Good Design = Energy Efficiency & Economy

High Performance and Sustainability on a Budget

Presented by:

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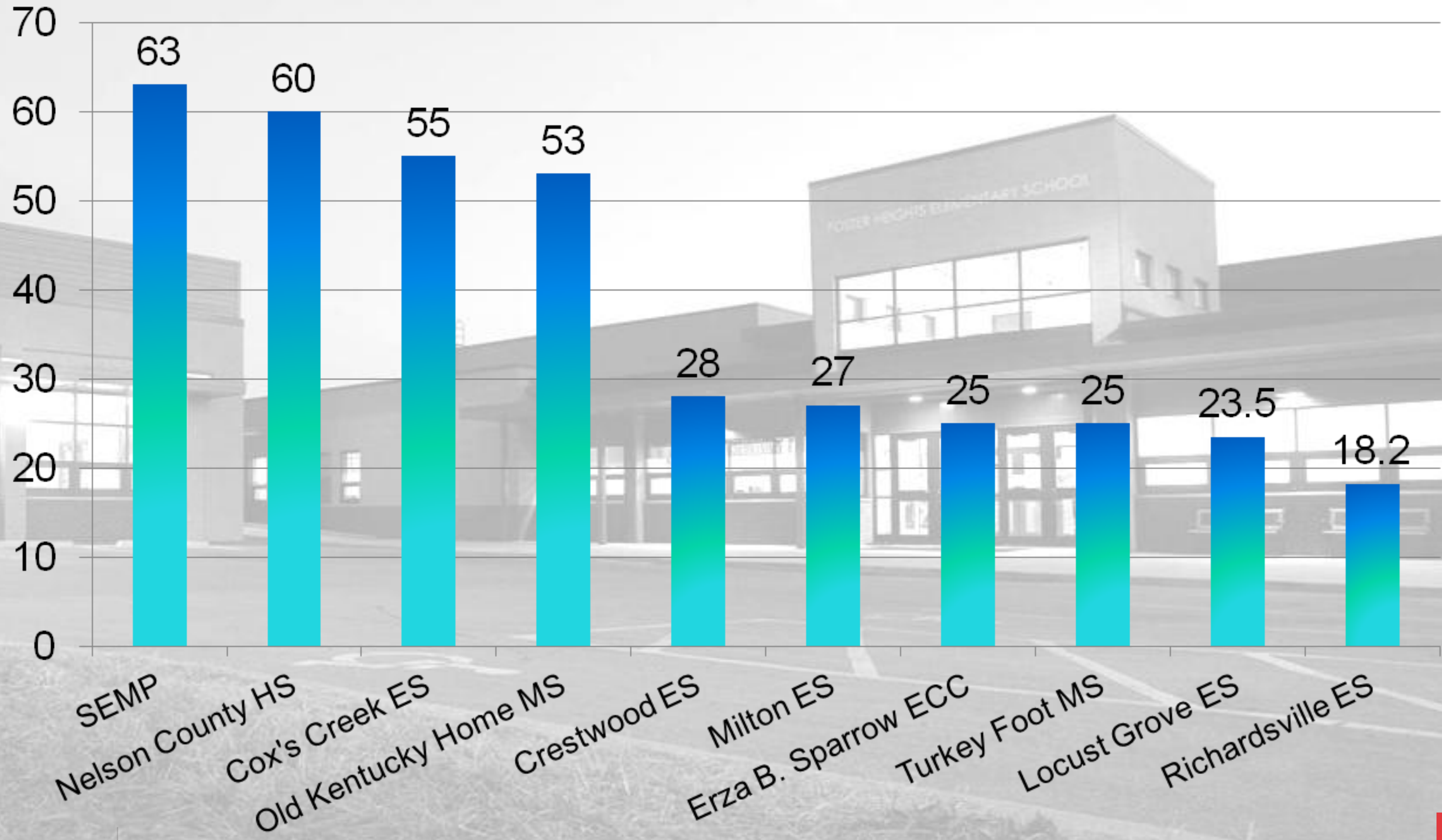
What is high performance and what is the typical cost?

Baseline Energy Usage

Buildings Energy Data Book – U.S. Department of Energy	**90 kBtu/sf yr (High School)** **68 kBtu/sf yr (Elementary School)**
ENERGY STAR Target Finder Score 50	**47 kBtu/sf yr (Elementary/Middle)** **51 kBtu/sf yr (High School)**
School Energy Management Project – 2011	**63 kBtu/sf yr (Kentucky Schools)**

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:

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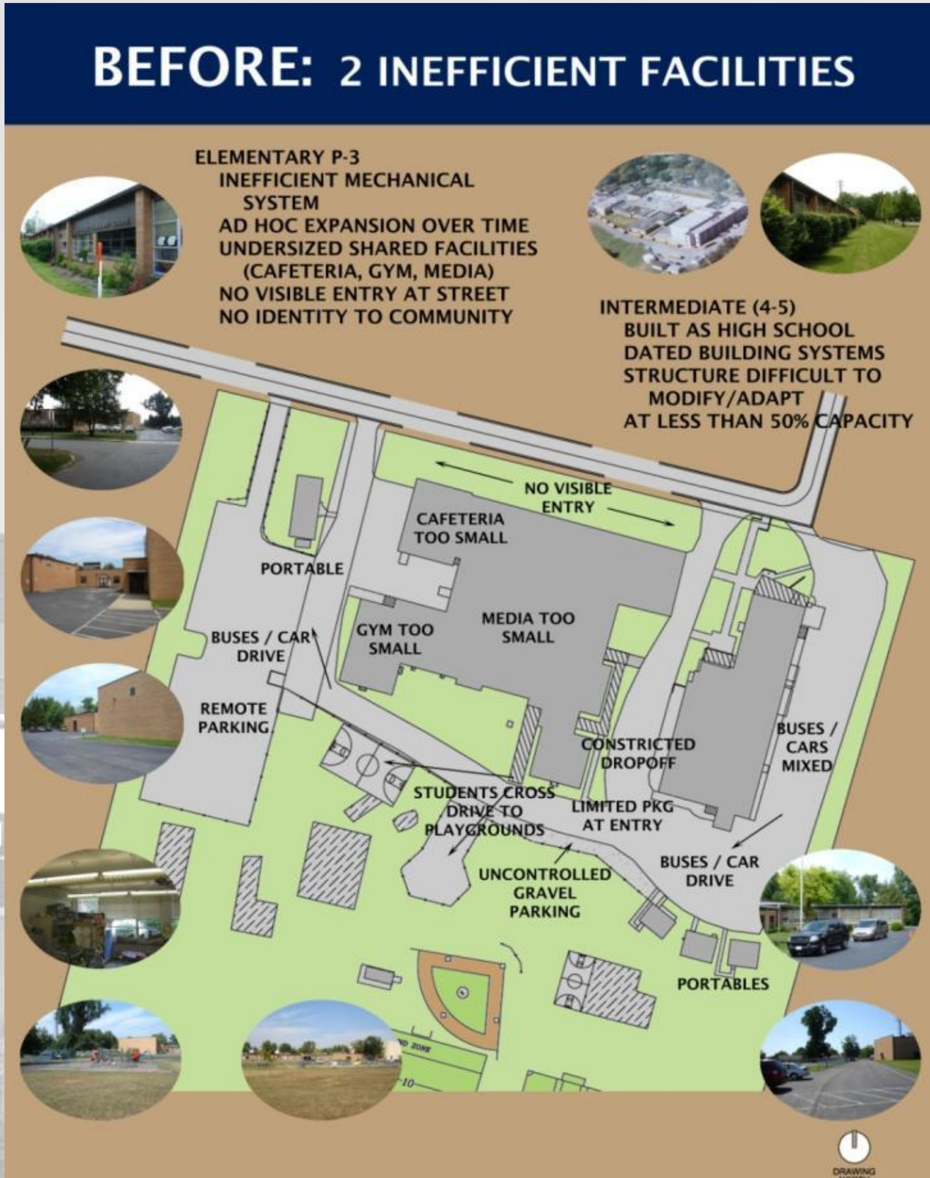
Case Study 1: Foster Heights Elementary

- **Existing school built in multiple sections: 1958, 1970, 1978, and 1992.**
- **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



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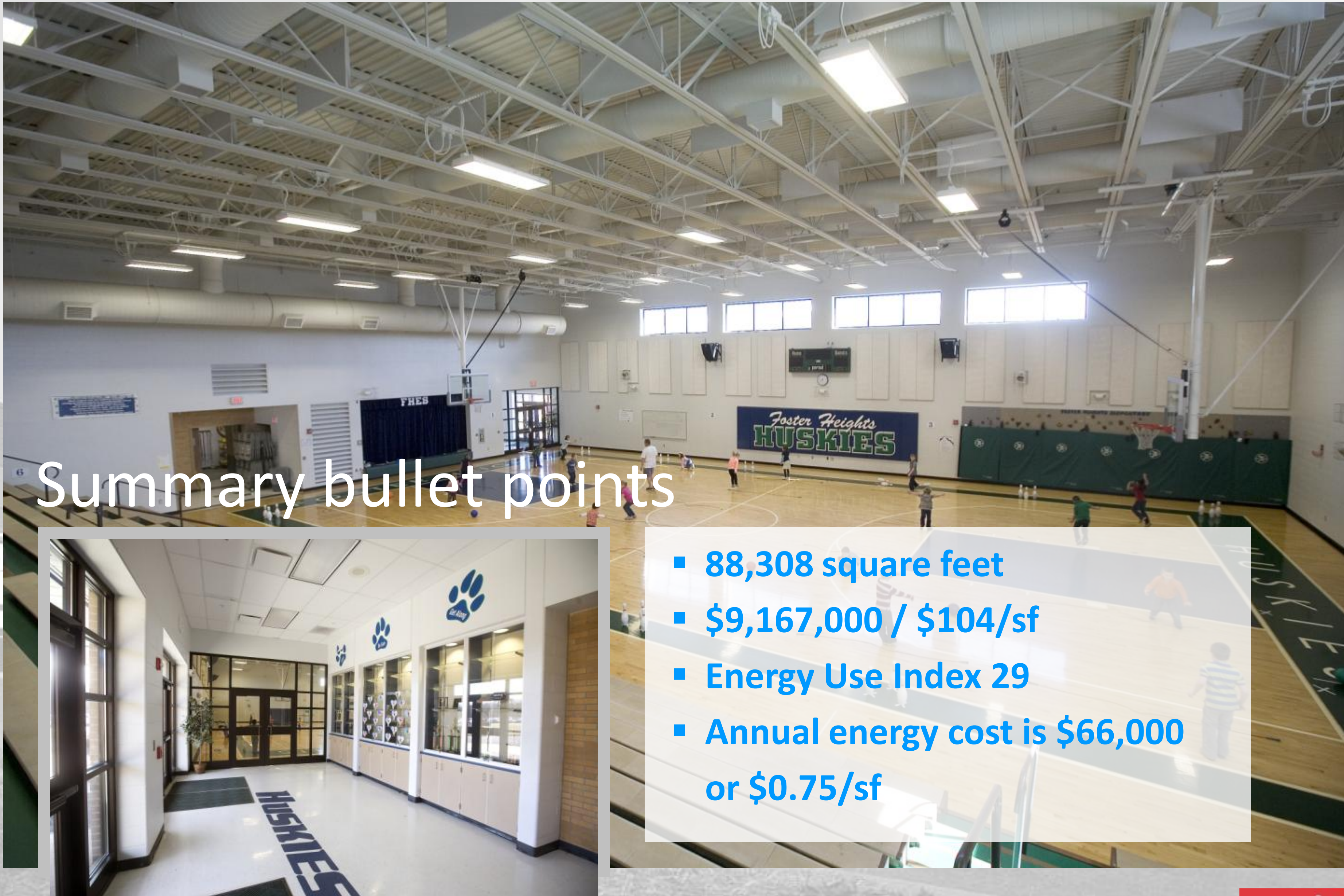
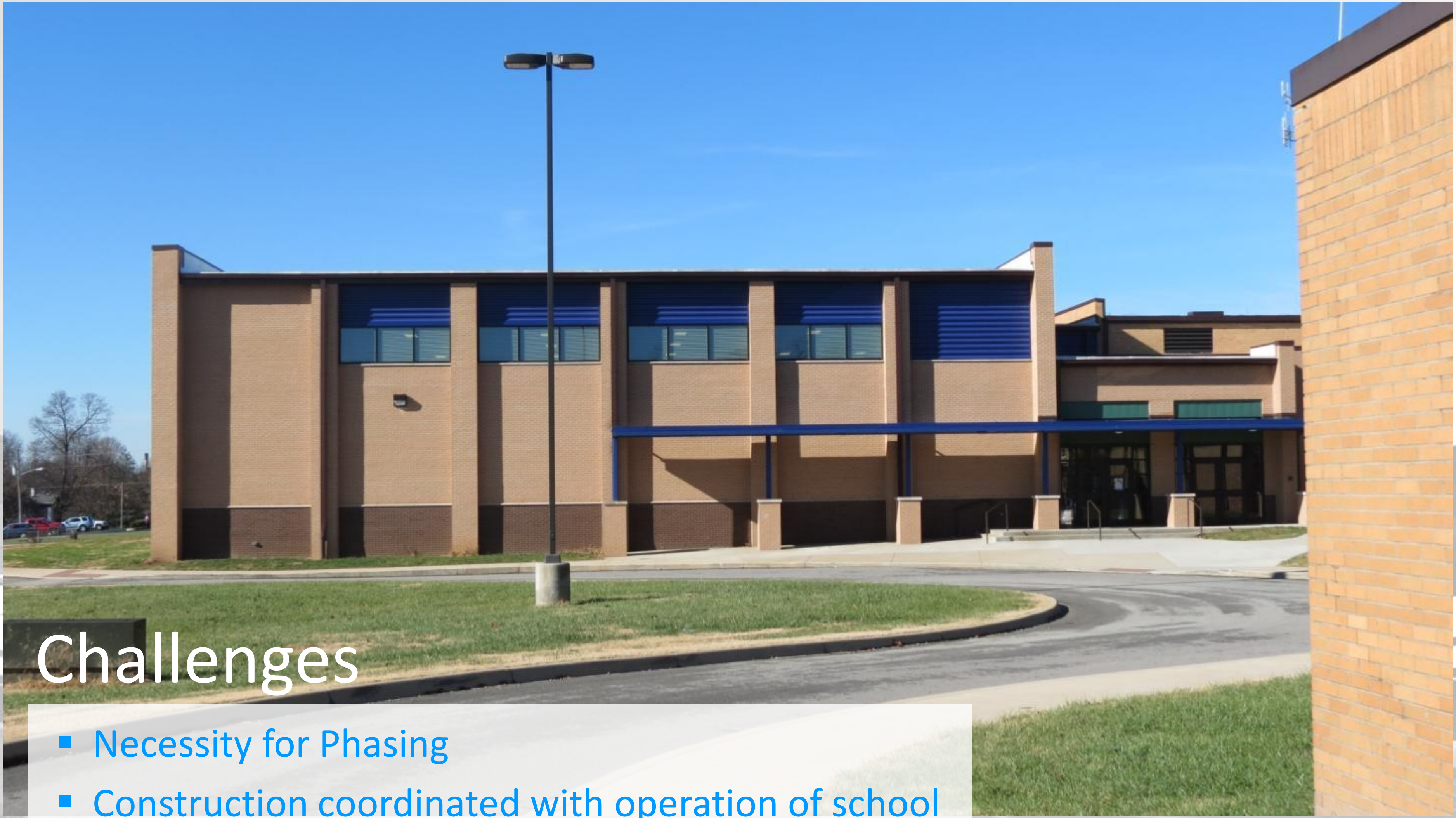
Summary bullet points



- 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

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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…

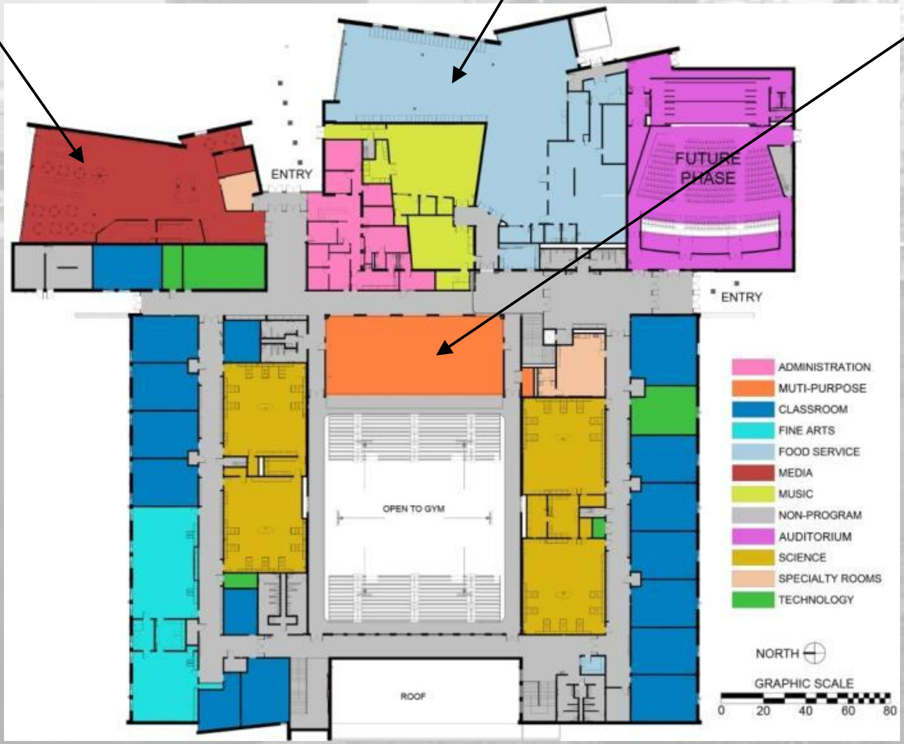
  that engages its community and users in a way that they will want to be its stewards for decades to come.

- The process starts with <u>integrated</u> thinking from the <u>whole team</u> from the <u>beginning</u>.

- 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:

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.

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.



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

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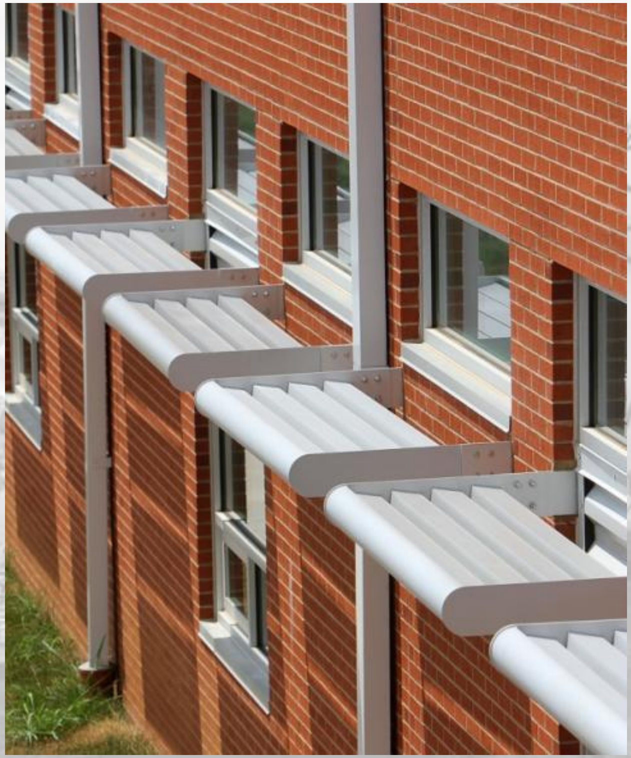
- An aggressive daylighting strategy was implemented in order to welcome as much natural light into the building as possible
- Lessening the need for electrical lighting and mitigating the temperature increase they cause
- Because of these strategies we were able to use fewer light fixtures, smaller 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

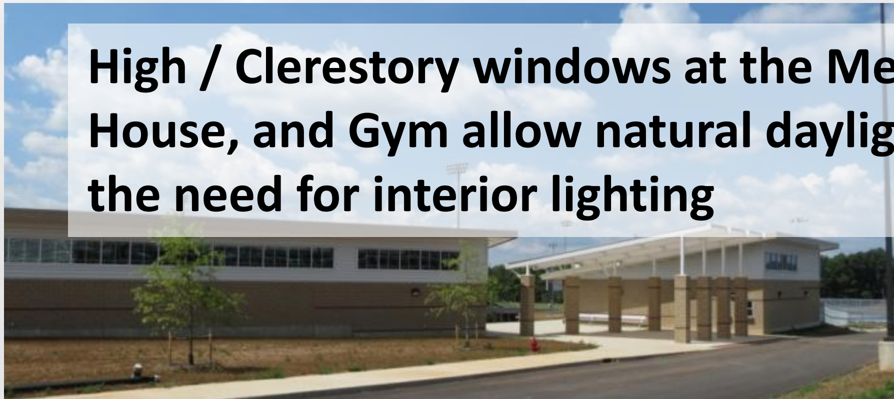
Smaller, controlled windows to the south direct light into the rooms up at the ceiling

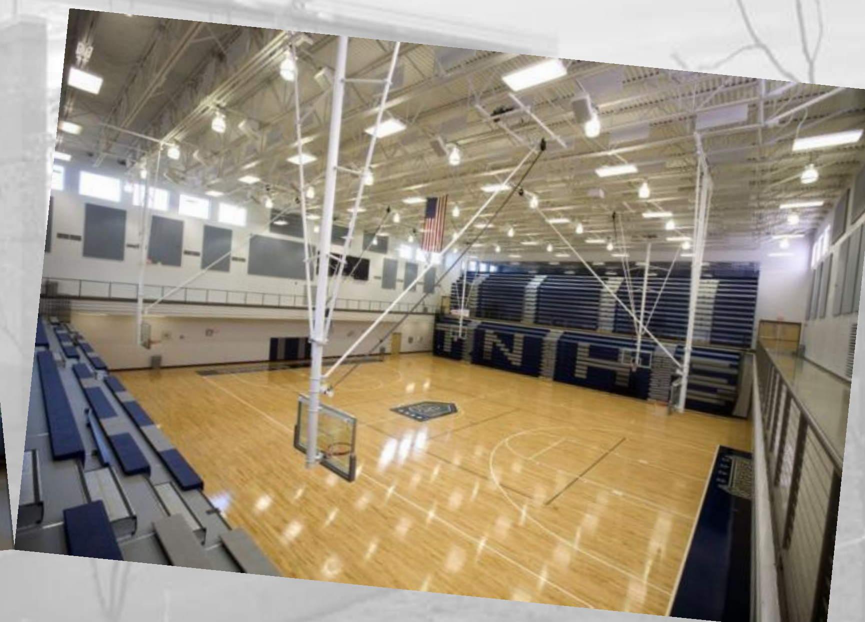
- Ceilings are sloped
- Aluminum light shelves reflect light
- Electrical lights off or dimmed 75% of the time

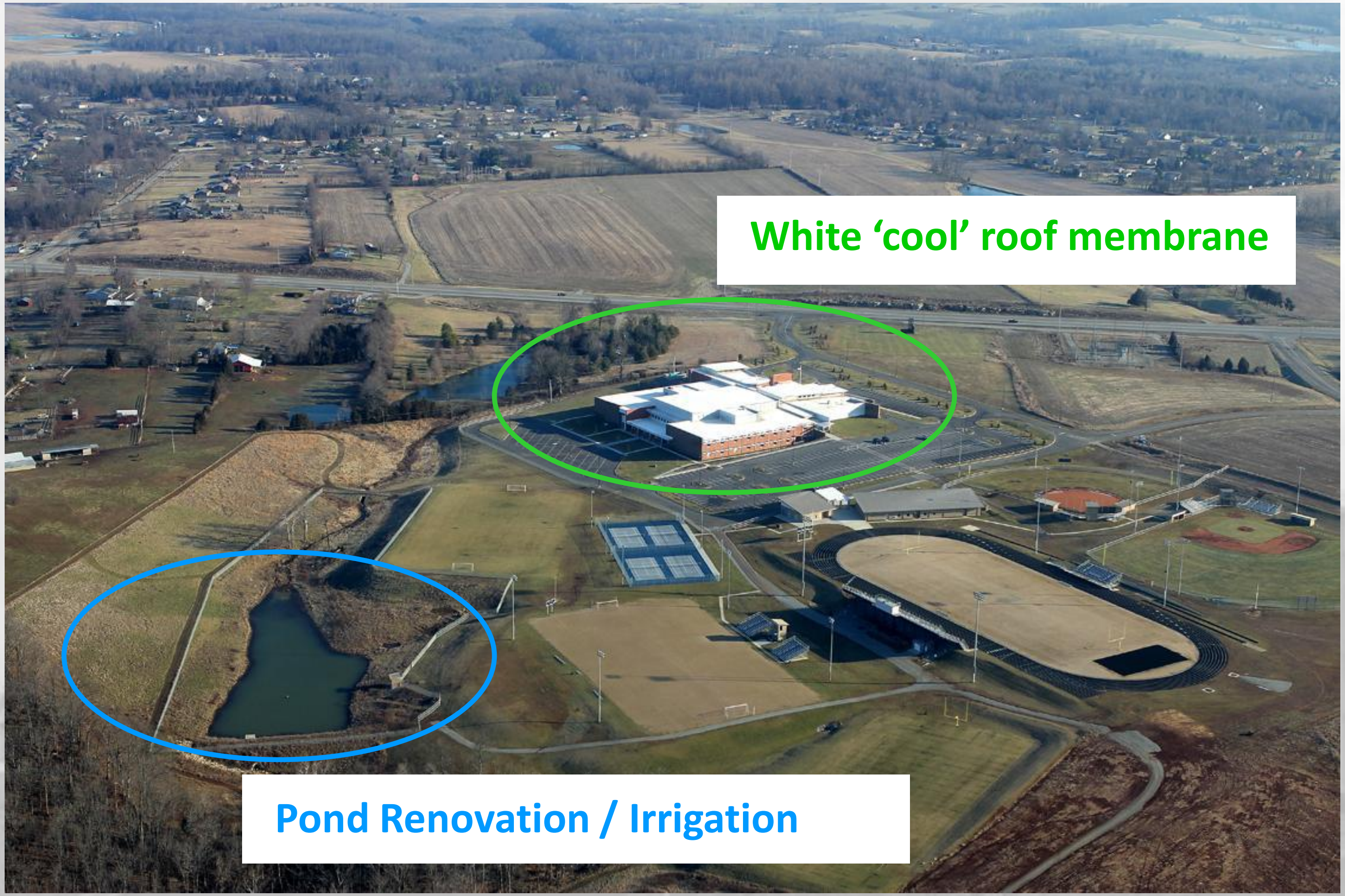
Lights will automatically dim to conserve energy

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

Big Picture

- **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**

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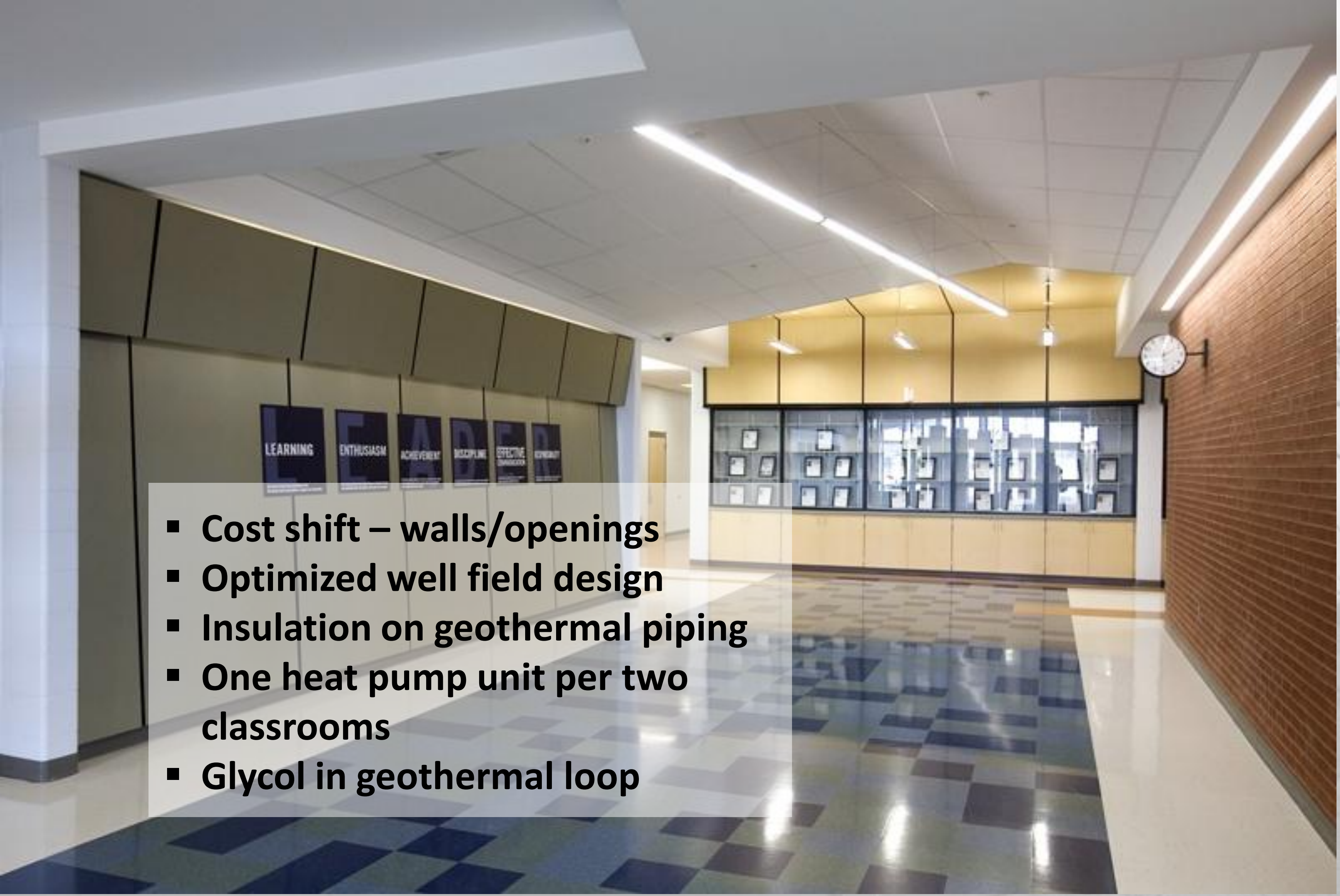

- Cost shift – walls/openings
- Optimized well field design
- Insulation on geothermal piping
- One heat pump unit per two classrooms
- Glycol in geothermal loop

Strategies for Cost Savings

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Lessons Learned

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

Savings

Construction Costs		
Thomas Nelson High School (146,000 sf)	$23,500,000	
National Median High School (146,000 sf)	$31,000,000	($8,000,000)
Regional Median High School (146,000 sf)	$26,000,000	($3,000,000)

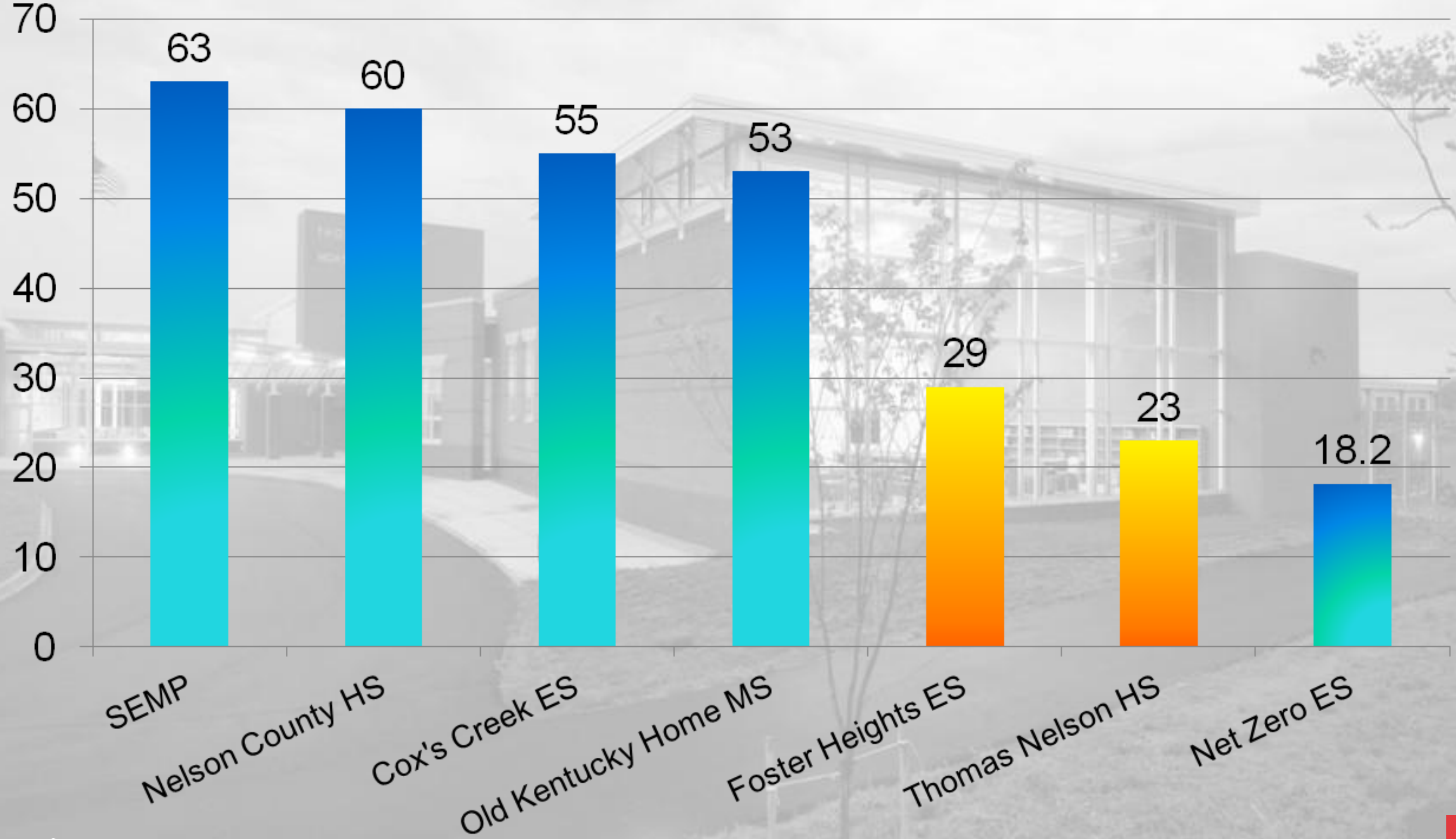
Construction Costs	
Foster Heights Elementary School Renovation (56,600 sf) New (31,667 sf)	$9,167,000

Savings

Annual Energy Costs		
Thomas Nelson High School (23 kBtu/sf yr)	$105,000	
Regional Median High School (90 kBtu/sf yr)	$420,000	($315,000)
Average Kentucky High School (63 kBtu/sf yr)	$280,000	($175,000)
Average Teacher's Salary in Kentucky	$50,000	Energy savings = 3-6 teacher salaries (annually)

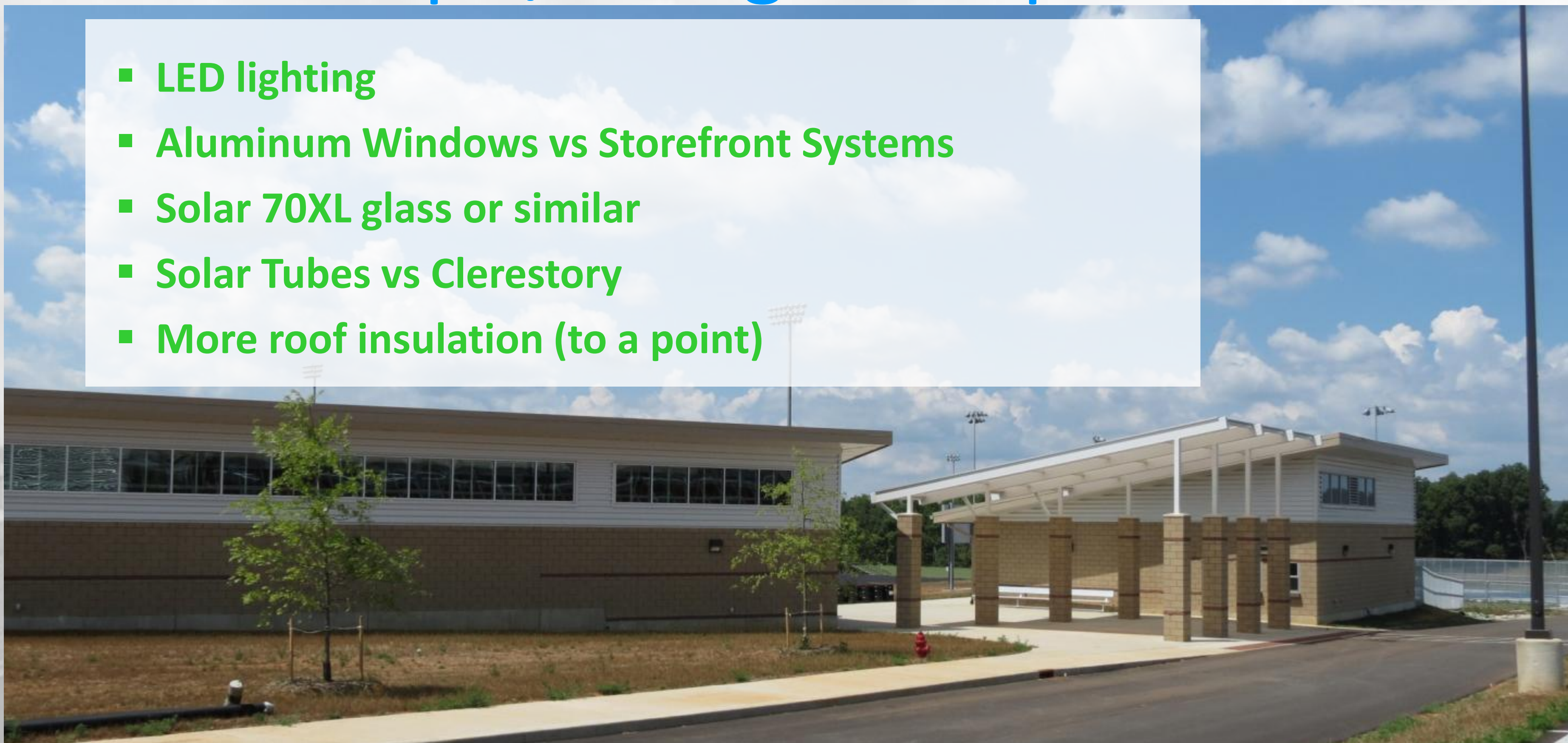
Annual Energy Costs		
Foster Heights Elementary School (29 kBtu/sf yr)	$105,000	
Regional Median Elementary School (68 kBtu/sf yr)	$158,000	($53,000)
Average Kentucky Elementary School (63 kBtu/sf yr)	$147,000	($42,000)
Average Teacher's Salary in Kentucky	$50,000	Energy savings = 1 teacher's salary (annually)

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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