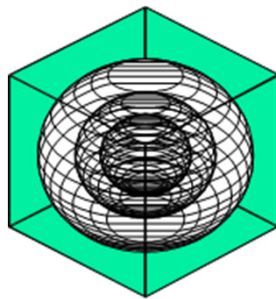


**COST-EFFECTIVE ENERGY EFFICIENCY MEASURES FOR  
ABOVE CODE (ASHRAE 90.1-2001 and 2007)  
RESTAURANT BUILDINGS IN THE CITY OF ARLINGTON**

**A Research Project for the City of Arlington**

**October 2011**



**ENERGY SYSTEMS LABORATORY**

**Texas Engineering Experiment Station  
Texas A&M University System**

# Background

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- ▶ Results of the current project: Recommendations of 18 energy efficiency measures (EEMs) to maximize energy savings for restaurant buildings in the CoA with
  - ▶ estimated cost of the improvement,
  - ▶ simple payback calculations, and
  - ▶ emissions savings.



# Methodology

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- ▶ ESL simulation model based on the DOE-2.2 of ASHRAE 90.1-2001 and 2007 code-compliant, restaurant building for Tarrant County
- ▶ A total of 18 energy efficiency measures (EEMs) for ASHRAE 2001 base-case
- ▶ A total of 16 energy efficiency measures (EEMs) for ASHRAE 2007 base-case
- ▶ Implementation costs of each measure with simple payback

# Methodology

- ▶ 5,500 ft<sup>2</sup>, one-story, building – Dining space modeled (4,000 ft<sup>2</sup>)
- ▶ Steel frame construction
- ▶ 35% WWR for front wall only (17% WWR for an entire building)
- ▶ Packaged rooftop air conditioner (CAV, DX, gas furnace)

PARAMETER	BASE-CASE CODES		REFERENCE
	ASHRAE 2001	ASHRAE 2007	
<b>Building Envelope</b>			
Area	5500 sqft For Dining: 4000 sqft For Kitchen: 1500 sqft		a) DOE Reference FSR Building (1) b) EPLUS file, Deru et al. 2011 c) College Station Restaurant Survey
Orientation	Facing South		No reference
Aspect Ratio	1:1.5		College Station Restaurant Survey
Floor to Floor Height	14 ft		Figure 2.6, Zhang et al (2010)
Floor to Ceiling Height	14 ft		Figure 2.6, Zhang et al (2010)
Roof Construction	Flat w/o Plenum		a) Zhang et al. (2010) b) College Station Restaurant Survey
	Continious Rigid Insulation over Metal Deck		College Station Restaurant Survey
	R-15 c.i.	R-20 c.i.	ASHRAE 90.1 2001 Table 5.5-3, ASHRAE 90.1 2007
Roof Exterior Material	Solar Reflectance: 0.3 (Abs: 0.7)	Solar Reflectance: 0.7 (Abs: 0.3)	ASHRAE 90.1 2001 Table 11.3.1, ASHRAE 90.1 2007
Wall Construction	Exterior Stucco Cladding Steel Framed 16 in o.c. Batt Insulation Gypsum Board		Table 18, Deru et al. 2011
	R-13	R-13 + R-3.8 c.i.	ASHRAE 90.1 2001 Table 5.5-3, ASHRAE 90.1 2007
Floor Construction	Slab-on-Grade 4 in. Concrete Slab Ceramic tile / Stone Floor		EPLUS file, Deru et al. 2011
Window to Wall Area Ratio (WWR)	17% East: 16.7% North: 0% West: 16.7% South: 35%		a) Deru et al. 2011
	Kitchen zone has no windows		
Window Specs	U-value: 1.22 (All other metal framing)	U-value: 0.65 (All other metal framing)	ASHRAE 90.1 2001 Table 5.5-3, ASHRAE 90.1 2007
	SHGC: 0.25 SHGC north: 0.61	SHGC: 0.25	ASHRAE 90.1 2001 Table 5.5-3, ASHRAE 90.1 2007
<b>Space Conditions</b>			
Number of People	Dining: 15 sqft/person		For Dining: Table 4, Deru et al. (2011), ASHRAE 62.1 (70 people / 1000 sqft)
Outside Air	Dining: 20cfm/person 5350 cfm	Dining: 7.5 cfm/person+0.18cfm/sqft 2720 cfm	ASHRAE 62.1 2001 ASHRAE 62.1 2007
Air Infiltration Rate	0.161 ACH for occupied periods 0.322 ACH for unoccupied periods		Sec 3.2.2.5, Hale et al. 2008
Thermostat Setpoint	70F Heating 75 F Cooling Setback during unoccupied hours. Optimal start control one hour before occupied hours. 65F Heating 80 F Cooling		Sec 13.7.6.2 ASHRAE 90.1 1989 Standard Practice
<b>Interior Lighting</b>			
Interior Lighting Building area method. Family Dining	1.9 W/sqft	1.6 W/sqft	ASHRAE 90.1 2001 Table 9.5.1 ASHRAE 90.1 2007

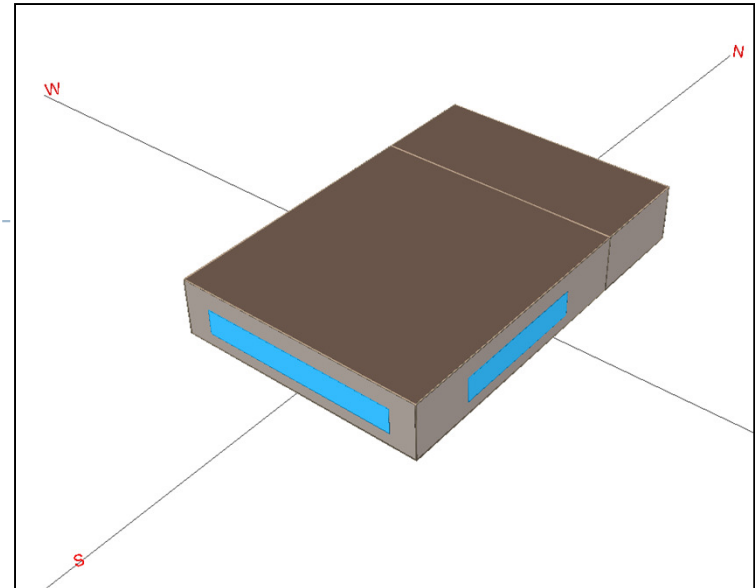
# Methodology

- ▶ 5,500 ft<sup>2</sup>, one-story, building – Dining space modeled (4,000 ft<sup>2</sup>)
- ▶ Steel frame construction
- ▶ 35% WWR for front wall only (17% WWR for an entire building)
- ▶ Packaged rooftop air conditioner (CAV, DX, gas furnace)

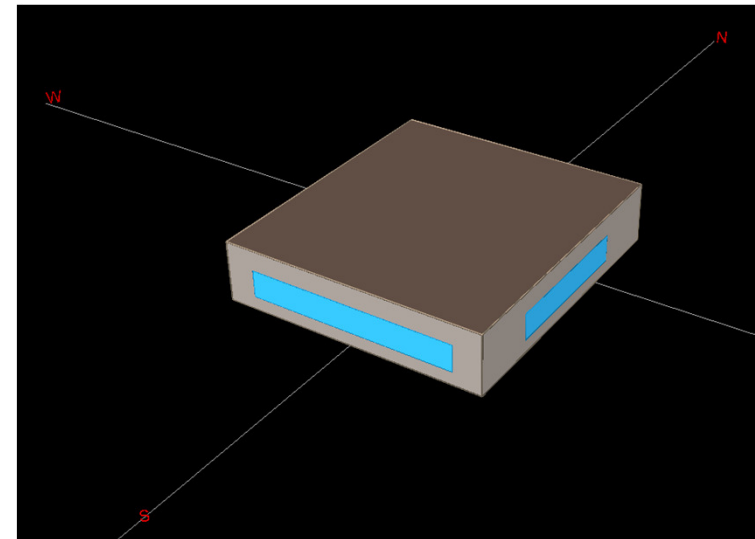
PARAMETER	BASE-CASE CODES		REFERENCE
	ASHRAE 2001	ASHRAE 2007	
<b>Exterior Lighting</b>			
Parking Lots	N.A	0.15 W/sqft	Table 9.4.5 ASHRAE 90.1 2007
Façade & Landscape Lighting	0.25 W/sqft	0.2 W/sqft	Section 9.3.2 ASHRAE 90.1 2001
Building Entrance (w/o canopy) Building Exit	33W/lin ft of door 20W/lin ft of door	30 W/ft of door width 20 W/ft of door width	Table 9.3.2 ASHRAE 90.1 2001 Table 9.4.5 ASHRAE 90.1 2007
Extra Power Allowance	N.A	5%	Section 9.4.5 ASHRAE 90.1 2007
<b>Equipment</b>			
Electric Equipment in Dining Space	5.625 W/sqft		Table 9, Deru et al., 2011
<b>HVAC Systems</b>			
Zoning	Dining zone		a) DOE Reference FSR Building (1) b) EPLUS file, Deru et al. 2011 c) College Station Restaurant Survey
HVAC System Type	Packaged single zone units w/ gas fired furnace		
HVAC Efficiency	≥240,000 Btu/hr and < 760,000 Btu/hr 9.3 EER Heating: ≥225,000Btu/hr 80% Ec	≥135,000 Btu/hr and < 240,000 Btu/hr 10.8 EER Heating: ≥225,000Btu/hr 80% Ec	For cooling: Table 6.2.1A, ASHRAE 90.1 2001 For heating: Table 6.2.1E, ASHRAE 90.1 2001 For cooling: Table 6.8.1B, ASHRAE 90.1 2007 For heating: Table 6.8.1E, ASHRAE 90.1 2007
HVAC Fan Specifications	Static pressure : 2.5 in-wc Fan efficiency: Overall Eff: 55% (Motor eff. @1800rpm: 87.5)		Sec 3.4.6 Zhang et al. (2010) Used by ASHRAE 90.1 SSPC to develop fan power requirements for the standard. Common design practice.
Economizer	N.A		
Demand Control Ventillation	N.A	Required as per code	Section 6.4.3.9, ASHRAE 90.1 2007
<b>Service Hot Water</b>			
Service Hot Water	Peak Hot Water Flow Rate - 133 gal/hr (4)		Table 9, Deru et al. (2011)
	Storage Type Water Heater - 100 gallon (5)		
	Thermal Eff. >75,000 Btu/hr Et: 80%		ASHRAE 90.1 2001 Table 7.8, ASHRAE 90.1 2007

# Methodology

- ▶ Dining space modeled for assessment of energy efficiency measures



Restaurant: 5,500 ft<sup>2</sup>



Restaurant Model : 4,000 ft<sup>2</sup>

# Methodology

- ▶ 18 EEMs for envelope and fenestration, HVAC System, service hot water (SHW) system, and lighting measures for ASHRAE 90.1 2001

ASHRAE 2001 BASE-CASE DINING ZONE ONLY		BASE-CASE	EEM	REFERENCE FOR EEM
<b>Envelope</b>				
1	Wall Insulation	R-13	R-13.0+R-7.5 c.i.	AEDG for Climate Zone 3
2	Roof Insulation	R-15 c.i.	R-25 c.i.	AEDG for Climate Zone 3
3	Roof Exterior	Absorptance: 0.7	SRI 78 Absorptance: 0.355	AEDG for Climate Zone 3
4	Window U-value	U-1.22	U-0.35	Specs for Double glazed, Low solar gain, Low-E glass, Argon / Krypton <a href="http://www.efficientwindows.org">http://www.efficientwindows.org</a>
5	Window Re-Distribution	17% East & West: 16.7% South: 35%	17% East & West: 10% South: 55.1%	
6	Window Shading	N.A	10 ft	
7	Window Shading & Redistribution	17% East & West: 16.7% South: 35% NA	17% East & West: 10% South: 55.1% Overhang: 10 ft	
8	Air Barrier	0.322	0.05	Hale et al. 2008
<b>Interior Lighting</b>				
9	Lighting Power Density	1.9 W/sqft	0.89 W/sqft	Table 9.5.1, ASHRAE 90.1 2010 For Family Dining
10	24 Hour Lighting	15%	10%	AEDG for Climate Zone 3
11	Daylighting Control (Sidelighting)	NA	Daylight control for vertical fenestration	Section 4.2.1.4 Zhang et al. 2010
			VT=0.27	Addendum BB (Draft) for ASHRAE 90.1 2007
<b>Exterior Lighting</b>				
12	Parking Lots	-	0.06W/sqft	Table 9.4.6, For Zone 2, ASHRAE 90.1 2010
	Façade & Landscape Lighting	0.25 W/sqft	0.075 W/sqft	AEDG for Climate Zone 3
	Building Entrance (w/o canopy)	33W/ft	20 W/ft of door width	Table 9.4.6, For Zone 2, ASHRAE 90.1 2010
	Building Exit	20W/ft	20 W/ft of door width	
	Extra Power Allowance	-	600 W	Table 9.4.6, For Zone 2, ASHRAE 90.1 2010
	Exterior Lighting Controls	Capable of reducing lighting levels when not in use.	Reduce exterior LPD to 25% (12:00AM - 6:00AM)	AEDG for Climate Zone 3
<b>HVAC Systems</b>				
13	HVAC System Efficiency	≥240,000 Btu/hr and < 760,000 Btu/hr 9.3 EER	≥240,000 Btu/hr and < 760,000 Btu/hr 10.5 EER	AEDG for Retail Buildings (Draft). Recommendations for climate zone 3.
14	Fan Efficiency	55%	65%	Section 4.4.4, Zhang et al. 2010
15	Economizer	NA	Yes Differential Enthalpy	Table 6.5.1.1.3A,B ASHRAE 90.1 2010
16	Furnace Efficiency	Heating: ≥225,000Btu/hr 80% Ec	Heating: ≥225,000Btu/hr 90% Ec	
17	Demand Control Ventilation System (1)	NA	Applied to Dining zone	Title 24, Section 121 (c) Section 6.4.3.9 ASHRAE 90.1 2010
<b>Service Hot Water Systems</b>				
18	Effiicient Water Heaters	Gas 80%	Gas 95%	Section 4.5.1, Zhang et al 2010

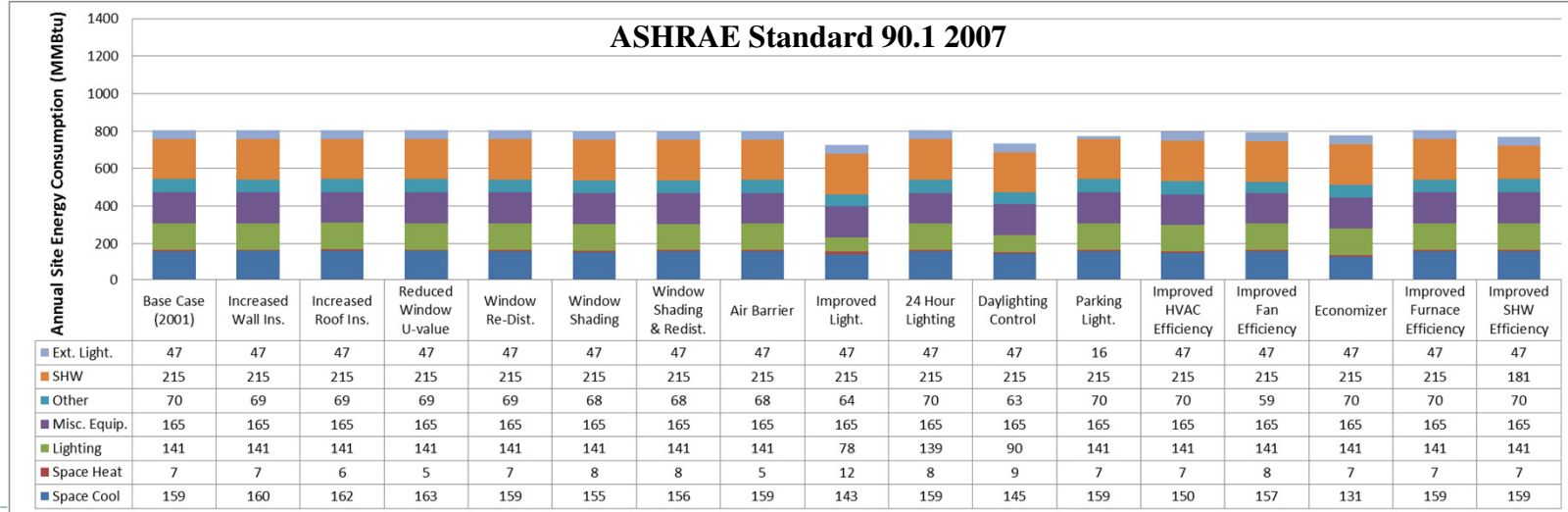
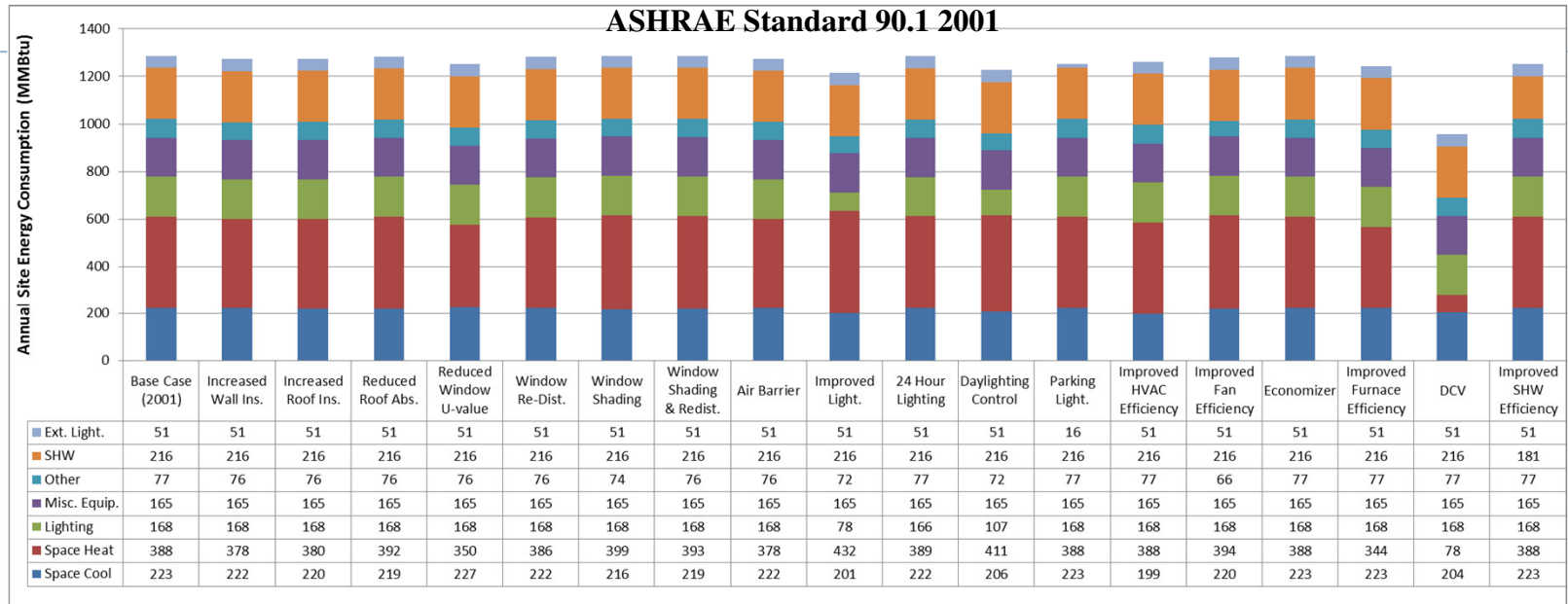
# Methodology

- ▶ 16 EEMs for envelope and fenestration, HVAC System, service hot water (SHW) system, and lighting measures for ASHRAE 90.1 2007

ASHRAE 2007 BASE-CASE DINING ZONE ONLY		BASE-CASE	EEM	REFERENCE FOR EEM
<b>Envelope</b>				
1	Wall Insulation	R-13 + R - 3.8 c.i.	R-13.0 + R-7.5 c.i.	AEDG for Climate Zone 3
2	Roof Insulation	R-20 c.i.	R-25 c.i.	AEDG for Climate Zone 3
3	Window and Door U-value	U-0.65	U-0.35	Specs for Double glazed, Low solar gain, Low-E glass, Argon / Krypton <a href="http://www.efficientwindows.org">http://www.efficientwindows.org</a>
4	Window Re-Distribution	17% East & West: 16.7% South: 35%	17% East & West: 10% South: 55.1%	
5	Window Shading	N.A	PF - 0.5	AEDG for Climate Zone 3
6	Window Shading & Redistribution	17% East & West: 16.7% South: 35% NA	17% East & West: 10% South: 55.1% PF - 0.5	
7	Air Barrier	0.322	0.05	Hale et al. 2008
<b>Interior Lighting</b>				
8	Lighting Power Density	1.6 W/sqft	0.89 W/sqft	Table 9.5.1, ASHRAE 90.1 2010 For Family Dining
9	24 hour Lighting	15%	10%	AEDG for Climate Zone 3
10	Daylighting Control	NA	Daylight control for vertical fenestration VT = 0.27	Section 4.2.1.4 Zhang et al. 2010 Addendum BB (Draft) for ASHRAE 90.1 2007
<b>Exterior Lighting</b>				
11	Parking Lots (Tradable)	0.15 W/sqft	0.06W/sqft	Table 9.4.6, For Zone 2, ASHRAE 90.1 2010
	Façade and Landscape Lighting (Non-Tradable)	0.2 W/sqft	0.075 W/sqft	AEDG for Climate Zone 3
	Extra Power Allowance	5%	600 W	Table 9.4.6, For Zone 2, ASHRAE 90.1 2010
	Building Entrance (w/o canopy) Building Exit	30 W/ft of door width 20 W/ft of door width	20 W/ft of door width 20 W/ft of door width	Table 9.4.6, For Zone 2, ASHRAE 90.1 2010
	Exterior Lighting Controls	Capable of reducing lighting levels when not in use.	Reduce exterior LPD to 25% (12:00AM - 6:00AM)	AEDG for Climate Zone 3
<b>HVAC Systems</b>				
12	HVAC System Efficiency	≥135,000 Btu/hr & < 240,000 Btu/hr 10.8 EER	≥135,000 Btu/hr and < 240,000 Btu/hr 11.5 EER	AEDG for Retail Buildings (Draft). Recommendations for climate zone 3.
13	Fan Efficiency	55%	65%	Section 4.4.4, Zhang et al. 2010
14	Economizer	NA	Yes Differential Enthalpy	Table 6.5.1.1.3A,B ASHRAE 90.1 2010
15	Furnace Efficiency	Heating: ≥225,000Btu/hr 80% Ec	Heating: ≥225,000Btu/hr 90% Ec	
<b>Service Hot Water Systems</b>				
16	Efficient Water Heaters	Gas 80%	Gas 95%	Section 4.5.1, Zhang et al 2010



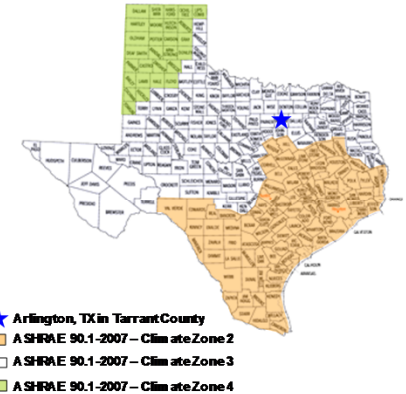
# Energy Savings from Individual and Group EEMs ASHRAE 90.1-2001/2007 Code-Compliant Restaurant Building



# Proposed Energy Efficiency Measures (EEMs) ASHRAE 90.1-2001 Code-Compliant Restaurant Building

## Description of Individual Measures

Individual Measures	Annual Energy Savings (%) <sup>1</sup>		Annual Energy Savings (\$/year) <sup>2</sup>	Annual Demand Savings (%)	Annual Demand Savings (\$/year) <sup>3</sup>	Combined Savings (Energy+Demand) (\$/year)	Estimated Cost (\$)		Simple Estimated Payback (yrs)
	Site	Source					Marginal Cost <sup>4</sup>	New System Cost <sup>5</sup>	
<b>A Envelope and Fenestration Measures</b>									
1 Improved Wall Insulation (From R-13 to R-13 + 7.5 c.i.)	1.0%	0.7%	\$144	0.5%	\$13	\$157	\$2,655 - \$3,983		16.9 - 25.3
2 Improved Roof Insulation (From R-15 to R-25)	1.0%	0.8%	\$180	1.1%	\$27	\$207	\$3,856 - \$5,784		18.7 - 28.0
3 Reduced Roof Absorptance (From 0.7 to 0.36)	0.2%	0.5%	\$154	1.0%	\$23	\$177	\$1,760 - \$2,640		9.9 - 14.9
4 Improved Window U-value (From 1.22 to 0.35)	2.7%	1.2%	\$178	0.1%	\$2	\$180	\$5,818 - \$8,728		32.3 - 48.4
5 Window Re-Distribution (East & West: 10%, South: 55.1%)	0.3%	0.3%	\$65	0.2%	\$4	\$69	\$0 - \$0		0.0 - 0.0
6 Window Shading (From None to 10ft)	-0.1%	0.7%	\$233	1.9%	\$46	\$279	\$38,107 - \$57,160		136.6 - 204.9
7 Window Shading & Redistribution (East & West: 10%, South: 55.1% Shading on South only: 10ft)	0.0%	0.4%	\$123	1.0%	\$24	\$147	\$10,851 - \$16,276		73.6 - 110.4
8 Air Barrier (From 0.322 to 0.05)	0.9%	0.6%	\$134	0.6%	\$14	\$148	\$5,885 - \$8,827		39.8 - 59.8
<b>B Interior Lighting Measures</b>									
9 Reduced Lighting Power Density (From 1.9 W/sqft to 0.89 W/sqft)	5.6%	11.3%	\$3,118	13.2%	\$317	\$3,435	\$3,723 - \$5,585		1.1 - 1.6
10 Reduced 24 Hour Lighting	0.1%	0.3%	\$72	0.0%	\$1	\$73	\$0 - \$0		-
11 Daylighting Control	4.6%	8.3%	\$2,265	8.8%	\$210	\$2,475	\$6,663 - \$9,994		2.7 - 4.0
<b>C Exterior Lighting Measures</b>									
12 Exterior Lighting Power Reduction (From 3.61 kW to 2 kW & reduction in usage to 25% of current usage from 12:00 AM to 6:00 AM)	2.7%	3.9%	\$1,030	1.0%	\$23	\$1,053	\$480 - \$720		0.5 - 0.7
<b>D HVAC System Measures</b>									
13 Improved HVAC System Efficiency (From 9.3 EER to 10.5 EER)	1.9%	2.7%	\$713	5.8%	\$139	\$852	\$1,366 - \$2,050		1.6 - 2.4
14 Improved Fan Efficiency (From 55% to 65%)	0.6%	1.4%	\$379	1.6%	\$37	\$417	\$928 - \$1,392		2.2 - 3.3
15 Economizer	0.0%	0.0%	\$7	0.0%	\$0	\$7	\$2,244 - \$3,367		344.9 - 517.4
16 Improved Furnace Efficiency (From 80% to 90%)	3.4%	1.7%	\$283	0.0%	\$0	\$283	\$1,360 - \$2,040		4.8 - 7.2
17 Demand Control Ventilation System	25.6%	14.3%	\$2,593	1.8%	\$43	\$2,637	\$737 - \$1,105		0.3 - 0.4
<b>E Service Hot Water Heater Measures</b>									
18 Improved Efficiency for Service Water Heaters (From Et 80% to Et 95%)	2.7%	1.3%	\$225	0.0%	\$0	\$225	\$342 - \$513		1.5 - 2.3



## Description of Combined Measures

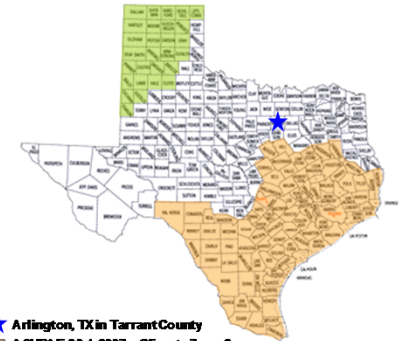
Combination of Measures <sup>6</sup>	Combined Annual Energy Savings (%) <sup>1</sup>		Combined Energy Savings (\$/year) <sup>2</sup>	Combined Demand Savings (%)	Combined Demand Savings (\$/year) <sup>3</sup>	Combined Savings (Energy+Demand) (\$/year)	Combined Estimated Cost (\$)		Simple Estimated Payback (yrs)	NO <sub>x</sub> Emissions Savings Annual (tons/yr)	SO <sub>2</sub> Emissions Savings Annual (tons/yr)	CO <sub>2</sub> Emissions Savings Annual (tons/yr)
	Site	Source					Marginal Cost <sup>4</sup>	New System Cost <sup>5</sup>				
<b>Combination 1</b>												
13 Improved HVAC System Efficiency (From 9.3 EER to 10.5 EER)	27.34%	16.79%	\$3,244	7.4%	\$178	\$3,422	\$1,366 - \$2,050		0.6 - 0.9	0.009	0.005	7.2
17 Demand Control Ventilation System								\$737 - \$1,105				
<b>Combination 2</b>												
9 Reduced Lighting Power Density (From 1.9 W/sqft to 0.89 W/sqft)	8.34%	15.21%	\$4,148	13.9%	\$335	\$4,482	\$3,723 - \$5,585		0.9 - 1.4	0.033	0.018	25.9
12 Exterior Lighting Power Reduction (From 3.61 kW to 2 kW & reduction in usage to 25% of current usage from 12:00 AM to 6:00 AM)								\$480 - \$720				
<b>Combination 3</b>												
9 Reduced Lighting Power Density (From 1.9 W/sqft to 0.89 W/sqft)	10.78%	16.52%	\$4,377	18.7%	\$449	\$4,827	\$3,723 - \$5,585		2.2 - 3.2	0.033	0.019	26.1
10 Reduced 24 Hour Lighting								\$0 - \$0				
11 Daylighting Control								\$6,663 - \$9,994				

- Note:
- Total energy savings from heating, cooling, lighting, equipment and DHW for emissions reductions determination.
  - Savings depend on fuel mix used.  
<sup>1</sup> Energy Cost: Electricity = \$0.095/kWh & Demand = \$5.00/kWh  
 Natural gas = \$0.65/therm
  - Yearly demand cost = Sum of monthly demand cost for 12 months
  - Marginal cost = new system cost - original system cost
  - New system cost = new system cost only
  - See individual measures above for specific savings
- [ASHRAE 90.1-2001 Code-Compliant Restaurant Building Description]
- \* Building type: Restaurant
  - \* Gross area: 5,500 sq-ft (Dining Area: 4,000 sq-ft; Kitchen Area: 1,500 sq-ft)
  - \* Building dimension: 61 ft x 91 ft x 14 ft (WxLxH)
  - \* Dining room dimension: 61 ft x 66 ft x 14 ft (WxLxH)
  - \* Number of floors: 1
  - \* Floor-to-floor height: 14 ft
  - \* Window-to-wall ratio: 17% for the entire building
  - \* HVAC system: EER 9.3 Rooftop PSZ & 80% Eff Furnace
  - \* DHW: Et: 80% Gas Water heater
- Savings calculations for all measures except exterior lighting performed for dining space only

# Proposed Energy Efficiency Measures (EEMs) ASHRAE 90.1-2007 Code-Compliant Restaurant Building

## Description of Individual Measures

Individual Measures	Annual Energy Savings (%) <sup>1</sup>		Annual Energy Savings (\$/year) <sup>2</sup>	Annual Demand Savings (%)	Annual Demand Savings (\$/year) <sup>3</sup>	Combined Savings (Energy+Demand) (\$/year)	Estimated Cost (\$)		Simple Estimated Payback (yrs)
	Site	Source					Marginal Cost <sup>4</sup>	New System Cost <sup>5</sup>	
<b>A Envelope and Fenestration Measures</b>									
1 Improved Wall Insulation (From R-13 + 3.8 c.i. to R-13 + 7.5 c.i.)	0.1%	0.1%	\$16	0.2%	\$3	\$19	\$506 - \$759		26.4 - 39.6
2 Improved Roof Insulation (From R-20 to R-25)	-0.4%	-0.5%	-\$110	-0.2%	-\$3	-\$114	\$1,760 - \$2,640		-
3 Improved Window U-value (From 0.65 to 0.35)	0.0%	-0.3%	-\$63	0.0%	\$0	-\$62	\$2,442 - \$3,662		-
4 Window Re-Distribution (East & West: 10%, South: 55.1%)	0.2%	0.2%	\$43	0.2%	\$4	\$46	\$0 - \$0		0.0 - 0.0
5 Window Shading (From None to 10ft)	0.7%	0.9%	\$175	0.9%	\$17	\$191	\$38,107 - \$57,160		199.0 - 298.6
6 Window Shading & Redistribution (East & West: 10%, South: 55.1% Shading on South only: 10ft)	0.6%	0.7%	\$137	0.7%	\$13	\$150	\$10,851 - \$16,276		72.3 - 108.4
7 Air Barrier (From 0.322 to 0.05)	0.5%	0.4%	\$62	0.8%	\$14	\$76	\$6,693 - \$10,039		88.4 - 132.5
<b>B Interior Lighting Measures</b>									
8 Reduced Lighting Power Density (From 1.6 W/sqft to 0.89 W/sqft)	9.8%	12.5%	\$2,430	11.5%	\$211	\$2,641	\$2,705 - \$4,058		1.0 - 1.5
9 Reduced 24 Hour Lighting	0.3%	0.4%	\$70	0.0%	\$0	\$71	\$0 - \$0		0.0 - 0.0
10 Daylighting Control	8.8%	10.9%	\$2,111	6.3%	\$115	\$2,226	\$6,663 - \$9,994		3.0 - 4.5
<b>C Exterior Lighting Measures</b>									
11 Exterior Lighting Power Reduction (From 3.61 kW to 2 kW & reduction in usage to 25% of current usage from 12:00 AM to 6:00 AM)	3.9%	4.8%	\$932	1.4%	\$25	\$957	\$480 - \$720		0.5 - 0.8
<b>D HVAC System Measures</b>									
12 Improved HVAC System Efficiency (From 10.8 EER to 11.5 EER)	1.2%	1.4%	\$274	2.5%	\$46	\$320	\$1,366 - \$2,050		4.3 - 6.4
13 Improved Fan Efficiency (From 55% to 65%)	1.5%	2.0%	\$384	1.8%	\$32	\$416	\$928 - \$1,392		2.2 - 3.3
14 Economizer	3.5%	4.3%	\$834	0.0%	\$0	\$834	\$1,523 - \$2,285		1.8 - 2.7
15 Improved Furnace Efficiency (From 80% to 90%)	0.1%	0.0%	\$5	0.0%	\$0	\$5	\$1,360 - \$2,040		250.0 - 375.0
<b>E Service Hot Water System Measure</b>									
17 Improved Efficiency for Service Water Heaters (From 80% to 95%)	4.3%	1.8%	\$224	0.0%	\$0	\$224	\$342 - \$513		1.5 - 2.3



- ★ Arlington, TX in Tarrant County
- ASHRAE 90.1-2007 - Climate Zone 2
- ASHRAE 90.1-2007 - Climate Zone 3
- ASHRAE 90.1-2007 - Climate Zone 4

## Description of Combined Measures

Combination of Measures <sup>6</sup>	Combined Annual Energy Savings (%) <sup>1</sup>		Combined Energy Savings (\$/year) <sup>2</sup>	Combined Demand Savings (%)	Combined Demand Savings (\$/year) <sup>3</sup>	Combined Savings (Energy+Demand) (\$/year)	Combined Estimated Cost (\$)		Simple Estimated Payback (yrs)	NOx Emissions Savings Annual (tons/yr)	SO <sub>2</sub> Emissions Savings Annual (tons/yr)	CO <sub>2</sub> Emissions Savings Annual (tons/yr)
	Site	Source					Marginal Cost <sup>4</sup>	New System Cost <sup>5</sup>				
<b>Combination 1</b>												
8 Reduced Lighting Power Density (From 1.6 W/sqft to 0.89 W/sqft)							\$2,705 - \$4,058					
11 Exterior Lighting Power Reduction (From 3.61 kW to 2 kW & reduction in usage to 25% of current usage from 12:00 AM to 6:00 AM)	13.8%	17.3%	\$3,362	12.9%	\$236.00	\$3,598	\$480 - \$720		0.9 - 1.3	0.025	0.014	19.8
<b>Combination 2</b>												
8 Reduced Lighting Power Density (From 1.6 W/sqft to 0.89 W/sqft)							\$2,705 - \$4,058					
12 Improved HVAC System Efficiency (From 10.8 EER to 11.5 EER)	12.2%	15.5%	\$3,022	15.5%	\$283.75	\$3,306	\$1,366 - \$2,050		1.5 - 2.3	0.023	0.013	17.9
13 Improved Fan Efficiency (From 55% to 65%)							\$928 - \$1,392					
<b>Combination 3</b>												
10 Daylighting Control								\$6,663 - \$9,994				
14 Economizer	16.1%	16.4%	\$3,052	6.3%	\$114.75	\$3,167	\$1,523 - \$2,285		2.6 - 3.9	0.021	0.012	16.6
17 Improved Efficiency for Service Water Heaters (From 80% to 95%)							\$342 - \$513					

### Note:

1. Total energy savings from heating, cooling, lighting, equipment and DHW for emissions reductions determination.
2. Savings depend on fuel mix used.
  - \* Energy Cost: Electricity = \$0.095/kWh & Demand = \$5.00/kWh
  - Natural gas = \$0.65/therm
3. Yearly demand cost = Sum of monthly demand cost for 12 months
4. Marginal cost = new system cost - original system cost
5. New system cost = new system cost only
6. See individual measures above for specific savings

### [ASHRAE 90.1-2007 Code-Compliant Restaurant Building Description]

- \* Building type: Restaurant
  - \* Gross area: 5,500 sq-ft (Dining Area: 4,000 sq-ft, Kitchen Area: 1,500 sq-ft)
  - \* Building dimension: 61 ft x 91 ft x 14 ft (WxLxH)
  - \* Dining room dimension: 61 ft x 66 ft x 14 ft (WxLxH)
  - \* Number of floors: 1
  - \* Floor-to-floor height: 14 ft
  - \* Window-to-wall ratio: 17% for the entire building
  - \* HVAC system: EER 10.8 Rooftop PSZ & 80% Eff Furnace
  - \* DHW: Eff: 80% Gas Water heater
- Savings calculations for all measures except exterior lighting performed for dining space only



# Proposed Energy Efficiency Measures (EEMs)

## Kitchen Exhaust Hoods

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- ▶ A Listed Hood can be operated at a lower exhaust rate than an unlisted hood of comparable style and size over the same cook line. Listed Hoods have been tested against a recognized standard such as Underwriters Laboratory (UL) Standard 170.
- ▶ Installation of a demand-based exhaust control.

\* NOTE: Short circuit hoods are not recommended. ASHRAE Codes have become more stringent with regard to the installation of short circuit hoods.

Questions?