AIMING AT ZERO

THE STRUGGLE TO GET THERE

MARCH 9, 2016

PERKINS+WILL

INTRODUCTION

STEPHEN MESSINGER

#1

Aiming at ZERO

1. Overview of Panel Discussion (5-10 min)
   - 2030, EUI/ LPD + Case Study Projects
2. Introduction of Panelists (5 min)
3. Initial Framework: the Owner's Perspective (5-10 min)
4. Aiming at ZERO (35-40 min)
   - Minimize Building Loads
   - Maximize Energy Efficiency
   - On Site Renewables
   - Minimize Consumption
5. Discussion + Questions (15-20 min)

LEARNING OBJECTIVES
Aiming at ZERO

1. Learn about role played by each team member guiding projects to reduce energy consumption
2. Understand parameters in decision making process
3. Use simple overarching strategy to address energy reduction at four levels
4. Apply lessons learned from projects and case studies to future endeavors
5. Compare potential design approaches for anticipated energy reduction and lifecycle cost

WHAT IS **ZNEB**?

zero net energy building

a building that is **optimally efficient** and over the course of the year **generates energy onsite** using clean **renewable sources** in a quantity equal to or greater than the total amount of energy consumed onsite

Definition from *The Massachusetts Zero Net Energy Building Task Force*

WHAT ARE THE BENCHMARKS? EUI / LPD / EMBODIED ENERGY

- **Energy Use Intensity (Kbtu/s.f./ yr.)** - (p) **Predicted vs. Proposed**

  the rest of the world uses Kw/m/yr. (watt=3.41btu)

- **Light Power Density (w/s.f.) Maximum Light Power Provided**

  now includes task lights

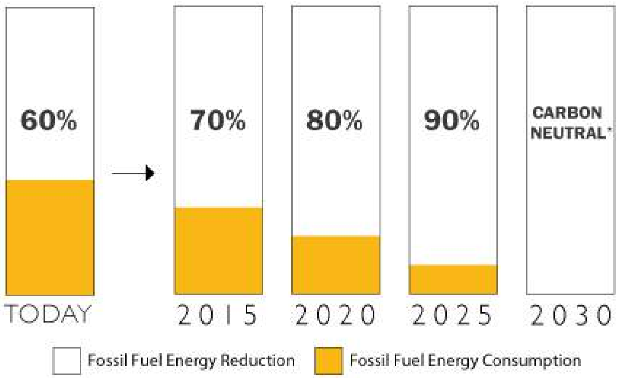
- **Embodied Energy to Mine, Produce, Ship and Erect / Install Products**

  more relevant for carbon footprint calculations, hard to calculate

ESTABLISHING ENERGY GOALS

Where to begin?

http://architecture2030.org/files/2030_Challenge_Targets_National.pdf



The 2030 Challenge

*Using no fossil fuel GHG-emitting energy to operate.

2030 CHALLENGE Targets: U.S. National Averages

ESTABLISHING ENERGY GOALS

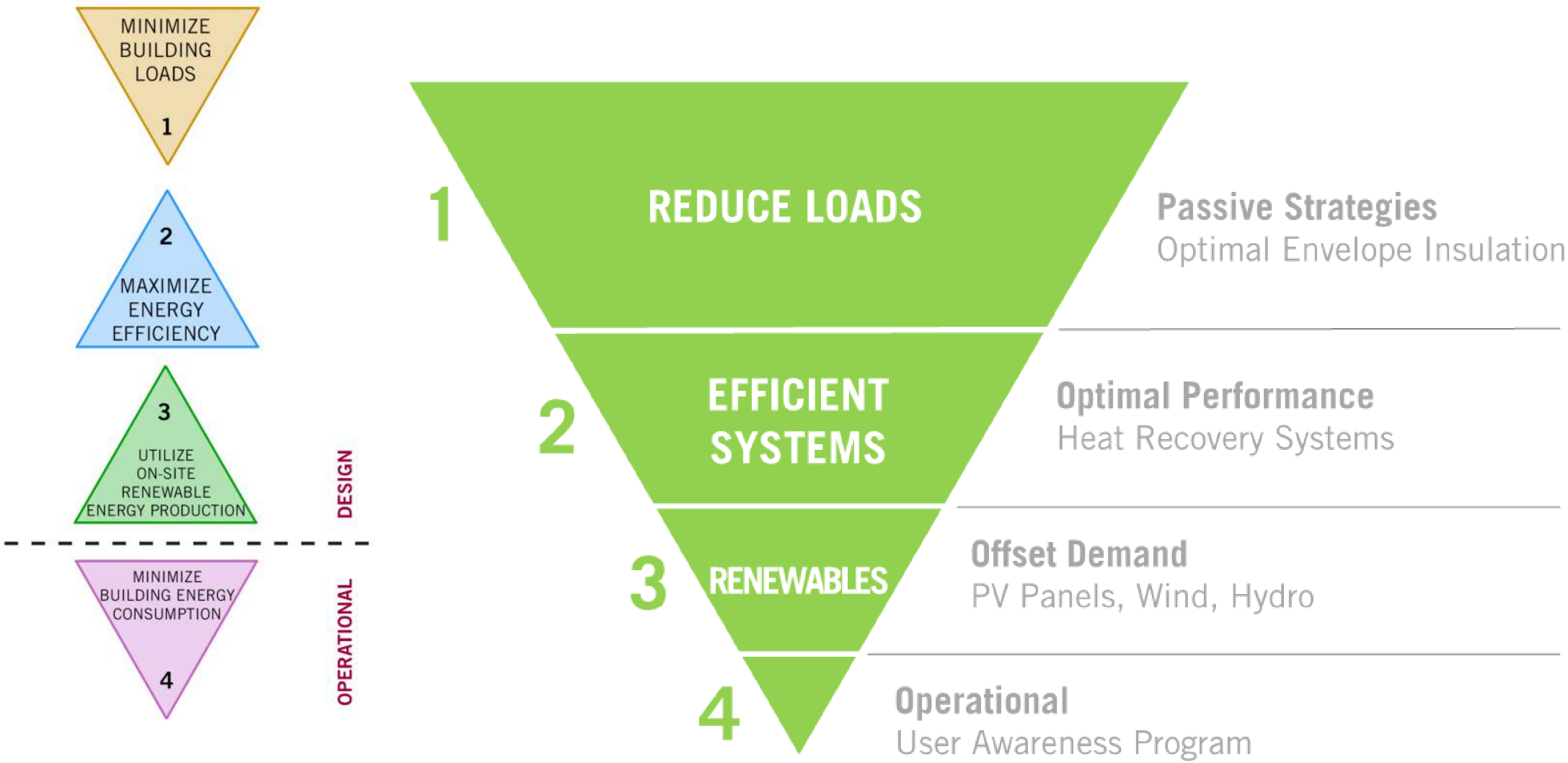
2030 CHALLENGE Targets: U.S. National Averages

U.S. Averages for Site Energy Use and 2030 Challenge Energy Reduction Targets by Space/Building Type[1]

From the Environmental Protection Agency (EPA): Use this chart to find the site fossil-fuel energy targets

Primary Space / Building Type[2]	Available in Target Finder[3]	Average Source EUI[4] (kBtu/Sq.Ft./Yr)	Average Percent Electric	Average Site EUI[4] (kBtu/Sq.Ft./Yr)	2030 Challenge Site EUI Targets (kBtu/Sq.Ft./Yr)				
					50% Target	60% Target	70% Target	80% Target	90% Target
Administrative / Professional & Government Office	✓								
Education		170	63%	76	**38.0**	30.4	22.8	15.2	7.6
College / University (campus-level)		280	63%	120	**60.0**	48.0	36.0	24.0	12.0
K-12 School	✓								

4 STEPS TOWARD ZERO NET ENERGY DESIGN



WHAT ARE THE BENCHMARKS? EUI / LPD / EMBODIED ENERGY

- **Energy Use Intensity (Kbtu/s.f./ yr.)** - (p) **Predicted vs. Proposed**

  the rest of the world uses Kw/m/yr. (watt=3.41btu)

EUI – based on averages

pEUI – predicted

EUIp – proposed

↓

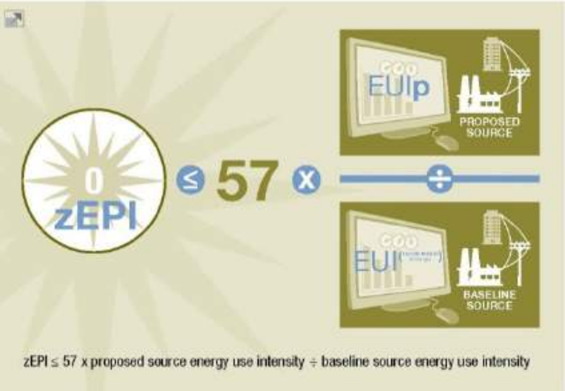
(use for energy model)

An Architect's Guide to Integrating Energy Modeling in the Design Process, AIA

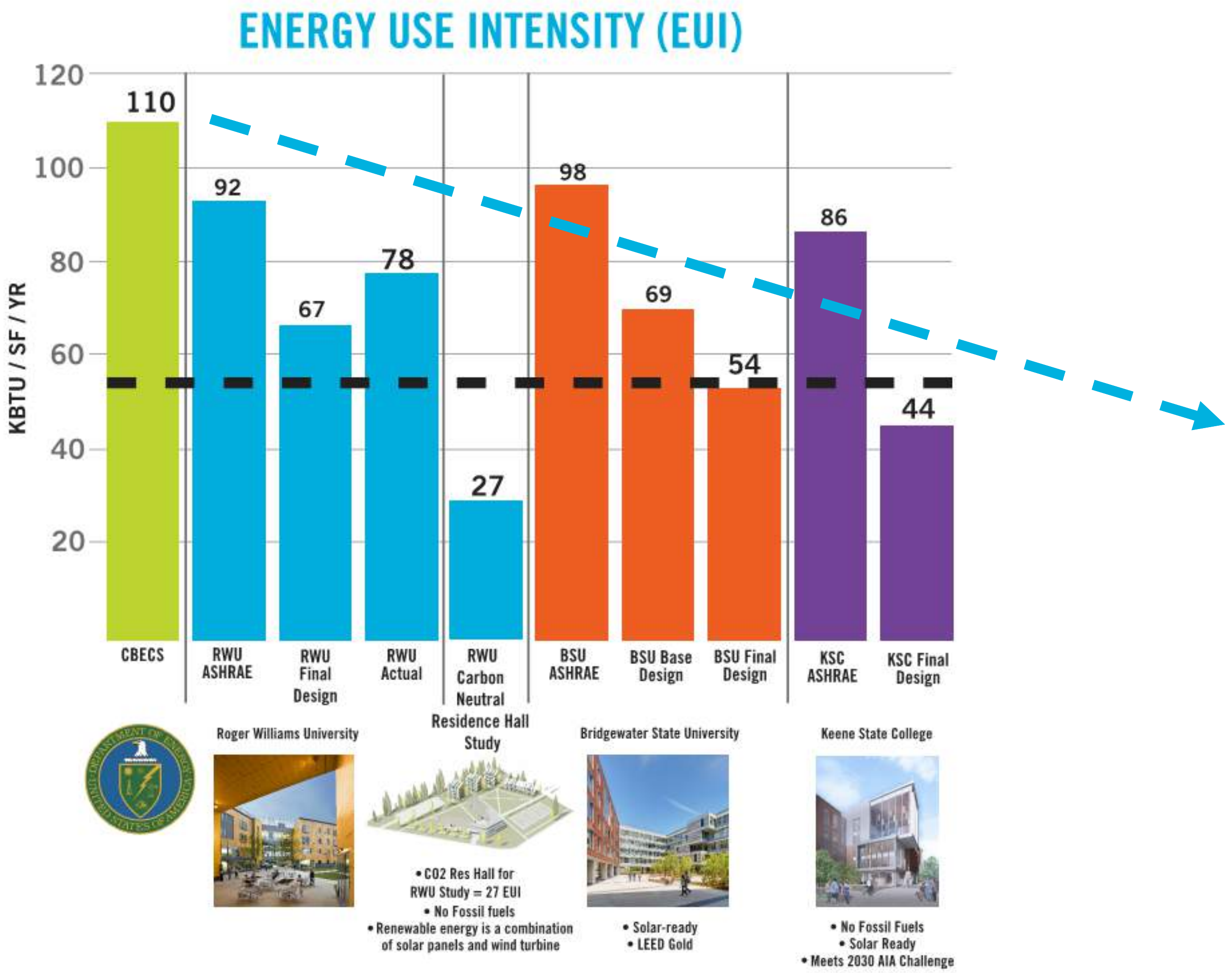
WHAT ARE THE BENCHMARKS? EUI / LPD / EMBODIED ENERGY

- **zero Energy Performance Index** (zEPI)

  value that represents the ratio of energy performance of a proposed building design compared to the average energy performance of buildings with similar occupancy and climate types, benchmarked to the year 2000



An Architect's Guide to Integrating Energy Modeling in the Design Process, AIA



ENERGY USE INTENSITY (EUI)
KBTU / SF / YR
120
100
80
60
40
20
110
92
67
78
27
98
69
54
86
44
CBECS
RWU ASHRAE
RWU Final Design
RWU Actual
RWU Carbon Neutral Residence Hall Study
BSU ASHRAE
BSU Base Design
BSU Final Design
KSC ASHRAE
KSC Final Design
Roger Williams University
Bridgewater State University
Keene State College
• CO2 Res Hall for RWU Study = 27 EUI
• No Fossil fuels
• Renewable energy is a combination of solar panels and wind turbine
• Solar-ready
• LEED Gold
• No Fossil Fuels
• Solar Ready
• Meets 2030 AIA Challenge

PANELISTS

AIMING AT ZERO: THE STRUGGLE TO GET THERE

#2

PANELISTS
Aiming at Zero

STEPHEN MESSINGER
AIA, LEED AP, BD+C
Project Architect
Perkins+Will

Moderator

YANEL DE ANGEL
AIA, LEED AP, BD+C
Associate Principal
Perkins+Will

Architect

CHRIS SHUMWAY
PE, LEED AP
President
Rist Frost Shumway

Engineer

JAY KAHN
AIA, LEED AP
VP for Finance + Planning
Keene State College

Owner

AMANDA FORDE
LEED AP, BD+C
Director of Capital Renewal
MSCBA

Owner

OWNER'S PERSPECTIVE

JAY KAHN AND AMANDA FORDE

#3

SETTING THE STAGE FOR SUSTAINABLE DRIVERS
Owner’s Perspective

- **KSC’s Physical Transformational Building Blocks**
    - Aligning form and function to mission and goals
    - Asset and historic preservation
    - Sustainability and life cycle costs

Enter to Learn
Go Forth to Serve

WHAT CAN WE CONTROL AND WHEN IN THE PROCESS?
Design Team Partnering with Clients

- **Client Visioning with Design Team**
  - Understand the project goals from the Client's perspective
  - Align the Client's mission with sustainable/design goals
  - Create a joint list of Sustainable Priorities
  - Create a list of sustainable strategies that support the established priorities
  - Assign responsibility to champion sustainable strategies

SUSTAINABLE STRATEGIES
matrix

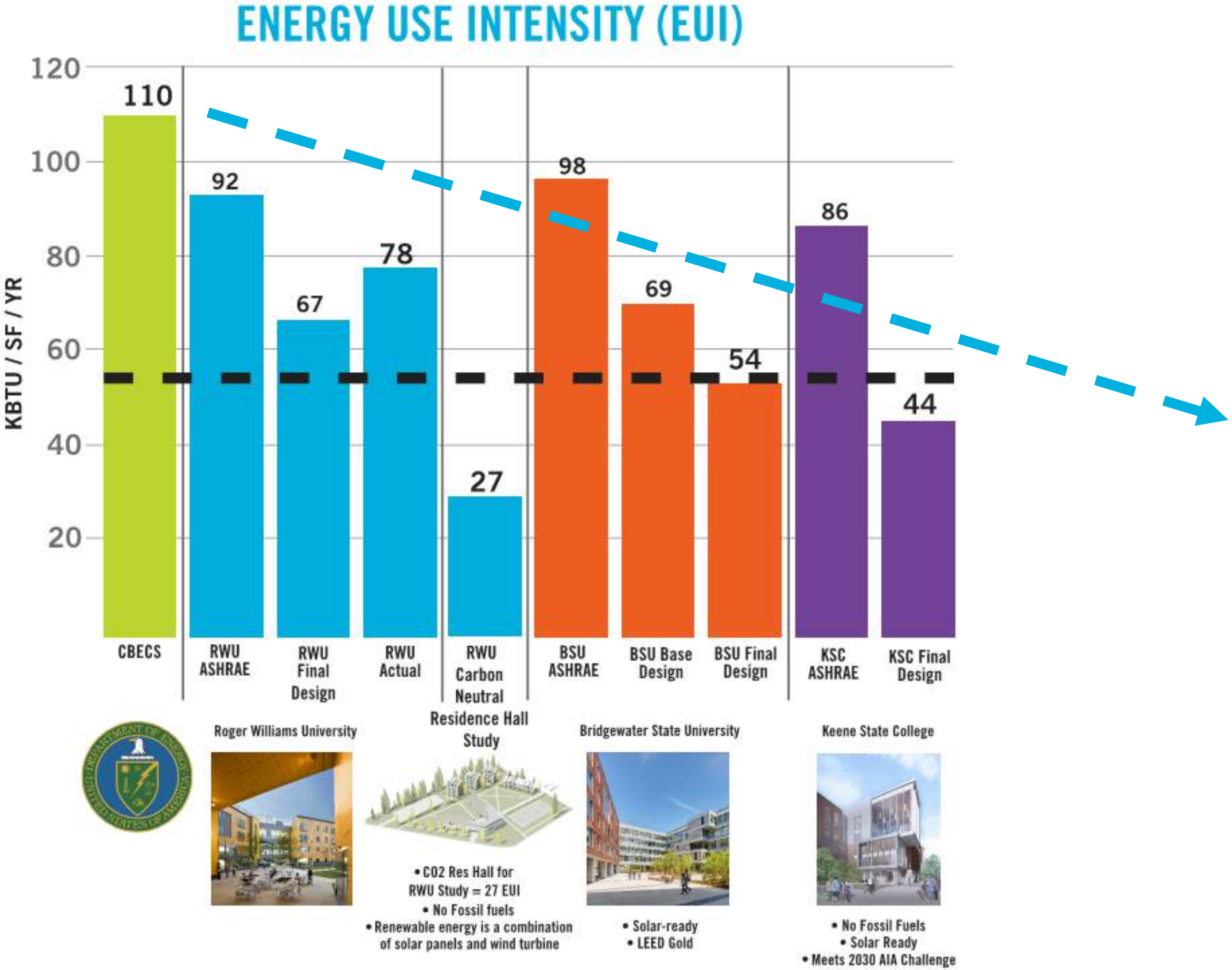
Status	Strategy	Image	Energy System Option	Impacts	Location	Advantages	Disadvantages	Potential
Y	HVAC		**Demand Controlled Ventilation**	HVAC controls	common areas, classrooms	reduced fan & thermal energy	additional sensors	
Y	HVAC		**Ventilation Energy Recovery**	ductwork, HVAC controls, equipment capacity	bathrooms, bedrooms	reduce heating and cooling loads	initial cost and size of equipment	
Y	HVAC		**Air Source Heat Pump - Variable Refrigerant Flow (VRF)**	mechanical system design, ceiling space for cartridge units in each space	building wide	increased efficiency as compared to unitary equipment	fan/filter located in occuppied space	
Y	HVAC		**Geothermal Close Loop Heat Exchange**	site availability and mechanical space, drilling bore fields	Quad	increased COP, low carbon heating and cooling source	initial cost, well field space	
Y	HVAC		**Modular Water-to-Water Heat Pumps**	mechanical system design	Mechanical Room	increased efficiency as compared to unitary equipment, redundancy	limited manufacturers of equipment	
Y	PLUMBING		**Shower Drain Energy Recovery**	drain piping	Kitchen waste drain pipes	reduced DHW energy from non renewable sources	initial costs, additional drain piping-vertical space needed	
Y	ELEC		**Building Wide Lighting Control System**	lighting control design	building wide	increased control over building lighting	initial cost	
Y	HVAC & ELEC		**Commissioning**	project close out	building wide	confirms system efficiency and operation	initial cost	

INTERACTIVE PRESENTATION

YANEL DE ANGEL + CHRIS SHUMWAY

#4

PERKINS+WILL


ENERGY USE INTENSITY (EUI)
KBTU / SF / YR
120
100
80
60
40
20
110
92
67
78
27
98
69
54
86
44
CBECS
RWU ASHRAE
RWU Final Design
RWU Actual
RWU Carbon Neutral Residence Hall Study
BSU ASHRAE
BSU Base Design
BSU Final Design
KSC ASHRAE
KSC Final Design
Roger Williams University
Bridgewater State University
Keene State College
• CO2 Res Hall for RWU Study = 27 EUI
• No Fossil fuels
• Renewable energy is a combination of solar panels and wind turbine
• Solar-ready
• LEED Gold
• No Fossil Fuels
• Solar Ready
• Meets 2030 AIA Challenge

ZNEB STUDY
Overview + Approach

1. RWU Project + Carbon Neutral Study
2. Site Strategies
3. Energy Consumption
4. Carbon Footprint

ROGER WILLIAMS UNIVERSITY

Bristol, Rhode Island

PERKINS + WILL

CO2 Neutral Residence Hall

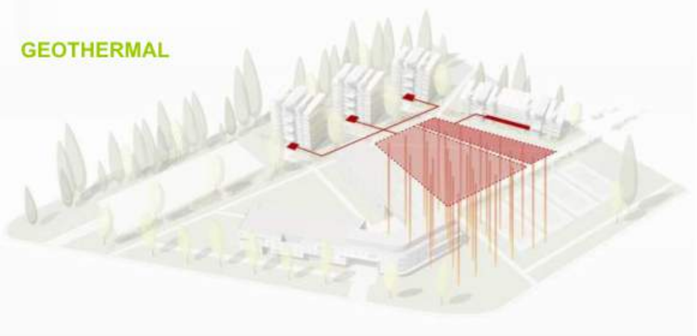
Phase 1: 128 Beds

Future Phases

384 Beds

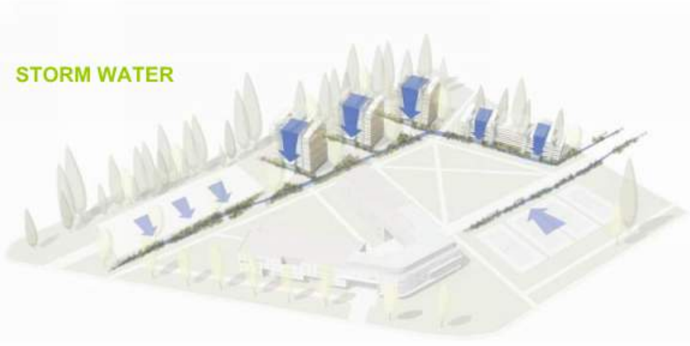
- Consideration of University Master Plan
- Minimized site disturbance
- Appropriate density
- Seasonal landscape/xeriscaping
- Pervious pavement
- Zoning for future growth
- Zoning for geothermal

GEOTHERMAL



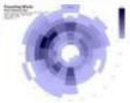
- Phase 1 requires 5 standing column wells
- Each well is 1,500 feet deep
- Wells are spaced 60 foot on center

STORM WATER



- Storm water runoff to be captured in bio-swales

WINTER WINDS



- Evergreen trees in the North side mitigate winter winds
- Winter winds are redirected between the buildings

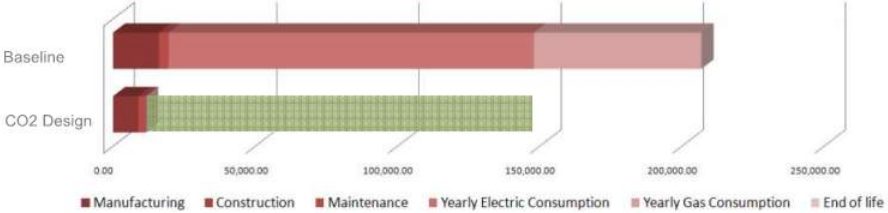
SUMMER WINDS

- Summer winds captured through Lounges and windows
- Buildings staggered to prevent wind flow blocking
- Natural ventilation system redirects wind inside building
- Deciduous trees shade building's South façade
- Heat chimneys remove warm air from interiors

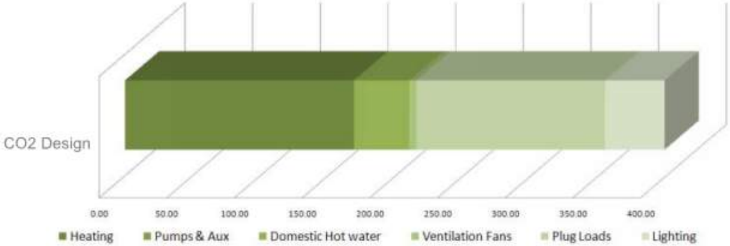
+ ENERGY CONCLUSIONS

PERKINS + WILL

Comparative Life Cycle Carbon Footprint



CO2 Design Electric Loads



Option 1

100% - PV Array 36,247 SF

(2/3 area of football stadium)

Option 2

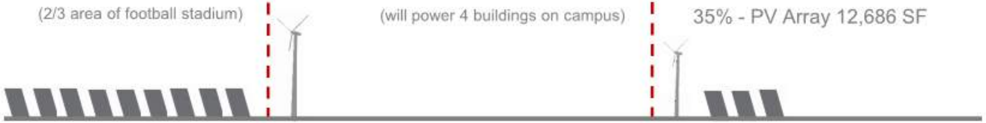
100% - .2x1000 kW Turbine (160 ft)

(will power 4 buildings on campus)

Option 3

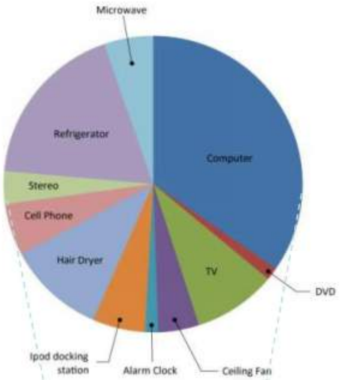
65% - 1x250 kW Turbine (100 ft)

35% - PV Array 12,686 SF



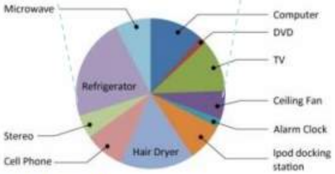
Total Energy production required during the lifespan of the building to offset CO2 impact from manufacturing processes, construction, operations and building end-of-life is **25,631.50 kWh/Year**

Standard Energy Consumption



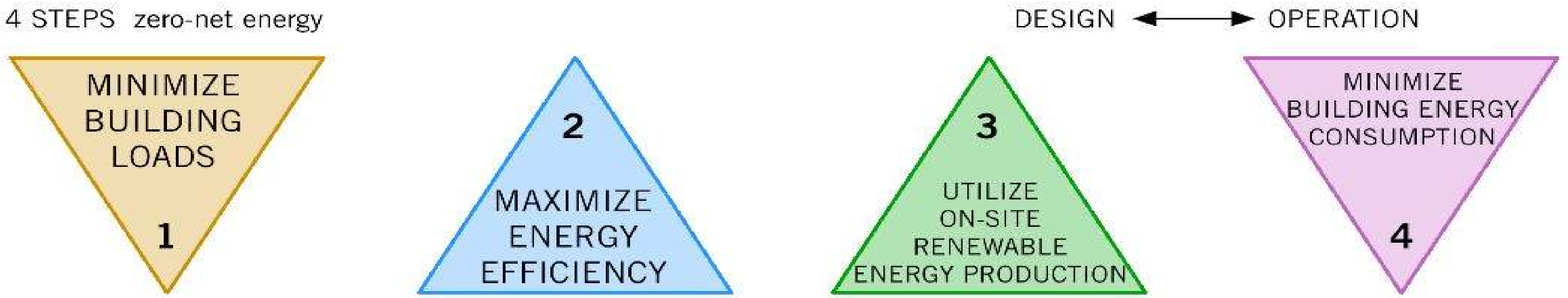
Baseline:
Suite Energy Consumption = **846 kwh/yr**

Energy Star Consumption



CO2 Neutral:
Suite Energy Consumption = **559 kwh/yr**

OVERARCHING STRATEGY



- Building Massing
- Solar Orientation
- Passive Natural Ventilation
- Square Footage Optimization
- High Performance Envelope
- Daylight Harvesting
- Plug Load Control
- Green Roofs

- High COP Thermal Energy
  - Geo-exchange
  - ASHP
- Valance Heating and Cooling
- ASHP Heating and Cooling
- Ventilation Energy Recovery
- Geo-exchange DHW
- Efficient Lighting and Controls

- Photovoltaic
- Solar Thermal
- Wind Turbine

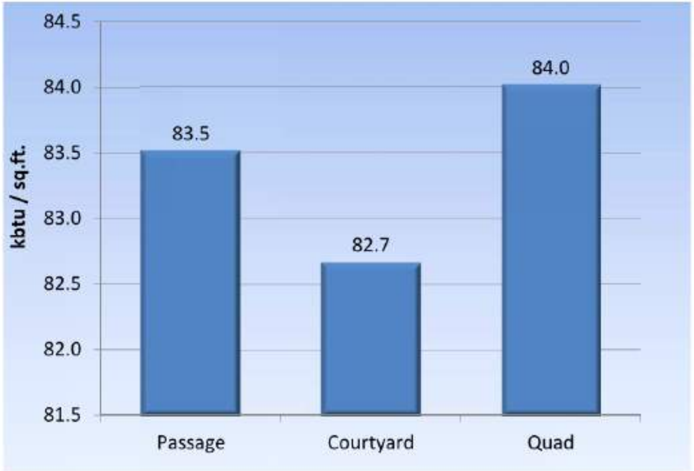
- Heating and Cooling Set Points
- Operable Windows "Kill Switches"
- User Group Awareness and Education
- Equipment Limitation/ Policy Change (No Micro-Fridges)
- Energy Star Equipment

STEP 1: MINIMIZE ENERGY USE

STEP 1: MINIMIZE ENERGY USE

- **Building Orientation & Solar Orientation**
- Harvesting Wind through Natural Ventilation
- High Performance Envelope
- Square Footage Optimization
- Daylight Harvesting
- Plug Load Controls*
- Green Roofs*

*studied but not accepted



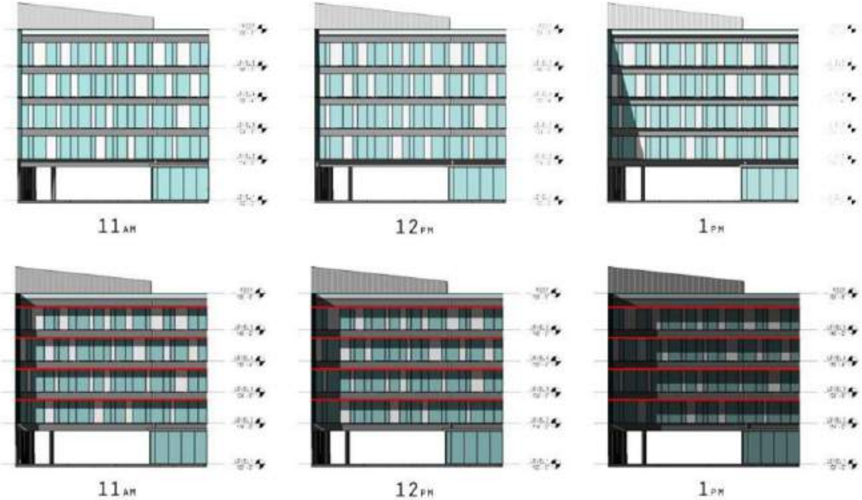
PASSAGE

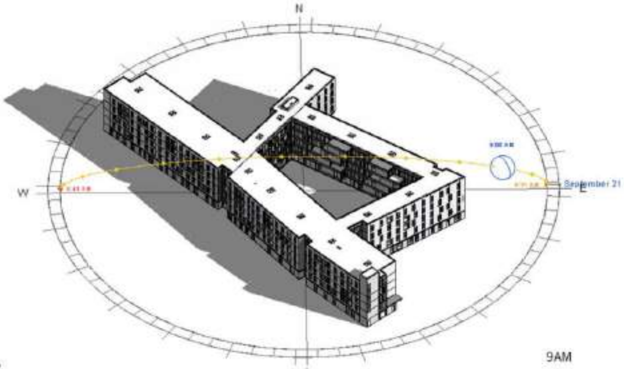
COURTYARD

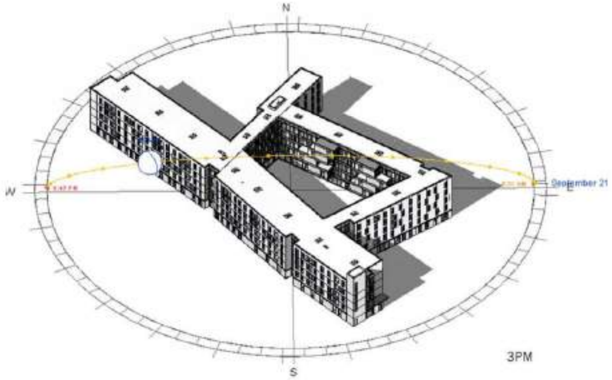
QUAD

STEP 1: MINIMIZE ENERGY USE

- **Building Orientation & Solar Orientation**
- Harvesting Wind through Natural Ventilation
- High Performance Envelope
- Square Footage Optimization
- Daylight Harvesting
- Plug Load Controls*
- Green Roofs*



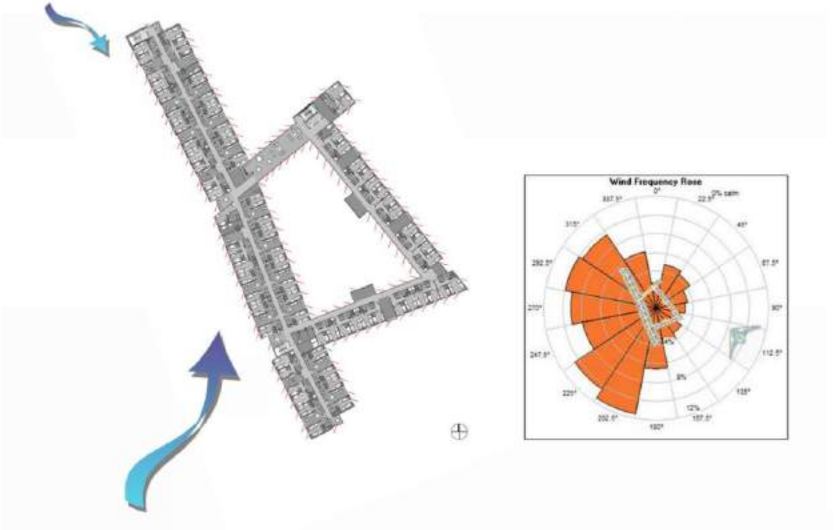


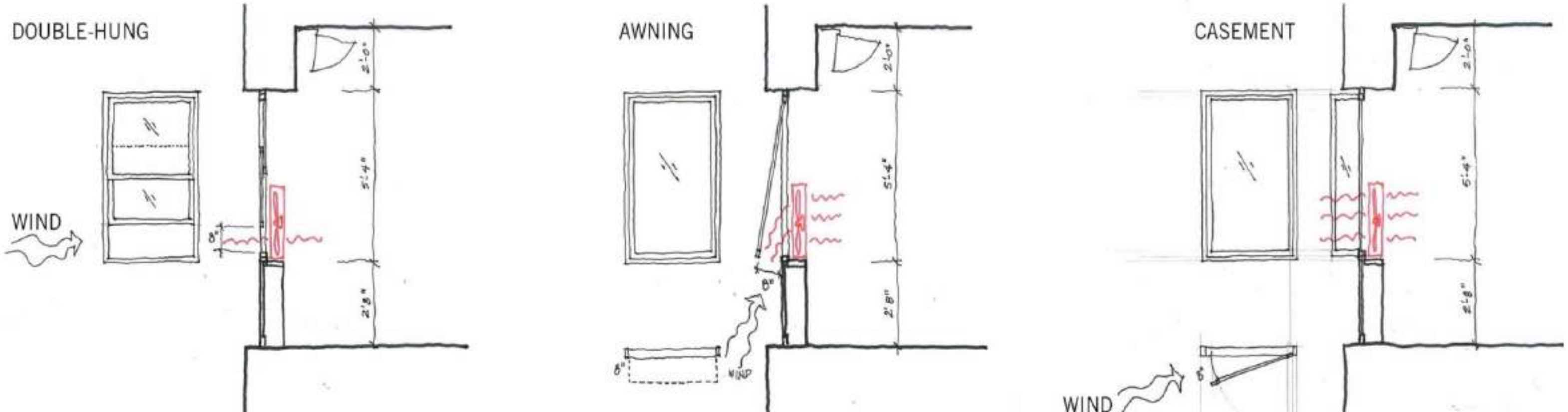


MINIMIZE BUILDING LOADS 1

STEP 1: MINIMIZE ENERGY USE

- Building Orientation & Solar Orientation
- **Harvesting Wind through Natural Ventilation**
- High Performance Envelope
- Square Footage Optimization
- Daylight Harvesting
- Plug Load Controls*
- Green Roofs*

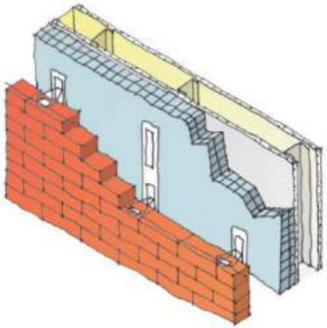


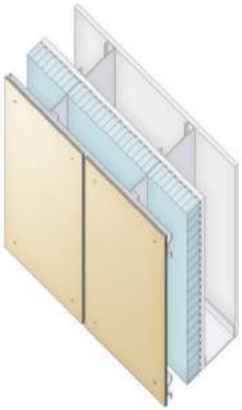


MINIMIZE BUILDING LOADS 1

STEP 1: MINIMIZE ENERGY USE

- Building Orientation & Solar Orientation
- Harvesting Wind through Natural Ventilation
- **High Performance Envelope:** insulation and fiberglass windows
- Square Footage Optimization
- Daylight Harvesting
- Plug Load Controls*
- Green Roofs*





Insulation Values Improved during construction!
Walls: R26 became R29 **Roof**: R38 became R49

STEP 2: MAXIMIZE ENERGY EFFICIENCY

STEP 2: MAXIMIZE ENERGY EFFICIENCY

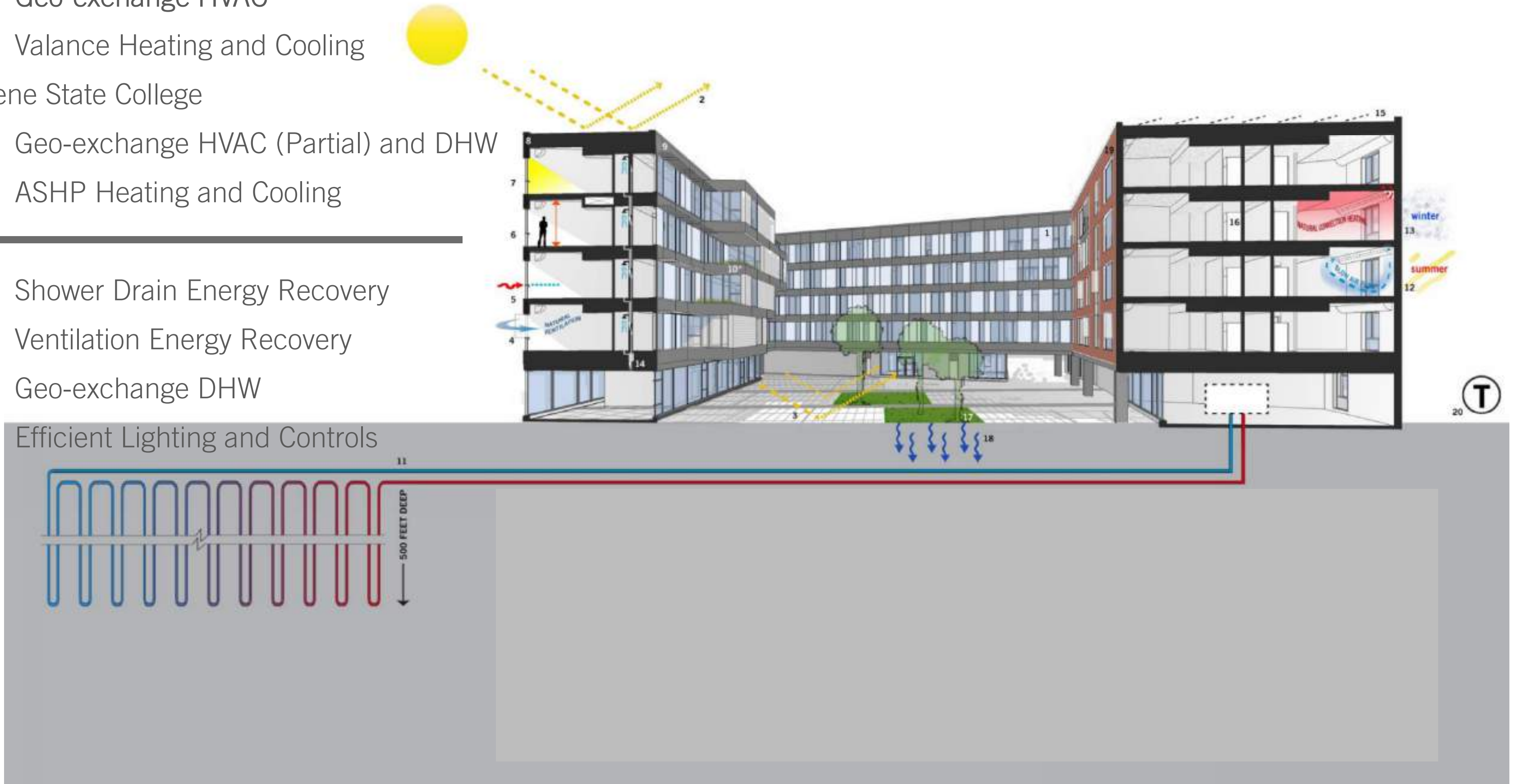
Bridgewater State University

- Geo-exchange HVAC
- Valance Heating and Cooling

Keene State College

- Geo-exchange HVAC (Partial) and DHW
- ASHP Heating and Cooling

- Shower Drain Energy Recovery
- Ventilation Energy Recovery
- Geo-exchange DHW
- Efficient Lighting and Controls



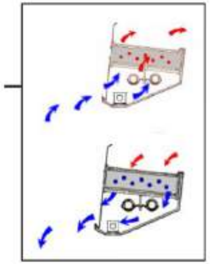
STEP 2: MAXIMIZE ENERGY EFFICIENCY

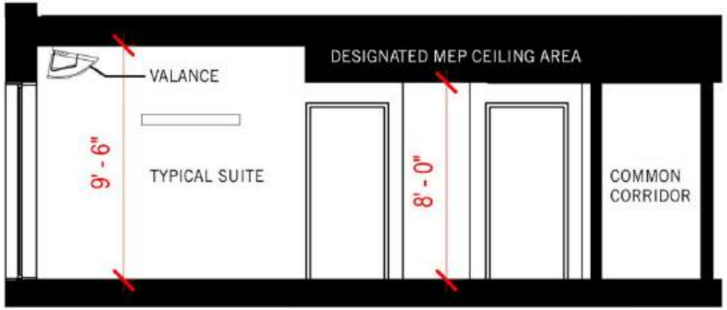
Bridgewater State University

- Geo-exchange HVAC
- Valance Heating and Cooling

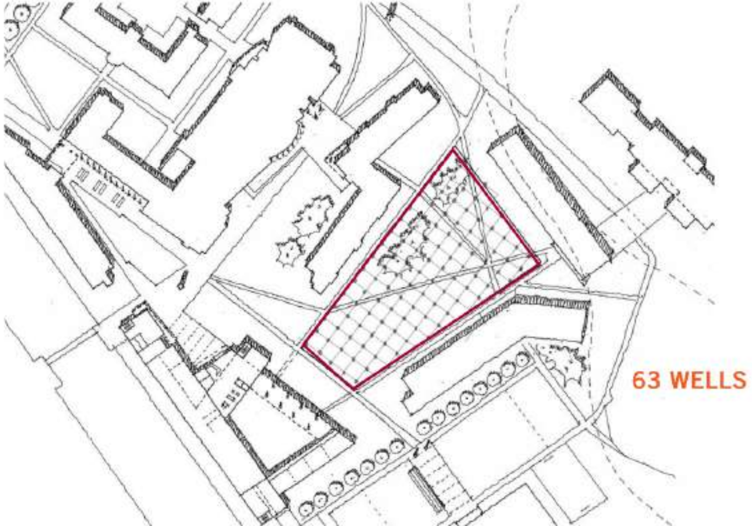
Keene State College

- Geo-exchange HVAC (Partial) and DHW
- ASHP Heating and Cooling





- Shower Drain Energy Recovery
- Ventilation Energy Recovery
- Geo-exchange DHW
- Efficient Lighting and Controls



STEP 2: MAXIMIZE ENERGY EFFICIENCY

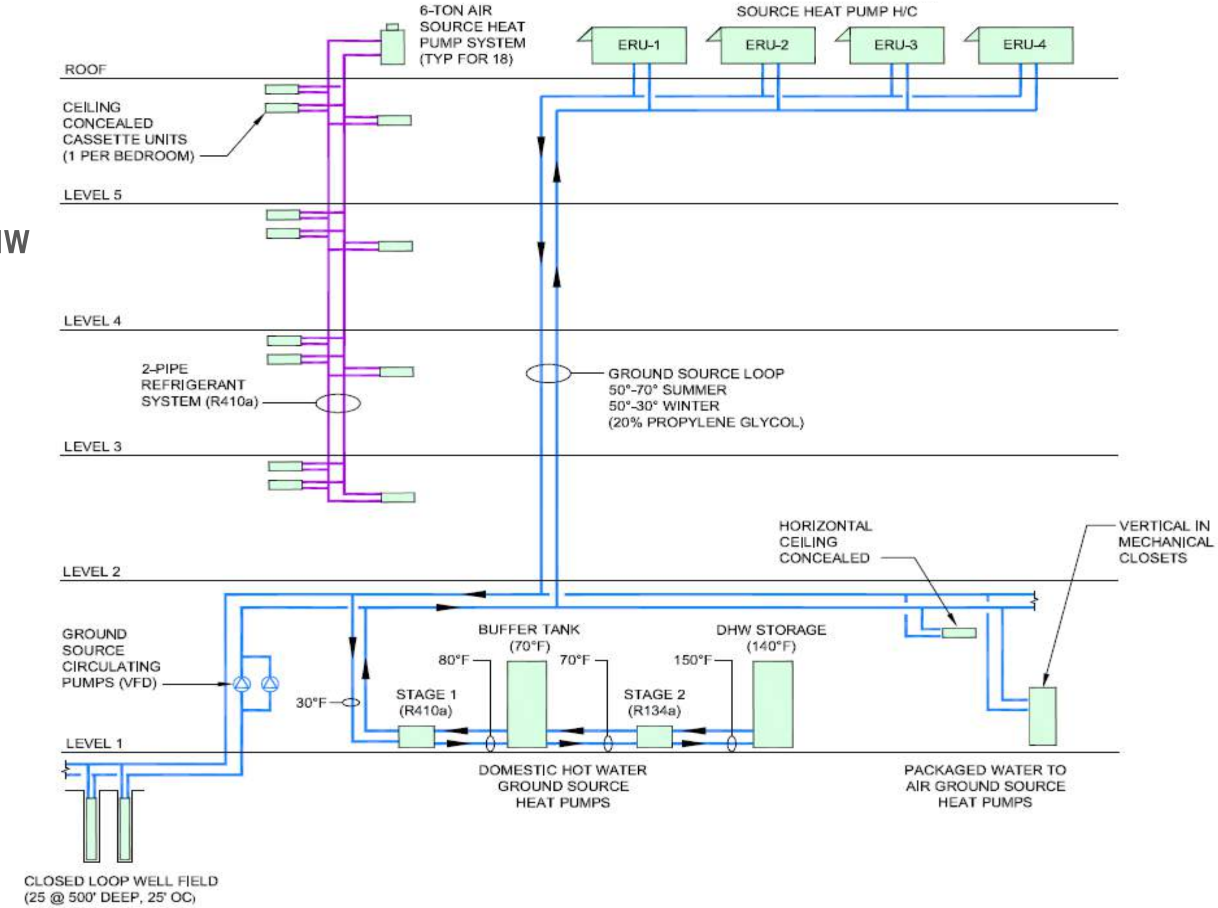
Bridgewater State University

- Geo-exchange HVAC
- Valance Heating and Cooling

Keene State College

- **Geo-exchange HVAC (Partial) and DHW**
- ASHP Heating and Cooling

- Shower Drain Energy Recovery
- Ventilation Energy Recovery
- Geo-exchange DHW
- Efficient Lighting and Controls



STEP 2: MAXIMIZE ENERGY EFFICIENCY

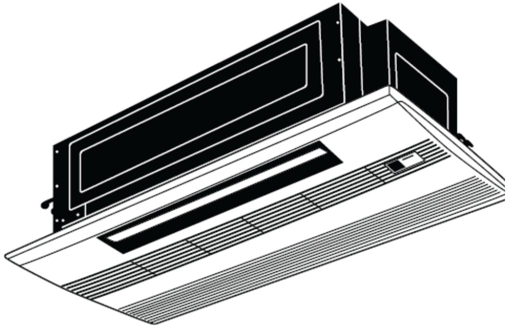
Bridgewater State University

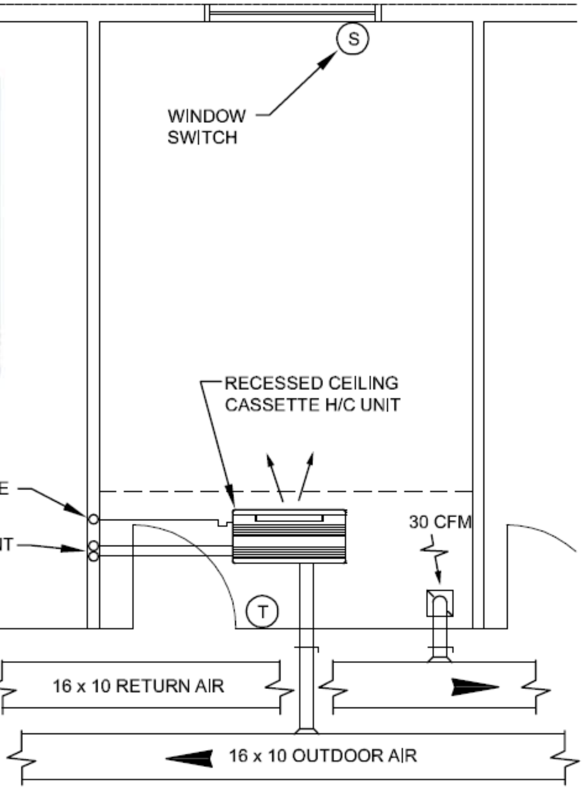
- Geo-exchange HVAC
- Valance Heating and Cooling

Keene State College

- Geo-exchange HVAC (Partial) and DHW
- **ASHP Heating and Cooling**

- Shower Drain Energy Recovery
- Ventilation Energy Recovery
- Geo-exchange DHW
- Efficient Lighting and Controls





STEP 2: MAXIMIZE ENERGY EFFICIENCY

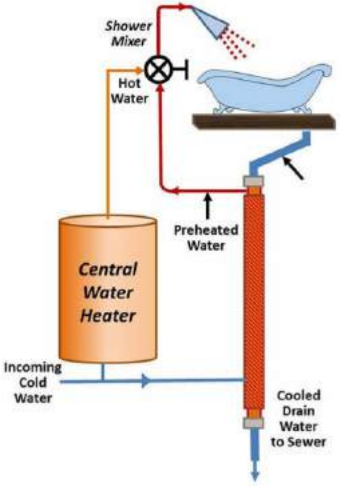
Bridgewater State University

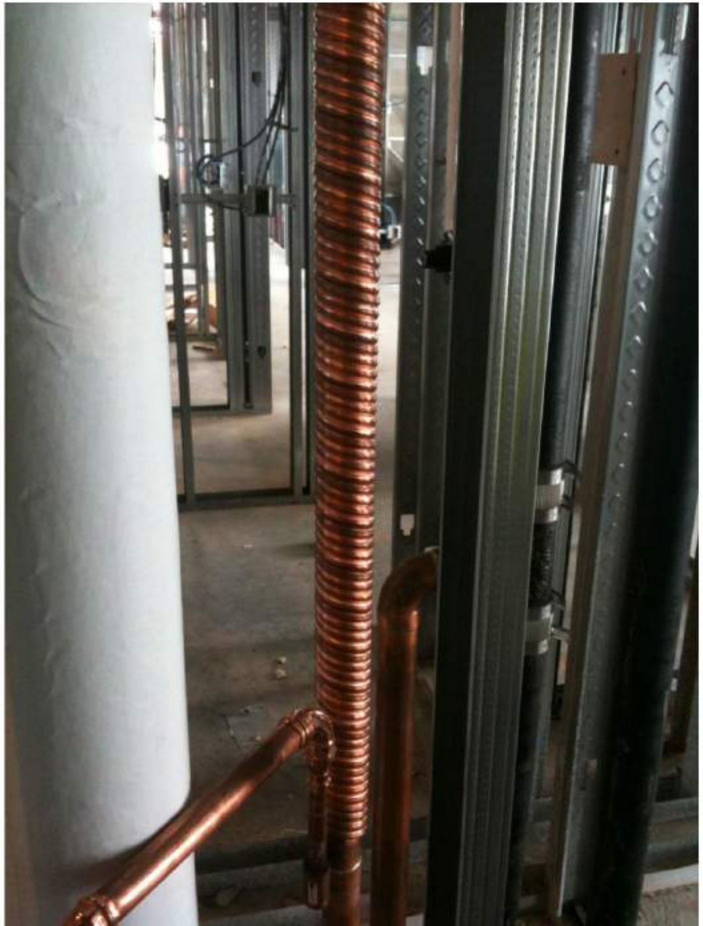
- Geo-exchange HVAC
- Valance Heating and Cooling

Keene State College

- Geo-exchange HVAC (Partial) and DHW
- ASHP Heating and Cooling

- Shower Drain Energy Recovery
- Ventilation Energy Recovery
- Geo-exchange DHW
- Efficient Lighting and Controls





STEP 3: ON SITE RENEWABLE ENERGY PRODUCTION

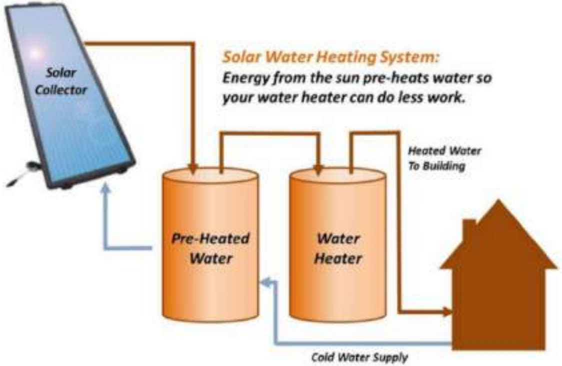
STEP 3: ON SITE RENEWABLE ENERGY PRODUCTION

- **Solar Thermal***
- Photovoltaic Power*
- Wind Power*
- Green Power

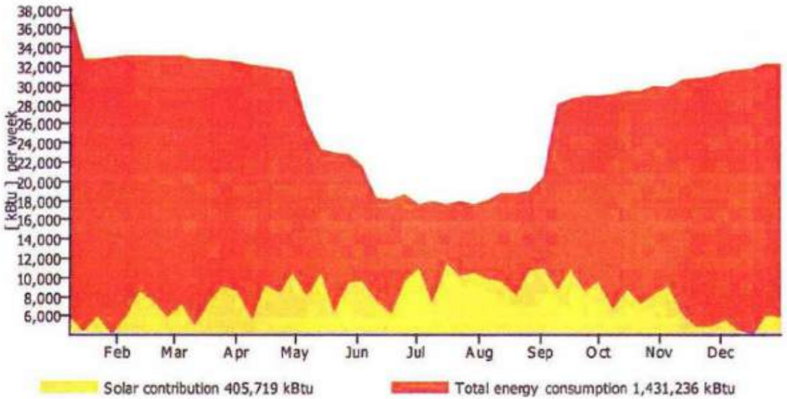
*studied but not accepted

If solar thermal was accepted...

- *50 panel (300 kBtu/hr) system would yield 20% to 30% of annual DHW energy*
- *$350,000 capital cost, 50+ year payback*
- *Owner reluctance for solar thermal*



Solar energy consumption as percentage of total consumption



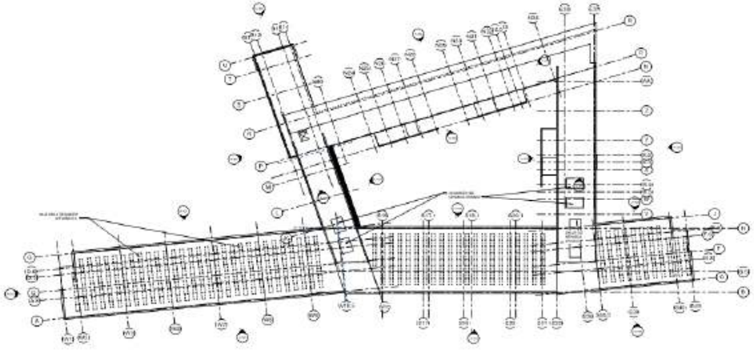
STEP 3: ON SITE RENEWABLE ENERGY PRODUCTION

- Solar Thermal*
- **Photovoltaic Power***
- Wind Power*
- Green Power

*studied but not accepted

If building was powered by PV panels...

- *Building roof solution would allow 200 to 300 kW, less than 10% of annual electric energy*
- *ZNEB solution would require +/-2MW, 3x adjacent quad green surface*
- *$9,500,000 capital cost, 30+ year payback*

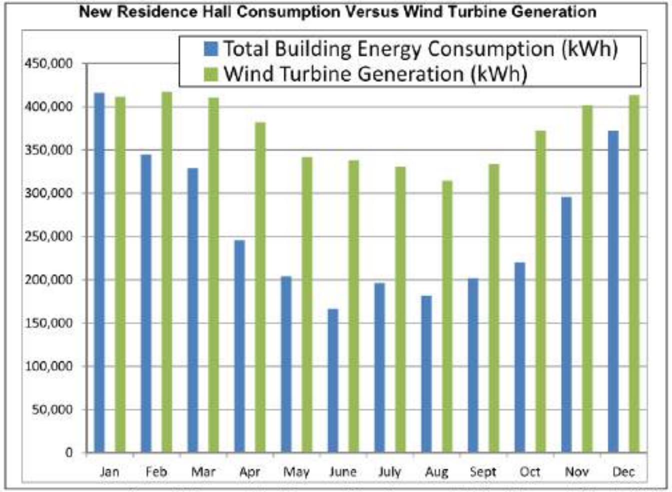


Roof PV panels could provide 6.5% of the building's energy: 3.5 kbtu/year

STEP 3: ON SITE RENEWABLE ENERGY PRODUCTION

- Solar Thermal*
- Photovoltaic Power*
- **Wind Power***
- Green Power

*studied but not accepted



Boreal Renewable Energy Development, Wind Report, Sept 2011

If the building was powered just by WIND...

- *Wind turbine at +/-2MW would provide approximately* **150% of annual electric energy**
- *$5,000,000 capital cost, less than 10 year payback*
- *Continued Owner consideration for wind power*

STEP 3: ON SITE RENEWABLE ENERGY PRODUCTION

- Solar Thermal*
- Photovoltaic Power*
- Wind Power*
- **Green Power**

*studied but not accepted

purchased 3,988,584 kWh Green-e Certified Clean Source

- *100% total usage for 2 years*

STEP 4: MINIMIZE BUILDING ENERGY CONSUMPTION

STEP 4: MINIMIZE BUILDING ENERGY CONSUMPTION

- **Window "Kill Switches"**
- User Awareness Programs
- Temperature Set Points
- Suite Refrigerator in lieu of Mini-Fridges
- Energy STAR Equipment / Appliances
- Natural Gas & Electric Metering/Trending

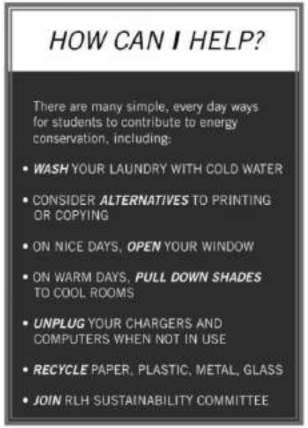
MINIMIZE BUILDING ENERGY CONSUMPTION 4

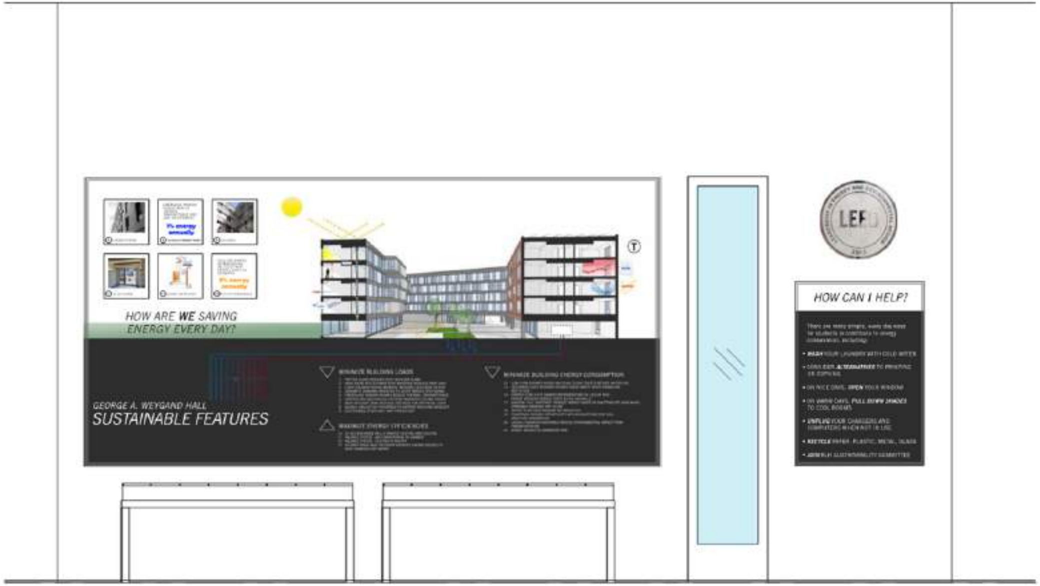
STEP 4: MINIMIZE BUILDING ENERGY CONSUMPTION

- Window "Kill Switches"
- **User Awareness Programs**
- Temperature Set Points
- Suite Refrigerator in lieu of Mini-Fridges
- Energy STAR Equipment / Appliances
- Natural Gas & Electric Metering/Trending

a BUILDING that TEACHES...

- *creates user awareness*
- *make users active participants*
- *influences a lifestyle*





NO MICRO-FRIDGES!

BEHAVIORAL CHANGES

heating/cooling set point control

occupant shared refrigerator

turning off lights when daylight is sufficient

closing/opening windows as required

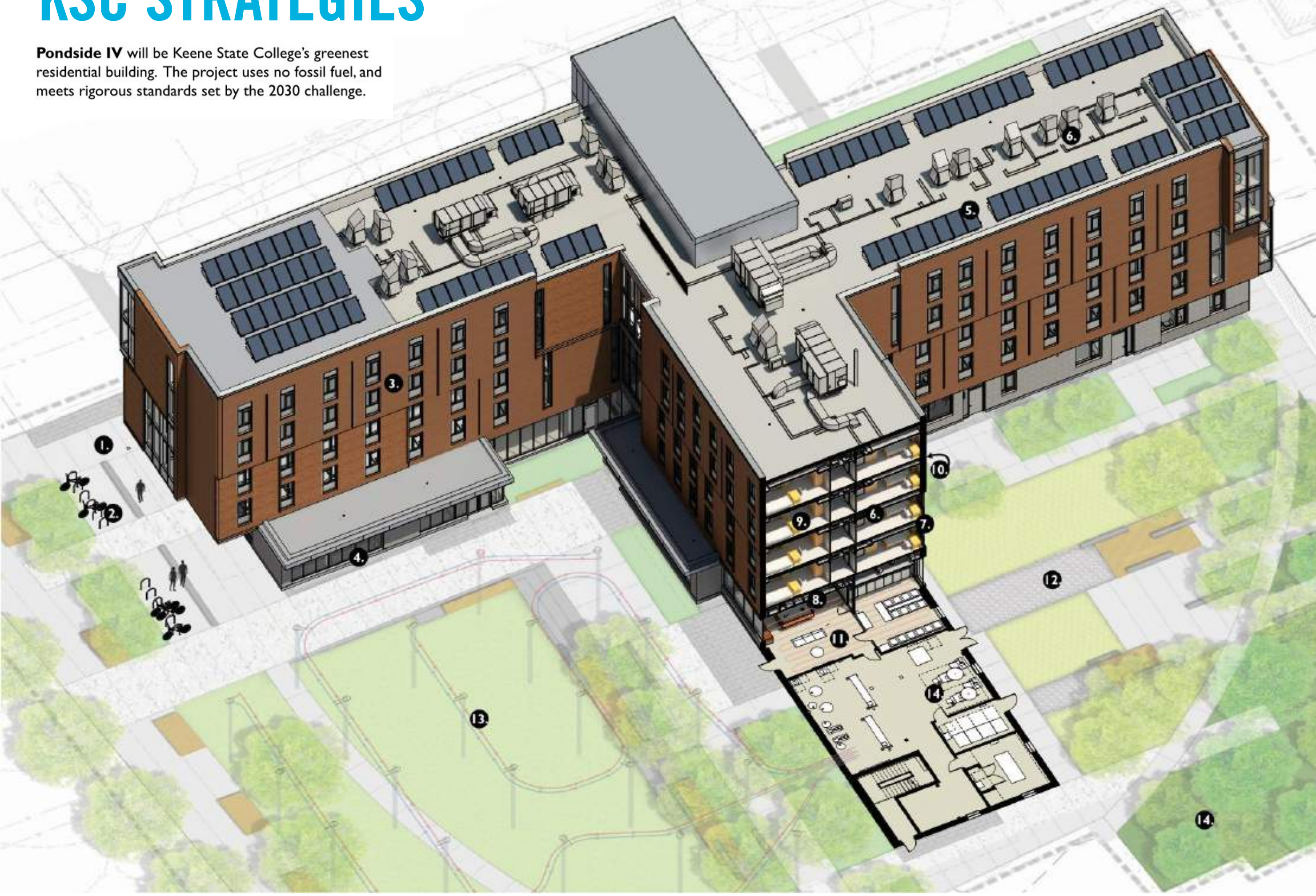
using window shades to mitigate heat gain or glare

using Energy Star equipment

turning off equipment when not in use

KSC STRATEGIES

Pondside IV will be Keene State College's greenest residential building. The project uses no fossil fuel, and meets rigorous standards set by the 2030 challenge.



1. **WALKABILITY**
design strengthens pedestrian axis - bus stop in front of building

2. **BIKE STORAGE**
outdoor and lockable indoor storage available

3. **HIGH PERFORMANCE ENVELOPE**
wall R-value: 28
roof R-value: 38

4. **EFFICIENT GLAZING**
low-e coating, argon gas insulated: maintains occupant comfort while preserving views

5. **PV-READY ROOF**
could potentially generate a percentage of building energy

6. **AIR TO AIR HEATING AND COOLING**
highly efficient units heat + cool residential floors, and allow individual temperature control for each unit

7. **OPERABLE WINDOWS**
provide natural ventilation - room HVAC automatically shuts off when window is opened

8. **EFFICIENT LED LIGHTING**
energy efficient, long lasting fixtures

9. **LOW-VOC MATERIALS**
used throughout building for healthier environment

10. **SHOWER DRAIN HEAT RECOVERY**
preheats domestic hot water to save energy

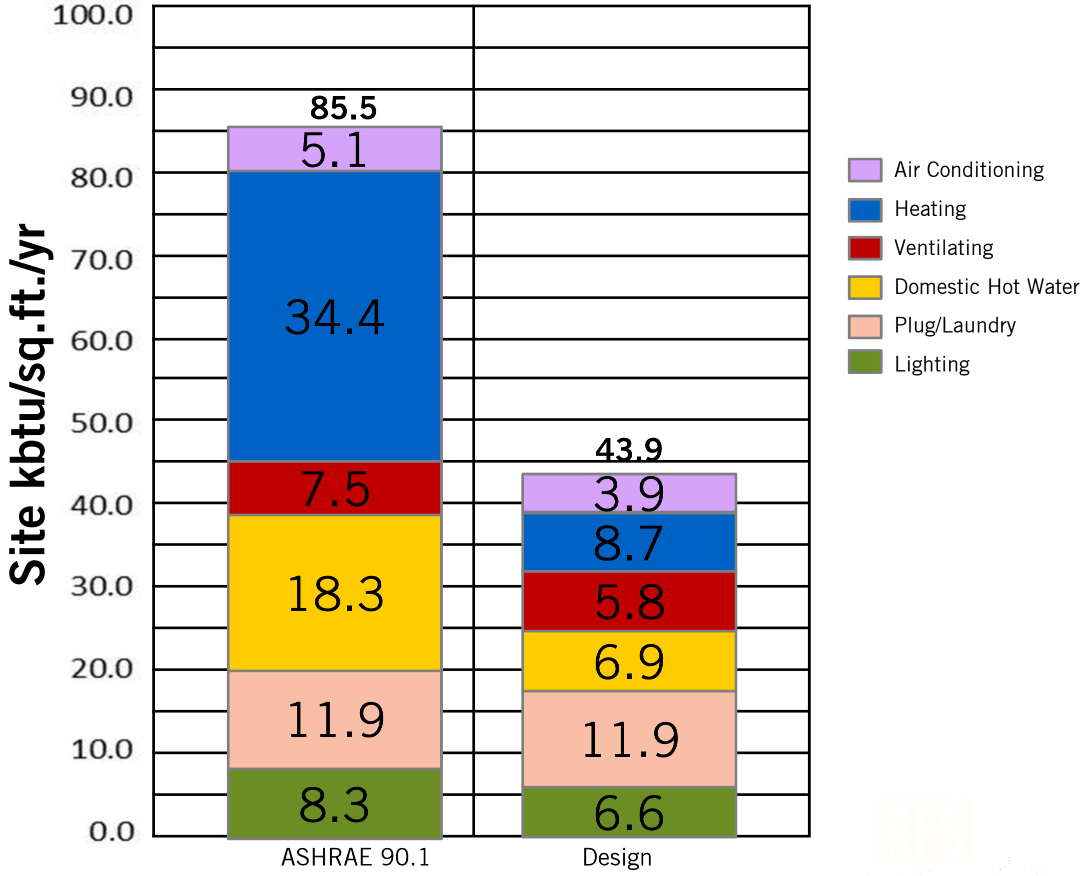
11. **RADIANT HEATED GROUND FLOOR**
maintains occupant comfort while minimizing energy use

12. **RAIN GARDEN AQUIFER RECHARGE**
roof stormwater diverted to a rain garden - reduces piping + allows water to return to aquifer after natural filtration

13. **GEOTHERMAL HEATING**
25 geothermal wells harvest earth temperature for radiant floor and preheating of domestic hot water

14. **NATIVE LANDSCAPING**
uses regional + adaptive species

KSC ENERGY LOADS BY BUILDING SUBSYSTEM



ECMs Incorporated

Heating, Ventilation, and Air Conditioning

- High-Performance Envelope
- Air-Source Heat Pumps (VRF)
- Window Kill Switches
- Ground-Source Heat Pumps
- Exhaust Air Energy Recovery
- Demand-Control Ventilation
- Variable-Speed Fan and Pumps

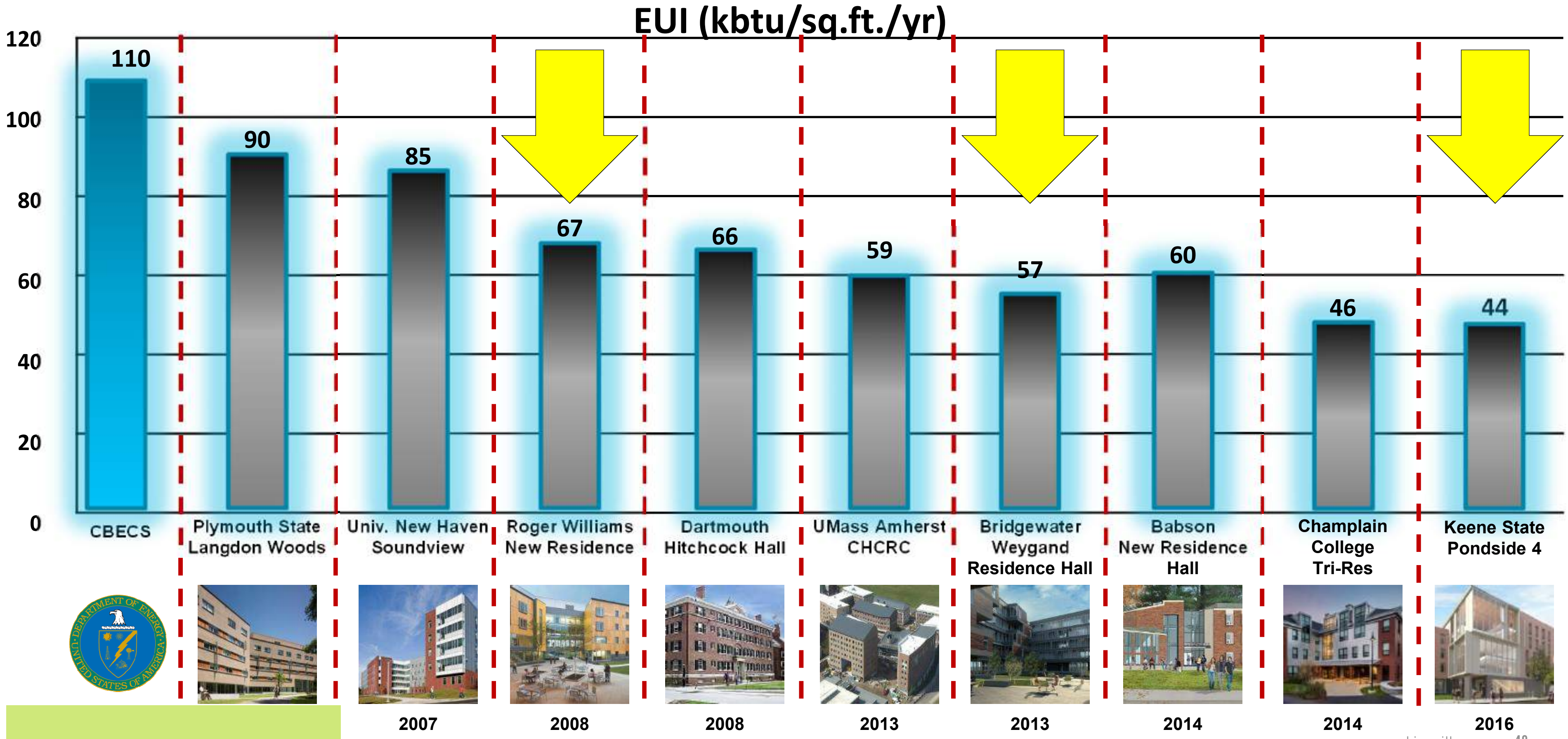
Domestic Hot Water

- Ground-Source Heat Pumps
- Shower Drain Energy Recovery
- Low-Flow Fixtures

Lighting

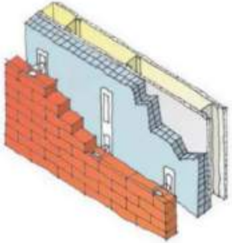
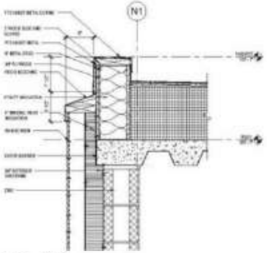
- LED Lighting
- Daylight Harvesting
- Lighting Controls

RESIDENCE HALL EUI PROGRESSION



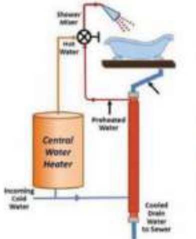
RFS #5 Slide

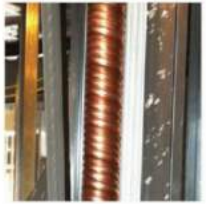
Questions + Conversation

~~R-25~~ R-29 walls // ~~R-38~~ R-49

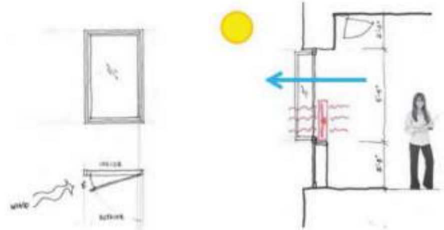

Geo-Exchange // Valance





Shower Drain Energy Recovery


Fiberglass Window Frames



Daylight // Natural Ventilation

Kill Switches

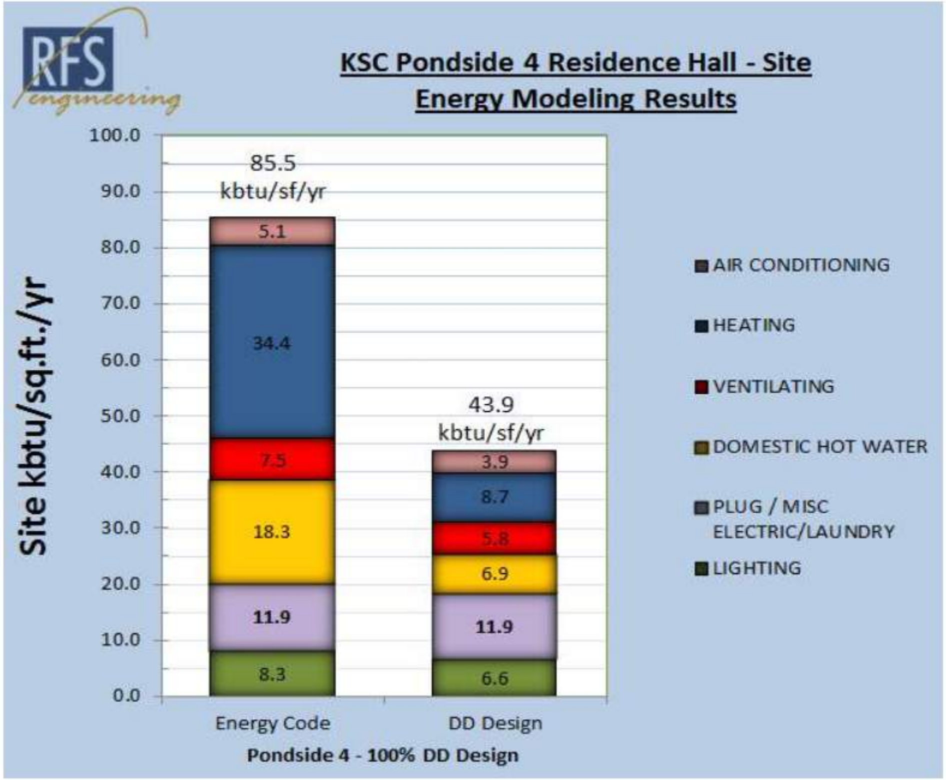
Lighting Efficiency


Brise Soliel // Fritted Glazing


Electric Car Charging Stations


No Micro-Fridges // 1 Refrigerator per Suite

ENERGY MODELING UPDATE



ECMs Incorporated

Heating Ventilation and Air Conditioning

- Envelope Optimization
- Air-Source Heat Pumps (VRF)
- Ground-Source Heat Pumps
- Exhaust Air Energy Recovery
- Demand-Control Ventilation
- Variable-Speed Pumps

Domestic Hot Water

- Ground-Source Heat Pumps
- Shower Drain Energy Recovery
- Low-Flow Fixtures

Lighting

- LED Lighting
- Daylight Harvesting
- Lighting Controls