

**Sustainable Architecture**  
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**Lecture - 14**  
**Process of Designing Green Building**

Good morning, here we are with the new lecture on the ongoing online course on Sustainable Architecture and I am your instructor Dr. Avlokita Agrawal assistant professor at Department of Architecture and Planning IIT Roorkee. In the previous lecture we have looked at all the terminologies and definitions for various concepts and approaches related to sustainable architecture. In today's lecture we will see we will understand the Process of Designing and Creating Sustainable Architecture.

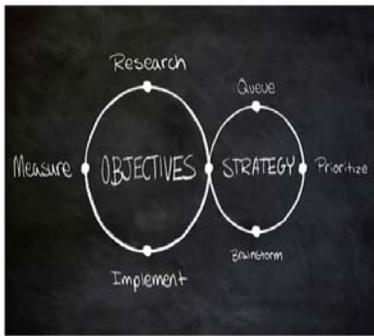
So, before we look at the process before we try to understand the different steps which will be taken in an organized stepwise manner, we must understand the objective of the design. So, when we are talking about when we are talking, looking at the sustainable design sustainable architecture so, the primary objective of design besides the building being functional and aesthetically beautiful we are looking at sustainability as if as the fundamental objective and which is what we are going to fulfill through the process.

So, within sustainability we are looking at the 3 dimensions again which is environmental, economical and social.

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**Objectives of Design**

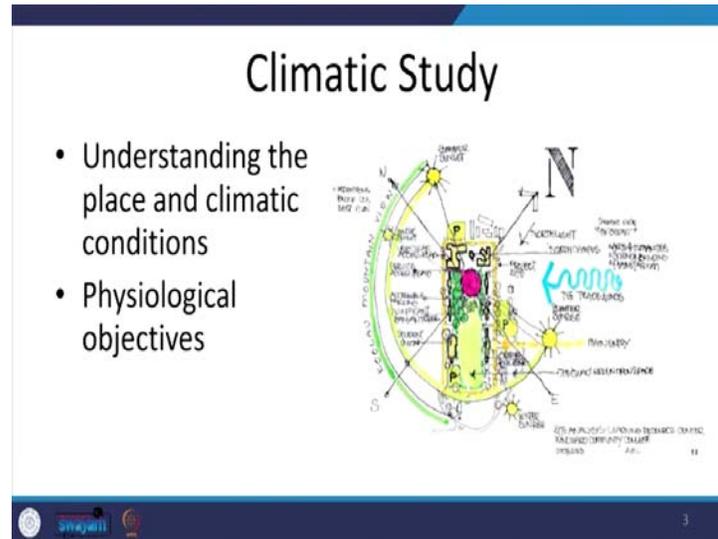
- Sustainability
  - Environmental
  - Economical
  - Social
- Functional
- Aesthetic



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Now, the rest of the lecture today's lecture is largely focused on the process of achieving this sustainable environmental sustainability for a sustainable building sustainable architecture.

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So, to start with designing a sustainable building, the first and foremost step is climatic study. We have to understand the place and climatic conditions and understand the physiological objectives of that place, we have to understand how much sun is available, we have to understand all the environmental parameters.

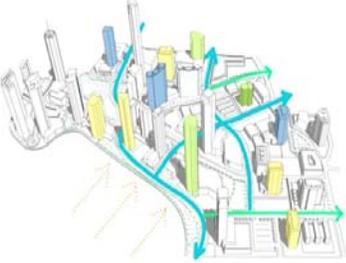
So, how much sun is available, what is the seasonal variation, what is the altitude, what is the range, what is the surrounding water bodies, the microclimate, the air, the direction of the wind which is coming and all these components aspects which form the climate of that place have to be understood deeply, based on those climatic conditions what is the physiological objective.

So, for example, a hot dry climate now there is very harsh sun in a hot dry climate. So, the solar radiation is very high hence the physiological objective is to cut off the solar radiation and hence you see in all the traditional architecture in hot dry climate that we have the shades overhangs, overhangs over the windows, overhangs over the walls even roof which cut off the direct sun. So, we have to understand the climate of the place and hence understand the physiological objective through which we can look for solutions. That is step 1.

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## Study of Site and Surroundings

- Site – surroundings – Context
- Local culture & tradition
- Materials and resources locally available
- Traditional architectural language and style
- Existing Site Features
- Preserving Protected areas



Step 2 is the study of site and surroundings, when I was talking about the climatic study we were talking in general about the place where we are going to for which we are going to design the building, now this is specific to the site and its surroundings. So, we have to look at the context here we are also looking at the local culture and tradition what is the type of architecture which is already available, the type of architectural vocabulary which is available, we also have to look at the materials and resources which are locally available.

So, we have to do a proper survey of the place to understand the type of material which is locally available and along with the material it also provides us with the skill set often people are trained to use ~~these locally available materials~~ these locally available materials in a particular manner. So, we must understand the locally available resources, both tangible as well as intangible, then we also have to look at the existing site features.

So, what is the slope on your site, what is the available vegetation which is there, is there a water body on the side, whether we have tall buildings, whether we have buildings around or not or whatever. So, the study of site and surroundings has to be done clearly.

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## Roles & responsibilities

- Clear roles and responsibilities
- Stage wise and sector wise sustainability aspects



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The next will be identifying the roles and responsibilities, often the things where the intent is good of designing a sustainable building the projects fail because we do not clearly delineate the role and responsibility. Now an architect cannot possibly handle all the rules so and in designing and delivering a building, there are many stakeholders who are involved. So, each one shall clearly be given a role and a responsibility in a stage wise manner which should be done right at the beginning of the project even before the designing is commenced designing is resumed.

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## Site Layout, Inter-shading

- Site planning as per climatic and site analysis
- Exploring optimised siting of buildings and layout



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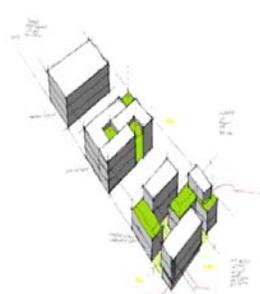
Once we very clearly know the roles and ~~responsibilities~~responsibilities, we are going ahead with the design process. So, after the site analysis understanding of this site and the surroundings we will go ahead and look at the site layout and all the buildings which are available around and the ones which are proposed on the building itself. So, we are looking at the site layout, we are looking at the options of site planning as per the climate and site analysis which has been carried out in the previous steps. And then we look at options to optimize the siting of building and layout based upon the mutual shading of buildings from each other with reference to the climate and site analysis.

Once we have done that we will come to design the form and orientation of the building.

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## Building Form & Orientation

- Optimised Form and Orientation
  - Study of climatic data and sun path
  - To lessen the insolation
  - For better performing buildings
- Fitting in the site context



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So, we have to optimize the form and orientation based upon the climatic data and in order to achieve the physiological objectives which have been identified as the very first step of the design process and then we put them bring them together to fit the site context because we have also carried out the site analysis.

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## Passive Strategies

- Earth-berming
- Earth Air-tunnel cooling
- Geo thermal cooling
- Wind catchers
- Water bodies & Evaporative cooling
- Pre-cooling of Ventilation Air



The image shows a building with a red earth-bermed exterior, illustrating passive cooling strategies. The building has a large, open-plan structure with a flat roof and a prominent chimney. The surrounding area is green and appears to be a rural or semi-rural setting.

Once we have broadly decided on the building form and orientation, we then go on to select the relevant passive strategies now these passive strategies are responding to the physiological objectives which we have identified.

So, just as I was giving an example, if the physiological objective is of cutting the direct solar radiation. So, we have different passive strategies which are available for different components of the building. If we are looking at the spatial component provision of veranda is a passive strategy, if we are looking at the wall component probably a thick mass and shaded walls is another passive strategy.

So, we look at various passive strategies for example, earth warming, earth tunnels, geothermal cooling, wind catchers and we find all these passive strategies being implemented in traditional architecture across the world depending upon the climate and the physiological objective of that place.

Then we go on to detail the building envelope.

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## Building Envelope design

- **Thermal insulation** (Walls)
- **Thermal mass** (increasing wall thickness)
- **Air cavities** (Providing air cavities in walls)
- **Surface finishes** (light coloured paints on wall)
- **Over-deck and under-deck insulation** (Roof)
- **Cool Roofs**
- **Green roof system**



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So, there are different points there are different methods of designing the building envelope on the basis of their thermal insulation. One is the physiological objective whether we need insulation so, for example, in a warm humid climate we do not need insulation we require thin walls which are able to allow natural ventilation a lot of ventilation.

So, these terminologies may be required or may not be required in every case, but some of these may be used. So, for example, thermal insulation for example, in extremely cold climates insulation is required where the diurnal range and the difference between indoors and outdoors is quite high.

Thermal mass increasing the thickness of the wall where a lot of heat storage is possible, air cavities providing air cavities in the wall is again sort of thermal insulation. Surface finishes, so light colored paints on the walls for climates where solar radiation is intense to reflect a lot of heat directly from the outdoors, over deck under deck insulation, green roofs, cool roofs. So, all of these are specific building envelope design components.

So, once we have designed the building largely using the passive design measures of design spatial design, we come to the individual component see wall, fenestration, roof and all these components.

So, each of these components they will be designed with respect to the material which is going in the arrangement of materials which is to be going in and we use the building materials to deliver that. So, we know the amount of insulation that we require, but what kind of material should be used, here we will then select the materials because we have already carried out this survey of this site, we have understood the site and the surroundings. So, we know what are the local materials which are available, we understand what are the materials which have lesser embodied energy and which also have lesser impact on environment.

We have already understood all the terminologies related to these materials. So, we know the materials which have lesser embodied energy, which have lesser carbon footprint, which have lesser environmentally ecological footprint. So, we understand what all materials are available and then we make an informed choice on selecting the right type of building material based upon our objectives of sustainability, functionality and aesthetics.

Now, till this point we were working only on paper, we were gathering data, we were designing on paper, we were looking at how the different forms and orientations and arrangements would work out. So, all of this was on the paper this was the design phase, now from this step onwards we start with the construction phase.

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## Site Preparation & Planning

- Soil erosion control measures
- Dust prevention measures
- Noise reduction mitigation measures
- Protecting existing vegetation
- Zoning and phasing of project
- Efficient deployment of materials and equipment



The photograph shows a construction site with a dirt road, a brick wall, and a person standing near the wall. The site appears to be in an arid or semi-arid region with sparse vegetation in the background.

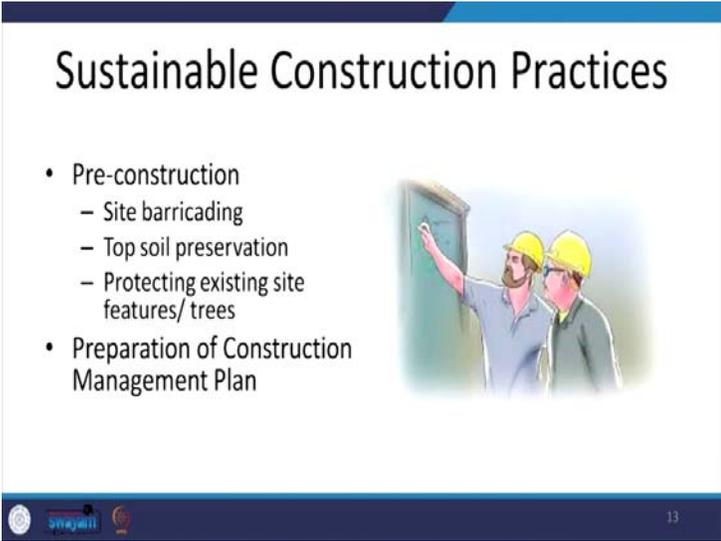
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So, this is pre construction, but post design which is site preparation and planning this requires a lot of management and planning before the construction commences, we are talking about steps such as soil erosion control measures, dust prevention measures.

So, we ~~can not~~cannot just go on and start constructing on the site we have to barricade it from all around to prevent the dust from going out to prevent the noise from going out reduce that to protect the existing vegetation. So, we have to mark the trees which are present on the site protect them cover them if they have to be transplanted then properly remove those trees along with the roots and take them to another place.

All that is before the actual construction begins this is just site preparation, from where the vehicles would enter, how will their wheels be washed out, when they go out, how will all that mechanism carry out, how the storage of construction waste will be stored. So, all of that is within site preparation and planning.

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The slide is titled "Sustainable Construction Practices" and features a bulleted list of key practices. To the right of the text is an illustration of two construction workers wearing yellow hard hats and safety glasses, one pointing at a green chalkboard. The slide footer includes a logo on the left and the number "13" on the right.

- Pre-construction
  - Site barricading
  - Top soil preservation
  - Protecting existing site features/ trees
- Preparation of Construction Management Plan

Then this is this is continuation of the same thing this is pre construction where we are talking about the topsoil preservation, the protection of existing site features, the barricading of the entire site and all of these.

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## Sustainable Construction Practices

- During construction
  - Dust suppression measures
  - Noise control
  - Material movement and management
  - Storm water management
  - Construction waste management
  - Disaster Risk Mitigation



The image shows a yellow water sprayer truck, commonly used in construction to suppress dust. The truck is positioned on a dirt road, and water is being sprayed from its front-mounted nozzles, creating a misty effect. The background shows a wooded area with trees.

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Now, once we have done the pre construction activities carried out them properly we go ahead with the activities during construction. So, we have to engage in sustainable construction practices which includes the dust suppression measures often construction is the biggest polluter in any city because of the amount of dust suspended particles it generates, because of the dust the vehicles which are moving in and out of the site they carry along with them. So, we have to reduce the dust which is on generated on site.

We have to control the noise which is generated from the site because of the huge machinery which is used because majority of the buildings are huge large buildings these days. So, a lot of noise is produced so, how to control that noise. This is the planning has already happened pre construction at the time of construction we have to implement all of these measures. We have to properly move the material and we have to move manage the movement of material.

The storm water management during construction often we planned for post construction once the building is up and ready to move in, we know how to manage storm water, but during construction people do not think about managing storm water. So, we see a lot of mishaps happening where the during the construction of the basement the walls of the basement they have collapsed and things like that because the stormwater management plan during construction did not exist. So, we have to implement that, we have to look at how the construction waste will be managed, we also have to look at the disaster risk

**disaster risk** mitigation during construction and post construction and the planning for it would have started from the design stage itself.

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## Facilities for Construction Workforce

- Healthy conditions for construction workforce
- Safety measures during construction
- Provision of basic amenities
- Health & education for children



The slide features a title 'Facilities for Construction Workforce' at the top. Below the title is a bulleted list of four points: 'Healthy conditions for construction workforce', 'Safety measures during construction', 'Provision of basic amenities', and 'Health & education for children'. To the right of the list is a photograph showing a busy construction site with several workers wearing yellow safety vests and hard hats, working on a concrete structure. In the background, there are construction vehicles and materials. At the bottom of the slide, there are logos for 'Swachh Bharat Mission' and '15'.

Along with the construction we have to plan and provide for the facilities for construction workforce, for their providing them with healthy conditions for living for their children to be safe. So, it is both health and safety measures which have to be ensured for all the construction workers and also their families, because realizing the fact that these construction workers have the families which are absolutely underprivileged. So, provision of the basic amenities for them health and education facilities for the children of these construction workers which often includes setting up of anganwadi or a small creche on the construction site itself.

So, all these measures are during the construction measures once the construction is complete now this kind of measure, till now we were talking about the architecture and civil part of it lighting is also an integral part of architecture, but this is all add-ons from here we start with the active systems till this point we were dealing largely with the passive systems.

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## Lighting

- Minimum required lighting levels
- Harvesting Daylight
- Efficient lighting design
- Lighting systems with high efficacy
- Lighting sensors and controls



Image source: [www.299lighting.co.uk](http://www.299lighting.co.uk)

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While from here we now add on the active systems into the building. The designing for this lighting would be happening simultaneously while the building envelope and the entire building is being designed.

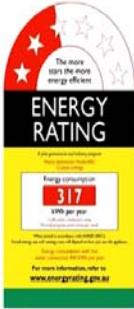
But here the attempt is the aim is to reduce the demand through passive design measures and then supplement whatever the ~~left-over~~ demand is through active measures say artificial lighting here. So, first we have to identify assess how much of the artificial lighting is required in addition to the natural light which is being provided for and then provide for the minimum required lighting level as per the standards and codes NBC for example, is for us. We have to look at the efficient design of lighting, we have to select the lighting systems which have very high efficacy.

So, choosing the right kind of technology and lighting industry is one such industry which has leapfrogged, almost 2 decades back we were largely using incandescent bulbs and the regular tube lights, gradually mean we moved on to CFLs and now we are on LEDs. So, all this has happened very fast and it is still evolving. So, we have to select these systems which have very high efficacy, along with the lighting systems these days we have increasing use of sensors and controls within the system to improve the efficiency to improve the efficiency of the entire lighting design.

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## Equipment & Appliances

- Right sizing and capacity
- Higher efficiencies
- Procurement Policy



The image shows a slide titled "Equipment & Appliances" with three bullet points: "Right sizing and capacity", "Higher efficiencies", and "Procurement Policy". To the right of the text is a graphic of an Energy Rating label. The label features a semi-circular scale with stars, indicating energy efficiency. The text on the label includes "The more stars the more energy efficient", "ENERGY RATING", "Energy consumption 317 kWh per year", and "For more information refer to www.energyrating.gov.au". At the bottom of the slide, there are logos for "swajati" and "17".

Besides lighting design, we are looking at the equipment and appliances which are going to be installed in the building over and above this passive system again part of the active system. So, we are looking at the right sizing and capacity of these equipments and appliances to be used, we are looking at the higher efficiency equipments and appliances and we also have to look at the procurement policy. For example, for a large campus where a number of air conditioners will be procured, we have to specify that all the air conditioners procured probably would be 5 star rated or 6 star rated like that. So, that is the procurement policy that we are talking at the institutional level.

Once all these appliances and systems have been put in place, we have to ensure that the indoor environment quality is maintained this is operational stage of the building, we have to maintain the healthy environment we have to ensure that this systems for ensuring sufficient amount of fresh air ventilation and exhaust systems exist.

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## Indoor Environment Quality

- Healthy Environment
- Fresh air ventilation
- Exhaust systems
- Low VOC materials and compounds
- Dust free interiors
- Acoustic control



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We have to look at the options alternatives which have low VOC materials and compounds being used, we have to look at less and less of suspended particles where the interiors remain dust free and we have to also look at the acoustic control depending upon the type and purpose of the building that we are designing.

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## HVAC

- Equipment sizing
- Variable refrigerant flow systems
- Efficiency – CoP/ EER
- Refrigerants (ODP)
- Thermal energy storage (TES)
- Air handling units (AHU)
- Fans and blowers
- Ducting
- Variable speed drives
- Controls



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HVAC is a part of the active system equipment and appliance design. So, we have to look at the sizing and we have to look at the efficiencies, the type of refrigerants which are being used the type of AHU, fans blowers, all these different components which go

within the HVAC system which is outer and outer active system. Now I have put all these active systems at the end because we have to realize that while delivering any sustainable building the initial steps the first step has to be to design the building structure in such a manner that the need for all these active systems is reduced the demand is reduced and then supplementing them with all these active systems.

Once we have completed the building ~~passive~~ adding the passive systems and the active systems on to it we have to measure, we have to monitor and verify the performance of the building, we have to commission the building and we have to put in place an operation and maintenance plan. This is necessary because we have to understand we have to know whether the systems which we have designed are performing as intended or not, if not where is the problem and correct that to ~~bring down the energy perform~~ bring down the energy consumption in the building and improve it is energy efficiency.

So, this tracking measurement and verification becomes very important for any sustainable building, any green building, anything that we are able to measure and monitor is what can be used to improve if we do not know what is happening, if we do not monitor the performance it will be very difficult to improve the performance of the building. Once this entire building is ~~therethere~~, we also have to simultaneously think of the landscape design the vegetation.

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## Landscape design

- Reduced turf area
- Minimise water consumption
- Drought tolerant species



The image shows a green lawn with a central sprinkler head. Several jets of water are spraying outwards, creating a misty effect. In the background, there are trees and a building. The overall scene is a typical residential or commercial lawn maintenance setup.



So, we have to design landscape areas in such a manner that we reduce the amount of resource consumption for the maintenance of the landscape. We have to minimize the water consumption which can be done through of the native species native trees and plants and reducing the manicured area of the landscape around the building.

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We have to look at the once the building has been commissioned it is operating that is when we have to look at the management practices for waste management. So, how is the segregation at source happening, how is the waste going for recycling, how is the organic waste being managed and recycled on site or sent to the recycling centers. So, we have to look at waste management practices, we have to look at water management practices, how the rainwater harvesting.

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## Sust. Water Management

- Rainwater harvesting
- Reduction in water consumption
- Waste water treatment
- Reuse of treated wastewater

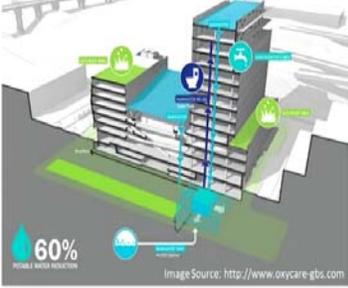


Image Source: <http://www.oxycafe-gba.com>

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So, we might have designed the systems, but we have to manage we have to run these systems. So, whether in water harvesting is happening as intended or not, whether water reduction consumption of water is reduced or not, whether wastewater is being treated and then used reused in the entire system or not. So, we have to look at the water management system.

Once all these systems are ~~designed~~designed, we supplement them with the renewable energy systems. So, we have already reduced the amount of energy the demand for energy through passive systems and also through very high--efficient active systems. Still whatever amount of energy is required can be produced on the site itself with the help of renewable energy systems so, that should be designed in the last.

So, it could be multiple ways for example, we have seen in the previous lecture how Suzlon One at in Pune has been generating the entire of it is energy needs by installing ~~wind~~ small wind towers, windmills on it is site, using solar photovoltaic, using hybrid systems. So, there are multiple renewable energy systems a variety of them which are available.

So, identifying the best one to be used integrating them with the building and using all of them collectively to generate the amount of energy which is going to be consumed by the building. I will conclude my lecture here and see you in the next lecture.

Thank you.