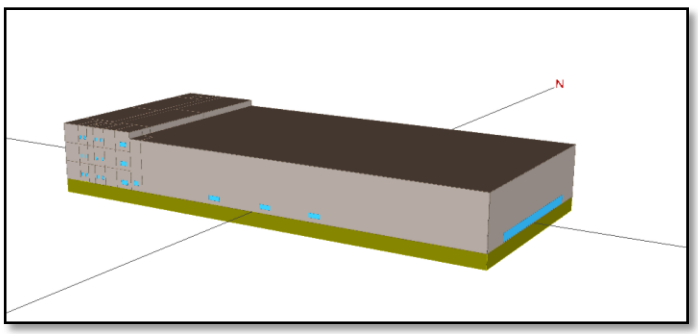
A.P. STATE ENERGY CONSERVATION MISSION (APSECM)

ENERGY CONSERVATIONBUILDING CODE 2017

SIMULATION REPORT

PROPOSED "INDUSTRIAL BUILDING" LOCATED AT PLOT No's: D1-93, D1-94(P), E2-111 & E2-110(P), SURVEY No: 480/2, SITUATED IN ANDHRA PRADESH MEDTECH, ZONE LTD., DIVISION No: 77, ZONE VI OF GVMC, NADUPURU, PEDAGANTYADA(M), VISAKHAPATNAM DIST, ANDHRA PRADESH.



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Contents:

Executive Summary-

Project team shall construct Industry building rest rooms, shed building, suits, Electrical rooms, lift area, staircase area etc. Project is constructed with ground floor located at Visakhapatnam district, Andhra Pradesh state.

Particulars	Details
Building	CommercialBuilding
Building Type	FactoryBuilding
Location	Visakhapatnam district, Andhra Pradesh state
Climate Zone	Warm & Humid
No of Tower	1
Net plot area (m^2)	8910
Built up area (m2)(Excluding parking area)	7119.20
EPI ratio	0.94
ECBC compliance level	2-star
Compliance method	Whole Building Energy Simulation

ECBC Compliance

The code compliance procedure requires the new building to fulfil a set of mandatory provisions in sections 4 to 7. Also, Code compliance requirement can be met by following one of the two methods.

- Prescriptive method
- Whole building performance (WBP)

Proposed building is following option 2 (Whole building performance) to show the compliance.

Whole building performance

Whole building energy performance is a computer based analytical process that help building owners and designers to evaluate the energy performance of a building and make it more energy efficient by making necessary modifications in the design before the building is constructed. Use of energy simulation software is necessary in option 2 to show compliance with ECBC via “Whole Building Performance Method”.

This includes performing a whole building 3D simulation of the building to simulate the existing design. This 3D model will mimic the existing design and include the entire design parameters such as materials, envelope, fenestration, HVAC, lighting, plug loads, other loads, people, occupancy etc. We have used DOE 2 based eQuest as the simulation program.

The energy performance of the design building is compared to the ECBC standard case to document the performance of the proposed design vis-à-vis the ECBC reference building.

How an energy simulation program works

A building’s Energy requirements change continuously under different conditions of weather, occupancy, operation etc. The sequence of calculation is repeated many times to simulate an annual operation cycle. The results of all the repeated calculations are then compiled to produce the total yearly consumption and costs.

For input and calculation purposes, the building is divided into thermal zones. Each thermal zone has certain load characteristics and is served by specific types of conditioning, lighting and other energy consuming systems. The program does most of its calculations separately for each zone.

Whole Building 3D energy simulation includes:

- Basic assessment and understanding of the architectural and constructional Philosophy along with the overall objective of the project
- Data collection of the required inputs for the Energy Optimization Program e.g.

  - Schedules of occupancies, holidays, lighting, equipment usage, etc.
  - All constructions material details and specifications
  - Details of windows, glazing, fenestration etc.
  - Details of lighting, equipment power density
  - Basic HVAC details like type of system, power consumption, air cooled, water cooled etc.
  - Details of other energy requirements like hot water, outside lighting etc.
- 3-D modeling of the building as per the software requirement and all relevant data entry into the Energy Optimization Software Program
- Bench marking the energy requirement for the Standard Design Case for minimum compliance energy levels as per ECBC.
- Developing Energy Efficiency Measures to better the minimum compliance energy levels as indicated above
- Putting together all Energy Efficiency Measures for the proposed building Design
- Arriving at the proposed case energy consumption results
- Arriving at the whole building energy reduction achieved of the proposed case vis-à-vis ECBC case.

Mandatory Requirements for ECBC Compliance

Building Envelope

Fenestration

U-factors

As per code:U-factors shall be determined for the entire fenestration system including the effect of the frame, the spacers in double glazed assemblies, and the glazing in accordance with ISO-15099, as specified in Appendix C of ECBC, by an accredited independent laboratory, and labeled and certified by the manufacturer or other responsible party.

U-factors for sloped glazing and skylights shall be determined at a slope of 20 degrees above the horizontal. For unrated products, use the default table in Appendix C11 (ECBC Manual).

Solar Heat Gain Coefficient (SHGC)

As per Code:SHGC shall be determined for the entire fenestration system including the effect of the frame in accordance with ISO-15099, as specified in Appendix C11, by an accredited independent laboratory, and labeled and certified by the manufacturer or other responsible party.

Exceptions:

- Shading coefficient at the center glass alone multiplied by 0.86 is an acceptable alternate for compliance with the SHGC requirements for the overall fenestration area
- Solar heat gain coefficient (SHGC) of the glass alone is an acceptable alternate for compliance with the SHGC requirements for the overall fenestration product

The Project Team shall install Single glass pane which is Single glazed low-e unit for whole building. Below are the details of proposed glass.

Air Leakage

As per Code: Air leakage for glazed swinging entrance doors and revolving doors shall not exceed 5.0 l/s-m2. Air leakage for other fenestration and doors shall not exceed 2.0 l/s-m2.

As per project: The Project Team has designed the building envelope to maintain the air leakages as mentioned below:

- Fenestration and doors shall not exceed 1.7 l/s-m2
- Glazed swinging entrance doors and revolving doors shall not exceed 4.2 l/s-m2.

Project is under initial stage of the design and same details will be share after appointing façade consultants.

Opaque Construction

As per Code:U-factors shall be determined from the default tables in Appendix C11 or determined from data or procedures contained in the ASHRAE.

Exterior Wall:

Entire exterior envelope shall by constructed by AAC blocks.Technical specification attached below: -

Wall Composition - AAC blocks				
Item	Thickness (mm)	Thickness (Inch)	R Value per inch (hr.sq.ft. °F/Btu)	R Value (hr.sq.ft. °F/Btu)
External Air				0.25
Plaster	20	0.787	0.2	0.157
AAC block	200	7.874	0.69	5.411
Plaster	20	0.787	0.2	0.157
Internal Air	-			0.68
Total				**6.656**
U Value (Btu/hr.ft².°F)				**0.1502**

Exterior Roof: Project team shall installRCC roof with Brick batt cobaatsite. Technical specifications are attached below: -

ROOF ASSEMBLY				
Particulars	Thickness (mm)	Thickness (Inch)	R Value per inch (hr.sq.ft. °F/Btu)	R Value (hr.sq.ft. °F/Btu)
External Air				0.25
High SRI tiles	10	0.394	0.08	0.03
Cement sand screed	50	1.969	0.2	0.39
Brick Batt Coba	80	3.150	0.2	0.63
Geotaxtile layer				0.00
Water proofing layer				0.00
RCC Slab	150	5.906	0.3	1.96
Internal Air				0.92
Total R Value				4.19
U Value (Btu/hr.ft².°F)				**0.239**

Opaque Assembly	Specifications
Exterior wall assembly	• U Value: -1.35 W/m2°K
Wall insulation	NA
Roof insulation	NA
Roof Assembly	• U Value: - 0.87 W/ M^2K

Building Envelope Sealing

As per code: Following area need to be sealed or airtight using caulked, gasket, or weather-strip to minimize air leakage:

1. Joints around fenestration and door frames
2. Openings between walls and foundations and between walls and roof and wall panels
3. Openings at penetrations of utility services through, roofs, walls, and floors
4. Site-built fenestration and doors
5. Building assemblies used as ducts or plenums
6. All other openings in the building envelope

As per project: Project Team has designed project to maintain the minimum air leakage with proper sealed, caulked, gasketed, or weather–stripped.

Envelopedescription

Building envelope generally known as the exterior façade such as wall, roof, glass and slab on grade, and is comprised of opaque components and fenestration systems. Opaque components include walls, roofs, external slab, basement walls, and opaque doors. Fenestration systems include windows, skylights, ventilators, and doors that are more than one-half glazed. The envelope protects the building 's interiors and occupants from the weather conditions and shields them from other external factors e.g.: noise, pollution, etc.

Building envelope parameters effect the total building energy consumption as well as the health of occupants inside the building. Design team is prime responsible for to make the building envelope energy efficient.

A good designed building envelope not only helps in complying with the Energy Conservation Building Envelope (ECBC) but can also result in first cost savings by taking advantage of daylighting and correct HVAC sizing. The building envelope and its components are key determinants of the amount of heat gain and loss and wind that enters inside. The envelope protects the building 's interior and occupants from the weather conditions and other external elements.

Building consumption is depend on the orientation of building, envelope parameters and type of material used in envelope. For better energy efficiency building project design team need to compliance the ECBC code and fulfil the all-mandatory requirements. Design team will incorporate AAC block on wall, 75 mm puff insulation on roof, energy efficient double-glazed unit for fenestration. This will reduce overall energy demand of the project.

Wall

This is a major part of building envelope. Wall receives large numbers of solar radiation. In India generally South wall receive the maximum number of solar radiations. So, this produces the heat gain inside the building. Heat storage capacity and heat conduction property of walls are prime

factors to meeting the desired thermal comfort conditions. The wall thickness, materials and finishes can be chosen based on the heating and cooling needs of the building. Appropriate thermal insulation and air cavities in walls reduce heat transmission into building which is the primary aim in a hot region.

The basic elements of the Wall system are:

- Exterior cladding (natural or synthetic)
- Drainage plane (s)
- Air barrier system(s)
- Vapor Retarder (s)
- Insulating Element(s)

Thermal storage / thermal capacity

Thermal capacity is the measure of the amount of energy required to raise the temperature of a layer of material, it is a product of density multiplied by specific heat and volume of the construction layer.

The main effect of heat storage within the building structure is to moderate fluctuation in the indoor temperature. In a building system, we can understand thermal mass as the ability of a building material to store heat energy to balance the fluctuations in the heat energy requirements or room temperature in the building due to varying outside air temperature. The capacity to store heat depends upon the mass and therefore on the density of the material as well as on its specific heat capacity. Thus, high density materials such as concrete, bricks, stone are said to have high thermal mass owing to their high capacity to store heat while lightweight materials such as wood or plastics have low thermal mass. The heat storing capacities of the building materials help achieve thermal comfort conditions by providing a time delay. This thermal storage effect increases with increasing compactness, density and specific heat capacity of materials.

Thermal performance of walls can be improved by following ways:

1. Increasing wall thickness
2. Providing air cavity between walls and hollow masonry blocks
3. Applying insulation on the external surface.
4. Applying light colored distemper on the exposed side of the wall.

Conductance

Conductivity (K) is defined as the rate of heat flow through a unit area of unit thickness of the material, by a unit temperature difference between the two sides. The unit is W/mK (Watt per meter - degree Kelvin). The conductivity value varies from 0.03 W/mK for insulators to 400W/mK for metals. Materials with lower conductivity are preferred, as they are better insulators and would reduce the external heat gains from the envelope.

Walls-insulation

Thermal insulation is of great value when a building requires mechanical heating or cooling insulation helps reduce the space-conditioning loads. Location of insulation and its optimum thickness are important. In hot climate, insulation is placed on the outer face (facing exterior) of the wall so that thermal mass of the wall is likely coupled with the external source and strongly coupled with the interior (Bansal, Hauser, Minke 1994).

Air Cavities

Air cavities within walls or an attic space in the roof-ceiling combination reduce the solar heat gain factor, thereby reducing space-conditioning loads. The performance improves if the void is ventilated. Heat is transmitted through the air cavity by convection and radiation. A cavity represents a resistance, which is not proportional to its thickness. For a thickness >20mm, the resistance to heat flow remains nearly constant. Ventilated air does not reduce radiative heat transfer from roof to ceiling. The radiative component of heat transfer may be reduced by using low emissivity or high reflective coating (E.g.: aluminum foil) on either surface facing the cavity. With aluminum foil attached to the top of ceiling, the resistance for downward heat flow increases to about 0.4 W/m2k compared to 0.21 W/m2k in the absence of the foil (Bansal, Hauser, Minke, 1994).

Windows

Windows are very important components of the building envelope and in addition to providing physical and visual connection to outside; they also allow heat and light inside and add beauty to the building. Solar radiation coming in through windows provides natural lighting, natural air and heat gain to the space inside, thus significantly impacting the energy usage of the building. The main purpose of a building and its windows is to provide thermal and visual comfort to the occupants using the minimum possible energy.

Proper location, sizing, and detailing of windows and shading form are important parts of the bio-climatic design as they help to keep the sun and wind out of building or allow them when needed. The location of openings for ventilation is determined by prevalent wind direction, openings at higher levels naturally aid in venting out hot air. Size, shape and orientation of openings moderate air velocity and flow in the room, a small inlet and a large outlet increase the velocity and distribution of air flow through the room. When possible, the building should be so positioned at the site that it takes advantage of prevailing winds. The prevailing wind direction is from the west/north-west. The recommendation is IS: 3362-1977 code of practices for the design of windows for lighting and ventilation. There should be sufficient air motion in hot-humid and warm-humid climates. In such areas, fans are essential to provide comfortable air motion indoors, fenestrations having 15% -20% of floor area are found adequate for both ventilation & day lighting in hot & dry, and hot & humid regions. Natural light is also admitted into a building through glazed openings. Thus, fenestrations design is primarily governed by requirements of heat gain and losses, ventilation and day lighting. The important components of a window are the glazing systems and shading devices.

Primary components of a window which have significant impact on energy and cost of the building for which guidelines are provided in this section are as follows:

- Window size, placement
- Glazing
- Frame
- Shading (external & internal)
- Window size & placement

Height of window head: The higher the window head, the deeper will be the penetration of daylight.

Sill height (height from floor to the bottom of the window):

The optimum sill for good illumination as well for good ventilation should be between the illumination workspace and head level of a person. Carrying out any task, the suitable work plane levels are to be 1.0 to 0.3 m high respectively.

- Strip windows provide more uniform daylight
- Punched windows should be paired with work areas to avoid creating contrasts of light and dark areas.
- Avoid big windows close to task areas since they can be source of thermal discomfort and might also cause glare.

Also, larger the windows, the more important glazing selection and shading effectiveness are to control glare and heat gain.

Use separate apertures for view and daylight—for good day lighting and glare control separate the view and light windows. Light window should have clear glass for maximum daylight penetration. Tinted glass could be used below for glare control. The structure in between the two provides a visual break and an opportunity to attach light shelf or shading device.

Glazing systems

Glazing is generally referred to the glass. The most common glazing material used in openings is glass, although recently polycarbonate sheets are being used for skylights. Before recent innovations in glass, films and coatings, a typical residential window with one or two layers of glazing allowed roughly 75% -85% of the solar energy to enter a building.

Internal shading devices such as curtains, or blinds could reflect some of that energy outside the building. The weak thermal characteristics of the windows became a prime target for research and development. In an attempt to control the indoor air temperature of buildings windows admit direct solar radiation and hence promote heat gain. This is desirable in cold climates but is critical in hot climates. The window size should be kept minimum in hot & dry regions. The primary properties of glazing that impact energy are:

- Visible reflectance (affecting heat and light reflection)
- Thermal transmittance or U - value (affecting conduction heat gains)
- Solar heat gain (affecting direct solar gain)
- Spectral selectivity (affecting daylight and heat gain)
- Glazing color (affects the thermal and visual properties of glazing systems and thus energy usage).

Visible transmittance (VLT %) or Daylight Transmittance

This is the percentage of normally incident visible light transmitted through the glazing. Glazing with a high visible transmittance is clearer in appearance and provide sufficient daylight and views. Clear glass, however, can create glare problem. Glazing with low visible transmittance give better glare control but offer minimal daylight integration and diminished views.

Visible reflectance or daylight reflectance

This is the percentage of incident light that is reflected. Most manufacturers provide both outside reflectance (exterior daytime view) and inside reflectance (interior mirror image at night). Treatments such as metallic coating increase the reflectance. Reflective glazing reflects a large portion of the solar radiation incident on it, thereby restricting heat gain inside the building, which is advantageous.

Disadvantage is that these reflective glazing allows low visible transmittance and thus minimal daylight integration.

Solar heat gain coefficient (SHGC)

The SHGC is the fraction of incident solar radiation admitted through a window, both directly transmitted and absorbed and subsequently released inward. SHGC is expressed as a number between 0 and 1. The lower a window's solar heat gain coefficient, the less solar heat it transmits. These properties are widely used in cooling load calculations. Glass with a lower SHGC or SC (Shading coefficient) helps in reducing cooling loads in hot climate zones. Design team has proposed double glazed unit with low SHGC. ECBC requirement for SHGC is 0.2 and design team has proposed glass with SHGC of 0.26. But design team is going with option 2 whole building energy simulation, so this meets the requirement of ECBC.

Heating Ventilation and air conditioning (HVAC)

Heating, Ventilation and Air Conditioning (HVAC) refers to the equipment, distribution systems, and terminals that provide, either collectively or individually, the heating, ventilation, or air-conditioning requirement to a building or a portion of building. The HVAC system accounts for a significant portion of a commercial building's energy use. HVAC energy use in a commercial building can increase/decrease significantly depending on how efficiently the combination of air side systems and central plant operates.

Mechanical Ventilation

As per project: Fresh air shall be provided through Mechanicalventilation inthe building as per ECBC 2017.

Minimum Equipment Efficiencies

As per code: Unitary air-conditioners shall meet or exceed the efficiency requirements given in Table 5-1. Window and split air conditioners shall be certified under BEE's Star Labeling Program. EER shall be as per IS 8148 for all unitary, split, packaged air conditioners greater than 10 kWr.

Table 5-1 Minimum Requirements for Unitary, Split, Packaged Air Conditioners in ECBC Building

Cooling Capacity (kWr)	*Water Cooled*	*Air Cooled*
≤ 10.5	NA	BEE 3 Star
>10.5	3.3 EER	2.8 EER

Efficiencies forAir-cooled Air-Conditioning Systems

As per project: Project team shall install Unitary/Split AC COP- 3.50.

Controls

Timeclock

As per code: All mechanical cooling and heating systems shall be controlled by a time clock that:

1. Can start and stop the system under different schedules for three different day-types per week
2. can retain programming and time setting during loss of power for a period of at least 10 hours, and

3. Includes an accessible manual override that allows temporary operation of the system for up to 2 hours

Exceptions to the above are:

1. Cooling systems < 28 kW (8 tons)
2. Heating systems < 7 kW (2 tons)

All heating and cooling equipment shall be temperature controlled. Where a unit provides both heating and cooling, controls shall be capable of providing a temperature dead band of 3°C (5°F) within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum. Where separate heating and cooling equipment serve the same temperature zone, thermostats shall be interlocked to prevent simultaneous heating and cooling.

All cooling towers and closed-circuit fluid coolers shall have either two speed motors, pony motors, or variable speed drives controlling the fans.

Temperature control
As per code: All heating and cooling equipment shall be temperature controlled. Where a unit provides both heating and cooling, controls shall be capable of providing a temperature dead band of 3 C (5 0F) within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum. Where separate heating and cooling equipment serve the same temperature zone, thermostats shall be interlocked to prevent simultaneous heating and cooling.

Fan control
As per project: ConstantAir volume (CAV)

Piping and Ductwork
As per code: Piping for heating systems with a design operating temperature of 60°C (140°F) or greater shall have at least R-0.70 (R-4) insulation. Piping for heating systems with a design operating temperature less than 60°C (140°F) but greater than 40°C (104°F), piping for cooling systems with a design operating temperature less than 15°C (59°F) and refrigerant suction piping on split systems shall have at least R-0.35 (R-2) insulation. Insulation exposed to weather shall be protected by aluminum sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above or be painted with water retardant paint. Ductwork shall be insulated in accordance with Table.

	Required Insulation[a] (R-values in $m^2 \cdot K/W$)	
Duct Location	Supply Ducts	Return Ducts
Exterior	R-1.4	R- 0.6
Ventilated Attic	R-1.4	R- 0.6
Unventilated Attic without Roof Insulation	R-1.4	R- 0.6
Unventilated Attic with Roof Insulation	R- 0.6	No Requirement
Unconditioned Space[b]	R- 0.6	No Requirement
Indirectly Conditioned Space[c]	No Requirement	No Requirement
Buried	R- 0.6	No Requirement

[a]Insulation R-value is measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 24°C (75°F) at the installed thickness

[b]Includes crawlspaces, both ventilated and non-ventilated

[c]Includes return air plenums with or without exposed roofs above.

As per project: Piping & duct work shall be provided as per ECBC compliance.

System Balancing

General

Construction documents shall require that all HVAC systems be balanced in accordance with generally accepted engineering standards.

Construction documents shall require that a written balance report be provided to the owner or the designated representative of the building owner for HVAC systems serving zones with a total conditioned area exceeding 500 m2 (5,000 ft.2).

Air System Balancing

As per code: Air systems shall be balanced in a manner to first minimize throttling losses. Then, for fans with fan system power greater than 0.75 kW (1.0 hp), fan speed shall be adjusted to meet design flow conditions.

As per project:NA

Hydroid System Balancing

As per code: Hydroid systems shall be proportionately balanced in a manner to first minimize throttling losses; then the pump impeller shall be trimmed, or pump speed shall be adjusted to meet design flow conditions.

Exceptions to the above:

(a) Impellers need not be trimmed, nor pump speed adjusted for pumps with pump motors of 7.5 kW (10 hp) or less,

(b) Impellers need not be trimmed when throttling results in no greater than 5% of the nameplate horsepower draw, or 2.2 kW (3 hp), whichever is greater.

As per project: All the requirements will be fulfilling at the construction stage.

Condensers

Condenser Locations

As per code: Care shall be exercised in locating the condensers in such a manner that heat sink is free of interference from heat discharge by devices located in adjoining spaces and also does not interfere with such other systems installed nearby.

As per project:NA

Treated Water for Condensers

As per code: All high-rise buildings using centralized cooling water system shall use soft water for the condenser and chilled water system.

As per project:NA

Service hot water heater & pumping (SWHP)

Not applicable

Lighting

Lighting alone accounts for almost 15% of the total energy consumption in India. Lighting is an area that offers many energy efficiency opportunities in almost any building facility, existing or new. Using efficient lighting equipment and controls is the best way to ensure lighting energy efficiency while maintaining or even improving lighting conditions. For a lighting designer, an energy efficient lighting design involves careful integration of many requirements and considerations such as building orientation, interior building layout, task illumination, daylight strategies, glazing specification, choice of lighting controls, etc.

The lighting requirements in ECBC apply to:

1. Interior spaces of buildings
2. Exterior building features, including façades, illuminated roofs, architectural features, entrances, exits, loading docks, and illuminated canopies
3. Exterior building grounds lighting that is provided through the building's electrical service

Exceptions to above:

1. Emergency lighting that is automatically off during normal building operation and is powered by battery, generator, or other alternate power source
2. Lighting in dwelling units

Lighting Controls

The simplest way to save energy is turning down or completely switching off the lights when not required which can be achieved by installing lighting controls. The lighting controls basically perform two functions: 1) they turn lights off when not needed, and 2) they modulate light output so that no more light than necessary is produced. The equipment required to achieve these functions varies in complexity from simple timers to intricate electronic dimming circuits, each applicable to different situations. Controls include occupant and motion sensors, time clocks, automatic or manual day lighting controls, and astronomical time switches (the automatic switches that adjust for the length of the day as it varies over the year).

Manual vs. Automatic Controls

Manual lighting controls range from a single switch to a bank of switches and dimmers that are actuated by toggles, rotary knobs, push buttons, remote control, and other means. Manual controls can be cost-effective options for small-scale situations. However, as the lighting system becomes larger, automated systems become more cost-effective and are better at controlling light. Manual controls may not give the desired results in real situations because the decision to shut off the lights when they are not needed is based entirely on human initiative. It is worthwhile to determine the amount of local vs. central control that is needed from the lighting control system.

Automatic Lighting Shutoff

The simplest way to reduce the amount of energy consumed is by switching off the lights when not required; however, this is not done as often as it could be. In response to this, the ECBC requires that several automatic switches be used which either work on time schedule or sense the presence of occupants.

Automatic Control Strategies

Several different approaches can be used to control electric lighting which are listed below:

- Scheduling Control: Use a time scheduling device to control lighting systems according to predetermined schedules.
- Occupancy Sensing: Control lights in the presence or absence of people in the space.
- Day lighting: Switch or dim electric lights in response to the presence or absence of daylight illumination in the space.
- Lumen Maintenance: Gradually adjust electric light levels over time to correspond with the depreciation of light output from aging lamps.

As per the Code:

Interior lighting systems in buildings larger than 500 m2 (5000 ft2) shall be equipped with an automatic control device. Within these buildings, all office areas less than 30 m2 (300 ft2) enclosed by walls or ceiling-height partitions, all meeting and conference rooms, all school classrooms, and all storage spaces shall be equipped with occupancy sensors. For other spaces, this automatic control device shall function on either.

a. A scheduled basis at specific programmed times. An independent program schedule shall be provided for areas of no more than 2,500 m2 (25,000 ft2) and not more than one floor: or,

b. Occupancy sensors that shall turn the lighting off within 30 minutes of an occupant leaving the space. Light fixtures controlled by occupancy sensors shall have a wall-mounted, manual switch capable of turning off lights when the space is occupied.

Exception to above:

See below some lighting control techniques.

Scheduling Control

Programmable timing, also known as automatic time scheduling, is the oldest form of automatic lighting control. Time scheduling manages the on and off of building’s lighting system. Scheduling system function by turning off all or some of the lights when a building space is unoccupied. In the most basic time-scheduling scheme, a time switches lighting circuit on or off based on programmable schedule.

Occupancy Sensor

Occupancy sensors are automatic scheduling device that detect motion and turns off and on accordingly. Most devices can be calibrated for sensitivity and for the length-of-time delay between the last detected occupancy and extinguishing of the lights. The most energy-efficient occupancy sensors, known as “manual- on, automatic-off”, require that the user manually switch on the lights when entering a controlled zone (the “light off” function is still automatic).

Space Control

As per code: Along with control for individual lights or sets of fixtures, master controls are requiring for each space which can shut off all the lights within the space. For example, the last person leaving the office is much more likely to use a master switch than to go through the office turning off every switch.

- Control a maximum of 250 sq. m. for a space less than or equal to 1000 sq. m., and a maximum of 1000 sq. m. for a space greater than 1000 sq. m.
- Be capable of overriding the required shutoff control for no more than 2 hours
- Be readily accessible and located so the occupant can see the control.

Control in day lighted Areas

As per code: Luminaire in day lighted area greater than 25 sq. m. shall be equipped with either a manual or automatic control device that,

- Can reduce the light output of the luminaires in the day lighted areas by at least 50%
- Controls only the luminaires located entirely within the day lighted area.

Exterior Lighting Control

As per the Code: Lighting for all exterior applications not exempted in Section 6.3.5 (of the Code) shall be controlled by a photo sensor or astronomical switch that is capable of automatically turning off the exterior lighting when daylight is available, or the lighting is not required.

Following lights are exempted under Section 7.3.5 of the Code only if they are equipped by an independent control device:

- Specialized signal, directional, and marker lighting associated with transportation
- Lighting used to highlight features of public monuments and registered historic landmark structures or buildings
- Lighting that is integral to advertising signage
- Lighting that is specifically designated as required by a health or life safety statute, ordinance, or regulation

Additional Control

As per the Code: The following specialty lighting spaces are required to have a control device that separates lighting control from that of general lighting.

The lighting applications listed below shall be equipped with a control device to control such lighting independently of the general lighting:

- Display/Accent Lighting: Display or accent lighting greater than 300 m2 (3000 ft2) area shall have a separate control device
- Case Lighting: Lighting in cases used for display purposes greater than 300 m2 (3000 ft2) area shall be equipped with a separate control device
- Hotel and Motel Guest Room Lighting: Hotel and motel guest rooms and guest suites shall have a master control device at the main room entry to control all permanently installed luminaries and switched receptacles.
- Task Lighting: Supplemental task lighting including permanently installed under-shelf or under-cabinet lighting shall have a control device integral to the luminaries or be controlled by a wall-mounted control device provided the control device complies with the mandatory conditions specified under the Space Control Head.
- Non-visual Lighting: Lighting for non-visual applications, such as plant growth and food-warming, shall be equipped with a separate control device.
- Demonstration Lighting: Lighting equipment that is for sale or for demonstrations in lighting education shall be equipped with a separate control device accessible only to the authorized personnel.

Exit Signs

As per the Code: Internally illuminated exit signs shall not exceed 5W per face.

Electrically powered exit signs normally use incandescent bulbs. Most LED and some CFL exit signs can meet ECBC requirement. Due to their lower power consumption, LED exit signs can be purchased with a built-in back-up power supply (i.e. batteries). With an estimated life span of 10 years or more, LEDs require significantly fewer lamp replacements than exit signs equipped

Electrical Power:

As per the Code: Power transformer of the proper rating and design must be selected to satisfy that minimum transformer of the proper ratings and design must be selected to satisfy the minimum acceptable efficiency at 50% and full rating.

Minimum acceptable efficiency at 50% and full load rating.

a) 5% of the maximum total loss values mentioned in IS 1180 for oil type transformers

in voltage class above 11 kV but not more than 22 kV

b) 7.5% of the maximum total loss values mentioned in above IS 1180 for oil type

transformers in voltage class above 22 kV and up to and including 33 kV

c) values listed in Table 7.1 for dry type transformers

As per the project: Project construction yet to be started. however, project team ensure that transformer shall be installed as per ECBC compliance level.

Table 7-1: Dry Type Transformers

Rating (kVA)	Impedance (%)	Max. Total Loss (W)					
		ECBC Building		ECBC+ Building		SuperECBC Building	
		50 % Load	100% Load	50 % Load	100% Load	50 % Load	100% Load
16	4.5	150	480	135	440	120	400
25	4.5	210	695	190	635	175	595
63	4.5	380	1,250	340	1,140	300	1,050
100	4.5	520	1,800	475	1,650	435	1,500
160	4.5	770	2,200	670	1,950	570	1,700
200	4.5	890	2,700	780	2,300	670	2,100
250	4.5	1,050	3,150	980	2,930	920	2,700
315	4.5	1,100	3,275	1,025	3,100	955	2,750
400	4.5	1,300	3,875	1,225	3,450	1,150	3,330
500	4.5	1,600	4,750	1,510	4,300	1,430	4,100
630	4.5	2,000	5,855	1,860	5,300	1,745	4,850
1000	5	3,000	9,000	2,790	7,700	2,620	7,000
1250	5	3,600	1,0750	3,300	9,200	3,220	8,400
1600	6.25	4,500	13,500	4,200	11,800	3,970	11,300
2000	6.25	5,400	17,000	5,050	15,000	4,790	14,100
2500	6.25	6,500	20,000	6,150	18,500	5,900	17,500
Total loss values given in above table are applicable for thermal classes E, B and F and have component of load loss at reference temperature according to Clause 17 of IS. An increase of 7% on total for thermal class H is allowed.							

Table 7-2: Permissible Losses for Oil Type Transformers. Total losses for oil type transformers shall confirm with Indian Standard IS 1180.

Rating (kVA)	Impedance (%)	Max. Total Loss (W)					
		ECBC Building		ECBC+ Building		SuperECBC Building	
		50 % Load	100% Load	50 % Load	100% Load	50 % Load	100% Load
16	4.5	150	480	135	440	120	400
25	4.5	210	695	190	635	175	595
63	4.5	380	1250	340	1140	300	1050
100	4.5	520	1800	475	1650	435	1500
160	4.5	770	2200	670	1950	570	1700
200	4.5	890	2700	780	2300	670	2100
250	4.5	1050	3150	980	2930	920	2700
315	4.5	1100	3275	1025	3100	955	2750
400	4.5	1300	3875	1225	3450	1150	3330
500	4.5	1600	4750	1510	4300	1430	4100
630	4.5	2000	5855	1860	5300	1745	4850
1000	5	3000	9000	2790	7700	2620	7000
1250	5	3600	10750	3300	9200	3220	8400
1600	6.25	4500	13500	4200	11800	3970	11300
2000	6.25	5400	17000	5050	15000	4790	14100
2500	6.25	6500	20000	6150	18500	5900	17500
Total loss values given in above table are applicable for thermal classes E, B and F and have component of load loss at reference temperature according to Clause 17 of IS 1180 i.e., average winding temperature rise as given in Column 2 of Table 8.2 plus 300C. An increase of 7% on total for thermal class H is allowed.							

Energy Efficient Motors
As per code: Motors shall comply with the following:

1. All permanently wired polyphaser motors of 0.375kW or more serving the building and expected to operate more than 1,500 hours per year and all permanently wired polyphaser motor of 50kW or more serving the building and expected to operate more than 500 hours per year shall have a minimum acceptable nominal full load motor efficiency not less than IS 12615 for energy efficient motors;
2. Motors of horsepower differing from those listed in the table shall have efficiency greater than that of the next listed kW motor;
3. Motor horsepower ratings shall not exceed 20 % of the calculated maximum load being served;
4. Motor nameplates shall list the nominal full-load motor efficiencies and the full- load power factor;
5. Motor users should insist on proper rewinding practices for any rewound motors. If the proper rewinding practices cannot be assured, the damaged motor should be replaced with a new, efficient one rather than suffer the significant efficiency penalty associated with typical rewind practices; and
6. Certificates shall be obtained and kept on record indicating the motor efficiency. Whenever a motor is rewound, appropriate measures shall be taken so that the core characteristics of the motor is not lost due to thermal and mechanical stress during removal of damaged parts. After rewinding, a new efficiency test shall be performed, and similar record shall be maintained

As per project: All motors efficiency shallas ECBC compliance level.

Power factor correction
As per code: All electricity supplies exceeding 100 A, 3 phases shall maintain their power factor between 0.95 lag and unity at the point of connection.

Check metering and monitoring
As per code:

- Services exceeding 1000kVA shall have permanently installed metering to record demand (kVA), energy (kWh), and total power factor. The metering shall also display current (in each phase and the neutral), voltage (between phases and between each phase and neutral), and Total Harmonic Distortion (THD) as a percentage of total current.
- Services not exceeding 1000 kVA but over 65 KVA shall have permanently installed electric metering to record demand (kVA), energy (kWh), and total power Factor (or kVARh).

- Services not exceeding 65 kVA shall have permanently installed electrical metering to record energy (kWh)
- HVAC feeders
- Utility & Common area loads
- Lighting & Raw power loads
- PHE loads
- Lift loads

Power distribution systems

As per code: The Power cabling shall be adequately sized as to maintain the power distribution losses not to exceed 1% of the total power usage. Record of design calculation for the losses shall be maintained.

Whole Building Performance Analysis

Project has proposed the following major energy conservation or efficiency measures in compliance with ECBC requirement,

- Energy efficient lighting fixtures (LED and T5)
- AAC blocks for exterior wall construction
- RCC roof construction with Brick batt Cobaand high SI tiles/paints
- High performance energy efficient single glazing proposed
- EfficientAir Cooled VRV/VRF Air cooled system-COP-3.50
- Voltage drop for feeders shall not exceed 2% at design load and voltage drop for branch circuit shall not exceed 3% at design load
- PV solar, minimum 2% of contract demand

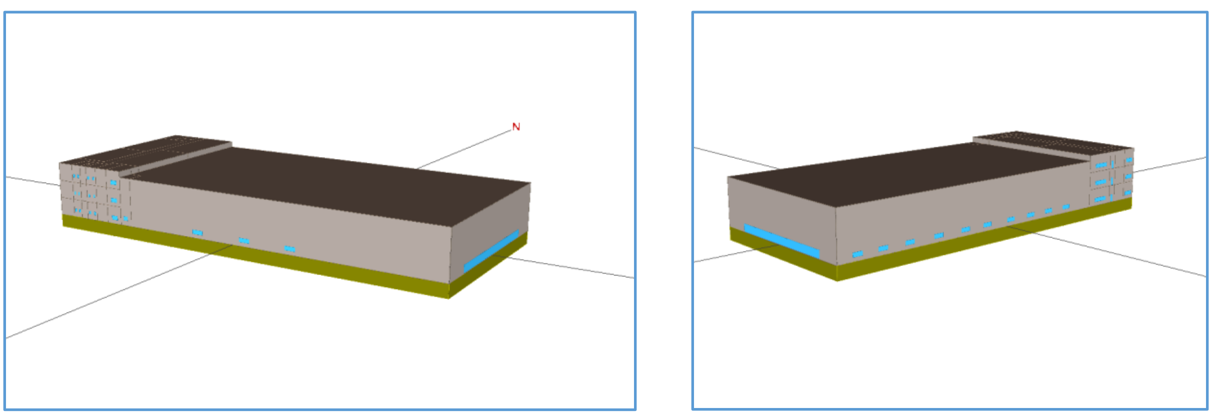

Figure –IndustryBuilding

Comparison between ECBC and Proposed case:

Input Parameters	Standard (ECBC) Case	Proposed Case	Units/Description
Exterior Wall	0.40	0.87	$W/m^2.k$
Exterior Roof	0.28	1.35	$W/m^2.k$
Glazing	3	5.6	$W/m^2.k$
SHGC	0.27	0.40	
SC	0.31	0.46	
VLT	0.27	33%	
Window wall ratio	<40%	4.66%	
Shading device	None	As per proposed design	
HVAC system	PTAC	PTAC	
COP	3.30	3.50	
Fan Control	Constant Volume	Constant Volume	
Cooling capacity	1	1.15	
Heating capacity	1	1.25	
Heating	Electric	Electric	
Equipment load	0.80 W/sq. ft. Conditioned Space.& Kitchen area	0.80 W/sq. ft. Conditioned Space& Kitchen area	

EPI details: -

Industry Building-

Plot area	8,910	sq. m.
Project Location	Proposed construction of Industrial Building situated at Visakhaptnam district, Andhra Pradesh state	
Proposed built up area (excluding basement parking area)	7,119.2	sq. m.
Proposed case annual energy consumption	13,11,200.0	kWh
ECBC case annual energy consumption	13,99,100.0	kWh
Proposed case EPI	184	kWh/sq. m.
ECBC case EPI	197	kWh/sq. m.
Conditioned area	3204	sq. mtr
Un-Conditioned area	3916	sq. mtr
EPI Ratio	0.94	
WWR%	4.66	
% Savings	6.28%	
ECBC Compliance level	2-Star	

Above results show, EPI ratio is less than 1 so, this meets the compliance requirement of ECBC through Whole building performance method.

4.0 APPENDIX-

Daylighting: -

Above grade floor areas shall meet or exceed the useful daylight illuminance (UDI) area requirements listed in Table 4-1 for 90% of the potential daylit time in a year. Mixed-use buildings shall show compliance as per the criteria prescribed in §2.5. Compliance shall be demonstrated either through daylighting simulation method in §4.2.3.1 or the manual method in §4.2.3.2. Assembly buildings and other buildings where daylighting will interfere with the functions or processes of 50% (or more) of the building floor area, are exempted from meeting the requirements listed in Table 4-1.

S.NO.	Space	Floor area (m^2)	Area meeting UDI requirements 90% of the potential daylight time of the year (m^2)	% age of area meeting UDI requirements 90% of the potential daylight time of the year (m^2)
1	Industry Building	7119.20	Exempted	

The results in the table above show that using a glass with VLT less than 0.3 the building will be ECBC compliant from a daylighting perspective.

Operational Schedules-

Table 9-17: Schedules for Assembly Buildings (B)

Assembly Buildings								
	Occupancy Schedule			Lighting Schedule			Equipment Schedule	
Time Period	Seating/Public Space	Exhibit Space	Meeting/ Conference	Seating/Public Space	Exhibit Space	Meeting/ Conference	Exhibit Space	Meeting/ Conference
00:00-01:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
01:00-02:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
02:00-03:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
03:00-04:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
04:00-05:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
05:00-06:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
06:00-07:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
07:00-08:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
08:00-09:00	0.50	0.50	0.00	0.90	0.90	0.10	0.00	0.00
09:00-10:00	0.60	0.50	0.50	0.90	0.90	0.90	0.90	0.80
10:00-11:00	0.70	0.80	0.75	0.90	0.90	0.90	0.90	0.80
11:00-12:00	0.70	0.80	0.75	0.90	0.90	0.90	0.90	0.80
12:00-13:00	0.70	0.80	0.75	0.90	0.90	0.90	0.90	0.80
13:00-14:00	0.90	0.25	0.50	0.90	0.50	0.50	0.50	0.50
14:00-15:00	0.90	0.25	0.75	0.90	0.50	0.90	0.90	0.80
15:00-16:00	0.70	0.80	0.75	0.90	0.90	0.90	0.90	0.80
16:00-17:00	0.70	0.80	0.75	0.90	0.90	0.90	0.90	0.80
17:00-18:00	0.70	0.80	0.75	0.90	0.90	0.90	0.90	0.80
18:00-19:00	0.80	0.50	0.50	0.90	0.90	0.50	0.00	0.00
19:00-20:00	0.80	0.00	0.00	0.90	0.10	0.10	0.00	0.00
20:00-21:00	0.80	0.00	0.00	0.90	0.10	0.10	0.00	0.00
21:00-22:00	0.70	0.00	0.00	0.90	0.10	0.10	0.00	0.00
22:00-23:00	0.60	0.00	0.00	0.90	0.10	0.10	0.00	0.00
23:00-24:00	0.50	0.00	0.00	0.90	0.10	0.10	0.00	0.00

-End of Report -