BUILDING ENERGY SYSTEMS AND AUDITING

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Week - 07

Lecture 33

Lecture 33 : Star Rating of Shopping Mall and BPO

Welcome to the NPTEL course on Building Energy Systems and Auditing. In Module 7, the third lecture will be delivered today. We are in Lecture 33, and we will discuss the star rating of shopping malls and BPOs. So, in this, we will discuss these two EPI values and how to calculate them for the shopping mall and the BPO. It will be very similar to what we discussed in Lecture 32. We will also see the two different types of indexing systems for EPI and AAH EPI here.

So, in the beginning, for shopping malls, the Bureau of Energy Efficiency has recommended a 1 to 5 scale for star rating based on the EPI values, which depend on the four climatic zones. Perhaps they may expand to other climatic zones in India. I mean to say that one of the climatic zones is left out, which is the cold climate. The only difference in this particular system is that we will calculate the EPI straightforward values. From the straightforward EPI values, the star rating will be decided without any consideration of the percentage of conditioned areas or similar factors.

So, again, let us briefly discuss the EPI, which is the Energy Performance Index of any building, measured in kWh per m^2/year. The yearly total amount of energy required to operate the building must be calculated, and then we divide that by the total active built-up area to determine the EPI. The Energy Performance Index bandwidth has been prescribed by the Bureau of Energy Efficiency, Government of India, for all four types of climates. For composite climate, if the bandwidth is, for example, 350 to 300, it is given a 1-star rating, as we discussed earlier. If it is above 350, it will not receive any star rating. If it is below 150, it will be given a 5-star rating system.

So, that is for the composite if you see the hot dry it is little bit little bit little bit I may say is little tight the first the 1 star first 1 star rating will be 300 to 250. whether if any

building is in situated in the hot and dry climate and want to take the 5 star rating. So, the operational energy EPI index must be below 100 whereas, if you see in the composite climate, it is below 150. Similarly, the warm and humid climate is below 250 is the 5 star. So, it is much more relaxed in that sense or in the other way if you see if you actually want to see into the other perspective, it is little tougher to control the or to actually your expenditure of the air conditioning and all these things is much higher with respect in the warm and humid climate which is

obvious because we have to also look after the humidity part also and the temperate climate if it is below 175 then only it will be given as the 5 star. So, these are the typical the bandwidth And, this is a straight forward I as I told because this does not depend upon the percentage of the air conditioned area which was earlier mentioned for the office building or so. So, and this is prescribed till date it may change in the in some of coming years because the Bureau of Energy Efficiency changes this thing last 10 years I have seen there are at least 2 times changes in this particular bandwidth or how to calculate that one for the EPI calculation and the nomination of the stall level they have changed twice .

So, let us discuss one small problem with a shopping mall which some data is given this has 3 zones the ground floor first and say first second and third. So, there are g plus 3 floors and there is zone 1 and zone 2 is air conditioned. So, I have mentioned the TR per m^2 values for zone 1 and zone 2. Zone 3 does not have anything so that means, it is a non air conditioned zone.

The lighting load in the all the three zones are mentioned 10 watt/m^2 which is your LPD value light lighting power density value. The first zone it is 10 watt/m^2, the second zone it is 12 and third zone it is 8 watt/m^2 and the area distributions in m^2 is also given. So, and this particular shopping mall is situated let us suppose it is situated in Visakhapatnam which is a warm and humid climatic zone of India. So, based on that let us other data which is has been given for this particular building maybe that can come out from the energy audit. The first one is that the shopping mall will definitely will have a food court that food court required 30 liter of LPG per day.

And an additional DG set diesel generator set is installed in that particular the in that particular shopping mall for the lighting the parking and garden area. So, that is garden area which require 10 liter of diesel per day. So, lighting of the parking and the garden areas, landscape areas are generated by this digital generated set. There are 4 escalators

which are having 150 kWh rating operative for that operate for 3 hours you may say for the whole day. and the three are open parking which estimated as almost about 2000 m² area, but these are all false this particular one is a very false data.

False data in the sense it is true data, but it not going to actively participate in the calculation because as per the as per the definition we have to actually take the area which are the building the built up area which does not include any lawns it does not include any kind of the parking areas also. So, even those the values are given to you should not take into account for the calculation that has to be. So, I will say that this I will just make a cross mark that it will not going to use for the calculation. The next one is the shopping mall generates 650 kWh solar energy to compensate its daily electricity requirement from the power grid.

So, whatever power grid has been given or it was taken from the power grid, which may actually be seen as the air conditioning load and the lighting load. Out of that, 650 kWh of solar energy per day is harvested in that particular shop. Mall through the maybe the rooftop, the rooftop PV cells. We have to assume that it will work for 12 hours per day, and the shopping mall is open almost every day. So, we will take as an assumption almost like 30 days in a month for my annual calculations, and those calorific values have been given. So, now, let us start the solution step by step. You have to be very meticulous while doing these problems, and we have to make some kind of logical understanding and go step by step. Please do not jump the steps.

It may reduce the time to solve the problem, but sometimes it involves many errors. So, what I will do is first calculate all the areas of the different zones, these three zones. So, I have calculated zone 1 area as 3400 m² and zone 2 as 3900. So, these are the if you add up, this will be 3900. If you add up this, the summation will be 3400, like that, and this will be 2300, the summation of zone 3. So, these three I have added first.

And then I have added all these three to find out what is the total built-up area. So, that is very important because I need this to calculate the EPI at the fag end of my calculation or my steps. But please remember those two data I am not going to use: the parking area and the lawn area, which were mentioned in the problem, but I am not going to use them. And let us go to the next step. So, first of all, let us find out the air conditioning load.

So, zone 1 and zone 2 are under air conditioned area. So, the areas are mentioned 3400 and 2900 in from the first step and the how much is the tonnage of refrigeration per m² is given. So, I can directly multiply these two. So, this is the first area, the area of the first

zone, the intensity of the air conditioning for the first area plus the second area is this one and the intensity of the air conditioning for the second area. Why I multiply with 3.5?

It is now must be very clear to you because 1 TR is equal to 3.5 kilowatt. And so, I have after this 3.5 multiplication the it is now come down to a kilowatt unit and the it operates per day to 12 hours. So, if I multiply with 12 hours. So, this like this 5922 kWh per day will be the requirement of for the air conditioning.

So, in this problem it was not mentioned that this air conditioning load how it is fluctuates. Mostly in the building it will be able to fluctuate in the summer and winter or maybe the normal months there should not be the same, but let us hope or let us assume that at least for this particular problem I will have not make it little complicated. So, it is for the average requirement for the year. And the annual air conditioning load is now calculated with multiply by 30 and

because it is 30 days a month and 12 month a year and that format. So, a total of 21,31,920 kilo tower is total requirement for whole year only for air conditioning. So, next we will go to the lighting calculation. So, lighting calculation all the three zones now we will have to take for this calculation because lighting loads or the LPDs are mentioned for the three different zone three different values. So, I will first multiply the zone area and corresponding LPDs 10, 12 and 8.

and then I multiplied that and that will come in a watt because the intensity of the lighting load is given in 10 watt/m^2. So, if I multiply with m^2 it will be watt. So, it is big number if I multiply that with 12 hours because it will work for 12 hours. So, whatever will come big value is the watt hour and then I divide that by 1000. So, I will get the 1190.4 kWh lighting load per day that is a per day requirement again like the earlier one I will multiply that with 30 and 12 just to see how much is the total the lighting load for the annual on the annual requirement or so. So, it is coming out to be 4,28,000 544 if my multiplication is correct probability is correct. So, these two major things I have been calculated the AC load is about 21 lakhs something and the lighting load is 4 lakhs much less, but still, it has to have some kind of impact. Now, the other loads that like food court and all because a building is function not only with the energy is not only required for the air conditioning and the and your lighting required for instruments for equipment for.

some kind of water pumping, the escalators lift and these malls are having going to be a food court and also there are multiple requirements. So, for that we have to take one and

other each individually treat them in a different way because something I get it for per day, something may I get it for month or week. So, the food court required 30 liter per liter of LPG per day. So, first this 30 liter will be converted to kWh. So, that is 6.94 kWh per liter is the LPG value.

So, I got this value. So, 208.2 kWh per day again we have to multiply that with 30 and 12. So, we will do later and this is the additional DG set which has to be give lighting in the parking areas and the garden areas that require 10 liters of diesel. So, the 10 liter of diesel the conversion factor is almost about calorific value is almost about 11.11 kWh per liter. So, I have multiplied that into 11.1.

So, if I got 111.1 kWh per day. So, these two are calculated per day and then there are 4 escalators which operates for 3 hours. So, that is also calculated. multiplied by 4; 150 kilowatt is multiplied by 4 there are 4 numbers and they are operating for 3 hours per day. So, 1800 kWh/day is the energy required for to run the escalators average the requirement.

So, those are per day. So, I have added those 3 added those 3 and I have multiplied that into 30 and then again with 12. So, make it in annual scale. So, that gives almost like 762948 kWh is the annual requirement.

So, let me check with this problem once again. So, this problem Once again if you see the additional DG set which required 10 liter per day diesel is for the parking and gardening. So, you may say that I am not taking the parking and the garden area for calculation, but why should I take this DG set required 10 liter per day petrol or diesel to light those no.

So, we may not take or as per the definition we are not going to take the parking area and the lawn area, but any energy is going to be expenditure on this two areas may be for lighting, may be for some kind of washing for pumping water or whatever may be for those areas or so that has to be included because that is the integral part of the functioning part of the building, but the areas cannot be taken into account. So, that you please remember So, now this 3 this 3 has to be added this 3 the annual energy for required for the air condition is 21 lakh something, annual lighting load is 4 lakh something and the other annual energy consumption is 7 lakh something this 3 has to be added and that has been added and that has been finally, found out that 33,23,412 kWh is the annual the energy required for this shopping mall ok.

So, this is the annual. So, now, I know the area the area is ok. Now, another step I have to made yes this is the I have forgot. So, I have to made it. So, that is the we have given one point in the description of the problem is that the shopping mall generates 650 kW solar electricity per day.

So, whatever is required this particular requirement is the total requirement 33 lakhs is the total requirement out of that something is generated from the solar and rest is the grid or and petrol and all those. So, I have to deduct that one because the total consumption of the energy should not include the RE generation the from the RE source renewable energy source. So, if it is 650 kW/day. So, again I multiply 30 and 12. So, a slick amount almost about 2,34,000 kWh amount of energy I can say I can harvest from the solar energy as a solar energy the throughout the year.

and that has to be deducted that has to be deducted from the total requirement. So, that means, 33 lakhs something is the total requirement out of that 2,34,000 is the generated by the renewable energy source. So, that means, this 33 - 2 whatever and that that means, the 30 lakhs 89,412 kWh is the energy expenditure through grid and through some generated activities through the petrol, diesel or maybe some other activity other fuel. So, that has to take into the calculation.

So, total minus the RE. So, that is from the grid and plus something not only grid plus some other sources or so ok. So, other non-RE sources you may say. So, this 30,89,000 is my now my number and this number has to be divided spreading this number is what number is number is the amount of electricity or the energy required from the non-RE sources throughout the year annual and this is the 9600 m^2 is the total built up area of the building. So, if I want to find out this EPI, EPI is coming out to be this 30,89,412 divided by 9600 m^2.

So, that gives me almost about 322 $kWhm^2$/year. So, that is the footprint that is the EPI of this particular shopping mall situated in a location which is a hot and sorry which is a warm and humid climatic zone of India. So, this is my table. So, I have to see that where it falls it is 322. So, it is somewhere there it is in between the bandwidth of 350 and 300.

322 is comes in between the 350 and 300. So, as per this particular recommendation by DEE this particular shopping mall will get 3 star rating. It will get 3 star rating and then it may further improve by virtue of some additional cut downs or maybe some additional regenerations or so, then it may go to 4 star or 5 star. So, then you have to be little bit if they go little bit below maybe 22 kWh below per year per m^2.

So, then it may get a 4-star rating also. So, this is the way we calculate for shopping malls, but please remember here what is the change with the earlier problem for the office building we discussed in lecture number 32 is that here we have not considered the percentage of the air-conditioned area, ok. And that particular equation table, $y = mx + c$, is not there; it is straightforward. The bandwidth is given, and from there we have to select But I have told you perhaps in the near future, the BEE may come up with some further recommendations regarding the divisional criteria of the percentage AC area or some other kind of classification.

So, we have to be very thorough about that. You have to be visited their website, the BEE website, time and again to update yourself in this regard. So, next we will discuss the BPO, that is, the business process outsourcing cases, or in general, we can say it is the IT, the information technology buildings, which in a different way. So, they—I may say that the Bureau of Energy Efficiency—have some other type of recommendation because this also comes under maybe an office building or maybe a commercial building, but as their operations, the nature of operations and all is

quite different from some other normal office buildings or so, maybe from a bank or maybe from a government office or maybe any kind of corporate office. This does not work the same way—for 24 hours, the intense amount of air conditioning or so. They may have non-air-conditioned areas also, probably for other supporting areas or so. So, they have come across another set of recommendations for star levels for these BPOs and the IT offices. Again, here they are recommended for these four: warm-humid, composite, hot-dry, and temperate climatic zones of India. Very similarly, in the office buildings and also for the shopping malls, we can only evaluate this targeting system of the buildings which are connected with a load of 100 kilowatts or more. 100 kilowatts is nothing. So, always most of the buildings will be above this 100-kilowatt mark.

So, here very similarly, we will first do the EPI. There is no change in the calculation. So, you see this formula is very, very similar. It is something like the same formula: the electricity purchased and generated per year or annually, excluding the early generation on the source, divided by the built-up area, which does not exclude any kind of road, lawns, parking, etcetera. So, that is fine, but after that, they have recommended another criterion—not criteria—and further purify or modify that index to AHH EPI.

So, the EPI is now AAH EPI, where the first 'A' stands for average, the next 'A' is annual, and the 'H' is hourly. So, if you see the unit, If you remember the first EPI unit—if I say

EPI—the EPI is kWh per m²/year, right? Annual. But AAH EPI is watt—first of all, this is watt-hour, watt per hour, and that is in per m² annually, which has to be calculated. So, what can I do?

I can actually multiply this EPI value by 1000. First, why? If I multiply that by 1000, this value becomes W/h/m²—this is annual. So, let us suppose this is the annual case, and then I will divide that by the daily operation—the daily operation of the days, which is the daily operation of the days multiplied by the days of the week and the 52 weeks in a year, something like that—and then that will actually be driven to the watt-hour per hour or something like that—per hour, how much watt I am consuming per m² of the area, okay? So, that way, we can actually find out.

So, I have taken another problem a BPO work in Chennai it is 24 into 5 more that means, 24 hours working and the 5 days per week. and it has a 7000 m² of the area, 5000 m² is IT office which is going to be the air conditioned and rest 2000 is the service areas also and total number of staff working in 1000. And, air conditioned load in the IT office is found to 0.005 TR/m² and the lighting loads are IT office is 14 and the service area is 10 watt/m². The equipment load is estimated 1.5 kWh and there is again a diesel set and food court and whatever is there. So, based on that.

I have to calculate this is in Chennai. So, warm and humid climate the diesel and the LPG conversion rate is given there. This is also the harvesting 150 kW energy of the energy which used for the parking light and garden light. So, this again will not come into any calculation because those are not come into the calculation.

Whatever the here in the beginning we have discussed that will come into the calculation because that is non-renewable energy sources and we have to find out the what is the ranking. So, straightforward very straightforward we first found out the air conditioned load. So, the 500 m² area under air conditioned of this 0.005 TR per m². 3.5 is the multiplication factor 24 hours for a day. So, almost like 2100 kWh is the energy required for a day.

Lighting is also calculated 5000 is 14 LPD and 2000 is the 10 LPD and that is also multiplied by 24 because 24 hours is working and then divided by 1000. So, that makes to the kWh equipment load is also for 1000 people. So, so total daily consumption is 5460 kWh ok. So, that is very simple.

So, then we have diesel and all those kinds of a things. So, diesel gives me almost about 750 kWh/month please remember this is per And the LPG is again per week 2000 something is per week. So, now, we make it annual yearly consumption of the daily. So, finally, just multiplying this is the monthly consumption by 12.

So, it I have to multiply with 12 and the weekly consumption is 52 because we assume that 52 weeks a year. So, we got these three big values which is has to be added up for yearly calculation. So, we can find out that this is some 15,68,000 kWh plus something kWh is the total consumption for yearly. Built up area is 7,000 and EPI is this to division so it is 224. But we cannot stop here because we have to go with the AA HPI.

So, these annual operating hours have to be first calculated. How much are the annual operating hours? 24 hours/day. So, I think I have written down 24 hours per day, 5 days a week, and 52. So, in a year, this BPO is working for

6,240 hours by virtue of the 24, 5, and 52 weeks. So, this is divided by that and multiplied by 1000. So, I got 36 W/h/m² as the footprint per hour footprint. Please remember that one EPI is the per-year footprint, and it is the per-hour footprint, which is why instead of the kWh, it is now in watt-hour, okay.

So, this is the change we have noticed from the absolute EPI to AAH EPI. Now, we have found out the percentage of area: 71.4% because 5,000 m² out of 7,000 is the air-conditioned area, and now we can go straight to this table, which is very similar to the table for the office building. where x represents the amount of the air-conditioned area, and here this is the warm and humid climate. So, for each of these 4 or 5 equations—5 equations—I put x as 71.4, yes, 71.4, and I calculated this bandwidth. These are the bandwidths, and my value is 36. So, definitely, it is in this.

So, I can give a 3-star rating to this particular BPO. So, if it is a little less than 30, I can give it 4 stars; if it is less than 23.5, it is 5 stars. So, that way it is calculated. The only change is that you have to convert the EPI to hourly average or average the annual the hourly EPI value, which we have to divide by the total operating hours of the office building also.

So, in conclusion, we have seen how to measure the EPI value for commercial buildings like shopping malls and BPOs, and EPI is the modified AHP, modified as the EPI in case of BPOs or IT offices. Thank you very much.