NZE Building Systems

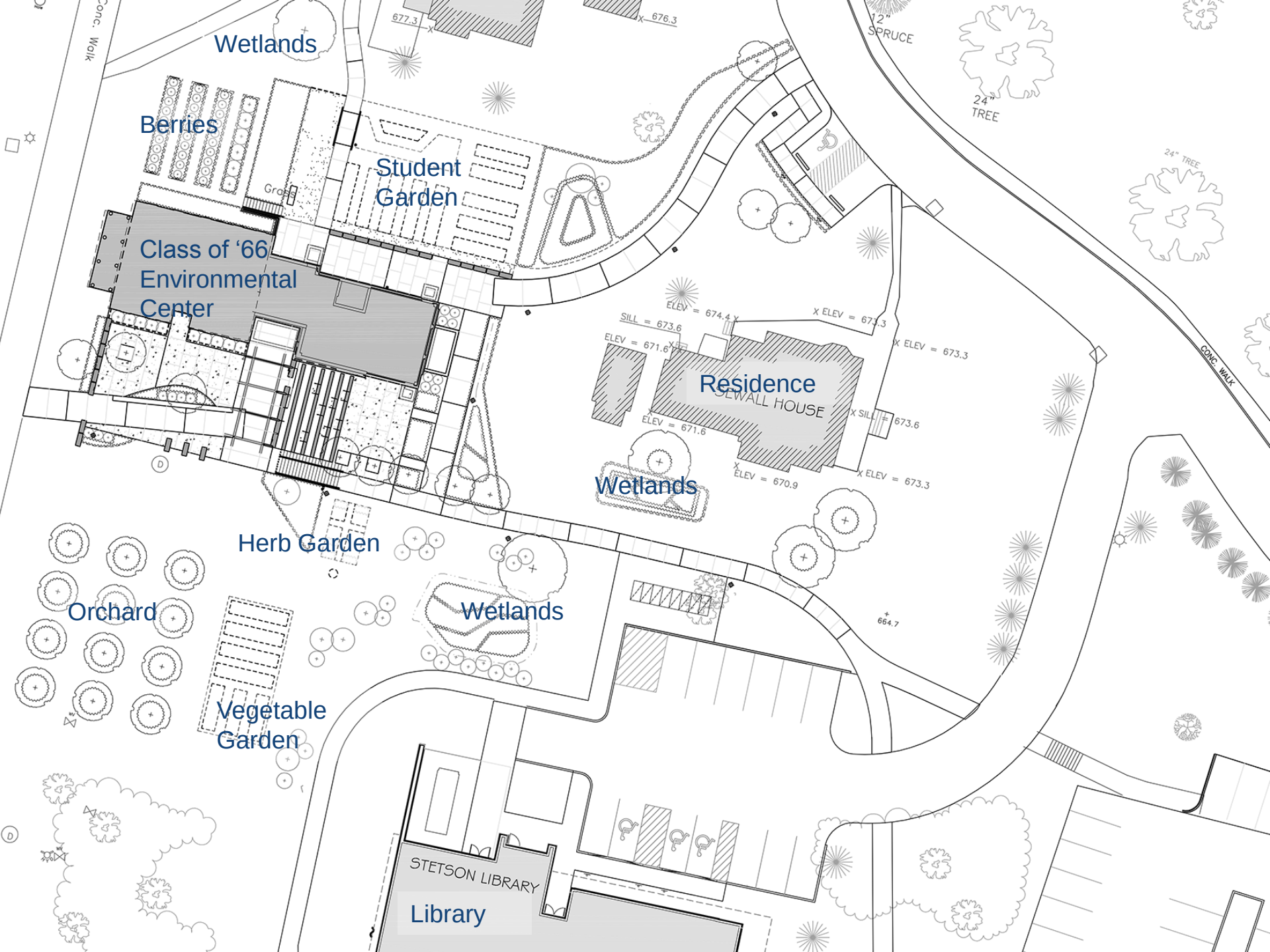
What are the right performance metrics?

What are the right levels of performance?

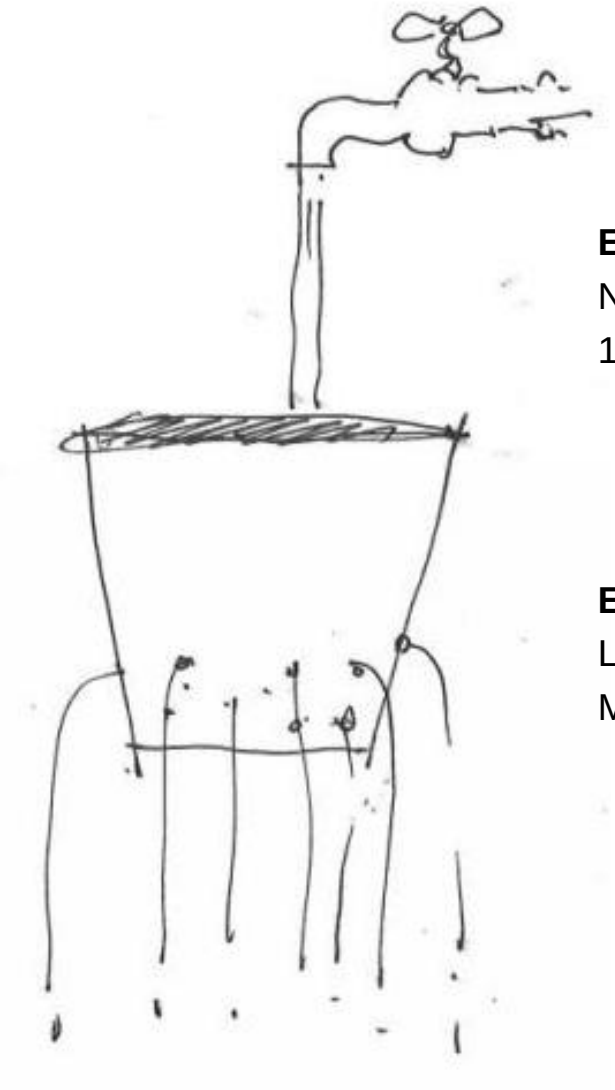
NZE Parameters

- Driving factors for Environmental Center at Williams College
  - Living Building Challenge candidate
  - Financial considerations
  - Carbon considerations
  - Thermal comfort/individual control
  - Educational opportunities

Class of 1966 Environmental Center


Wetlands
Berries
Student Garden
Class of '66 Environmental Center
Residence
SEWALL HOUSE
Wetlands
Herb Garden
Orchard
Wetlands
Vegetable Garden
STETSON LIBRARY
Library
CONC. WALK
12" SPRUCE
24" TREE
24" TREE
677.3
676.3
ELEV = 674.4
X ELEV = 673.3
SILL = 673.6
ELEV = 671.6
X ELEV = 673.3
X SILL = 673.6
ELEV = 671.6
ELEV = 670.9
X ELEV = 673.3
664.7

Schematic Energy Flows



Energy In

No combustion

100% on site production

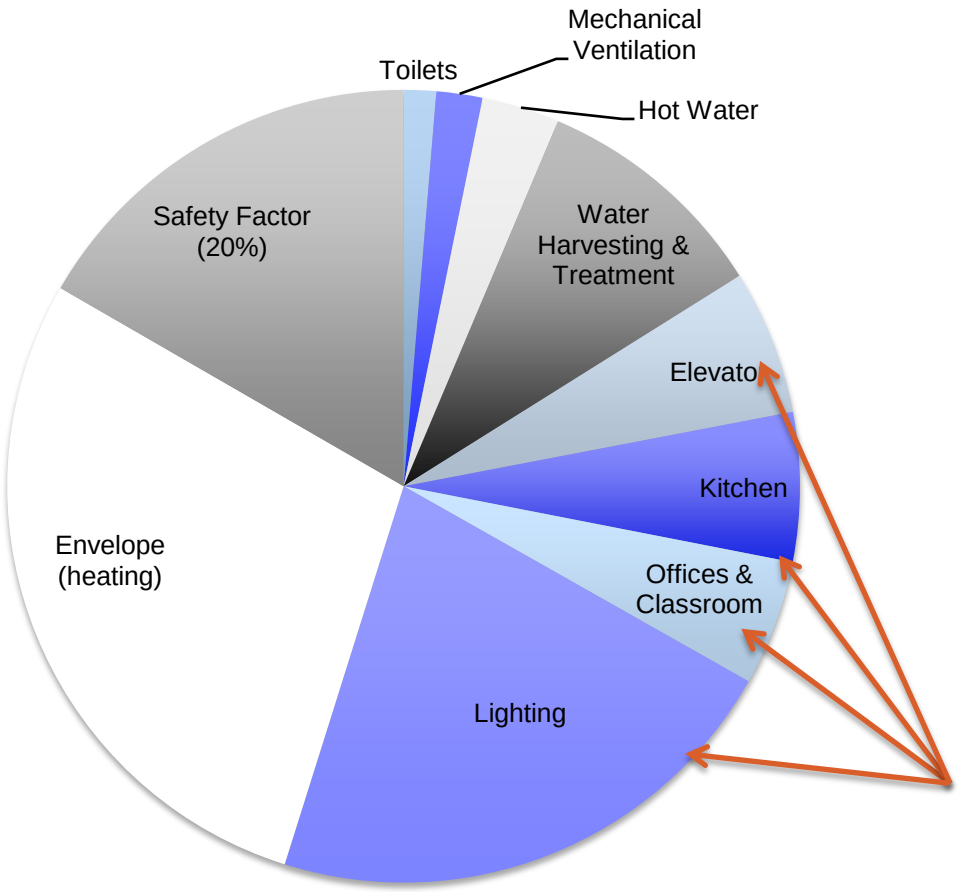
Energy Out

Least energy waste

Maximum efficiency of necessary energy use

Where Will Energy Go?

Class of 66 Environmental Center
Energy Consumption Estimate by End Use kWh/yr



Loads	kWh/yr
Toilets	718
Mechanical Ventilation	1,025
Hot Water	1,729
Water Harvesting	5,302
Elevator	3,218
Kitchen	3,315
Office & Classroom	2,792
Lighting	11,810
Envelope (heating)	15,529
SubTotal	45,437
Safety Factor, 20%	9,087
Building-mounted PV	32,423
Garden Array	22,476

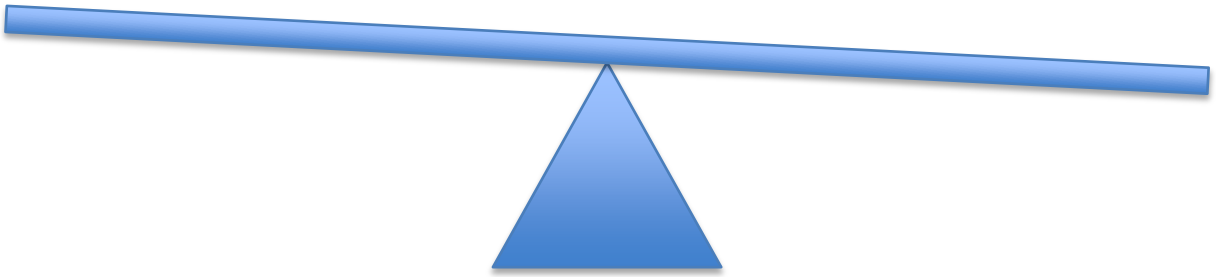
Behavior Driven Energy Consumption

Only 30-40% of energy is base building services

What to Balance?

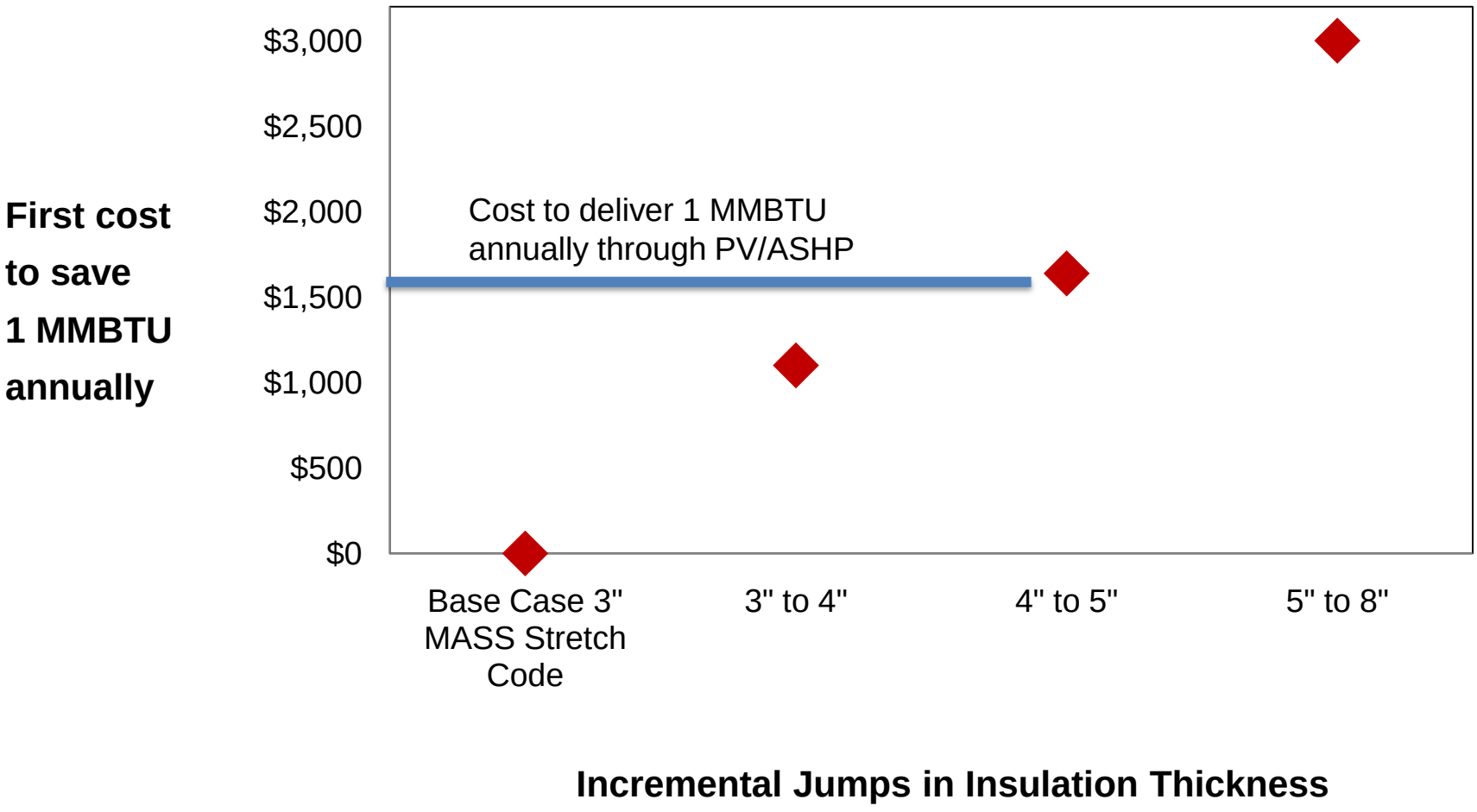
- Cost of energy savings
- Embodied carbon
- Education of occupants

- Cost of energy production
- Carbon payback
- Reduction of building usage

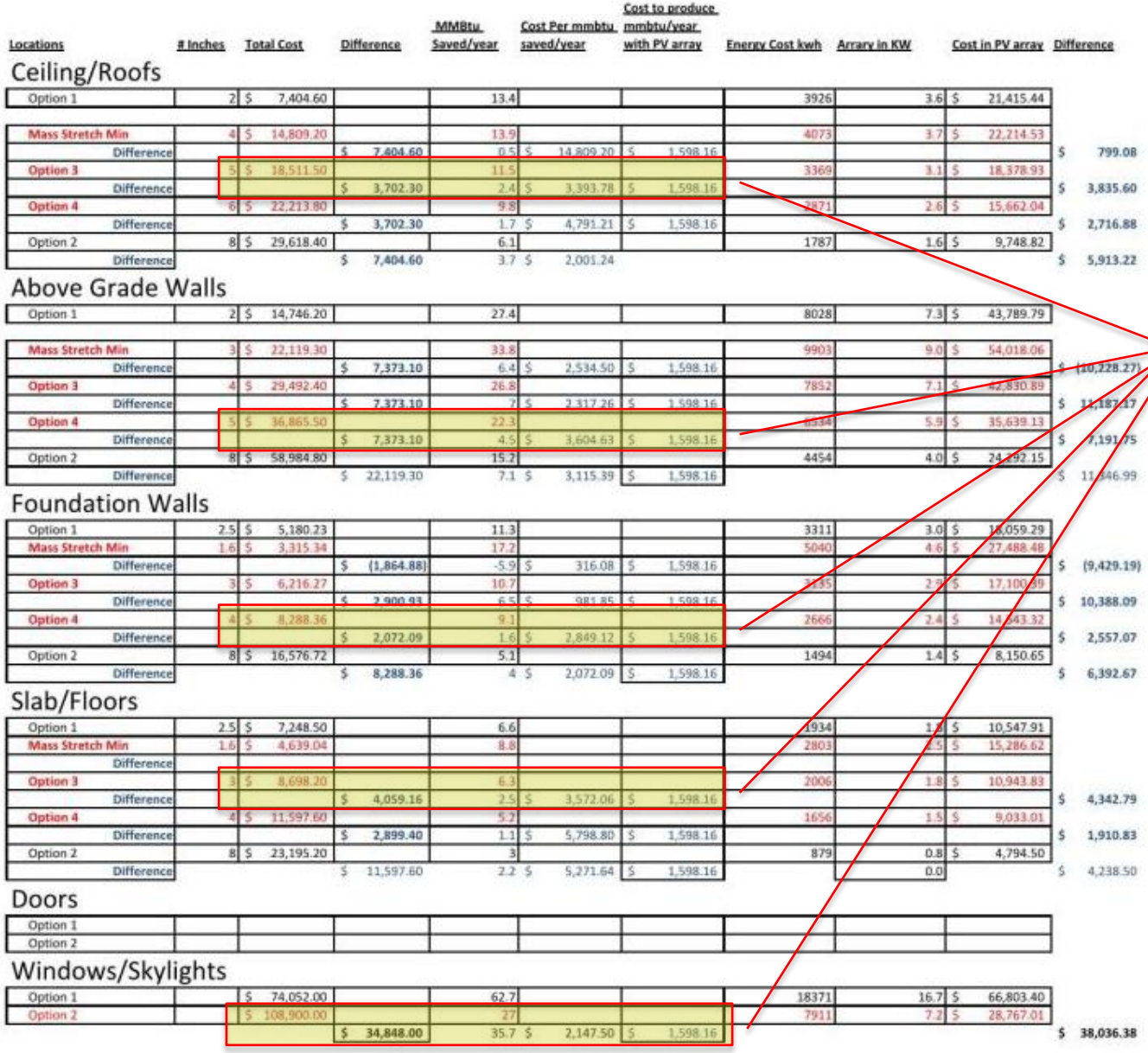


Added Cost of Added Savings

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



Balance Investment Between Measures



Locations	# Inches	Total Cost	Difference	MMBtu Saved/year	Cost Per mmbtu saved/year	Cost to produce mmbtu/year with PV array	Energy Cost kwh	Arrary in KW	Cost in PV array	Difference
Ceiling/Roofs										
Option 1	2	$ 7,404.60		13.4			3926	3.6	$ 21,415.44	
Mass Stretch Min	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	5	$ 18,511.50		11.5			3369	3.1	$ 18,378.93	
Difference			$ 3,702.30	2.4	$ 3,393.78	$ 1,598.16				$ 3,835.60
Option 4	6	$ 22,213.80		9.8			2871	2.6	$ 15,662.04	
Difference			$ 3,702.30	1.7	$ 4,791.21	$ 1,598.16				$ 2,716.88
Option 2	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	2	$ 14,746.20		27.4			8028	7.3	$ 43,789.79	
Mass Stretch Min	3	$ 22,119.30		33.8			9903	9.0	$ 54,018.06	
Difference			$ 7,373.10	6.4	$ 2,534.50	$ 1,598.16				$ (10,228.27)
Option 3	4	$ 29,492.40		26.8			7852	7.1	$ 42,830.89	
Difference			$ 7,373.10	7	$ 2,317.26	$ 1,598.16				$ 11,187.17
Option 4	5	$ 36,865.50		22.3			6534	5.9	$ 35,639.13	
Difference			$ 7,373.10	4.5	$ 3,604.63	$ 1,598.16				$ 7,191.75
Option 2	8	$ 58,984.80		15.2			4454	4.0	$ 24,292.15	
Difference			$ 22,119.30	7.1	$ 3,115.39	$ 1,598.16				$ 11,946.99
Foundation Walls										
Option 1	2.5	$ 5,180.23		11.3			3311	3.0	$ 16,059.29	
Mass Stretch Min	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	3	$ 6,216.27		10.7			3135	2.9	$ 17,100.39	
Difference			$ 2,900.93	6.5	$ 981.85	$ 1,598.16				$ 10,388.09
Option 4	4	$ 8,288.36		9.1			2666	2.4	$ 14,543.32	
Difference			$ 2,072.09	1.6	$ 2,849.12	$ 1,598.16				$ 2,557.07
Option 2	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	2.5	$ 7,248.50		6.6			1934	1.8	$ 10,547.91	
Mass Stretch Min	1.6	$ 4,639.04		8.8			2803	2.5	$ 15,286.62	
Difference										
Option 3	3	$ 8,698.20		6.3			2006	1.8	$ 10,943.83	
Difference			$ 4,059.16	2.5	$ 3,572.06	$ 1,598.16				$ 4,342.79
Option 4	4	$ 11,597.60		5.2			1656	1.5	$ 9,033.01	
Difference			$ 2,899.40	1.1	$ 5,798.80	$ 1,598.16				$ 1,910.83
Option 2	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										
Option 1		$ 74,052.00		62.7			18371	16.7	$ 66,803.40	
Option 2		$ 108,900.00		27			7911	7.2	$ 28,767.01	
			$ 34,848.00	35.7	$ 2,147.50	$ 1,598.16				$ 38,036.38

Parametric modeling of every component

Sweet spots where investment in saving a BTU is equivalent to the investment in making a BTU.

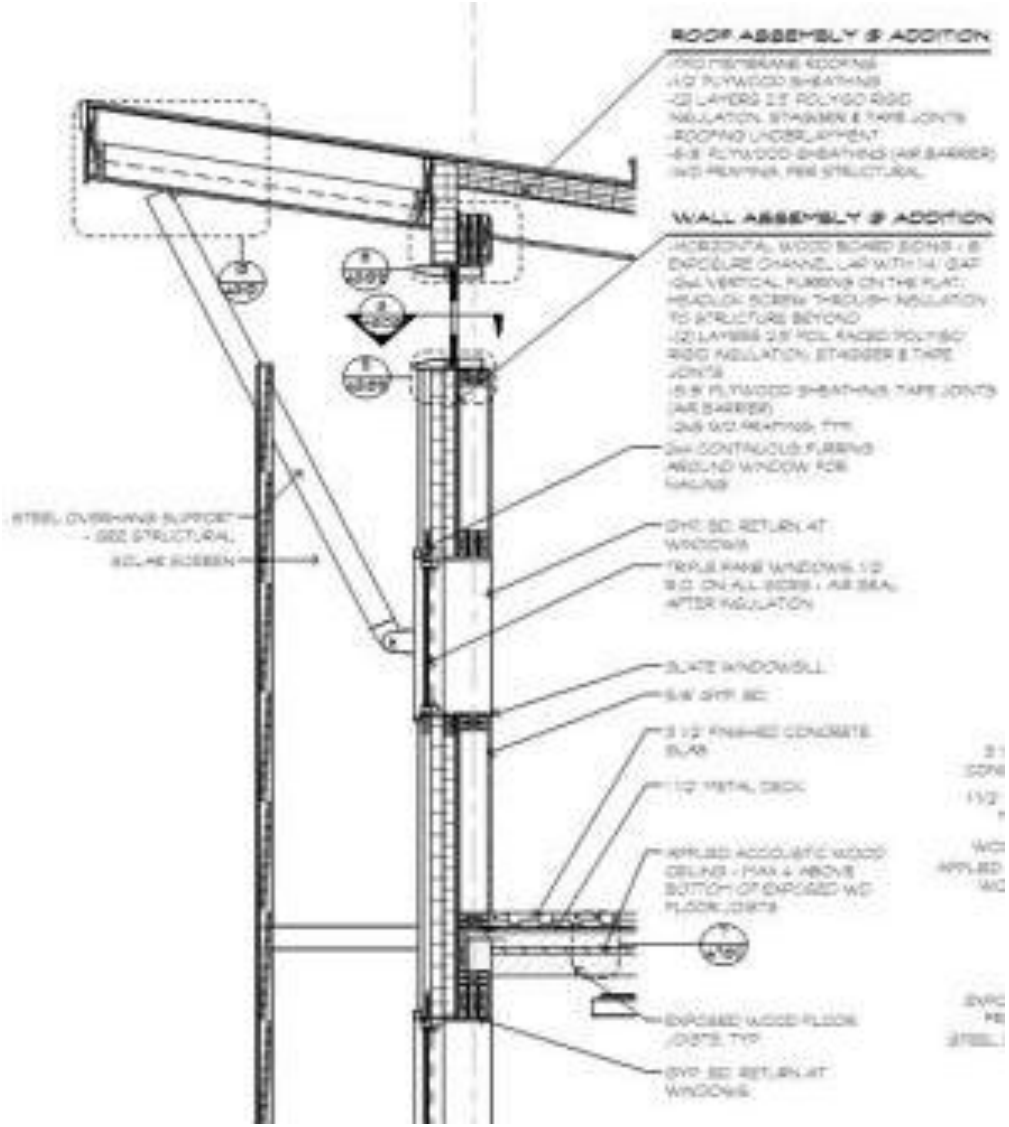
Good Enough Envelope

Roof / wall: 5” polyiso

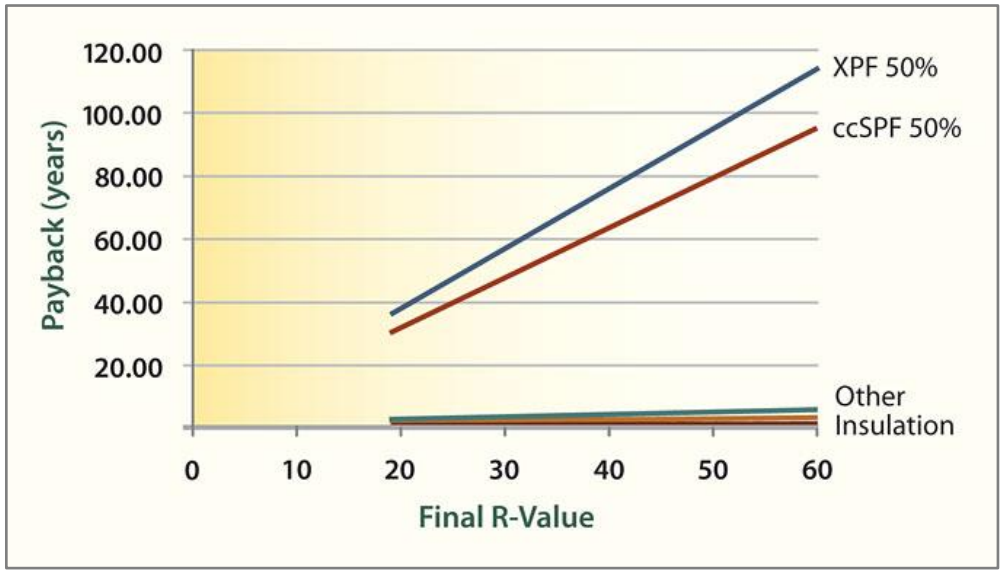
Windows: R-5

Below grade walls: 5” XPS

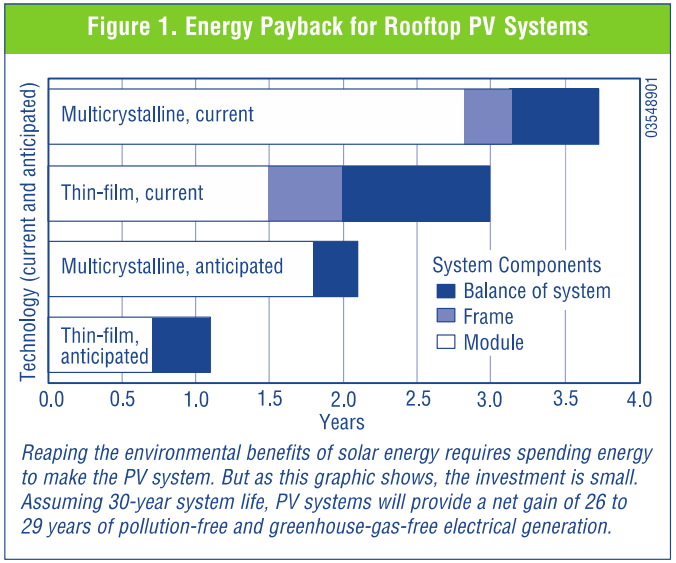
Slab: 3” XPS



CO2e Payback for Insulation vs. PV



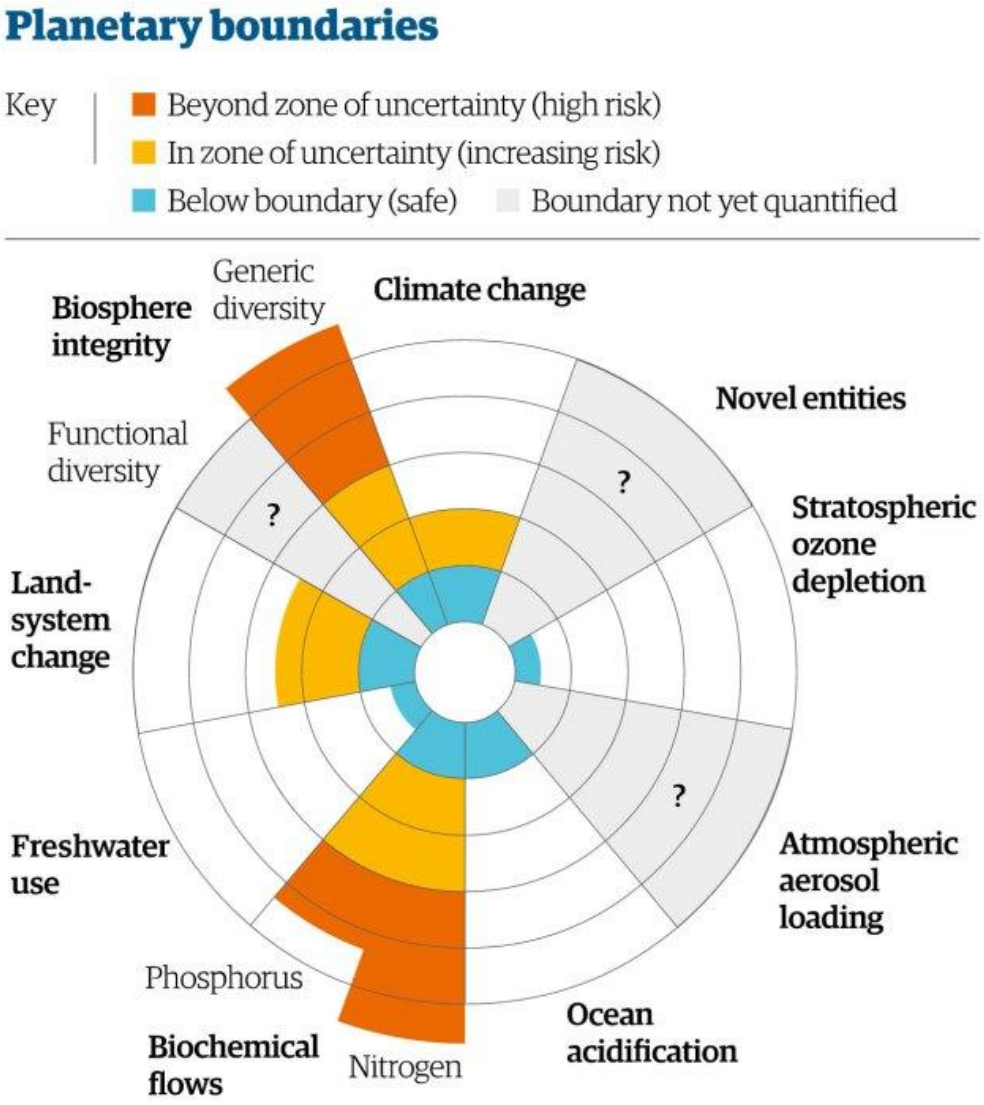
CO2e Payback for Insulations (Building Green)



Energy/CO2e Payback for PV (NREL)

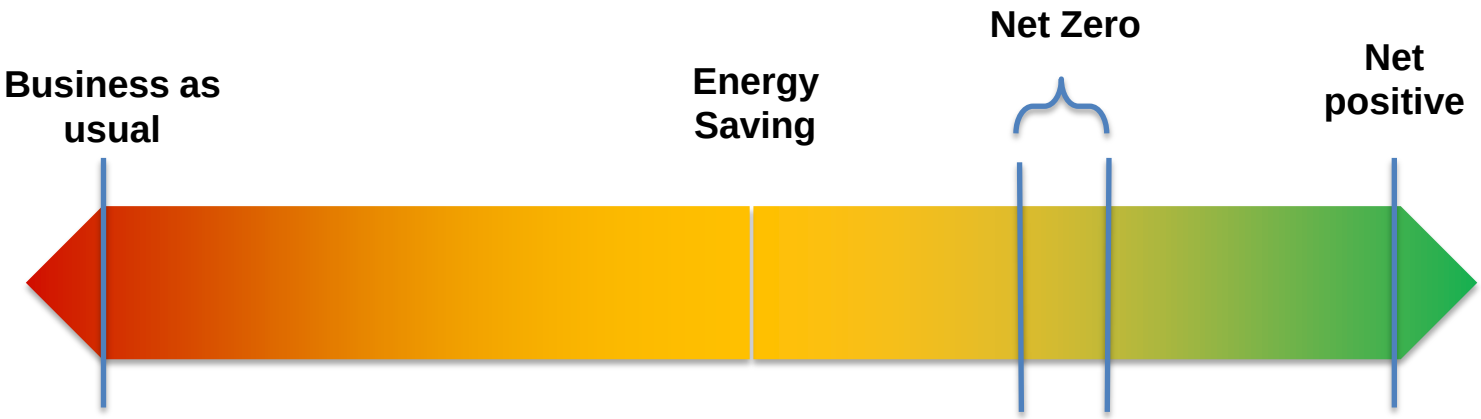
The blowing agent in closed-cell foams is the single largest factor to consider

Climate Change is Only Part of the Picture



Nothing Absolute About Net Zero

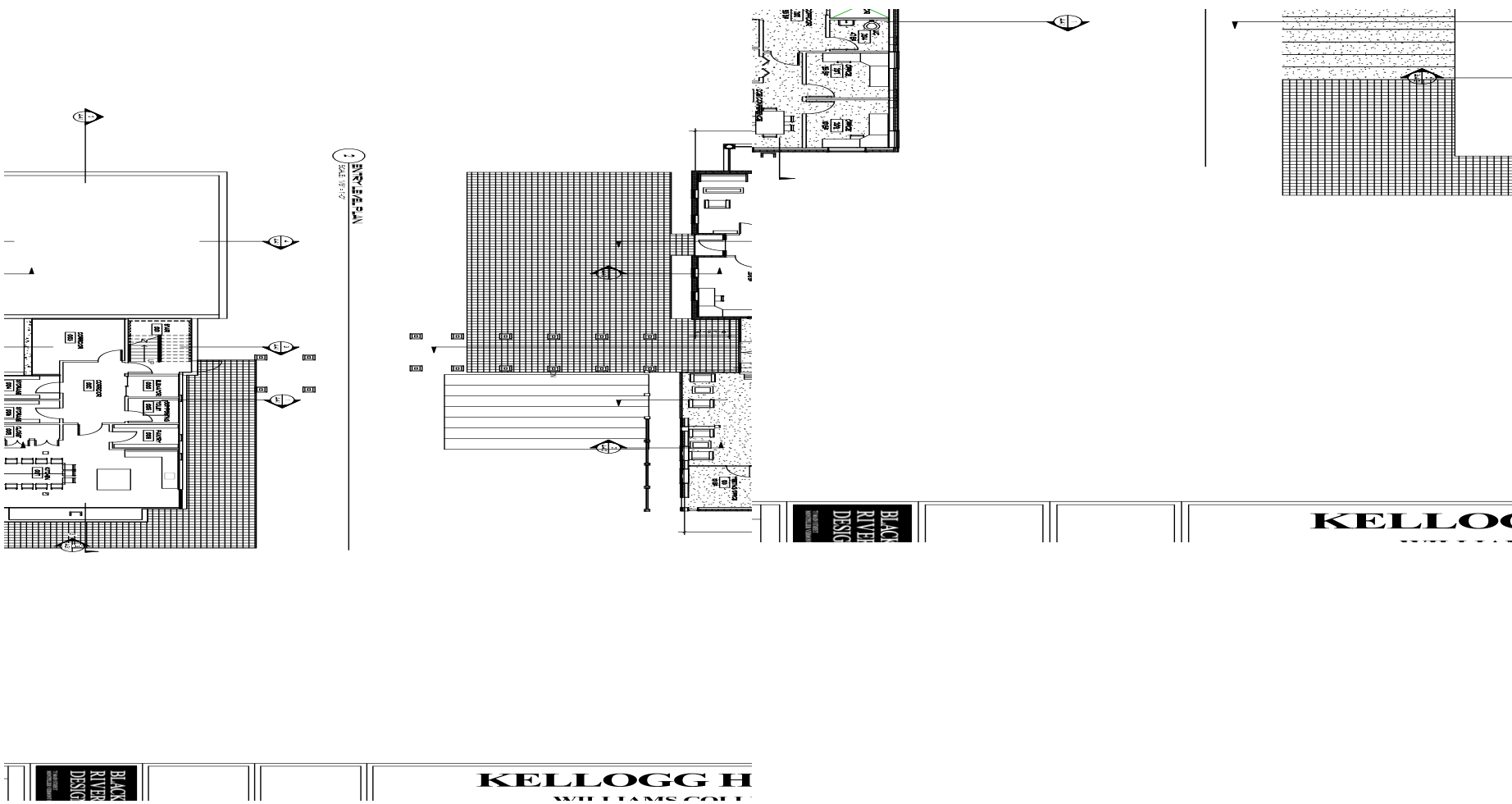
- Where does a project draw the impact boundary? Where should it?
- What is the best use of resources?
- How busy should our most efficient buildings be?



Occupant Behavior NZE Building

- Controlling the 50% to 70%
- Role of Dashboards
- Role of Occupants & Facilities

Class of ‘66 Environmental Center Program

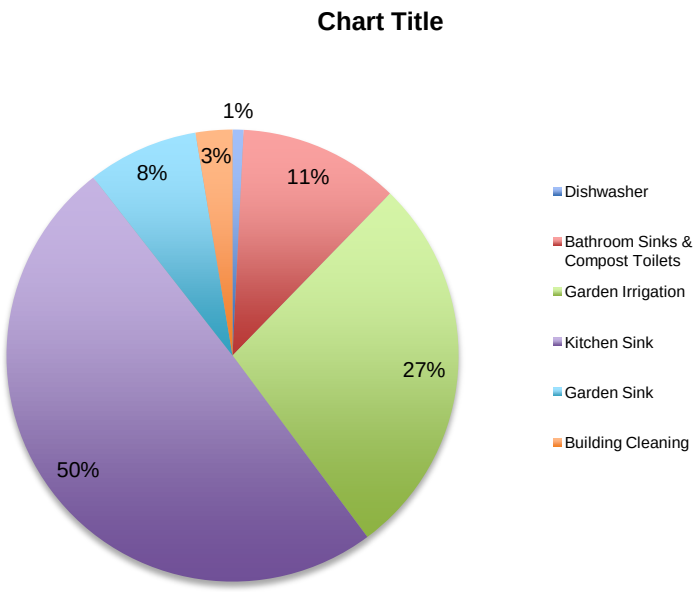


Net Zero Energy Assumptions

Kellogg House Energy Requirements & Assumptions July 2, 2013							
Square Footage							
Yearly Energy Estimates						3.413	
Loads	**Assumption, Data Source**	**Behavioral Component**	**kWh/yr**	**kWh/sf**		**kBtus/yr**	**kBtu/sf**
Offices							
Computers & Monitors	NREL estimated 2.43 kBtu/sf/yr	all new high efficiency computers and monitors for staff. Laptops preferred	878			2,997	
	Williams Offices = 1,225 sf for 2,977 kBtu/yr						
Telephones	VOIP phones. NREL estimated 0.28 kBtu/sf/yr. For Williams = 343		100			343	
Fax Machine, Scanner & Copier (one machine)	Cannon image Runner. Multifunctional Device Typical Weekly consumption estimated at .7kWh/week, or 35 for 50 weeks. (Energy Star product).This estimate is slightly than "average".	One multi function printer/copier/scanner shared among all faculty and staff	250			853	
Task Lights	6 watt lights. 13 desks. 8 hours/day, 50 weeks	one new LED task light provided per workstation	156			532	
Misc Equipment (chargers, etc)	NREL estimated 97 kBtu/sf/yr	Power strips turned off when offices unoccupied	635			2,167	
			631				
Conference Room and Classroom							
Monitor	90-176 watts when on. 30 on standby. Williams to have a policy about turning off monitor completely when not in use. 3 hours/week for classes. 4 hours/week for meetings		88			300	
	NREL estimate 55 kWh/sf/yr = 674 sf based on office sf						
Projector	http://www.epson.com/cgi-bin/Store/jsp/Product.do?BV_UseBVCookie=yes&sku=V11H269020.	standby	580			1,980	
Multimedia console	Measured in Clark Hall		104			356	

Net Zero Water Assumptions

Kellogg House Water Requirements & Assumptions May 13, 2013					
Water Collection Surfaces	3,260 sf				
Yearly Energy Estimates					
Loads	**Assumptions**	**gallons/ day**	**gallons/yr- weekday (50 weeks)**	**gallons/yr weekend (50 weeks)**	**Yearly Totals**
Bathroom Sinks & Compost Toilets	Toilet MAX is 4.5 gal/day. Sink use that corresponds with this toilet use would be 10 gal/day. Weekend use is estimated at 1/2 weekday use.	14.5	3,625	750	4,375
Kitchen Sink	54 gallons/day estimate based on 30 minutes of use/day. No difference between weekday and weekend use.	54.0	13,500	5,400	18,900
Dishwasher	CMA Dishmachines, 17 Gallons/Hour. Estimated 4 cycles per day = 0.168hrs/day	2.9	215	86	301
Garden Irrigation	1"/wk. Gardens = 4000sf		10,496		10,496
Garden Sink	27 gallons/day estimate based on 15 minutes of use/day during the 16 week growing season. No difference between weekday and weekend use.	27.0	2,160	864	3,024
Building Cleaning					1,000
Total Estimated Consumption		98.4	37,096		38,096



LBC vs. Typical Campus Building

	Typical new campus Building	**Envi Center**	**How to Provide Net Zero**
EUI	50-75 kBtu/sq/yr	<25 kBtu/sq/yr	Building quality/efficiency, occu pant engagement
Water	4 gal/person/day	.25 gal/person/day	Composting toilets, water storage capacity, occupant engagement

Communicate with Building Occupants & Facilities

Communicate with Building Occupants & Facilities

Communicate with Building Occupants & Facilities

- Regular meetings to review building usage trends and Net Zero Energy status
- Formal or informal contract with building occupants about energy consumption (work in rooms with other people, wear sweaters, unplug computers)
- Share individually identifiable data about energy consumption?
- Change the way the data is presented to keep people’s attention
- Some restriction of usage may be necessary.
- Ongoing Cx
- Make it someone’s responsibility to monitor systems and and give feedback

Communicate with Building Occupants & Facilities

- Architects and Engineers can provide efficient systems but it's still the occupants' behaviors that determine energy consumption
- Behavioral modifications can't be punitive and be successful (from a consumer point of view, for a Higher Ed client)
- Goal of any new NZE project, on a campus or otherwise, is to reduce overall carbon emissions – broader context

Thank you

Further questions?

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