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“Conservation Strategies In Hot-Humid Environment In Saudi Arabia ”

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Conservation Strategies In Hot-Humid Environment In Saudi Arabia

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Abstract—Recently energy savings have become more pronounced as a result of the world financial crises as well the unstable oil prices. Certainly all entities needs to adapt Energy Conservation and Management Strategies due to high monthly consumption of their spread locations and advancements of its telecom systems. These system improvements necessitate the establishment of more exchange centers as well provide energy savings. This paper investigates the impact of HVAC System Characteristics, Operational Strategies, the impact of Envelope Thermal Characteristics, and energy conservation measures. These are classified under three types of measures i.e. Zero-Investment; Low-Investment and High-Investment Energy Conservation Measures. The study shows that the Energy Conservation Measures (ECMs) pertaining to the HVAC system characteristics and operation represent the highest potential for energy reduction, Attention should be given to window thermal and solar radiation characteristics when large window areas are used. The type of glazing system needs to be carefully considered in the early design phase of future buildings. Paper will present he thermal optimization of different size centers in the two hot-dry and hot-humid Saudi Arabian city of Al Khobar, east province.

INTRODUCTION

- ❑ Energy management/conservation is core issue for KSA's Research.
- ❑ Government' promised to reduce the consumption by 30%-50% in their buildings.
- ❑ Energy regulations will be enforced as globally accepted standards .
- ❑ Energy savings became more pronounced as the global financial crises in KSA.
- ❑ KFU as well needs such energy conservation and energy management strategies.
- ❑ Implementing of conservation can be cost-effective means of reducing energy consumption in buildings.
- ❑ 70% of the total electric energy use in KSA by residential.
- ❑ 15%, 19% and 40% annual energy can be saved in large, medium and small office buildings through envelope thermal optimization in the hot-humid climate of Riyadh.
- ❑ Similarly, 8%, 12% and 24% can be obtained in Jeddah.
- ❑ E.G. The energy consumption for a Supermarket (954 m²) located in Eastern Province: 38% by air conditioning, 42% in appliances, and 20% for lighting.

DISCUSSION AND APPROACH

- ❑ Hot-Humid Weather needs provide a highly reliable, comfort and energy efficient air-conditioning system in any building.
- ❑ HVAC Systems consume 50 to 65% of the total power consumption in any building.
- ❑ Some of the previous measures:
 - ✓ Awareness regarding building orientation.
 - ✓ Architectural features.
 - ✓ Avoiding overcooling or overheating.
 - ✓ High sensibility of air-conditioning system.
 - ✓ Automation and building management systems.
 - ✓ Variable voltage and variable frequency drives.
 - ✓ Heat recovery wheel.
 - ✓ Panel cooling.
 - ✓ Vapor absorption machines.
 - ✓ Minimizing the space for air conditioning application.

ENERGY SIMULATION AND SOLUTIONS

- ❑ Three primary energy-consuming sectors: industry, transportation, and buildings.
- ❑ For example, in an industrialized nation like the U.S.:
 - ✓ Industry & transportation account for 37% and 27% of the total energy use.
 - ✓ Buildings: 36% of total energy use consumed in residential and commercial.
- ❑ In Saudi Arabia:
 - ✓ Buildings account for a major share: about 76 % of the total for the year 2002.
 - ✓ Industrial consumption of electric energy was 23 % for the same year. T
 - ✓ This includes the Eastern Region of the Kingdom.
 - ✓ For other regions KSA with less intensive industrial activities, more than 90% of electric energy is consumed by buildings.

ENERGY SIMULATION & ANALYSIS SOFTWARE

The Investigation Approach.

- ❑ Energy performance of sample of buildings under various retrofitting measures.
- ❑ Actual collected data pertaining to thermo-physical charac.s & energy consumption.
- ❑ Each zone of the building was physically investigated.
- ❑ VisualDOE energy simulation for formulating the base case models.
 - ✓ Detailed energy audit is conducted to collect physical, thermal & operational characteristics.
 - ✓ Four buildings regarded as a representative sample in terms of size, type of HVAC systems and thermal and operational characteristics were selected and modeled.
 - ✓ The models are planned to be adjusted till achieving acceptable performance by comparing its prediction with actual energy consumption data collected as part of the audit process.

ENERGY SIMULATION & ANALYSIS SOFTWARE

Formulation of the Base Case Models.

❑ A model was developed for each of the simulated buildings via VisualDOE .

Building Location	Khobar	
Conditioned floor area (m2)	2913	
Window Area (m2)	290	
Floor to floor height (m)	5	
Wall U-value (W/m2.oC)	Exterior: 1.91 Interior: 2.19	
Roof U-value (W/m2. oC)	Roof: 0.32; Floor: 0.01 Slab: 0.13; Ceiling: 2.78	
Window Type	Glass Block (Single Clear)	
Window Shading	None	
Lighting power density (W/m2)	AHU Room: 17 Battery Room: 6 Equipment Room: 22	LDN Room: 21 MDF Room: 13 Office: 19
	PCM Room: 23 Rectifier Room: 17	Stair Case: 3 Toilet: 7
Equipment power density (W/m2)	AHU Room: 8 Battery Room: 8 Equipment Room: 8	LDN Room: 8 MDF Room: 8 Office: 59
	PCM Room: 15 Rectifier Room: 18	Stair Case: 8

ENERGY SIMULATION & ANALYSIS SOFTWARE

The Base Model Calibration Process

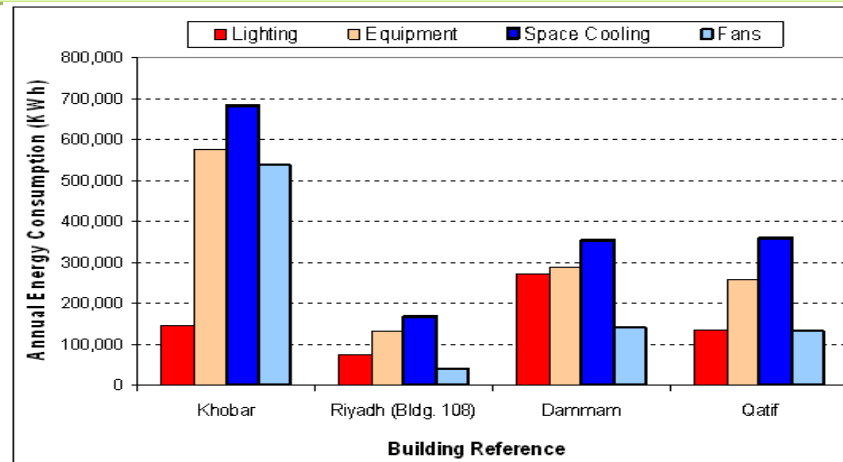
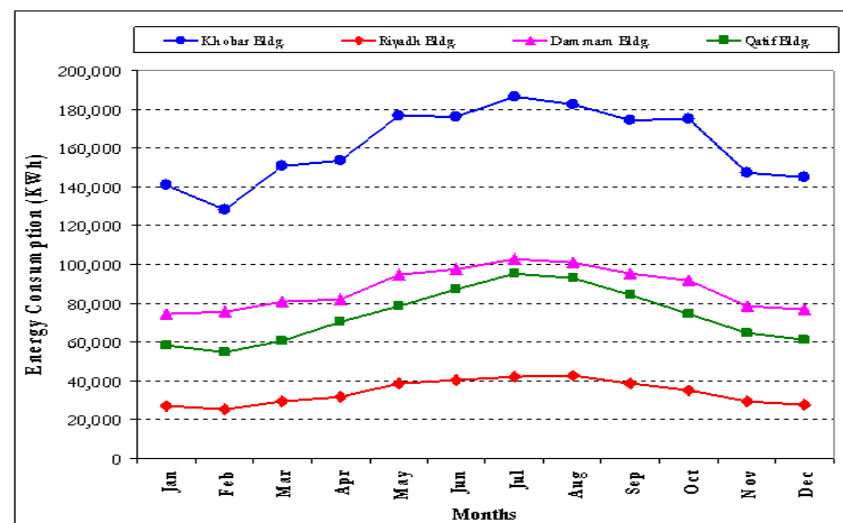
Summary of thermal and operational characteristics of Simulated STC Exchange Buildings
(Input Data for Simulation)

Building Location	Khobar
Air infiltration rate (ACH)	0.2
Maximum occupancy	10 Persons
HVAC system type	Packaged VAV, Packaged Signal Zone, Packaged Multi Zone
Outdoor Air Quantity (L/s)	2024.21
Total Cooling Capacity (kW)	35.17 kW (each system)
Type Cooling Coil	DX High Efficiency
Type of Fan	Defined by Energy Input Ratio (EIR)
Cooling temperature (oC)	22
Weather Data File	Dhahran 2002

ENERGY SIMULATION & ANALYSIS SOFTWARE

The Base Model Calibration Process

The resulting monthly total energy consumption. •



ENERGY SIMULATION & ANALYSIS SOFTWARE

Potential Energy Conservation Measures (ECMs).

- ❑ HVAC and Lighting System Operation - Zero-Investment Energy Conservation Measures
 - ✓ ECM 1: Set point Temperature Reset.
 - ✓ ECM2: Night Time Setback.
 - ✓ ECM 1&2: Combination of ECM 1 and ECM 2.

- ❑ Low-Investment Energy Conservation Measures.
 - ✓ ECM 3: Airside Economizer Cycle.

- ❑ High-Investment Energy Conservation Measures.
 - ✓ ECM AC-1.

CHARACTERISTICS OF SIMULATED BUILDING

		HVAC and Lighting Systems Operation					
		Thermostat Setpoint Reset	Thermostat Night Setback	Combination of	Economizer	Demand Controlled Ventilation	Lighting Schedule Control
Category Of Use	Base Case	ECM 1	ECM 2	ECM 1+2	ECM 3	ECM 4	ECM LS
	(KWh)	(KWh)	(KWh)	(KWh)	(KWh)	(KWh)	(KWh)
Lighting	145,176	145,092	145,092	145,092	145,176	145,176	141,278
Equipment	575,112	575,112	575,112	575,112	575,112	575,112	575,112
Space Cooling	682,679	442,744	429,621	421,712	666,318	256,747	467,674
Fans	536,754	129,485	129,485	129,485	536,754	72,342	127,445
Total	1,939,721	1,292,433	1,279,310	1,271,401	1,923,360	1,049,377	1,311,509
Energy Reduction %	--	- 33%	-34 %	-34 %	- 1%	- 46 %	-32 %
HVAC Type ECMs							
		A/C Type 1	A/C Type 2	Combination of	Combination of		
Category Of Use	Base Case	ECM AC1 VAV	ECM AC2 CAV-Rh	ECM 1-4 & AC1	ECM 1-4 & AC2		
	(KWh)	(KWh)	(KWh)	(KWh)	(KWh)		
Lighting	145,176	145,176	145,176	145,092	145,092		
Equipment	575,112	575,112	575,112	575,112	575,112		
Space Cooling	682,679	75,568	75,439	27,275	27,069		
Fans	536,754	536,754	536,754	69,262	69,064		
Total	1,939,721	1,332,610	1,332,481	816,741	816,337		
Energy Reduction %	--	31 %	31 %	58 %	58 %		
Building Envelope ECMs							
		Interior Shading	Added 1.25" EPI to Wall	Added 2.5" PRI to Roof	Combination Wall & Roof Insulation		
Category Of Use	Base Case	ECM E-1	ECM E-2	ECM E-3	ECM E-2&3		
	(KWh)	(KWh)	(KWh)	(KWh)	(KWh)		
Lighting	145,176	145,176	145,176	145,176	145,176		
Equipment	575,112	550,688	575,112	575,112	575,112		
Space Cooling	682,679	674,044	619,533	680,742	521,717		
Fans	536,754	534,297	477,712	535,203	304,662		
Total	1,939,721	1,904,205	1,817,533	1,936,233	1,546,667		
Energy Reduction %	--	- 2%	- 6 %	0 %	- 20%		

CONCLUSIONS

		HVAC and Lighting Systems Operation					
		Thermostat Setpoint Reset	Thermostat Night Setback	Combination of	Economizer	Demand Controlled Ventilation	Lighting Schedule Control
Category Of Use	Base Case	ECM 1	ECM 2	ECM 1+2	ECM 3	ECM 4	ECM LS
	(KWh)	(KWh)	(KWh)	(KWh)	(KWh)	(KWh)	(KWh)
Lighting	145,176	145,092	145,092	145,092	145,176	145,176	141,278
Equipment	575,112	575,112	575,112	575,112	575,112	575,112	575,112
Space Cooling	682,679	442,744	429,621	421,712	666,318	256,747	467,674
Fans	536,754	129,485	129,485	129,485	536,754	72,342	127,445
Total	1,939,721	1,292,433	1,279,310	1,271,401	1,923,360	1,049,377	1,311,509
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		A/C Type 1	A/C Type 2	Combination of	Combination of		
Category Of Use	Base Case	ECM AC1 VAV	ECM AC2 CAV-Rh	ECM 1-4 & AC1	ECM 1-4 & AC2		
	(KWh)	(KWh)	(KWh)	(KWh)	(KWh)		
Lighting	145,176	145,176	145,176	145,092	145,092		
Equipment	575,112	575,112	575,112	575,112	575,112		
Space Cooling	682,679	75,568	75,439	27,275	27,069		
Fans	536,754	536,754	536,754	69,262	69,064		
Total	1,939,721	1,332,610	1,332,481	816,741	816,337		
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Category Of Use	Base Case	ECM E-1	ECM E-2	ECM E-3	ECM E-2&3		
	(KWh)	(KWh)	(KWh)	(KWh)	(KWh)		
Lighting	145,176	145,176	145,176	145,176	145,176		
Equipment	575,112	550,688	575,112	575,112	575,112		
Space Cooling	682,679	674,044	619,533	680,742	521,717		
Fans	536,754	534,297	477,712	535,203	304,662		
Total	1,939,721	1,904,205	1,817,533	1,936,233	1,546,667		
Energy Reduction %	--	- 2%	- 6 %	0 %	- 20%		

CONCLUSIONS

- ❑ HVAC systems used in the investigated Buildings are variable air volume (VAV) but mixed with many other types of systems that have no controlled ventilation.
- ❑ The findings are limited to energy savings associated with different alternatives in existing Buildings in which basic energy conservation measures such as envelope thermal insulation are not usually applied.
- ❑ It is expected that applying such measures will be economically viable considering the type of climate and the Buildings physical and operation characteristics.
- ❑ A total reduction of around 3-20% is obtained by applying both wall and roof insulation.
- ❑ Changing window shading conditions has very limited impact with 1-2% change in annual cooling energy requirements which can be attributed to the small window area relative to the whole Buildings envelope.
- ❑ The quoted numbers and percentages are reflective of Buildings operated in hot and hot-humid climates of the central and eastern region of Saudi Arabia.

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