Achieving Superior Energy Efficiency

in Commercial and Multi-Family Buildings through Passive House

2019 Duluth Energy Design Conference

rendering by LHB

precipitate
ARCHITECTURE | PLANNING | RESEARCH

THE SHEWARD PARTNERSHIP, LLC
www.thesheward partnership.com

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CONTINUING EDUCATION

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LEARNING OBJECTIVES

1. Describe the challenges and benefits of applying PHIUS+ Passive House certification to a commercial and large multi-family project.
2. Understand the PHIUS Passive House certification process and timeline.
3. Explain the health and wellness benefits of building to the PHIUS+ Passive House Standard.
4. Describe how increasing the efficiency of the building envelope can significantly reduce the size, complexity, and cost of HVAC systems.
5. Analyze building energy models to inform decisions throughout the design process.
6. Understand the role engineers can expect to play in collaboration with passive house consultants and the design team.
7. Analyze the financial costs and tradeoffs of building a passive building versus a code compliant building.

PRESENTATION OVERVIEW

Introduction

Overview of Passive House

Case Study #1

Case Study #2

Questions

REAL-TIME POLLING

We invite you to participate with your smart phone! To start, send the following text message.

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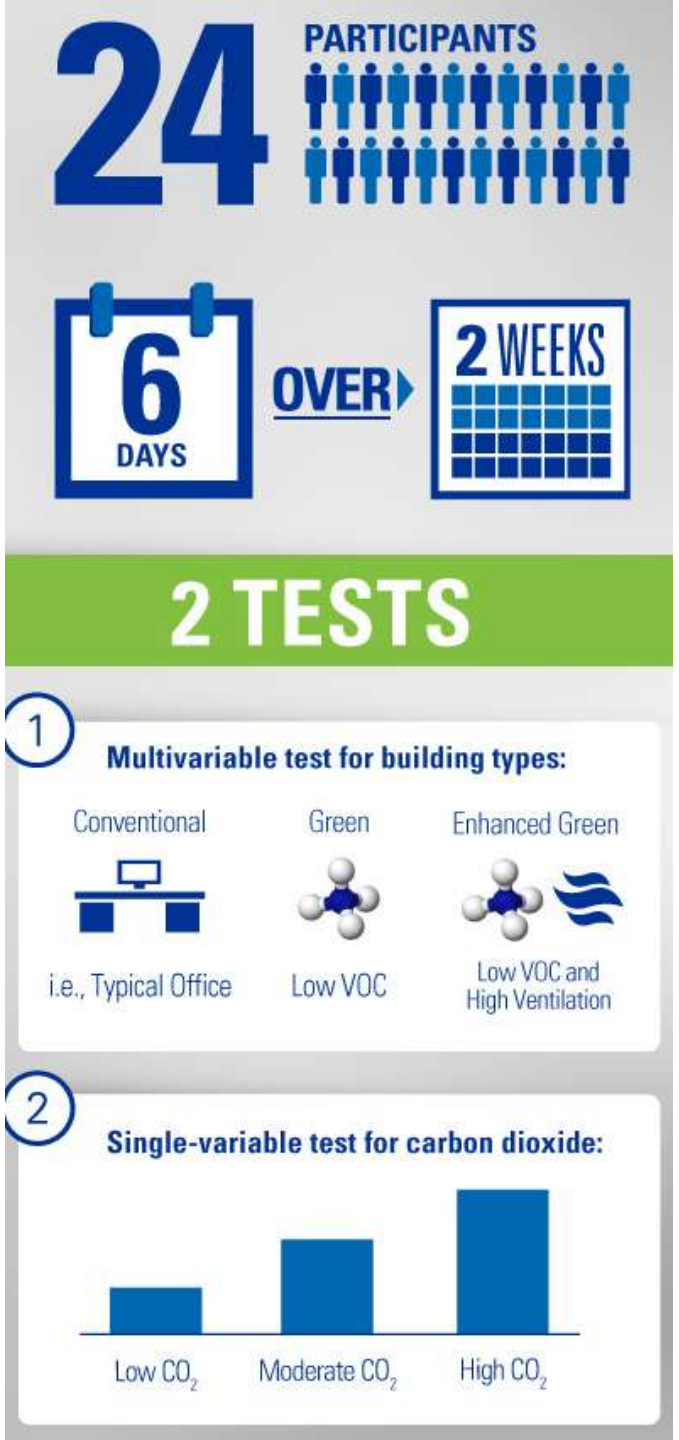
GREEN BUILDING TRENDS

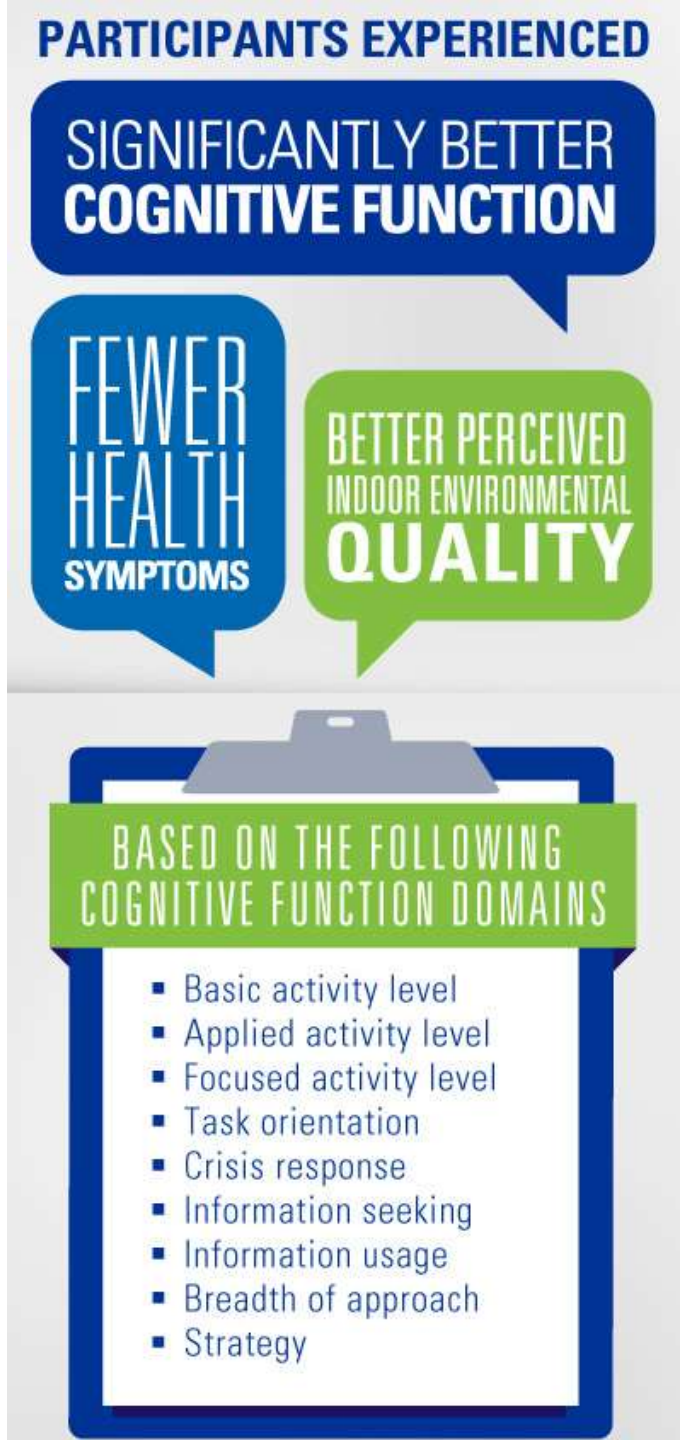
- Greater focus on occupant health and well-being
- Improve occupant engagement, productivity, and satisfaction
- Balance energy efficiency with superior indoor environmental quality and comfort

IMPROVED VENTILATION

- Study compared standard office environment with improved indoor conditions
  - VOC contaminants
  - Outdoor air rates
- Superior indoor air quality resulted in improved focus and problem solving abilities

Harvard Center for Health & the Global Environment - 2015





EMISSIONS & HEALTH

- Coal-fired power plants result in harmful emissions and outdoor air pollution
- Hazardous air quality conditions can exacerbate asthma and allergy symptoms
- Childhood asthma is the leading cause of student absenteeism and accounts for 13.8 million missed school days each year

Centers for Disease Control - 2015

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PASSIVE HOUSE OVERVIEW

The Distillery - Boston

PASSIVE HOUSE INSTITUTE US

- Passive House Institute initially founded in 1996 in Germany
- PHIUS established in 2007
- PHIUS+ 2015 released 3/2015
  - Cost-effective passive energy efficiency strategies
  - Cost-optimized by climate zone
  - Software, tools, and support
  - Third-party verification required

Group Design Build – Residence, Cambridge MA

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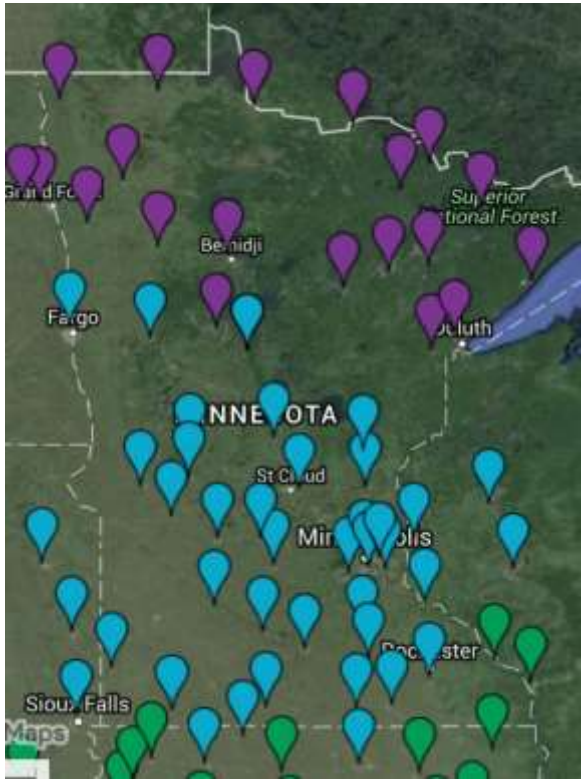
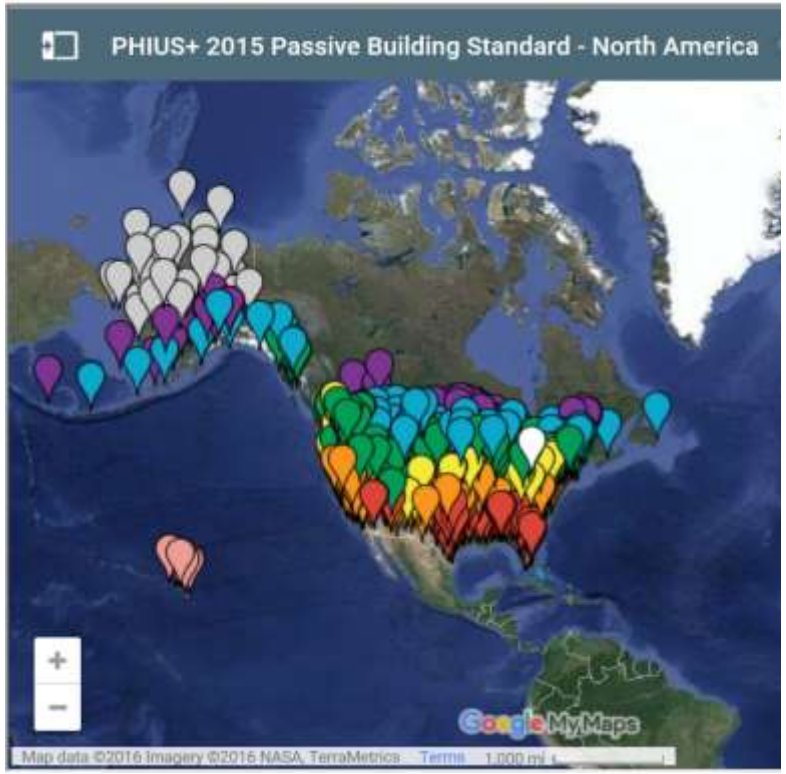
CLIMATE SPECIFIC TARGETS

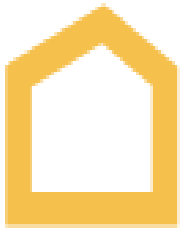
Minneapolis, MN Targets

- Heating demand 7.4 kBtu/SFyr
- Cooling Demand 2.31 kBtu/SFyr
- Heating Load 5.4 Btu/hr SF
- Cooling Load 4.2 Btu/hr SF
- Source Energy
  6200 kWh/Person yr
- Air Tightness 0.05 cfm50/SF
  (0.4 ACH50 for this building)



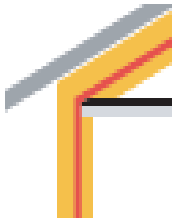


PHIUS+ 2015 PRINCIPLES

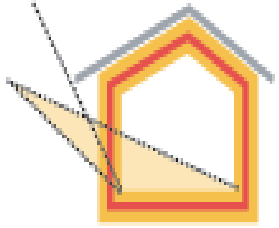


Superinsulation

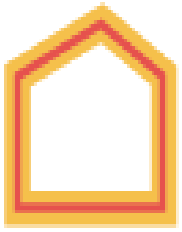
High Performance Windows & Doors



Eliminate Thermal Bridges



Optimize Solar Gain

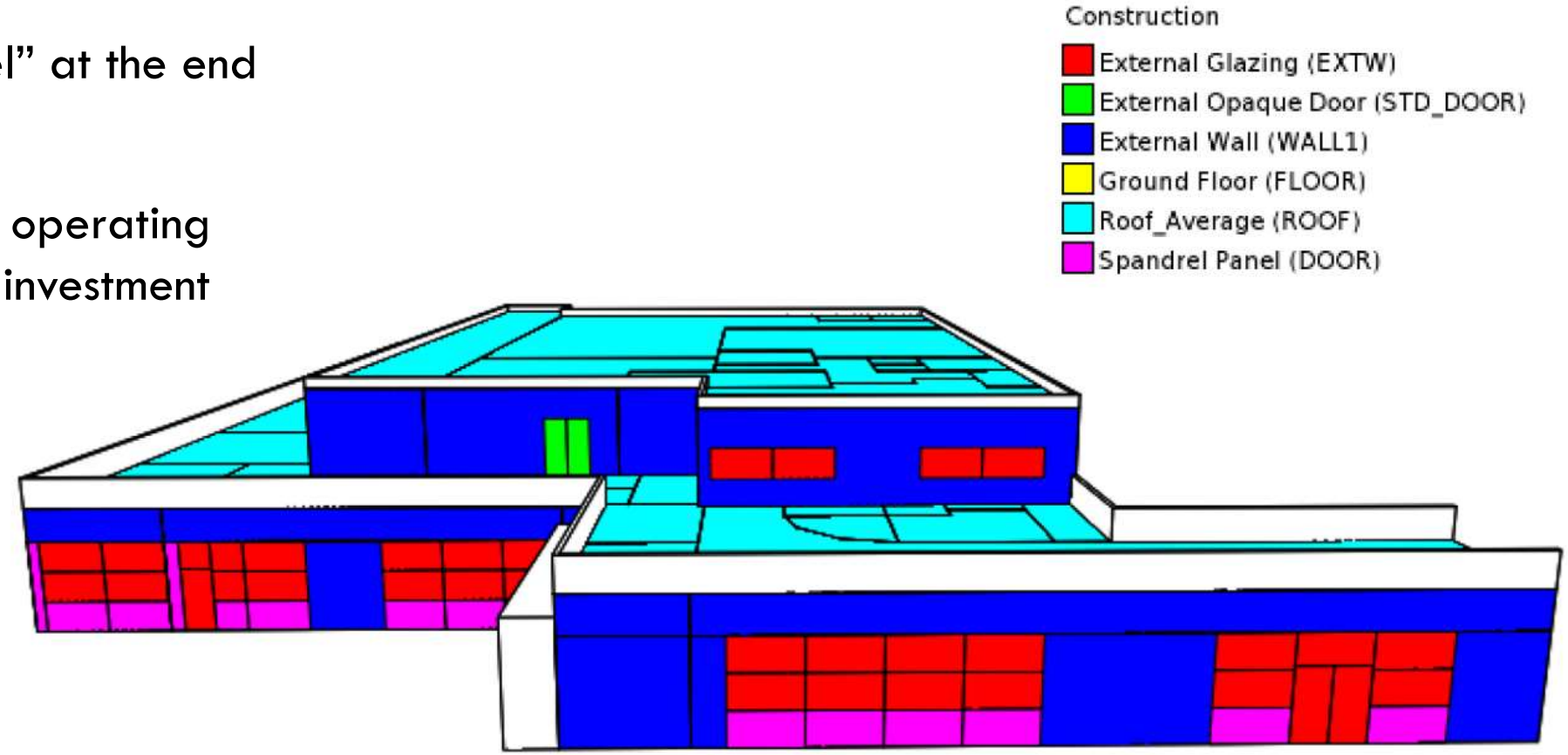


Airtightness

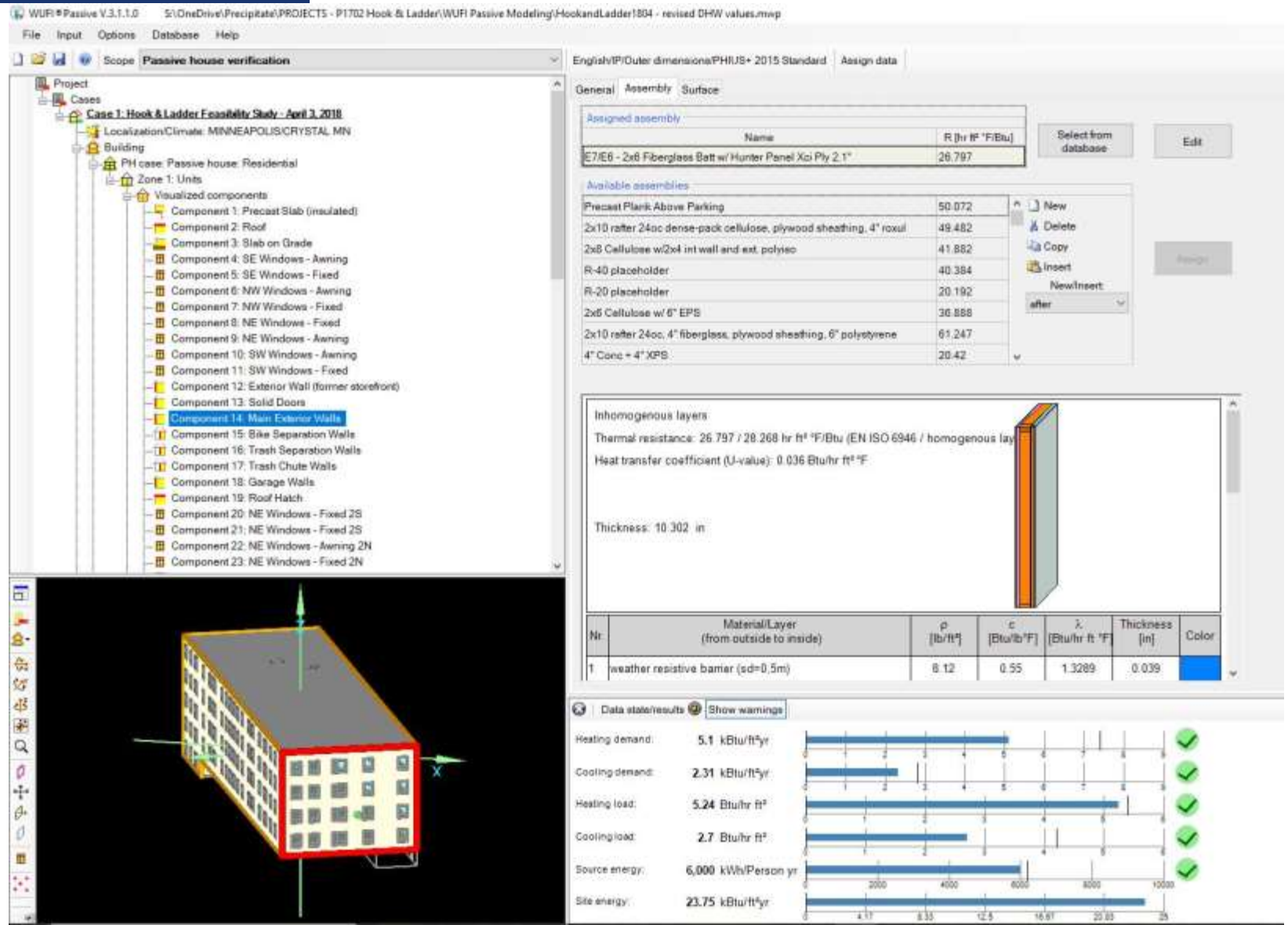
Energy Recovery Ventilation

ENERGY MODELING

- Holistic, iterative analysis tool during design
- Not a “proof model” at the end of design
- Calculate first cost, operating cost, and return on investment



WUFI Passive



CASE STUDY #1

PROJECT INTRODUCTION

THE GODDARD SCHOOL

- Providing private preschool and daycare for over 30 years
- 65,000 students in more than 460 schools in 36 states
- 6 weeks to 6 years old
- Comprehensive play-based curriculum

BE AMAZING, LLC

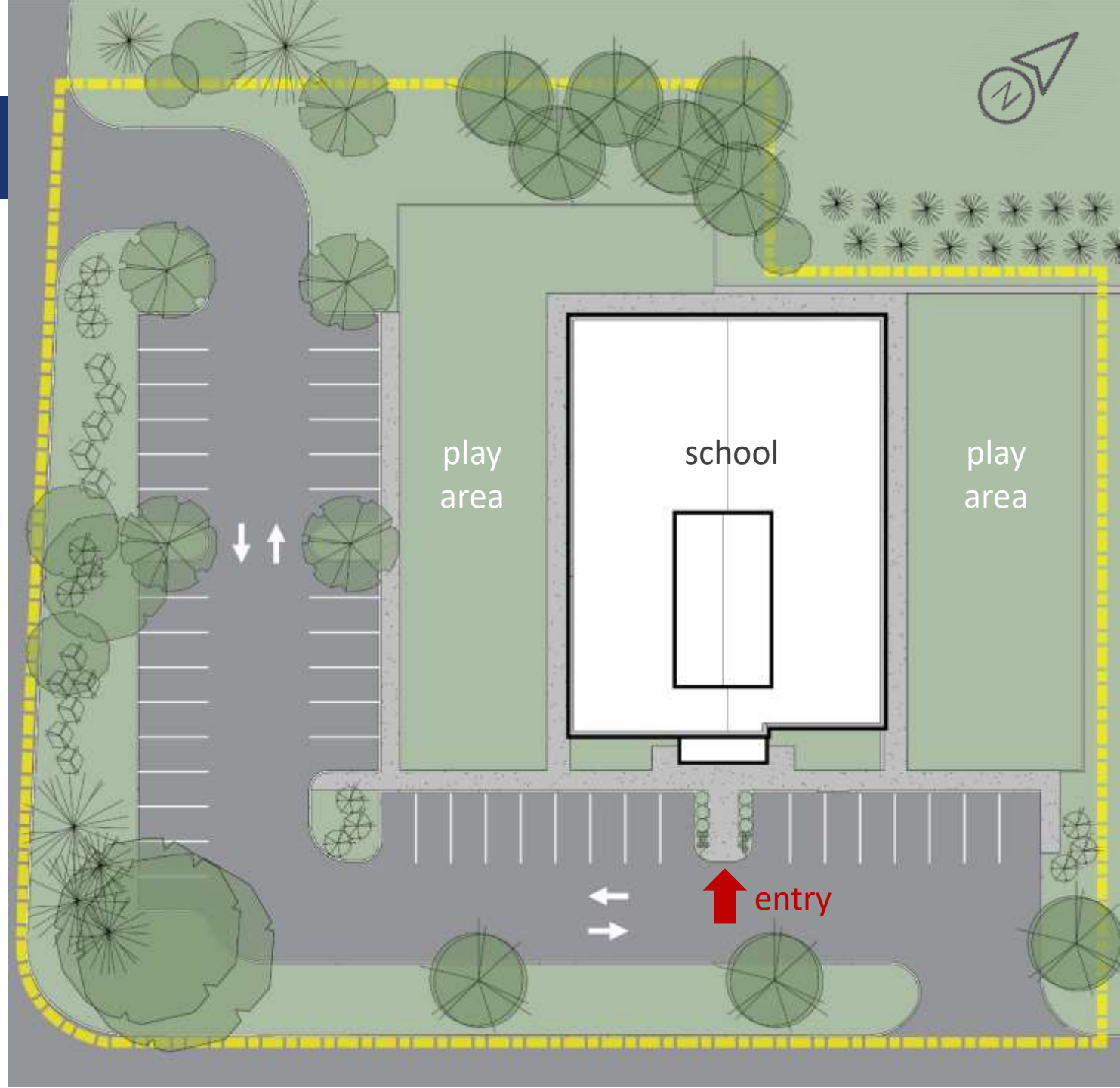
- Franchise per corporate design standards
- Family team planning for long-term ownership
- Sustainability Goals
  - Environmental stewardship
  - Occupant health
  - Ongoing operational costs

Don’t wait for the “the unicorn client”

Building Green Blog Post “Why We Let Ourselves Do Mediocre Work”
by Tristan Roberts

PROJECT OVERVIEW

- Plymouth Meeting, Pennsylvania
- Prototype building plan
- 56,000 square foot lot
- 8,700 square foot building
- 132 students and 32 adults
- Project Team
  - Owner: Be Amazing, LLC
  - Architects: The Sheward Partnership
  - MEP Engineers: Alderson Engineering
  - Contractor: MidAtlantic Construction
  - CPHC: The Sheward Partnership



TIMELINE

2015

2016

Sep 2015
Feasibility Study

Jan 2016
Sustainability Goal Setting Charrette
Due to Pennsylvania green building grant, targeted LEED Gold and PHIUS+ 2015 certification

2017

Sep 2016
Bid Set
Some sustainability strategies were bid as add alternates

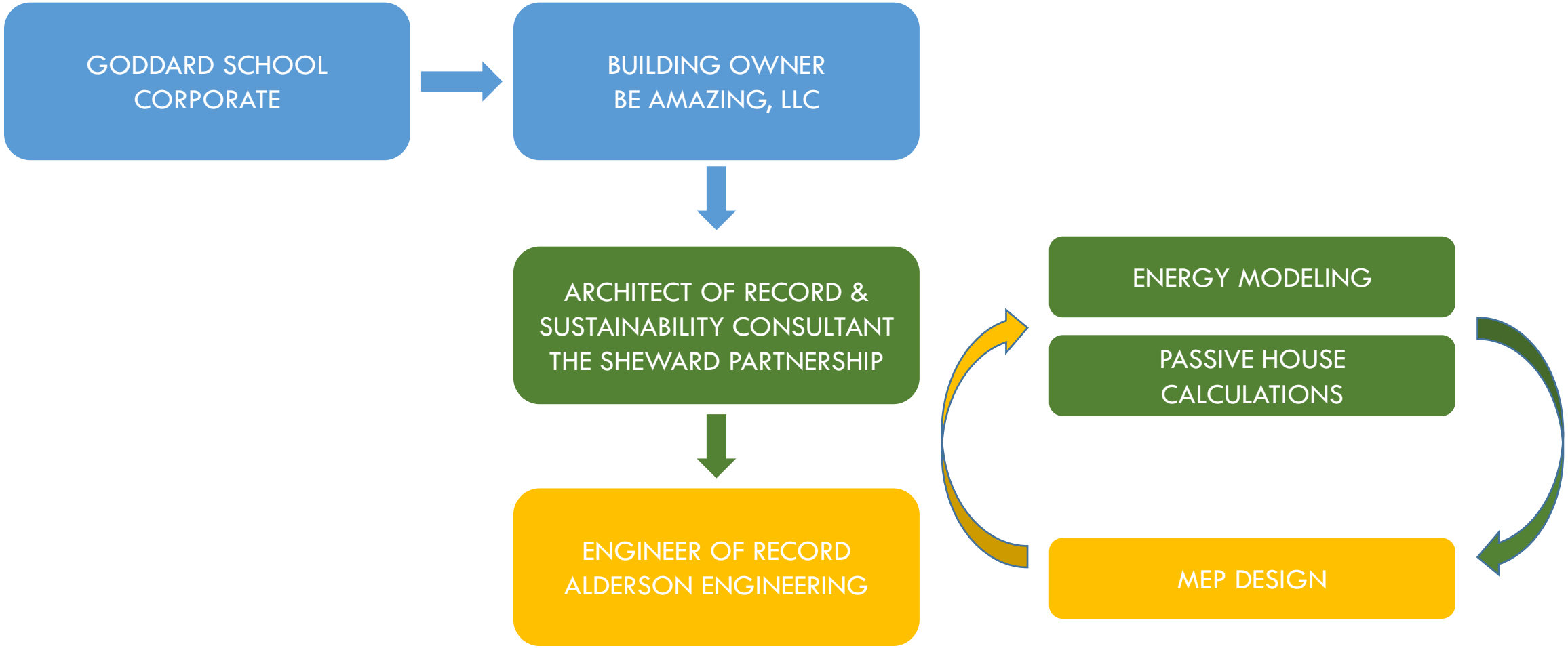
Jan 2017
Construction Start
Budget constraints resulted in pursuit of LEED Gold certification only

2018

Oct 2017
Occupancy

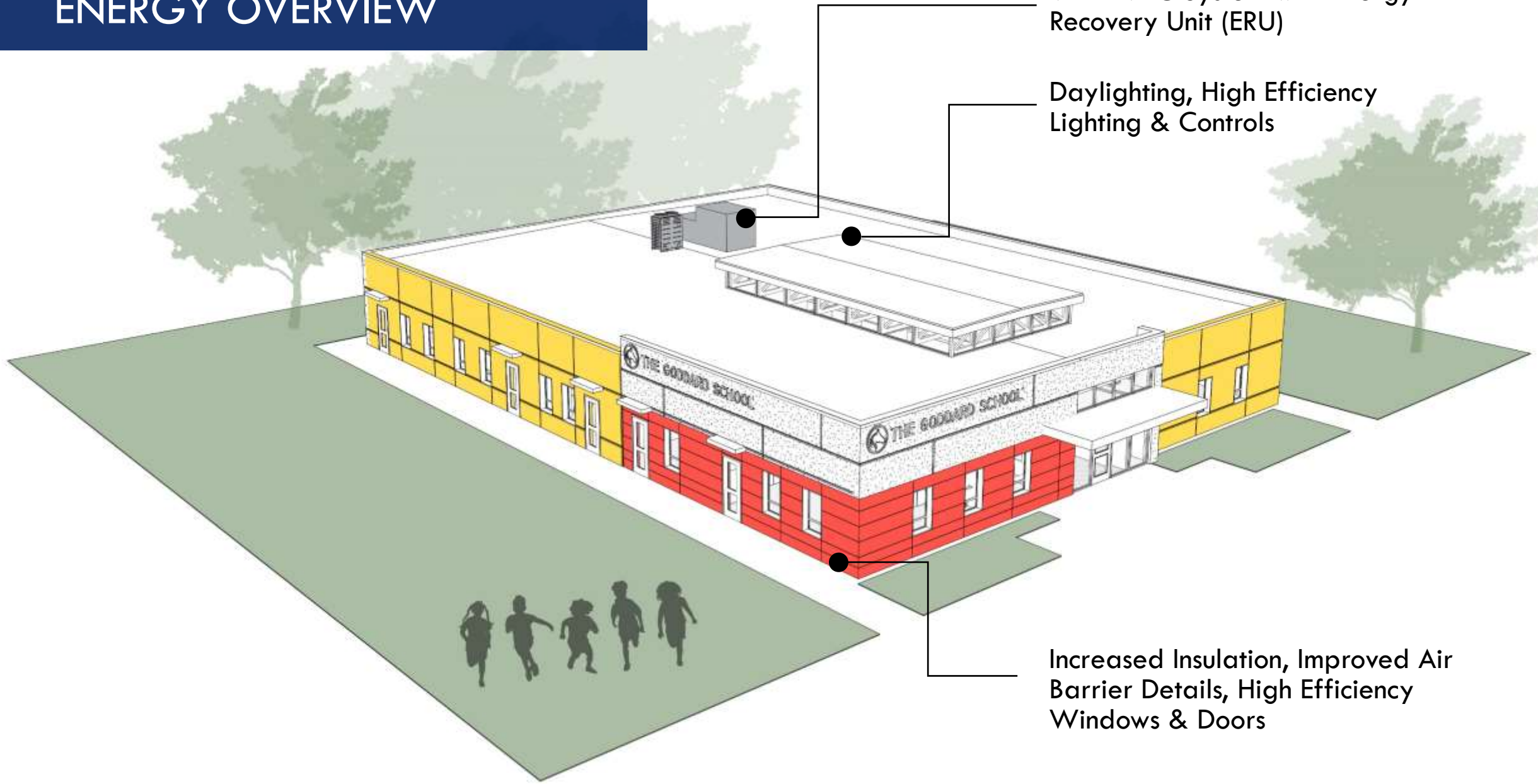
Jan 2018
Achieved LEED Gold Certification

TEAM STRUCTURE



ENERGY MODELING AS A TOOL

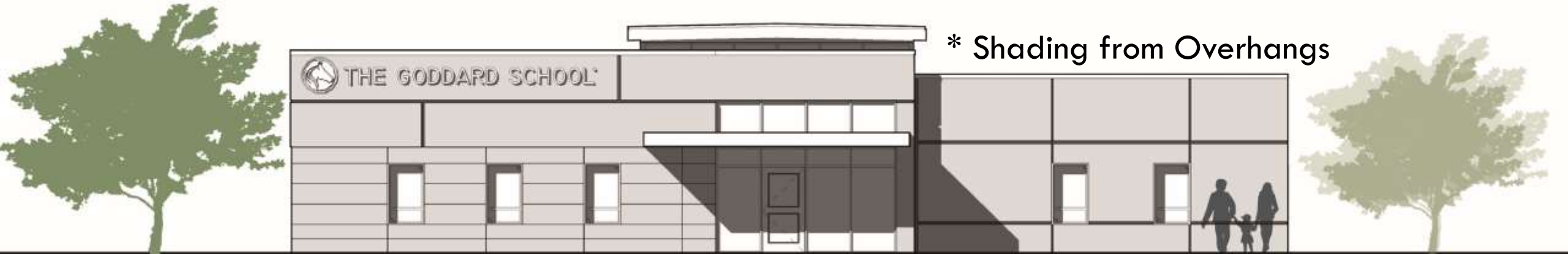
ENERGY OVERVIEW



ENVELOPE

Code Baseline	
Roof Insulation	R-20
Wall Insulation	R-13 + R-7.5 CI
Slab Insulation	None
Casement Window	U-0.40
Curtain Wall	U-0.50

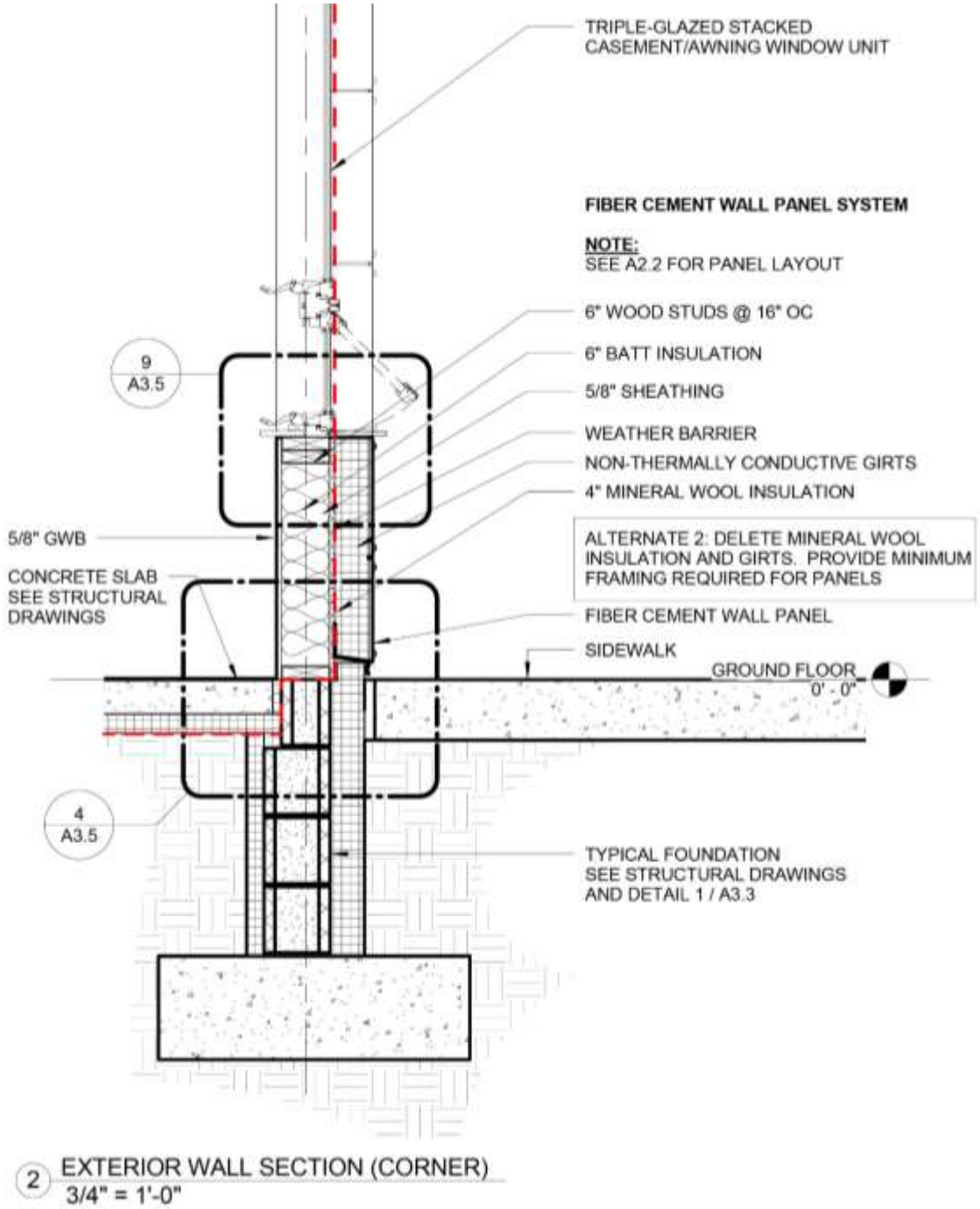
Actual Installation	
Roof Insulation	**R-50**
Wall Insulation	**R-20 + R-20 CI**
Slab Insulation	**R-12 CI**
Casement Window	**U-0.15**
Curtain Wall	**U-0.39**



* Shading from Overhangs

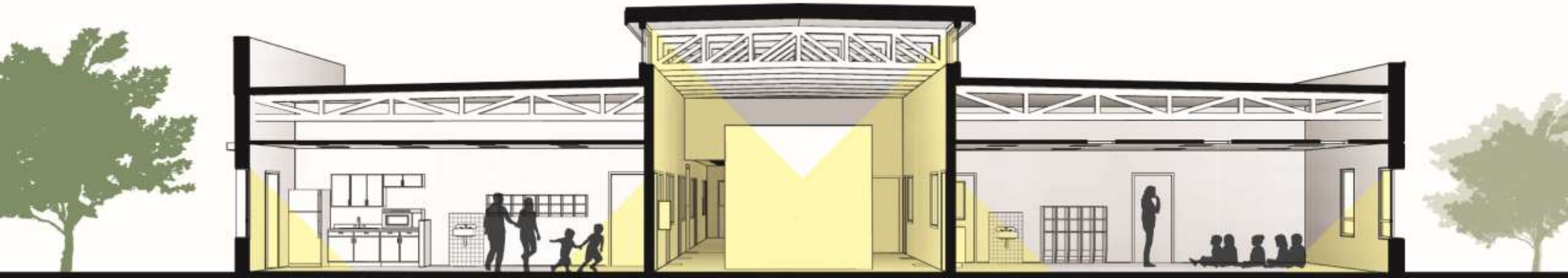
AIR BARRIER

- Details in construction documents
- Highlight air barrier continuity
- Aid design and construction teams



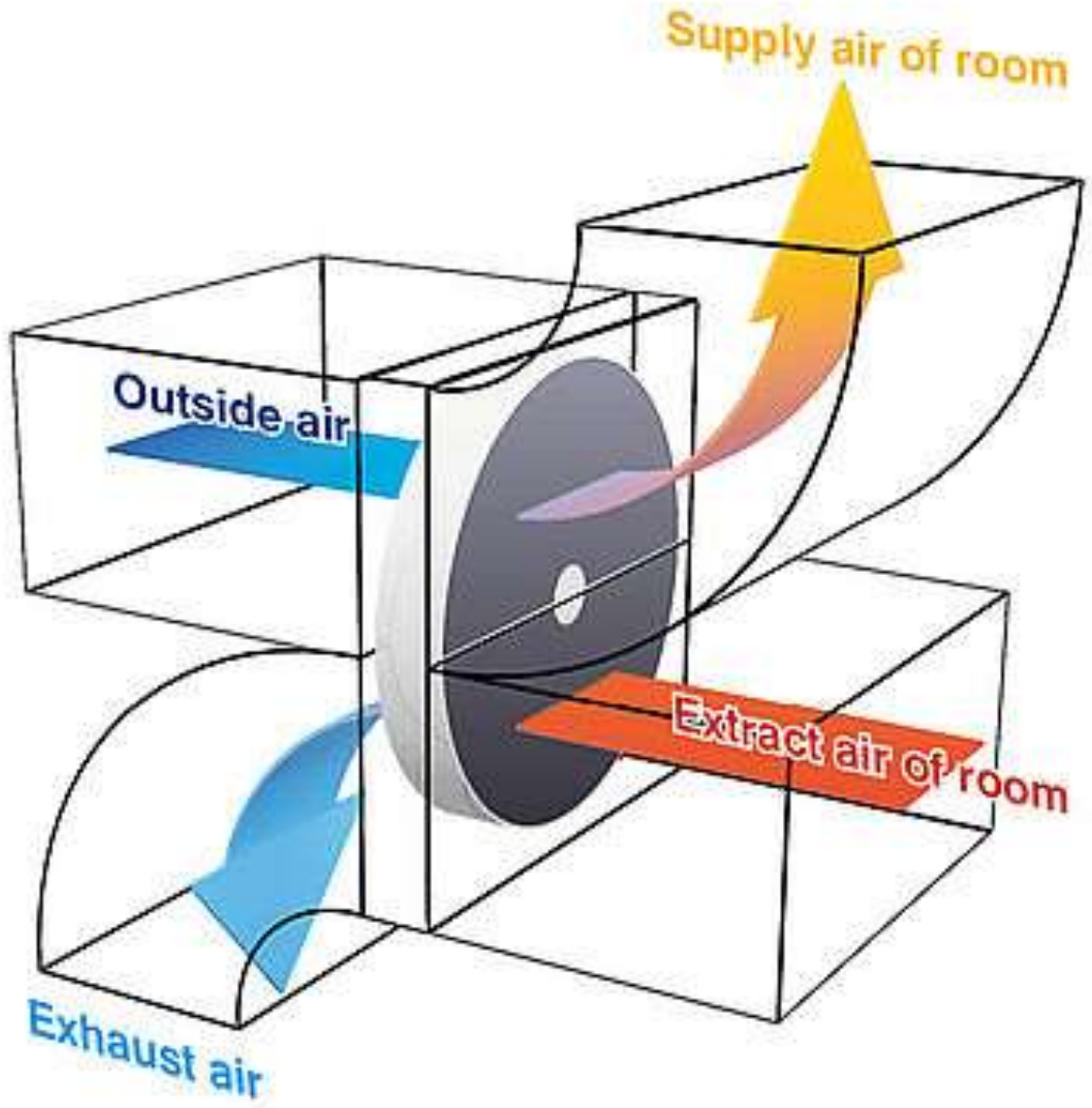
LIGHTING & DAYLIGHTING

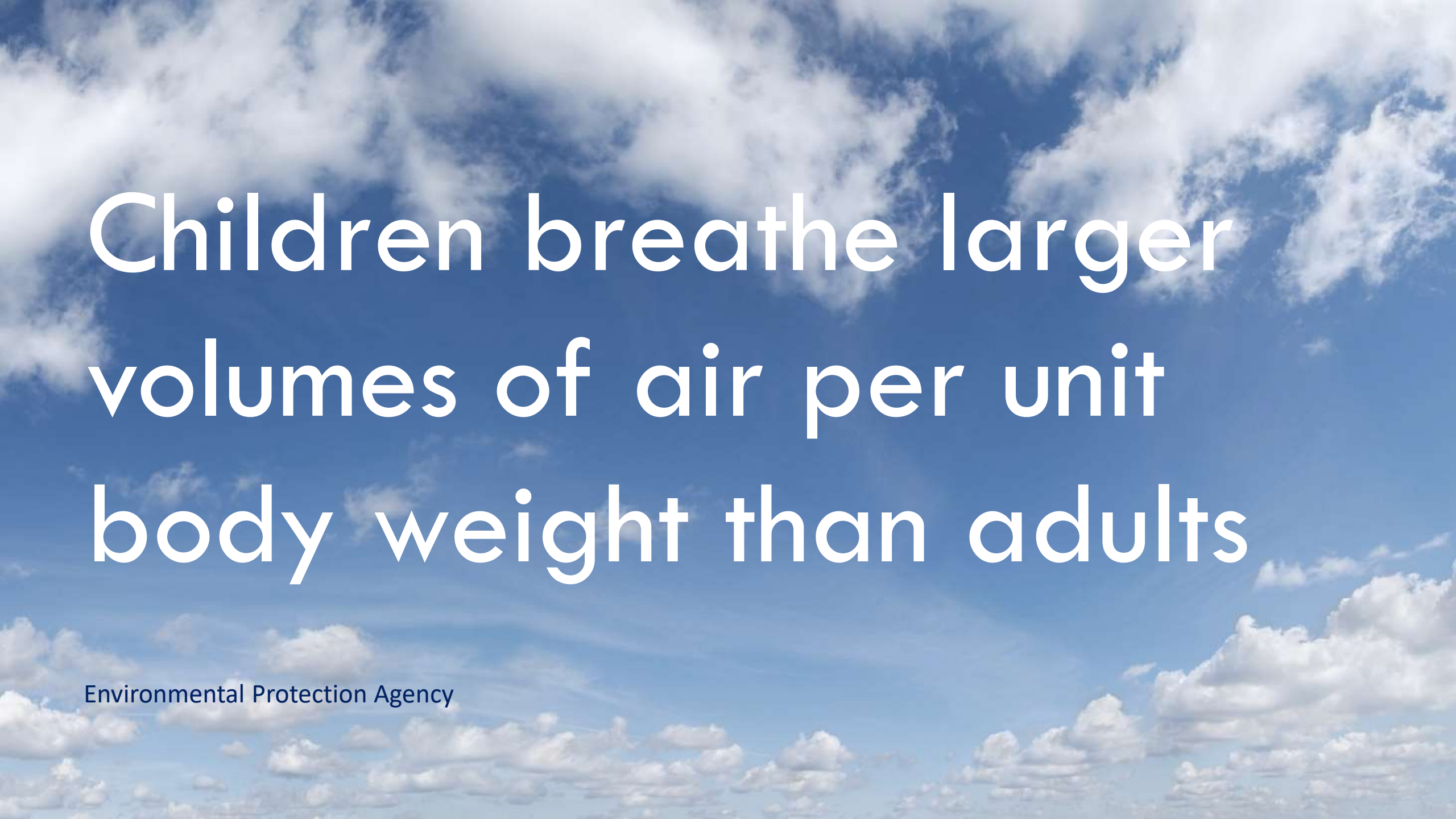
- LED lighting fixtures at 0.55 watts per square foot
- Daylight Harvesting, Dimming and Occupancy Controls
- Glazing Location & Quantity
- Window Treatment



HVAC

- Variable refrigerant flow (VRF) heating and cooling
- Latent and sensible wheel-type energy recovery
- Building automation system



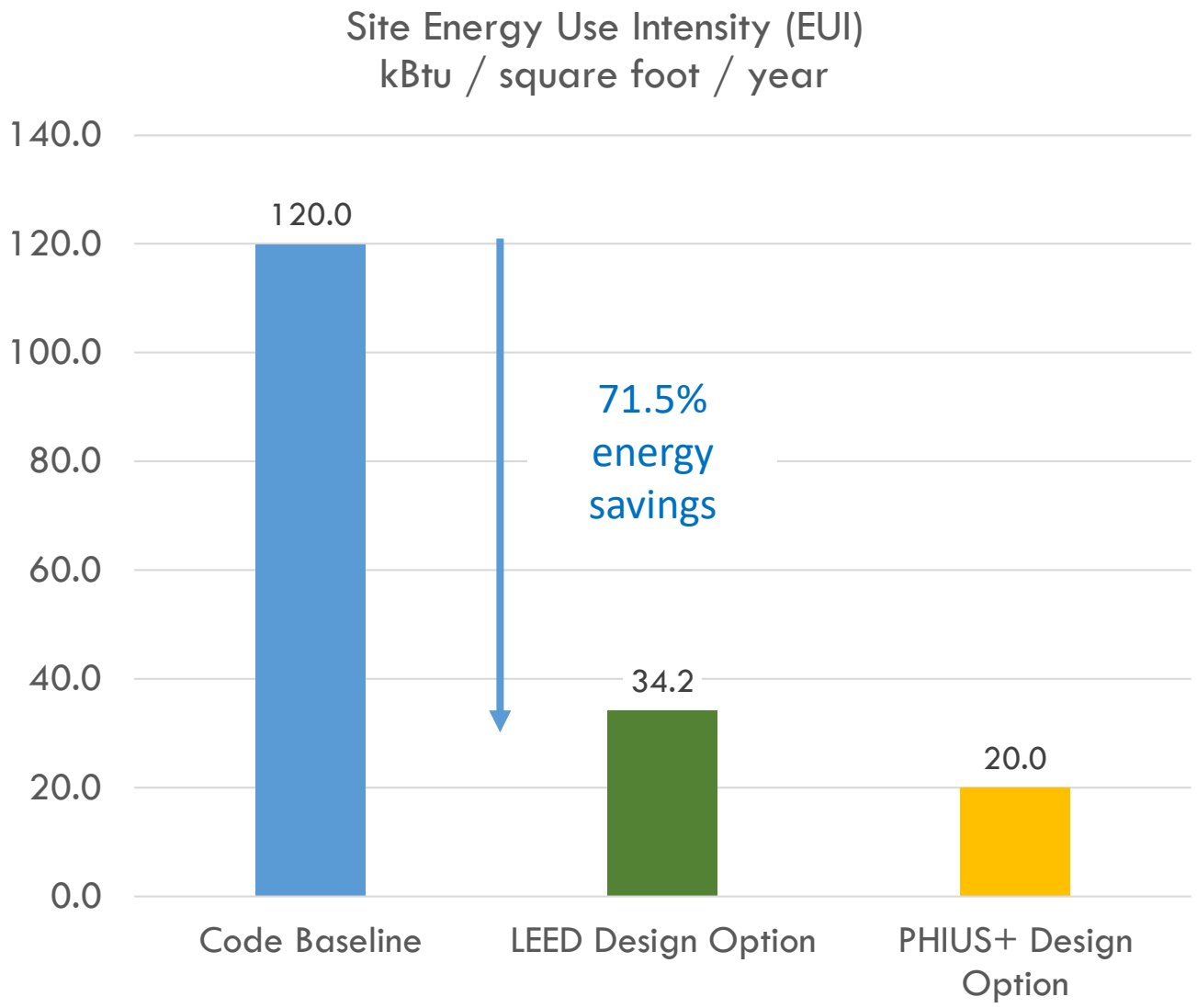

Children breathe larger volumes of air per unit body weight than adults
Environmental Protection Agency

VENTILATION

- Code ventilation rate equivalent for children and adults
- Ventilation is large component of total building energy consumption
- Balance supply and exhaust, ventilation flow rates and maintain proper pressure

SCHEMATIC MODELING

- Schematic design energy modeling results
- Used passive principles to achieve energy goals
- Schematic PHIUS+ model is Net Zero Energy Ready (NZER)



HEALTH & WELL-BEING

LEED GOLD

- Achieved LEED Gold certification under the LEED for New Construction v2009 Rating System
- Coordination with Goddard design standards
- Focus on health and well-being

INDOOR AIR QUALITY

- Energy recovery resulted in higher quality system than typical for low-rise application
- Passive House principles result in reduced infiltration and exfiltration rates
- Tighter envelope could result in greater indoor air contaminant levels

INDOOR AIR QUALITY (IAQ)

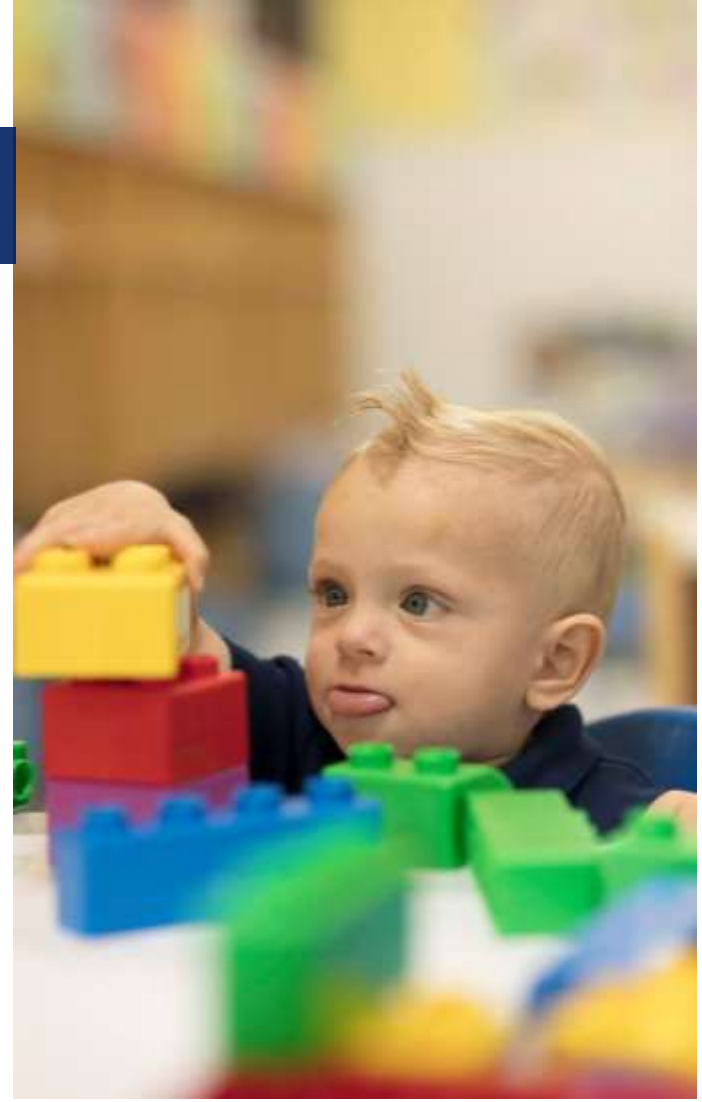
- Low-emitting materials in coordination with Goddard design standards
- Goddard supplies casework direct with no added urea formaldehyde resins

IAQ BEFORE & AFTER

- Construction IAQ Management Plan
- General Contractor completed building flush-out to remove dust and contaminants
- Green Cleaning Policy uses materials and equipment that are less toxic and promote indoor air quality

COMFORT

- ASHRAE 55 addresses temperature, humidity, air movement and radiant temperature
- Lighting and thermal comfort controls for staff
- Daylight and views



LESSONS LEARNED

BLOWER DOOR TESTING: DURING CONSTRUCTION

- PHIUS+ requires whole-building air tightness test and performance

  q50 <= 0.050 CFM_{50} / SF

- Per square foot of building envelope
- We completed preliminary test before gypsum wallboard to identify major issues
- Preliminary Results: 0.20 CFM_{50} / SF

BLOWER DOOR TESTING: END OF CONSTRUCTION

- PHIUS+ requires whole-building air tightness test and performance

  q50 <= 0.050 CFM_{50} / SF

- We completed final test before occupancy
- Final Results: 0.070 CFM_{50} / SF

TIPS FOR SUCCESS

- PHIUS+ provided an established roadmap to superior energy performance versus “testing” 15+ energy conservation measures
- Engage General Contractor early in process
- Review potential lead times of products contributing to Passive House

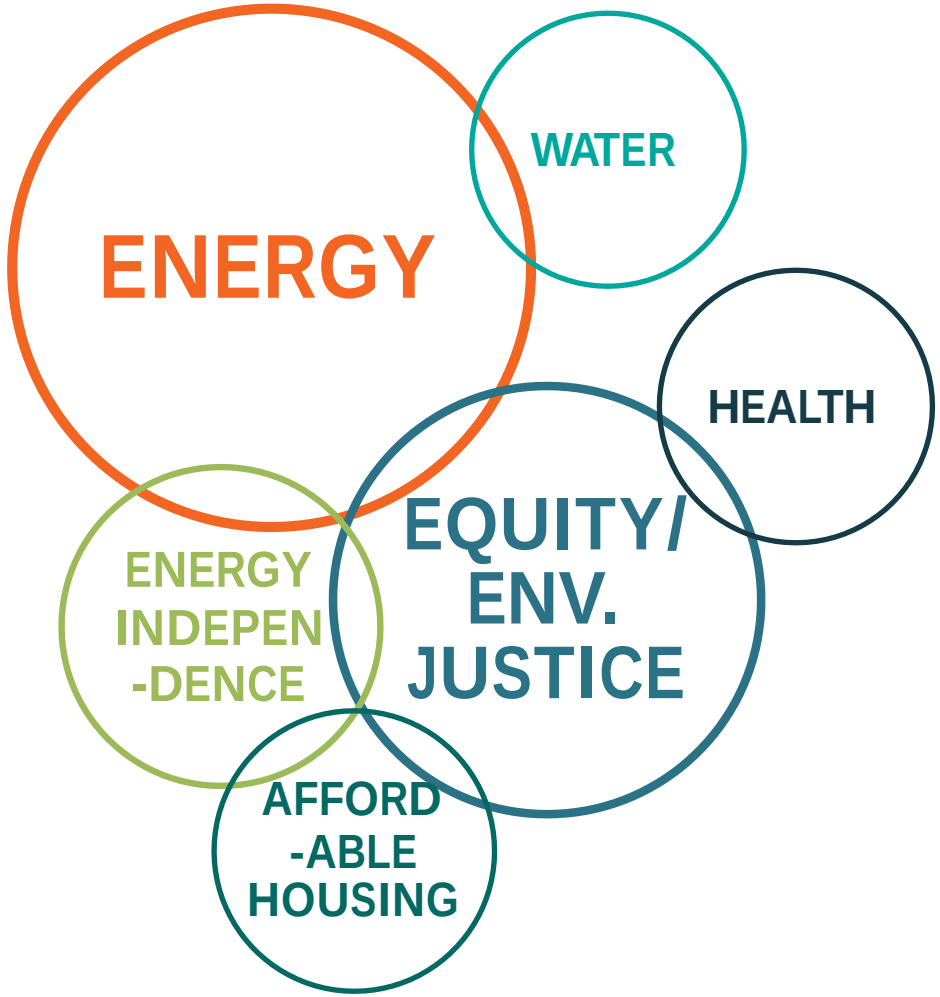
CASE STUDY #2

rendering by LHB

PROJECT OVERVIEW

- Minneapolis, Minnesota (6A)
- 118 total units Affordable Housing
- One standard and one PHIUS building with same unit mix
- PHIUS Building Metrics
  - Units 59
  - iCFA 53,000 SF
  - Envelope/iCFA 1.06
  - Occupants 156
  - Density 341 SF/Occupant

WHY PHIUS FOR AFFORDABLE HOUSING?



TIMELINE

2016

2017

2018

Spring 2016
Schematic Design
PHI Feasibility Study
Targeted PHI due to neighborhood demand and developer interest

Spring-Summer 2017
Design Development
PHIUS+ 2015 chosen as rating system, iterative WUFI Passive models

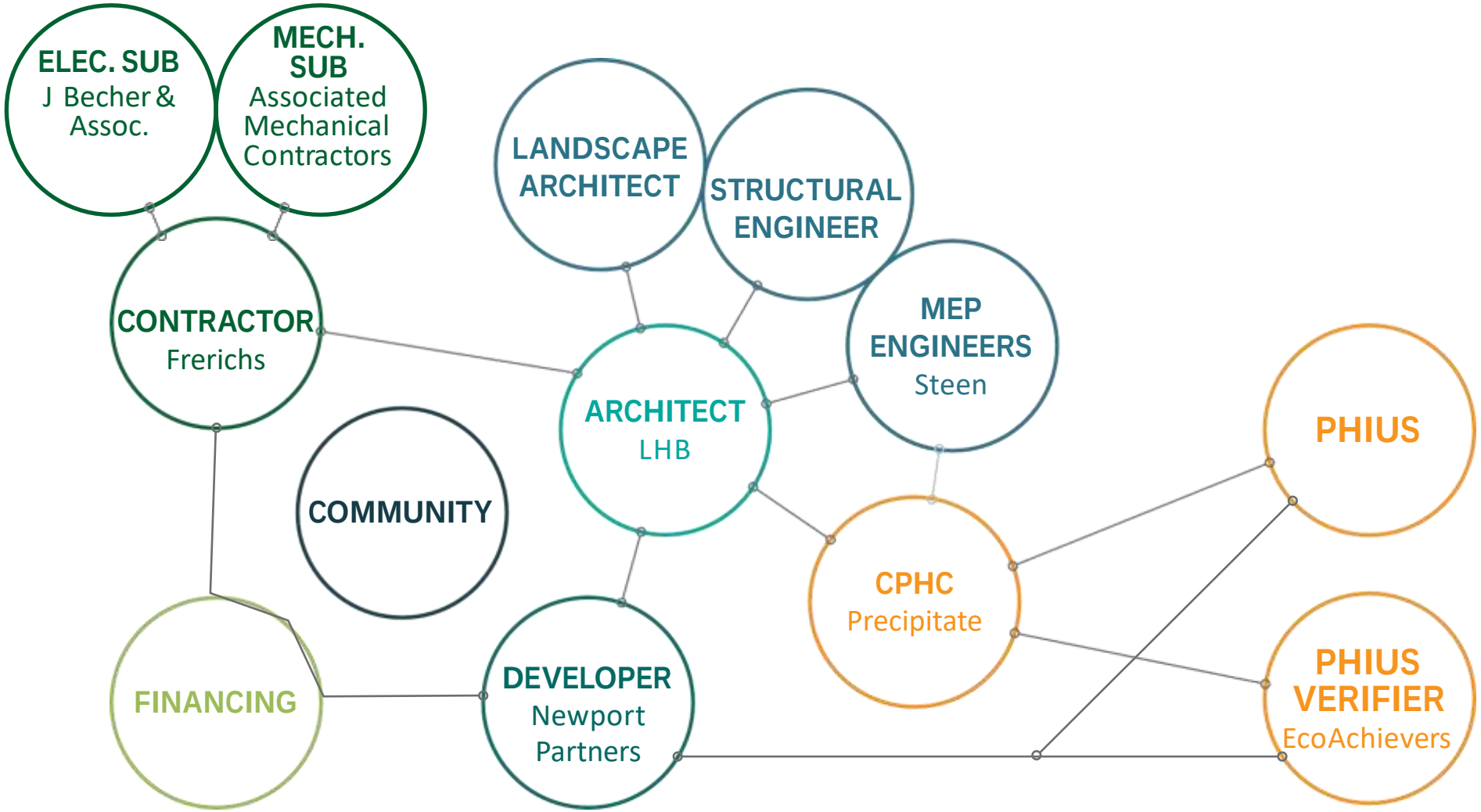
Fall 2018
PHIUS Review Begins
Three rounds of submissions

April 2018
Achieved PHIUS+ 2015 Pre-Certification

August 2018
Construction Start
PHIUS Verifier engaged throughout construction process

FEBRUARY 2019 PROGRESS

TEAM STRUCTURE



STRATEGIES OVERVIEW

INCREASED R-VALUES AND AIR SEALING

Roof Insulation	**R-55**
Wall Insulation	**R-19 + R-9.6 CI**
Slab Insulation	**R-20 CI**
Awning Window	**U-0.17, SHGC 0.2**
Fixed Window	**U-0.15, SHGC 0.27**

SYSTEMS

VRF HVAC System with Centralized Energy Recovery Ventilation (ERV)

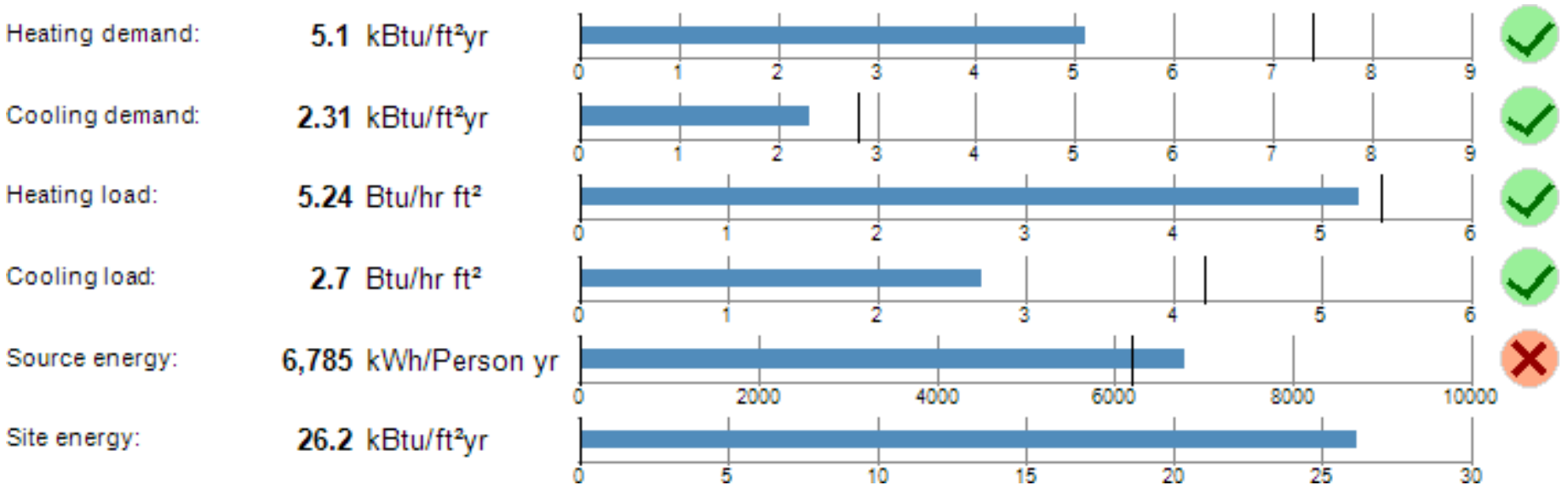
All LED Lighting

Heat Pump Dryers

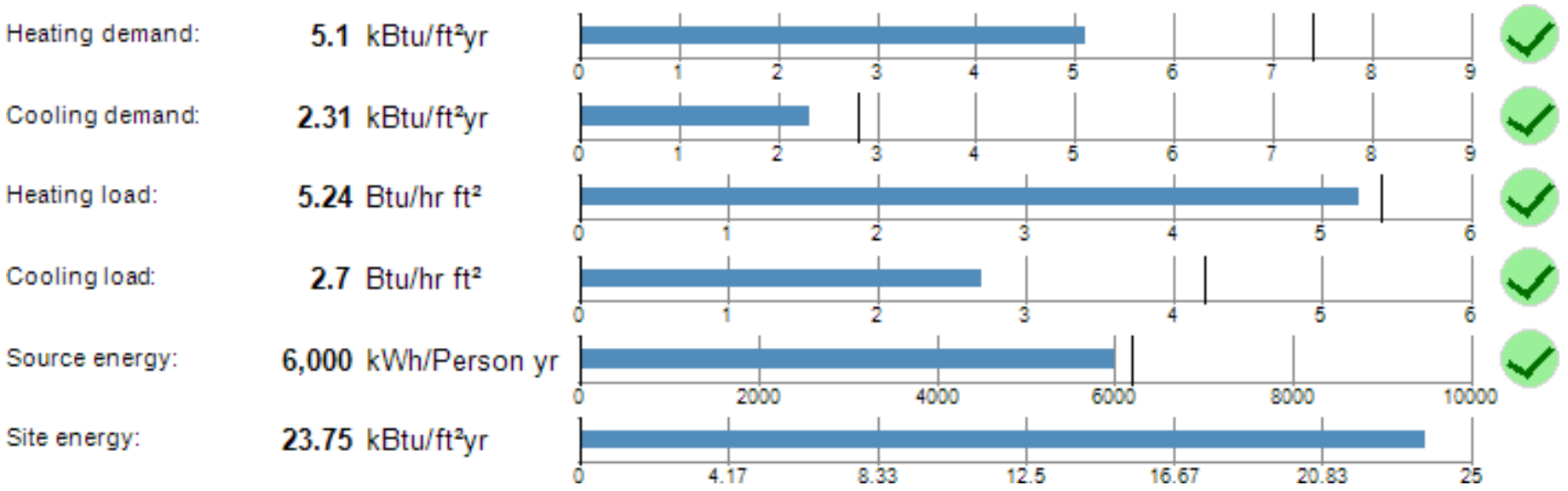
DHW Preheat by VRF

40 kW Rooftop Solar

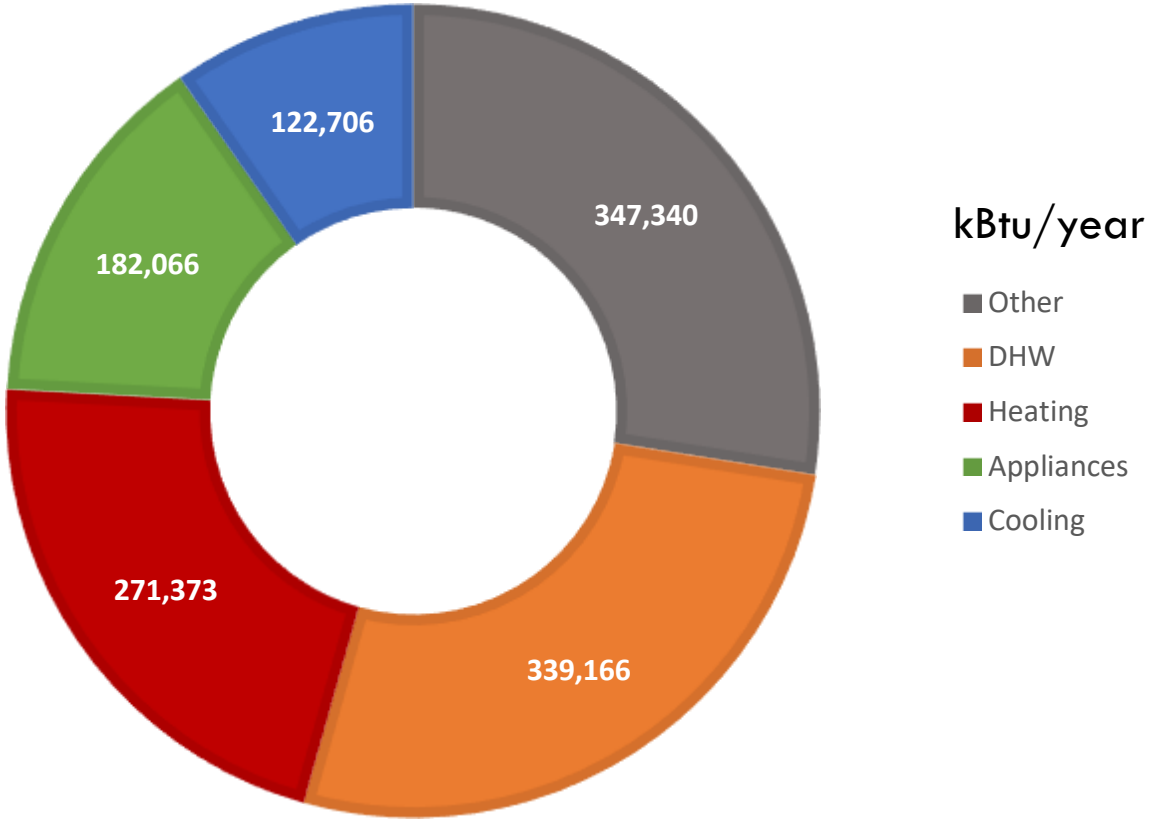
ENERGY TARGETS



ENERGY TARGETS

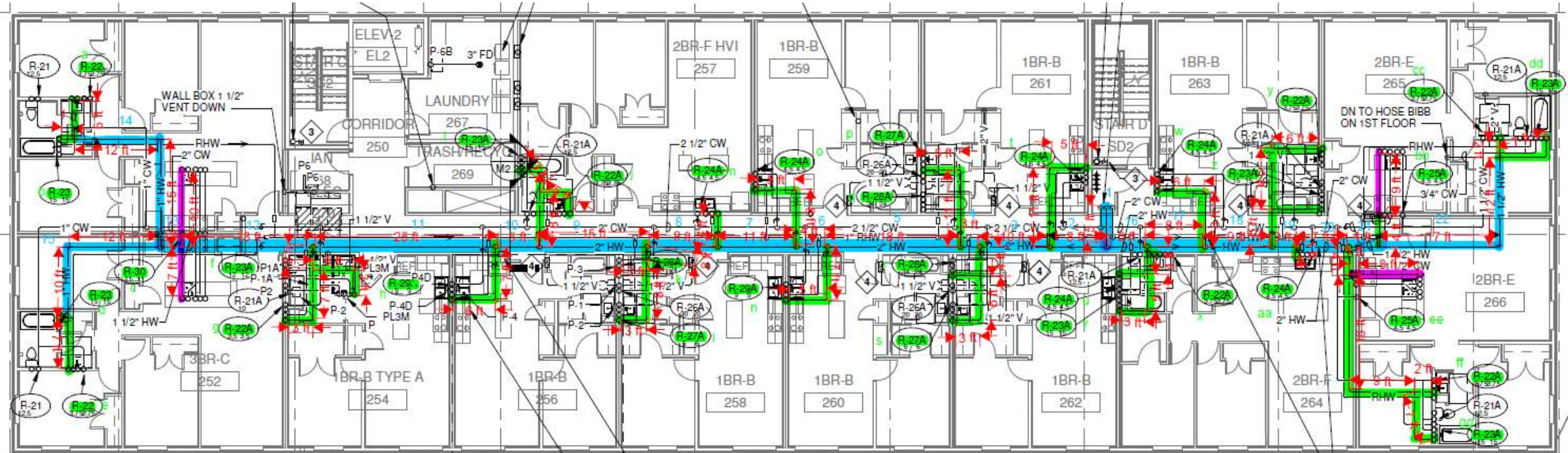


TOTAL ENERGY DEMAND



DOMESTIC HOT WATER

- Recirculating Loop layout
- VRF used for DHW preheat up to 400 gallons whenever excess heat
- Could alternatively use solar preheat

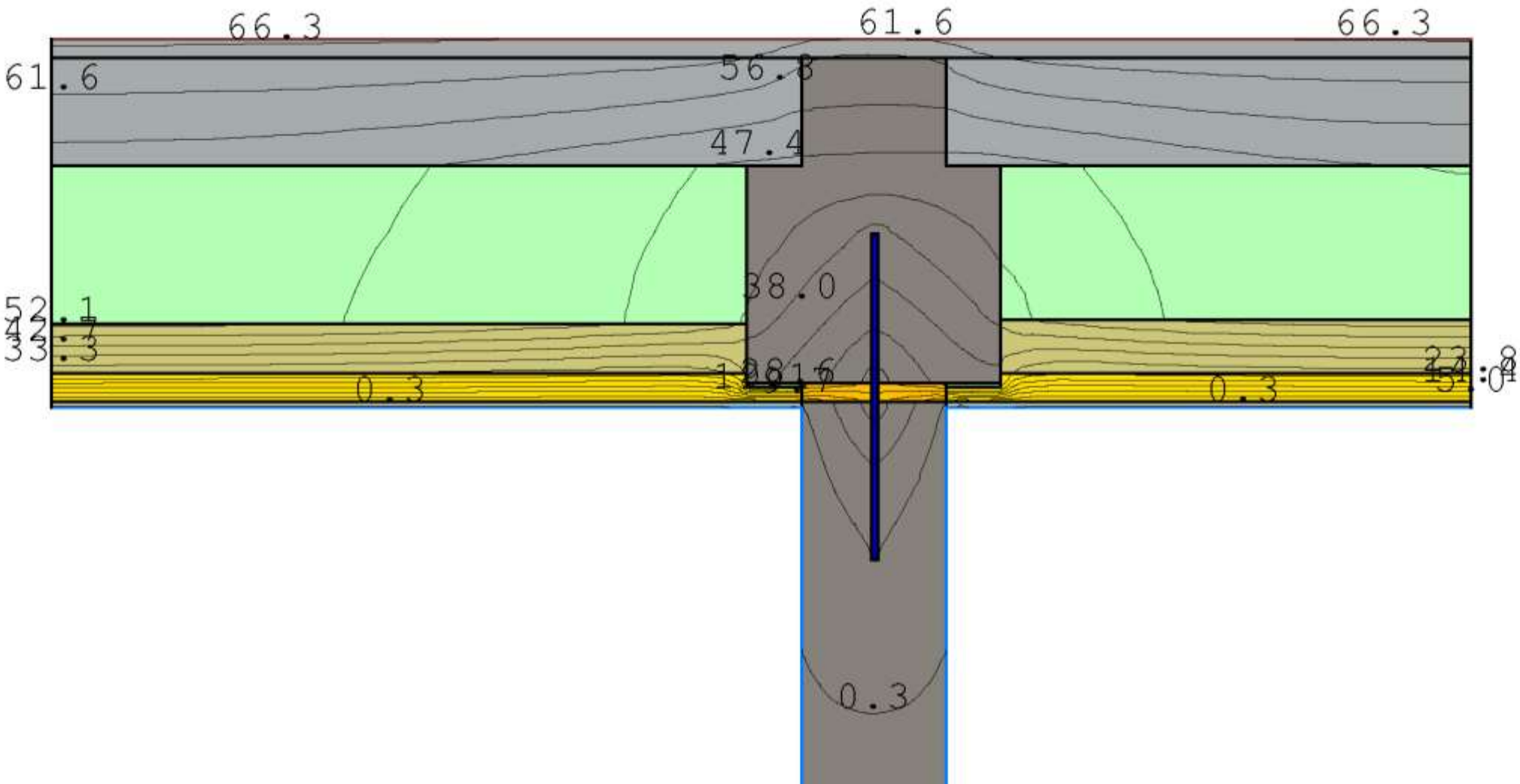


THERMAL BREAKS

WITHIN THERMAL ENVELOPE

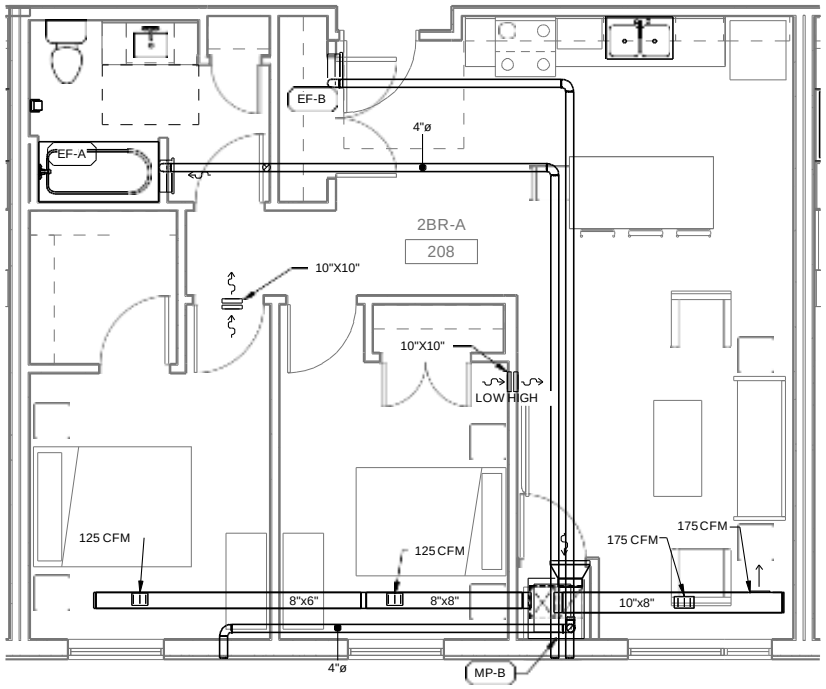
THERMAL BREAK AT TUCK-UNDER PARKING

THERM MODEL



HVAC

STANDARD BUILDING



PHIUS+2015 BUILDING

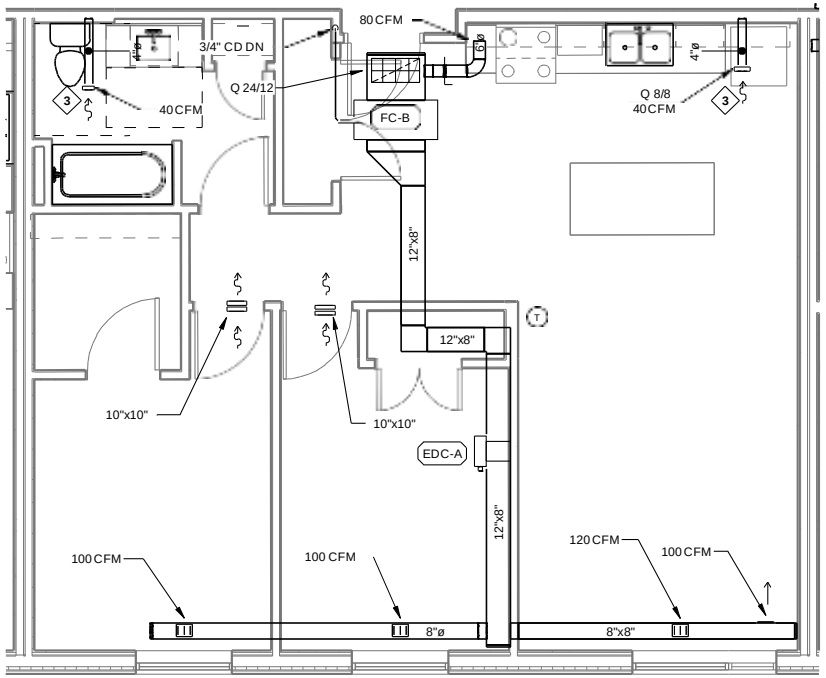


image credit: LHB

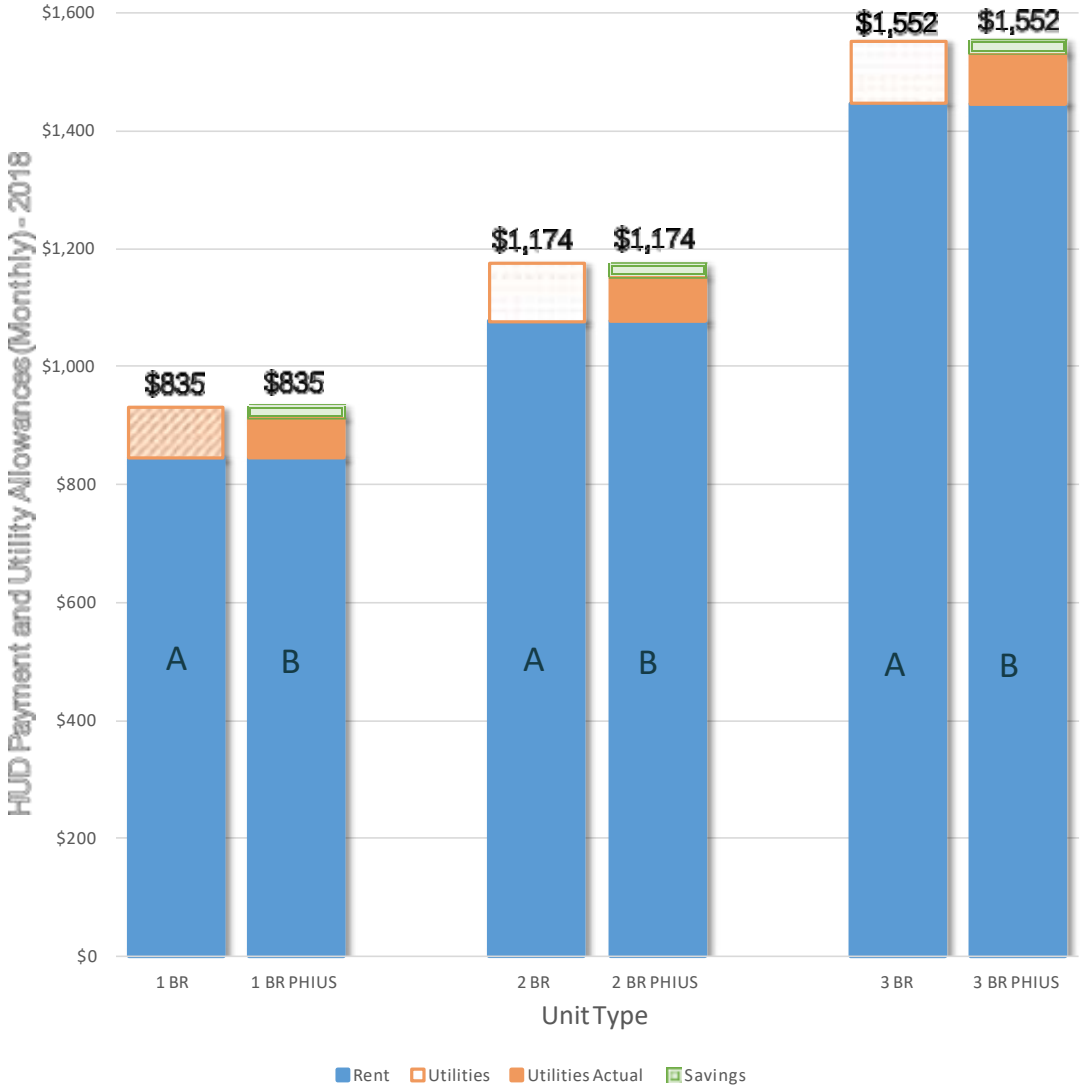
Somewhat over-ventilated space to avoid high humidity
Would have been helpful to oversize distribution ducts (max HP for fans)

DRYERS

- 3 Standard, 6 Heat Pump Condensing Dryers
- Reduced make-up air allowed us to come in under energy targets
- Heat Pump Condensing Dryers aren't yet available for commercial leasing – waiting for future technological advancements

UTILITY DELIVERY STRUCTURE

- Utility Supplied Metering
  - 120 Electric meters
  - 61 Gas meters
  - Residential energy rate
  - 118 units annual utility services charges $27,289
- Wireless Monitors
  - 2 Electric meters
  - 2 Gas meters
  - Commercial energy rate
  - No Utility Service Charges
  - $32,580 in Utility Service Savings



Graphic courtesy LHB

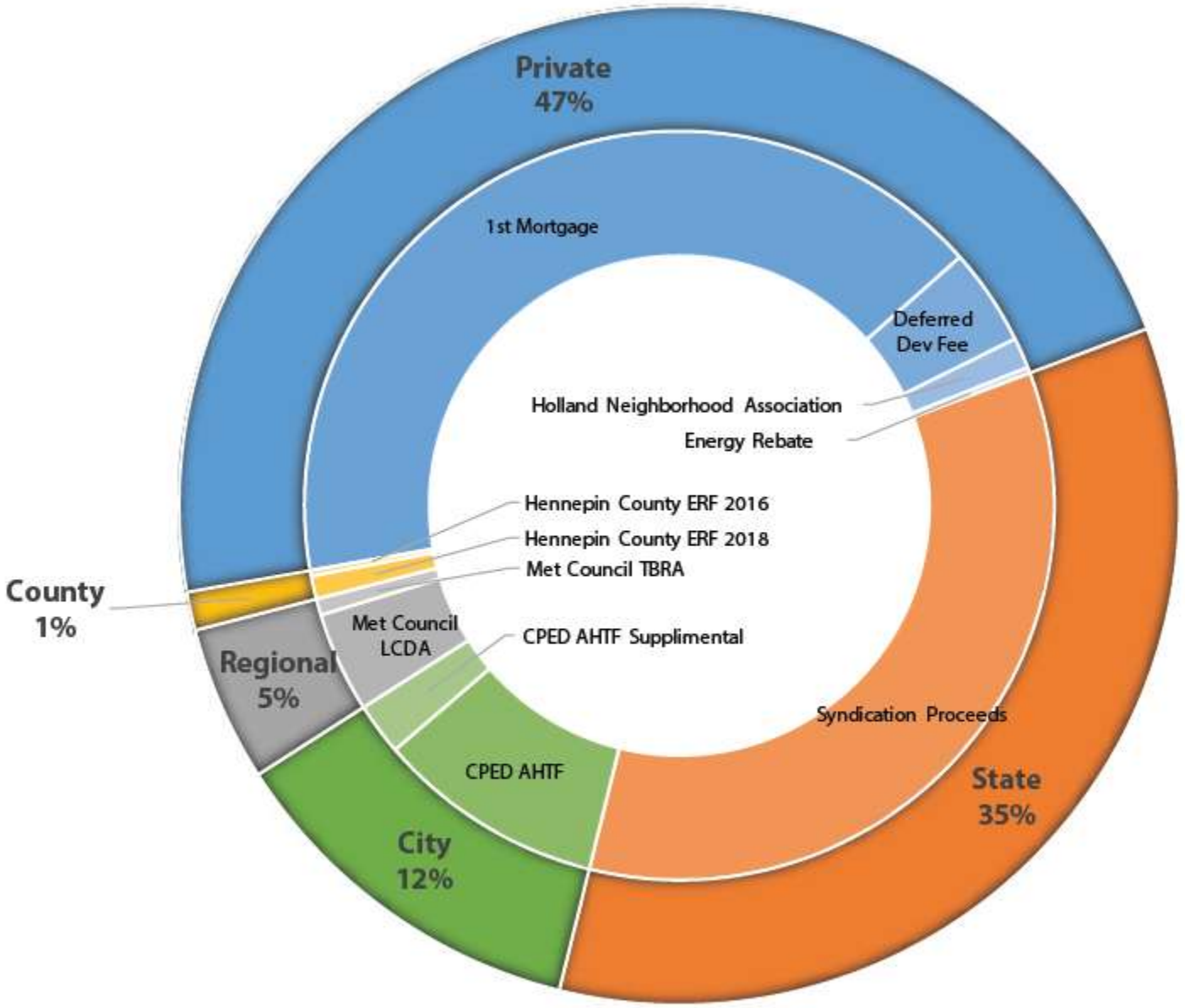
COST COMPARISON

PHIUS Building Unit Cost
(Excluding site)

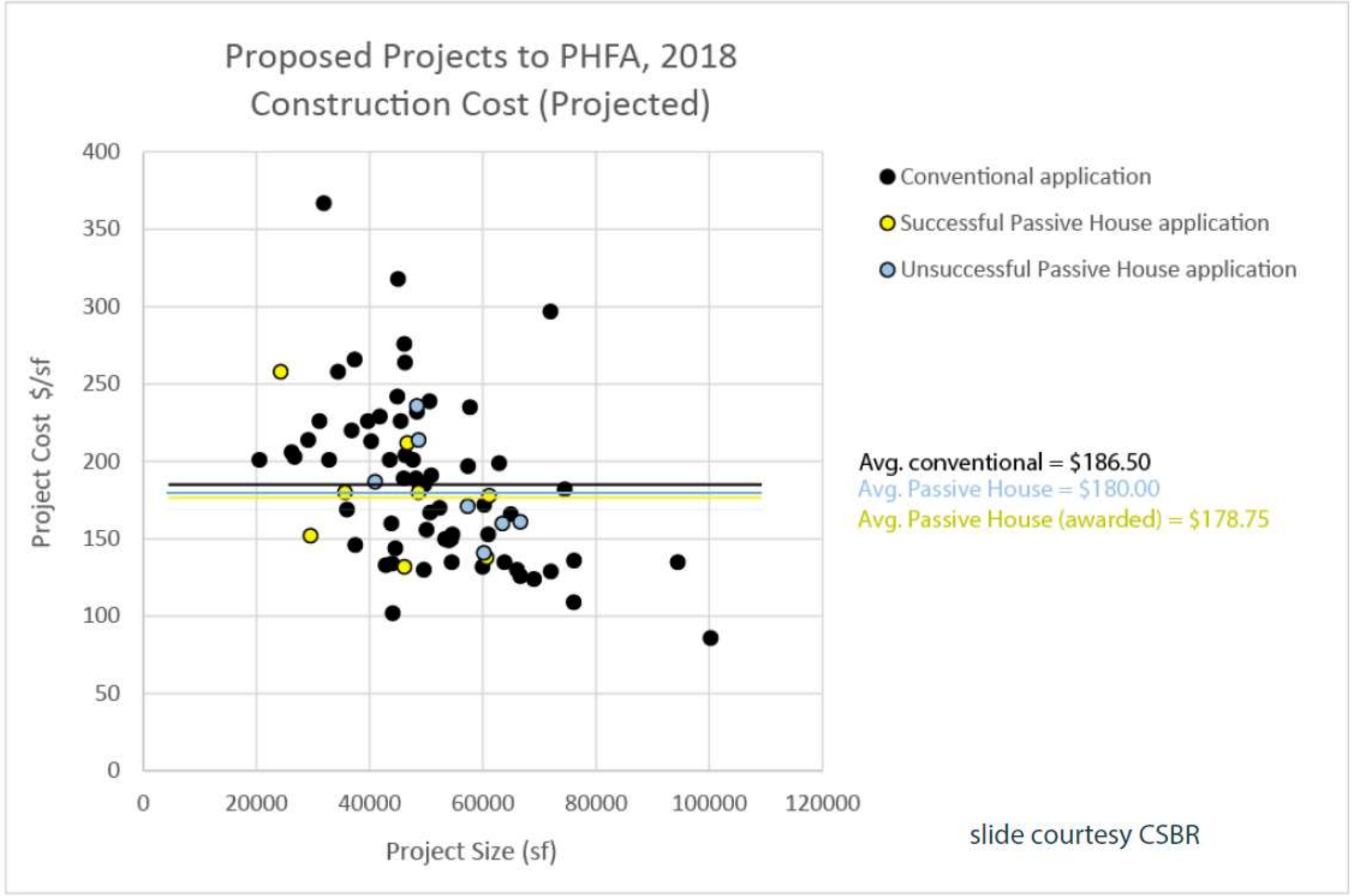
- $163,750
- +$140,000 total for solar

Standard Building Unit Cost
(Excluding site)

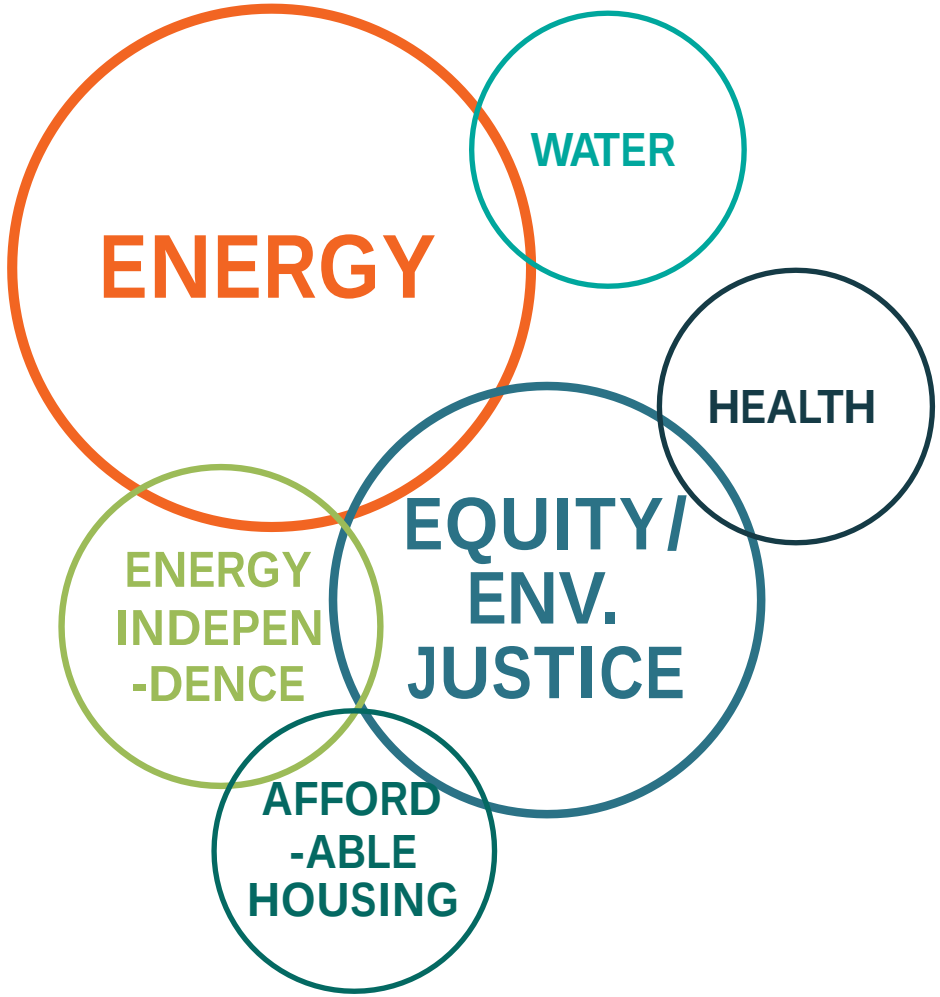
- $163,995



Graphic courtesy LHB


Proposed Projects to PHFA, 2018
Construction Cost (Projected)
Project Cost $/sf
400
350
300
250
200
150
100
50
0
0
20000
40000
60000
80000
100000
120000
Project Size (sf)
Conventional application
Successful Passive House application
Unsuccessful Passive House application
Avg. conventional = $186.50
Avg. Passive House = $180.00
Avg. Passive House (awarded) = $178.75
slide courtesy CSBR

WHY PHIUS FOR AFFORDABLE HOUSING?



WHY PHIUS FOR AFFORDABLE HOUSING?

PHIUS+ 2015 REQUIREMENTS

- High-performance building envelope
  - Thermal comfort
  - Moisture control
  - Durability
- Fresh air requirements
  - Direct bedroom supply
  - MERV 8 (MERV 12)
  - Limited exposure to combustion gas
- DHW design

OCCUPANT BENEFITS

- Resilience
  - extreme weather
  - power outages
  - housing cost uncertainty
- Remediation of environmental pollution
- Increased occupant comfort
- Increased occupant health
  - reduction in mold, bacteria, dust, pests
  - cardiovascular
  - stress

COMMUNITY BENEFITS

- Lower turnover = connection to community
- Resilience
- Proactive care for vulnerable populations
- Economics
- Emissions
- Prototype

OWNER BENEFITS

- Funding opportunities
- Reduced maintenance/ operation costs
  - utilities
  - envelope durability (3rd party verified)
  - lower turnover

For more information on some benefits, see Norton, Ruth Ann, Brendan Wade Brown, Kiki Malomo-Paris, and Elizabeth Stubblefield-Loucks. "Non-Energy Benefits of Energy Efficiency and Weatherization Programs in Multifamily Housing: The Clean Power Plan and Policy Implications." *Green & Healthy Homes Initiative*, September 2016.

TIPS FOR SUCCESS

- Meet early and often with the team, and have MEP charrettes directly with CPHC
- Determine who is gathering performance data from manufacturers
- Use WUFI Passive model for its intended purpose – certification & envelope optimization
- Submit requests for Technical Committee Review for innovative system design
- Avoid excessive SF/person
- Consider which rooms are ‘inside building envelope’
- A PV system will likely be necessary in multifamily housing to meet per-person source energy targets

Group Design Build – Residence, Cambridge MA

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Thank you!

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