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Cost Effective Energy Efficient School Design –Applied Research

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The sustainable and energy efficient design of school buildings has been a significant focus of the design community in the past few years. This effort has culminated in a number of design guidelines such as Leadership in Energy and Environmental Design (LEED) for Schools-New Construction and Major Renovations. There has recently been some concern voiced suggesting that some energy efficient school designs use much higher first cost building systems that may have higher maintenance costs and are being questioned relative to their fire resistance and indoor environmental impact.

The goal of this project was to develop a list of low life cycle cost systems that can be used for energy efficient school designs in Kentucky. Specially, the study focused on building envelope systems, day-lighting, and heating and cooling system configurations that have, or could be, incorporated into school designs. Each of the systems was incorporated into a typical prototype middle school configuration and the effect each system has on the overall energy used over the life cycle of the building was determined using the eQuest analysis program, for five typical Kentucky climates. Conventional materials and construction practices where used where feasible and differential cost were developed for each system variation.

The results of this study show that:

1. Increasing the thermal resistance (R) of mass masonry and concrete walls much beyond the code minimum values did not significantly decrease the yearly energy use in typical school buildings. The same can be said for the effects of air barriers and high thermal resistance for roofs, windows and doors. Figure 1 shows the tail off in energy savings typically found for increases in thermal resistance in mass walls. A similar result was found in this study, as shown in Figure 2.

2. Simple paybacks periods for increases in thermal resistance of the walls, roof, windows and doors are typically in excess of 100 years, with some closer to 300 years (see C ECM's in Figure 3). For Kentucky, southern Indiana and Ohio climates, optimum R values for masonry cavity wall systems appear to be in the R 12 to R 14 range.

3. More efficient mechanical equipment, both conventional and ground source heat pump systems provide significant yearly energy savings. The higher savings are obtained using ground source heat pump systems (in excess of 70%) but savings in excess of 60 % can be obtained using conventional VAV systems with chillers and boilers, coupled with aggressive controls (see Figure 2). It should be noted that use of conventional HVAC systems and controls have simple payback periods less than 2.5 years and the use of ground source heat pump systems increase these payback periods over 23 years.

4. Aggressive control systems have the most significant impact on energy use and typically have low payback periods (less than 2 years)

5. More efficient lighting systems have a significant impact on energy use and low payback periods. However, while more energy efficient lighting reduces electrical energy use, this energy savings is partially offset by the increase in heating energy needed.

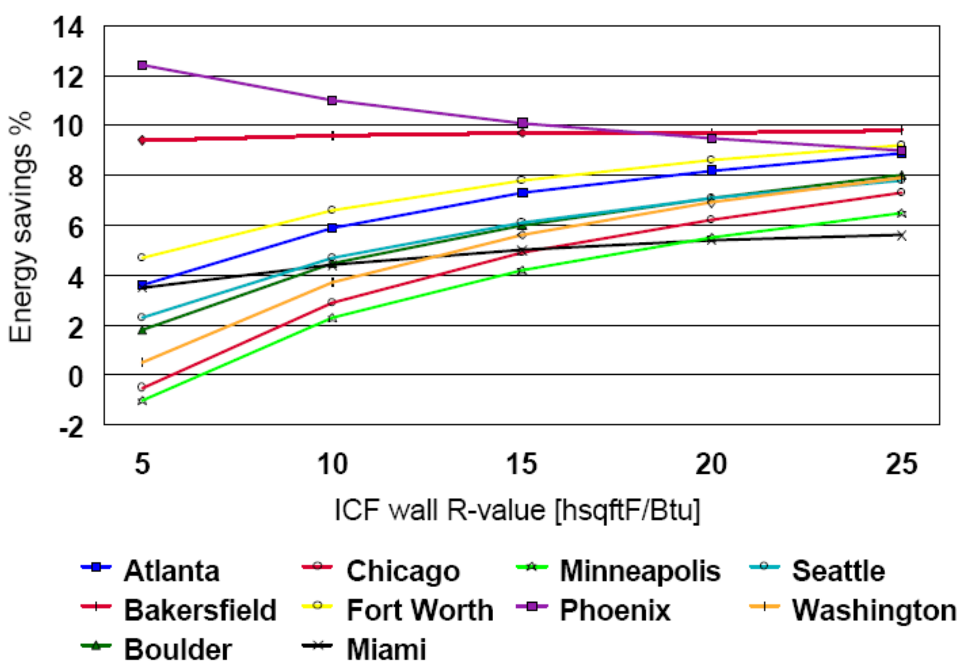
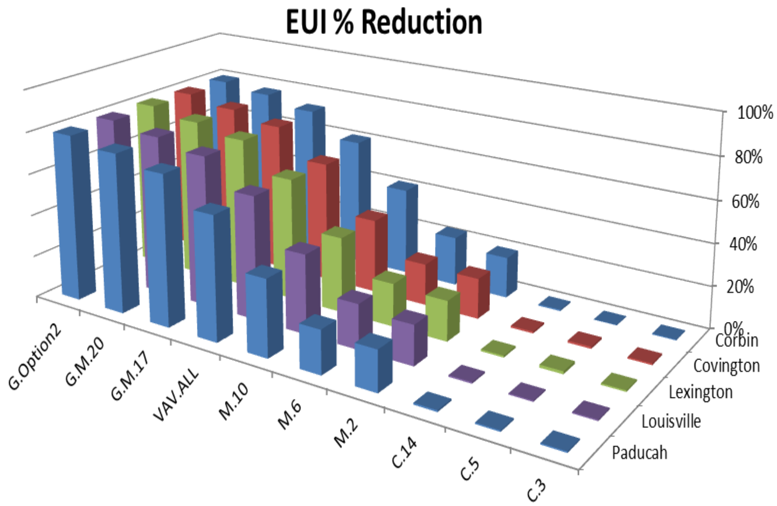


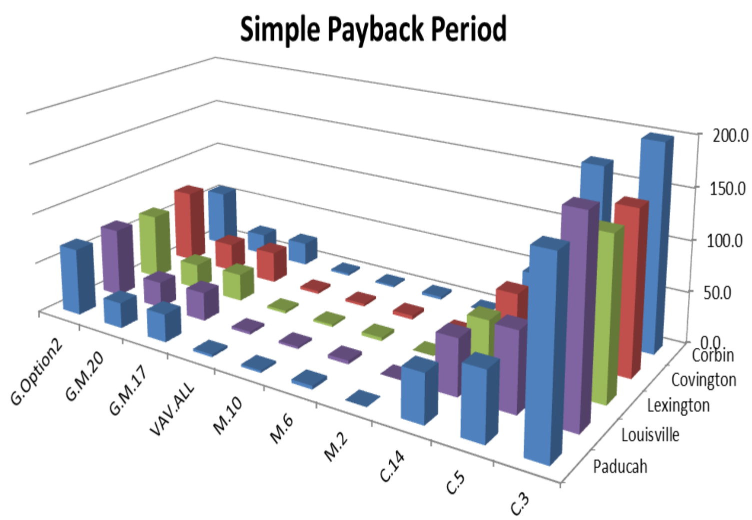
Figure 1 Energy Savings of Mass ICF and Concrete Walls (Kosny et-al, ORNL, 2003)



ECM	Corbi	Covingt	Lexingt	Louisvil	Paduc
C.3	0.4%	0.8%	0.7%	0.6%	0.6%
C.5	0.2%	1.0%	1.3%	0.6%	0.6%
C.14	0.6%	0.9%	0.8%	0.7%	0.8%
M.2	19.6%	19.1%	19.0%	18.7%	19.0%
M.6	23.4%	19.7%	20.3%	21.1%	20.3%
M.10	41.7%	35.1%	35.7%	37.3%	36.1%
VAV.ALL	61.0%	57.6%	58.1%	58.5%	58.5%
G.M.17	72.6%	71.6%	72.1%	71.9%	71.6%
G.M.20	77.2%	75.9%	76.3%	76.2%	75.9%
G.Option2	79.9%	79.7%	80.1%	79.7%	79.5%

C.3	Change 3" exterior Polyisocyanurate to 5" exterior Polyisocyanurate (Roof)
C.14	Air barrier – 0 .2 Air changes per hour
C.5	Change 1-1/4" Polystyrene to 3" ployisocyanurate (CMU Walls)
M.2	Large Temperature Setbacks
M.6	Modified Fan Schedule – Fans to shut down during unoccupied hours until a space drops below the setpoint temperature.
M.10	VAV Box Minimum Air Flow Schedule – Dampers on the VAV boxes to close if the space temperature setpoint is satisfied.
VAV.ALL	Best ECMs for the baseline building modeled as one ECM. Most efficient building design for the VAV system.
G.M.17	Replace the VAV HVAC System with a Geothermal Heat Pump System
G.M.20	Modified Fan Schedule – Fans to shut down during unoccupied hours until a space drops below the setpoint temperature.
G.Option2	Best ECMs for the baseline building modeled as one ECM. Most efficient building design for the geothermal system.

Figure 1 Energy use Index for Select Energy Conservation Measures (ECM)



Simple Payback Period (Years)					
ECM	Corbin	Covington	Lexington	Louisville	Paducah
C.3	218.8	156.3	151.8	188.5	174.0
C.14	804.5	195.3	69.9	335.0	272.2
C.5	168.3	45.5	17.5	75.3	64.5
M.2	0.0	0.0	0.0	0.0	0.0
M.6	2.8	3.8	3.4	3.5	3.4
M.10	1.8	2.5	2.3	2.3	2.3
VAV.ALL	2.2	2.8	2.5	2.6	2.5
G.M.17	23.2	31.0	27.0	28.1	27.3
G.M.20	21.1	28.2	24.7	25.6	25.0
G.Option2	57.2	73.7	64.9	67.7	66.2

Figure 2 Simple Payback for Select ECM's