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Optimization of Lighting Loads with Emission Analysis: A Simulation Apparoach with RETSCREEN 4.0

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***Abstract*— Electric lighting consumes 20% of total electricity production worldwide. Most of the buildings use electric lighting without proper design and optimization. Day lighting integration is also a better choice for optimizing the power consumption of lighting. A proper design of lighting by considering all modern approaches will considerably decrease the power consumption and reduces not only the electrical bills and also carbon emissions. The reduction in lighting load will reduces the buildings cooling load and indirectly benefits to decrease the energy demands of the building. In this paper an analysis has been done on the lighting loads of an Engineering college situated in Gunupur, India. The report will comprises of better utilization of lighting loads with emission analysis along with local weather conditions. RETSCREEN 4.0 simulation approaches will eases the analysis and calculations and it will have the dynamic response which analyzes the local weather conditions.**

***Keywords*— Optimization; Day lighting; RETSCREEN 4.0; Weather conditions; Simulation**

I. INTRODUCTION

Lighting is provided in industries, commercial buildings, indoor and outdoor for providing comfortable working environment. The primary objective is to provide the required lighting effect for the lowest installed load i.e. highest lighting at lowest power consumption. Dwellings with completely closed surroundings without any natural light consume higher lighting energy, for example, in closed buildings an artificial environment is created through energy. While designing any house, ensure sufficient openings to enable natural lighting.

In everybody's life, lighting comes as an essential need after cooking. If habits are well organized and lumen levels studied, then a substantial amount of savings in lighting can be achieved. Based on the designated daily usage profiles and annual modes, the normalized, total annual electrical energy consumption in all climate types is on average within the range of 0.63–0.79, relative to the total electrical energy consumed by the prototype when it constantly displays the maximum intensity setting [1]. Hence, proper lighting optimization by integrating with local weather conditions will decrease the requirement of power demand. Shading systems have the potential to reduce energy consumption of electric lighting and improve visual comfort. Various automated control systems of shading device and electric lighting have been widely used. However, existing lighting and shading systems typically operate independently, i.e., information is not shared, and thus system performance is not optimal [2].

Building automation and control systems allow buildings to be controlled and managed, thus increasing the users' comfort and reducing the operation and maintenance costs. As far as the lighting services are concerned, control systems offer an important opportunity of managing lighting systems and reducing energy consumption, due to the use of integration strategies between daylight and electric lighting and strategies based on the occupancy of spaces[3]. In this paper an analysis has done on the optimization of building lighting with all available modern approaches by using a simulation software called RETSCREEN 4.0

II. METHODS TO PLAN LIGHTING DESIGN

The lighting design by integrating local day lighting with weather conditions requires a simulation tool and to compare the power consumption with the base case and proposed case. The main aim of this paper is to evaluate the suitability of different choices in lighting and comparison of different case studies. For these comparisons a simulation environment for general use which supports in depth assessment of the factors that affect energy consumption and environmental performance of buildings.

The evaluation of simulation showed that software tools that are designed to simulate intelligent systems are very helpful in solving specific problems of various subsystems of the buildings. The energy performance of a lighting system is influenced by a number of factors. These typically include the illumination level required for the type of space being, the lamp and fixture type selected (e.g. incandescent vs. compact fluorescent), the luminous efficacy and electricity load for each lamp, the total number of fixtures installed, and finally, the operating hours of the lamps. Fig. (1) gives the better idea about the losses in lighting fixtures. The percentage loss between electricity and useful illumination will be around 20-25% only.

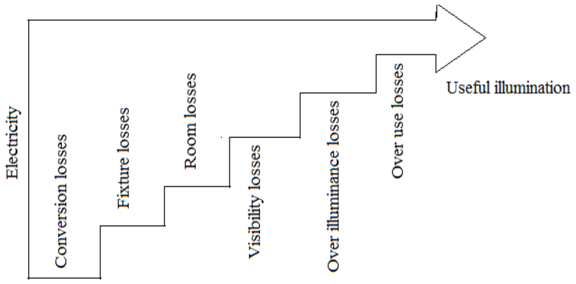

Fig.(1): Lighting fixture losses

A. RETSCREEN Software integration:

The RETSCREEN Software Lighting Model can be used worldwide to evaluate the energy use and savings, costs, emission reductions, financial viability and risk for lighting energy efficiency measures. The software can model a wide variety of projects ranging from installation of high efficiency lamps and luminaries in houses, commercial and institutional buildings and industrial facilities, to installation of timers, twilight switches and occupancy sensors in commercial and institutional buildings, to lamp height reduction combined with de-lamping in industrial facilities. The software contains a database of lamp and fixture efficiency for lighting systems such as incandescent; halogen; fluorescent; high and low pressure sodium; mercury vapour; metal halide and light emitting diode (LED) lamps. The model also calculates the cross-effects of other energy efficiency measures employed in the facility (e.g. heating and cooling impact of installing efficient lighting systems).

B. How much light is needed?

Every task requires some lighting level on the surface of the body. Good lighting is essential to perform visual tasks. Better lighting permits people to work with more productivity. Typical book reading can be done with 100 to 200 lux. The question before the designer is hence, firstly, to choose the correct lighting level. The second question is about the quality of light. In most contexts, quality is read as color rendering. Depending on the type of task, various light sources can be selected based on their color-rendering index.

III. SIMULATION APPROACH FOR LIGHTING DESIGN

A. selecting the weather zone

The compatibility of the RETSCREEN software is it s ability to locate the weather zones and the number of days subjected to better day lighting and weather conditions including pressure and wind directions. There parameters will also influence the day lighting optimizations with artificial lighting. In this study engineering college library has chosen for lighting optimization. Fig (2) shows the basic window of the RETSCREEN software which is the local weather conditions and initial settings.

The main feature of this software is it will integrates the data and the lighting fixtures by considering the local weather parameters.

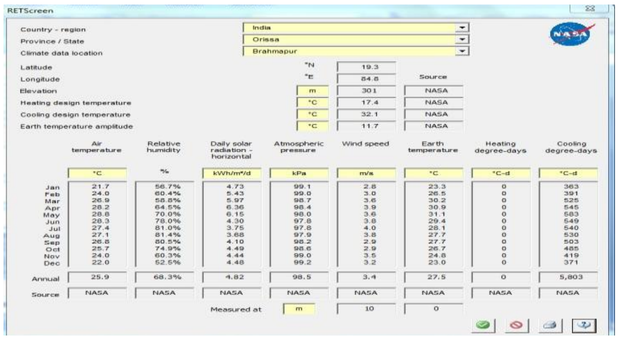

Fig (2): RETSCREEN Weather data

Step 1: Starting worksheet: this is the entrance window of RET screen software which gives the detailed information about the both Project Information and the Site reference conditions.
Therefore the Project Information contains the following details of Project Name, Project location, from where the project is preparing, for what applications, type etc.
It also contains the project type, facility type and analysis types.
Project Type: The user selects the proposed project type considered from the ten options in the drop-down list: "Power," "Power - multiple technologies," "Heating," "Cooling," "Combined heating & power," "Combined cooling & power," "Combined heating & cooling," "Combined cooling, heating & power," "Energy efficiency measures" or "User-defined." Note that the use of the word "power" means "electricity generation" in the RET Screen Model.
Facility type gives the users to select the facility type considered from the five options in the drop-down list: "Residential," "Commercial," "Institutional," "Industrial" and "Other."
Analysis type gives the users to select the type of analysis from the drop-down list. "Method 1" is selected so that less detailed information is required (i.e. most of the worksheets close) while if "Method 2" is selected, more detailed information is required. Typically, Method 1 is used first to determine if a Method 2 analysis is warranted.

Heat value reference: Heating value is a measure of energy released when a fuel is completely burned. Depending on the composition of the fuel (amount of hydrogen) the amount of steam in the combustion products varies. Higher heating value (HHV) is calculated assuming the combustion product is condensed and the steam is converted to water. Lower heating value (LHV) is calculated assuming the combustion product stays in a vapour form. The user should not change this selection once the analysis has started.

Higher heating value is typically used in Canada and USA, while lower heating value is used in the rest of the world. Hence LHV is selected.

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Currency: To perform a RET Screen project analysis, the user may select a currency of their choice. The user selects the currency in which the monetary data of the project will be reported.

Units: The user can choose to view the output of the model in different units by selecting between "Metric" or "Imperial" units from the drop-down list. If the user selects "Metric," all output values will be expressed in metric units. But if the user selects "Imperial," output values will be expressed in Imperial units where applicable.

For selecting climate location:
To access the RET Screen Climate Database click on the "Select climate data location" hyperlink or use the RET Screen menu or toolbar.

Step 2: Energy Model data sheet

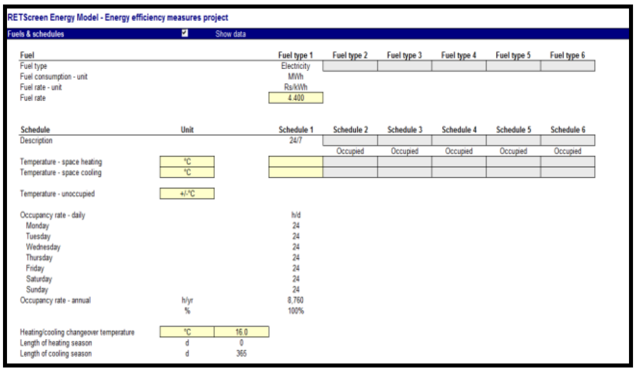


Fig. (3): Energy model data sheet

Fuel: We can specify one or more fuel types for the base case and the proposed case facilities. In addition to electricity (Fuel type 1), we can choose up to five additional fuel types to be considered for the base case and proposed case heating and cooling systems, considered in the forms below.
Fuel type: Select the fuel type from the drop-down list. Depending on the selection of "Heating value reference" in the Start worksheet the relevant heating value will be used for the calculations.
Fuel consumption Unit: Select the fuel consumption unit.
Fuel rate Unit: The model displays the fuel rate unit used for each fuel type.
Fuel rate: Enter the fuel rate (price per unit fuel) for each fuel type.
Schedule: We can specify one or more operating schedules for the base case and the proposed case facilities. In addition to the schedule 1 "24/7" (24 hours per day / 7 days per week), we can define up to five additional schedules to be considered in the Building envelope and Ventilation forms below.
Description: Enter the description of the schedule.
Temperature space heating: Enter the space heating temperature set point for occupied periods, for each schedule specified.
Temperature space cooling: Enter the space cooling temperature set point for occupied periods, for each schedule specified.
Temperature – unoccupied: Enter the difference between temperature set points for occupied and unoccupied periods (in absolute value) for each schedule specified. For example, if +/-3°C is entered, then the "setback" temperature for space heating will be 3° lower during unoccupied periods and the "setup" temperature for space cooling will be 3° higher during unoccupied periods.

Occupancy rate – daily: Enter the number of hours per day that are considered as occupied periods for each day of the week and for each schedule specified.
Occupancy rate – annual: The model calculates the number of hours per year that are considered as occupied periods for each schedule specified. The model also calculates the occupancy rate, in %, for the entire year.
Heating/cooling changeover temperature: Enter the outdoor temperature (air temperature) at which the HVAC (heating, ventilating and air-conditioning) system will normally change from heating to cooling and vice-versa.
Length of heating season: The model calculates the length of the heating season based on the heating/cooling changeover temperature and the climate data entered in the Start worksheet.
Length of cooling season: The model calculates the length of the cooling season based on the heating/cooling changeover temperature and the climate data entered in the Start worksheet.
Here selected fuel type as electricity and the corresponding rate is also considered as 4.4 Rs/kwh. Schedule 1 is selected for 24/7 means 24 days per month per a week. Generally the selected site having hottest climatic conditions since length of cooling season is selected for 365 days.

Step 3: Facility characteristics:

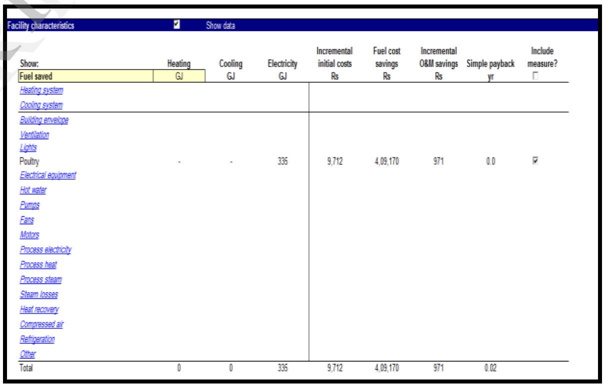


Fig. (4): Lighting load particulars

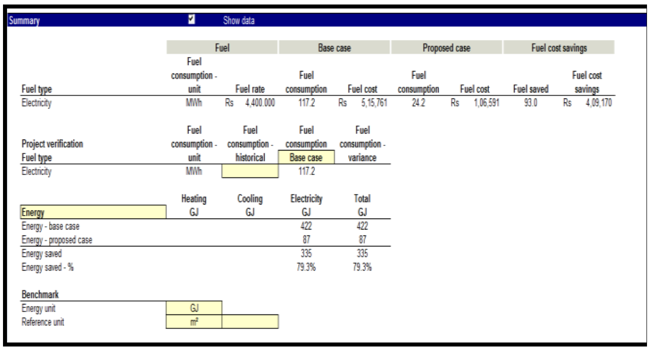
In this section, enter the information about the facility characteristics, for the base case and the proposed case facilities. The user clicks on the blue hyperlinks (e.g. Heating system, Cooling system, Building envelope, etc.) to access the data entry forms used to describe the facility. In addition, the key results of the model are displayed in this section (e.g. fuel saved, simple payback, etc.).

In this window facility characteristics are selected for Poultry. The values for base case and proposed case are entered then the payback period is obtained as zero. Therefore we can use the efficient devices. Its consumption of electricity, Incremental fuel cost, O & M cost, Fuel savings, simple payback period is obtained.

Step 4: Summary

This section summarises key information for the base case and proposed case facilities, including detailed information for each fuel type used, as well as fuel consumption and annual energy use information for heating, cooling and electricity. This section also provides a tool to allow the user to benchmark their project for various energy and reference units.

This window gives the summary of the case. It is considered for both proposed and base cases. The total details of Fuel Type, energy consumption are given. By using efficient appliances the saving of fuel is 93kwh and its cost is saved by Rs 4, 09,170.



Summary ☑ Show data

Fuel type	Fuel: Fuel consumption - unit	Fuel: Fuel rate	Base case: Fuel consumption	Base case: Fuel cost	Proposed case: Fuel consumption	Proposed case: Fuel cost	Fuel cost savings: Fuel saved	Fuel cost savings: Fuel cost savings
Electricity	MWh	Rs 4,400.000	117.2	Rs 5,15,761	24.2	Rs 1,06,591	93.0	Rs 4,09,170

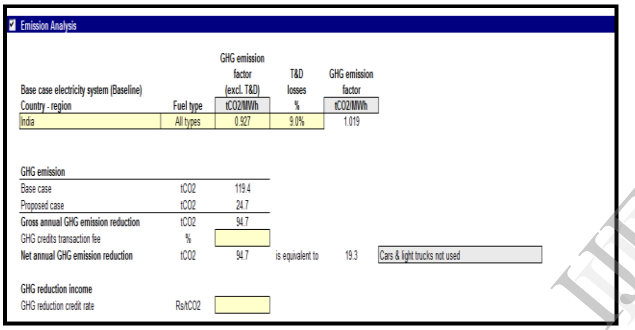
Project verification Fuel type	Fuel consumption - unit	Fuel consumption - historical	Fuel consumption Base case	Fuel consumption - variance
Electricity	MWh		117.2	

Energy	Heating GJ	Cooling GJ	Electricity GJ	Total GJ
Energy - base case			422	422
Energy - proposed case			87	87
Energy saved			335	335
Energy saved - %			79.3%	79.3%

Benchmark		
Energy unit	GJ	
Reference unit	m²	

Fig. (5): Financial analysis

Step 5: Emission Analysis



☑ Emission Analysis

Base case electricity system (Baseline) Country - region	Fuel type	GHG emission factor (excl. T&D) tCO2/MWh	T&D losses %	GHG emission factor tCO2/MWh
India	All types	0.927	9.0%	1.019

GHG emission					
Base case	tCO2	119.4			
Proposed case	tCO2	24.7			
Gross annual GHG emission reduction	tCO2	94.7			
GHG credits transaction fee	%				
Net annual GHG emission reduction	tCO2	94.7	is equivalent to	19.3	Cars & light trucks not used

GHG reduction income		
GHG reduction credit rate	Rs/tCO2	

Fig. (6): Emission analysis

The user indicates by ticking the box whether or not the optional Emission Analysis worksheet is used. If the user ticks the box, the user should complete the Emission Analysis worksheet. Certain input fields will be added to the Financial Analysis worksheet in order to calculate the GHG reduction income. If the user does not tick the box, the user should then go directly to the Financial Analysis worksheet.

Detailed energy audit is also called comprehensive audit or investment grader audit. It expands on the general energy audit. It covers estimation of energy input for different processes, collection of past data on production levels and specific energy consumption. It is a comprehensive energy audit action plan to be followed effectively by the industry[4]. In this the green house gas emission is considered. When the gas emission factor and losses are considered then we can get the Gross annual reduction of the GHG emission. Here we got this value as 94.7%.

IV. Conclusion

This paper has presented an analysis on a case study of adopting energy efficient technology in lighting and how the emission analysis can be done by using RET Screen software. The report also contains of better utilization of lighting loads with local weather conditions. This type of approach will saves the calculation time and it will provides the exact information about all technical approaches by considering local weather conditions including day lighting parameters.

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