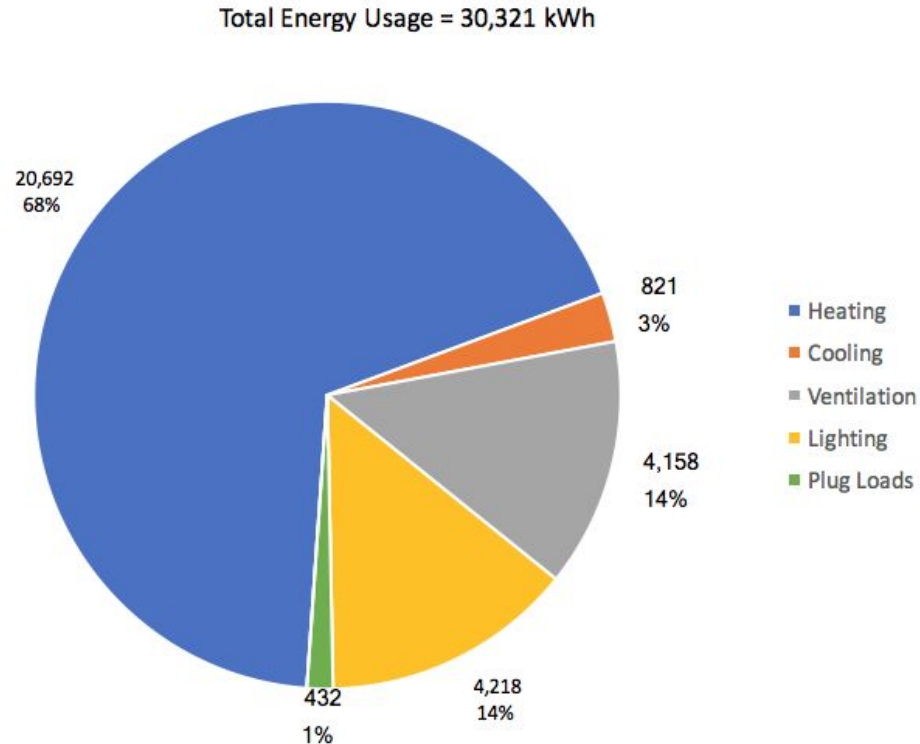


Energy Breakdown for Restaurant



HEED calculations

Energy Breakdown for Workout Studio

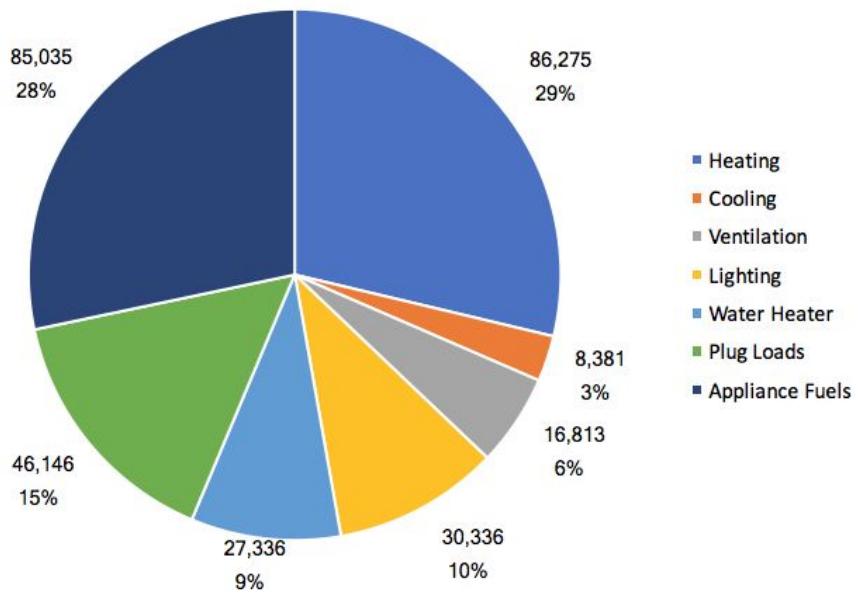


HEED calculations

Energy Breakdown By Building

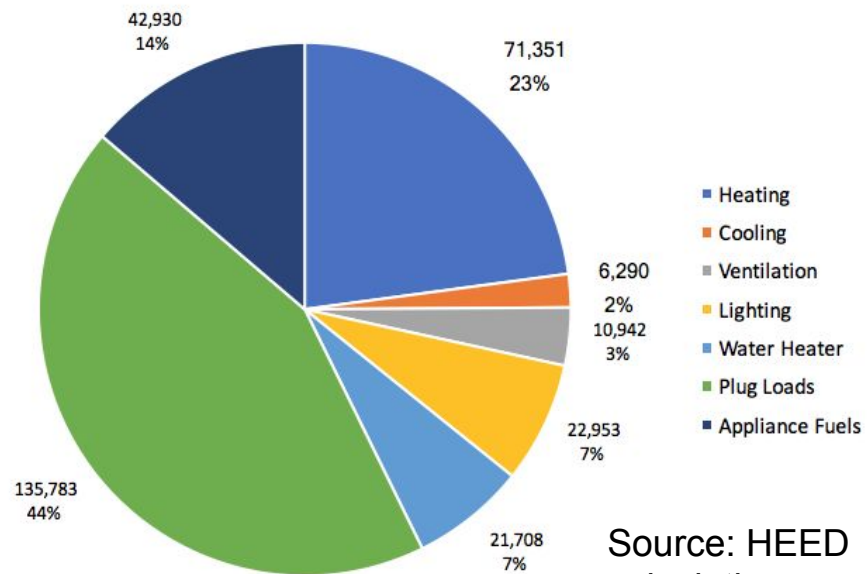
Building 1

Total Energy Usage: 300,322 kWh



Building 2

Total Energy Usage 311,956 kWh



Source: HEED calculations

Solar Array Production

Building 1 Roof Array 91.5kW

- Annual Production: 118,000 kWh

Building 2 Roof Array 75kW

- Annual Production: 97,760 kWh

Using premium 19% efficient panels

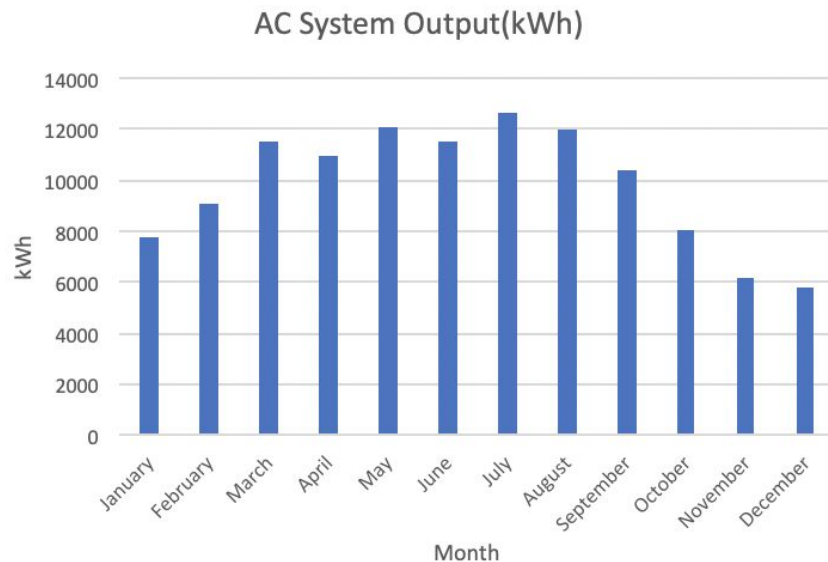
Fixed 30° Tilt, mounted to roof



Solar Array Production

Building 1 Roof Array 91.5kW:

- 280 panels
- 327 Watts/panel
- 30° angle
- 171° azimuth
 - (orientation of building)
- PVWatts to predict yearly energy

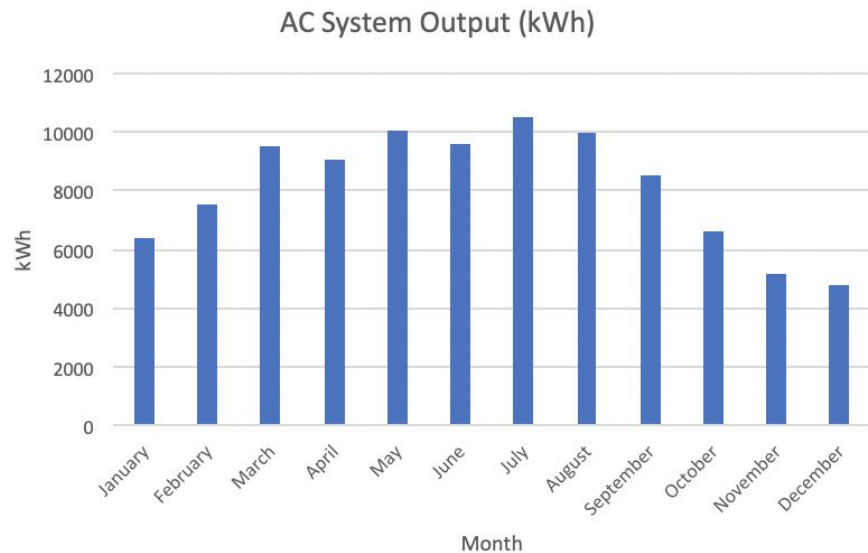


PVWatts: 118,000 kWh AC electricity total from building 2

Solar Array Production

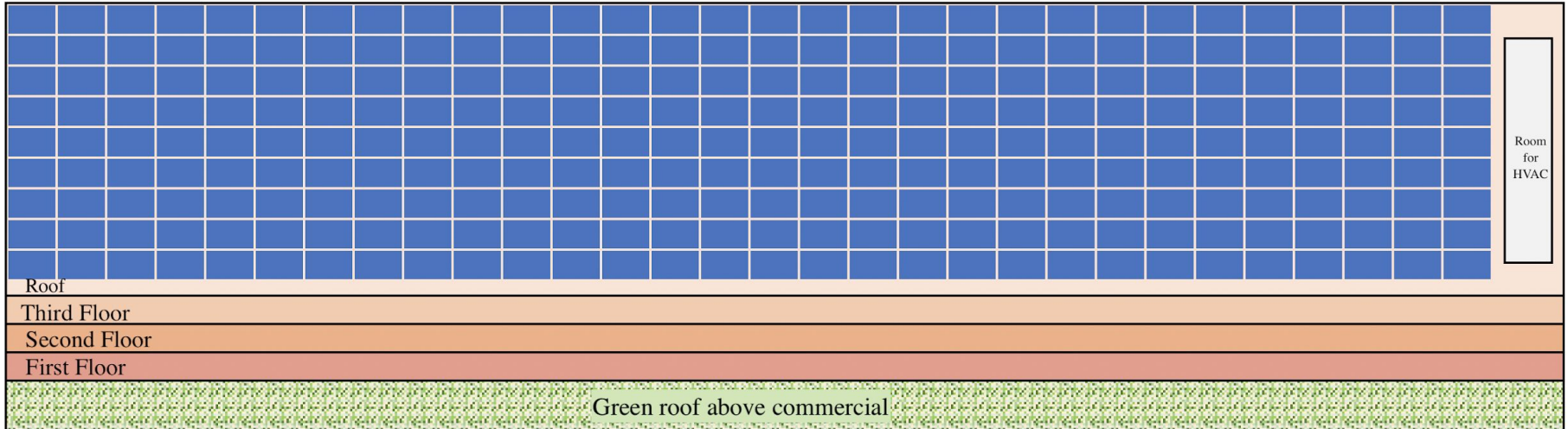
Building 2 Roof Array 75kW:

- 230 panels
- 327 Watts/panel
- 30° angle
- 168° azimuth
 - (orientation of building)
- PVWatts to predict yearly energy



PVWatts: 97,760 kWh AC electricity total
from building 2

Bird's eye view of solar panels on roof of Building 1



Electricity Consumption & Production

Yearly electricity consumption: 612,279 kWh

Production: 215,760 kWh using net metered solar PV

Purchased from utility: 396,519 kWh

Utility Bill

Benefits from net metered solar go to developers.

12.73 ¢/kWh for electricity in Lebanon, NH

Residential Units

Studio Apartments \$55/month

1 Bedroom Apartments \$65/month

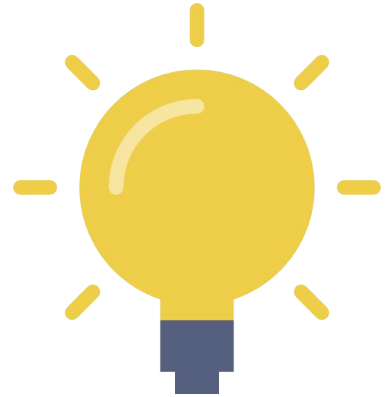
Commercial Units

Grocery Store \$1,553/month

Studio \$292/month

Restaurant Electricity \$301.50/month

Restaurant Propane \$362.94/month



Emissions

Energy	Amount (kWh)	Emission Rate (MTCO ₂ e/kWh)	Emissions (MTCO ₂ e)
<u>Electricity</u>			
Produced by PV	215,760	-	-
Produced by Grid	396,519	0.000113	44.91
Total	612,279		44.91
Amount (MMBTU) Emission Rate (MTCO₂e/MMBTU) Emissions (MTCO₂e)			
<u>Propane</u>			
Restaurant	105.69	0.063050	6.66
Total			6.66
Total			51.58

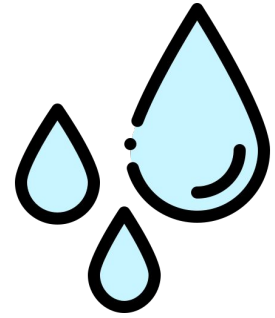
Energy in Construction - Embodied Energy

Bill of Materials	kJ/kg	kg of CO₂ per kg
Plaster	6.75	0.38
Wood	8.5	0.46
Brick	3	0.24
Cellulose	1	0
Waterproof membrane	25	2.7
	MJ/m²	kg of CO₂ per kg
Premium PV	4070	208

Water Use (both buildings)

Use equation $37.2n + 69.2$ for each unit, n accounting for people per unit

- 7500 gallons/day from residents
- 2190 gallons/day for commercial spaces
 - 12 employees consuming 10 gallons for grocery store and coffee shop
 - 150 customers in each space per day consuming 3 gallons
 - 250 meals served a day
- 3,540,000 gallons annually
- Due to soil conditions will not do rainwater collection
 - Unable to have gravity fed system
 - Would only account for 10% of water needs (29,500 gallons/month)

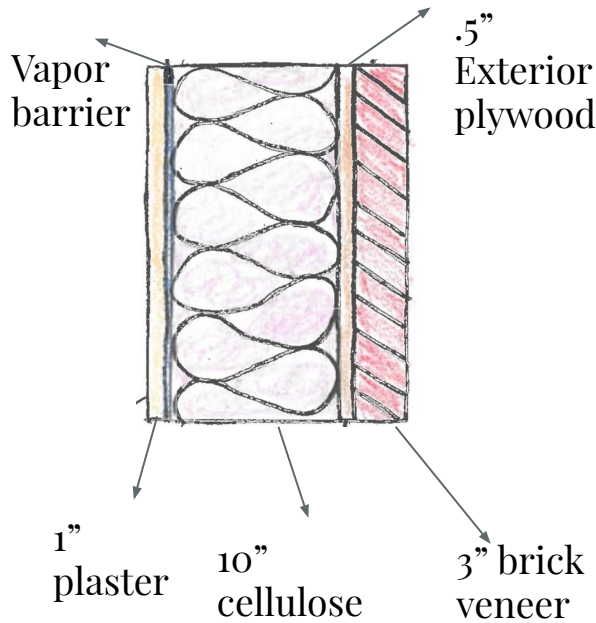


Materials

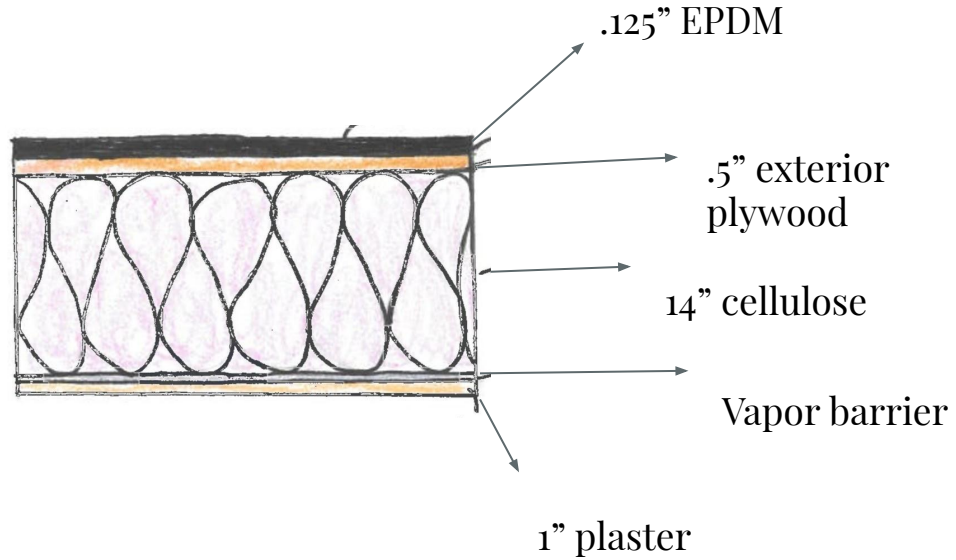
- Double studded walls
 - Reduces thermal bridging, saves energy
 - Cellulose treated with borate as primary insulator
- Cross Laminated Timber used in the structure
 - Takes carbon out of the environment
- Triple-glazed windows
- Reused brick for veneer
- **Emotional/Mental Health:** Visible wood lowers stress and improves health
- **Environmental Health:** Green roof

Cross Sections of Building

Double Studded Wall **R-wall = 37.35**



R-roof = 51.3



Green Roof

- Improves stormwater management
- Extensive (less than 4 inches of soil and plant)
- Sedum, succulent and other low maintenance colorful plants
- **Physical Health:** improves air quality, creates a more comfortable space
- Helps cool building in the summer



Economic Analysis

Costs

- \$300/sqft construction
 - Based on \$200/ft² hard costs, 20% of that for soft costs, and separate acquisition costs
- \$6.1 million for construction of both buildings
- Operating cost of \$182,000/year - based off 60 unit apartment complex in Massachusetts
 - Property management - \$20k
 - Taxes - \$45k
 - Insurance - \$22k
 - Repairs and Maintenance - \$25k
 - Reserves - \$20k
 - Water/Sewer - \$32k

Economic Analysis

Residential Revenue

- The Lebanon area runs at \$1.70/sqft per month
 - Data collected from Emerson Luxury apartments
- Small studios for \$850/month; Largest bedrooms for \$1500/month
- Collect \$67,500/month with all units being rented ~ \$800,000/year
- Solar Panel net metering \$27,530
- Payback in 10.5 years

Commercial Revenue

- Collect \$10/sqft per year
 - Approximation based on other listings in the Lebanon area
- Grocery store \$50,000/year; Restaurant \$35,000/year



LEED

55/110 Points

Silver Certifiable (50-58 Points)

Key Results

HERS Score of 26

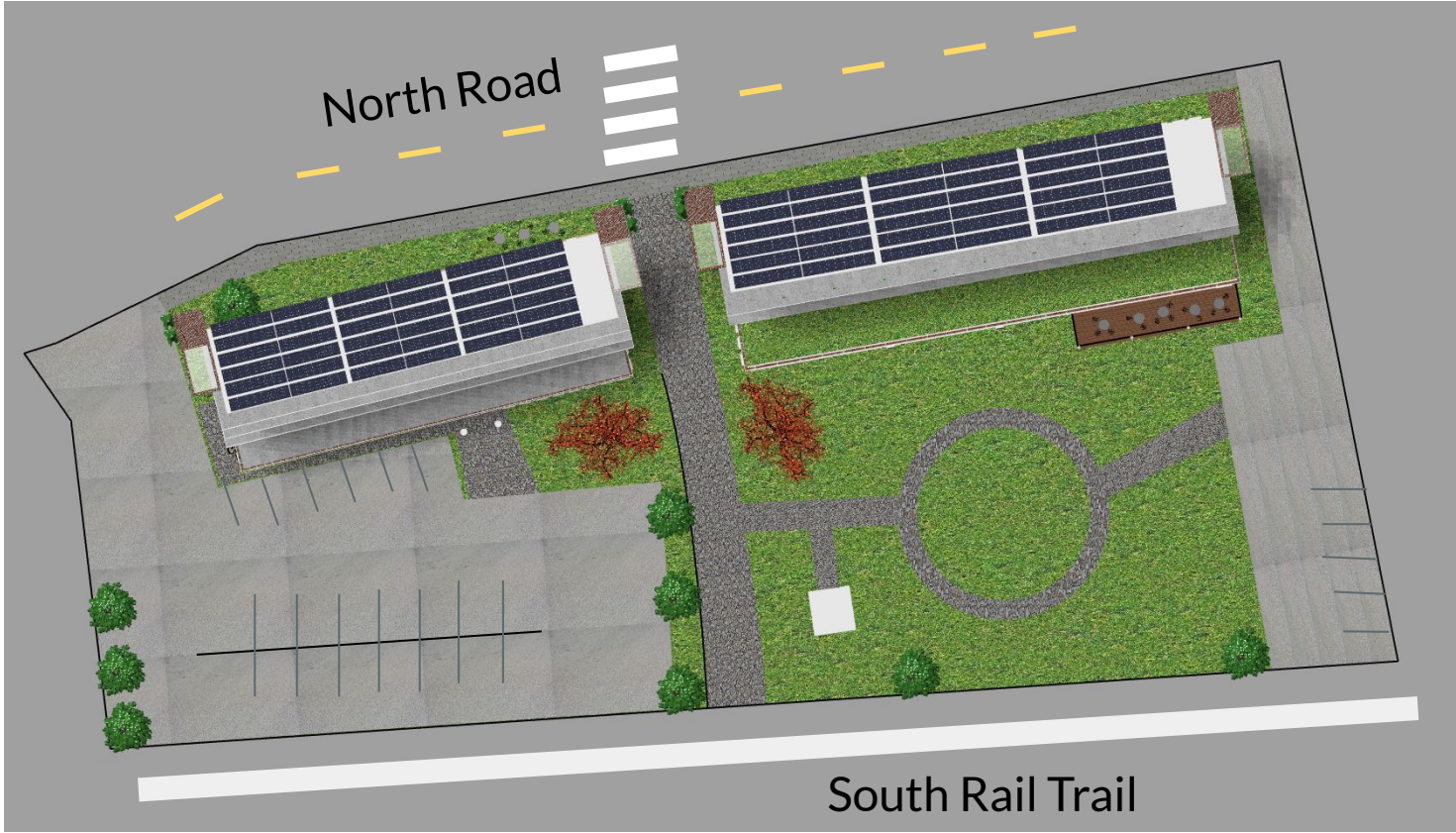
Location and Transportation

Landscaping

Solar



Layout & Healthy Living



Thank You & Questions

References

<https://web.archive.org/web/20070706120640/http://standby.lbl.gov/ACEEE/StandbyPaper.pdf>

<https://www.sciencedirect.com/science/article/pii/S1876610214034055>

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Ibes, Dorothy, et al. “Greenspace Ecotherapy Interventions: The Stress-Reduction Potential of Green Micro-Breaks Integrating Nature Connection and Mind-Body Skills.” *Ecopsychology*, vol. 10, no. 3, Sept. 2018, pp. 137–50. *liebertpub.com* (Atypon), doi:[10.1089/eco.2018.0024](https://doi.org/10.1089/eco.2018.0024).

https://extension.unh.edu/resources/files/Resource005899_Rep8265.pdf

Appendix - Studio and Mini Gym

