Achieving Net-Zero Energy in a Campus Building

New Environmental Center at Williams College

Presenters

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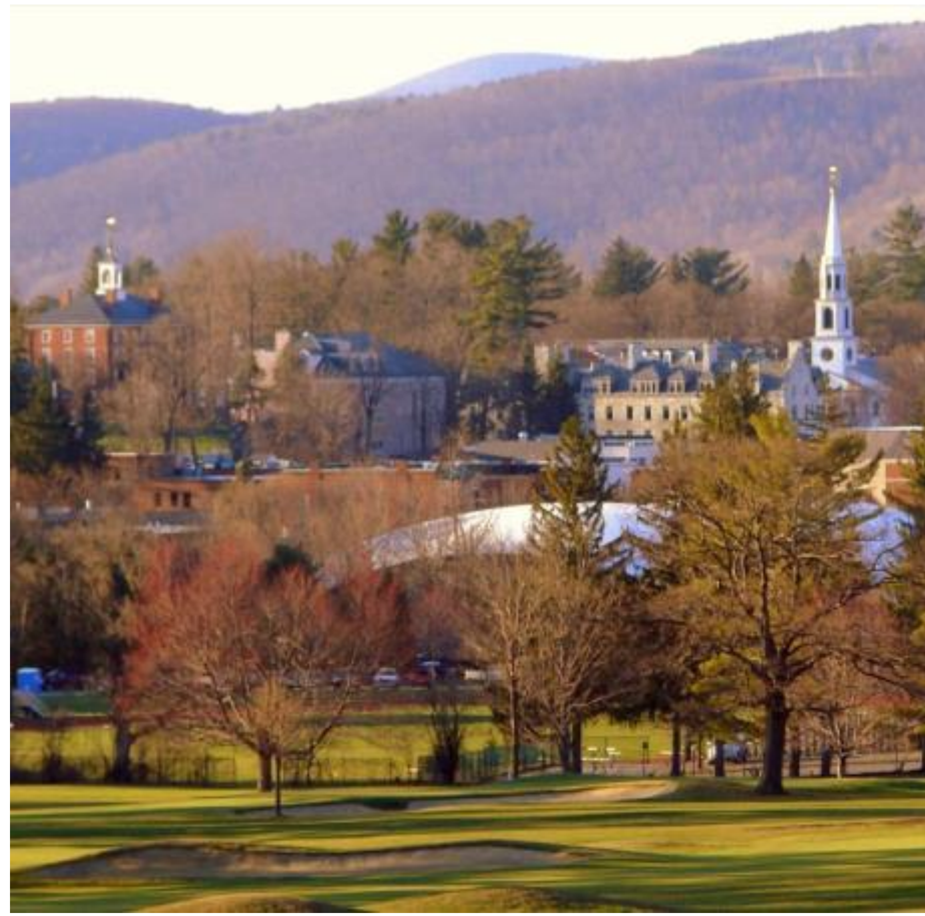
BLACK RIVER DESIGN ARCHITECTS

integrated ecostrategy

Achieving Net-Zero Energy in a Campus Building

1. Net-zero concepts
2. Living Building Challenge new Environmental Center at Williams College
3. Impact on the design process
4. Net-zero strategies
5. Building in feedback mechanisms to impact occupant behavior
6. Learning opportunities
7. Institutional benefits

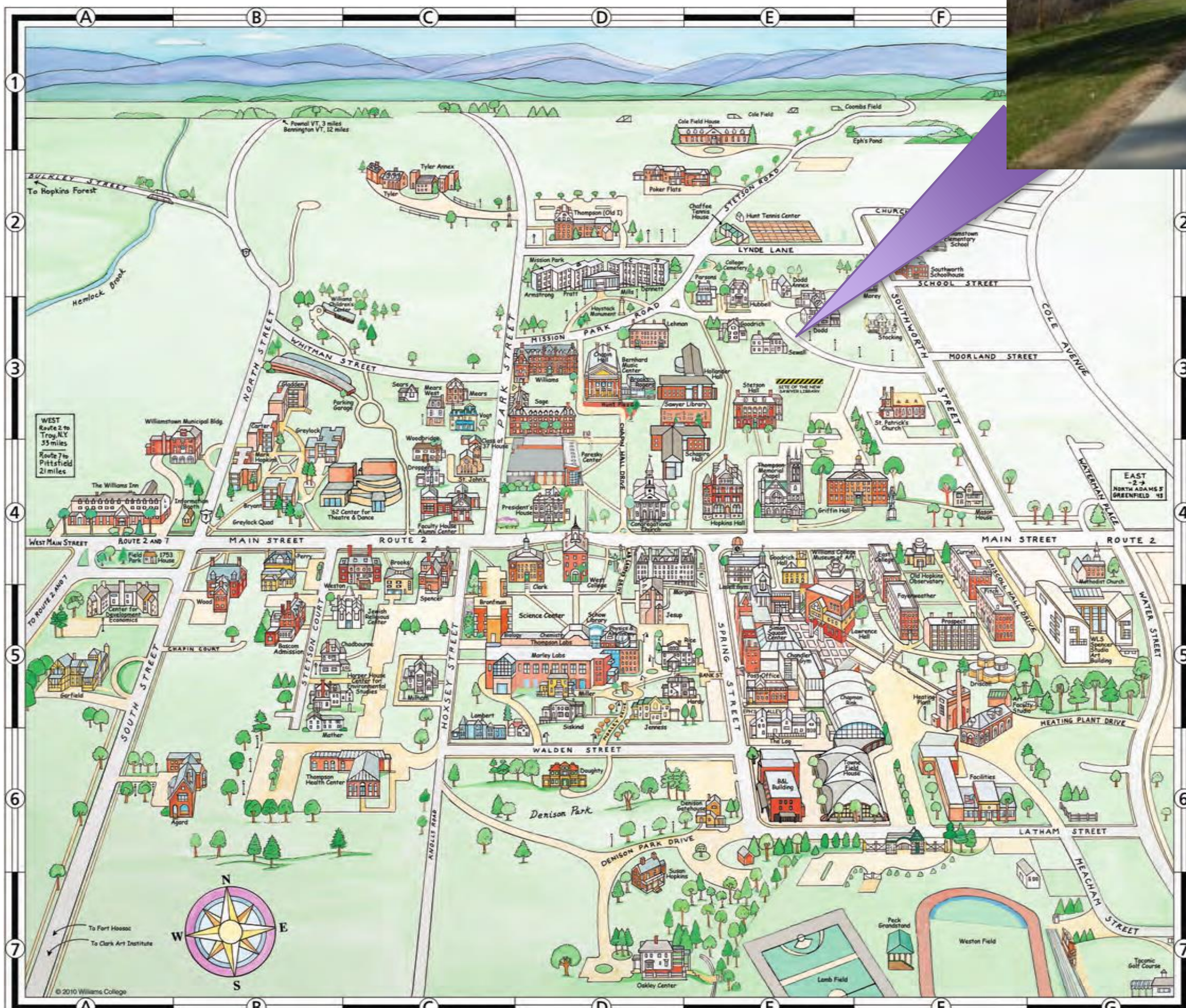


1. Living Building Challenge & Net Zero Concepts

"Imagine a building designed and constructed to function as elegantly and efficiently as a flower."

- Net zero energy
- Net zero water
- The cycle of food
- Carbon effect
- Other related impacts:
  - Transportation energy
  - Communities, not buildings are regenerative

2. Center for Environmental Studies & Zilkha Center for Environmental Initiatives



Williams

Williams College, Williamstown, Massachusetts, USA

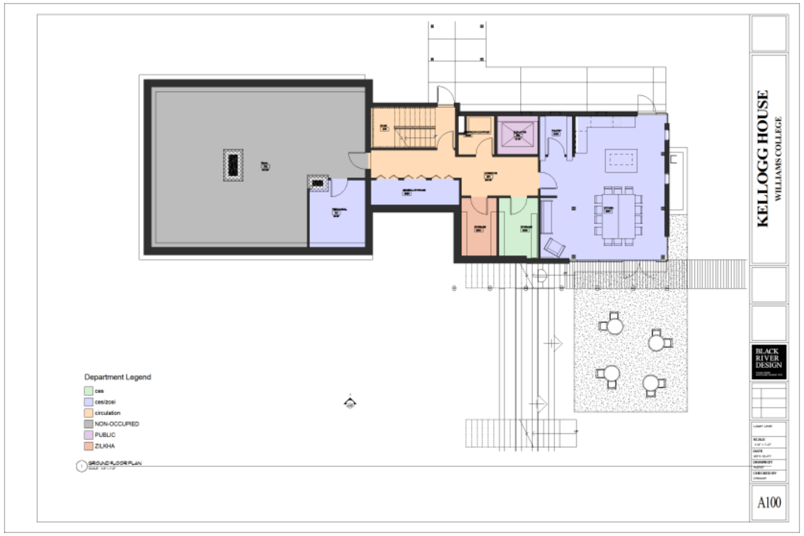
Project is in the middle of campus

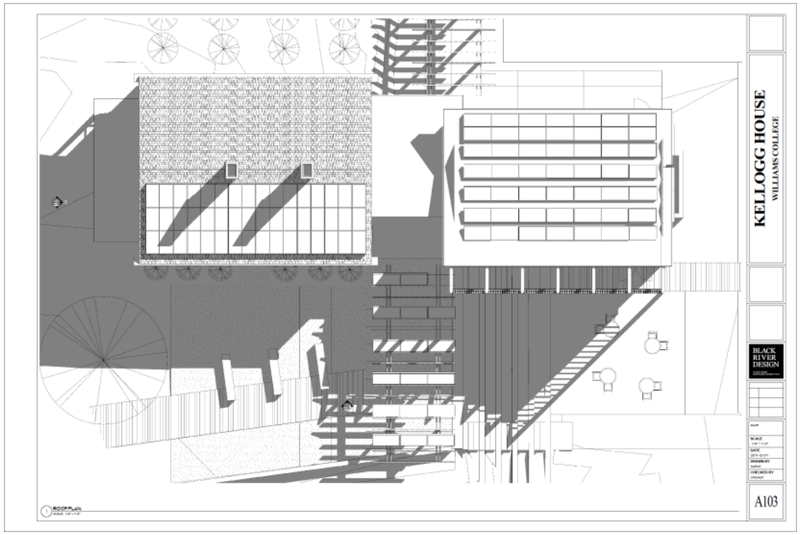
Old Kellogg House

(the additional challenge of making a historic building net zero)

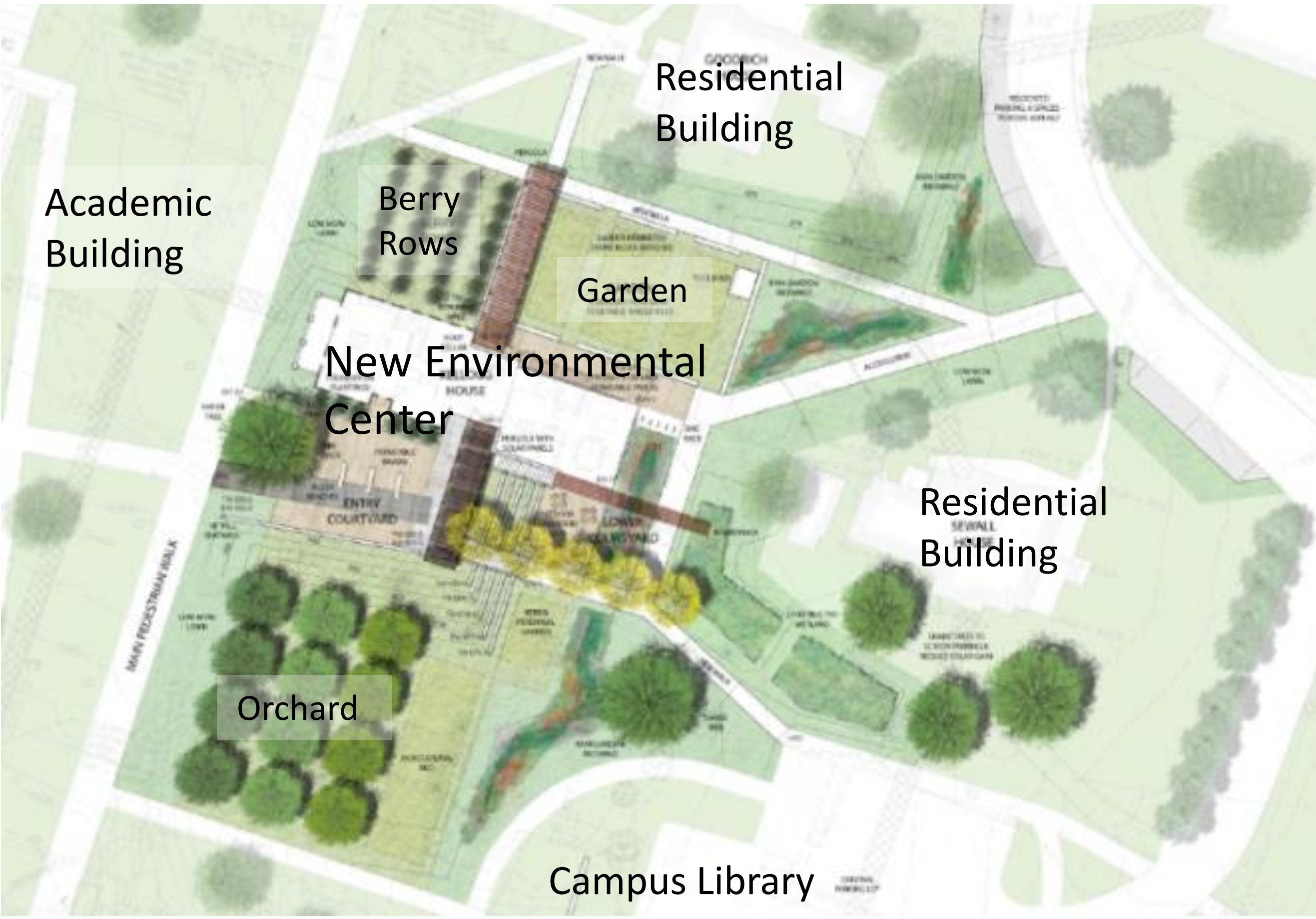
Repurposing an existing historic 1792 building (recycling at its best)

Center for Environmental Studies & Zilkha Center for Environmental Initiatives



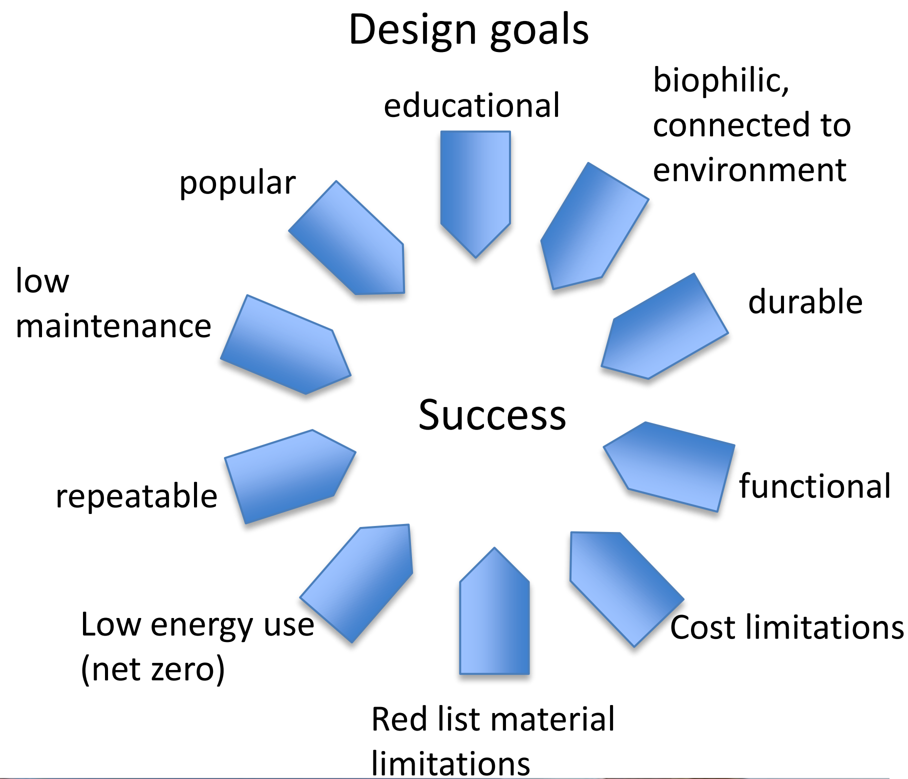


Food & Agriculture



Site Plan

What constitutes a successful sustainable building?



The most sustainable buildings are the ones we love the most.

Connecting indoor spaces to exterior spaces and the environment

3. Impact on the Design Process

1st Step – Goal Alignment

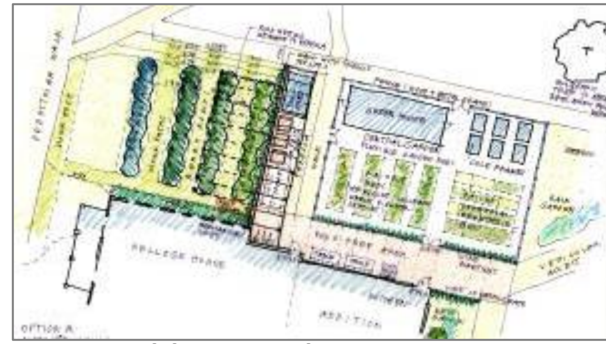
LEED vs. LBC

LIVING
BUILDING
CHALLENGE

65 LBC projects

LEED vs. LBC

Net zero energy



Sustainable Agriculture

Net zero water

Materials

Materials

11 RED LIST

BUILDING	✓
RENOVATION	✓
NEIGHBORHOOD	✓
LANDSCAPE + INFRASTRUCTURE	✓

INTENT

The intent of the Red List imperative is to eliminate from the market worst-in-case materials/chemicals with the greatest impact to human and ecosystem health.

REQUIREMENT

The project cannot contain any of the following Red List materials or chemicals:

- Asbestos
- Cadmium
- Chlorinated Polyethylene and Chlorosulfonated Polyethlene
- Chlorofluorocarbons (CFCs)
- Chloroprene (Neoprene)
- Formaldehyde (added)
- Halogenated Flame Retardants
- Hydrochlorofluorocarbons (HCFCs)
- Lead (added)
- Mercury
- Petrochemical Fertilizers and Pesticides
- Phthalates
- Polyvinyl Chloride (PVC)
- Wood treatments containing Creosote, Arsenic or Pentachlorophenol

13 RESPONSIBLE INDUSTRY

BUILDING	✓
RENOVATION	✓
NEIGHBORHOOD	✓
LANDSCAPE + INFRASTRUCTURE	✓

INTENT

The intent of the Responsible Industry imperative is to reduce the damaging environmental and social impacts related to industries reliant on natural resource extraction.

REQUIREMENT

The project must advocate for the creation and adoption of third-party certified standards for sustainable resource extraction and fair labor practices. Applicable raw materials include stone, rock, metals and timber.

For timber: all wood must be certified by the Forest Stewardship Council (FSC), from salvaged sources, or from the intentional harvest of timber onsite for the purpose of clearing the area for construction.

14 APPROPRIATE SOURCING

BUILDING	✓
RENOVATION	✓
NEIGHBORHOOD	✓
LANDSCAPE + INFRASTRUCTURE	✓

INTENT

The intent of the Appropriate Sourcing imperative is to support regional economies and expertise and to reduce the environmental impacts associated with transporting people and products.

REQUIREMENT

The project must incorporate place-based solutions and contribute to the expansion of a regional economy rooted in sustainable practices, products and services. Source locations for materials and services must adhere to the restrictions found in Table 3.

Table 3. Zone Restrictions

ZONE	MAX. DIST.	MATERIALS OR SERVICES	MASTERFORMAT 2012 CLASSIFICATION
7	20,004 km (12,430 mi)	Ideas	–
6	15,000 km (9,321 mi)	Renewable Technologies	Divisions: 42, 48
5	5,000 km (3,107 mi)	Assemblies that actively contribute to project performance and adaptable reuse once installed	Divisions: 08 (all exterior products), 14*, 22, 23*, 26*, 33*, 44*, 46* Sections: 07 33 00, 07 50 00*, 10 22 00*, 10 70 00*, 44 40 00*
4	2,500 km (1,553 mi)	Consultant Travel	–
3	2,000 km (1,243 mi)	Light or low-density materials	Sections: 07 31 00, 07 40 00, 09 50 00, 09 60 00
2	1,000 km (621 mi)	Medium weight and density materials	Divisions: 06, 08 (all interior products) Sections: 07 32 00, 09 20 00, 09 30 00, 12 30 00
1	500 km (311 mi)	Heavy or high-density materials	Divisions: 03, 04, 05*, 31, 32

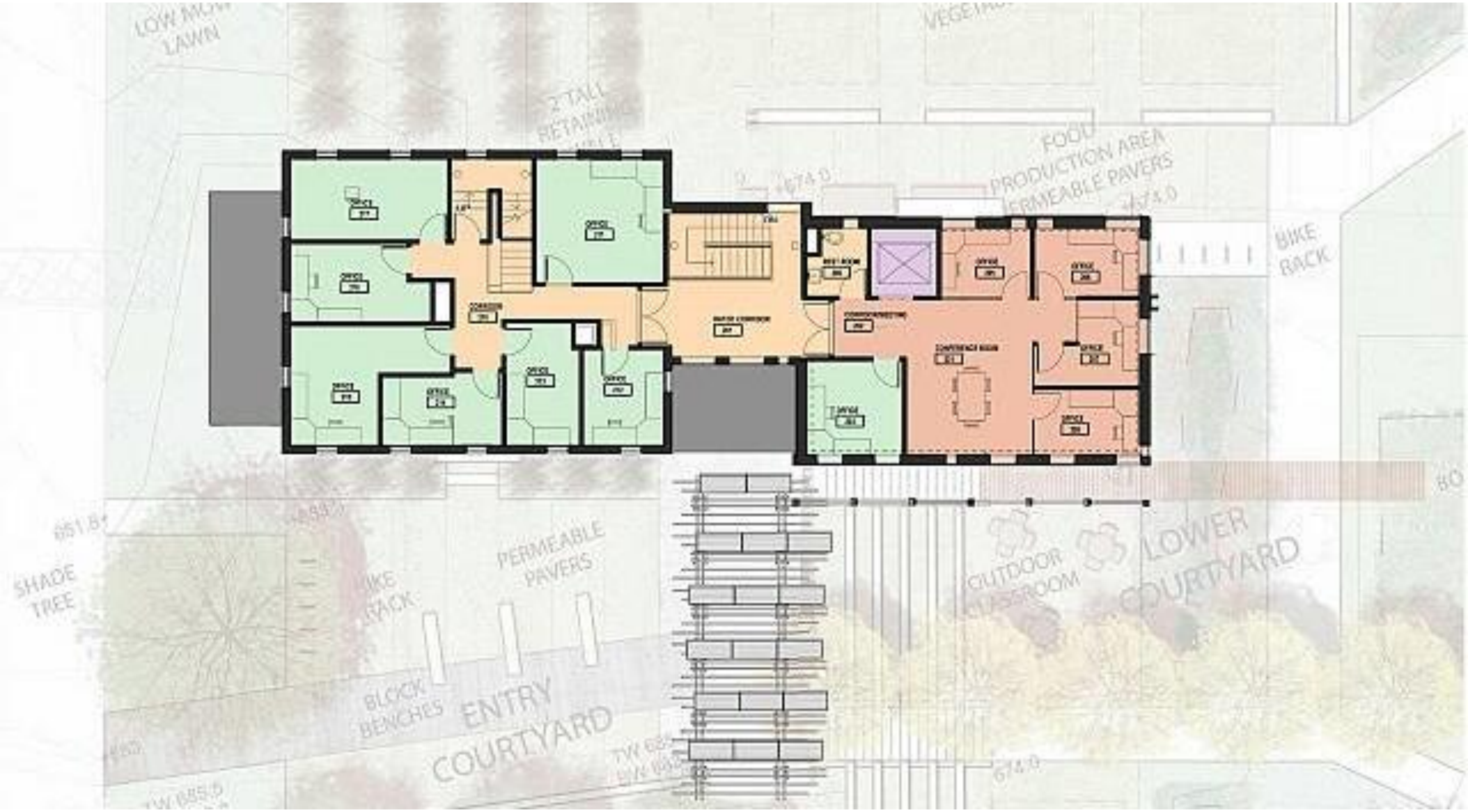
* Zone designation refers to the location of the manufacturing facility only; source location is not tracked. Note that this is a clarification to the language in the Standard.

Figure 1. Example of Zone Allowances from Portland

Performance-Based Certification

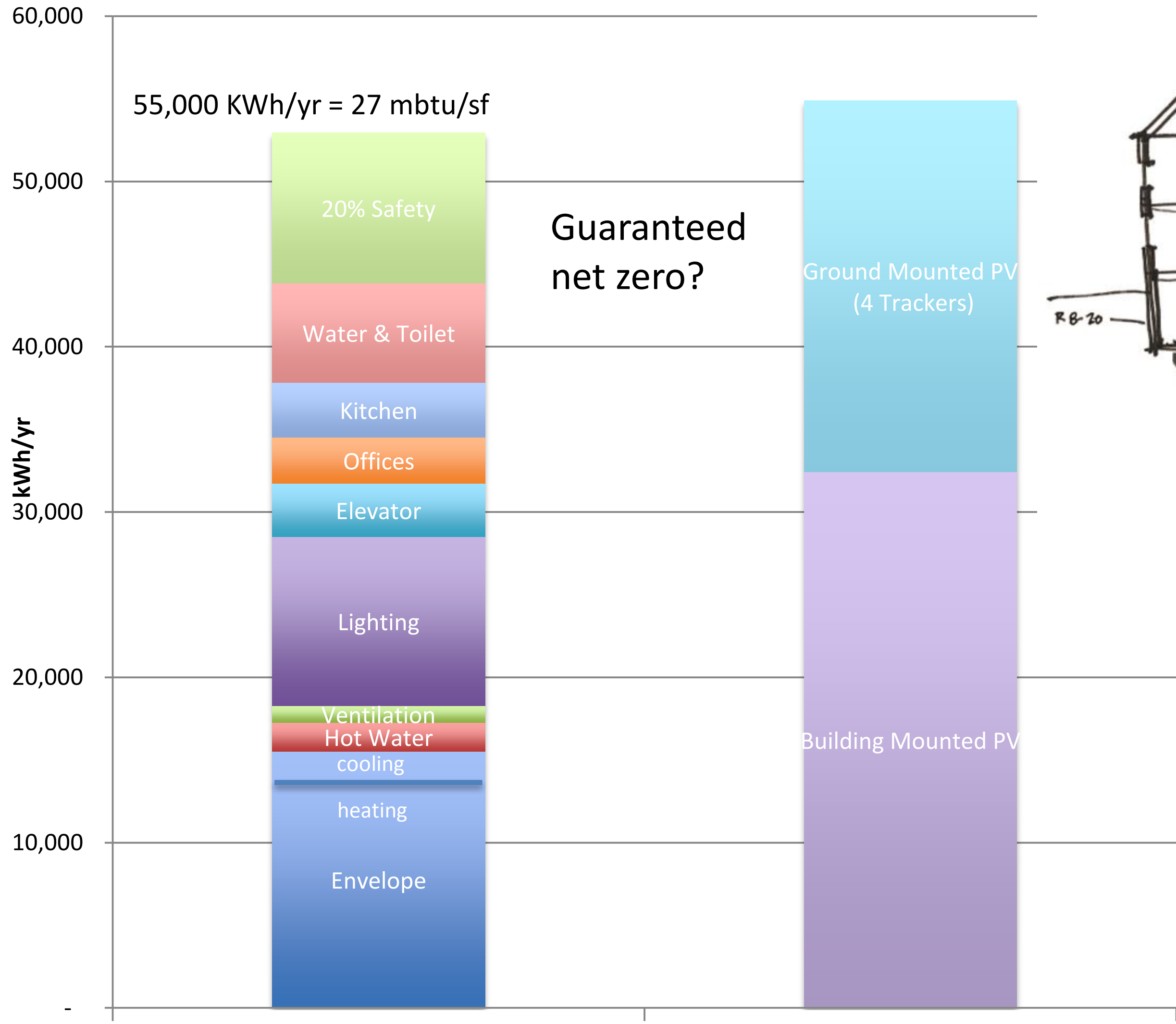
Redefining Success

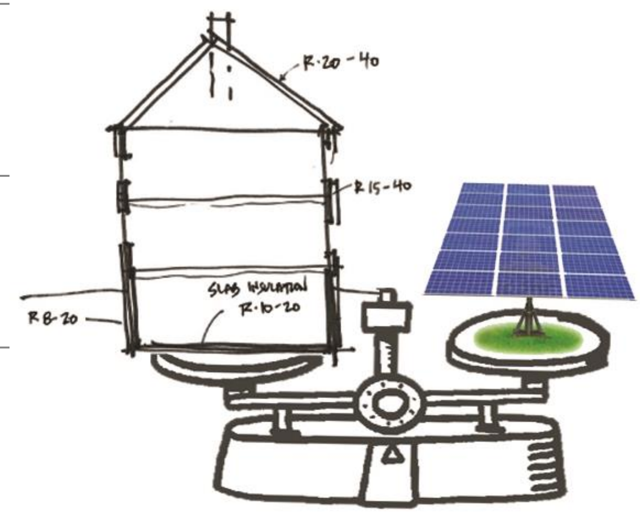
Size Matters



4. Net Zero Strategies

Balancing Supply & Demand





<table>
<tr><th>Traditional Payback Analysis</th><th>Most Cost Effective Net Zero</th></tr>
<tr><td>• Positive cash flow
• Select a payback period</td><td>Balance cost of saving a BTU vs. generating a BTU</td></tr>
<tr><td>Factors (guesses)
• Borrowing rate
• Inflation rate
• Fuel inflation rate</td><td>Factors (guesses)
• Longevity of energy saving component
• Ease of upgrading energy saving component
• Longevity of energy generating component</td></tr>
<tr><td colspan="2">Strategy: spend money on saving energy, until it is less expensive to purchase the energy.</td></tr>
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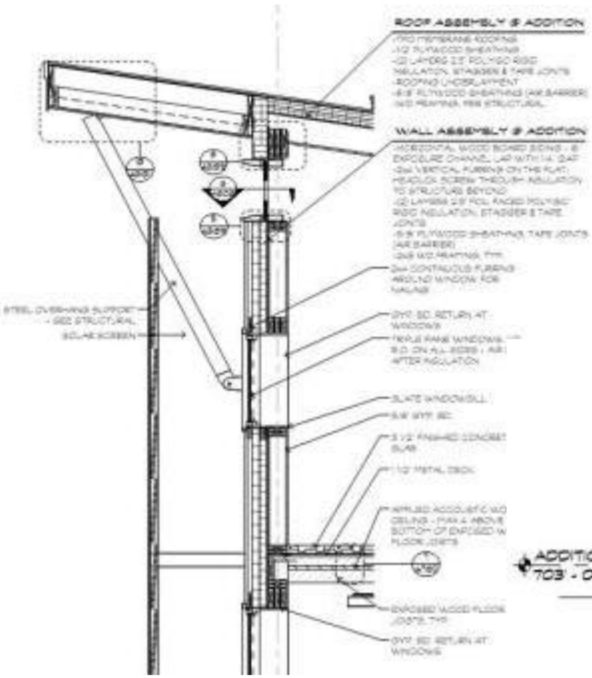
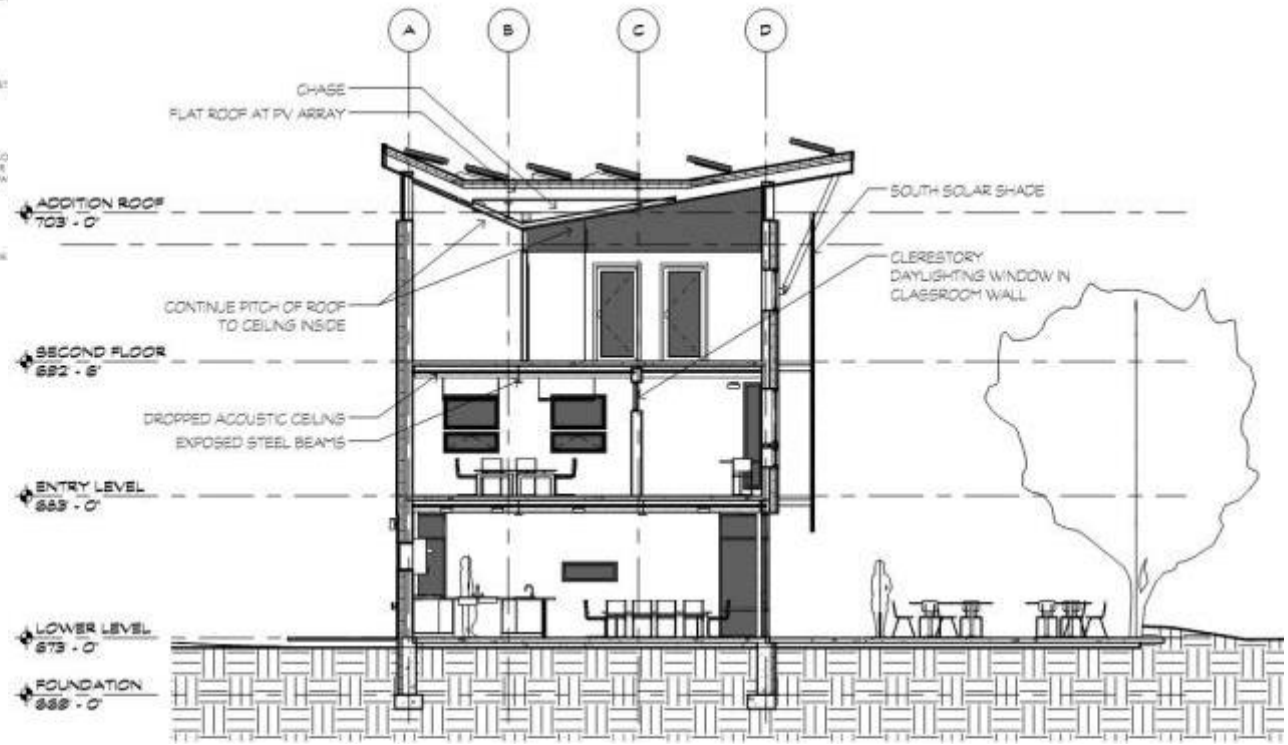
Impact on Envelope



Roof / wall: 5” polyiso
Windows: R-5
Below grade walls: 5” XPS
Slab: 3” XPS



Energy vs. Cost
Option 1

Locations	Material	Unit	Unit Cost	SF	Price Per #	R-Value	# Inches	Total Cost	Difference	MMBtu Saved/year	Cost Per mmbtu saved/year	Cost to produce mmbtu/year with PV array	Energy Cost kwh	Array in KW	Cost in PV array	Difference
											$ 40.00					
Ceiling/Roofs																
Option 1	Polyiso	1" per sf	$ 1.05	3526	$ 3,702.30	10	2	$ 7,404.60		13.4			3926	3.6	$ 21,415.44	
Mass Stretch Min	Polyiso	1" per sf	$ 1.05	3526	$ 3,702.30	20	4	$ 14,809.20		13.9			4073	3.7	$ 22,214.53	
Difference									$ 7,404.60	0.5	$ 14,809.20	$ 1,598.16				$ 799.08
Option 3	Polyiso	1" per sf	$ 1.05	3526	$ 3,702.30	25	5	$ 18,511.50		11.5			3369	3.1	$ 18,378.93	
Difference									$ 3,702.30	2.4	$ 1,542.63	$ 1,598.16				$ 3,835.60
Option 4	Polyiso	1" per sf	$ 1.05	3526	$ 3,702.30	30	6	$ 22,213.80		9.8			2871	2.6	$ 15,682.04	
Difference									$ 3,702.30	1.7	$ 2,177.82	$ 1,598.16				$ 2,716.88
Option 2	Polyiso	1" per sf	$ 1.05	3526	$ 3,702.30	40	8	$ 29,618.40		6.1			1787	1.6	$ 9,748.82	
Difference									$ 7,404.60	3.7	$ 2,001.24					$ 5,913.22
Above Grade Walls																
Option 1	Polyiso	1" per sf	$ 1.05	7022	$ 7,373.10	10	2	$ 14,746.20		27.4			8028	7.3	$ 43,789.79	
Mass Stretch Min	Polyiso	1" per sf	$ 1.05	7022	$ 7,373.10	15	3	$ 22,119.30		33.8			9903	9.0	$ 54,018.06	
Difference									$ 7,373.10	6.4	$ 1,152.05	$ 1,598.16				$ (10,228.27)
Option 3	Polyiso	1" per sf	$ 1.05	7022	$ 7,373.10	20	4	$ 29,492.40		26.8			7852	7.1	$ 42,830.89	
Difference									$ 7,373.10	7	$ 1,053.30	$ 1,598.16				$ 11,187.17
Option 4	Polyiso	1" per sf	$ 1.05	7022	$ 7,373.10	25	5	$ 36,865.50		22.3			6534	5.9	$ 35,639.13	
Difference									$ 7,373.10	4.5	$ 1,638.47	$ 1,598.16				$ 7,191.75
Option 2	Polyiso	1" per sf	$ 1.05	7022	$ 7,373.10	40	8	$ 58,984.80		15.2			4454	4.0	$ 24,292.15	
Difference									$ 22,119.30	7.1	$ 3,115.39	$ 1,598.16				$ 11,346.99
Foundation Walls																
Option 1	XPS	1" per sf	$ 1.09	1901	$ 2,072.09	10	2.5	$ 5,180.23		11.3			3311	3.0	$ 18,059.29	
Mass Stretch Min	XPS	1" per sf	$ 1.09	1901	$ 2,072.09	8	1.6	$ 3,315.34		17.2			5040	4.6	$ 27,488.48	
Difference									$ (1,864.88)	-5.9	$ 316.08	$ 1,598.16				$ (9,429.19)
Option 3	XPS	1" per sf	$ 1.09	1901	$ 2,072.09	15	3	$ 6,216.27		10.7			3135	2.9	$ 17,100.39	
Difference									$ 2,900.93	6.5	$ 446.30	$ 1,598.16				$ 10,388.09
Option 4	XPS	1" per sf	$ 1.09	1901	$ 2,072.09	20	4	$ 8,288.36		9.7			2666	2.4	$ 14,543.32	
Difference									$ 2,072.09	1.6	$ 1,295.06	$ 1,598.16				$ 2,557.07
Option 2	XPS	1" per sf	$ 1.09	1901	$ 2,072.09	40	8	$ 16,576.72		5.1			1494	1.4	$ 8,150.65	
Difference									$ 8,288.36	4	$ 2,072.09	$ 1,598.16				$ 6,392.67
Slab/Floors																
Option 1	XPS	1" per sf	$ 1.09	2660	$ 2,899.40	10	2.5	$ 7,248.50		6.6			1934	1.8	$ 10,547.91	
Mass Stretch Min	XPS	1" per sf	$ 1.09	2660	$ 2,899.40	8	1.6	$ 4,639.04		8.8			2803	2.5	$ 15,286.62	
Difference																
Option 3	XPS	1" per sf	$ 1.09	2660	$ 2,899.40	15	3	$ 8,698.20		6.3			2006	1.8	$ 10,943.83	
Difference									$ 4,059.16	2.5	$ 1,623.66	$ 1,598.16				$ 4,342.79
Option 4	XPS	1" per sf	$ 1.09	2660	$ 2,899.40	20	4	$ 11,597.60		5.2			1656	1.5	$ 9,033.01	
Difference									$ 2,899.40	1.1	$ 2,635.82	$ 1,598.16				$ 1,010.83
Option 2	XPS	1" per sf	$ 1.09	2660	$ 2,899.40	40	8	$ 23,195.20		3			879	0.8	$ 4,794.50	
Difference									$ 11,597.60	2.2	$ 5,271.64	$ 1,598.16		0.0		$ 4,238.50
Doors																
Option 1																
Option 2																
Windows/Skylights						U-Value										
Option 1	2x Glazing	sf	$ 51.00	1452		0.3		$ 74,052.00		62.7			18371	16.7	$ 66,803.40	
Option 2	3x Glazing	sf	$ 75.00	1452		0.19		$ 108,900.00		27			7011	7.2	$ 28,767.01	
									$ 34,848.00	35.7	$ 976.13	$ 1,598.16				$ 38,036.38

SWEET SPOT: WHERE INVESTMENT IN SAVING A BTU IS EQUIVALENT TO THE INVESTMENT IN MAKING A BTU

MBTU to KWh/year= MMBTU/3413
KWh/year - KW= (kwh year)/1100
Cost Straight = $4,000 per kw
Cost Endowed = $6,000 per kw

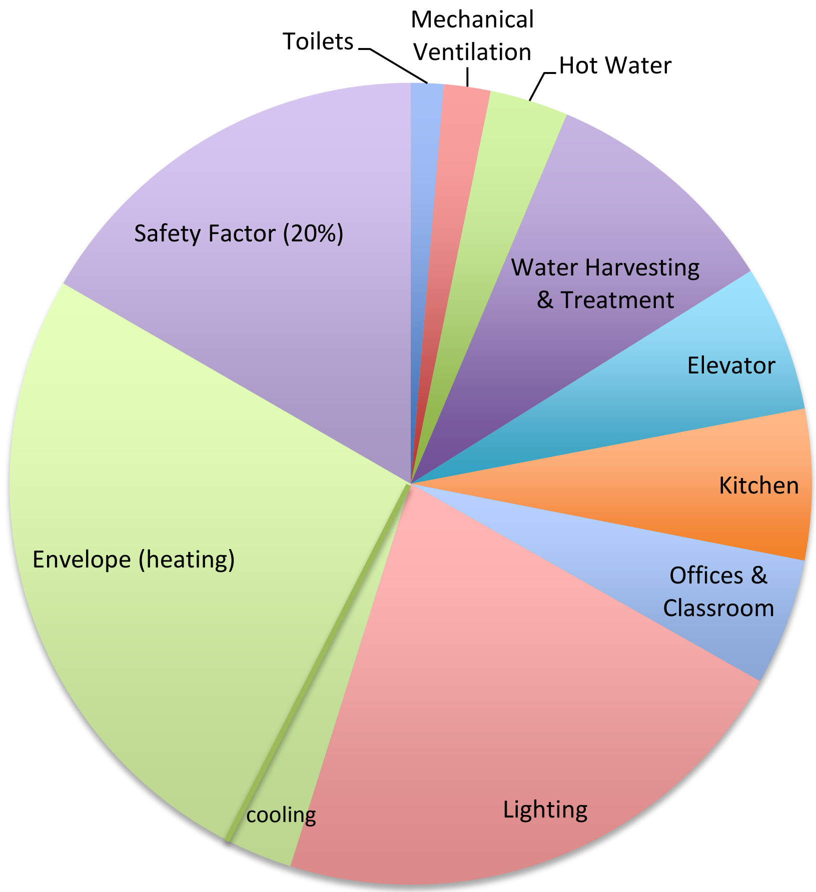
Energy modeling of every component

Invest in energy savings until it is less expensive to invest in energy generation.

Above Grade Walls	# Inches	Total Cost	Difference	MMBtu Saved/year	Cost Per mmbtu saved/year	Cost to produce mmbtu/year with PV array
Option 1	2	$ 14,746.20		27.4		
Mass Stretch Min	3	$ 22,119.30		33.8		
Difference			$	6.4	$	$ 1,598.16
Option 3	4	$ 29,492.40		26.8		
Difference			$ 7,373.10	7	$ 1,053.30	$ 1,598.16
Option 4	5	$ 36,865.50		22.3		
Difference			$ 7,373.10	4.5	$ 1,638.47	$ 1,598.16
Option 2	8	$ 58,984.80		15.2		
Difference			$ 22,119.30	7.1	$ 3,115.39	$ 1,598.16

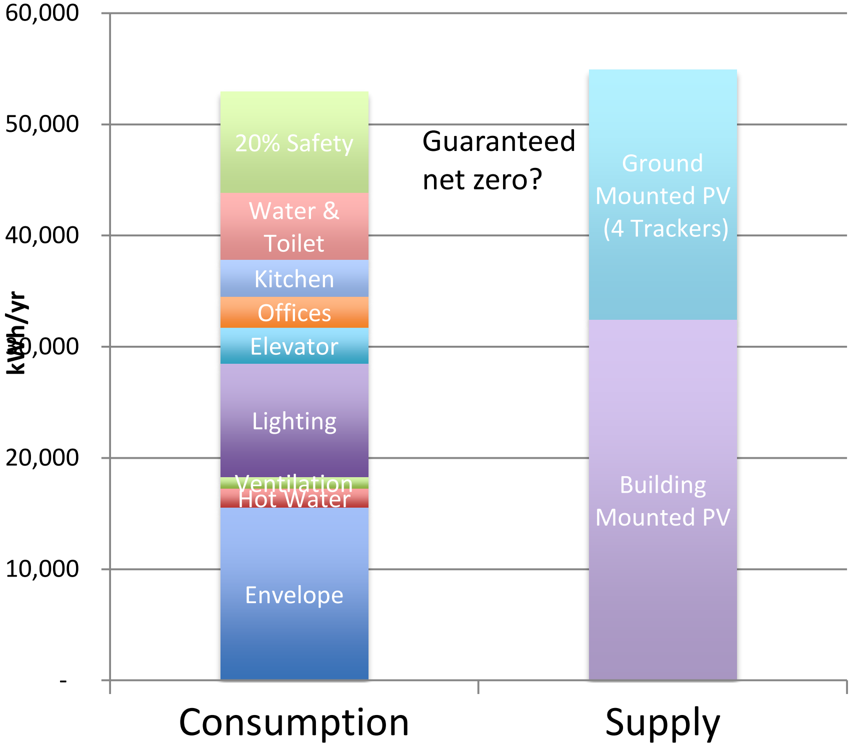
Invest in energy savings until it is less expensive to invest in energy generation.

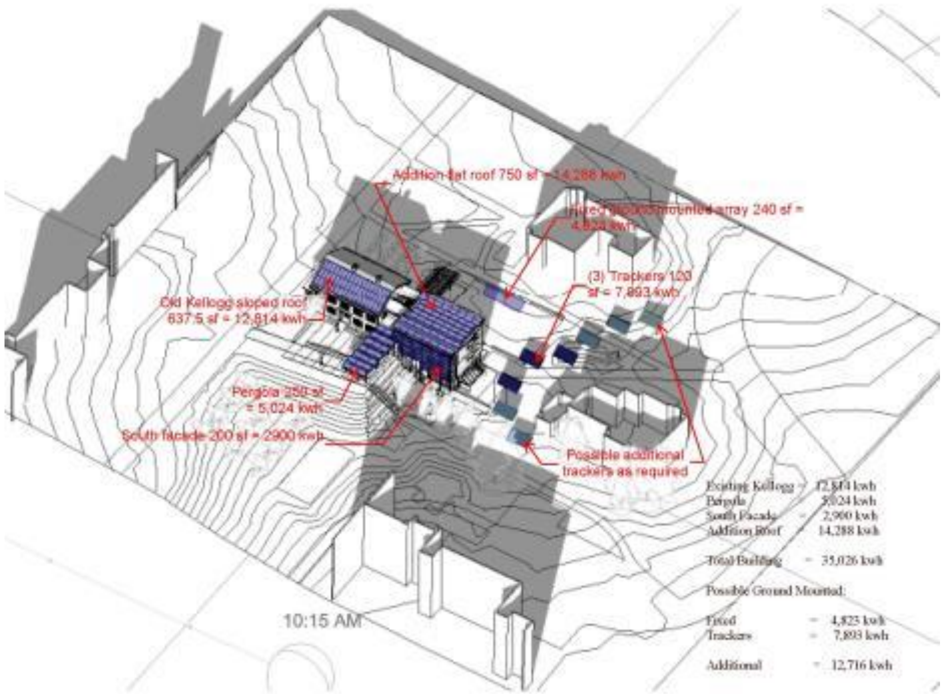
Projected Energy Use



A large portion on the energy use in dependent on human behavior.

Safety Factor



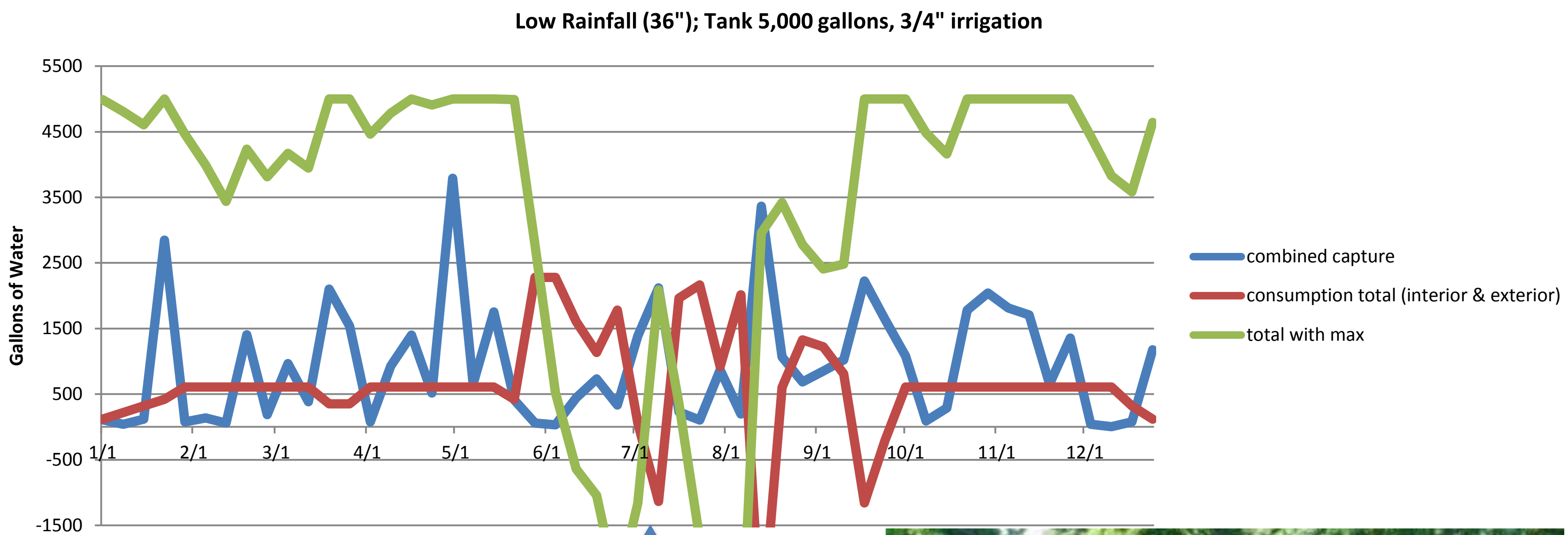


Other Elements Impacting Net Zero

Kitchen

Air Conditioning

Other Elements Impacting Net Zero



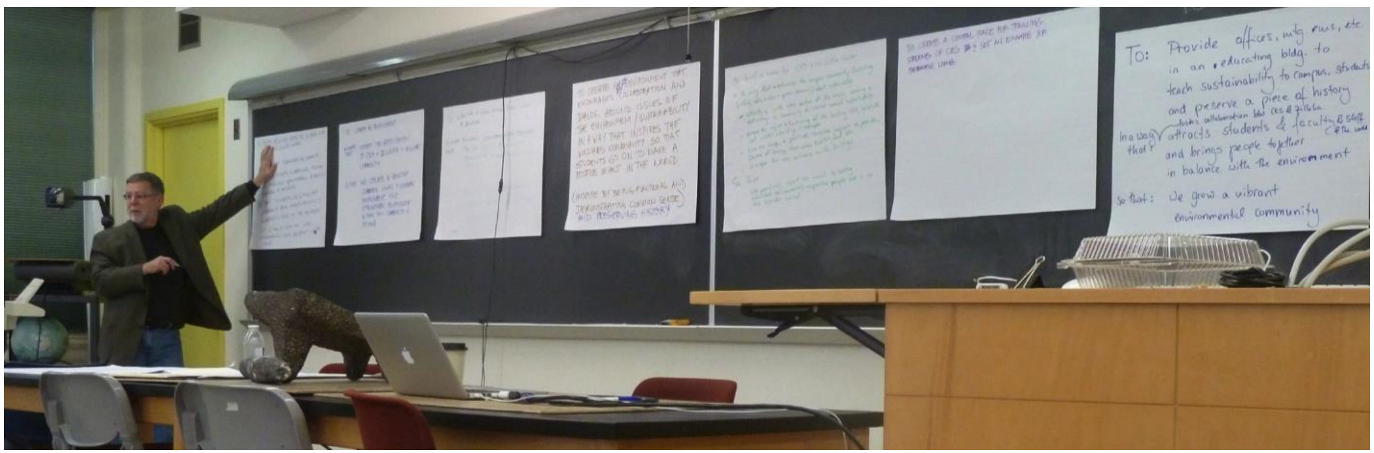
Irrigation Season

Accounting for Water's Energy Impact

5. Building in Feedback Mechanisms to Impact Occupant Behavior

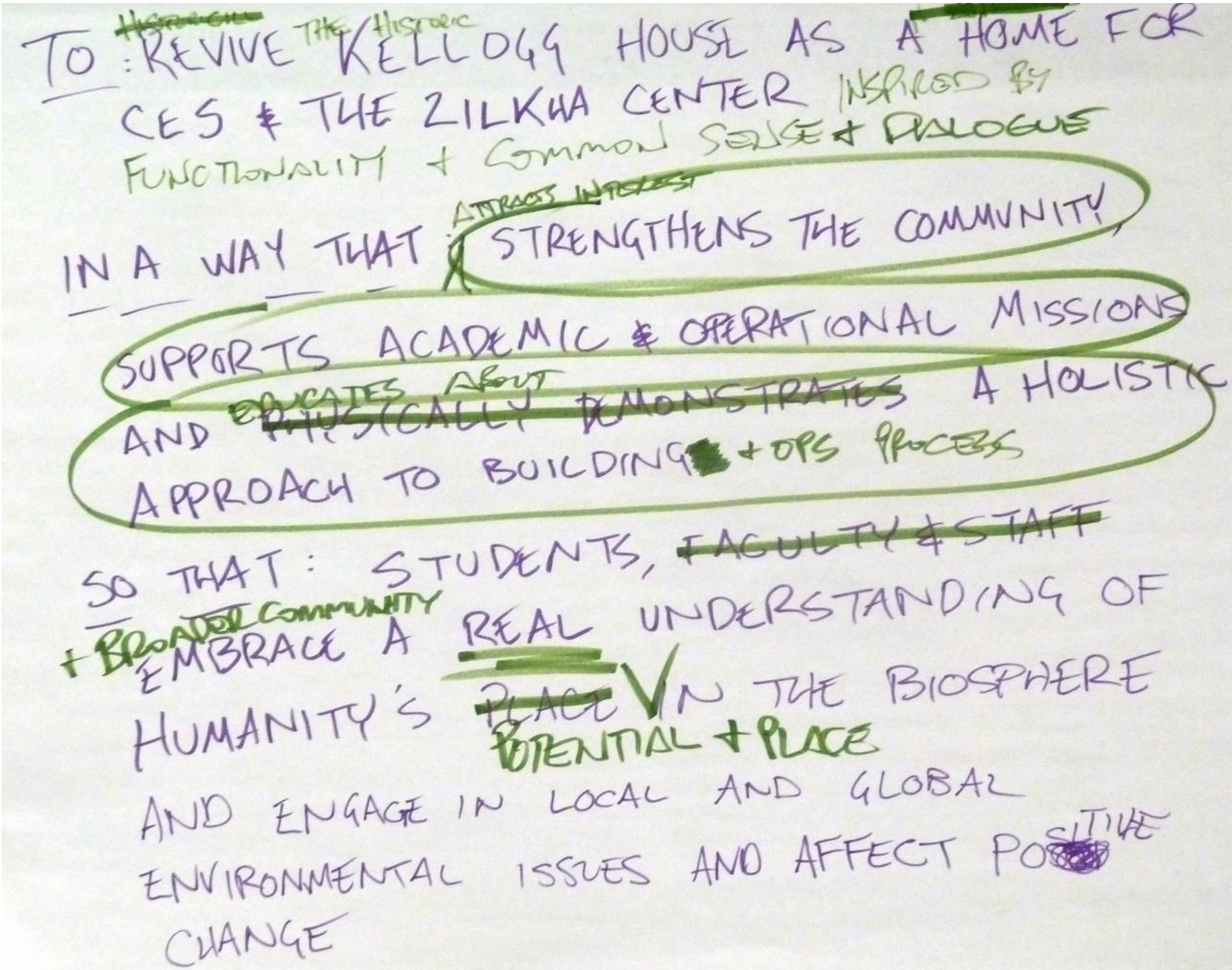
- Building in feedback mechanisms, so it is clear that behavior matters
- Increase awareness of the connection to the environment & natural cycles
- When failure is a “teaching opportunity”
- Research opportunities
- Building as living organism
- Building as a challenge!

6. Learning Opportunities



- Being engaged in a living building
- Biophilia – connection to nature
- Benefit of the potential for failure
- Research opportunities
- College courses relating to something tangible
- Building as an exhibit for a wider audience

7. Institutional Benefits



- Presence of young, bright, open minds – future leaders
- Resources available for long term thinking
- Colleges have significant (and expensive to maintain) building stock
- Institutions are all in the marketing business (to high school students) and have to be at the forefront
- Leadership involves looking ahead

Achieving Net-Zero Energy in a Campus Building

Questions?

Presenters

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