The Cost of Upgrading Lighting Technology

Experience. Delivery. Results.

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Overview

- The Main Goal is to show the facts in upgrading Yesterday's products

Keep In Mind

- When in doubt on product ask yourself: "Does a company I already trust make that product?"
- If it sounds to good……

Yesterday's Design for Today's Use

- Pen/Paper,Whiteboard,Smartboard,I-Pad,Books
- If designed in 70s or 80s or earlier chances are spaces are over lit by 30%
- Space Considerations:
  - What tasks are being performed in each space? What is level of importance of the lighting. Is the space use the same? (IT Classrooms)
- What is the main motivation for the retrofit?
  - Energy savings?
  - Maintenance Savings?
  - Better quality lighting?
  - Satisfying a green initiative?

LED Update:
Better Materials, Reduced Prices

- Less material, lower cost
- LED Toffers – 35-60W $100-$200
- 60W A19 equivalent – 9.5W, $12.97
- 25W Streetlight 2700 lumen, $99

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PAR38 Replacement

Halogen 75 watt

- 5000 annual hours
- 4 months life
- Lamp cost $3.00
- Lamp cost/year $12.00
- Energy cost/year $26.25
- Annual cost $36.25

LED 20 watt

- 5000 annual hours
- 5 years life
- Lamp cost $40.00
- Lamp cost/year $8.00
- Energy cost/year $7.00
- Annual cost $15.00

PAR30 Replacement

Halogen 50 watt

- 5000 annual hours
- 4 months life
- Lamp cost $3.00
- Lamp cost/year $12.00
- Energy cost/year $17.50
- Annual cost $29.50

LED 12 watt

- 5000 annual hours
- 4 years life
- Lamp cost $30.00
- Lamp cost/year $6.00
- Energy cost/year $3.15
- Annual cost $9.15

MR16 Replacement

Halogen 35-50 watt

- 6000 annual hours
- 3 months life
- Lamp cost $5.00
- Lamp cost/year $10.00
- Energy cost/year $13.50
- Annual cost $23.50

LED 12 watt

- 6000 annual hours
- 4 years life
- Lamp cost $25.00
- Lamp cost/year $3.0
- Energy cost/year $2.10
- Annual cost $5.10

BR30 Replacement

Incandescent 65 watt

- 3000 annual hours
- 6 months life
- Lamp cost $3.00
- Lamp cost/year $6.00
- Energy cost/year $11.70
- Annual cost $17.70

LED 10 watt

- 3000 annual hours
- 8 year life
- Lamp cost $25.00
- Lamp cost/year $3.75
- Energy cost/year $1.80
- Annual cost $5.55

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LED Downlight Fixture

- Costs have come down, due to supply and demand
- Best applications: retail, office, atrium, long hours
- More options now available for higher wattage (higher ceiling height)
- Reliable dimming
- Incumbent: CFL similar in cost
  - But Lower fixture efficiency
- Color tunable available

LED Downlight Retrofit

- Available in 4”, 5”, 6”
- Match to color of other lights
  - (2700K, 3000K, 4000K)
- CRI>80
- 850 lumens – 8.8 watts
- 1250 lumens – 12.8 watts
- Dimmable*

Downlight Fixture vs. Retrofit

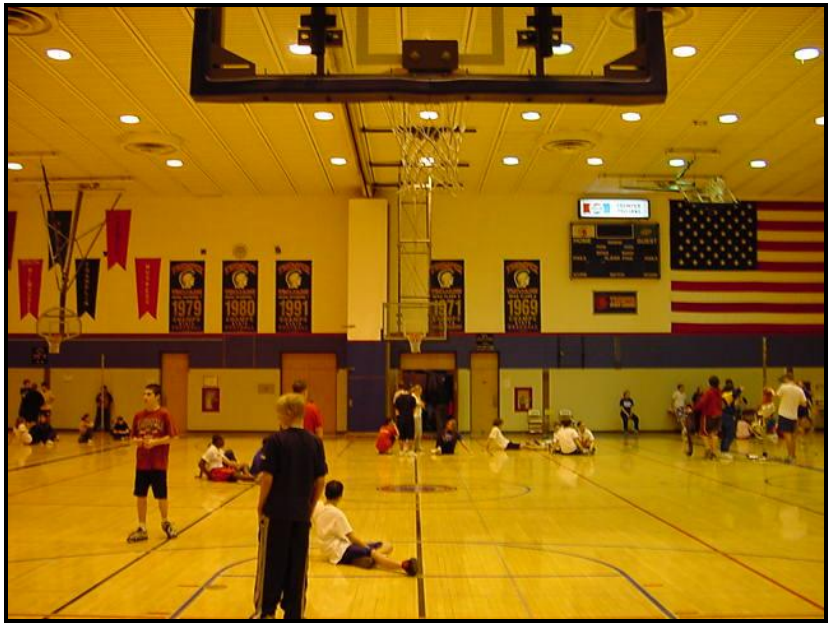
Fixture

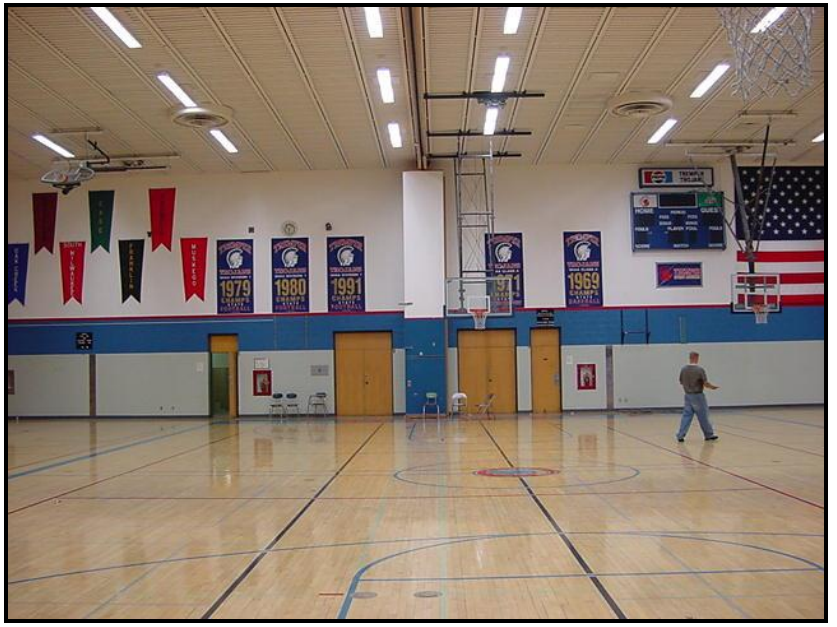
- Owner occupied or long term lease
- Dimming controls
- High end finishes
- Square aperture
- Wall wash
- Diameter over 6”
- Higher lumen output needed
  - HID or CFL replacement

Retrofit

- 4”-6” round aperture
- Minimal controls
- Leased Space
  - Take it with
- Not break ceiling plane
  - Dust sensitive
  - Asbestos concerns
- Lower first cost

High Bay Upgrades





- Fluorescents can save 52% of energy costs
- Less Lumen Depreciation and Better Light Quality
- ROI is 2 to 3 years

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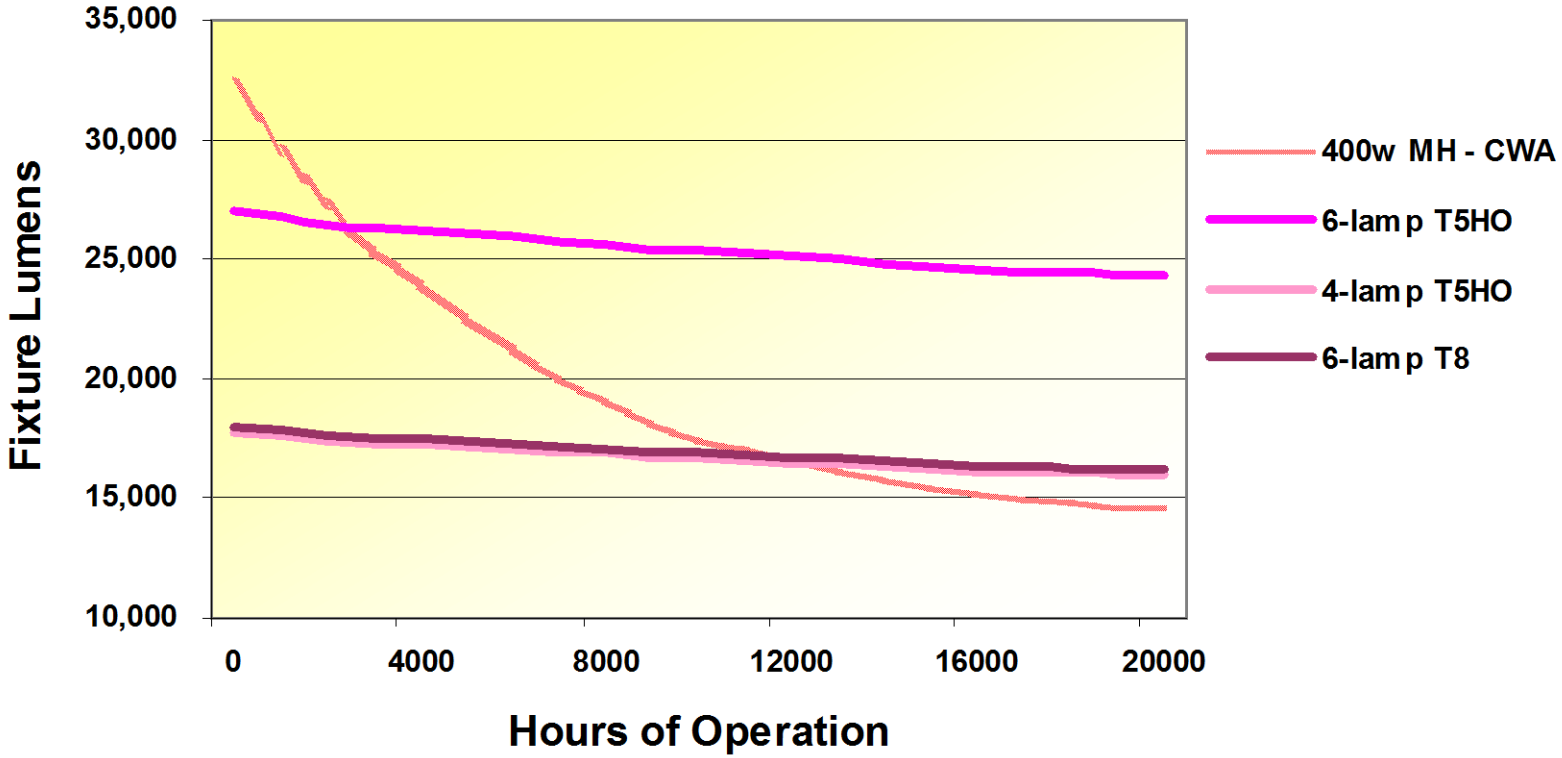
HIGH BAY FLUORESCENT

- 20,000 hour + life
  - Some up to 84,000!
- High lumen maintenance
- Higher CRI than HID
- Inexpensive
- Larger fixture housing
- Easy to maintain
  - But, more lamps to change

FIXTURE LUMEN MAINTENANCE
Why Linear Fluorescent Works



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Kersey Middle School Gym

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Warehouse High Bay

Before

After

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HID to LED: High Bay

- Great for Aisle lighting, high cost for gyms
  - Precise control, adjustable
  - Instant on/off
  - Integrated controls, mesh network
- Replace 250W, 400W HID
  - 1000W not cost effective yet
- Watch out for high temperature

Alternatives in LED

- 108, 145, 218 and 292 watt versions
- Narrow, medium and wide beams
- 108 w/8,856 lumens
- 292 w/23,944 lumens

- 93 watts , 6461 lumens
- Wide beam
- Aisle beam available

- 112, 139 and 169 watt versions
- Narrow, medium and wide beams
- 112 watts/7975 lumens (80 CRI)
- 139 watts/9969 lumens (80 CRI)

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Alternatives in LED

- 1 to 12 module versions
- Narrow, medium and wide beams
- Aisle beam available
- 79 to 125 watt modules
- 104 w/9,177 lumens

- 61-385 watt versions (80 CRI, 4500K)
- Medium (“high bay”) and Wide (“low bay”) beam
- 129 w/11,275 lumens

Summary

Typical Luminaire 4000-4500K

Typical efficacy of luminaire 75 to 90 initial LPW/ 63 to 77 mean LPW

Up to about 385 watts in one box/1500 watts using modular assemblies

Alternatives in Induction

- Long life alternative
- Representative Data
  - (2) 150 watt lamps, 24030 initial fixture lumens, 312 watts, 77 initial lumens per watt, 69 mean lumens per watt
  - Requires lamp specific optics
  - 100,000 hour lamp life
  - 4100K, 80 CRI

Which High Bay To Choose?

Lamp	Initial Fixture LPW	Mean Fixture LPW	Cost/initial lumen	Watts per 20K mean lumens	Lamp Life in hours	Notes
Fluorescent T5HO	91	85	$0.015	235	24K	Cold not OK
Fluorescent T8	97	**92**	$0.013	**217**	36K	Neither hot/cold
LED	75-90	63-77	$0.045	260-317	50K	Cold OK
HID Magnetic old	78	**47**	$0.005	**425**	20K	Cold OK
HID electronic new	85	68	$0.015	294	20K	Cold OK
Induction	77	69	$0.017	290	100K	Cold OK

Install Automated Controls

- Occupancy sensors
  - Auto off when no one detected
  - save up to 80% or more in energy costs (unoccupied warehouse, break room, etc)
- Vacancy sensors
  - manual on, auto off
- Infrared/ultrasonic/dual technology/microphonic
- Dimming/daylighting controls can reduce energy costs and extend lamp life
  - Use programmed start ballast

Motion Sensor Energy Savings

- Break/Lunch room: 30%
- Classroom: 38%
- Mail/Copy Room: 62%
- Restroom: 52%

Daylighting Opportunities

- Take advantage of existing opportunities
  - ***Missed opportunity in this photo?***
  - *(daylight sensors would turn off the redundant perimeter lighting)*
- Couple dimming controls with daylighting, where appropriate
- Design daylighting into new construction

LED Panel/Troffer

- 15-45% energy savings over traditional fluorescent
- DLC listed products
- LED's troffers are comparable/better to T8's
- 2'x2' - 35-50 Watts
- 2'x4' – 40-60 Watts
- 50,000 Hours
  - Comparable to HPT8

8’HO case study

- Existing Main Source: 8ft 2 Lamp HO Strip Fixtures
- Annual Hours: 5840
- Layout: Open
- Controls: Multi-switched
- Daylight: Front windows
- CRI: 68
- Pre Light Levels: 42 F.C.
- IES Recommendations: 50
- Activity in Space: Occupied when open
- Other: Poor color rendering

BASIC Replacement: Retrofit with 8ft 4-lamp T8 Kits

- Layout: 1 for 1
- Controls: Multi-switched
- Daylight: Front windows
- CRI: 80+
- Post Light Levels: 65 FC
- Results:
  - Energy savings
  - Improved CRI
  - Higher light levels

Replacement: Redesign with 40W LED Fixture

- Layout: re-design space using lighting software & new LED
- Controls: Dual level
- Post Light Levels: 60 FC
- Results:
  - Increased savings using less fixtures
  - Higher CRI
  - Perception higher quality space/design

Troffer Alternatives (including surface versions)

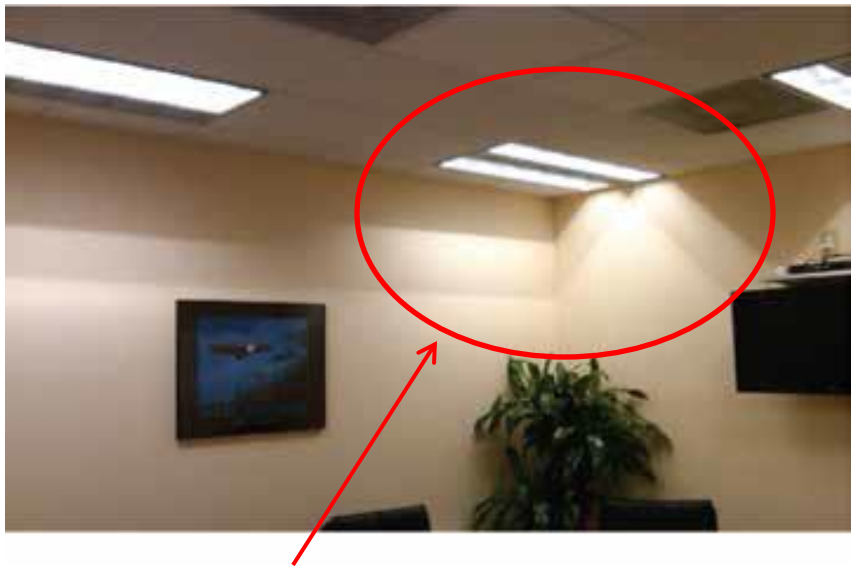
Parabolic – 55 to 80% efficient

Basket 45-75% efficient

Lens troffer– **70 to 88%** efficient

High performance lens – **80 to 90%** efficient

Fluorescent Delamping



1/3 energy savings, BUT -Glare/shadow on the wall, empty cell in middle of the fixture.

A better way -Troffer retrofits

- Parabolic 60% efficient
- HE fluorescent troffer retrofit 90% efficient
  - More lumens make it out of fixture, need less to start
  - More even distribution eliminates hot spots

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LED Direct/Indirect Pendant Solution?

- 35-50 Foot Candles Required in Schools
- AV Foot Candle Light Levels of 10-20
- Pen/Paper + I-Pad= Dimming controls or dual level lighting
- LED Pendant Cost $350-$700 for 4-8ft
- T8 Pendant $250-$450 for 4-8ft
- Approximately 8W Savings of LED over T8

Tube LED vs. Fluorescent: Comparing Four Foot Lamps

Brand P Line Voltage T8 LED (Integral)	Brand P External Driver T8 LED	Brand P T8 Fluorescent
Rewire fixture	Replace ballast with driver	Replace ballast with efficient .71BF ballast program start 46 watts
Integral driver	Rewire fixture	3100 lumen T8 lamps F32T8/841/HP
1650 lumens per lamp	2433 lumens per lamp (per DLC)	$4 per lamp
19 watts per lamp	48 watts per 2 lamps input to driver	$22 per ballast
$40 per lamp	$50 each per lamp	Lamp rated 36,000 hours@ 12 hrs (PS)
Lamp rated 40,000 hours	$22 driver	LLD = .97
LLD = .85	Lamp rated 50,000 hours	
	LLD = .85	

LLD = Lamp lumen depreciation at 50% of rated life

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Tube LED vs. Fluorescent: Comparing Four Foot Lamps

Brand P Line Voltage T8 LED (Intergral)	Brand P External Driver T8 LED	Brand P T8 Fluorescent
87 initial lumens per watt	104 initial lumens per watt	96 initial lumens per watt
73.8 mean lumens per watt	88.5 mean lumens per watt	92.8 mean lumens per watt
$80 plus labor to install	$122 plus labor to install	$34 plus labor to install
Initial light output 3300 lumens from 2 lamps (33% less light)	Initial light output 4866 lumens from 2 lamps	Initial light output 4402 lumens from 2 lamps (9% less light)
Initial power input 38 watts (37% reduction)	Initial power input 48 watts (20% reduction)	Initial power input 46 watts (23% reduction)
Lamp life 40,000 hours	Lamp life 50,000 hours	Lamp life 36,000 hours

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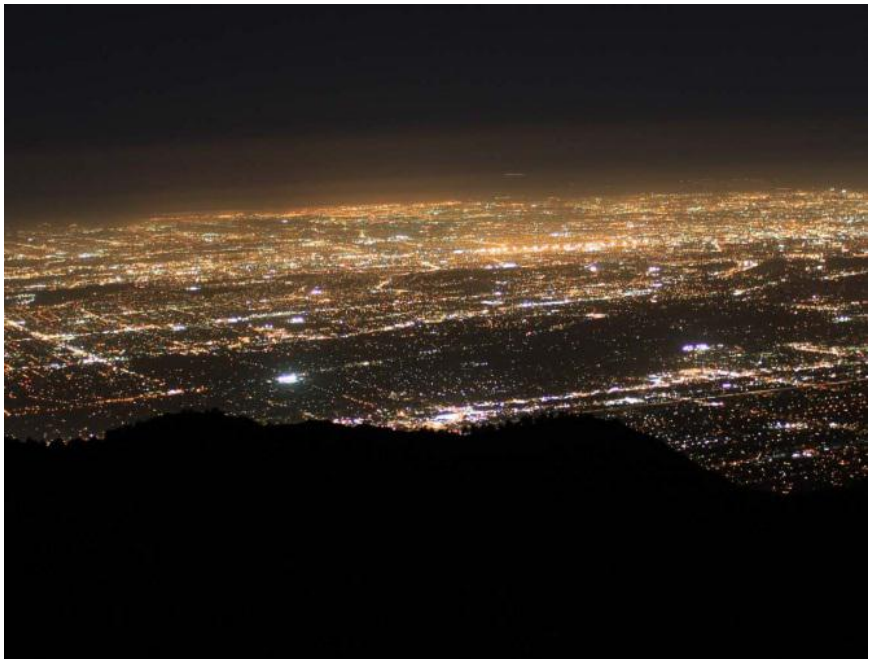
Summary: Tube LED Replacement Lamps

- Fluorescent is comparably energy efficient and long life, but less expensive
- **Most TLED's reduce light levels to save impressive amounts of energy**
- Fluorescent color is comparable or better
- Fluorescent can be dimmed and still cost less
- TLED makes sense in some circumstances, e.g. in cold temperatures
- LED cost will fall over time best options are LED troffers
- There is a lot of dishonest LED marketing

LED in Exterior Applications

Los Angeles, CA Streetlighting

2008 **2012**



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Why LED is different

- More uniform lighting
- Less light at base of pole
- Lower average light level
- Lower wattage possible
- Same pole count and height
- Use 40% of the watts of magnetic ballasted metal halide
- Use 60% of the watts of HPS


ACE
FOOD
DRUG

LEDs in Exterior Applications

- DOE report*: LED Efficacy exceeds HID 250W
  - Some 400W
- Long life - maintenance savings
- Work well in cold temperatures
- Many Dark Sky Compliant
- Parking lot, Garage, Street, Sign
- Canopy, Wall/Security, Pathway

* http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/lf-snapshot2013_outdoor-area-lighting.pdf

Exterior Parking Lot

- Fall is a good time to look at upgrades
  - Lights come on earlier, outages noticeable
  - Cost to rent a lift is the same for lamp replacement or longer lasting upgrade

- LED upgrades offer
  - Even illumination
  - Longevity/Maintenance savings
  - Control savings
    - Various light level scene selection based on occupancy
    - Instant on/return to full light level

- Check all lighting for controls opportunities

Pole Lighting Comparison

Metal Halide

- White light CRI 65
- 39 mean lumens per watt (250 watt)
- Shoebox fixture $250 plus labor to install
- Average mean light level 1.5 footcandle
- Minimum light level 0.1 footcandle
- **Lamp life 20,000 hours**
- **Energy $120/year**

High Pressure Sodium

- Pink-yellow light CRI 21
- 78 mean lumens per watt (150 watt)
- Shoebox fixture $250 plus labor to install
- Average mean light level 1.8 fc
- Minimum light level 0.12 footcandle
- **Lamp life 30,000 hours**
- **Energy $75/year**

LED

- White light CRI 75
- 75 mean lumens per watt (90 watt)
- Shoebox fixture $600 plus labor to install
- Average mean light level 1.1 fc
- Minimum light level 0.12 footcandle
- **Lamp life >50,000 hours**
- **Energy $36/year**

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LED Wall Packs

- Replace HID 50W-400W
- Enhanced color quality
  - Better for security cameras and facial recognition
- Control glare and light trespass
- Many Dark Sky compliant

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Wall Pack Comparison

Metal Halide

- White light CRI 65
- 26 mean lumens per watt (50 watt)
- Fully shielded fixture $150 plus labor to install
- Lamp life 10,000 hours
- Energy $31/year

High Pressure Sodium

- Pink-yellow light CRI 21
- 44 mean lumens per watt (35 watt)
- Fully shielded fixture $150 plus labor to install
- Lamp life 30,000 hours
- Energy $20/year

LED

- White light CRI 75
- 75 mean lumens per watt (20 watt)
- Fully shielded fixture $300 plus labor to install
- Lamp life >50,000 hours
- Energy **$9**/year

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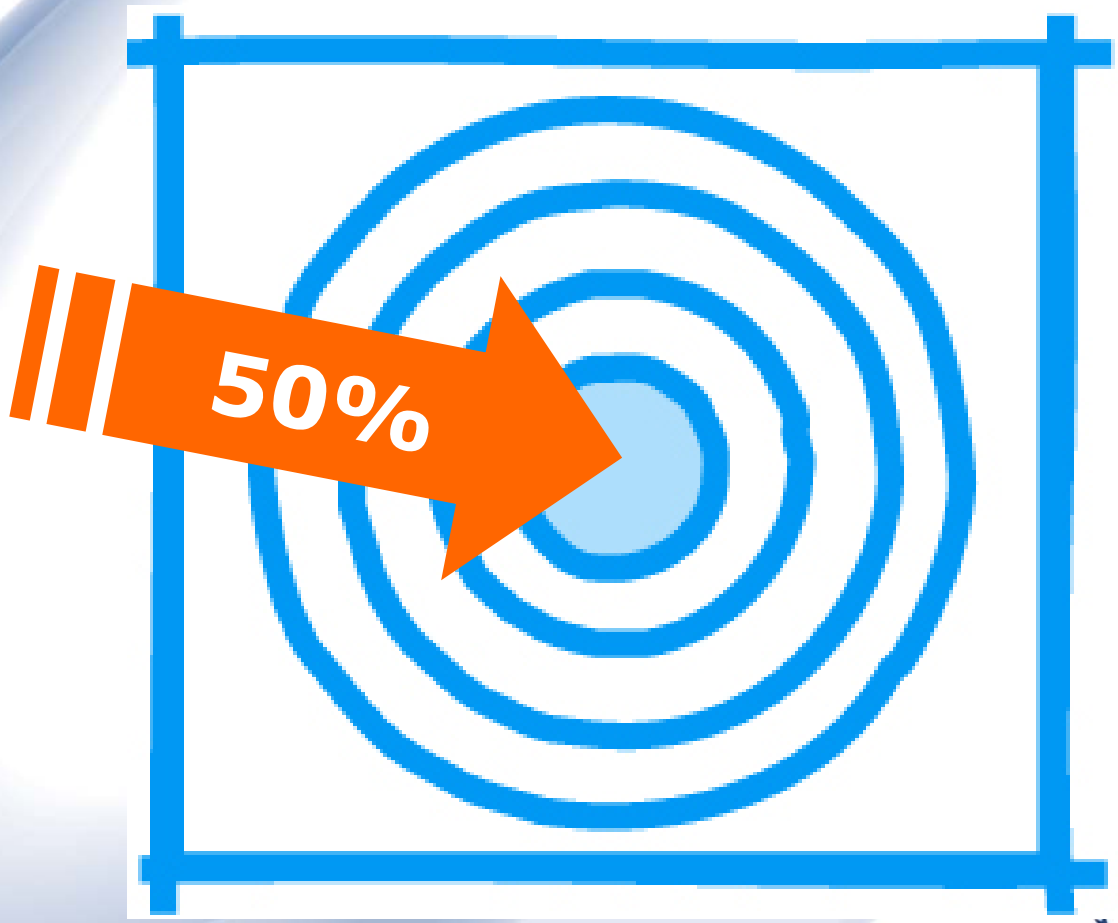
Questions???

PSD 2010 Bond Project Update

January 9, 2014

POUDRE SCHOOL DISTRICT

Setting Energy Goals



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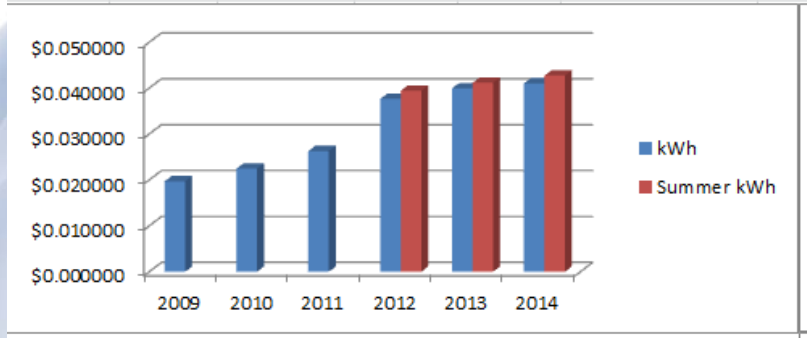
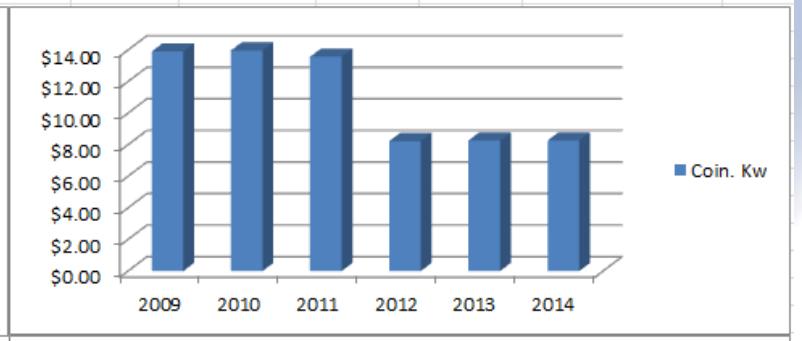
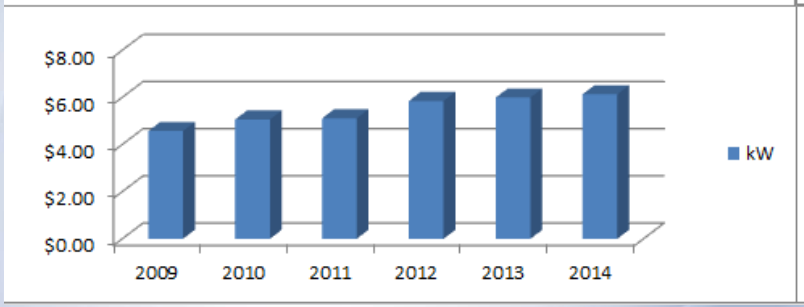
Fort Collins Utilities Electric Rates 2009-2014

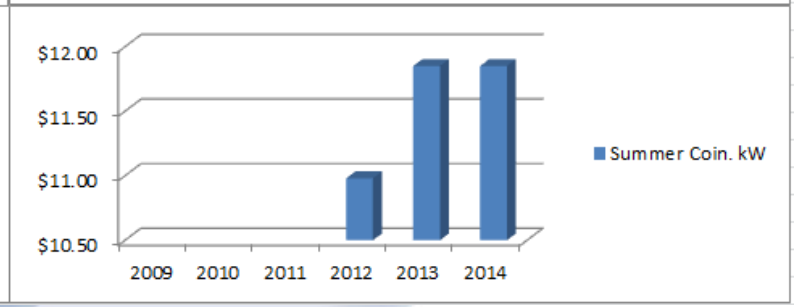
	kWh	Summer kWh	Cost kW	Coin. Kw	Summer Coin. kW
2009	$0.019700		$4.57	$13.91	
2010	$0.022470		$5.06	$13.97	
2011	$0.026290		$5.11	$13.57	
2012	$0.037630	$0.039420	$5.85	$8.23	$10.98
2013	$0.039962	$0.041128	$5.99	$8.27	$11.85
2014	$0.041022	$0.042718	$6.13	$8.27	$11.85

	kWh	Summer kWh	Percent kW	Coin. Kw	Summer Coin. kW
2009					
2010	14.06%		10.72%	0.43%	
2011	17.00%		0.99%	-2.86%	
2012	43.13%	49.94%	14.48%	-39.35%	-19.09%
2013	6.20%	4.33%	2.39%	0.49%	7.92%
2014	2.65%	3.87%	2.34%	0.00%	0.00%
Total	**83.05%**	**58.14%**	**30.92%**	**-41.30%**	**-11.16%**









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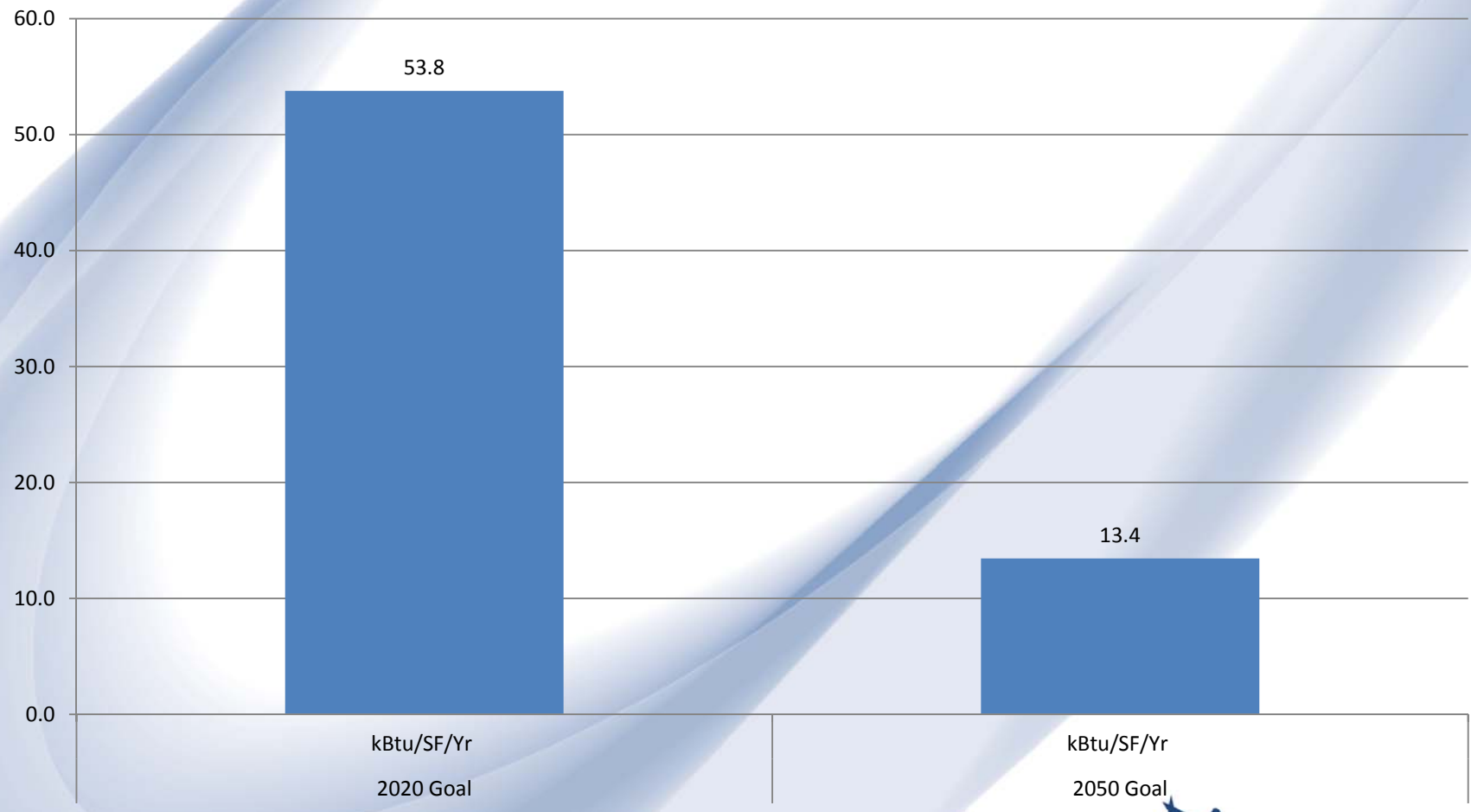
PSD 2010 Bond Energy Goals



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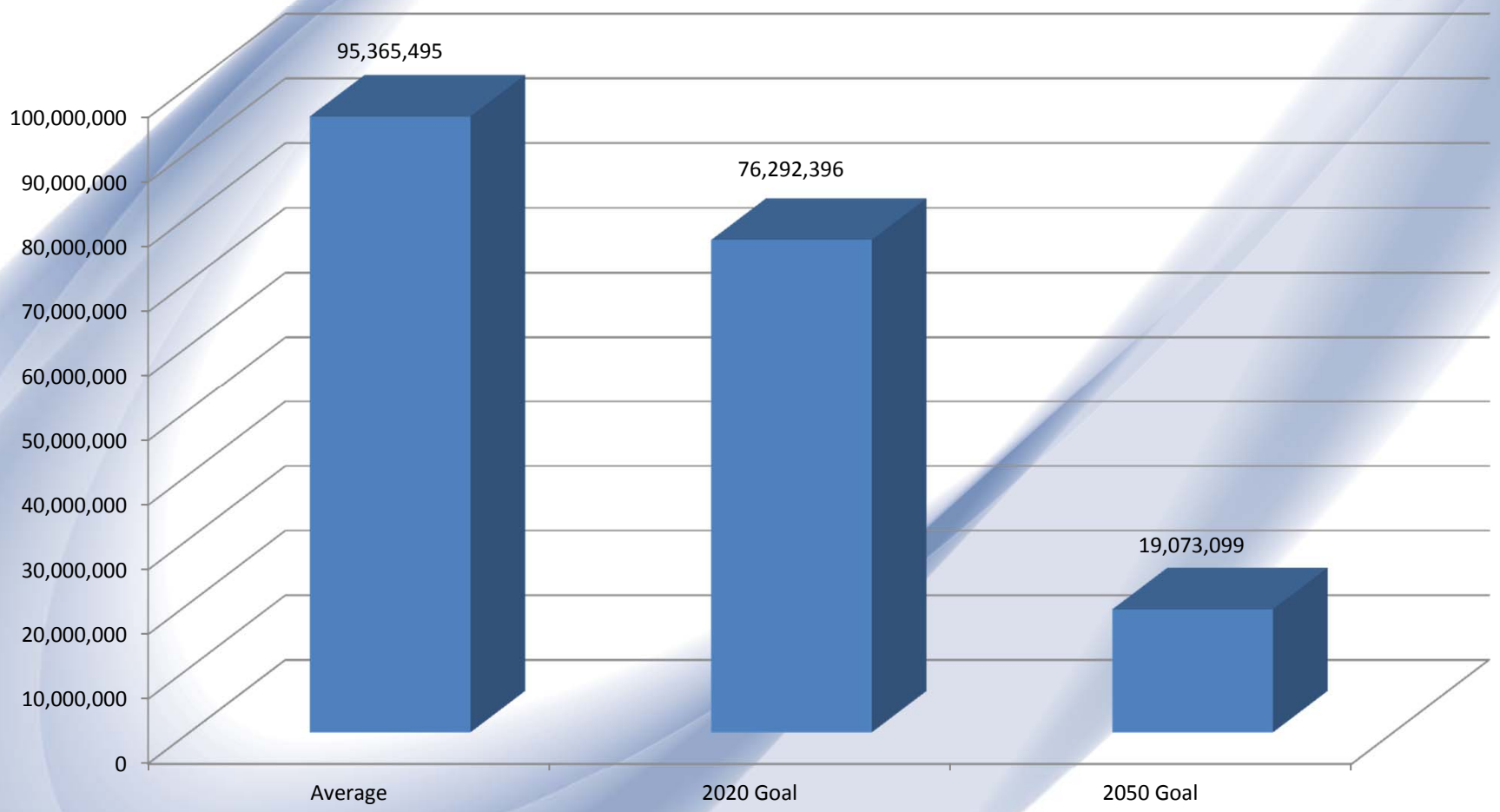
2010 Bond Total Gallons Goal



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PSD Integrated Design Team

- Building envelope studies (required for rebates).
- Retro commissioning/Life Cycle Cost Analysis.
- ASHRAE 90.1 Energy modeling (calibrated with last 5 years actual use & required for rebates).
- Performance goals (comfort/energy/water/etc.).
- Internal and external design team coordination.
- Collaborative design.
- Financial analysis.
- Final design energy modeling (required for rebates).
- Updated Tech-Spec.
- Construction Recycling.
- Commissioning (required for rebates).

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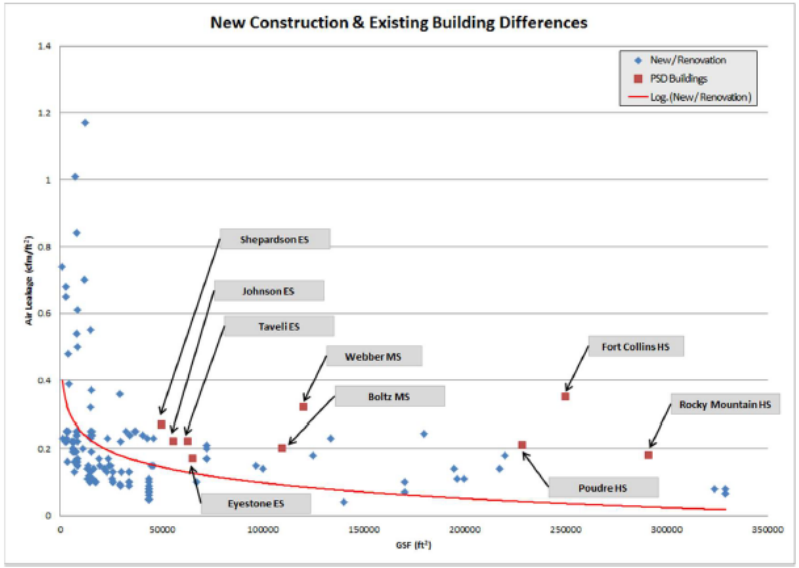
Building Envelope Studies

Poudre School District 2011 Testing

PSD 2011 Air Leakage Testing Results



RCx and Life Cycle Cost Analysis

Retro-Commissioning Study Report
Poudre School District
Poudre High School
September 8, 2011

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EATON
Powering Business Worldwide

EMC ENGINEERS, INC.

POUDRE SCHOOL DISTRICT

Energy Analysis and ASHRAE 90.1 Baseline Energy Modeling

POUDRE
HIGH SCHOOL
ENERGY ANALYSIS

Energy
Analysis
Report

09/15/2011 Fort Collins, CO

EATON
Powering Business Worldwide

This report has been prepared to present the energy analysis results of the Poudre High School. It contains a listing of recommended energy conservation measures and the energy savings and economic evaluation of these measures.

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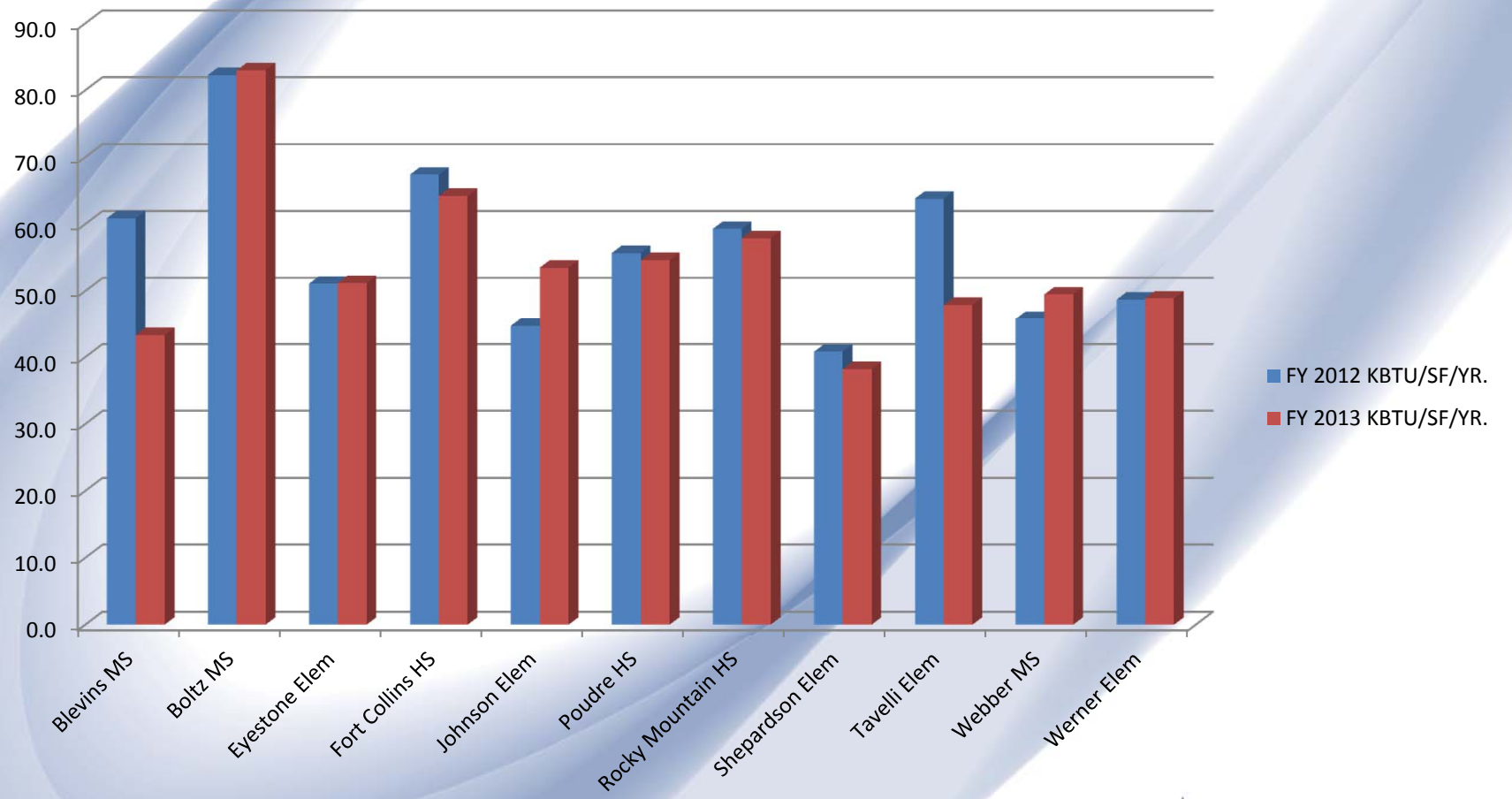
2012 Project Energy Performance



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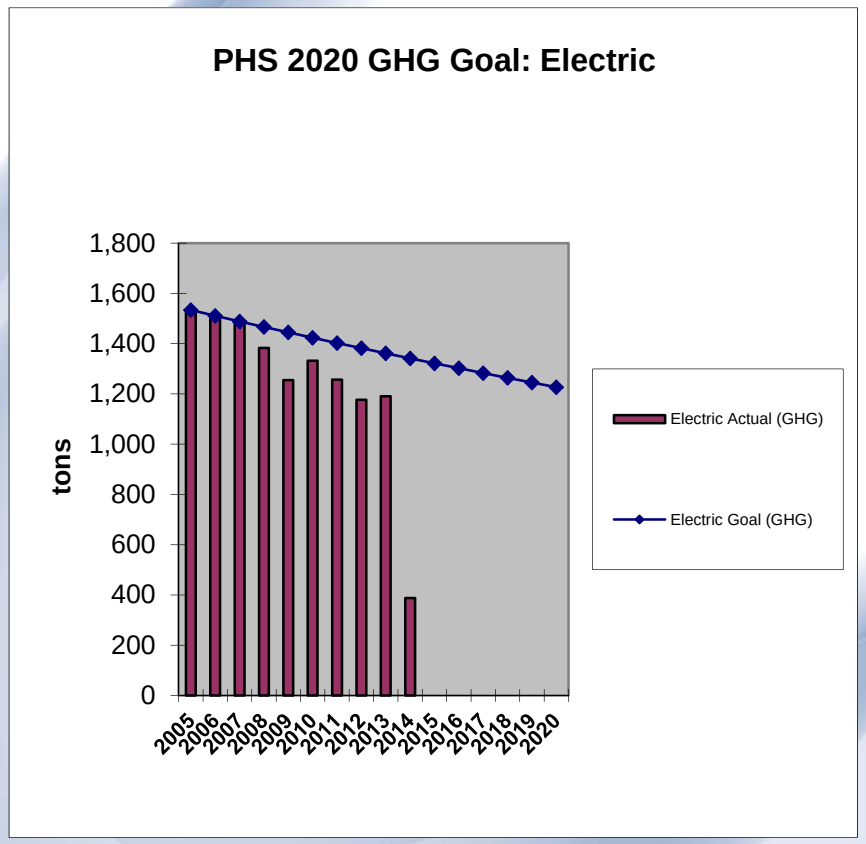
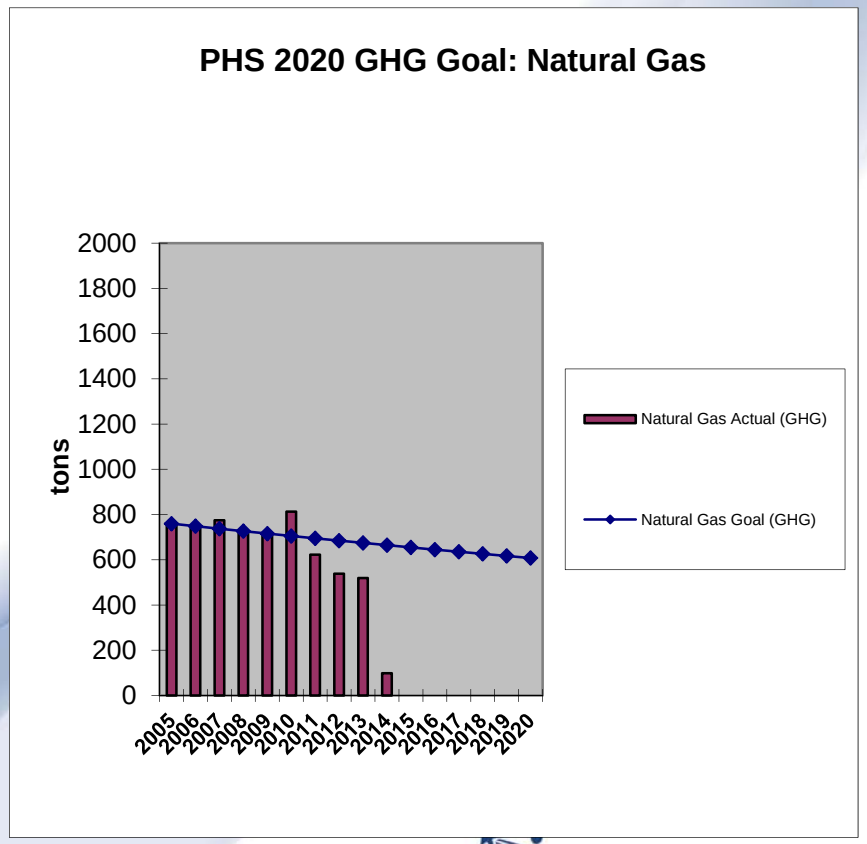
High School Examples





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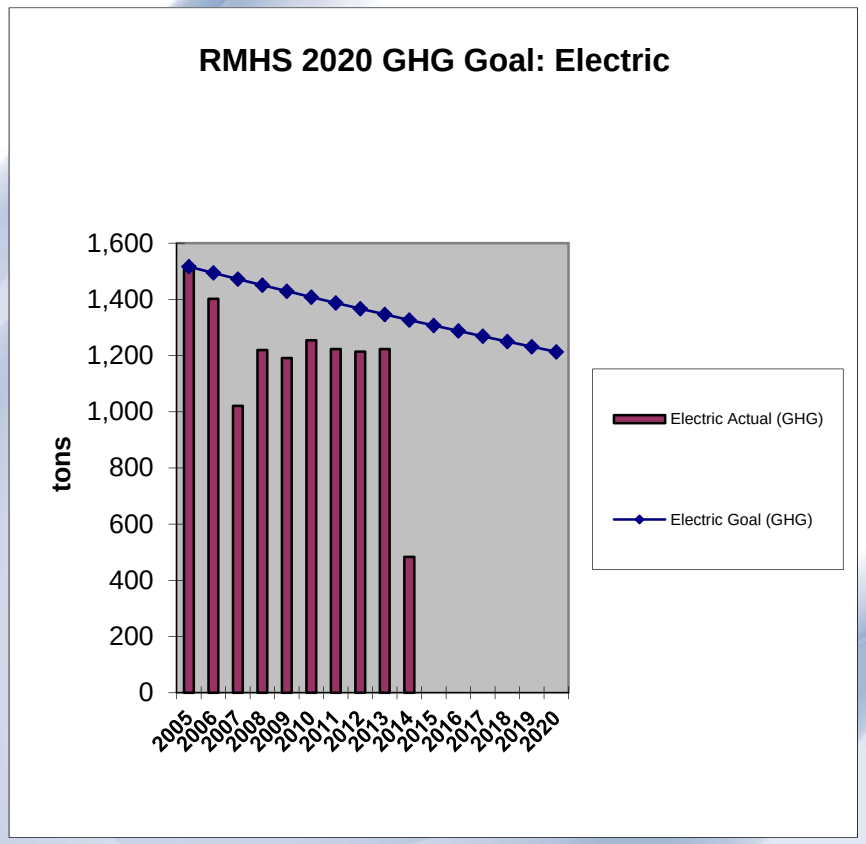
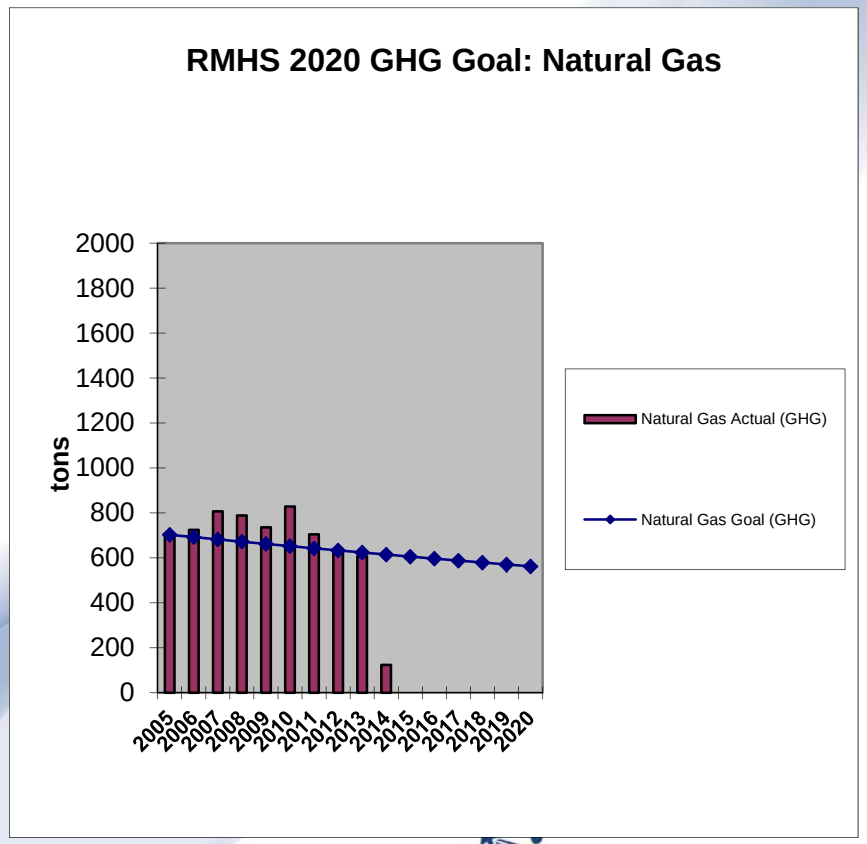
High School Examples





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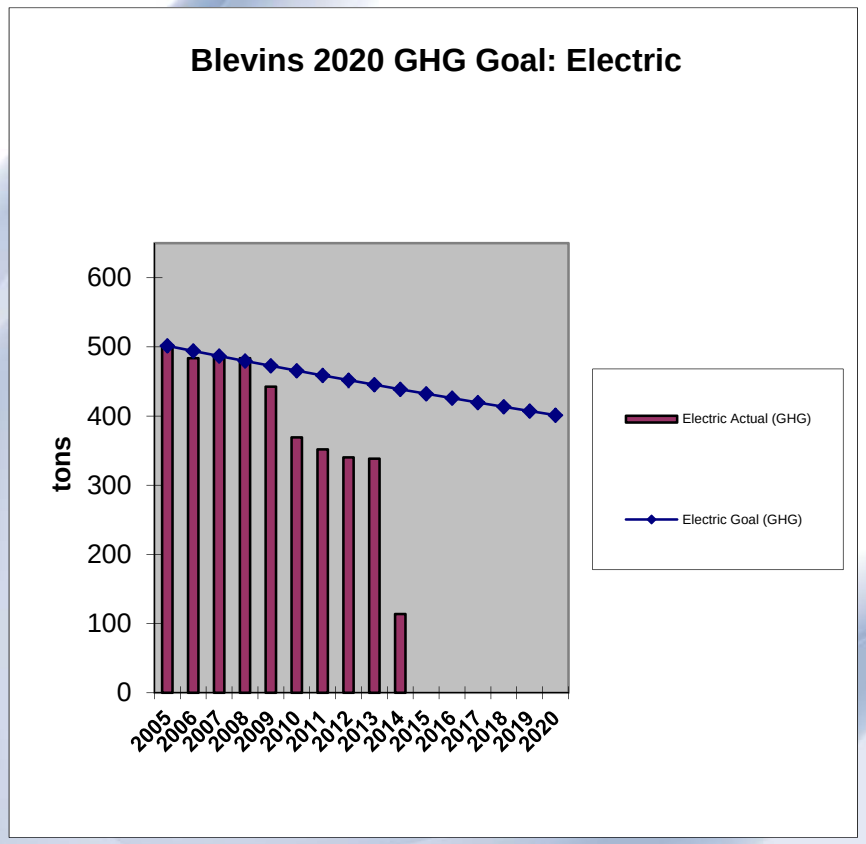
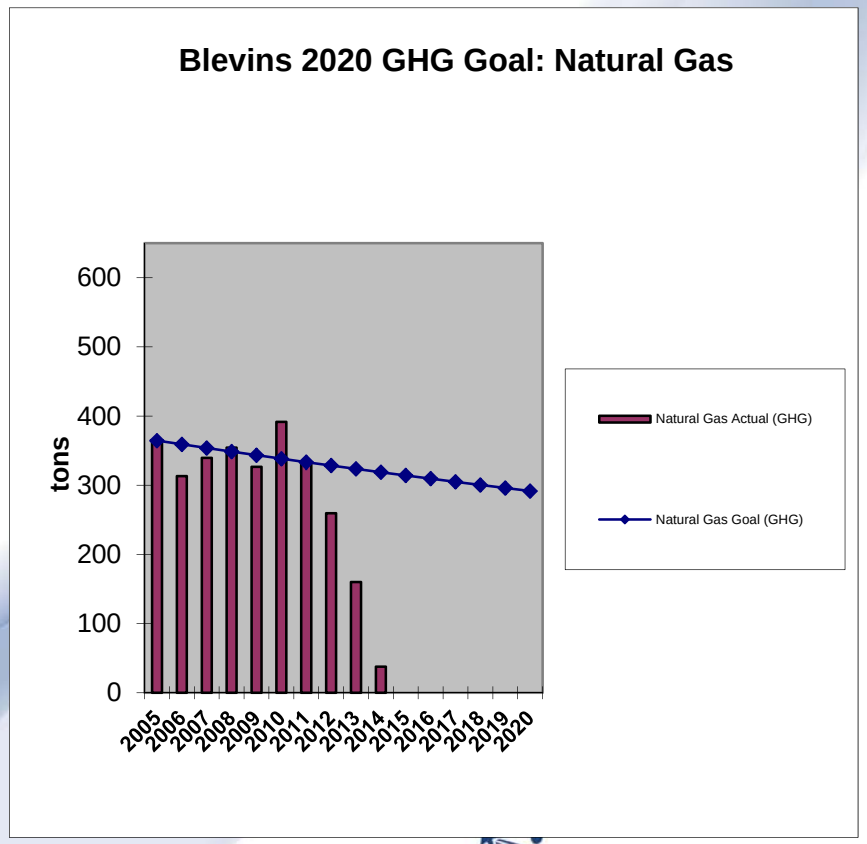
Middle School Examples





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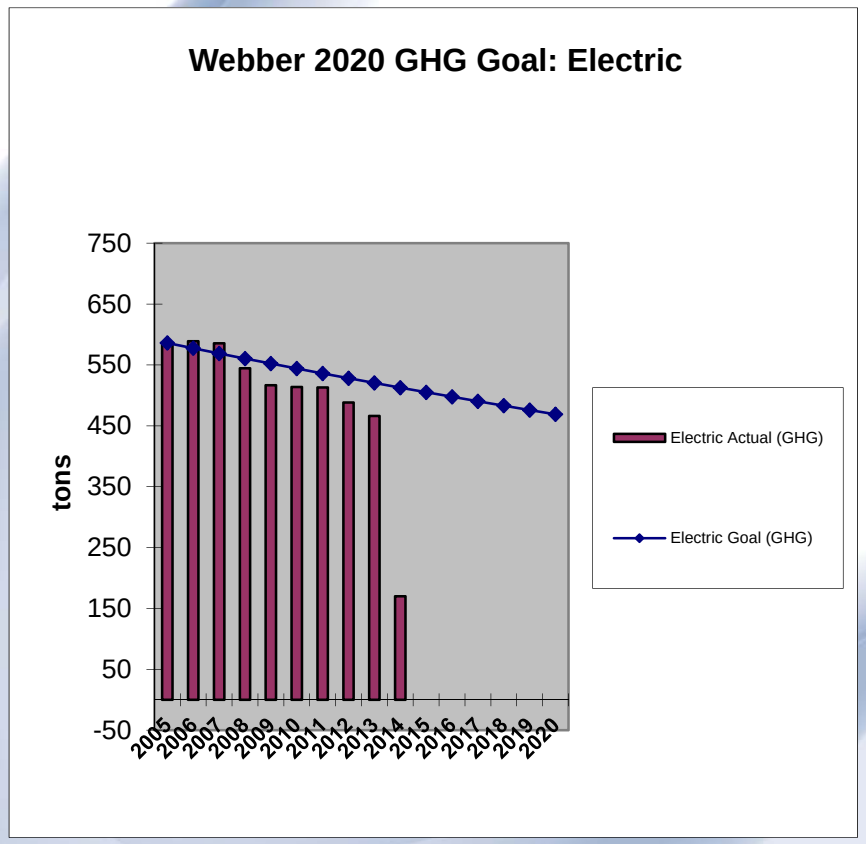
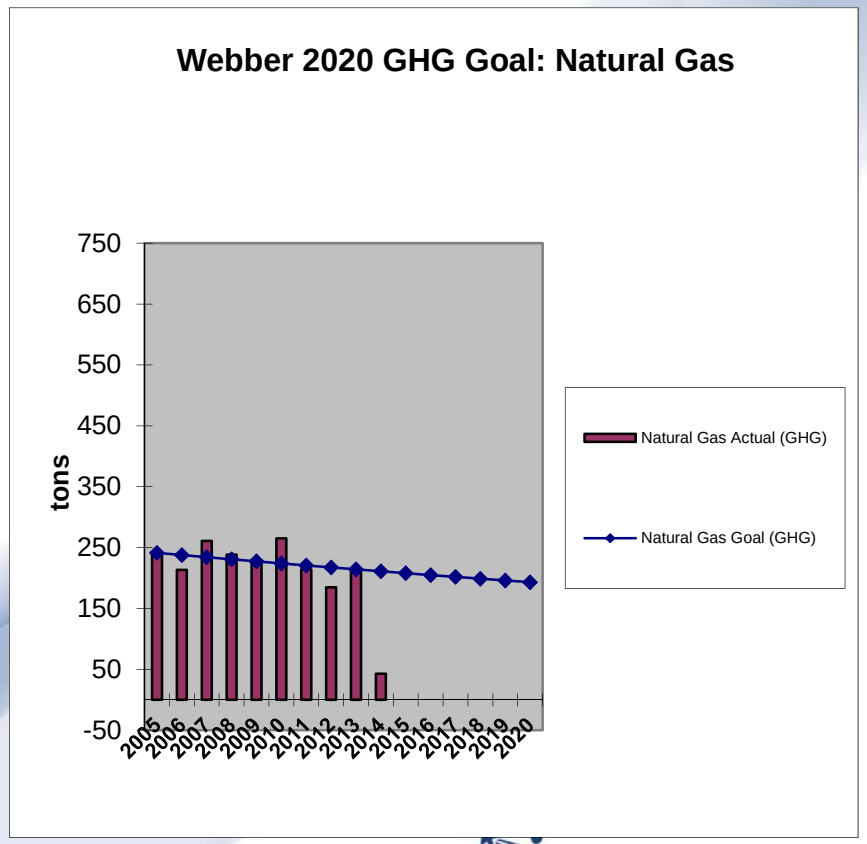
Middle School Examples





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2012 Cost Analysis

2012		Building Envelope	RCx-LCCA-Energy Modeling	Design Cx	Construction Cx	Total	Cost/SF	Design Rebate	Perfomance Rebate	ROI
BLEVINS MS-McKinstry	104,635		$43,947	$16,650	$22,100	$82,697	**$0.79**		$6,662.80	8.1%
BOLTZ MS-AEC	88,000	$24,795	$42,800	$12,000	$30,400	$109,995	**$1.25**		$3,348.70	3.0%
EYESTONE ELEM-McKinstry	65,636	$19,190	$27,568	$15,000	$32,500	$94,258	**$1.44**		$5,807.50	6.2%
FCHS-Eaton	286,552		$51,400	$14,900	$42,200	$108,500	**$0.38**	$19,250	$27,862.00	25.7%
JOHNSON ELEM-McKinstry	56,396	$19,190	$22,600	$12,110	$24,200	$78,100	**$1.38**		$646.30	0.8%
PHS-Eaton	277,413	$39,235	$47,700	$20,400	$67,600	$174,935	**$0.63**	$18,871	$17,443.80	10.0%
RMHS-AEC	291,858	$39,995	$69,700	$10,000	$35,090	$154,785	**$0.53**	$19,593	$4,419.50	2.9%
SHEPARDSON ELEM-Eaton	48,812	$19,190	$28,500	$12,400	$24,400	$84,490	**$1.73**		$2,138.60	2.5%
TAVELLI ELEM-AEC	63,927	$19,380	$39,500	$12,000	$27,400	$98,280	**$1.54**		$6,428.60	6.5%
WEBBER MS-Eaton	124,227	$24,985	$36,800	$14,500	$31,300	$107,585	**$0.87**	$11,211	$8,851.60	8.2%
WERNER ELEM-McKinstry	53,180		$21,100	$12,110	$20,100	$53,310	**$1.00**		$294.00	0.6%
2012 Total	1,460,636	$205,960	$431,615	$152,070	$357,290	$1,146,935		$68,925	$83,903	
						$1,146,935			$152,828	13.3%

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Fort Collins 2014 Utilities Rebate Criteria

Building Performance Goal

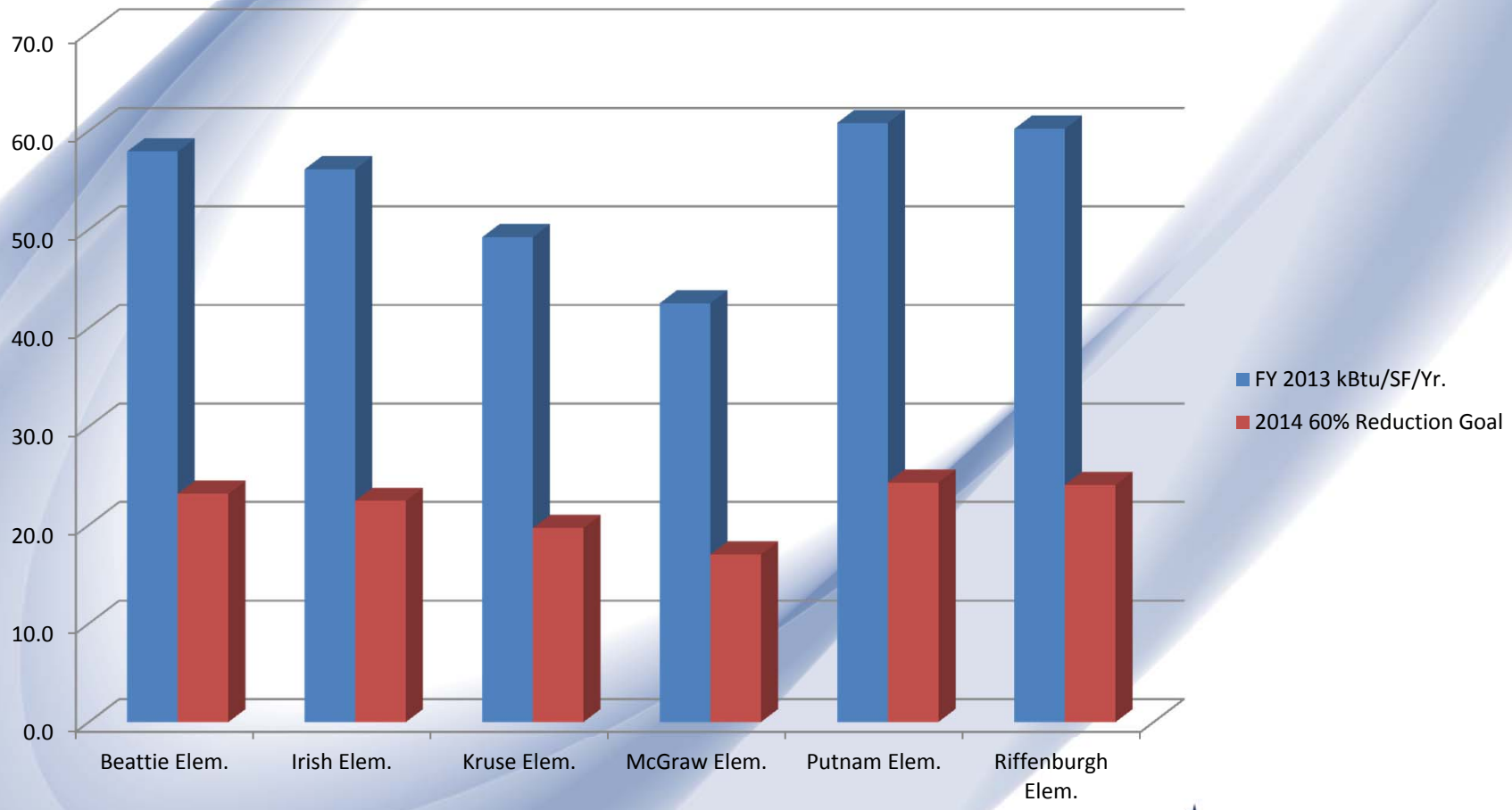
- Based on Architecture 2030 Challenge®
  - Target EUI percent below regional median for project building type:
    - 60% now through 2014
    - 70% in 2015
    - 80% in 2020
    - 90% in 2025
    - Carbon-neutral in 2030, using no fossil fuel GHG (greenhouse gas) emitting energy to operate
  - Final target approved by IDAP Manager
- Target EUI set based on completion date of 100% CDs and construction has to be complete within 2 years of the design

Fort Collins 2014 Utilities Rebate Criteria

Table 2-1: Examples of New Construction/Major Renovation Energy Efficiency Measures

Category	Measure	
Envelope	Continuous air barrier Improved wall insulation High efficiency glazing	Improved roof insulation Cool roof
Lighting	High efficiency fixtures (Interior) Lower ambient lighting levels Highly reflective ceiling	Occupancy sensors Efficient exterior lighting fixtures
Daylighting	Light conveyors Interior/exterior light shelves Sloped ceiling Reflective ceiling	Stepped daylighting controls Dimming daylighting controls Skylights/roof monitors Tuned glazing
HVAC Systems	High efficiency chiller High efficiency boiler Water side economizer Ground-source heat pump Water-source heat pump Variable refrigerant flow heat pumps Building thermal mass Point-of-use domestic hot-water heaters	Evaporative cooling technologies VFDs on pumps and cooling tower fans Infrared heating Displacement ventilation Radiant heating/cooling Natural ventilation Chilled beams High efficiency refrigeration equipment
On-site renewable systems	Onsite micro-wind Photovoltaic solar	Solar water heating
Passive design strategies	External overhangs Building orientation Low pressure drop duct & piping design	Optimizing window to wall ratio Trees for shading and wind protection

2014 Bond Project Energy Performance Goals



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Lessons Learned to Date

- Never try to renovate 1.4 million SF in one summer!
- Tight summer construction window has created several issues.
- Adequate budgets to include preliminary design activities.
- Adequate budgets for energy efficiency and Cx.
- Setting design goals to meet rebate opportunities.
- Could be a great example for 3rd party financing or a performance contract to enhance budgets and performance.
- Construction delivery method changed from DBB to CMGC model for this summer.
- We most likely won't touch these schools at this scale for another 20 years-missed opportunities!

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“Eating your energy efficiency vegetables before enjoying your renewable energy dessert”

Discussion & Questions?? ☺

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