EA Credit 1: Successful Implementation Beyond Baseline Performance:

Systems Design & EA Credit 1: Top 10 Energy Efficiency Measures for Demand Reduction

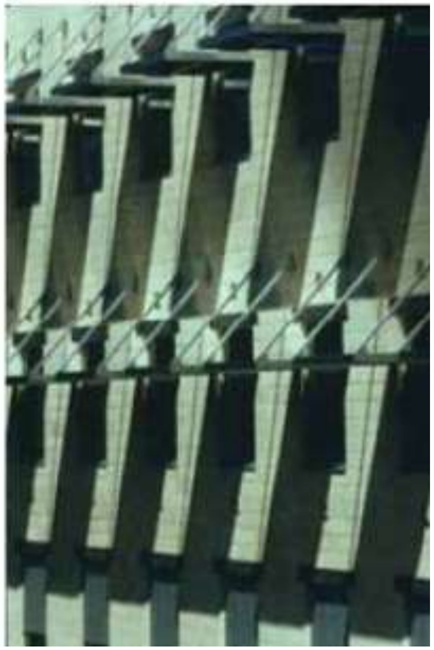
U.S. Green Building Council

Course Objectives

- ✓ Recognize energy demand reduction techniques that support energy efficient building design and help earn credits under LEED NC: EA Credit 1
- ✓ Assess opportunities for integrating energy modeling during systems design stage, decision making and planning process.
- ✓ Evaluate the pros and cons of energy modeling as a design tool for complying with LEED criteria
- ✓ Discuss cost impact of demand reduction measures by evaluating case specific examples

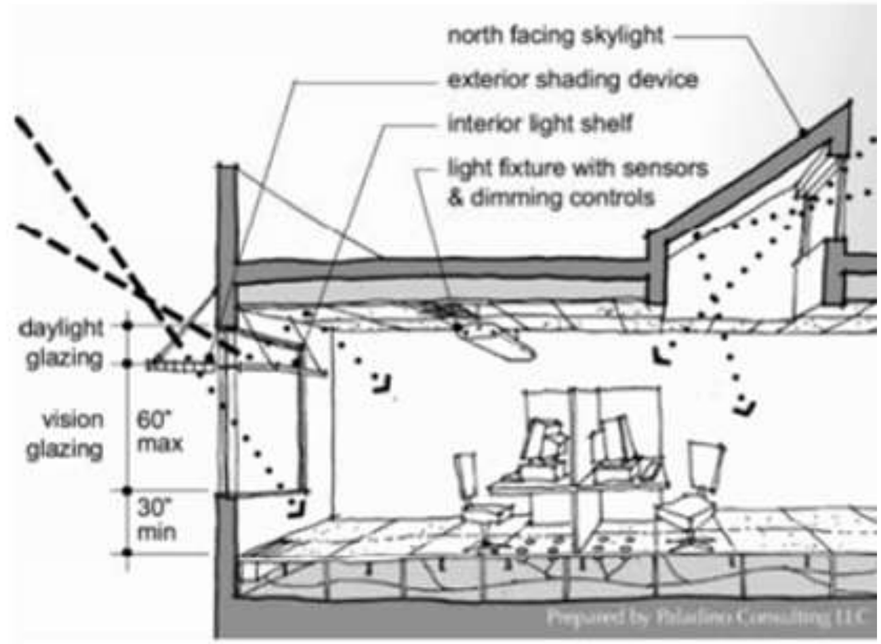
Reduce the Loads

- Size
- Orientation
- Massing
  - Window Area
  - Shading
- Envelope
  - Insulation
  - Fenestration
  - Thermal Mass
- Daylighting

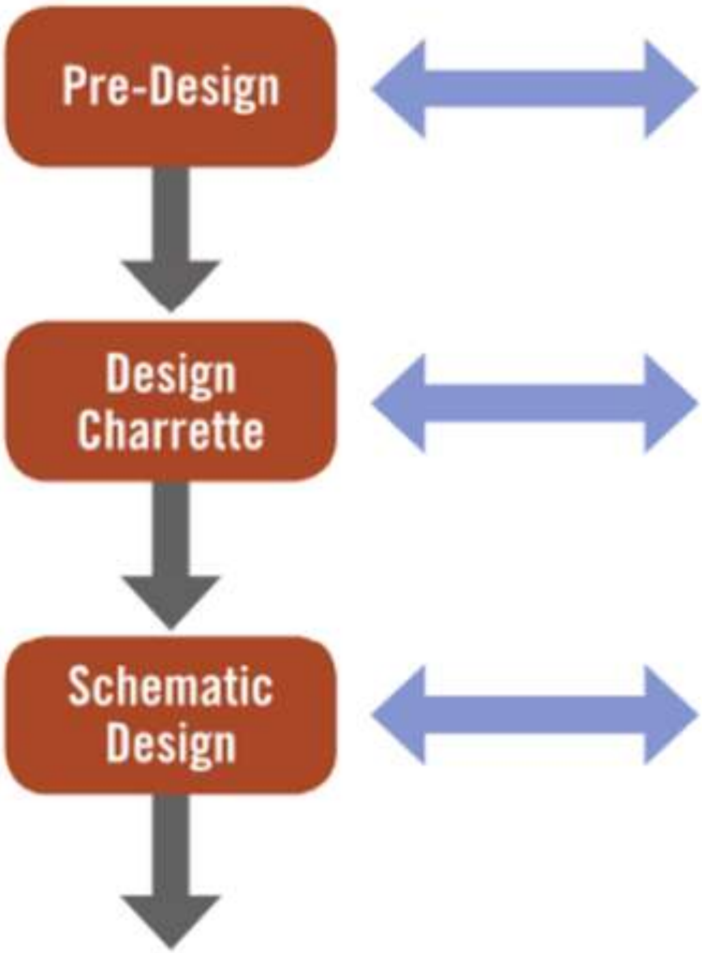


Reduce the Loads

- Lighting Design
  - LPD, levels, controls
- Plug Loads
- Process Energy
- HVAC
  - Peak loads
  - Load shifting
  - DCV
- Project Example



Using Modeling Effectively

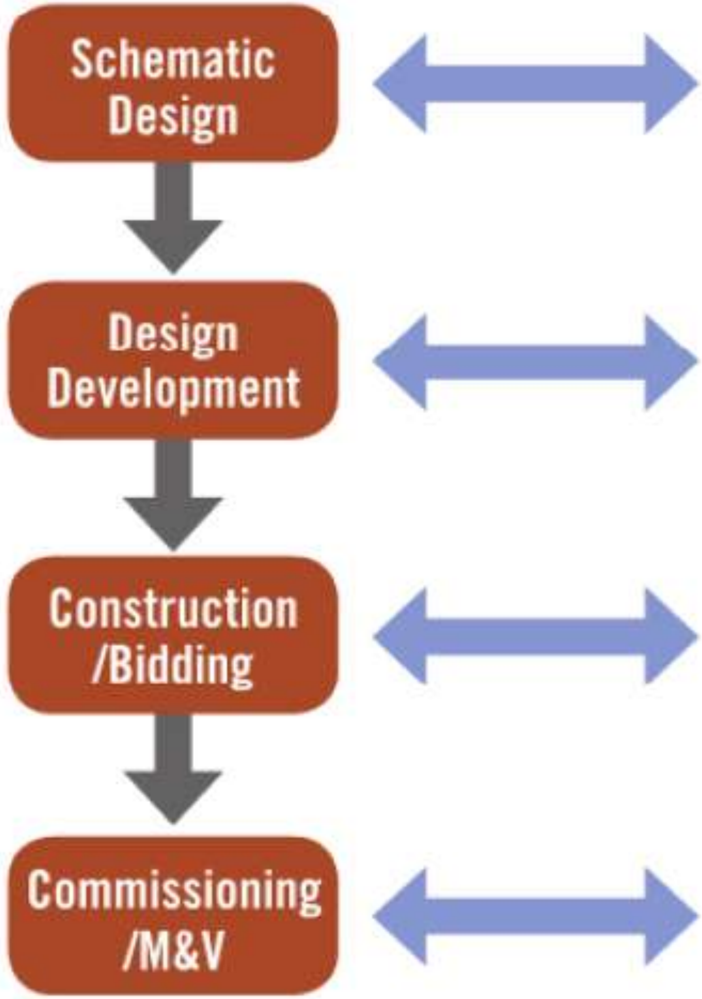


- Climactic Analysis
- Benchmarking Analysis
- Identify infrastructure and site issues

- Identify strategies
- Goal setting

- Develop high-performance vision
- Shape, massing
- Daylighting
- Windows & Building envelope
- HVAC options
- Develop base case

Using Modeling Effectively



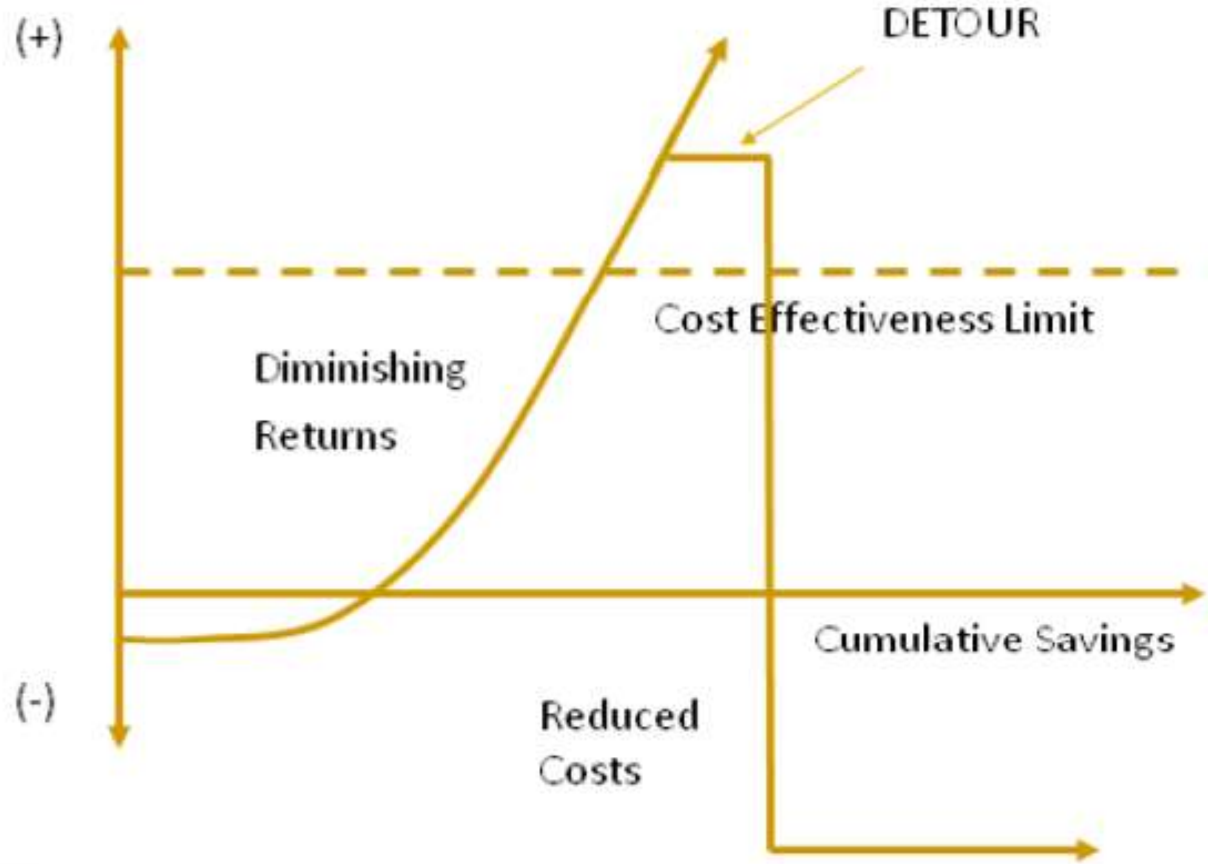
- “Wizard” level models
- Load reduction iterations
- Combination runs
- Revised base case
- HVAC system comparisons

- Fine-tune details – system optimization
- Check progress - LEED points

- “Value” engineering
- Final model
- Document for LEED

- Calibrate model
- Troubleshoot operation

Tunneling through the Cost Barrier



Bottom Line Impacts

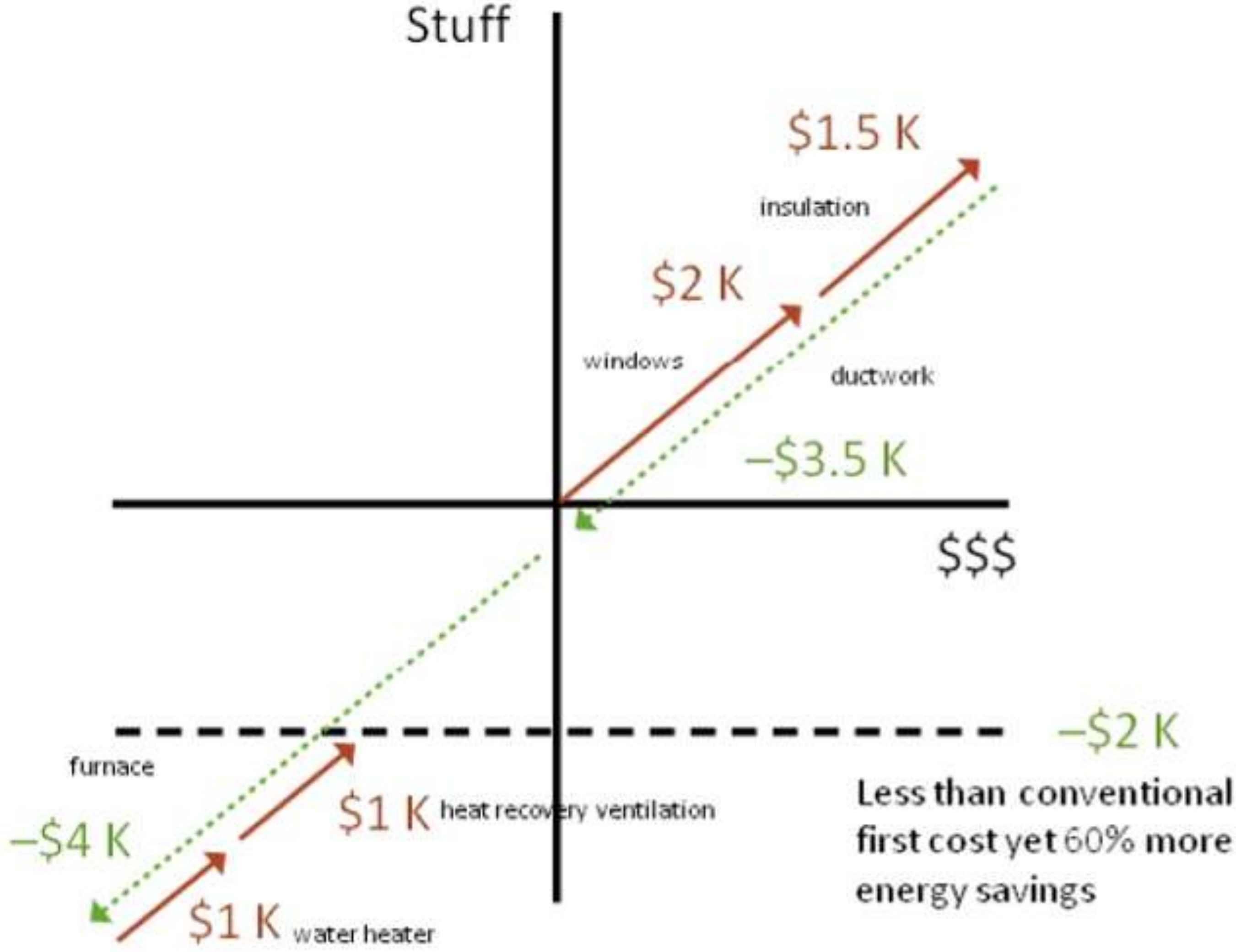
Grand Forks
Office Example

Incremental Costs

Windows	$67,500
Daylighting	$18,000
Insulation	$17,200
Lighting	$21,000
HVAC	-$160,000
Total	-$36,300

Energy Savings
$75k/year

Cascading First Cost Trade-Offs



Optimize systems

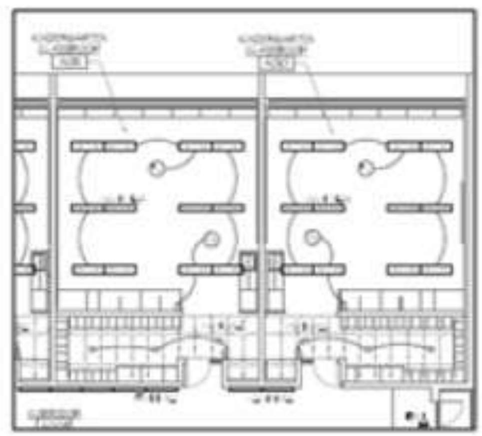
- Lighting Design
  - Lighting Power Density (LPD)
  - Lighting Controls

Load Calculations — Lighting Design

Prelim → SD → DD → CD →

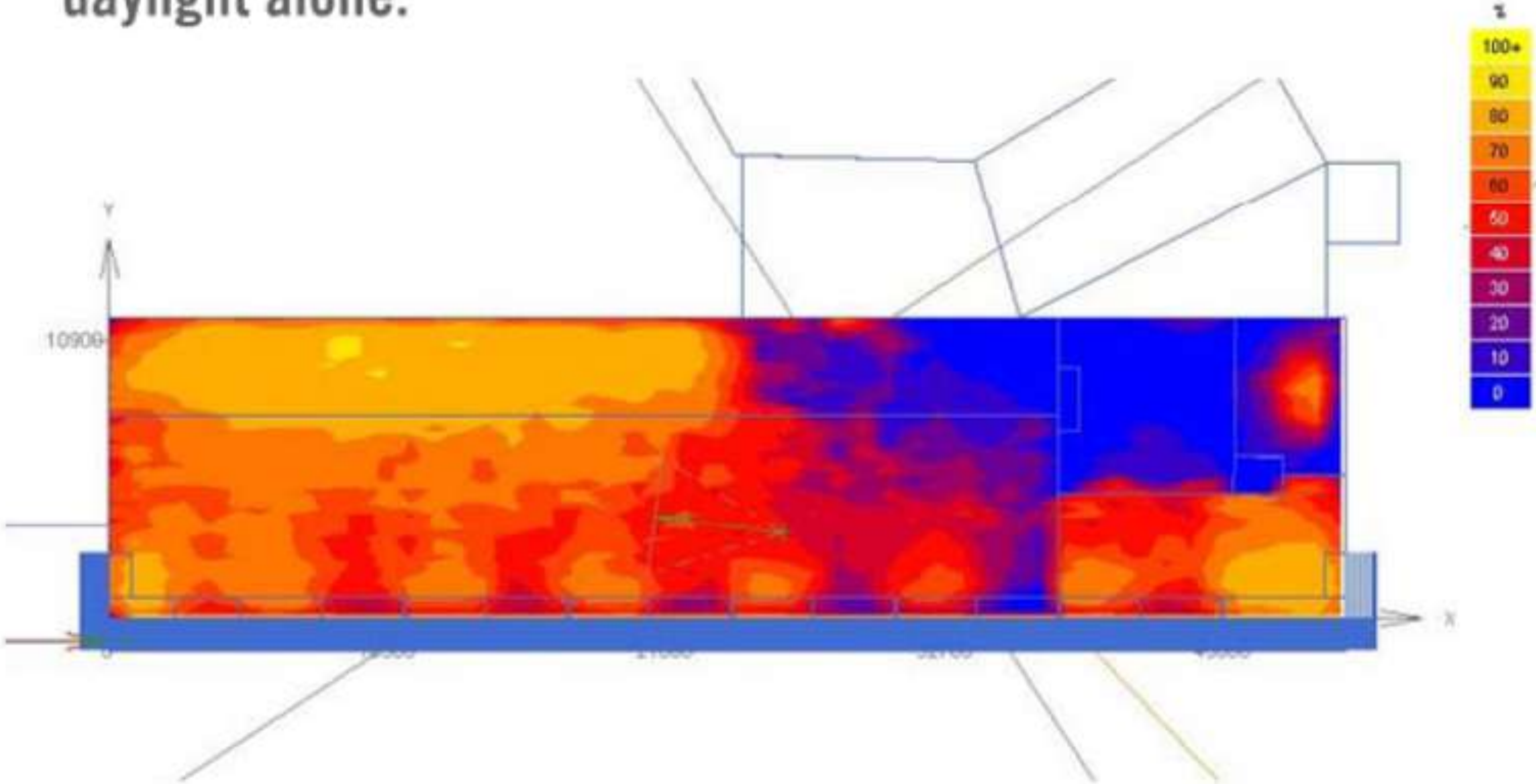
- Rules of Thumb
- Code Values

- Preliminary design
- LPD goals



Daylighting Autonomy

It is the percentage of occupied hours per year, when the minimum illuminance level can be maintained by daylight alone.



Plug Loads

Table G-B— Accpetable Occupant Densities. Receptacle Power Densities, and Service Hot Water Consumption[1]

Builfing Type	Occupancy Density[2] ft^2/Person (Btu/h x ft^2)	Receptacle Power Density[3] Watts/ft^2 (Btu/h x ft^2)	Service Hot Water Quantities[4] (Btu/h x Person)
Asssembly	50 (4.60)	0.25 (0.85)	215
Health/Instituional	200 (1.15)	1.00 (3.41)	135
Hotel/Motel	250 (0.92)	0.25 (0.85)	1,110
Light Manufacturing	750 (0.31)	0.20 (0.68)	225
Office	275 (0.84)	0.75 (2.56)	175
Parking Garage	NA	NA	NA
Restaurant	100 (2.30)	0.10 (0.34)	390
Retail	300 (0.77)	0.25 (0.85)	135
School	75 (3.07)	0.50 (1.71)	215
Warehouse	15,000 (0.02)	0.10 (0.34)	225

1. *The occupancy densities, receptacle power densities, and service hot water consumption values are from ASHRAE Standard 90.1–1989 and addenda*
2. *Values are in square feet of conditioned floor area per person. Heat generation in Btu per person per hour is 230 sensible and 190 latent. Figures in parenthesis are equivalent Btu per hour per square foot.*
3. *Values are in Watts per square foot of conditioned floor area. Figures in parenthesis are equivalent Btu per hour per square foot. These values are the minimum acceptable. If other process loads are not input (such as for computers, cooking, refrigeration, etc.). it is recommended that receptacle power densities be increased until total process energy consumption is equivalent to 25% of the total.*
4. *Values are in Btu per person per hour.*

Suggestions for Reducing Plug Load Energy

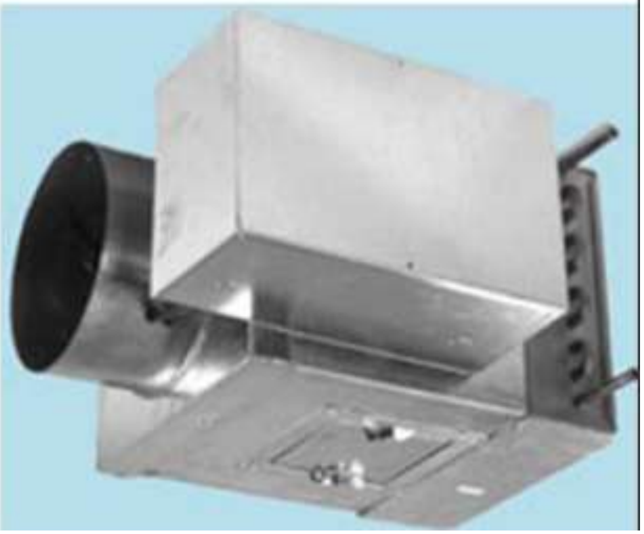
- specify manual pull down screens
- purchase a top freezer refrigerator not a bottom freezer w/ french doors, consider a smaller capacity - possible to reduce consumption by 100 kWhs per year or more
- Bosch and Asko make dishwashers which use 180 - 194 kWhs per year - up to 23% less than the product in the cut sheet
- a Sub-Zero 700BR small refrigerator uses 17% less energy than the U-Line
- here is a dual carafe coffee maker which is 1200 watts lower than the one included in the cut sheets - http://www.bettymills.com/product_manuals/wilburcurtis/D1000GTBrochure.pdf
  - replace all desktop computers with laptop computers

Suggestions for Reducing Plug Load Energy

- the elevator generally does not count toward the W/sf for plug load (on this list it accounts for almost half of the calcualted W/sf)
- consider a Philips 42PFL5603D which uses less than 100 watts (about 2/3 less than the 52 inch Sony model)
- investigate projectors with lower energy use, several companies are introducing LED projectors this year which promise to significantly lower energy consumption
- the total W/sf for plug loads in a facility like this should be well under 0.75
- the final plug load will be determined by the equipment which will be installed
- some of these loads would likely not be coincident with the peak cooling load such as the coffee maker
  - in addition Phipps should institute a policy to ban personal electronic equipment like space heater, coffee makers, etc.

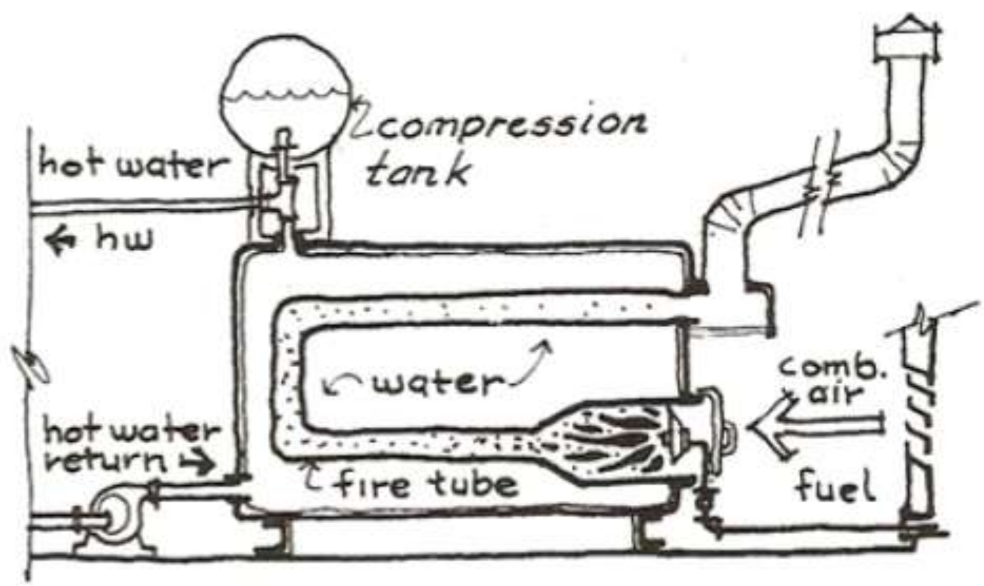
HVAC Systems Components

- Plant Components – Generate Heat and "Coolth"
- Distribution Components – The Delivery System for the Heating, Cooling and Ventilation Air



Plant Components - Heating

- Electric Resistance
- Fossil Fuel (Boilers/ Furnaces)
- Heat Pumps



Condensing Boilers

- Uses a second heat exchanger to recover heat from exhaust gases
- Vapors in flue gases Condense
- Efficiencies up to 98%

Plant Components - Cooling

Air Cooled

- "package DX Units"
- Chillers
- Heat Pumps

Water Cooled

- "self contained" units
- Chillers
- Heat pumps
- Evaporative Cooling

Variable Refrigerant Volume

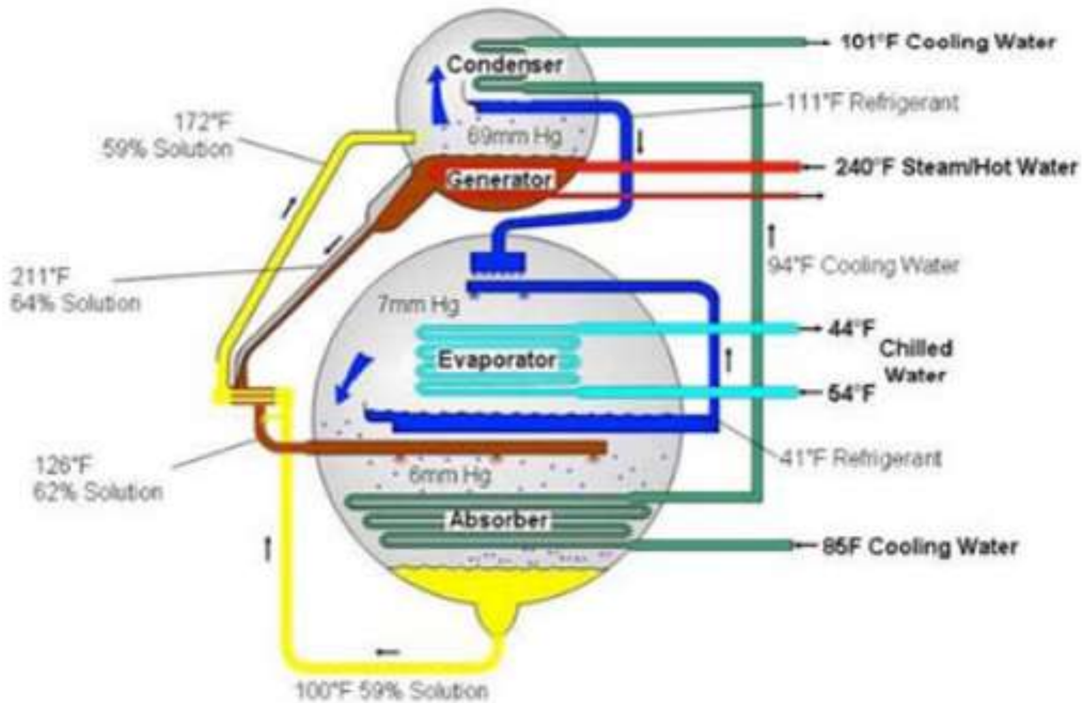
- Allow multiple DX units on a single condensing unit
- Popular in highrise residential
- Can be used as a heat pump for both heating and cooling

Evaporative Cooling

- Evaporation of water used to cool air
- Direct or Indirect
- Suitable for high temperature low humidity climates
- Many systems incorporate some evaporative cooling via cooling towers and evap condensers

Absorption Cooling

- Heat drives a chemical reaction that cools water
- No conventional refrigerants used
- Works well with CHP

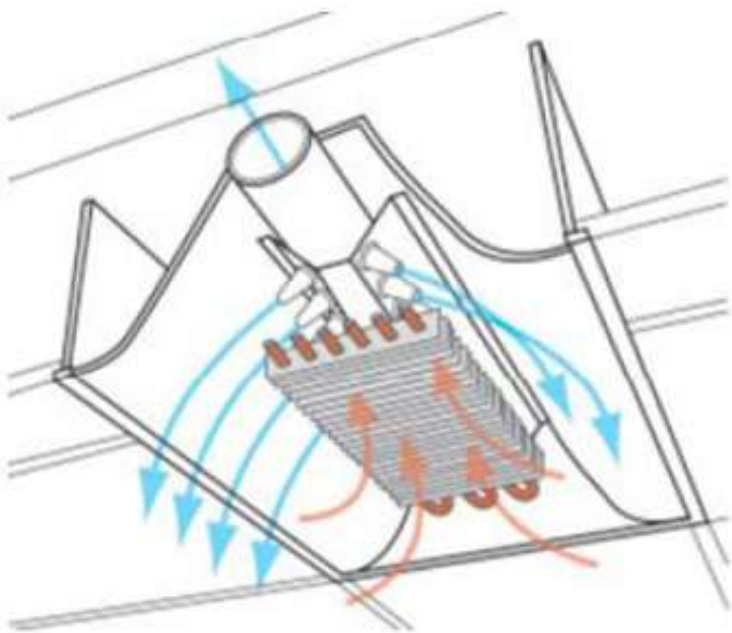


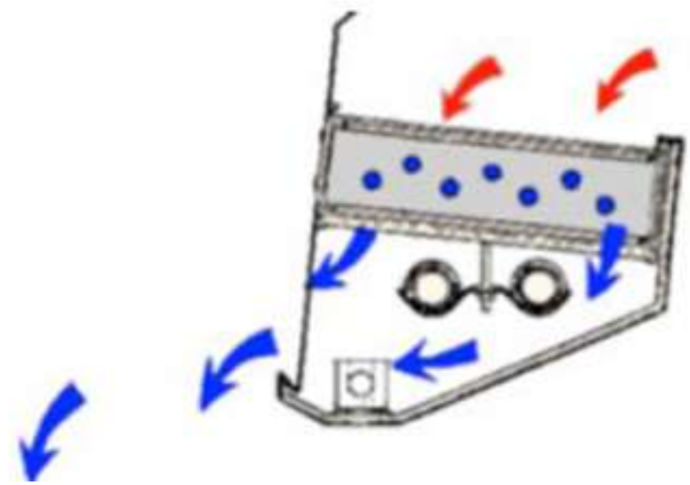
Dedicated Outdoor Air Systems (DOAS)

- Hydronic systems combined with a ventilation only, air system.
- adequate ventilation is provided regardless of heating or cooling requirements.
- Ducts are sized just large enough for ventilation – typically 1/5 the size that would be required for full conditioning in an air based system.
- Potential advantages for indoor air quality and energy efficiency.

Hydronic (DOAS) Systems – Chilled Beams

- Active: includes air supply
- Passive: stand alone





Air Systems – Displacement Ventilation

- Supply air introduced at floor level
- Temperature slightly below the desired room temperature.
- supply air "displaces" the warmer room air,
- Heat and contaminants rise to the ceiling level where they are exhausted from the space

Air Systems - Underfloor (UFAD)

- Benefits of Displacement
- Added Flexibility
- User Control

Zoning

Reheat is Wasteful and Expensive

- Internal zones are dominated by internal heat gains and rarely require supplemental heating if the air delivery systems are designed properly.
- External zones may require heating or cooling depending on the balance of internal heat gains and heat transfer through external surfaces.
- If a single HVAC unit serves both internal and external zones in a building where heating is required, reheat will almost certainly be required.
- Whenever you see a heating coil in the ductwork or terminal unit, question its presence.

Energy Recovery
Why Pay Twice?

- Ventilation/Exhaust Air Streams
  - Requires properly designed systems
- Process Energy
  - Especially for process intensive buildings
- Across Coils via Heat pipes
  - Great for displacement ventilation and underfloor air delivery systems with higher supply air temps.
- Equipment Specific
  - e.g., chiller energy recovery, hot gas reheat, heating domestic hot water with cooling heat pumps. Etc.

Energy Recovery

Common LEED Mistakes

- Energy Recovery
  - Must include sensible and latent efficiency ratings
  - Must show how energy recovery system is bypassed during mild conditions
  - Must show that ventilation air is turned off (zero flow) during periods when the building is unoccupied, even when fans are cycled to maintain setback temperatures
  - Must verify that ventilation rates are consistent across all LEED credits (they will be checked)

IEQc2: Increased Ventilation

- In reality increasing ventilation will generally increase real energy costs, sans energy recovery or DCV.
- In LEED, with no DCV, the baseline and proposed energy models both use the same ventilation rates (minimum or increased), and therefore the "theoretical" energy results are not affected significantly when increasing ventilation.
- Adding demand controlled ventilation will reduce the proposed ventilation loads, and LEED will require that the baseline ventilation rate = ASHRAE VRP minimums when DCV is used. So different combinations have different EAc1 results.

Increased Ventilation/DCV

- For projects not pursuing IEQc2 (not increasing ventilation rates) and without DCV, both the baseline and proposed energy models should use the ASHRAE 62.1 minimums based on the ventilation rate procedure, or some higher amount determined by the designers.
- For projects pursuing IEQc2 (30% increase in ventilation) but without DCV, both the baseline and proposed energy models should use the 62.1 ventilation rate procedure with an increase in outdoor air of 30%. *
- *note that ASHRAE is currently considering a modification to the standard that would set the baseline to the 62.1 ventilation rate procedure minimum, so be careful to verify this on future projects

Increased Ventilation/DCV

- For all projects that include DCV, whether or not pursuing IEQc2 (increased ventilation), the baseline energy model should use the ASHRAE 62.1 minimum ventilation rate procedure without any increase in outdoor air. The proposed model should reflect the actual design, including DCV.
- Note that this generally results in an EAc1 energy penalty for projects pursuing both IEQc2 (increased ventilation) and implementing DCV. In the real world, DCV savings will be realized regardless of which baseline is chosen for LEED accounting purposes.

Ventilation Rates

Common LEED Submittal Mistakes

- Common LEED Submittal Mistakes: If the HVAC system is a heating/cooling system, zone air distribution effectiveness, Ez, is often entered incorrectly (generally should be 0.8 in a system supplying heated air, not 1.0 as is often assumed).
- Ventilation rates must be the same in the baseline and proposed energy models.
- Fans must be "on" when building is scheduled as occupied and "off/cycled to meet loads" when the building is scheduled as unoccupied.
- Ventilation air must be "off" when the building is in unoccupied mode (except for specific exceptions)

Ground Source Heat Pumps

What is so special about them?

- On the cooling side of things, GSHPs operate with similar (+/-) efficiencies to other cooling technologies.
- On the heating side, however, GSHPs can be much more efficient than a fossil fuel boiler or even a 100% efficient electric heating coil.
- This is because heat pumps use the magic of refrigerants, much like chillers do, to achieve Coefficients of Performance of much large than 1.

Where do GSHP Systems Thrive?

- GSHP systems work well in buildings that have somewhat balanced heating and cooling loads throughout a calendar year, or for systems where supplemental heating and/or cooling can be used to shave off excess heating and cooling demand, or where excess load can be used for another purpose (ice melting, for example.)
- In general, climates that experience four seasons can benefit from GSHP systems.

Common EAc1 Mistakes

- Glazing u-value given is center of glass and not overall unit u-value (including frame)
- Similarly walls must include thermal bridging effects of framing members in determining overall u-values
- External lighting power must agree with calculations in SSc8. Also, baseline calculations must differentiate between tradable and non-tradable lighting surfaces.
- ASHRAE 90.1 Allowable Fan Power (Section G3.1.2.9) - AFP includes ALL supply, return, and exhaust fans associated with the same system. So one fan power allowance is split between the supply, return, and exhaust fans.
- The proposed energy model must include all fans as designed, including independent exhaust and transfer fans not otherwise included in air delivery systems.

More EAc1 Common Mistakes

- Hot water temperature reset schedule not indicated
- Supply air temperature reset schedule not indicated
- Incorrect baseline pumps control method and sizes
- Process energy that is less than or exactly 25% of the baseline energy must be explained in a narrative, and calculations are preferred
  - Process energy includes elevators, kitchens, A/V equipment, computers, data centers, manufacturing energy, etc.
  - A value of exactly 25% indicates that you may be trying to "cheat" the system so this raises red flags for the reviewers

Advanced Energy Modeling for LEED Technical Manual

- Help guide your project team on EAc1 requirements and documentation
- Available now at www.usgbc.org/publications