Energy Efficiency / Renewable Energy (EE/RE) Projects in Texas Public Schools

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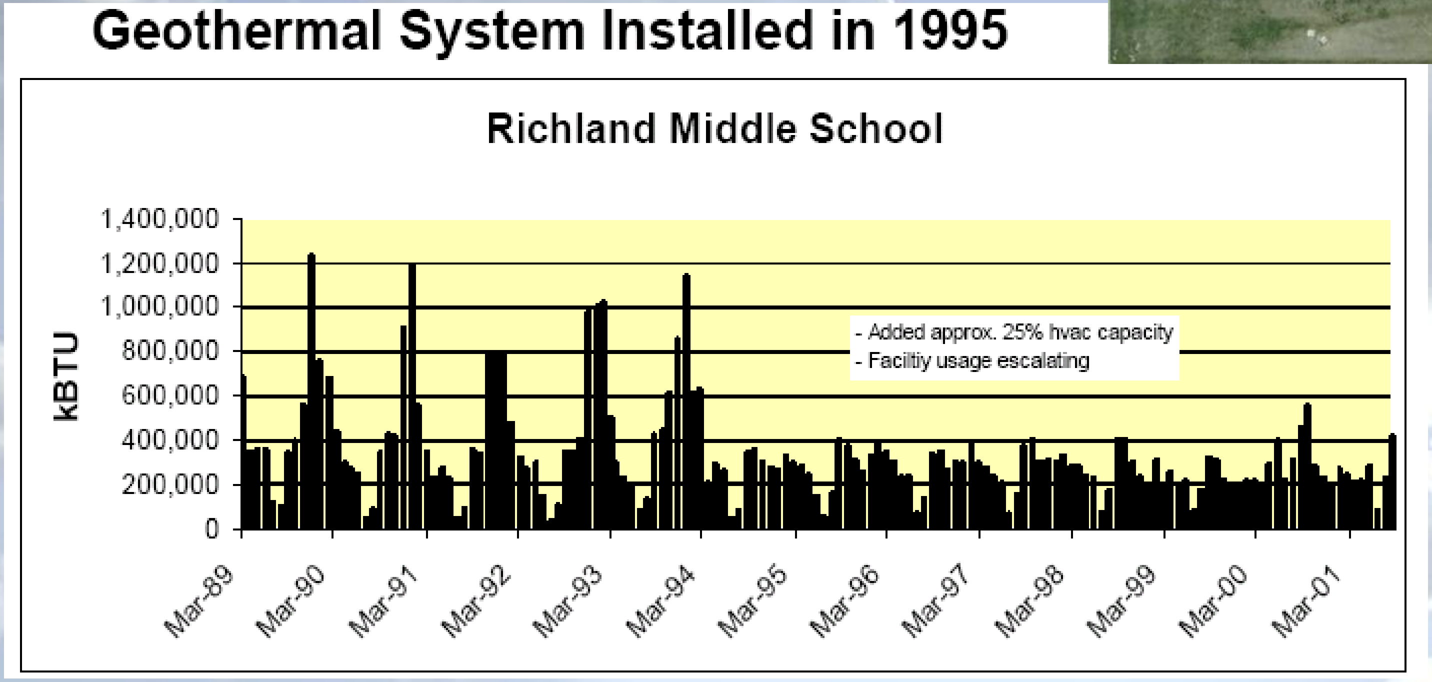
Why care about energy efficiency-renewable energy in schools?

- Lower energy costs
- May help avoid tax hikes, may provide more funds for instruction
- Cushions the district from any future energy price “shocks” or shortages
- SB 300 requires ISD energy plans
- May be able to obtain assistance grants or low-cost loans
- Reduces air pollutants, particularly ozone and greenhouse gases

Energy efficiency and renewable energy in schools – Texas ISDs are already doing great things

Birdville ISD: ground source heat pumps



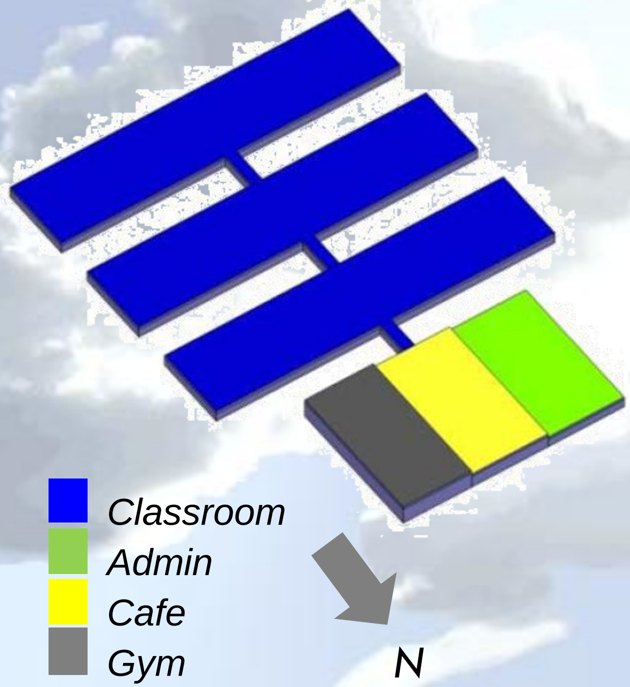
More great Texas examples…

Irving ISD:
Nation's largest net-zero energy school

- ***Geothermal air conditioning and heating***
- ***Solar photovoltaic panels***
- ***Wind turbine devices***
- ***Efficient thermal envelope***
  (high levels of insulation for walls and roof
- ***Daylight harvesting and light shelves***
- ***Energy efficient lighting and kitchen equip***
- ***Reduced plug load for computers***

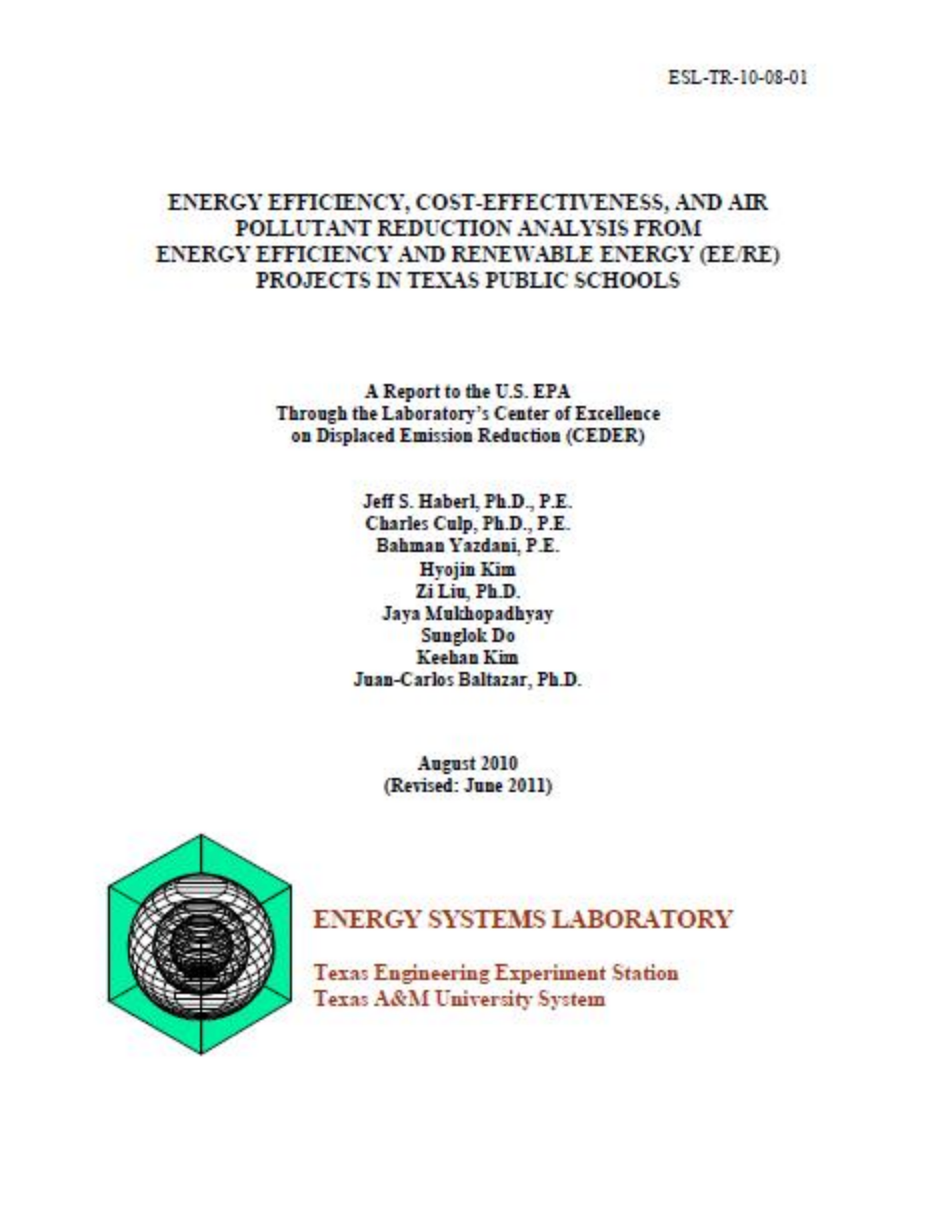
Background

- Texas A&M University's Energy Systems Lab, under contract from EPA, modeled 18 different ee/re measures for schools throughout Texas, by climate zone.
- It assumed a 79,430 sq. ft. 1-story primary school in the modeling
- Looked at both retrofitting and new construction
- Outputs: Electricity, gas, and total energy savings; initial costs and payback periods for retrofits; initial costs and payback periods for those features in new construction; also, air pollution emissions savings



Background

- Results published in Report now available from Texas A&M University's Energy Systems Lab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ENERGY EFFICIENCY, COST-EFFECTIVENESS, AND AIR POLLUTANT REDUCTION ANALYSIS FROM ENERGY EFFICIENCY AND RENEWABLE ENERGY (EE/RE) PROJECTS IN TEXAS PUBLIC SCHOOLS

A Report to the U.S. EPA
Through the Laboratory's Center of Excellence
on Displaced Emission Reduction (CEDER)

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ENERGY SYSTEMS LABORATORY

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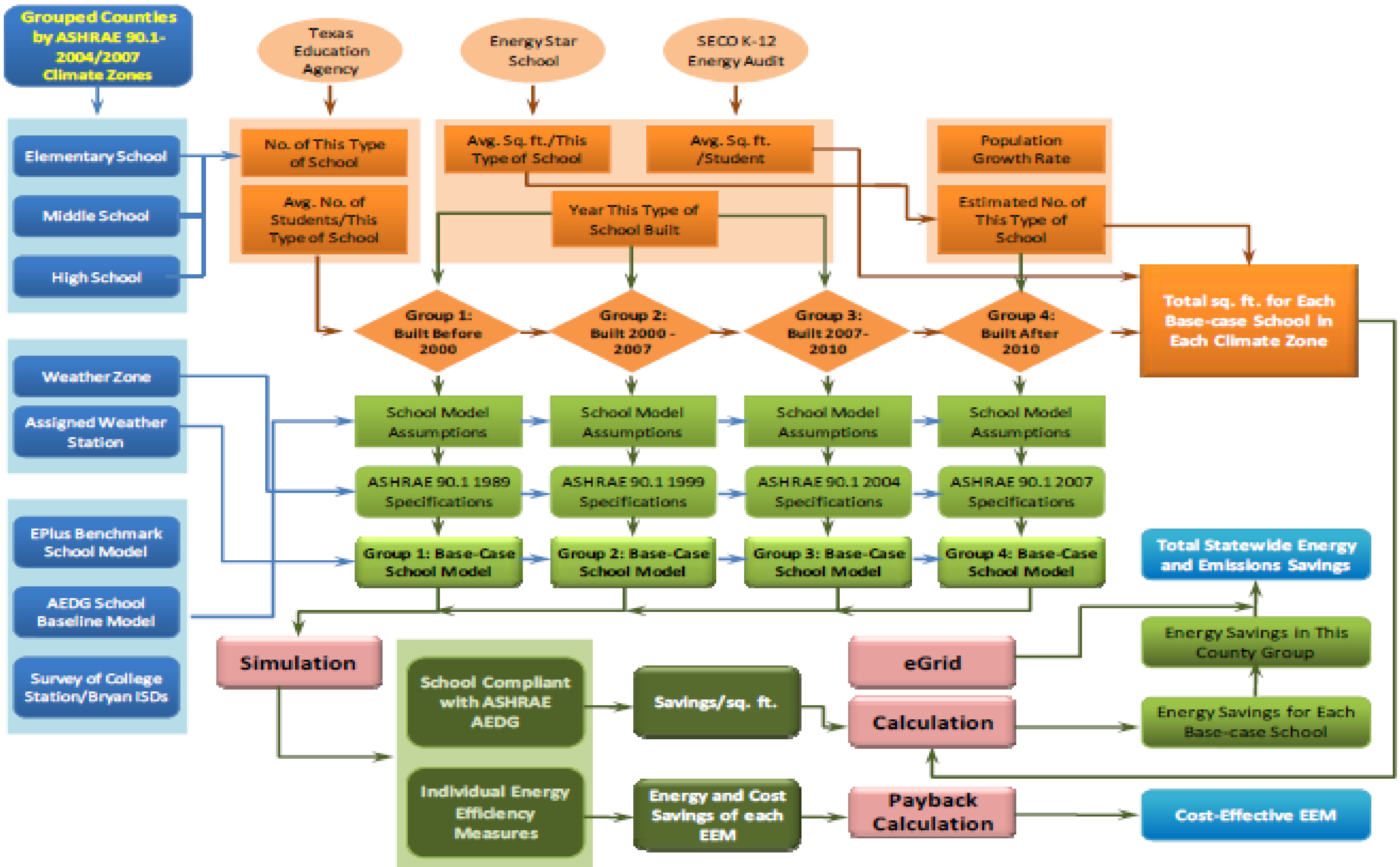
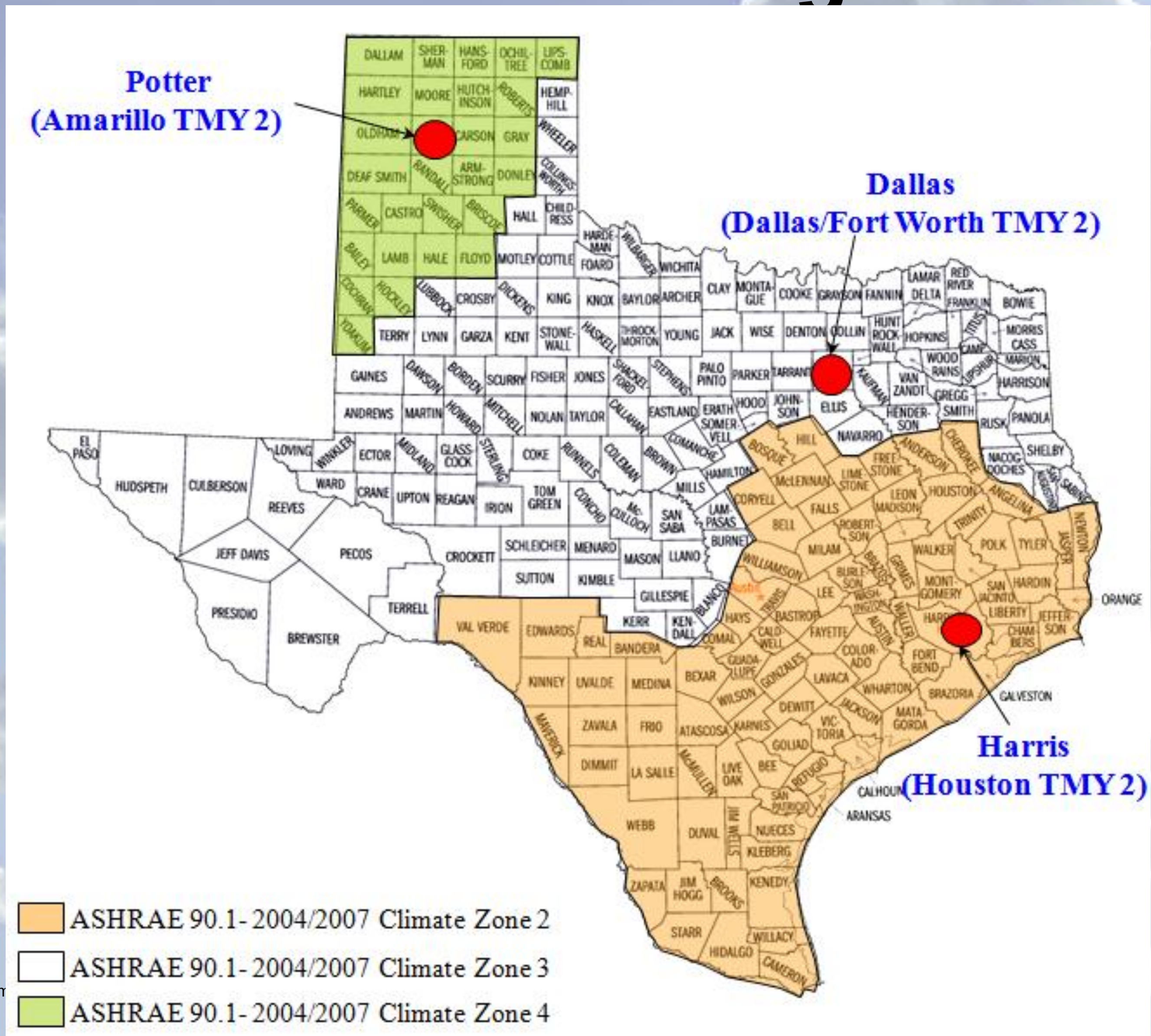
Analysis Methodology



Texas climate zones used in the modeling



18 EE/RE Measures

Envelope

- Increased Roof Insulation
- Decreased Glazing U-Value
- Decreased Infiltration

Lighting

- Decreased Lighting Power Density
- Occupancy Sensor for Lighting Control
- Daylight Dimming Controls
- Skylights

DHW

- Improved DHW Heater Efficiency
- Tankless Water Heater

HVAC System

- OA Demand Control
- Improved AC Efficiency (EER)
- Improved Heating System Efficiency
- Decreased Supply Fan Power Consumption
- PVAVS with VFD for Fan Control
- PVAVS with Variable Speed for HW Pump

Renewable

- Solar PV
- Solar DHW
- Ground Source Heat Pump

BASE-CASE SCHOOL MODEL

Characteristics of Base-Case Model

The following characteristics were used for the base-case school model:

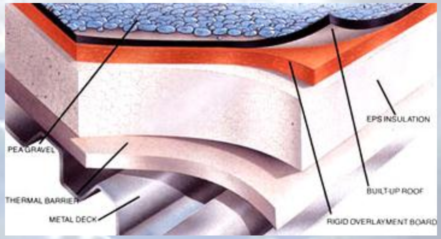
- **Building Envelope**
  - 1-story, 79,430 ft^2
  - 10% WWR
- **Space Condition**
  - Heating: 70 F (60.8 F setback)
  - Cooling: 77 F (87.8 F setup)
- **HVAC System Characteristics**
  - 30 ton PVAVS for Classrooms
  - 10 ton PSZ for Admin/Café/Gym
  - 80% eff. gas boilers and furnaces
- **DHW System Characteristics**
  - Two Gas Storage Water Heaters

Characteristics	Assumptions			Information Source
	Harris County (Climate Zone 2)	Dallas county (Climate Zone 3)	Potter county (Climate Zone 4)	
Building				
Building Type	Primary School			
Gross Area (sq. ft.)	79,430			TEA Survey: Primary School
Number of Floors	1			EnergyPlus Benchmark
Ceiling-to-Floor Height (ft.)	10 ft (Classroom, Admin, Café, Gym)			EnergyPlus Benchmark
Orientation	South facing			
Construction				
Wall Construction	Steel-Framed with 4" studs spaced at 16" on center			EnergyPlus Benchmark
Roof Configuration	Flat built-up, Insulation entirely above deck			EnergyPlus Benchmark
Foundation Construction	4" Concrete slab-on-grade floor			EnergyPlus Benchmark
Wall Absorptance	0.55			DOE 2.1E BDL SUMMARY, Page 12
Wall Insulation (hr-sq.ft.-°F/Btu)	R-13			ASHRAE 90.1-1999 Appendix B
Roof Absorptance	0.7			ASHRAE 90.1-1999 11.4.2
Roof Insulation (hr-sq.ft.-°F/Btu)	R-15 ci			ASHRAE 90.1-1999 Appendix B
Slab Perimeter Insulation	None			ASHRAE 90.1-1999 Appendix B
Ground Reflectance	0.24			DOE 2.1E BDL SUMMARY, Page 20
U-Factor of Glazing (Btu/hr-sq.ft.-°F)	1.22		0.57	ASHRAE 90.1-1999 Appendix B
Solar Heat Gain Coefficient (SHGC)	0.25	0.39		ASHRAE 90.1-1999 Appendix B
Window Area	10% Window to wall ratio			Bryan/College Station School Survey
Exterior Shading	None			ASHRAE 90.1-1999 11.4.2
Space Conditions				
Space Heating Set point	70 F(Occupied), 60.8 F(Unoccupied)			EnergyPlus Benchmark
Space Cooling Set point	77 F(Occupied), 87.8 F(Unoccupied)			
Lighting Power Density (W/ft^2)	1.5			ASHRAE 90.1-1999 Table 9.3.1.1
Equipment Power Density (W/ft^2)	1.06			AEDG
Mechanical Systems				
HVAC System Type	PVAVS: Classroom PSZ: Admin/Café/Gym			EnergyPlus Benchmark
Air Conditioning System Efficiency	PVAVS: 9.5 EER PSZ: 10.3 EER			ASHRAE 90.1-1999 Table 6.2.1A
Heating System Efficiency (%)	80%			ASHRAE 90.1-1999 Table 6.2.1F
Cooling Capacity (Btu/hr)	Autosized			
Heating Capacity (Btu/hr)	Autosized			
Economizer	No			ASHRAE 90.1-1999 6.3.1
Ventilation	15 % of design flow			
Supply Air Flow (cfm/sq.ft)	Classroom: 1.00 cfm/sq.ft. Admin: 1.03 cfm/sq.ft. Cafe: 1.69 cfm/sq.ft. Gym: 1.72 cfm/sq.ft.			Simplified School Model (Im 2009)
Supply Fan Power (hp/1000cfm)	PVAVS: 1.7 hp/1000cfm PSZ: 1.2 hp/1000cfm			ASHRAE 90.1-1999Table 6.3.3.1
DHW System Type	Two gas storage water heaters (125 gallon, 199,000 Btu/hr)			EnergyPlus Benchmark
DHW Heater Efficiency (%)	80 % Et			ASHRAE 90.1-1999Table 7.2.2
DHW Temperature Setpoint (F)	140 F			EnergyPlus Benchmark

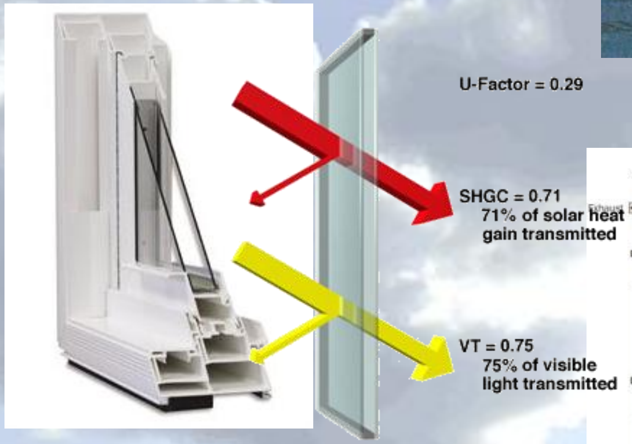
18 EE/RE MEASURES

18 EE/RE measures were simulated. These include measures for the building envelope, lighting, HVAC, DHW, and renewable energy systems.

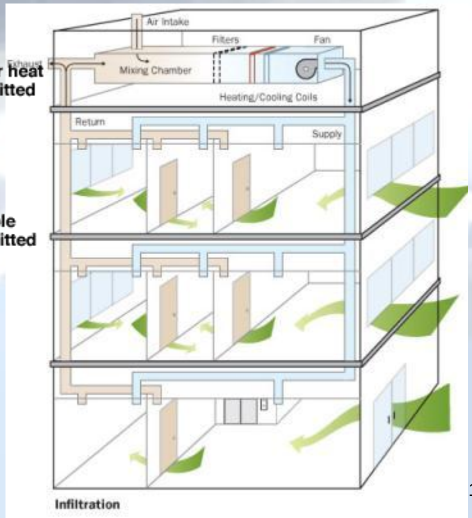
Envelope Energy Efficiency Measures



1) **Increased Roof Insulation**
   - Installs higher level of roof insulation for efficient thermal envelope



2) **Decreased Glazing U-Value**
   - Selects lower U-value glazing



3) **Decreased Infiltration**
   - Improves air tightness of building envelope
   - Minimizes thermal bridging (e.g., continuous insulation)
   - Uses air barriers

18 EE/RE MEASURES

Lighting Energy Efficiency Measures

4) Decreased Lighting Power Density
- Uses T8 lamps instead of T12

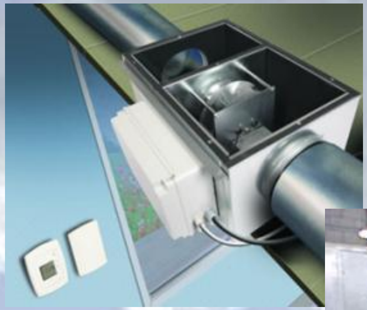
5) Occupancy Sensor for Lighting Control
- Utilizes occupancy sensors for indoor lighting controls

6) Daylight Dimming Controls
- Adjusts lighting levels by the level of daylight detected using photo sensors

7) Skylights
- Skylights in the cafeteria and gymnasium

18 EE/RE MEASURES

HVAC System Energy Efficiency Measures (1/2)



8) **OA Demand Control**
   - Utilizes CO_2 sensors to ventilate the building by actual occupancy

9) **Improved AC Efficiency (EER)**
   - High EER rating AC (e.g.10.6 EER PVAVs & 12.2 EER PSZ systems)

10) **Improved Heating System Efficiency**
   - Higher than 90% AFUE
   - Condensing boilers

18 EE/RE MEASURES

HVAC System Energy Efficiency Measures (2/2)

11) Decreased Supply Fan Power Consumption
- Low power consumption supply fan

12) PVAVS with VFD for Fan Control
- Variable speed control for fans using Variable Frequency Drives (VFDs)

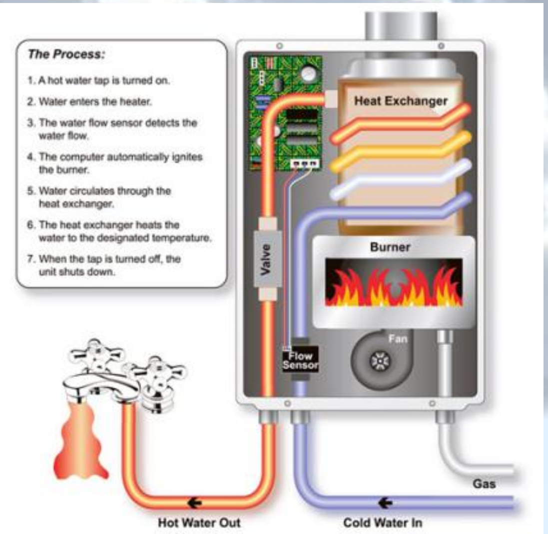
13) PVAVS with Variable Speed for HW Pump
- Variable speed control for hot water pumps using Variable Frequency Drives (VFDs)

18 EE/RE MEASURES

DHW Energy Efficiency Measures

14) Improved DHW Heater Efficiency
- Higher than 95% thermal efficiency
- Condensing water heater

15) Tankless Water Heater
- Provides hot waters as needed
- Eliminates standby energy losses



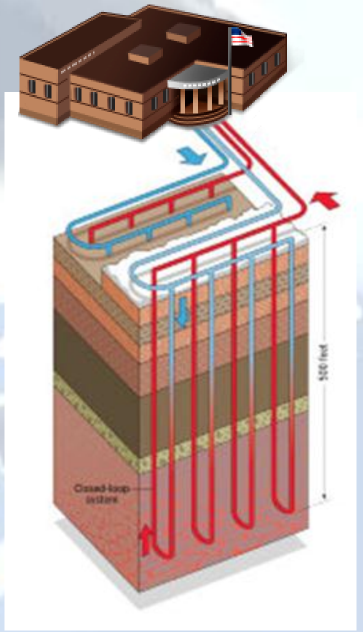
18 EE/RE MEASURES

Renewable Energy Efficiency Measures

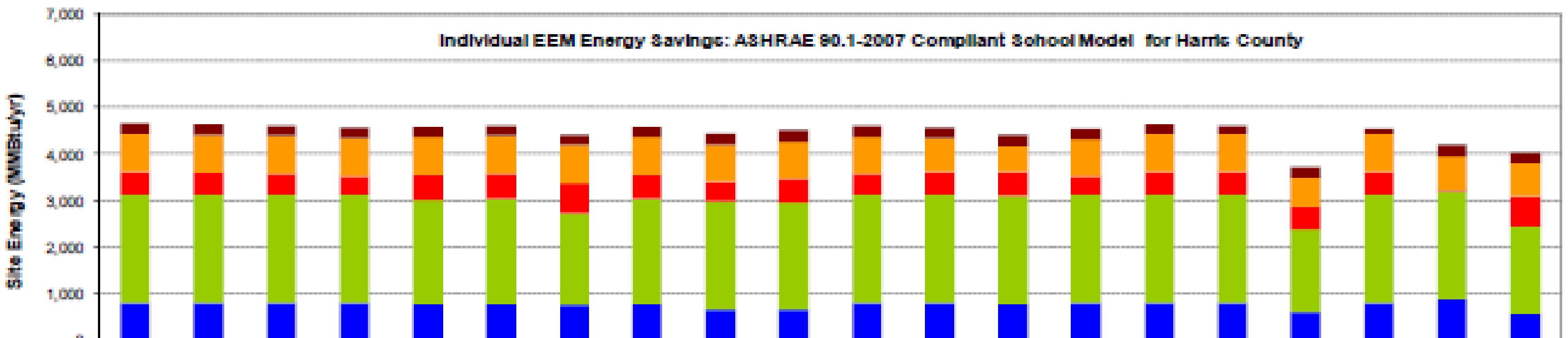
16) Solar PV
- Simple sustainable energy technology
- Converts sunlight into electricity

17) Solar DHW
- Converts sunlight into useful thermal energy for water heating systems

18) Ground Source Heat Pump
- Pumps heat from/to the ground
- Utilizes constant ground temperature
- Provides both heating and cooling



Individual ECRMs Studied vs Basecase

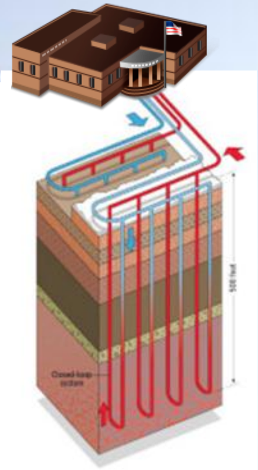


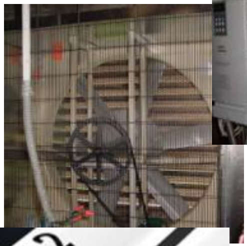
	Base Case (2007)	Increased Roof Insulation	Decreased U-Value	Decreased Infiltration	Decreased LPD	Occupancy Sensor	Daylight Dimming	Skylights	OA Demand Control	Improved AC Eff.	Improved Heating System Eff.	Decreased Fan Power	PVAVS with VFD	HW Pump with VSD	Improved DHW Heater Eff.	Tankless Water Heater	Solar PV	Solar DHW	GSHP	AEDG
Total	4,648	4,631	4,606	4,555	4,587	4,598	4,415	4,576	4,423	4,498	4,596	4,559	4,400	4,530	4,620	4,593	3,702	4,528	4,185	4,012
DHW	225	225	225	225	225	225	225	225	225	225	225	225	225	225	197	170	225	105	225	205
Fans+Pumps	816	814	814	812	817	817	833	817	810	816	816	727	575	806	816	816	620	816	737	734
Heating	493	479	451	405	536	536	643	516	416	493	441	493	512	385	493	493	493	493	18	639
Lgt+Appl	2,328	2,328	2,328	2,328	2,229	2,241	1,973	2,241	2,328	2,328	2,328	2,328	2,328	2,328	2,328	2,328	1,768	2,328	2,328	1,879
Cooling	786	785	789	785	779	779	740	777	643	636	786	786	760	786	786	786	597	786	877	556

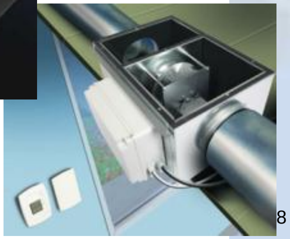
Figure 8. Energy Use of Individual EE/RE Measures for ASHRAE 90.1-2007 Compliance Base-Case School: Harris County (Climate Zone 2)

Some Notable Highlights for Retrofitting – Dallas climate zone

Measure	*Initial Cost*	*% Energy Savings*	*Payback Period*
Solar PV	$1,679,333	21.0%	36 years
Ground source heat pump	$120,000	11.2%	25 years
Daylighting control	$85,085	6.0%	4.4 years
Variable frequency drive in fan control	$39,780	5.5%	3.0 years
Lighting upgrade – change out fixtures and ballast from T12 to T8	$79,430	5.0%	4.7 years
Demand control ventilation	$37,360	4.4%	6.3 years

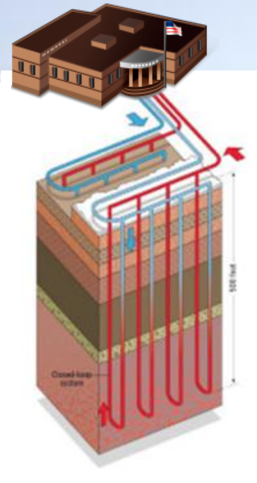


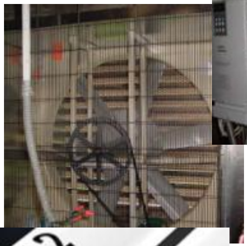


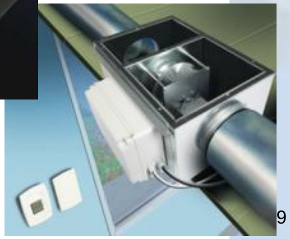


Some Notable Highlights for Retrofitting – Houston climate zone

Measure	*Initial Cost*	*% Energy Savings*	*Payback Period*
Solar PV	$1,679,333	18.8%	40 years
Ground source heat pump	$120,000	7.6%	80 years
Daylighting control	$85,085	6.6%	4.2 years
Variable frequency drive in fan control	$39,780	5.6%	3.1 years
Lighting upgrade – change out fixtures and ballast from T12 to T8	$79,430	5.4%	4.6 years
Demand control ventilation	$37,360	4.6%	5.0 years

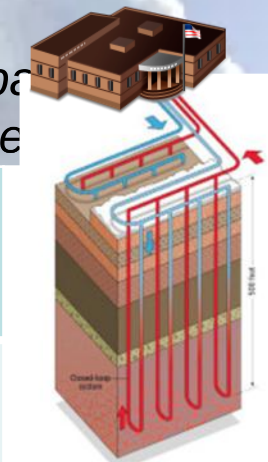


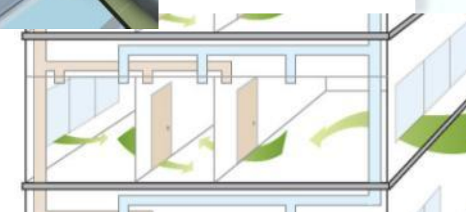




Some Notable Highlights for Retrofitting – Amarillo climate zone

Measure	*Initial Cost*	*% Energy Savings*	*Payba Pe*
Ground source heat pump	$120,000	24.2%	12 years
Solar PV	$1,679,333	20.0%	33 years
Demand control ventilation	$37,360	9.2%	6.7 years
Decreased infiltration	$16,250	5.8%	3.6 years
Variable frequency drive in fan control	$39,780	4.3%	2.9 years
Decreased supply fan power consumption	$17,500	3.3%	2.0 years





Summary

- If all the EE measures recommended in the ASHRAE AEDG for K-12 Schools were installed in new and existing schools, savings would be over 10.5 million MMBTUs/year and 2.2 million tons/year of CO_2 emissions.
- The shortest payback periods (2.0 to 3.2 years for existing schools; 0 to 4.5 for new schools) from decreased supply fan power, tankless water heater, VFD for fan control, and VFD for hot water pumping.
- The second shortest payback periods (4.2 to 5.8 years for existing schools; 3.1 to 7.5 for new schools) from lighting measures, including decreased lighting power density, occupancy sensor for lighting control, daylight dimming controls.

Summary

- For new school buildings, short payback periods were also expected from improved AC efficiency (1.6 to 2.8 years) and improved DHW efficiency (3.1 to 3.3 years).
- Renewable energy options (solar photovoltaics, ground source heat pumps) resulted in the highest annual energy savings.
- The lowest initial costs were from variable speed drive for hot water pumping, tankless water heater, solar hot water heaters, and improved DHW efficiency.

Questions?

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