Sustainable Architecture
Prof. Avlokita Agrawal
Department of Architecture and Planning
Indian Institute of Technology, Roorkee

Lecture – 54
Whole Building Performance – IV

Good morning. Welcome to this 4th lecture of this week, where we are learning this Software for Whole Building Simulation and in the previous lecture, we have already created the building, geometry, we have input the activity schedules, we have input the different parameters related to the activity of the building which is going to be performed in the building, we have already put in the parameters related to the construction of the building. So, we already have put in the values for the walls, roof, windows, openings and also the design of the openings as far as its distribution is concerned which is window wall ratio.

So, today, we will be looking at the active parameters. So, we will be looking at the artificial lighting and HVAC input parameters. All the parameters which we have done so far were either going to remain constant for the base builsing and proposed building or they are the passive parameters, passive design parameters.

Here, when we are talking about artificial lighting, we will largely be talking in terms of lighting power density and when we are talking about HVAC, we will be talking about the coefficient of performance the COP of HVAC which is going to bring in the difference between the performance of a base case and the proposed case.

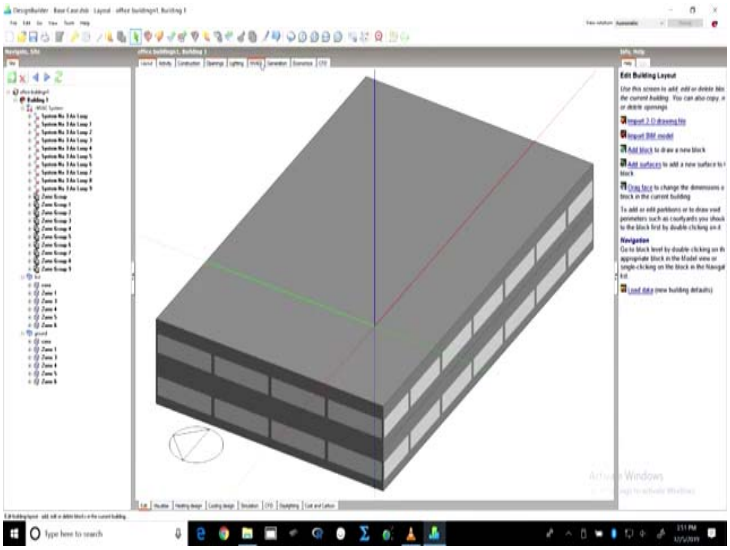
Now, just as we have done for the construction, the materials for the base case, the values for LPD and COP for a base case come directly from the codes. So, here again the relevant code is ASHRAE 90.1 or we can take the values from ECBC whichever is relevant. So, we directly, depending upon the type of the building and usage of the building, we will take these prescriptive values from the codes and put them in.

So, let us see how do we input all these values in our software and in the model that we have created so far and we are continuing with the same model. I just hope that you have already created the building and you are following the steps along with me. It does not necessarily need to be an office building and the same building that I am creating, you

can pick up any drawing, you can pick up any building and you can continue to create it with me. I reiterate if you have any problems, kindly write to me, I will try to respond back immediately. So, that you do not have problems.

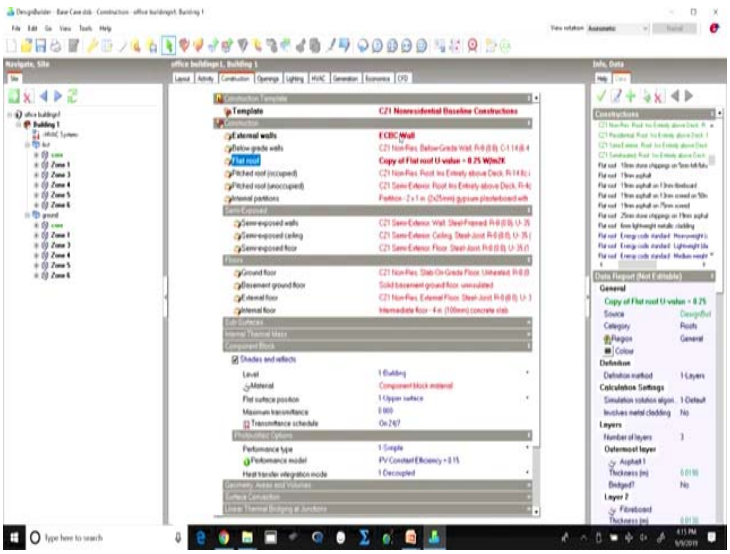
In addition, there are ample tutorials which are available, you can simultaneously take help of that, but in case of any problem, come back to us. So, let us switch to the software screen now and let us input the parameters related to lighting and HVAC.

(Refer Slide Time: 03:20)

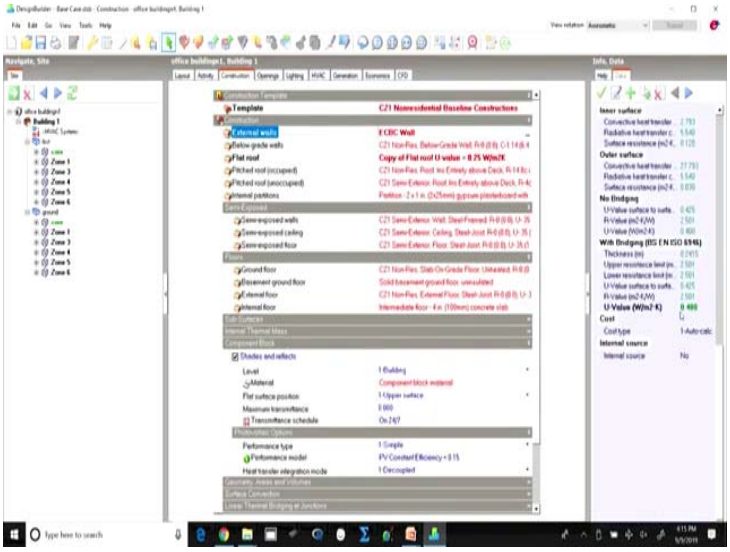


So, in the previous 3 lectures, we have already created this building geometry, where we have defined the activities, we have also defined the construction.

(Refer Slide Time: 03:29)

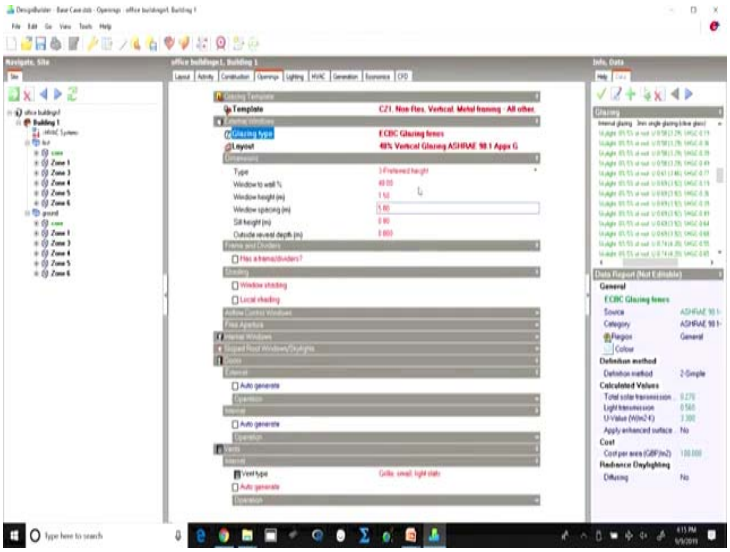


(Refer Slide Time: 03:39)



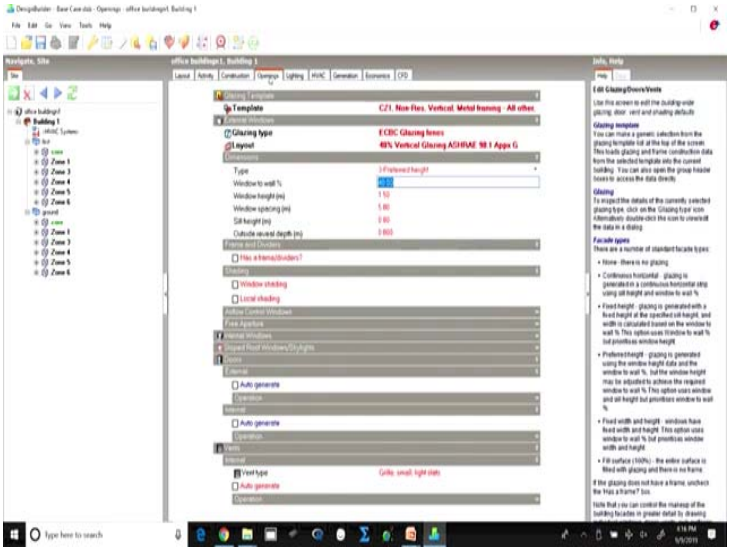
So, I have already shown you the process and I for your reference, I have changed the walls to ECBC wall, where the U-value, you can quick check it the U-value has been set as 0.4 which is prescribed in ECBC. I have taken the copy of a flat roof U-value, where the U-value has been prescribed to 0.33 which is as per the ECBC again.

(Refer Slide Time: 03:58)



And in the openings I have changed the glazing type to ECBC glazing fenestration and if you look at the values here, I have changed it to U-value of 3.3 and a solar heat gain value SHGC value of 0.27. So, and keeping the WWR as 40 percent.

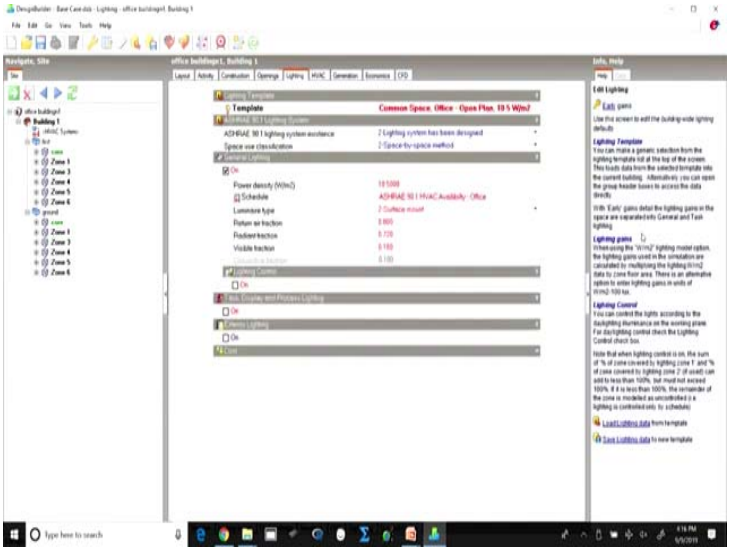
(Refer Slide Time: 04:22)



So, what we have done so far is we have taken all the prescriptions as per ECBC and we have given all these values as an input into this building, which we are currently examining and this is the base case. So, for base case just to remind you over and again, we will take all the prescriptive values as given in ECBC and put it in the input

parameters. Once we have created this building geometry and construction and openings, we will move on to more active features.

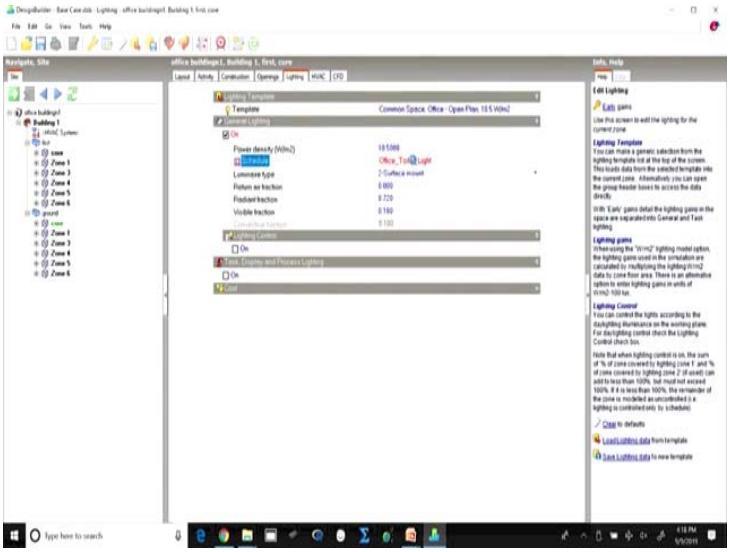
(Refer Slide Time: 04:51)



So, first one of this is lighting. So, in the lighting a common space template for an open plan office has been taken, where it uses the template the lighting power density of 10.5 Watt per meter square which is taken as the base case in ECBC as well. So, we are taking it as 10.5 Watt per meter square and we are taking it as a general lighting which is on with a power density of 10.5 and within this 10.5, the luminary type which is surface mounted and the radiant fraction of it, to the visible fraction of it, all of these have been taken.

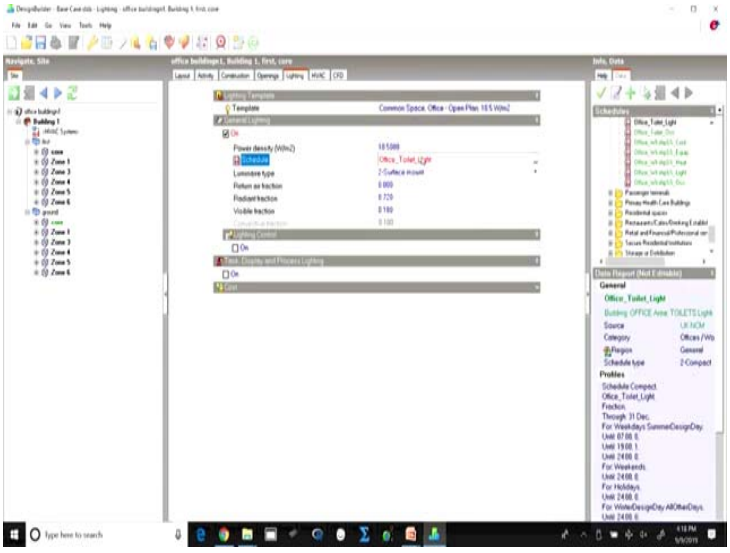
Now, the radiant fraction of it will add to the heat gain inside the building. For the base case the lighting control will not be on and we will not have to ask or display light or processed light, exterior lighting also we are considering as off and we are for now we are not taking into account the cost. Here, the space use classification is space by space method and the entire building for that matter has been taken for a 10.5 Watt per meter square lighting power density.

(Refer Slide Time: 06:16)



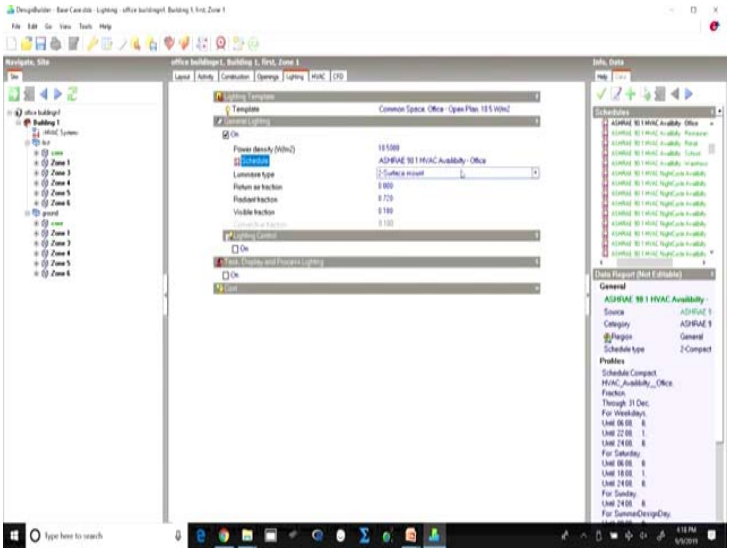
Let us check the core. So, for the core also, it is the same template and it is taken as 10.5 Watt per meter square which is what is taken even in the office toilet. So, the schedule although varies.

(Refer Slide Time: 06:29)



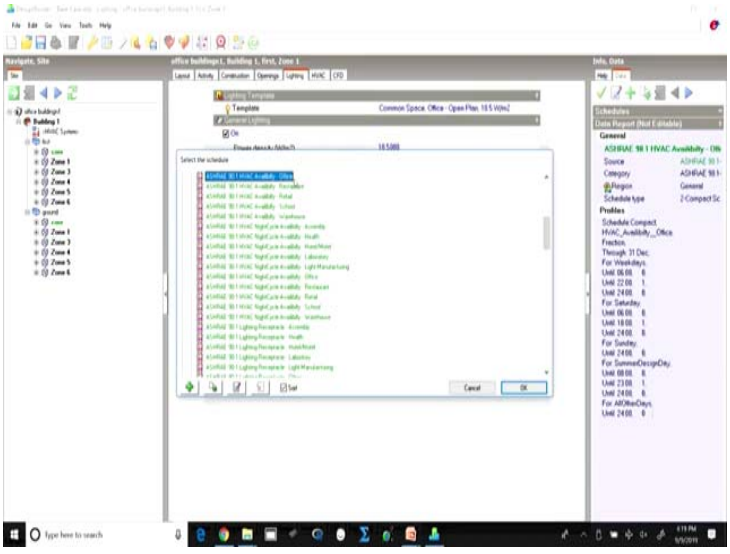
So, the schedule for this is office toilet light because we had fixed the use of the space as a toilet.

(Refer Slide Time: 06:39)



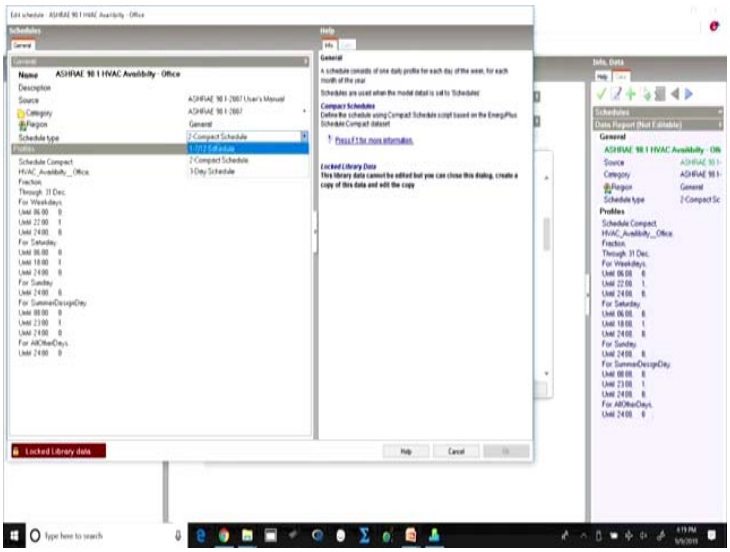
However, if you go to other zones, the lighting schedule changes. So, if we want a different lighting schedule, we can change it. However, it would not matter much because the same schedule is will have to be taken for the proposed case as well. So, this is how we change the lighting in all the zones here.

(Refer Slide Time: 07:09)

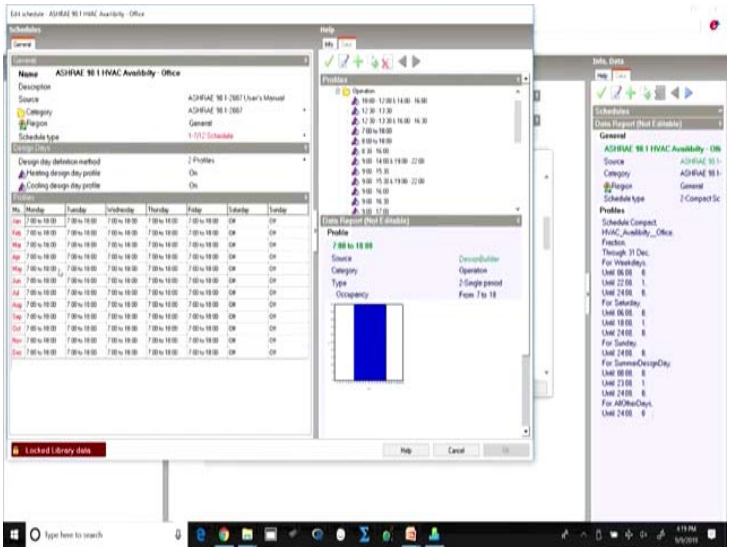


So, now another thing which if we look at this HVAC, since there is no lighting control and we and if we look at the lighting schedule and if we check it, we see that the lighting is considered to be on from 7 to 18.

(Refer Slide Time: 07:13)



(Refer Slide Time: 07:16)

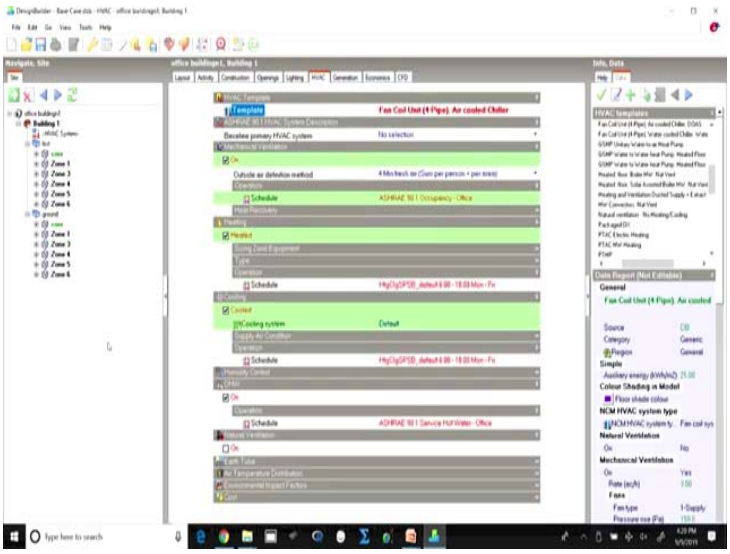


Now, that is it implies that 100 percent of the lights are going to be on for complete office working time. So, 100 percent light will be on from 7 to morning 7 to evening 6, this is what the current schedule implies.

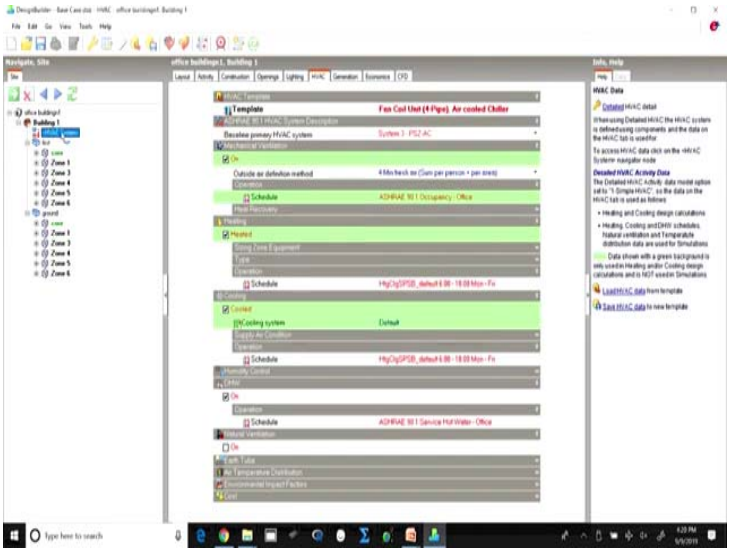
However, if we are taking into account, when we go on to design and simulate the proposed case and the moment we turn the lighting controls on which will imply that the lights will be on only when sufficient daylight is not being made available. We can immediately see the difference that will be brought in the electricity consumption

because of only adding the lighting controls. So, this is what we will provide as an input right in the beginning for the base case

(Refer Slide Time: 08:23)

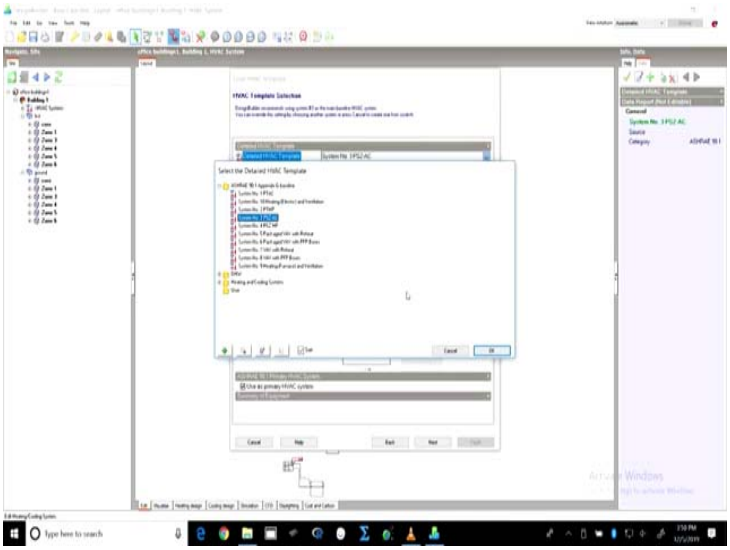


(Refer Slide Time: 08:33)



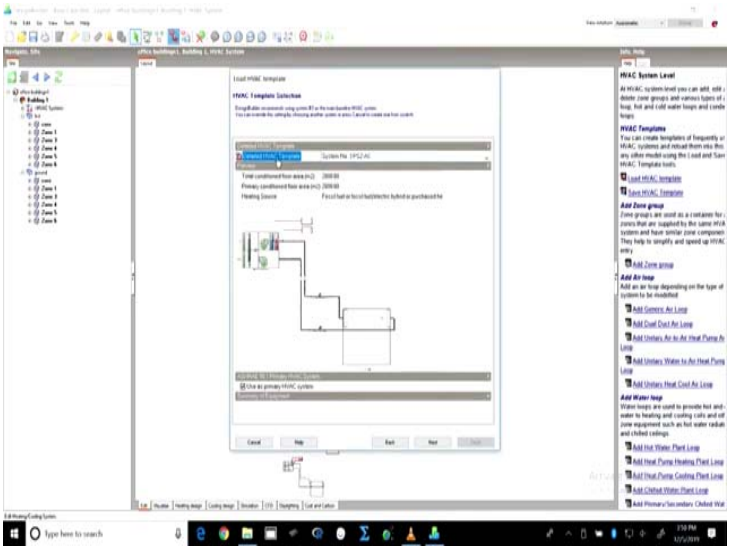
The next is HVAC; when we are talking about HVAC, automatically it has taken the template and the baseline primary system here will be taken as system 3 as per the ASHRAE.

(Refer Slide Time: 08:49)



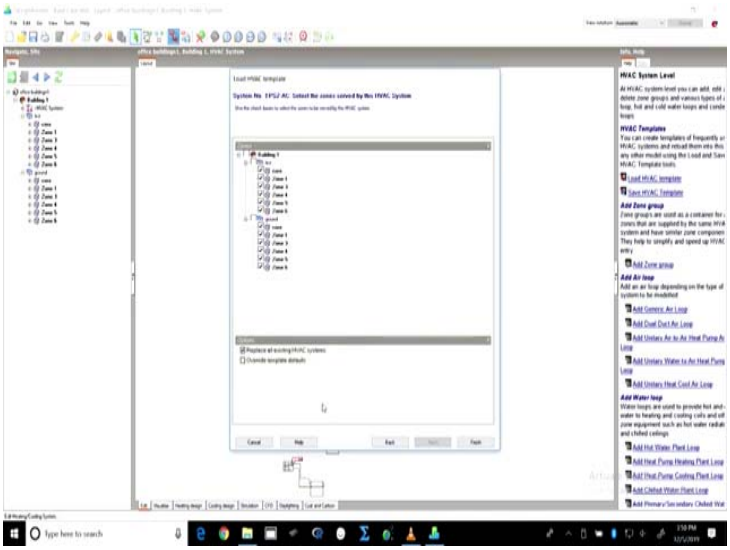
And when we have selected the system, we go into the details of this HVAC system to check. As per ASHRAE, if we look at the office building system 3 is prescribed.

(Refer Slide Time: 08:56)



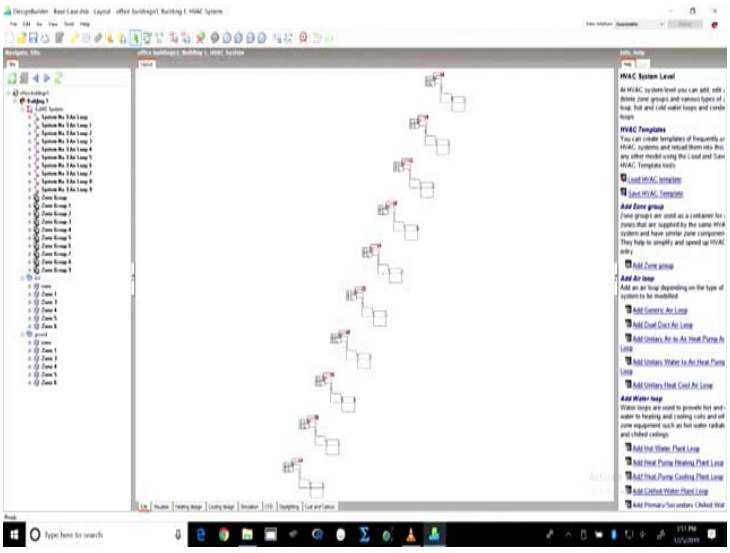
And if we select this and if we set it to be used as a primary HVAC system, this system will be applicable to all the zones.

(Refer Slide Time: 09:01)



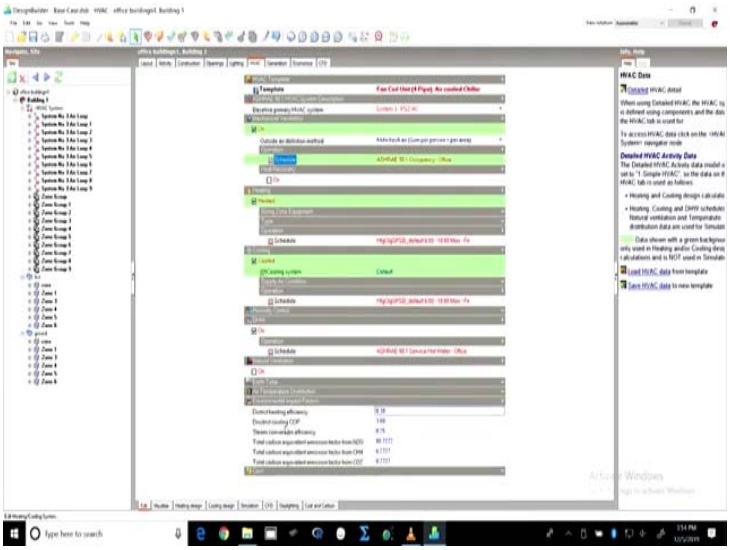
However, we decided that the core is not going to be served by the HVAC system. So, we have checked these two core zones off and now, this HVAC system will be serving all the remaining zones. So, once we have done this, we apply it.

(Refer Slide Time: 09:27)



And that is how we can see that the selected HVAC system has been applied to all the zones here and it will automatically apply the HVAC system to the entire building. Here, once we go into the system detail, we can change the coefficient of performance for each of these systems for the HVAC.

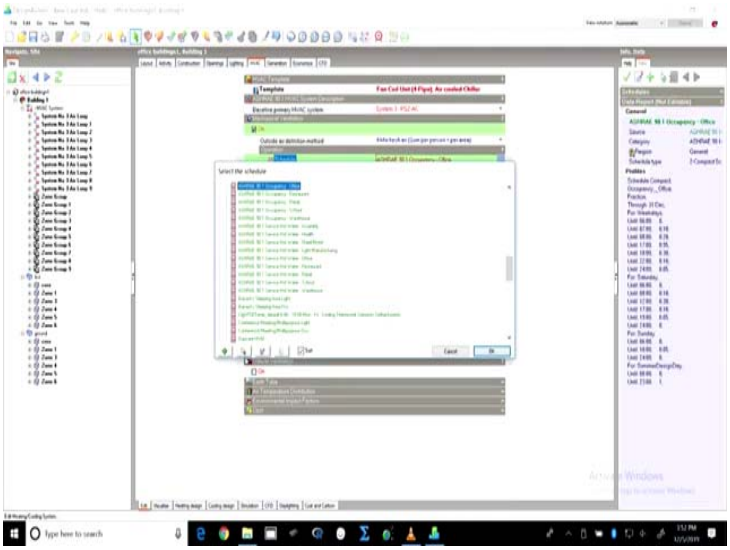
(Refer Slide Time: 10:00)



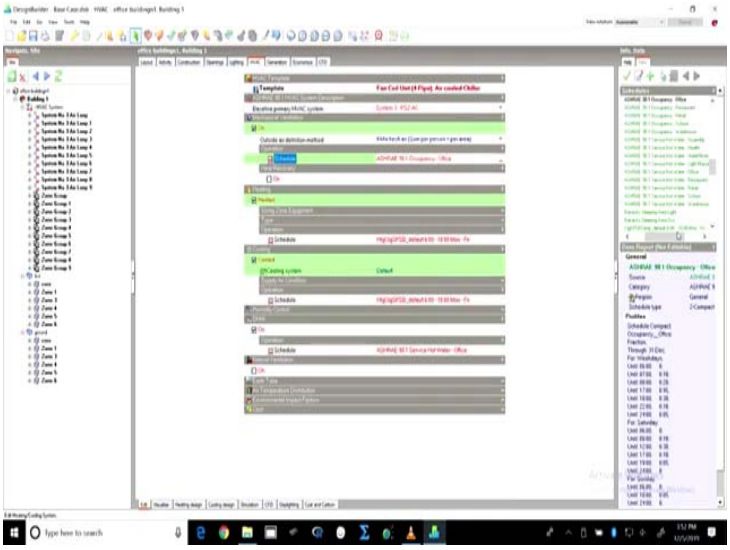
Along with this, we can have the mechanical ventilation, heating and cooling is definitely on when we are talking about air conditioning. We are talking about mechanical ventilation; we can also have the definitions for introducing the outside air. It could be per person or per area or it could be the sum per area per person plus per area.

Now, this is dependent upon the code that we are following. So, if you remember we were talking about NBC and which is the same as has been referred to in ECBC. So, minimum fresh air which is the sum per person and per area will be applicable in our case. So, we define the outside air definition method and we can also define the operation schedule. In this case, the heat recovery is not checked on, we are not taking into account the heat recovery.

(Refer Slide Time: 11:04)

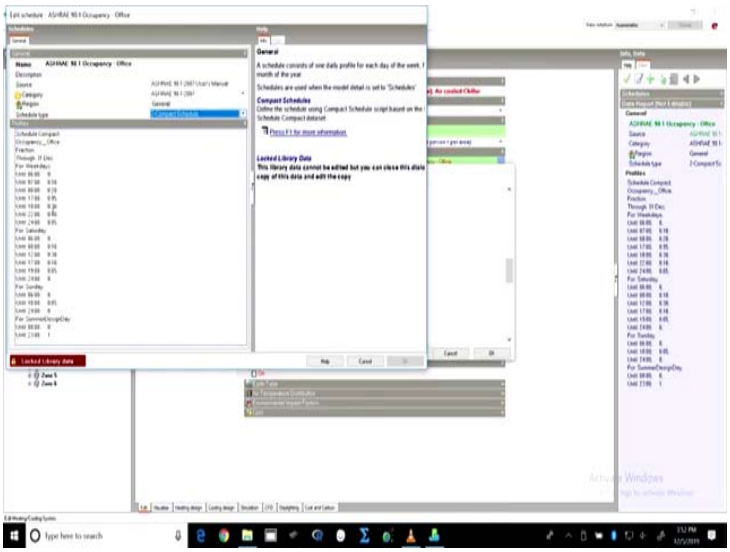


(Refer Slide Time: 11:10)

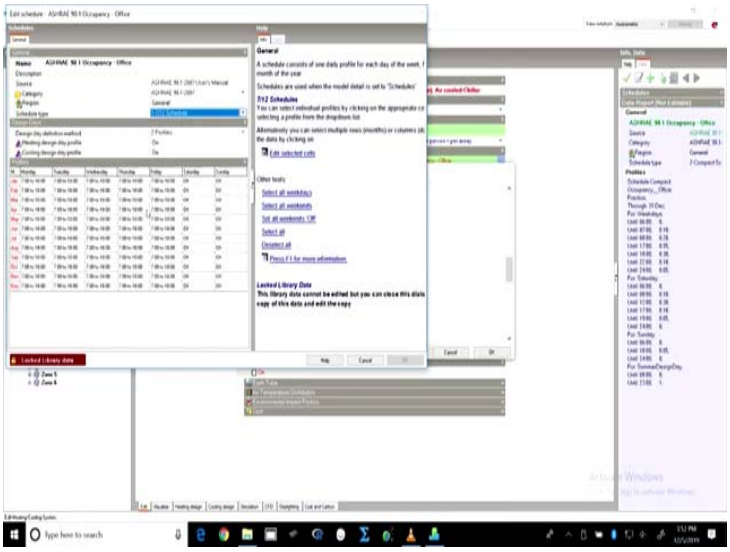


So, the schedule of it is currently like this, where it is on for most of the time during the day. However, the percentage of it opening is changing.

(Refer Slide Time: 11:17)



(Refer Slide Time: 11:20)

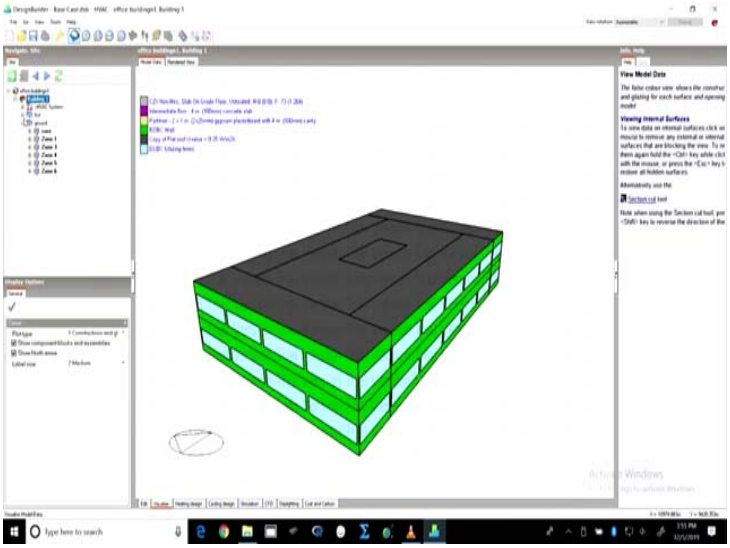


So, from morning 8 till evening 5, it is on 95 percent and for the rest of the period, it is varying from 0 to 30 percent. So, that is what is the current occupancy schedule which is which can be seen here from the compact schedule. If we want to change it, we can change it or we could also introduce our own schedules here. Heating and cooling are taken as default systems which are coming automatically from this primary HVAC system which we have defined from the ASHRAE template and based upon the ASHRAE Appendix G, the code.

In case natural ventilation is on we can check it on and we can also define the rates of natural ventilation. However, in this case here the building is centrally air conditioned. So, we are not taking into account the natural ventilation. In case there are other parameters features available for example, the earth tube or we are talking about some other environmental impact factors such as district heating and we are taking into account, the efficiency and COP of district heating, then that will be mentioned here.

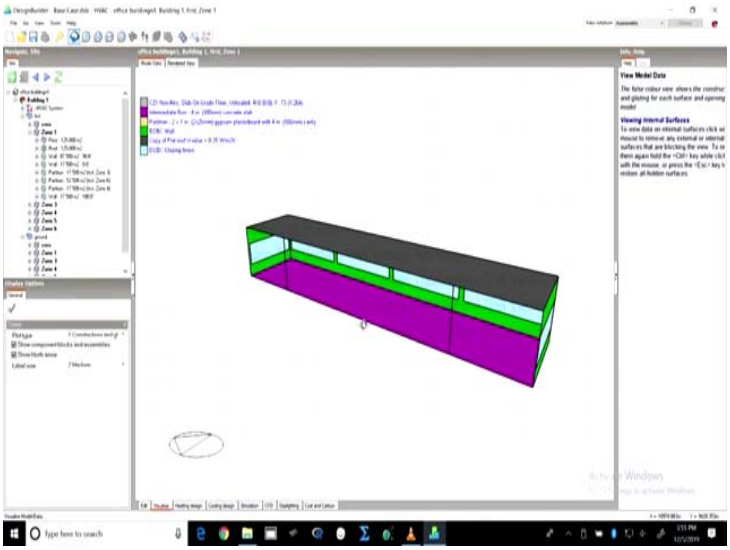
In this case here in the base case has only these many input parameters and with this our base case is fairly ready and we have almost all the systems which are to be supplied for creating a complete base case model. Once we have done this, we can actually visualize how the building is going to look like.

(Refer Slide Time: 13:07)



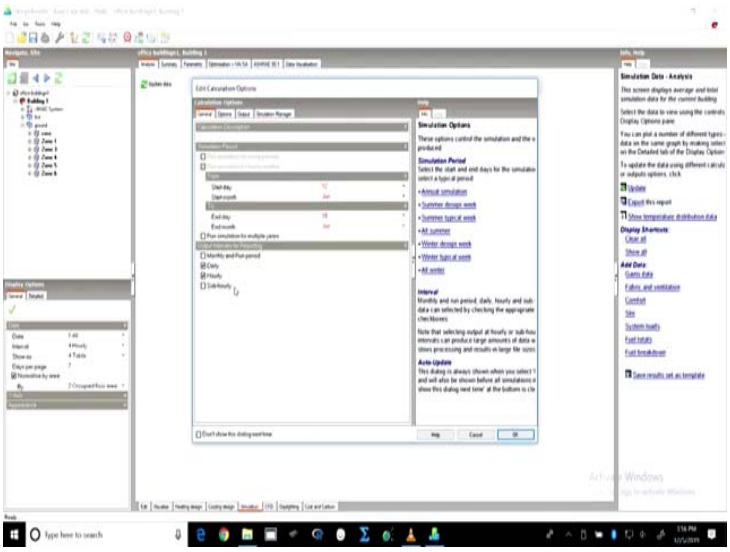
So, we can see what are the different types of materials which are used, we can see the different zones. So, it will give us a quick overview of the building which has been created.

(Refer Slide Time: 13:26)

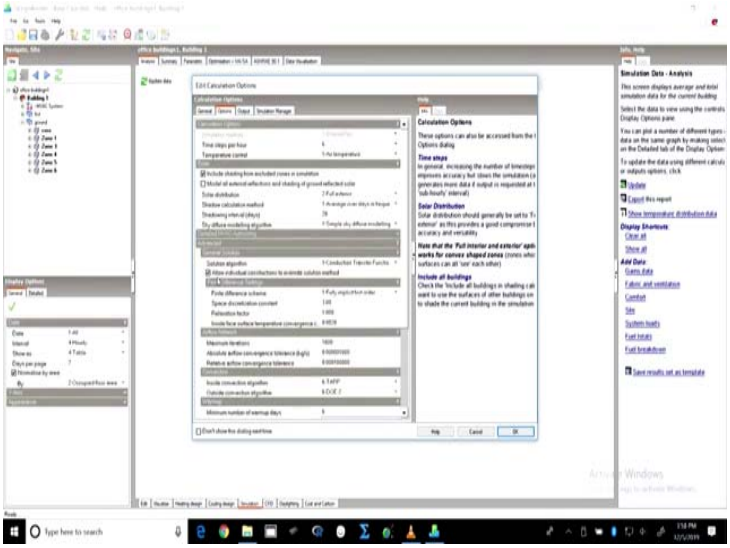


So, once all these input parameters have been given, we can go on to individually simulate the building only for heating design or cooling design or we may go on to simulate it for an year or the period, which will take into account oth the cooling periods and the heating periods.

(Refer Slide Time: 13:48)



(Refer Slide Time: 14:03)

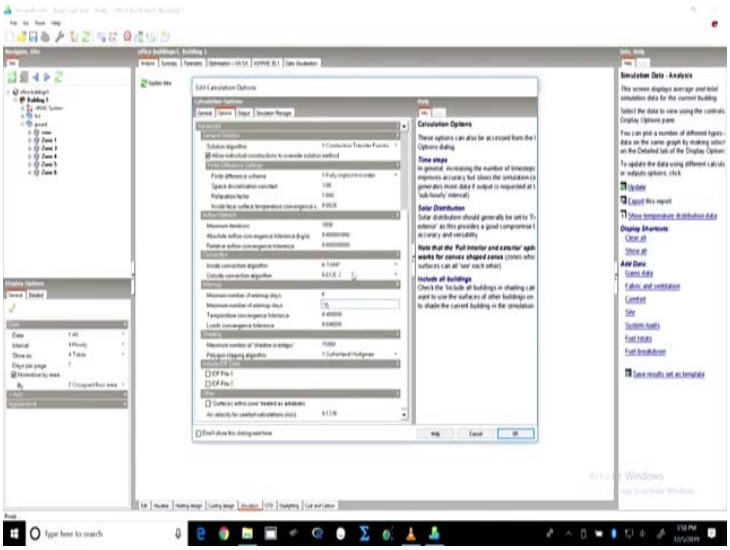


So, here when we start with the simulation, we have to define the period. So, we can define it for say one year; one entire year starting from 1 st January to 31 st December or we could do it only for a summer typical week or we can do it for a winter typical week or we can do it for a design week. So, for now let us look at the summer design week, which will be used to design these systems and check their efficiencies and if we look at the output intervals of reporting.

So, here since we are doing it only for a week, a monthly or run monthly period is not required, but a run period is required. We would be interested in looking at hourly values and this is what we will set here. If we go in options it will be the time steps per hour that it takes by default is 6 and the temperature control is air temperature. So, here we will continue to be using the air temperature, we will include the shading from excluded zones and simulations.

So, suppose we had a component block, so, we would take into account the shading from all such zones and blocks here. We can also model all the external reflections and shading of ground reflected solar. So, in case we want to look at the day lighting calculations, we will definitely check this box on. In case we are not looking at day lighting initially, we may just check it off for faster calculations. For base case, we are not looking at the HVAC auto sizing.

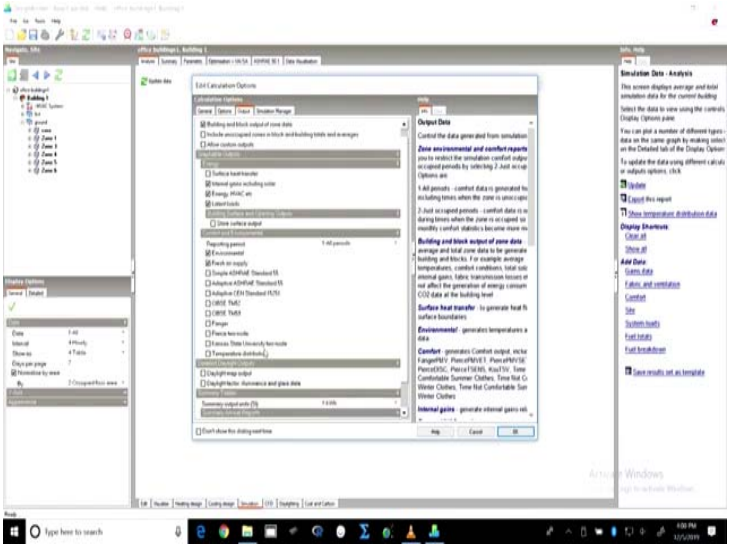
(Refer Slide Time: 15:47)



In advanced, we can look at the algorithms which will be used for convection and warmer periods. So, for now for the base case, we will keep most of these as constant because here there are many definitions, there are many algorithms; but we will keep the ones which are default for now and we will keep the same for the proposed case as well.

So, when we are looking at warmup period, we are looking at the minimum 6 warmup days before the system achieves certain temperatures and the envelope is heated. So, warmup days are the days where the building would have been simulated for these many days and the structure would have gained enough warmth to take into account the heat exchange because of the envelope. So, all this is included in the advanced details for the simulation.

(Refer Slide Time: 16:56)



We can also look at the output what all do we require in output. So, we may want building block output of zone data we may want to include the unoccupied zones. We may want to allow custom outputs for here. Right now, we want only the building and block output of zone data. When we are talking about energy, we are looking at the heat gains including solar energy, HVAC etc, the latent loads.

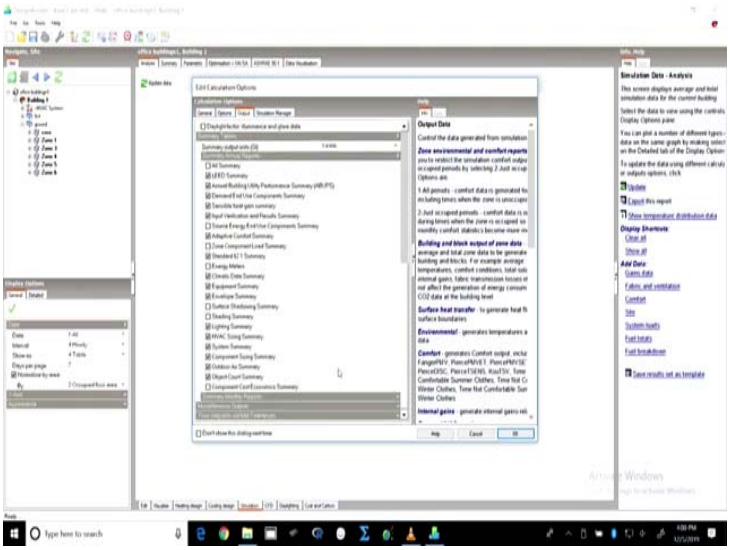
We are not including the surface heat transfer right now, it will not be reported. It is only the output, but for calculations for analysis purpose, it is definitely there already. When we are talking about the comfort and environmental, we are looking at the environmental parameters that is for the air temperature, the solar radiation, the heat gains and all.

We may want to look at any other. So, suppose we are looking at find your comfort model, we can do that we can look at the adaptive ASHRAE Standard 55 or simple standard ASHRAE Standard 55 data as well for the given building. So, what is the comfort level based upon this? However, here since we are concerned about the energy consumption and we will be comparing the energy consumption of base case with the proposed case, that is how only the energy parameters matter more and we will check on in those in.

More is the number of parameters; more is the time it takes to simulate because all these output parameters will have to be calculated. In case we want detail daylight outputs, we will have to check this on. So, day daylight map output and also daylight factor

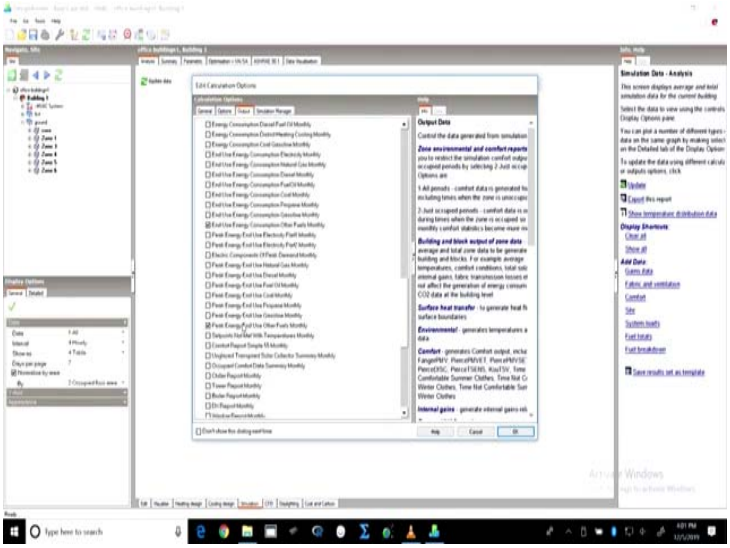
illuminance and glare data. We may want summary tables with the summary output units currently in kilo Watt hour, we may change it to Mega Joules or Giga Joules, depending upon what the requirement is, what the scale of the building is.

(Refer Slide Time: 19:09)



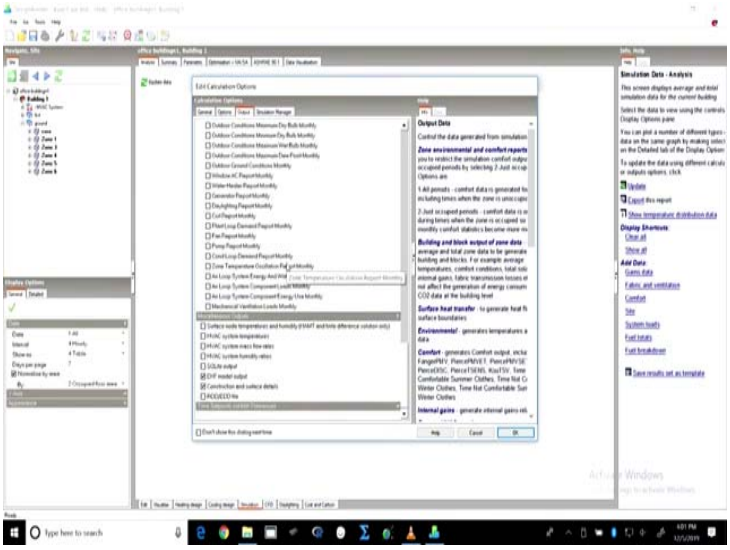
So, for small buildings, we would usually keep it at a kilo Watt hour. So, when we are looking at the annual reports. So, if we look at all these output parameters. So, these are the parameters which will be provided in the summary. So, if we do not want some of these, we may just check them off. If we want a couple of them, we may want them in the report. So, depending upon what is it that you require, you may just go through each one of these and turn them turn them on or off.

(Refer Slide Time: 19:38)



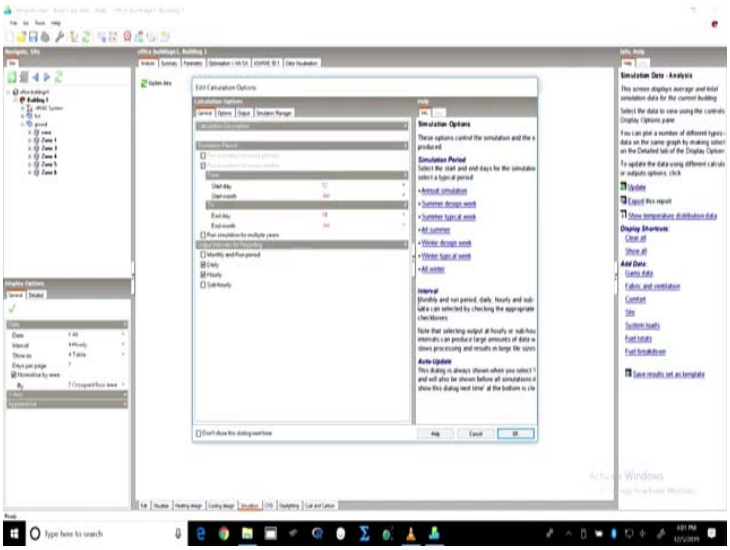
So, same is for monthly reports, if you want more of them, we can just check them on.

(Refer Slide Time: 19:44)



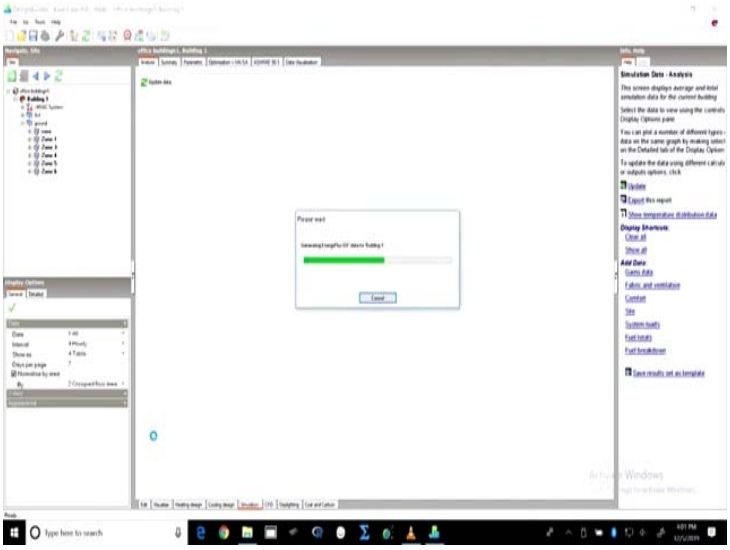
We can also look at some miscellaneous outputs, if at all we want that. So, that also we check.

(Refer Slide Time: 19:58)



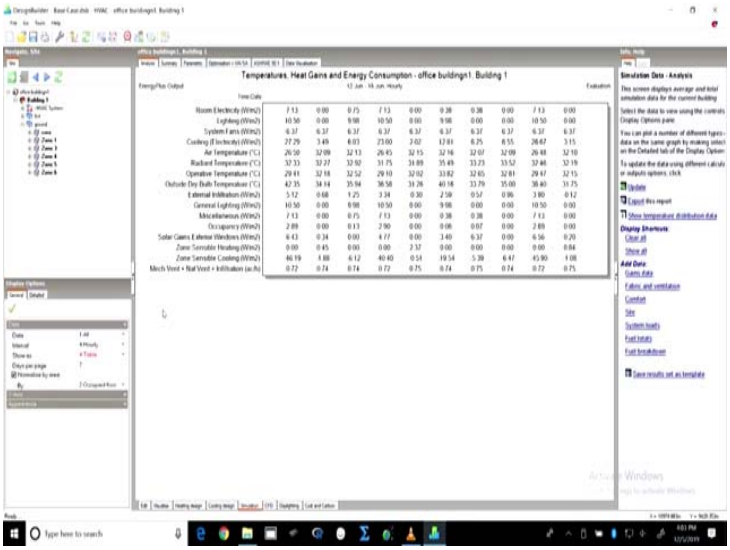
So, once we have done that and we click ok.

(Refer Slide Time: 20:01)



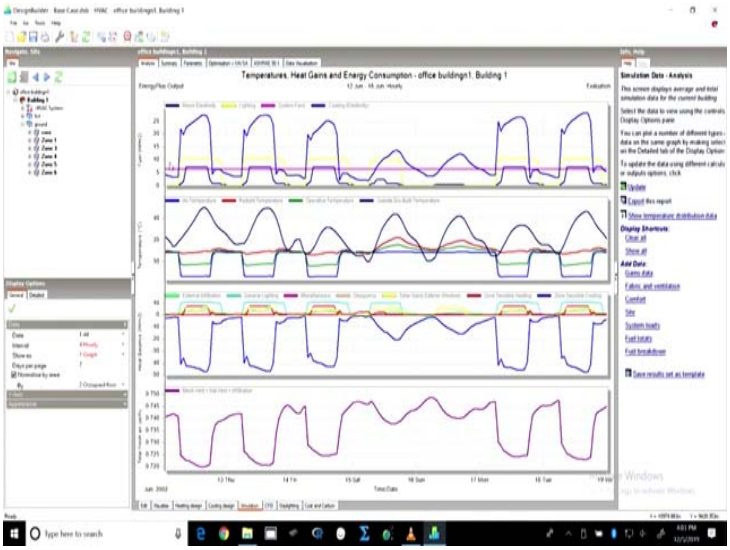
The system will automatically start simulating the building for the given simulation data.

(Refer Slide Time: 20:16)



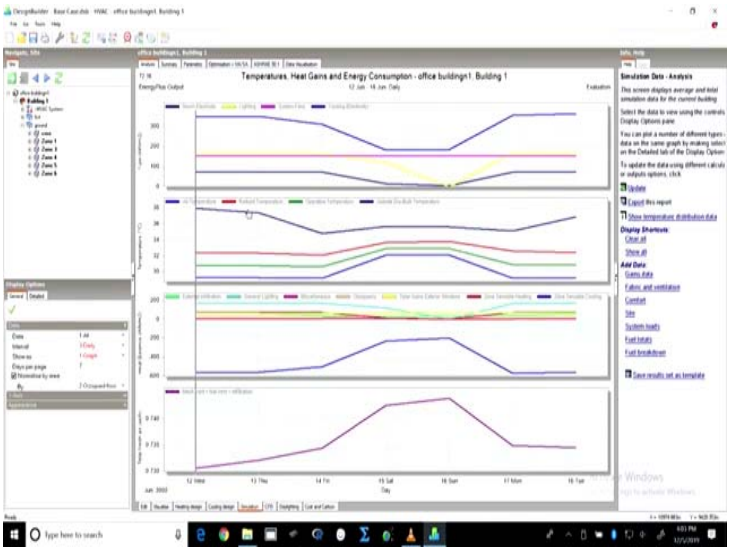
Clicked on the simulation and for the given requirements of the output for simulation, this is the kind of screen that we would get. So, this has this is on a daily interval. If we have an hourly interval, we would we have already generated the hourly data for a summer week which is how we simulated it and we have got for temperature, radiance, the heat balance, the overall fresh air which has been received, the fuel consumption for different purposes for lighting, for fans, for cooling and room electricity. So, this is what we have achieved for a week

(Refer Slide Time: 21:06)



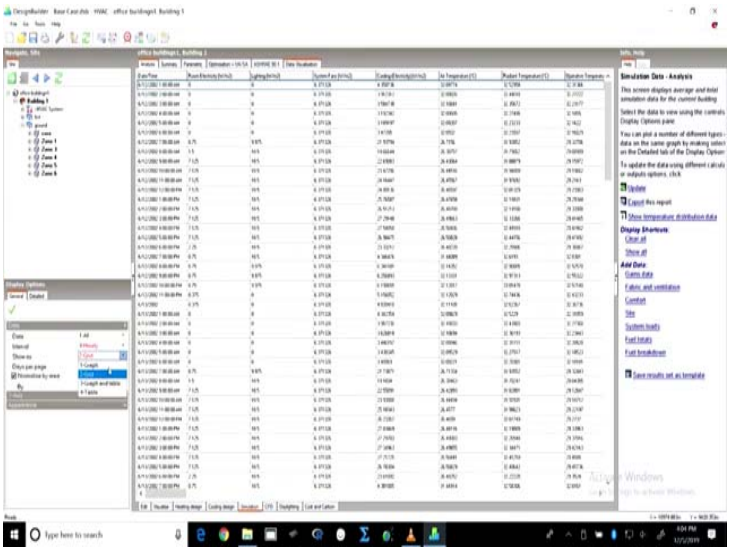
We can also look at it in grid or graph and table, where we can also look at these values.

(Refer Slide Time: 21:13)



We can look at the daily distribution. We can look at the weekly distribution. Here, the monthly would not work. Sorry, we cannot look at the weekly distribution, we can look at the monthly distribution. But since we simulated only for 7 days, it will not work here. So, we can only look at it in grid format or table format; but we usually it is easier for us to apprehend it in a graphical format and for whatever bandwidth for whatever interval, you want to look at it.

(Refer Slide Time: 21:45)



So, this is what will come. So, in the next lecture, we will see how to understand and analyze this data and then, we will move on to simulating the proposed case in comparison with the base case. So, we will close it here for now. See you again tomorrow and I hope by tomorrow, you would have been able to simulate the buildings that you have started with.

So, thank you for being with us. See you again tomorrow. Bye.