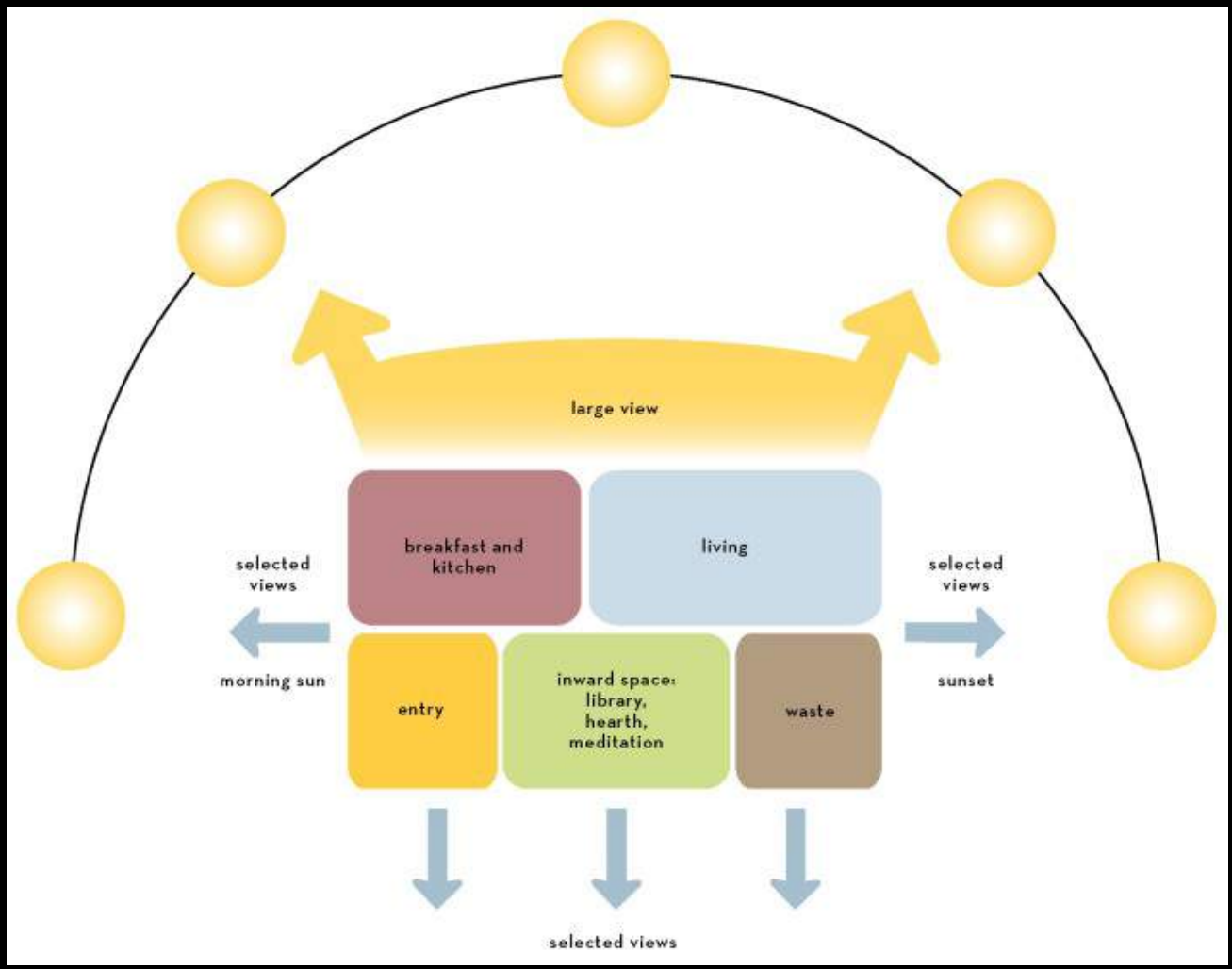
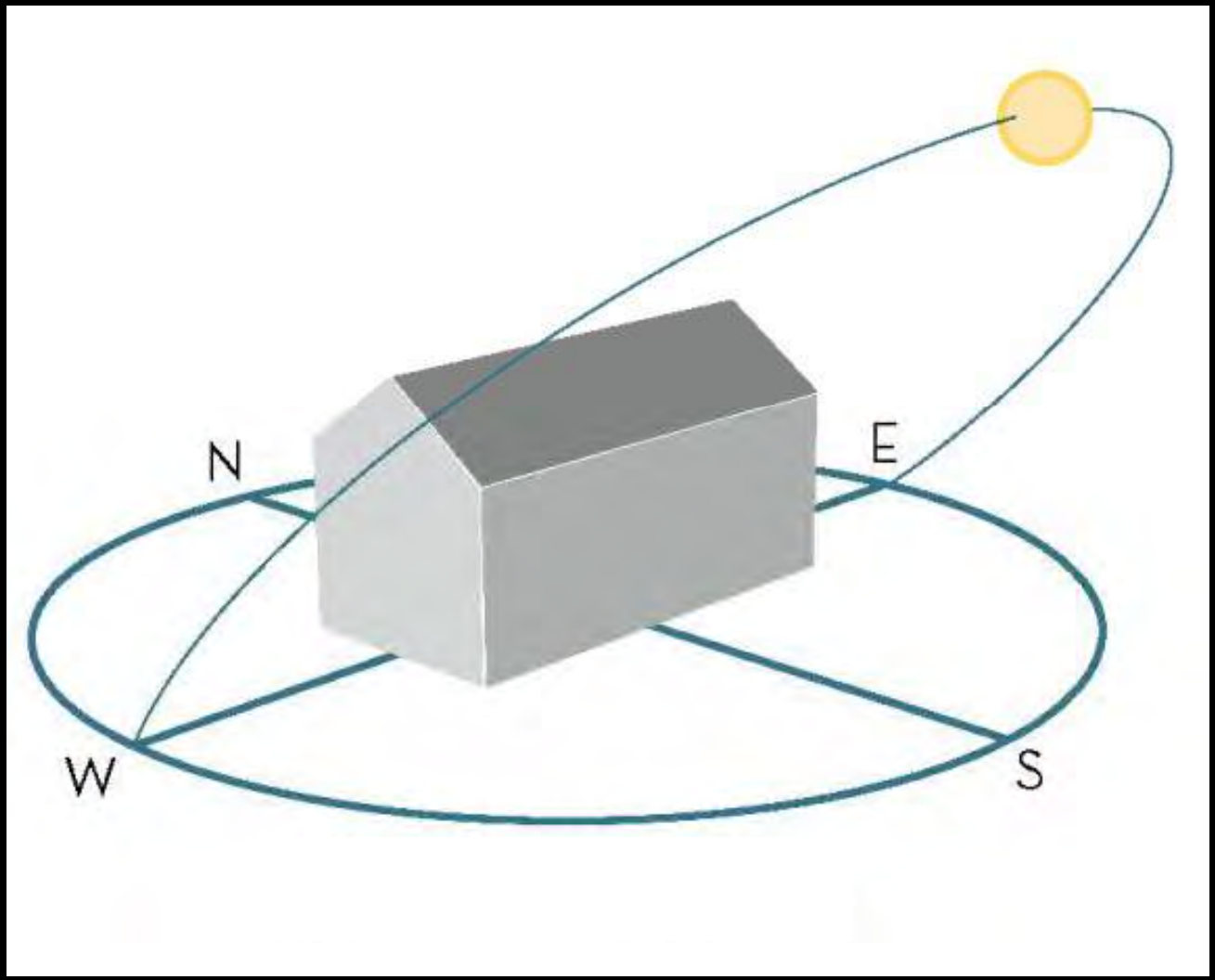
Step 6 -Design Living Buildings and Places

Connect Daily Living to Site



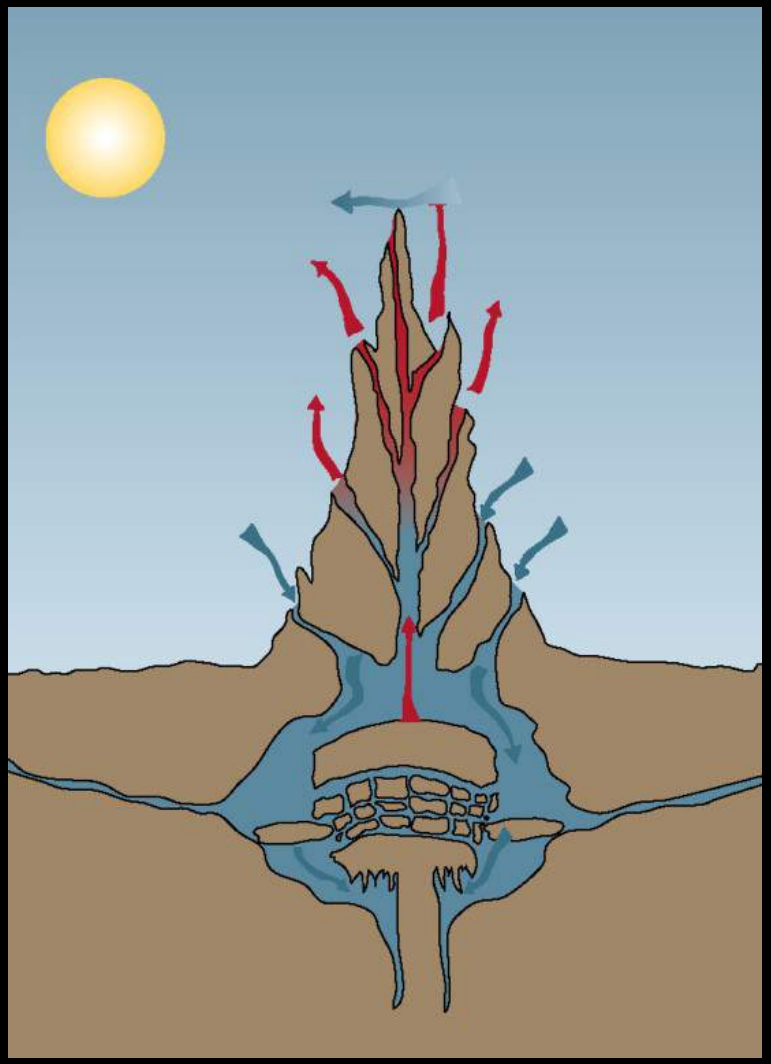
Step 6 -Design Living Buildings and Places

Elongate on East and West Axis



Step 6 -Design Living Buildings and Places

Biophilia + Biomimicry

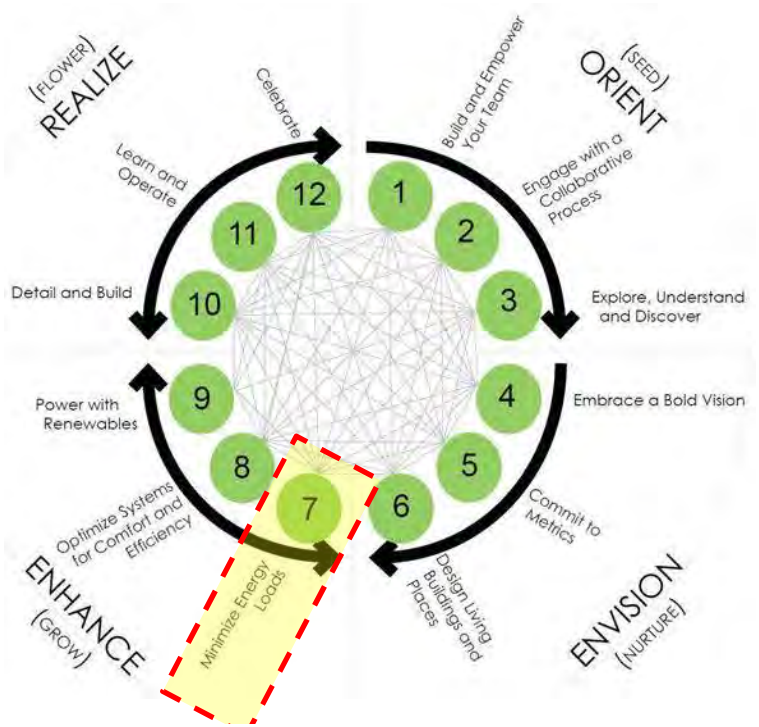


Step 6 -Design Living Buildings and Places

Health for Occupants and Environment

ENHANCE

- Step 7-Minimize Energy Loads
    1. Establish an Energy Intensity Number
    2. Estimate and Target Disaggregated Building Loads
    3. Focus on Building Envelope Loads



Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

- **"Whole Think"** = Understand Loads Deeply and Clearly
  - *Who: Green champion, engineers, architect*
  - *When: Schematic*
  - What are the loads?
    - ***Who Does What, Where and When in the building***
  - What are the resources?
  - Thoughtfully match resources to loads

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

Who: How many people in each area?

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

- **Where**:
  - Tabulate this information, by room number or zone.

NRG

Internal loads -- Equipment, Lights and People

Modified by NJM 2/4/03

			PEOPLE		
Room Number	Room Name	Zone Name	Peak No. of People	Average No. of People	Zone Diversity
101	Corridor w/stair 1	NW corridor			
102	Staff Library	Library/account Man.	4	1	0.25
103	Account Manager	Library/account Man.	2	1	0.50
104	Large conference	SW 1st floor conferenc	6	0	0.00
105	Files	West admin			

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

When:

- When are how many people in what areas?
- What loads are not coincident?
- Tabulate a schedule.
- *Serious geek zone!*

Science Center Laboratory Occupancy
OCCUPANCY SCHEDULES
Total Building, with Diversity

Hour	5	6	7	8	9	10	11
Weekday Avg Occ.	1	1	5	32	32	41	42
Weekend Avg Occ.	1	1	6	6	6	7	7
Weekday Peak Occ.	1	1	8	52	52	54	55
Weekend Peak Occ.	0	0	11	11	11	11	11

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

What:

- What indoor climate conditions are required in each area?
- What lighting is required in each area?
- What electrical equipment in each area?
- How much ventilation for each area?
- How much hot and cold water is required?

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

Indoor Conditions -- Temperature and RH Control Setpoints

Schedule Number	Type of Spaces Served		Winter		Summer	
			Occupied	Un-Occupied	Occupied	Un-Occupied
1	Air-Conditioned	Temp, F	68	60	75	80
	Spaces	RH, %	Uncontrolled	Uncontrolled	Uncontrolled*	Uncontrolled*
2	Non-air-	Temp, F	68	60	no air conditioning	
	conditioned	RH, %	Uncontrolled	Uncontrolled	Uncontrolled	Uncontrolled
3	Solarium &	Temp, F	50	50	No AC, natural ventilation [1]	
	Eco Machine [2]	RH, %	Uncontrolled	Uncontrolled	Uncontrolled	Uncontrolled
4	Vesibule	Temp, F	50	50	no air conditioning	
		RH, %	Uncontrolled	Uncontrolled	Uncontrolled	Uncontrolled

* dehumidification delivered by cooling system based on expected sensible fraction, but control based on space temperatu

[1] Natural ventilation on 80F (adjustable) setpoint with modulating window operation. EcoMachine to have RH sensor to operate HRV during heating season, with option for electromechnical timer over-ride with timer in EcoMachine mechanical room

[1] Note that natural ventilation designed to maintain inside 10F higher than outside, so Solarium and EcoMachine can be quite warm in summer!

[2] Heating system has capacity to heat space to 68F at winter design conditions; Solarium to have air conditioning, but not enabled in control system

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

Ventilation Rate based on ASHRAE 62-2007 + 30%

Space type	Volume	control	Setpoint
Circulation	0.08 cfm/sq.ft	On except late night	
Classrooms	CO2 based	modulated	[3]
Offices, closed	20 cfm [2]	occupancy	per office
Offices, open	CO2 based	modulated	[3]
Mechanical room	1 cfm/sq.ft.	On when cooling needed	
Stairwells	none		
Solarium	variable	natural ventilation	Temp-based [1]
Ecomachine room	variable	natural ventilation	Temp-based [1]

[1] EcoMachine room has relative humidity (RH) sensor to operate heat recovery ventilation based on RH. No other ventilation provided

[2] While this is higher than ASHRAE 62-2007 + 30%, it is difficult to verify ventilation below this flow rate

[3] CO2 setpoint to be based on providing air flow equivalent to ASHRAE 62-2007 + 30%

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

Illumination Levels and Lighting Energy Density Goals

Type of space	footcandles	Installed watts/sq.ft. maximum
Open and closed office ambient	30	0.8
Office task lighting	50	included in above
Classrooms	50 [1]	0.8
Laboratory	50 [1]	0.8
Circulation ambient	10 - 20	0.5
Solarium	30	0.8 [2]
Ecomachine	30	0.8 [2]
Exterior lighting		
Parking/walks, minimum	0.1	
Perimeter of building	0.1	

[1] 50 fc available, but multiple level switching or dimming for lower levels
[2] If additional plant lighting is needed -- outlets with switches in mechanical room adjacent to EcoMachine room to be provided

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

Lighting control strategy

Space type	Occupancy Control Strategy	Daylight harvesting control strategy
Corridors and circulation	auto-on/auto-off occupancy sensor with minimum light level maintained 24/7	Daylight cutoff where sufficient daylight available
Open office	auto-on/auto-off occupancy sensor	auto-dimming where sufficient daylight available
Closed office, with windows	manual-on/manual-off with auto-off two level lighting, second stage manual	*(human occupant is daylighting control)*
Closed office, no windows	auto-on/auto-off occupancy sensor two level lighting, second stage manual	
Classrooms	manual-on/auto-off occupancy sensor multi-level lighting	auto-dimming where sufficient daylight available
Vestibule	Scheduled hours	Daylight cutoff
Bathrooms, storage, janitor	auto-on/auto-off occupancy sensor	
Mechanical	manual control	
Solarium	auto-on/auto-off occupancy sensor for low level, manual-on/auto-off high level	Daylight cutoff
EcoMachine	auto-on/auto-off occupancy sensor [1]	Daylight cutoff [1]
Outdoor lighting	Scheduled hours	Daylight cut-off

[1] Set up with over-ride for stay-on, stay-off or auto. Provide connected 4x4 box for future time clock over-ride. Daylight cutoff level adjustable adjustment within 8' of floor. Need to coordinate with EcoMachine designer

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

- All this goes into the Owners Project Requirements (OPR)
- See *Aiken OPR 17 Sep 10.pdf*

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

- Full blown *who what when where* matrix
- *NRG-Occupancy and Internal loads mod by NMLD.xls*

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

Develop a list of very specific "solution concepts" or "strategies" to meet each objective

- *Who: Design team job to do first cut; Review and revise with Owner*
- *When: Schematic*

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

- GOAL
  - OBJECTIVE/METRIC
    - STRATEGIES

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

- GOAL: Very high energy efficiency
  - OBJECTIVE/METRIC: EUI of 20 kBtu/sq.ft.-yr
    - STRATEGIES:
      - Super-insulation in walls – R-40 double stud wall
      - air or ground source heat pumps
      - energy-recovery ventilation
      - more…

Analyze strategies

Question assumptions

- *Who: Design team job to do first cut; Review and revise with Owner*
- *When: Schematic*

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

Tons of Cooling Required for 1000 cfm			
Indoor Condition	Temp.	75 F	78F
	RH	50%	50%
Design condition	DB/WB		
Burlington Energy Code	84/69	1.9	1.6
Typical	90/73	3.2	2.9

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

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- ***Conservation vs Efficiency***
- ***Risk Management***

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

Tons of Cooling Required for 1000 cfm			
Indoor Condition	Temp.	75 F	78F
	RH	50%	50%
Design condition	DB/WB		
Burlington Energy Code	84/69	1.9	1.6
Typical	90/73	3.2	2.9

- ***Risk Management***
  - ***Risk is explicit***
  - ***Fall-back is ready***
  - ***Owner owns responsibility for choice***
  - ***Have it in writing***
- ***Examples?***

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

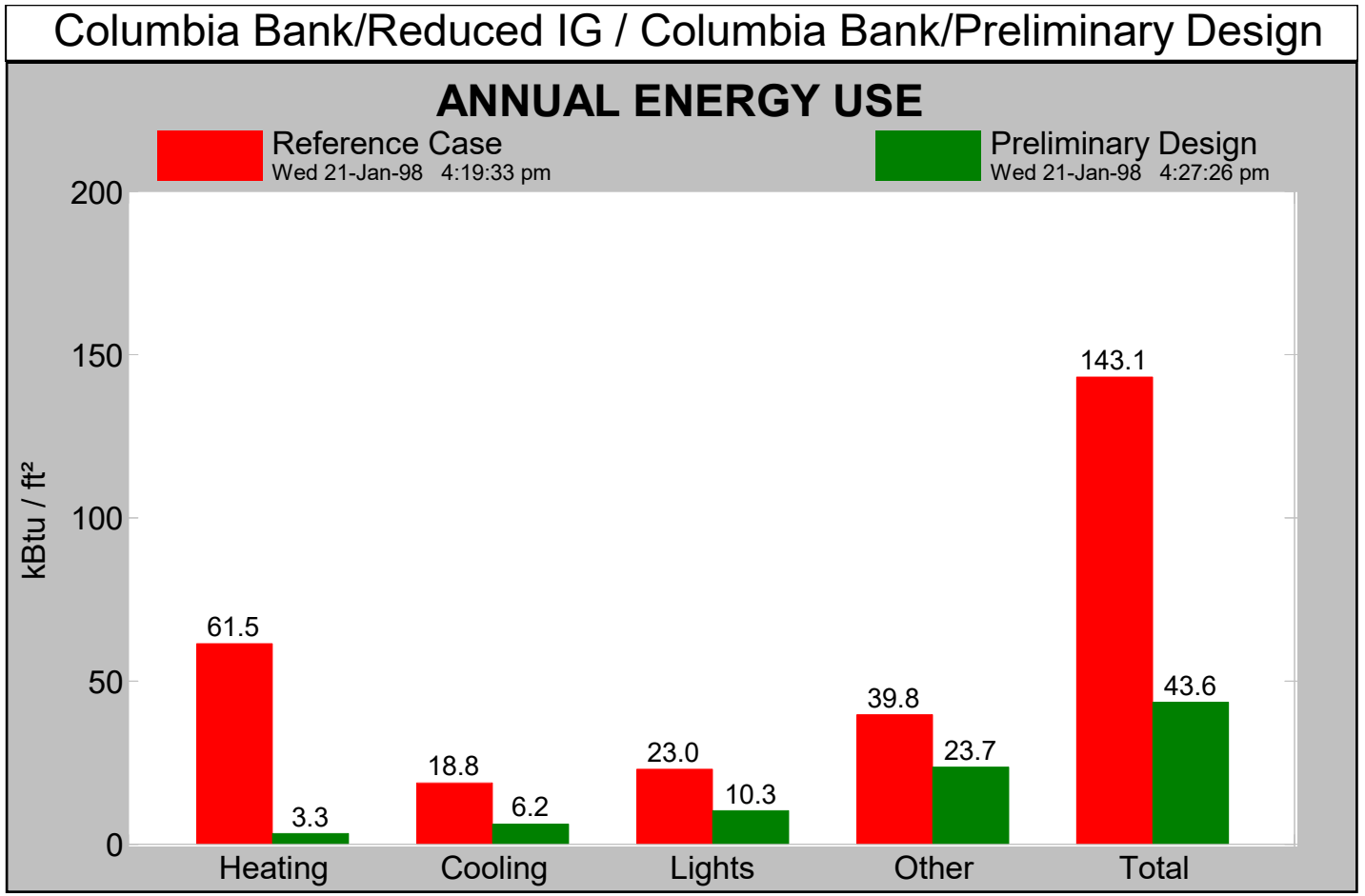
Annual Energy Use Analysis

- Tools:
  - Energy-10 for schematic design
  - Bin analysis or 8760 hour spreadsheet for annual ventilation energy.
  - Equest, Energy Plus and others for DD and CD
  - Daylighting tools:
    - Energy-10
    - Skycalc (for skylights) *Portland SkyCalc301.xls*
    - Radiance (for daylighting modeling)

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

Understand the Building



Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

Aiken Energy Analysis -- Wall System Selection
Kohler & Lewis
December 10, 2009

Option	Walls	Window	Peak Heating Load (MBH)	Annual Heating Load (kBTU/yr)	Peak Cooling Load (Tons)	Annual Cooling Load (kBTU/yr)
1A	Brick – Air Space – Gyp Bd. – Studs filled with 5.5" spray foam + 1" interior Polyiso + (2" poly iso at columns) with 18" thick concrete floor **[R-**	"R-3"	737	407,135	63	174,189
1B	Brick – Air Space – Gyp Bd. – Studs filled with 5.5" spray foam + 1" interior Polyiso + (2" poly iso at columns) with 18" thick concrete floor **[R-8.1]**	Accurate Dorwin (R-5)	648	301,116	62	231,146
2	Brick – Air Space – Gyp Bd. – Studs left filled with fiberglass – 4" polyiso (unknown impact on heat piping) – air and vapor control layer - with 18" floor **[R-11.2]**	Accurate Dorwin (R-5)	643	287,178	62	235,997
3A	Brick – Air Space – air control layer - 4" spray or rigid urethane foam – gyp bd. Studs filled with fiberglass – gyp bd., with 18" floor **[R-32.0]**	Accurate Dorwin (R-5)	562	197,105	61	273,430
3B	Brick – Air Space – air control layer - 6" spray or rigid urethane foam – gyp bd. Studs filled with fiberglass – gyp bd., with 18" floor **[R-44.0]**	Accurate Dorwin (R-5)	550	187,503	60	278,142

Making sense of energy modeling

- **Look for the Big Numbers**
- What are the big energy users
  - Ventilation?
  - Heating? Cooling?
  - Building enclosure? Which parts?
  - Internal gains – equipment? people?
  - Equipment efficiencies?

Evaluate the options

- **For each potential upgrade:**
- Run peak load and annual energy use for each
- Analyze costs for each upgrade
- (May be many re-runs.)

Evaluate the options

Sample list of options to analyze

- Improved insulation
- Lower air leakage rate
- Lower solar heat gain windows
- Higher insulation value for windows
- Higher equipment efficiency (boilers, chillers, air handlers, elevators, other)
- Energy Recovery ventilation
- Daylighting
- Passive solar gain (mostly residential)

Evaluate the options

Example of single option analysis

- 5000 cfm ventilation, 10 hrs/day 7 days/week
- **Energy Recovery Ventilation**
- Cost for ERV: ~$20,000 installed
- Cooling devoted to ventilation without ERV: 9 tons
- AC Downsizing savings: 6 tons at $2500 per ton, saves $15,000
- Net cost for ERV: $5,000

Evaluate the options

Example of single option analysis

- **Energy Recovery Ventilation**
- Net installed cost: $5,000
- First year savings: $3,000
- First year rate of return on investment: 60%
- 20 year present value of savings: $70,000
- 20 year net present value: ~$65,000

Evaluate the options

- *What about risk of ERV failing and not enough cooling?*
- Risk management is critical
- ***Owner to understand risk, fall-back, cost and savings, and accept risk***

Evaluate the options

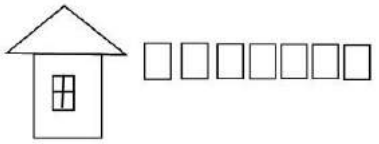
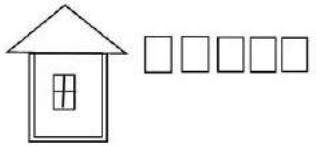
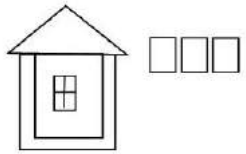
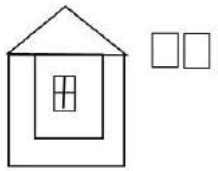
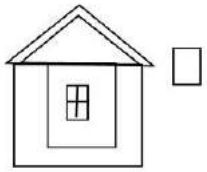
- ***Who is involved in this conversation?***
  - ***Whole systems thinker***
  - ***Energy modeler***
  - ***Mechanical Engineer***
  - ***Cost estimator***
  - ***Architect***
  - ***Owner***

Evaluate the options

- To meet a net zero goal, the process is different, ***VERY different,*** than typical "payback" or "return on investment" decision making.

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

		Cost for Rehab Only	Cost for PV Only	Total Cost for Rehab + PV Total
Existing Unit		--	$$$$$$$$	$$$$$$$$
Low level Rehab		$$	$$$$	$$$$$$
Level 2 Rehab		$$$	$$$$	$$$$$$
Level 3 Rehab		$$$$	$$$	$$$$$$
Level 4 Rehab		$$$$$$	$$	$$$$$$$$

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

NRG Warehouse/manufacturing area:

Meet lighting load with PV at minimum cost

Space	**80' X 240'**
Ceiling height	**~30'**
Light level	**30 fc**
PV cost	**$7 per watt**
Skylight cost	**$1,500 each**
Skylight size	**4x6**
Sunoptics triple, prismatic	

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

NRG: 20k sq.ft. Warehouse/manufacturing area:

Meet lighting load with PV at minimum cost

See *Portland SkyCalc301.xls*

NRG Skylight Sizing Number skylights	kWh/yr lighting	Cost to install PV's to meet load	Cost to install skylights	Cost for PV's + skylights
48	14,000	$98,000	$ 72,000	$ 170,000
30	16,000	$112,000	$ 45,000	$ 157,000
24	**17,000**	**$119,000**	**$ 36,000**	**$ 155,000**
18	19,000	$133,000	$ 27,000	$ 160,000
12	22,000	$154,000	$ 18,000	$ 172,000

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

Warehouse/manufacturing area

Step 7 – Minimize Energy Loads

Establish EUI, Target Building Loads, Focus on Envelope Loads

NRG Warehouse/manufacturing area:

Meet lighting load with PV at minimum cost