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SMART CITIES

ENERGY SIMULATION OF HIGH PERFORMANCE GREEN BUILDINGS

FOR ENERGY AND GREEN BUILDING SPECIALISTS

KRISHNAJI PAWAR, LEED AP BD+C, GSAS CGP, ISO 14001:2015, GCP

ENERGY SPECIALIST CURRICULUM

ENERGY MODELING SPECIALIST

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ENERGY CONSERVATION MEASURES

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LEARNING OBJECTIVES



Energy Conservation Measures

What is an Energy Conservation Measure?

How to Run an Energy Conservation Measure (ECM) Analysis

Different Types of Energy Conservation Measures

Results

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HOW TO RUN AN ECM ANALYSIS

An Energy Conservation Measure (ECM) is proposed to improve the energy efficiency of building infrastructure, including heating/cooling/ventilation systems, utility systems, roof, and windows by replacement and/or upgradation of the existing systems in a cost-effective manner. DOE-2 tool makes running an ECM analysis completely automated and instantaneous.

Although energy conservation measures can be implemented one at a time, the true potential of the strategies can be seen holistically as part of the cost vs energy optimization. The feasibility of any ECM implementation is highly dependent on the capital of the ECM and Return on Investment (ROI). With DOE-2 Tool, it is easy to calculate the return on investment if the capital cost for the ECMs is known. The main reason being the consideration of the cost as one of the parameter for the analysis.



ENERGY CONSERVATION MEASURES

An energy conservation measure is simply a project or technology implemented to reduce energy consumption in a building or facility. These energy conservation measures or “ECMs” can be implemented one at a time or as part of a bigger energy savings project. When ECMs are implemented one at a time it is easy to measure return on investment or ROI on each measure.

Energy conservation measures are the upgrades, retrofits, repairs and replacements that businesses can implement to become more energy efficient. These measures can significantly reduce operating costs while providing operational benefits by allowing businesses to replace old, outdated equipment.



TABLE OF CONTENTS

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List of Tables

Table No.	Table Title	Page No.
Table 1	Universe of building envelope for baseline and proposed case	6
Table 2	Universe, SHGC and T-Vis of Glazing in baseline and proposed case	10
Table 3	Design Temperature in summer	11
Table 4	Design Temperature in winter	11
Table 5	Relative Humidity	11
Table 6	Air Infiltration Rate	11
Table 7	Hourly Occupancies and Schedules	15
Table 8	Data on local utility rate	14
Table 9	Electrical Energy use and savings by Performance Rating Method	18
Table 10	Energy & Cost Summary by Fuel	19

List of Figures

Fig. No.	Figure Title	Page No.
Fig. 1	Climate Data for Abu Dhabi - Maximum Daily Temperatures	7
Fig. 2	Climate Data for Abu Dhabi - Average Dry Bulb Temperatures	7
Fig. 3	Climate Data for Abu Dhabi - Daily Solar Radiation	8
Fig. 4	Climate Data for Abu Dhabi - Relative Humidity (10AM daily)	8
Fig. 5	3D view of project from Visual DOE	15
Fig. 6	Plan View - Ground Floor	16
Fig. 7	Plan view - Typical Floor	16

EXECUTIVE SUMMARY

The proposed project is a Warehouse & Office for WILIS & FLOORS WOODS EAST FZCO in plot No. S2090 located in Jebel Ali Free Zone, Dubai U.A.E. The building comprises of office and warehouse space with a total built up area of 400 K Sq. Ft. The project has required EED certification from the UAEDEC, which is also a requirement of the Environmental Health and Safety (EHS) administration of Dubai. An important component of LEED certification is achieving energy performance of the building as per the credit EA 1.1. For this purpose, a detailed energy model was constructed on the warehouse and office building. This model compares the energy impacts of various mechanical air distribution strategies, building envelope performance design criteria and evaluate the benefits of energy efficiency measures integrated into the design.

Preliminary building energy modeling was carried out to ascertain the energy savings as per the credit requirements. The modeling was conducted in accordance with the Building Performance Rating Method (BPRM) of ASHRAE / ISO 9001:2004 Appendix G up to 10 points possible). A base model was created as per ASHRAE 90.1, 2004 standards. The proposed design was incorporated and various energy conservation measures were simulated using the model.

Based on the model results the energy conservation measures are: improved EER values for the Split Unit AC systems, lower UFD values, highly insulated envelope, high performance glazing, Efficient Energy Recovery Ventilator (ERV) units and variable speed drives. The energy modeling results including the energy conservation measures indicate a building energy efficiency of approximately 28.0%.





1. INTRODUCTION

The U.S. Green Building Council's Leadership in Energy and Environmental Design Rating System (LEED) is an international benchmark for sustainable buildings. LEED recommends energy modeling to assess the designed energy use of a building and to quantify the possible savings attributable to the proposed design. Energy modeling allows computer-based tools which simulate the energy consumption of a building throughout its entire year of operation. The energy simulation helps to optimize building design and it allows the design team to prioritize investment in the strategies that have the greatest impact on the building's energy use. Also, the operational and maintenance costs of the building can be reduced by adopting appropriate energy conservation measures.

The WALLS & FLOORS MIDDLE EAST FZOD building is technically classified as a non-residential building by the American Society of Heating, Refrigeration, and Air-conditioning Engineers (ASHRAE). The building primarily consists of open office, conference, reception, office rooms, dining room, party & active storage. All regulated load components have been considered and optimized in terms of design and specifications. The project is incorporating several energy saving features which include a reduced overall conductance for the roof, highly insulated mass walls, high performance glass with optimum visible light transmittance and high efficient HVAC systems.



2. METHODOLOGY

The proposed building was evaluated on the basis of the methodology outlined in building Performance Rating Method (PRM) of ASHRAE / ESNA 90.1-2004. The method considers the proposed building performance, compares it with the baseline building performance and determines the percentage improvement in energy cost for the project. A front-end to DOE-4.1 engine was used as the simulation tool. The energy simulation software used for this project has all the capabilities described in other section '02 Simulation General Requirements Appendix G of ASHRAE 90.1-2004 or the analogous section of the alternative qualifying energy code used. Furthermore, the baseline building and the proposed building in the energy simulation runs use the assumptions and modeling methodology described in Appendix G of ASHRAE 90.1-2004. The building was modeled with a number of individual energy conservation measures (ECMs). The ECMs on the final list were then combined into a single case to model the proposed building.

As stipulated by the PRM Method, the proposed Budget Building (base case) is identified in terms of:

1. Building Geometry
2. Simulation software – Visual DOE, Windows graphical interface to DOE-4.1 energy simulation program.
3. Weather data – The weather data of Abu Dhabi is taken as the reference for the project. The daily maximum temperature, dry bulb temperature, daily solar radiation and relative humidity are indicated in figure nos. 1, 2, 3 and 4.

3. MODELING SIMULATIONS

3.1 Building Classification

The WALLS & FLOORS MIDDLE EAST FZOD building classification as a non-residential building requires that the base case HVAC system be modeled as a Package Single Zone (ref: ASHRAE 90.1, pg. 170. Exceptions to GS 1.1). Principal Heat/Cooling Sources. For a space summary refer Appendix A.



3.2 Building Envelope (Base Case)

ASHRAE building envelope procedures were followed, including specified U-values, without accounting for shading features in the proposed design. The Window to Wall Ratio (WWR) was accurately traced from AutoCAD drawings of the project, including all glazing areas and skylights.

3.2.1 Building Envelope (Proposed)

The glazing in this model accurately represents the total amount of area glazing per zone throughout the entire design. The base case and proposed case have U-values that meet ASHRAE standards. U-values for roof, wall and floor construction are indicated below in Table-1:

Table-1: U-value of building envelope for base case and proposed case.

	U-Values (Btu/h-ft ² -°F)	
	Base Case	Proposed
Roof Construction	0.063	0.062
Wall Construction	0.124	0.089
Floor Construction	0.35	0.055

3.3 High-Performance Glazing

The proposed building is employing high performance glazing to decrease the solar heat gain and cooling loads. Table-2 shows the U-value, solar heat gain coefficient (SHGC) and Visible transmittance (T_v) of the glazing modeled in both cases.

Table-2: U-value, SHGC and T_v of Glazing in base case and proposed case.

	U-Value		SHGC		T _v	
	Base Case	Proposed	Base Case	Proposed	Base Case	Proposed
Office	1.22	0.315	0.25	0.25	0.7	0.5
Reception	1.22	0.315	0.61	0.25	0.7	0.5
Stairs	1.22	0.315	0.61	0.25	0.7	0.5
Lobby	1.22	0.315	0.61	0.25	0.7	0.5

3.4 Lighting (Base Case)

The LPD (light power density) values used for the various rooms comply with ASHRAE 90.1-2004 standards. Office spaces and corridors have LPDs of 1.1 watt/ft² and 0.8 watt/ft² respectively.

3.4.1 Lighting (Proposed)

The proposed building saves over 22.2% of lighting energy over the base case using the whole building method approach. The space-by-space approach was selected over the whole building method to provide a better building calibration for zone loads. Efficient compact fluorescent lamps were used in most of the office space to achieve the savings. Further, fixtures with efficient lamps are a part of the design. The LPD value given by ASHRAE for space-by-space classifications was followed for the simulation.

Note: When running the simulation a 10% reduction in LPD for the proposed was proposed.

3.5 HVAC (Base Case)

The base case HVAC system was modeled as a Package Single Zone. (ref: ASHRAE 90.1, pg. 170. Exceptions to GS 1.1). The correct fan power and EER was calculated from ASHRAE Appendix G and input separately.



3.5.1 HVAC (Proposed)

The proposed system is designed as Split Duct AC (ducted) and air systems (two duct) we assumed that PSZ for Split Duct AC with Ducted Type and PSZAC for Split Duct AC without duct for Energy Modeling respectively, with EER value 10.8 in all spaces. Proposed HVAC system is designed with summer temperatures and winter temperatures are indicated in Table-3 and Table-4 respectively. Table-5 and Table-6 shows the relative humidity and infiltration rate used in various rooms.

Table-3: Design Temperature in summer

Room Type	Data or Description
Office	74 °F
Reception	74 °F
Lobby	77 °F

Table-4: Design Temperature in winter

Room Type	Data or Description
Office	No Heating
Reception	No Heating
Lobby	No Heating

Table-5: Relative Humidity

Room Type	Data or Description
Office	Not controlled
Reception	Not controlled
Lobby	Not controlled

Table-6: Air Infiltration Rate

Room Type	Data or Description
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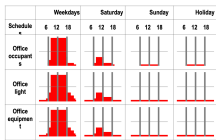
Office	0.5 ACH
Reception	0.5 ACH
Stairs	0.5 ACH
Lobby	0.5 ACH

This final system modeled in Visual DOE represents the actual installed HVAC system. Default values from the software for supply fan were used for the simulation. Thermostat type is in proportion with a thermostat range of 4° Fahrenheit.

3.6 EPC/Occupancy

The EPC and occupancy were modeled consistently for both the base case and the proposed case. This is required under LEED criteria. Table-7 illustrates the building occupancy, schedule for lighting and equipment use load curves.

Table-7: Hourly Occupancies and Schedules





3.7 UTILITY COST

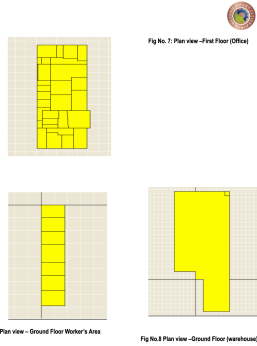
Annual energy cost as required by the performance rating method is determined based on the rate of the purchased energy such as electricity, gas and chilled water. Table-8 shows the local utility rate of electricity purchased for this Dubai project.

Table 8: Data on local utility rate

Category	Commercial
Base cost (\$ / kWh)	0.07
Electricity duty (\$ / kWh)	0.0
Municipal Tax (\$ / kWh)	0.0
Maximum demand charges (\$ / kWh)	0.0
Total cost (\$ / kWh)	0.07

4. WHOLE BUILDING ENERGY PERFORMANCE RESULTS

Figs 5-7 depict the three dimensional view of building model, ground floor plan and typical floor plan as obtained from the whole building simulation of proposed project using Visual DOE.



DIFFERENT TYPES OF ENERGY CONSERVATION MEASURES

There are many types of energy conservation measures that can be implemented. Some ECMs have a quicker return on investment than others, but any ECM properly implemented can help achieve energy conservation goals. Some types of ECMs include:

- ✓Lighting Upgrades
- ✓Insulation upgrades and building envelope
- ✓HVAC equipment upgrades
- ✓Energy generation such as solar
- ✓Power upgrades and quality improvements
- ✓Energy dashboards



DIFFERENT TYPES OF ENERGY CONSERVATION MEASURES +

Lighting upgrades : One of the most popular ECMs is a lighting upgrade. Lighting upgrades are often considered the “low hanging fruit” of energy conservation. Often companies look to improve their lighting from outdated or old lighting to newer technologies such as LED. Other ECMs in lighting could include sensors and sky lights.

Insulation and building envelope :Identifying where you are losing energy on your building envelope can greatly increase the return on investment of other ECMs. These ECMs can include upgrading roofs and building insulation as well as improving windows and doors to meet modern storm standards.



DIFFERENT TYPES OF ENERGY CONSERVATION MEASURES +

HVAC equipment upgrades :Upgrading HVAC equipment can greatly increase return on investment as well. Often when buildings are built or have been operating for some time, they need to be commissioned or retro commissioned to operate more efficiently. This, along with upgrading controls to meet building operations can also conserve energy.

Renewable Energy generation. There are many forms of energy generation that can help a company meet or exceed its energy conservation group goals. One of the most popular today is Photovoltaic or PV solar. Solar is a great way to generate power to help save money and energy, however like all ECMs, you should look at the effects of renewables on your facility



DIFFERENT TYPES OF ENERGY CONSERVATION MEASURES +

Power upgrades :Upgrading power equipment and understanding power quality is an important step in any company's energy conservation plan. Poor power quality can cause all kinds of issues inside of a facility that can be costing companies money. Things like improving power factor and load balancing can help save money and increase energy efficiency.

Energy dashboards : The most critical energy conservation measure that a company can implement is energy analytics or dashboard program. These programs such as Summa Energy Solutions' Vitality Platform can help identify ECMs as well as properly measure the return on investment of the ECMs implemented. These systems can easily be implemented through smart meter technology.



ENERGY CONSERVATION MEASURES

ECM 1: "SB"- Single glass with plane 9 inches brick wall, inside plaster and out side exposed, roof insulation medium 5 inches vermiculite and white tiles.

ECM 2: "DB"- Double glass with plane 9 inches brick wall, inside plaster and out side exposed, roof insulation medium 5 inches vermiculite and white tiles.

ECM 3: "SC"- Single glass with Cavity brick wall, inside plaster and out side exposed and 1 inches EPS insulation. Roof insulation medium 5 inches vermiculite and white tiles.

ECM 4: "SP"- Single glass with Cavity brick wall, inside plaster and out side exposed and 2 inches EPS insulation. Roof insulation medium 5 inches vermiculite and white tiles.

ECM 5: "DP"- Double glass with Cavity brick wall, inside plaster and out side exposed and 2 inches EPS insulation. Roof insulation medium 5 inches vermiculite and white tiles.



RESULTS

Extreme Wet Day	ECM-1-SB	ECM-2-DB	ECM-3-SC	ECM-4-SP	ECM-5-DP
HVAC Design Day Cooling-GF Drawing Room Capacity (Tons)	2.35	2.18	2.34	2.34	2.17
HVAC Design Day Cooling-GF Kitchen Drawing Capacity (Tons)	1.06	1.02	1.05	1.05	1.01
HVAC Design Day Cooling-GF Bed Room Capacity (Tons)	0.62	0.61	0.62	0.62	0.60
HVAC Design Day Cooling-FF Guest Room Capacity (Tons)	0.40	0.40	0.33	0.32	0.31
HVAC Design Day Cooling-FF Kitchen Capacity (Tons)	0.13	0.13	0.12	0.12	0.12
HVAC Design Day Cooling-FF Guest Suit Bed Room Capacity (Tons)	0.61	0.60	0.55	0.54	0.53
Total Ton (s) in Different ECM	5.20	4.96	5.05	5.02	4.78



RESULTS

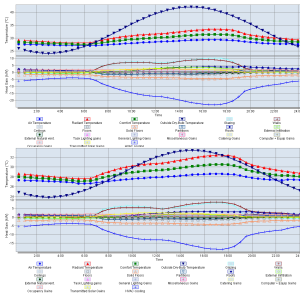


Ton (s) cooling Dry Day	ECM-1-SB	ECM-2-DB	ECM-3-SC	ECM-4-SP	ECM-5-DP
HVAC Design Day Cooling-GF Drawing Room Capacity (Tons)	2.91	2.74	2.90	2.90	2.73
HVAC Design Day Cooling-GF Kitchen Drawing Capacity (Tons)	1.32	1.25	1.31	1.31	1.24
HVAC Design Day Cooling-GF Bed Room Capacity (Tons)	0.91	0.87	0.90	0.90	0.86
HVAC Design Day Cooling-FF Guest Room Capacity (Tons)	0.57	0.54	0.48	0.46	0.43
HVAC Design Day Cooling-FF Kitchen Capacity (Tons)	0.18	0.17	0.17	0.17	0.16
HVAC Design Day Cooling-FF Guest Sall Bed Room Capacity (Tons)	0.85	0.81	0.77	0.76	0.72
Total Ton(s) in Different ECM	6.75	6.41	6.56	6.52	6.17

RESULTS



- ✓The peak cooling load for the drawing room is coming about 147 w/m² in an extremely dry day situation
- ✓The same is reduced to 119 w/m² in a wet day condition.
- ✓The total tonnage of the house is 6.5 ton on dry day and 5 tons on a typical wet day.
- ✓The transient thermal behavior and the heat balance has been shown on an average basis for the two i.e. dry and wet days.
- ✓The graph also depicts the average comfort, sensible and radiant temperatures.



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