BUILDING ENERGY SYSTEMS AND AUDITING

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Lecture 40

Lecture 40: Net Zero Building and Sustainability

Welcome to the NPTEL course on Building Energy Systems and Auditing. In module number 8, Green Energy and Sustainability, we are in the very last lecture, lecture 40. It will be on net zero building and sustainability. In this particular lecture, we will cover the concept of net zero and its types, and also, we will give a very brief introduction to sustainability. Here, if you see, net zero is now a widespread concept around the world, and what is this widespread concept that was actually being discussed? So, what is the net zero building concept?

Basically, it is a building that has some kind of demand. I may say that the demand is a kind of energy demand of a particular building, mostly for operational purposes. I am not considering the embodied purpose, only the operational purpose, and that particular energy, if it can produce the supply side, if it is going to produce the energy. By its own site or maybe renewable energy from some other sources, and it does not consume any kind of non-renewable energy by virtue of this balance of the demand and the supply side, then that particular building can be called net zero. Or maybe at present, if the building is almost going to be very close to that particular balance line, we can still call that a net zero building.

So, in this net zero, if I see, there is a demand, and to meet the demand, we need to provide some kind of supply, and that supply should be on-site or maybe off-site from renewable energy sources. So, that is going to be a challenge for us to take on that particular challenge. What can we do? I have written down two typical points. Of course, these two typical points we have discussed earlier also. One is we need to reduce the need for energy in the building. So, we have to make the building energy efficient in such a way that. The building needs to take care of all the activities with all the comfort scales,

everything to take care of all of those. We need to reduce the need for energy, that is one, and that we can implement from the very beginning, from the design of the building, architectural design, the material, the envelope design, etcetera.

And the second point is offset the remaining building energy needs need to be through the renewable energy source. Yes, even if you reduce the energy demand by virtue of your passive solar implementations and all still you require some amount of energy on that offset energy can be harvested in the in the in the particular site which we have discussed the last four lectures in this particular module renewable energy and that can be give a kind of a balance. So, therefore, we can say that there are only few net zero buildings of course, is there and very highly efficient in that sense. And with advancement of the renewable energy technologies, we are we told that the solar panels can have a kind of efficiency around 20% or so less than 20% or so. So, we need to have much more scientific intervention in that ah much higher efficient panels need to be installed and there are lot of other type of techniques like maybe some kind of the ah ah maybe the fuel cell or maybe the hydrogen as a fuel.

And, sometimes ammonia is also going to act as a fuel nowadays. So, those are coming up gradually in future definitely ah we can think of a pure ah a more net zero and pure pure in the sense ah I may say that it is almost going to not only net zero maybe there some negative net negative kind of a scenario also. we can have a type of strategies to play. So, the one is the the the part a we can say it is the passive strategies which we have just now discussed reduction of the need of the energy through implementation of the energy efficient measures ah we have a length ah in the last 7 modules probably we have in length we have discussed that one there will be much more techniques and all. So, that can be implemented there will be some technique which can become in the future

So, those are the passive strategies and the techniques that we can actually going to have. The B part is the active strategies that means, that offset part that we have to generate the renewable energy in the site which we have not covered in a much length of course, but at least in the last four lectures we have covered that one. So, again let us have a kind of a brush up of the passive strategies what are what are we have we can have building geometry changes, we can change the the orientations, we can allow much more amount of natural lighting that daytime electrical use for the lighting is reduced. We can have more ventilations, natural ventilations also, but yeah there is a issue sometimes maybe the outdoor air is polluted and from that point of view may not like to have the natural

ventilation that is another issue. the it has more more amount of pollution particularly if you see the if you see the the this this winter time in our capital Delhi.

It is better to stay inside and keep the windows closed, even if natural ventilation gives you some benefit. However, people do not want to open the windows because of the high level of air pollution. So, those are other issues are, of course, there. These are some points that we have already discussed. We can use some kind of ESTs, which are energy-saving techniques, and design the envelope accordingly, as we have already discussed.

We can have a heat storage mechanism from solar panels, where we can store some heat, and that heat can be converted into other forms of energy, such as refrigeration cycles. We can have some kind of efficient lighting design. In active strategies, we can explore harvesting renewable energies. We have discussed energy from biomass, geothermal, wind, and solar, and we can also have some kind of backup storage. The use of fuel cells is growing very rapidly to provide backup energy systems, such as fuel cells.

We can have different types of energy storage systems, such as district cooling. We can store energy in the form of thermal mass, like ice for cooling or hot water for heating, and so on. Now, if I consider the energy demand and supply equilibrium, If I plot this broadly on the x and y axes, where the x-axis represents the total annual energy demand of a building, Total energy demand, as we discussed earlier, includes different components like HVAC, electric illumination, and other components, such as cooking in the food court or generator sets for additional power backup.

So, those are if I cumulatively if you add up, so that is your total energy demand. And the y axis what I am going to put I will put the annual renewable energy used. So, if there are some buildings which can have some kind of renewable energy. So, how much is that particular energy I can actually plot in the the y axis. So, in that y axis.

So, suppose this yellow dot is the particular building which is going to I mean it is it is annual energy consumption is 2000 kWh. this is annual total it in that both are both things are there the non renewable also are there and the renewable energies are also there. That means, in 2000 kilo tower it may not be only the electrical the load it may be the electricity purchase plus the petrol purchase or diesel purchase for LPG cylinder or something. So, and also the renewable energy that is generated from the grid or the or from the site or from the offsite ah ah it can be taken.

So, whole sole it is it is the 2000 kWh it is total energy demand of the of the building. Whereas, the y axis it is 500 that means, 500 kWh is your energy that is generated as or used as annually used as renewable energy. that may be on side or that may be off side that is different, but this is 500 kWh is the energy that was it is needed for the per year per year or so. So, that means, if this is 45° line this line is 45° this balance line is 45°. this dotted line is 45° line is a line of equilibrium.

Why this line of equilibrium? So, if I draw a 45° line and if I draw a perpendicular from 2000, this length is also going to be 2000, this length is also going to be 2000 that is you from the property of the triangle. And this 2000 is what? It is your annual energy consumption out of that how much is this? out of the this is your renewable energy this is your 500.

So, that means, this is your 1500 that is the non-renewable energy non-renewable energy and this is the renewable set ok. So, if you see here so, this is the R e. and this is the total in total energy. So, let us suppose an annual or all annual and this is my this dotted line 45° line the balance. If this dot this this particular yellow dot is the annual energy consumption of a welding.

So, if this dot lies over here, but there is beyond this particular 45° line. lies over here that means, I think I have the second ah next slide is over that that means, this is equal to this and this is also equal to this as because this is 45°. So, all this is it is a rectangle ah sorry it is the square. So, that means, total energy consumption is equal to the renewable energy consumption.

So, there is no non-renewable energy over here if this ball or this particular point touches this dotted line. So, that is a balanced line. So, the line of equilibrium is where the total demand is equal to the renewable energy supply. So, I have done this in the next slide. If this dot, this point,

that is my consumption of the total energy point, actually touches this particular 45-degree line of equilibrium. That means your non-renewable energy is 0, and your total energy consumption, whatever it may be—if it is not 2000, suppose this is 1000. So, this is 1000 by virtue of the triangle property and all. So, the non-renewable energy is 0. So, this is the point where I must say that if this particular point touches this particular 45-degree line, then this building is going to be net-zero.

So, this dotted line is the line of equilibrium. Is it clear? I think it is clear to you. Now, if this particular point moves further, moves further, what does it mean?

That means, your demand is 1500 suppose and you are here. So, this is 1500 fine, but how much you are producing as an annually as a non-renewable energy it is higher than that that means, 2000 more than to 1500. So, non-renewable exactly no question of any kind of non-renewable energy and renewable energy is 2000. So, excess generation is 500 kWh, is not it? Because you require 1500 your generation is 2000 per year that means 500 kWh excess over 1500.

is excess you are generating and excess generating what you will do? You will actually send it to the grid to somebody or some some electrical ah the agency that they can use it for some other building or so. So, from your so, this is we can say it is a definitely non non non not net 0 it is a a net negative kind of a building kind of a you are running negative your whatever is your demand you're harvesting or your production is much more than the demand. So, the excess you are going to sell it or give it back to the society or maybe you can say it is in the grid.

So, it is possible. So, it is this yellow point is the annual energy consumption point is may below this dotted line. If it is below the dotted line, then you are a not a non-zero net zero. you are little bit less than that, but probably you are approaching you are very close to the dotted line or whatever. If it is on dotted line then it is a non net 0 building, but is above the dotted line is a net negative building or something like that you may say and you are having much much good potential in the sense your generation is much more with respect to the demand and that extra amount of energy you can sell it out.

So, now let us go to the classification. There are a few classifications of the net zero classification. Actually, there are four types of classification that we suggest at present, and those four are: the first one is the net zero site energy. The second one is the net zero source energy, the third one is the net zero energy cost, and the last one is the net zero energy emission. So, in brief, we will discuss these four, and we will stop here. I mean, the discussion will stop here. So, let us see what these four types of net zero are.

But before we go to the four types of net zero, we need to see the system boundary. System boundary or the site boundary, you may say, or the system boundary for the energy transfer and the energy generation, and all for net zero counting. So, suppose this dotted line is marked as a geographical location. There is a site that is my building or whatever. And in that particular building, there are three components in it. One

component is the central component, which is here. It is a building energy demand. The building has some demand. You may introduce a lot of passive solar architecture, a lot of passive strategies. The demand will definitely be more, but the demand cannot be zero. There will be a demand.

And you have to meet that demand. There are two other sources or components in this particular system boundary. Those two components can meet the demand, and that source will give you the electricity or the power or the energy. One is outside the boundary. What is outside the boundary? It is delivered energy. Somebody is delivering it to you. It may be a non-renewable energy delivery, or it may be a renewable energy. So, suppose there is another source that can give you that is on-site, on-site renewable energy generation.

In the on site in your building in my building my campus my IIT Kharagpur campus or maybe my housing society, I cannot generate the energy by virtue of the non-renewable kind of energy. I cannot put up the thermal power plant ok. So, whatever I have to generate in my site in my campus or whatever I have to have the renewable energy sources. I may go for the solar panels, I may go for the wind turbines and all, I may go for the bioelectricity, I may install some kind of a fuel cell the component over there. So, I can only generate the renewable energy in the on site.

Now, let us come to the delivered energy where I am getting the energy from the outside. When I getting the energy from the outside to meet my building energy demand, I can have three four arrows. I have shown three arrows here, one from the grid electricity which is in general we common practice is that we take the electricity from the grid. And that grid electricity actually comes from where from the thermal plant or somewhere and that is actually burning coals or maybe petrols or whatever.

Maybe sometimes it is a hydroelectricity which is renewable, but still mostly it is all the non-renewable kind of energy. So, this is the grid energy, grid electricity. I may purchase fuel for also for me to meet the energy demand, I can purchase some kind of a diesel to run my generator set, I can actually purchase some kind of a LPG to cylinder to run some cooking or some heating the water for me for my purpose or so, for me suppose it is a hotel I am using some kind of the LPG to for the boiler and all. also, I can actually take some kind of a R e last arrow the bottom most arrow stands for the R e the renewable energy also I can take from the grid. So, that is also I can take.

So, I can actually take a renewable also or the non-renewable. and from the onsite I can only go to have the renewable energy. Based on that I have a balance with each other I mean I have a some mostly I can maybe I am purchasing only the non-renewable energy. Sometimes I can generate the all the nothing can be purchased only the RE can generated on site or maybe I can purchase some kind of a fuel and some RE and I produce some kind of a. So, there may be a ah different combinations possible based on that combinations there are four classifications of the the the net zero.

And, there is a last component also here which is a exported energy which is definitely going to be the renewable energy that is what we have discussed. This is possible when your system boundary or this balance you are here. you're this is your RE this is your total energy this is 45° when you are here then only you can go to export the export the renewable energies also ok. So, you can export the renewable energy in that sense. So, now from this particular point of view

we will see the four types of classification. The first one is the net zero site energy. Net zero site energy refers the amount of energy provided by on-site RE. So, the on-site RE sources equal to the amount of energy used by the building. So, used by the building.

So, it is site. So, I have the on-site and used. So, these two are going to be in the in in the in the system nothing can is exported nothing I am going to get delivered or whatever. So, this is the that if the system is something like that, I can say it is the site energy.

So, it is over a year of consume consumption is a one of the very I mean say it is a one of the the possible way or the very simple way to understand the net zero building. So, net zero site energy the other three is a little bit having some kind of a twist. The last line if you see it renders the site net zero energy buildings easier to implement because energy supply targets to reach the neutrality are low. So, that means, it is very easier to target because whatever I my demand is I want to generate that much in my site.

So, I can have a very well balanced design of the early system in my site itself. I do not have to bother anything, I do not have to sell it out, I do not have to do anything purchase from the outside also. So, only there are two one is my demand and one is the supply side I can design the how many solar panels I required and how many wind whatever whatever I required I can actually do that. Now, next one is the net zero source energy.

Net zero source energy is not site; please remember it is source. Now, when a particular energy—if I am actually purchasing from outside—suppose x amount of energy I am

purchasing from outside, some x. And also, I am generating some kind of energy, which is a little more than that—suppose 1.5 times x or something—and my total requirement is the 2.5x. This is also RE; this is also RE. So, no question is that these two are balancing. Whatever my requirement is, 2.5x, and I am actually getting all of them. By virtue of the renewable energy, x from the outside I purchase it and also generate something, 1.5x—both will give me 2.5. If this is the scenario, I can still say this is something like the net-zero site, but it is not net-zero source because when it comes from this RE from its source,

there is some kind of loss because of this—the transmission loss and whatever, OK. So, in that loss, I am not going to encounter that loss; I have to encounter such a way that I have to actually put some kind of factor over here. So, this loss is also going to be fulfilled by my balance sheet. So, instead of—if I actually get some kind of 0.85x or something,

and I need to have some kind of the final balance of 2.5 or something by encountering this particular loss. So, that kind of scenario—if I can have it—is very complex, I may say, I must say. So, that particular balance is called the net-zero source energy because, from the source point of view, I am net-zero. That x—what I am actually generating over here, actually, it is 0.85—15% is lost; 15% I am getting into weight.

And I am thinking of that there are some amounts of the energy that is I am going to use which is equal to 2.5 because why 2.5 why not 1.5 plus 0.85 because it is 2.5 because 1.5 is directly from the site and x is from the source. So, x is from the source. So, I have to potential amount of 2.5 x has to be the amount of. So, this source energy or maybe the other one that is particularly your site energy net zero. Please read this box the sentence given in the box net zero site and net zero source energy building are more viable in the small and medium size of the building comparatively large scale of the building it is very difficult to manage.

The next is the net zero cost which is again kind of a thing. I am not going to see the amount of energy I am going to transfer and all. I am just going to see the total cost that our purchase and my production that to the cost of the energy is equals. I may generate the energy from my site as a rate of 4 rupees per unit. and I can actually generate I can purchase it may be 2 rupees something like that.

So, by virtue of these two the difference in the rate of the generation and the purchase I can have a net zero cost. So, that is also possible. So, probably I have written somewhere

it is probably it is possible if the purchase cost of energy is much low with respect to the generation cost. Then only it is possible.

Next, one is a very similar way you can say net zero emission. So, instead of the cost, instead of the energy, I will see the balance between the CO2 equivalent emissions from my demand and my purchase. Also, from that point of view, you can say that yes, it is the net zero emission for buildings also. So, next, we will go to the definition of sustainability. So, it is again a huge, huge chapter. So, I have just three slides for you.

So, in 1987, the first, ah, in a Brundtland report, it was mentioned that there is a concept of sustainable development. And this sustainable development concept was presented in that particular Brundtland report as: sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own demands. So, we should actually develop in such a way that the needs for today are met, you can meet those kinds of demands of today without compromising the demands for the future. So, this concept was actually needed and is leading to the world's poorest people over the years through some kind of social organizations and also based on this particular sustainable development.

There are three P's—another concept of three P's came into the picture because of the people are actually going to do some kind of profit, and there is a kind of economic drive, and we also know that through the economic drive, we need energy, and there is a degradation of the environment or so. So, those three P’s are profit, people, and planet. We have to see the profit, so there is definitely a need for some kind of margin for our sales and purchases and all. We should also look into the people—that is the community point of view—and then the planet, which is the environmental point of view.

And from that point of view, we have the three domains of vanes of a vane diagram of the sustainability which talks about the environment, social and economic development, altogether holistic development between these three we should not look into only one sector. we should see the other sectors also because without economy the things cannot drive the social structure those are also has to be sustained with the sustainable environment. So, what we have discussed still these particular lectures in our this NPTEL lecture is that is the part of the environmental ah things not on not I have not we have not touched the water, we have not touched the soil, we have not touched the air, we have touched only the energy management of building. Even we have not touched the energy

management of industries, transportation sectors and all which is another kind of a subject.

So, we have only touched the architectural and the part or maybe you can say the building science part of the building energy management or so with some ideas of auditing. So, these are the some of the references and so the concept of net zero we have discussed, we have discussed some of the demand supply and sustainability pillars and all those kinds of a thing. So, thank you very much for joining me in this particular course. I wish you all the best for your end semester examination and I hope you have enjoyed the course you have if you have some something to say good bad about this particular course please write it in our forum.

So that we can take care of any such of you feedbacks and we can improve our self. And I hope everybody of you can join in this particular the end semester examination and the certification. Thank you.