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Casestudy on the life cycle cost of Energy Efficient building

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ABSTRACT

Hot and humid climates are cooling dominated and require constant cooling and dehumidification to achieve a comfortable indoor environment, but lead to higher cooling energy costs. Being the most prevalent type of commercial building in India, net-zero small office buildings have the greatest potential in energy savings in India next to residential homes.Various building designs are examined to reduce energy consumption of the building by utilizing energy modeling software. The final package of energy efficiency measures achieves 59% in energy savings of an established energy model baseline. A photovoltaic (PV) system provides the annual energy needs of the small office building. A life cycle cost (LCC) analysis determines whether the additional first costs associated with the net-zero small office design will pay back in energy cost savings. The results proved that the measures used to achieve 59% energy savings were cost effective. In addition, the PV system selected to generate the necessary energy for the small office building was cost effective as long as it met certain efficiency and cost criteria.

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I. INTRODUCTION

As concerns over energy independence in the India and global warming increase well into the 21st century, many are seeking ways to continually increase energy efficiency and reduce energy consumption. Commercial and residential buildings alone account for 40% of primary energy consumption in the India and 70% of electricity usage (CBECS, 2003). The demand for energy by the commercial sector is projected to increase by 1.2% per year from 2006 to 2030, driven by trends in population and economic growth (EIA, 2009). In order to reduce the energy consumption of the commercial building sector, the Department of Energy (DOE) has established the Commercial Building Initiative, a goal to create technologies and design approaches that lead to marketable zero-energy commercial buildings (ZEB) by 2025. This goal is evident in Section 422 of the Energy Independence and Security Act of 2007, which calls for the increased production of clean renewable fuels and increased efficiency of products, buildings, and vehicles (EISA, 2007).There are several definitions for a ZEB. Each definition differs depending on the boundary and metric used to define the building. A net ZEB is, ideally, a building that through high efficiency gains can meet the rest of its energy needs through renewable technologies. Zero is the point at which the building no longer consumes energy but rather produces it. At the zero point, the sum of the energy flows in equal the sum of the energy flows out. There are four definitions used for ZEB's: net-zero source energy building, net-zero site energy building, net-zero energy cost building, net-zero energy emissions buildings.A source ZEB produces at least as much energy as it uses in a year, when compared to the energy produced at the source. Source energy refers to the primary energy used to generate and deliver the energy to the site. The boundary of the system encompasses the building, transmission system, power plant, and the energy required getting the fuel source to power the plant. To calculate a building's total source energy, both imported and exported energy is multiplied by an appropriate site-to-source energy factor

II. Objective

This study is made to assess and quantify the energy savings potential of a small commercial office building located in a hot and humid climate. The percent savings goal was based on the definition of net site energy use: the amount of energy used by a building minus any renewable energy generated within its footprint. The whole-building energy savings method was used to determine energy savings to achieve a net-zero energy building, in line with the Performance Rating Method detailed in Appendix G of Standard 90.1-2004 (ANSI/ASHRAE/IESNA 2004a).

Historically, energy savings have been expressed in two ways: for regulated loads only and for all loads (whole building). Regulated load metrics did not include plug and process loads that were not code regulated. Whole-building energy savings, on the other hand, included all loads (regulated and unregulated) in the calculations. In general, whole-building energy savings were more challenging than regulated load savings given the same numerical target, but more accurately represented the impact of the building on the national energy system.

In order to fulfill the objective, existing floor plans of a small commercial office building were utilized as a starting point to develop a prototype small commercial office building. Once a prototype building was established, a baseline model of the prototype building was created as dictated by the criteria of Appendix G of ASHRAE 90.1-2004 (ANSI/ASHRAE/IESNA 2004a). The baseline prototype building was then simulated using the Typical Meteorological Year 3 (TMY3) weather data for Gainesville, FL to establish a yearly baseline energy usage.A number of reports and datasets were surveyed to develop typical commercial office building characteristics including the Commercial Building Energy Consumption Survey (CBECS 2003) and the DOE Commercial Building Research Benchmarks for Commercial Buildings (Deru, Griffith et al. 2008). The modeling methods outlined in Appendix G of Standard 90.1-2004 (ANSI/ASHRAE/IESNA 2004a) provided the majority of baseline modeling information.

A life cycle cost (LCC) analysis was performed to determine the economics of additional costs incurred by the proposed package of energy efficiency measures versus the baseline. The Building Life Cycle Cost program developed and provided by the National Institute of Standards and Technology (NIST) was utilized to calculate life cycle cost. LCC estimates were calculated in present-value dollars, where all futures costs were discounted to a present value as of the base date and summed to arrive at the total life-cycle cost of the proposed package. The analysis assumed a project life of 20 years and a 3.0% real discount rate. Operations and maintenance costs were not included into the LCC estimates. Energy escalation rates were based on energy price projections provided by DOE’s Energy Information Administration (EIA).

Cost estimates were based on several sources. One of the most widely accepted sources of construction cost information was the RS Means Guide (2009), which was utilized for much of the cost estimating. Other sources utilized for cost information were from published reports and online information. Unfortunately, conflicting sources of information yielded dramatic differences in cost. The total building cost was estimated using data from the 2009 RS Means Building Construction Guide. For the small office building in this study, the total construction cost estimate was calculated to be Rs 118.80/ft2, for a total building construction cost of Rs869,616. The general approach was to take a conservative estimate when confronted with various or vague cost estimates. Details in the cost estimate calculations are found. Two main cost scenarios were explored for this study. The first cost scenario explored costs of only the proposed package of EEMs that were analyzed in this study, while the second cost scenario determined the costs of a solar PV system. A baseline LCC established the LCC of the baseline case, where no upfront costs were incurred

Summery of Proposed package LCC Analysis

Package	Additional Cost	% of Building Cost	Annual Energy Savings	LCC	Simple Payback
Baseline	R s -		Rs -	Rs 138,713	-
Package w/o PV	Rs 45,690	5.3%	Rs 4,953	Rs 103,172	9.22

Table Summary of PV system LCC analysis (including proposed package costs)

Package	Additional Cost	% of Building Cost	Annual Energy Savings	LCC	Simple Payback
Baseline	R s -		Rs -	Rs 138,713	-
40 kW (10% efficient)					
(Rs10/W)	Rs 444,842	54%	Rs 8,206	Rs 444,842	54.21
(Rs8/W)	Rs 364,842	42%	Rs 8,206	Rs 364,842	44.46
(Rs6/W)	Rs 284,842	33%	Rs 8,206	Rs 284,842	34.71
(Rs4/W)	Rs 204,842	24%	Rs 8,206	Rs 204,842	24.96
(Rs2/W)*	Rs 124,842	14%	Rs 8,206	Rs 124,842	15.21
30 kW (15% efficient)					
(Rs10/W)	Rs 344,842	40%	Rs 8,206	Rs 344,842	42.02
(Rs8/W)	Rs 284,842	33%	Rs 8,206	Rs 284,842	34.71
(Rs6/W)	Rs 224,842	26%	Rs 8,206	Rs 224,842	27.40
(Rs4/W)	Rs 164,842	19%	Rs 8,206	Rs 164,842	20.09
(Rs2/W)	Rs 104,842	12%	Rs 8,206	Rs 104,842	12.78
20 kW (20% efficient)					
(Rs10/W)	Rs 244,842	28%	Rs 8,206	Rs 244,842	29.84
(Rs8/W)	Rs 204,842	24%	Rs 8,206	Rs 204,842	24.96
(Rs6/W)	Rs 120,000	14%	Rs 8,206	Rs 120,000	14.62
(Rs4/W)	80,000	9%	Rs 8,206	Rs 80,000	9.75
(Rs2/W)	R 40,000	5%	Rs 8,206	Rs 40,000	4.87

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