Good Design = Energy Efficiency & Economy
High Performance and Sustainability on a Budget

Presented by:
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Studio Kremer Architects
What is high performance and what is the typical cost?
<table>
<thead>
<tr>
<th>Source</th>
<th>Baseline Energy Usage</th>
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</thead>
<tbody>
<tr>
<td>Buildings Energy Data Book – U.S. Department of Energy</td>
<td>90 kBtu/sf yr (High School)</td>
</tr>
<tr>
<td></td>
<td>68 kBtu/sf yr (Elementary School)</td>
</tr>
<tr>
<td>ENERGY STAR Target Finder Score 50</td>
<td>47 kBtu/sf yr (Elementary/Middle)</td>
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<tr>
<td></td>
<td>51 kBtu/sf yr (High School)</td>
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<tr>
<td>School Energy Management Project – 2011</td>
<td>63 kBtu/sf yr (Kentucky Schools)</td>
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</table>
How much energy does a high performance school use?
Cost

According to the “2013 Annual School Construction Report” published by *School Planning and Management*:

- **Median regional (KY, NC, SC, TN) construction cost**
  - Elementary School - $200.00/sf new; $55/sf reno
  - High School - $189.00/sf new

- **National construction cost**
  - Elementary School - $204.00/sf new; $60/sf reno
  - High School - $214.37/sf new
Case Study 1:
Case Study 1: Foster Heights Elementary

- Adjacent former high school was used as an intermediate school (grades 4-5) due to overcrowding at Foster Heights.
- The district had to decide whether to:
  - Renovate both facilities
  - Renovate one and retire the other, or
  - Tear down and replace the elementary school with a new building

- The design team prepared a master plan recommending two phases of renovation of the elementary school and retirement of the intermediate school facility.
BEFORE: 2 INEFFICIENT FACILITIES

- ELEMENTARY P-3
  - INEFFICIENT MECHANICAL SYSTEM
  - AD HOC EXPANSION OVER TIME
  - UNDERSIZED SHARED FACILITIES (CAFETERIA, GYM, MEDIA)
  - NO VISIBLE ENTRY AT STREET
  - NO IDENTITY TO COMMUNITY

- INTERMEDIATE (4-5)
  - BUILT AS HIGH SCHOOL
  - DATED BUILDING SYSTEMS
  - STRUCTURE DIFFICULT TO MODIFY/ADAPT
  - AT LESS THAN 50% CAPACITY

Before – no entry at street side

Before – inefficient adjacent facility
ad hoc site use
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NOW: 1 CONSOLIDATED FACILITY

- ELEMENTARY 1-5
  - SINGLE FACILITY ACCOMODATES 1 THROUGH 5
  - ELIMINATES SECOND SCHOOL BLDG & REDUNDANT ADMINISTRATION
  - FULLY RENOVATED + EXPANDED FACILITIES
  - DEDICATED BUS TRAFFIC, PARKING & DROP-OFF FOR SAFETY

- NEW ENTRY ALIGNED WITH CITY STREET
- INTERMEDIATE (CLOSED)

- NEW DAYLIT CLASSROOMS
- NEW ADMIN
- NEW GYM
- EXPANDED MEADOWS
- EXPANDED PARKING
- CLEAR STUDENT PATH TO PLAYGROUND
- DEDICATED BUS TRAFFIC
- RENOVATION OF ALL FACILITIES INCLUDE:
  - HVAC ELECTRICAL WINDOWS CEILINGS FLOORS KITCHEN
Summary bullet points

- 88,308 square feet
- $9,167,000 / $104/sf
- Energy Use Index 29
- Annual energy cost is $66,000 or $0.75/sf
Challenges

- Necessity for Phasing
- Construction coordinated with operation of school
- Site availability
- Mechanical space
Strategies for Energy Savings

- Use of Geothermal HVAC
- Dedicated Outdoor Air Systems (DOAS)
- Packaged DX w/ Energy Recovery
- High Performance Fluorescent Lighting
- Simplified kitchen equipment
- Two-stage High Efficiency Heat Pumps w/ non-centralized pumping
Strategies for Cost Savings

- Utilizing one heat pump to serve two classrooms
- No anti-freeze/glycol in geothermal loop
- Maximum reuse of existing spaces and materials
- Optimize wellfield design
- Better windows = fewer geothermal wells
- Packaged DOAS with energy recovery
- Minimize kitchen equipment cost
Lessons Learned

- Be attentive to eave construction > humidity issues
- Be realistic about future phasing / addition plans
- This project’s successes opened the door to deeper discussions of energy savings with the district
Savings

- After one year in use Phase 1 showed performance results that met the ENERGY STAR requirements with a score of 99 out of 100.
- After Phase 2 completion, the current energy consumption is 29 kBtu/sf/yr, less than half that of a typical new school.
Case Study 2:
• The design team worked closely with the committee of 20-30 faculty, staff, administrators, parents and community members that the Superintendent convened over several months
• Goal was to ensure that the design communicated that the school is part of the larger community

- Material selections and forms complement the surrounding landscape
- The architects studied elements of buildings in the historic downtown
A school is such a big investment that it needs to become a community landmark and anchor, serving the whole community over a long period of time.

‘Green’ thinking, for this design team, was an integral part of a holistic effort to design a project that is efficiently planned, economical to operate and, most importantly...

that engages its community and users in a way that they will want to be its stewards for decades to come.

The process starts with integrated thinking from the whole team from the beginning.
Space-planning was pursued to maximize efficiency and connectivity of circulation (i.e., no ‘dead ends’).

Space-planning was pursued to maximize efficiency and inter-connectivity of circulation. Public spaces were configured in order to provide maximum flexibility in how they could be used:

Media Center: Except for the lecture area where fixed data/power is provided, the space is designed to be adaptable to suit evolving uses and technologies.

Cafeteria: Choices of seating type/spatial character – booth, café, group tables – were provided. Accommodation for future serving options (e.g., kiosk or food court style) was provided.

Multi-Purpose Room: unassigned space can be:
1) closed for activities (cheering, wrestling, ROTC...),
2) opened to main hall to expand public space, or
3) used as expansion for the Gym when the upper bleachers are opened.
Nelson County Schools’ commitment to geothermal HVAC

There is a single unit per pair of classrooms

Each bore (or well) was installed to a depth of 400 feet

The whole well field is made up of 162 of these 400’ deep bores.
Geothermal and hydronic piping at the water-to-water heat pumps utilized to generate hot and chilled water for the dedicated outdoor air units (DOAS).
This project utilized Insulated Concrete Forms (ICF), a system that consists of rigid forms set in place and filled with concrete.

- This increased wall insulation and decreased air infiltration
- Allowing the engineers to reduce the sizes of HVAC system
• An aggressive daylighting strategy was implemented in order to welcome as much natural light into the building as possible
• Lessening the need for electrical lighting and mitigating the temperature increase they cause
• Because of these strategies we were able to use fewer light fixtures, smaller HVAC equipment, and lights can be off or dimmed a large percentage of the time.
Large window openings to the north allow as much light to enter these spaces as possible
  - North light doesn’t produce significant glare
  - Electrical lights dimmed 35% or off

Smaller, controlled windows to the south direct light into the rooms up at the ceiling
  - Ceilings are sloped
  - Aluminum light shelves reflect light
  - Electrical lights off or dimmed 75% of the time

Lights will automatically dim to conserve energy

Most lights in the building are on occupancy sensors
High / Clerestory windows at the Media Center, Cafeteria, Field House, and Gym allow natural daylighting into these spaces, reducing the need for interior lighting.
White ‘cool’ roof membrane

Pond Renovation / Irrigation
- 146,000 square feet
- $23,557,000
- $150/sf including field house (10K sf), fields, and other site development
- Actual 21.9 kBtu/sf yr
- **Annual energy cost: $103,164 or $0.71/sf**

- Field house and playing fields are separately metered
  - Actual 54 kBtu/sf yr
  - $1.56/sf annual energy cost
Strategies for Energy Savings

- Two story compact design
- North/South Classroom Wings
- Geothermal HVAC with DOAS
- Energy efficient lighting
- Daylighting – ROI analysis
- Optimized controls
- White roof
- Geothermal domestic hot water
- ICF Wall Construction – first cost analysis
Strategies for Cost Savings

- Cost shift – walls/openings
- Optimized well field design
- Insulation on geothermal piping
- One heat pump unit per two classrooms
- Glycol in geothermal loop
Lessons Learned

- Geothermal piping temperatures at start-up
- Reconsider use of VRV
## Savings

### Construction Costs

<table>
<thead>
<tr>
<th>School Description</th>
<th>Cost</th>
<th>Savings</th>
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<tbody>
<tr>
<td>Thomas Nelson High School (146,000 sf)</td>
<td>$23,500,000</td>
<td></td>
</tr>
<tr>
<td>National Median High School (146,000 sf)</td>
<td>$31,000,000</td>
<td>($8,000,000)</td>
</tr>
<tr>
<td>Regional Median High School (146,000 sf)</td>
<td>$26,000,000</td>
<td>($3,000,000)</td>
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<tr>
<td>Foster Heights Elementary School Renovation</td>
<td>$9,167,000</td>
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# Savings

## Annual Energy Costs

<table>
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<tr>
<th>School Type and Location</th>
<th>Annual Energy Cost ($ USD)</th>
<th>Energy Savings Relative to Median</th>
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<tbody>
<tr>
<td>Thomas Nelson High School (23 kBtu/sf yr)</td>
<td>$105,000</td>
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<tr>
<td>Regional Median High School (90 kBtu/sf yr)</td>
<td>$420,000</td>
<td>($315,000)</td>
</tr>
<tr>
<td>Average Kentucky High School (63 kBtu/sf yr)</td>
<td>$280,000</td>
<td>($175,000)</td>
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<tr>
<td>Average Teacher’s Salary in Kentucky</td>
<td>$50,000</td>
<td>Energy savings = 3-6 teacher salaries (annually)</td>
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<td>$105,000</td>
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<tr>
<td>Regional Median Elementary School (68 kBtu/sf yr)</td>
<td>$158,000</td>
<td>($53,000)</td>
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<tr>
<td>Average Kentucky Elementary School (63 kBtu/sf yr)</td>
<td>$147,000</td>
<td>($42,000)</td>
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<tr>
<td>Average Teacher’s Salary in Kentucky</td>
<td>$50,000</td>
<td>Energy savings = 1 teacher’s salary (annually)</td>
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How much energy does a high performance school use?
Next Steps / Things to Explore

- LED lighting
- Aluminum Windows vs Storefront Systems
- Solar 70XL glass or similar
- Solar Tubes vs Clerestory
- More roof insulation (to a point)
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