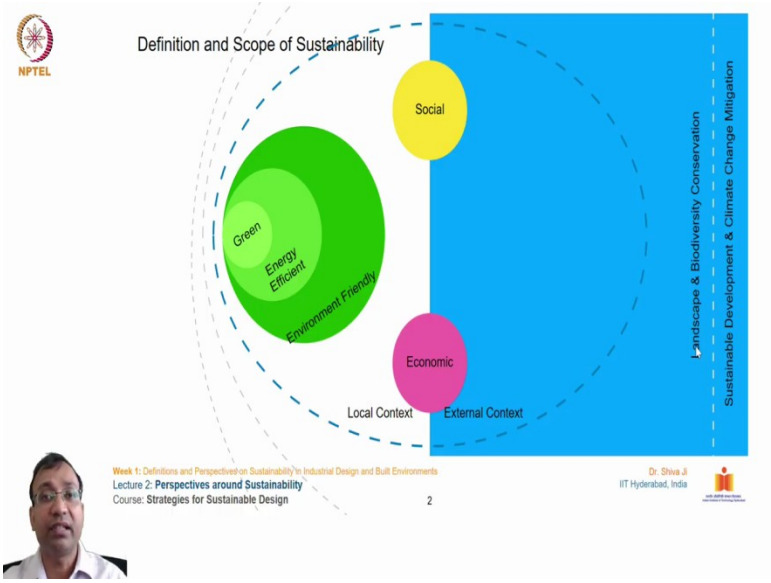
Strategies for Sustainable Design
Professor. Shiva Ji
Indian Institute of Technology Hyderabad
Lecture 4 & 5
Spheres of Energy Efficient Green Environmental Sustainable Designs

Hello everyone, so welcome you all to the lecture 4 and 5, this talks about Spheres of Energy, Energy Efficient Green, Environmental and Sustainable Designs. So, we will talk about these, ((

(Refer Slide Time: 00:32)



We generally actually use these terms, but sometimes we ended up using them at the wrong place, because they mean actually something very specific. So, in this illustration, you can see it is very clear over here, green is the smallest unit of like, such like a sustainable design and then comes to like the energy efficient then comes environment friendly and then comes the sphere of sustainability. So, in this actually is sphere of sustainable like a design.

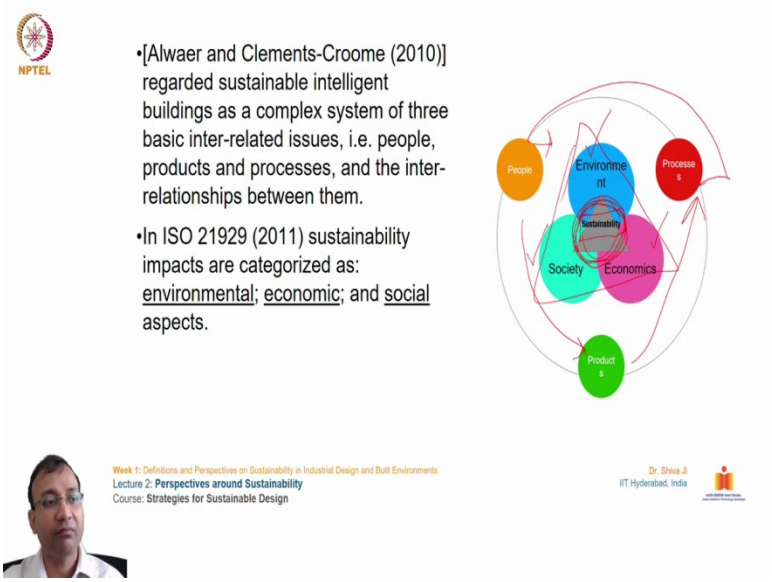
So, there is the environment like aspect with this green circle and there is like a social aspects. So, with the yellow circle and these pink color circle represents the economic aspect of that sustainable development and in this time, these sustainable development also, there are like a two factors like a two factor like one is the local context and the second one is the external context. So, this is on the, like a landscape part.

So, we have been discussing about the local context and the external context. So, that is the one and then even when there are things beyond actually the reaches of the sustainable design. So,

that one speaks of landscape and biodiversity conservation. So, this actually comes at the level of like a bigger position like a country or maybe a very big region, like for example, like Siberia or Arctic or Antarctic or things like that.

And there is even a bigger actually effort in terms of like the scope and reach of it. So, that one is like a sustainable development and climate change mitigation. So, in this one, actually, we deal with the situation at the global level. So, at the global level, it becomes like a thesustainable development and climate change mitigation. So, coming from a like the green one until the like a global level. So, there is a huge range of it. So, we should always be careful and what we are referring to and in what context. So, it is very important for us to distinguish actually these terms which seems like overlapping.

(Refer Slide Time: 02:36)



So, let us see, some like observations by some researchers. So, here Alwaer and Clements-Croome, they say they regarded sustainable intelligent building as a complex system of like a three basic interrelated issue that is people product and processes and the interrelationship between them. So, here you can see this ESE aspects of sustainability is like a spreading over here and these people processes and products are a part of this whole ecosystem and they are encompassing it.

Because, anything and everything we can associate within these three, like people being like us, humans and the processes means anything and everything which humans have created and even

then if it is existing like a natural like a fashion and the products what we humans are producing as a resultant of our later growth and development model. So, that becomes the upper part of this product actually carry.

So, between these three, this entire like ESE aspects can be actually encompassed and we can establish with the help of their establishing their interrelationship, we can understand the phenomenon which is happening at these three levels. So, you can see like the people products and processes, so between these three actually the ESE lie, it lies and at the overlapping intersection of these three, the factor of like a, this sustainability actually comes into picture.

So, wherever we are able to satisfy the needs and requirements of these three all together at the same time, it becomes a Sustainable Model of Growth and Development. So, that is what it means. Well, this ESE is derived by even like ISO as an organization they actually produce like a certain set of like regulations. For the manufacturing sector for like, like the construction sector for like a normal practices. For like our manufacturing and everything. So, they also categorize these sustainable impacts in a three environmental, economic and social.

(Refer Slide Time: 04:53)

So, there is actually a typology in like a building if you particularly see in like the architecture, so there are like energy efficient buildings which talk about being good on the like energy ok and then there is an environment friendly buildings which talk about more than energy, when energy is just one aspect of the whole thing. So, any energy for example, when we consider like any other like electrical appliances or the home, home appliances.

So, they come with this BEE star ratings. So, from 1 to 5 they are rated on the star rating. So, that rating is only for the energy savings. So, if that particular product is complying the set norms

of like energy saving, then it actually rated as for like a 1 to 5 star actually rating depending upon the actually the slab what the BEE actually as an organization they have actually set for.

So, that actually slang also they keep on improving over the years. So, the if some product is qualifying for like a 1 star like at this year, so then the main next set of like that selection, that 1 star may become the actually threshold of qualifying. So, there may be some products, which were actually designed by the companies which could not actually achieve even 1 star and they were kind of declared not worthy for the market, not worthy for the consumers to be like taken up and to buy.

So, that is why they were actually not allowed to the market and this way we see these products which were like I areas like for example, HVAC like air conditioners, so they come with these star ratings, refrigerators they come with these star ratings, even computers also come like the US made computers are there is this energy saving star actually you may be seen while you start your personal computer.

So, even that actually one screen actually reflects at the beginning of the booting about the computer. So, these are all actually mean for the energy savings means. So, energy saving means is like one of the aspects among the sustainable like a practices, but there are like a lot many other things than just being like energy saving. So, next comes our environment friendly building.

So in this actually category, the buildings, they actually tend to be like an environment friendly, for example, they should not actually pull in for example, every building like a building works as an organism it gets born one day, it lives its life, it consumes energy, it excretes like waste, you know. So it is a. so building is type of a living organism, well it is nonliving thing, but it is, it functions like an like a living organism.

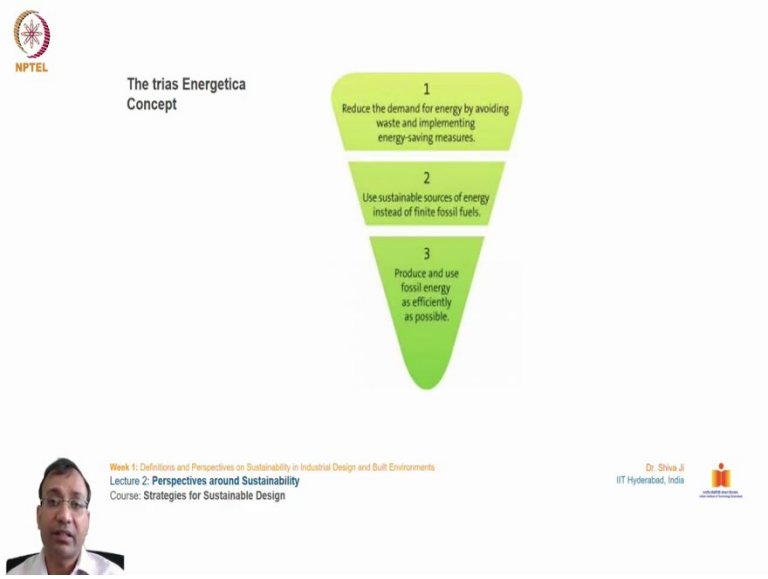
So, there will be some waste. So, a building as an organism must correspond to its surroundings, and that is what it means with the (())(07:43) environment friendly buildings. The third one comes like sustainability. So, what are the distinctions from the previous ones to this one? Well, it is simply like, it caters to the social and economic factors also, along with that environmental factors.

So, the moment we talk like how one building is related with the society, where there are new challenges, which come up before the designer before the architect and engineer like how to design a building which is socially also responsible, economically also responsible and obviously environmentally or socially responsible.

So, now you understand the difference between like energy efficient building, environment friendly building and a sustainable building. So, here like a green actually becomes a subset of the bigger set of like being sustainable.

We saw in the first illustration over here like a green is the beginning point. So, maybe here you can refresh your understanding again, it starts with the green then it goes to the energy efficient then it becomes environmental friendly, then it becomes sustainable and then the other two actually much broader actually perspectives come in that distance.

(Refer Slide Time: 08:58)



So, here in this slide it talks about like how we can go about consuming energy. So, the first and foremost the effort should be there to reduce the demand. So, once the demand is like lesser we can exert actually lesser impact on the globe. So, reducing the demand should be the guiding factor while designing. So, by avoiding actually like a wastage of like energy and materials and resources.

We can improve upon like a waste and other like wastage of energy, wastage of the resources, wastage of the material and all of those things. The second step in this actually progressor in this concept actually suggests use sustainable sources of energy instead of finite fossil fuels. Well, of course, we know finite fossil fuels are going to last up to like a one actually fixed time and by the time they exhaust they may already have a crucial and critical and tremendous like a impact on this planet, because we all know like how much of emissions they actually generate.

The third one, even if you still like a need energy or like a, for like X amount then produce and use that for fossil energy as efficiently as possible. So, you must actually be responsible if you are using fossil fuels, because if you are not able to meet like a, if you are not able to undertake your activities without this effort at least you should do it much more responsibly.

So, this is actually concept of like a Trias Energetica it talks about it here like reducing the demand and then sourcing infinite resources of energy in instead of like a finite sources of the energy and then using it efficiently. So, these are actually driving guidelines you can take into this context which become very relevant for with the effort of each and every of us, this is going to actually succeed.

(Refer Slide Time: 11:00)

So, for example, any urban living a house. So, there are actually different components within a house as you can see over here, if you take the example of like air conditioners. So, they are

mainly used for like a heating or like a cooling and ventilation. So, that is why they call it like a heating ventilation air conditioning system.

So, if you are using if you are in a cold country of course, we will be using it for heating purposes and if you are in a hotter country, we will be using for the cooling purpose. So, this actually takes the major actually portion of the overall energy what we consume in our, buildings by air conditioning. So, we must pay attention to like these HVAC unit to optimize reduce and depend on the finite source of energy as much as we can.

Next like there are actually considerations like you know, thermal insulations, because we may have studied in our textbook, while learning transmit energy while we transfer heat from one place to another even when we transfer like electricity from one place to another, there is always some, like some percentage of like large impact. So, how that loss can be like a minimized how that loss can be actually kept to the minimal.

So, that because every unit of that energy is very important and it takes a ton. It has a lot of impact on the surrounding. So, by losing it simply we are wasting that much of resource. So, that resource is very valuable, very critical. So, how we can, well minimize this. So, that effort actually should be made over here for using insulations in the places, in the portions of the building, where there is any chance of the leak is in the energy.

The next one like a efficient lighting of course, so this change has come of at least in India like are we are aware of like, we have moved on from the incandescent bulbs to like a CFL based bulbs and LED bulbs these days. So, the consumer actually a fraction of electricity of what it was used by the incandescent bulbs. So, the earlier these bulbs used to consume like a 100 watt per like a bulb, now you can have thousands of LEDs, you can run them in just 100 watts of power.

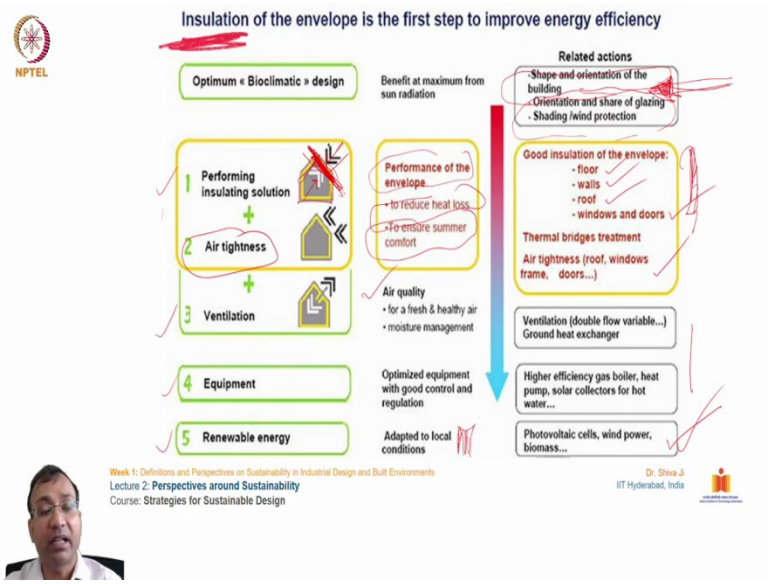
So, this is the huge difference actually, which has come. But further it needs to be like enforced and ceiling insulation is part of that insulation. Thermal barrier like, again we have to check the transmission of our energy or heat from one chamber to the next one. So, we should put it like the thermal barriers, thermal insulators in the place where the leak is possible.

Even air barrier, you know the efficient windows because windows are the actually portions from where there is they are the direct openings. So, there is a lot of like no Sun energy which

gets inside the, Sun's heat energy and light gets inside the actual interior. So, how we can still receive the only light part and we can reduce the heat, if it is not needed, then by putting up like a efficient heat reduction actually glazing we can improve on this efficiency.

And if we need heat for example, if you are in a situated in a like a cold climate. So, of course we need also, need the heat also, so how the heat can be allowed in actually in that scenario. So, we can devise this actually glass in such a way, so that it facilitates depending upon our like quantity, the interiors and of course, the mechanical ventilation is there to improve on this thing.

(Refer Slide Time: 14:42)



So, with this if you see the insulation is one of the very important actually things it becomes very important thing over here the transmission of like energy particularly if we talk about. So, like a how this envelops is the first step to improve the energy efficiency. The moment we are talking about energy efficiency, the first and foremost opportunity comes right in the insulation part. So, here you can see in this it goes from 1 to 5 and performing like insulation solutions in the building, as you can see from inside to outside.

So, the building surface the building membrane, is the one actually element which interacts with the atmosphere which interacts the outside like a surrounding like atmosphere. So, how we can insulate and save as much as we can. Air tightness and ventilation equipment and renewable energy.

So, these are the actually, so these are actually some yellow crosses is the performance, improving the performance of it reducing the heat loss, ensuring like a summer comfort and ensuring like a winter comfort and these once actually to improve the air quality inside the like the space.

For fresh and healthy air and the next one talks about optimized equipment with good control and regulation. So, this one actually talks about controlling the equipment and controlling the regulations of it and the last one talks about it, to like adopt to like a local conditions. So, like a how in the local conditions we can redesign our conventional like a design like elements in the buildings and we can improve upon this thing.

On the last section, if you see here, like a related action, so the shape and orientation of the buildings can be like improved. So, that to maintain the like this we saw over here like a how much of like a heat and radiation we are going to our building is going to receive in which direction. So, based on that direction and based on the local climatic situation and geographical conditions, we can reorient and reshape our buildings.

So, that is where actually the strategic actually design element comes into picture. So, we as a designer, we as an architect and engineer we can contribute for the efficiency while designing itself, because that is actually first and foremost actually step in the whole design process till the like delivery, that is, so that we, so that there is very little need of like a controlled environment very so that there is very little actually need of the such efforts from like the external sources such as like electricity and these things to control them.

The next one orientation and the share of the glazing. So, this can be reduced to control the overall, reception of the heat and radiation from the outside or the shading wind protection. So, this can be utilized and in the middle part if you see a good installation of the envelops in terms flooring, in terms of a walls, in terms of roofing, you know windows and doors.

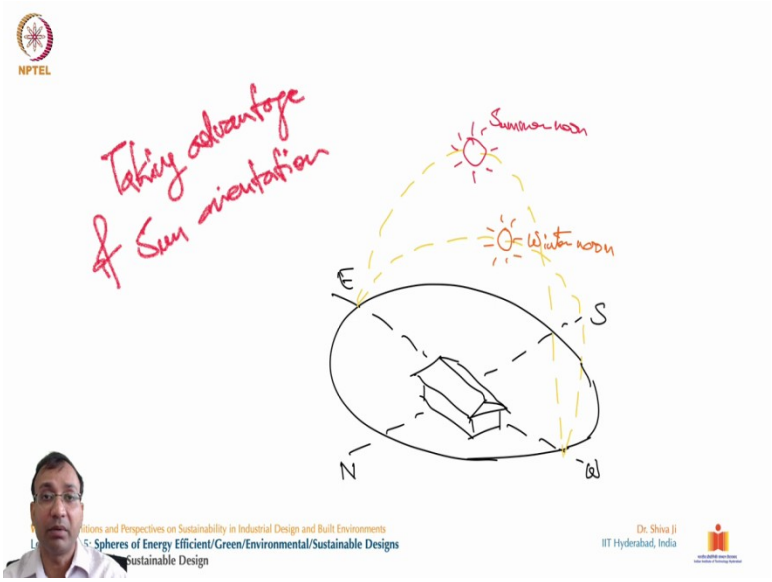
So, these should be like a properly insulated for controlling heat and thermal bridges treatment, air tightness and also these are of course, very important to reduce the convection and conduction basis we loss of energy from inside to outside or opposite and ventilation and this. So, in the renewable energy, portion if you see, there are some efforts in the recent decades which are made

for like a photo voltaic cells, wind power biomass and so these actually we use for like, for example, these days a new concept has come up for like a net zero energy ratings.

So, Indira Paryawaran Bhavan in New Delhi, in India is the first net zero energy building which generates its own power. More than 100 percent. So, what it does, it utilizes it's, the power requirements from the site itself and its supplies to the grid, whatever the excess amount of energy they actually generate. So, they are not actually depending upon the external sources such as like a coal and a hydro power and nuclear power any such power to get the receive the energy for their consumption or that particular site.

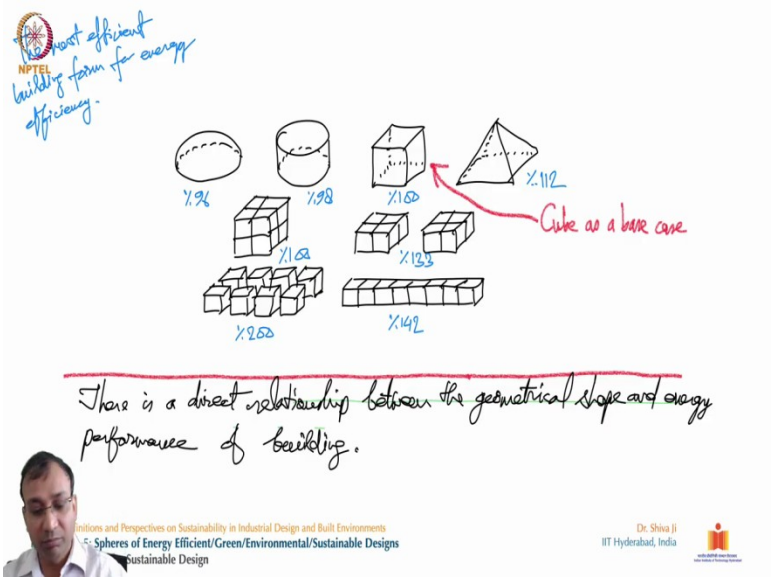
So, they are generating it by themselves. So, that is an effort through which we can minimize the dependence on the grid. So, once we are dependent, we are not dependent on the grid we can generate our own like the power requirements and even we can supply to the outside.

(Refer Slide Time: 19:19)



So, this is one actually sketch you may have already seen it like how with the location of the like a solar or like a latitude and longitude, we can optimize on the efficiency of the design, by orientation changing, by changing in the form, by changing in the overall volume, the materials which are coming in that particular activity direction, whether do we need like a heating or cooling. So, depending upon that we can choose like, facilitating materials, insulator materials or this conventional like a materials for facilitating that.

(Refer Slide Time: 19:52)



So, let us see, like how the form of the building can be used as like a strategic input for designing metrics. So, if we take this cube as your like a base case, so if cube is like this is a, if this is like a holding like 100 percent of volume by like 100 percent of the surface area. So, if that case is one case like a base case unit case. So, depending upon that if we compare the other geometries, for example these are hemisphere one. So, this is a hemisphere the circular base and a hemisphere on top of it. Now, this is a cylinder a cylindrical structure over here.

So, this has like a 96 percent of this quotient this has like a 98 percent of it and now this actually requires 112 percent. Pyramid actually shaped with a square base and if we divide this same cube into like a small cubes. For example, like 8 cubes over here in a cube. So, this also gives like 100 percent, the moment we again take out those cubes separately. For example, if we divide this building into like two different floors like then it increases by 33 percent it reaches to 133 percent and the exposure increases to like almost double.

In case if we are keeping these 8 smaller cubes which came from this block in a different place. So, see how the requirement of actually is just got double the requirement of the energy just got double and in this one if you create if you keep them in a linear fashion there is like 142 percent. So, there are actually you can see with this actually illustration over here, it depending upon the form, shape, size and scale of the building, the energy requirement of the building actually changes.

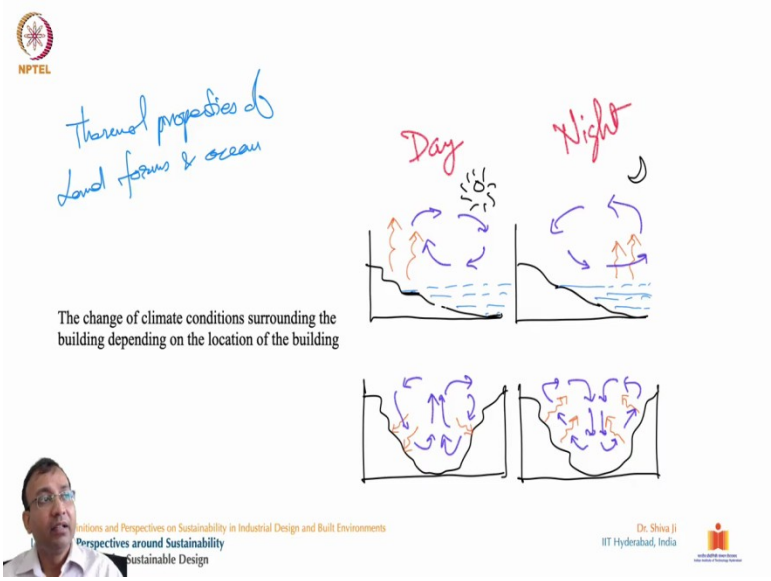
So, while designing how we should be responsible, how we should be cautious, cautious about taking the decision based on the form and shape of the building is very important because the energy consumption of the building is going to be there, for all of its life on daily basis. So, whatever like for example, the embodied energy is used in the production of anything. So, the operational energy will be very, very high.

So, the rate of consumption should be minimized from the design stage itself that is the intention over here. So, this actually slide talks about there is a direct relationship between geometrical shape and energy performance of the building. So, it becomes very critical for us as a designer and architect to take care of these things. So, different results were obtained in this illustration as you can see in the energy performance of these masses, which had the same volume but made in different forms.

So, they carry the same volume, but the surfaces actually got interesting. In some cases they decrease like in the hemisphere, if you see it decreased by 2 percent and in the cylinder also it increased by 2 percent in the hemisphere it is decreased by like a 4 percent. But rest of the other since the surface area is increasing. So, the energy consumption actually got increased tremendously. In this case actually, if you see it got increased by like a twice.

So, if there is a building block of just one bigger unit and if we bifurcate if you defragment that block into smaller box, it is going to exert a lot of like impact not of consumption of the energy is going to increase. So, that we should always like actually considered while designing our buildings. So, that is actually the intent of this lecture over here to give you the insight on this part. Let us move on to the next slide.

(Refer Slide Time: 23:34)



And so how the location of actually our site. Our building is also very important that we have to understand with the like how the Earth as a like, the soil as a material is will behaves day and night, how the water body has a bigger mass have like a biggest mass of like a water behaves in the day in the night and how the geographical like a feature such as like Eclipse and valleys they behave differently.

So, based on the actually the Sun heat they actually get heat up. So, the land actually heats up very fast the water body heats up a little slower. So, the cycle of this, if the there is a Sun in the daytime, so the temperature of the air will increase very fast, but the temperature in the water will the water will start heating, heating, heating and it will reach its pinnacle in the night time not in the day time.

And further again the cooling, when the cooling starts in the night time, the ocean the water body will start cooling down cooling down and it will cool till the daytime is there. So, there is an overlap. So, this actually this difference in the property of this heating and cooling, actually creates actually the air movement and this is one of the really important reasons why do we have winds on our planet.

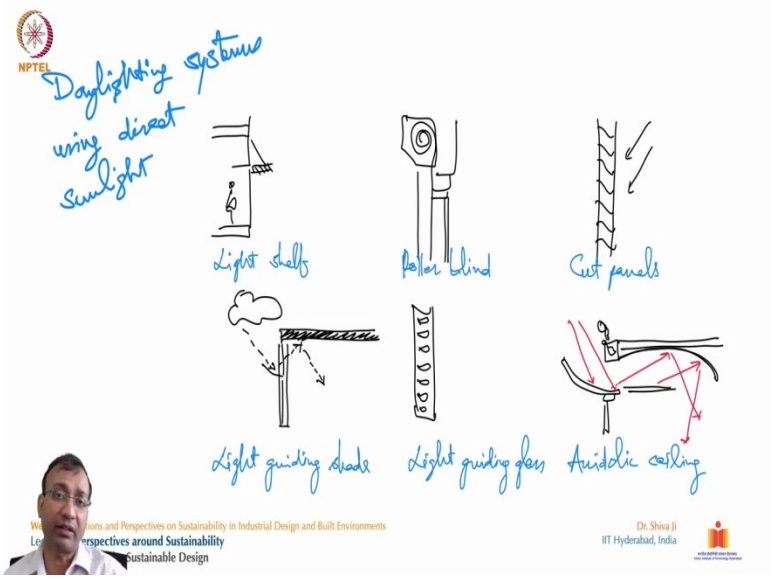
Because we have like Earth as the surface and water surface also and the differential heating in them, it creates the actually low pressure and high pressure zones and those actually are responsible for the wind movements.

So, we while designing a building, we must take care of the ventilation. So, in which direction the ventilating units such as like doors and windows and ventilation should be kept. So, for that entity, this understanding of this air moment, we must be we must have to actually take into consideration. So, if we have a house over here on this cliff. So, this is very important for us to understand why, what time of the day we want this ventilation because this actually is circle you see from here is moving like a clockwise and this one is moving like anti clockwise.

So, in the nighttime it is going to be having such, such a way in the daytime is we are going to have in such a way. So, it is different and in a valley also you see it is reversed in the daytime, the actually the hot air is the rising from here in the middle and in the nighttime, the hot air is actually is rising from along the surface of this valley. So, it is completely like opposite over here in these two scenarios and in these two scenarios over here.

So, we must have the understanding of the topography, geography and climate of any place and the orientation of the like the Sun and prevailing wind directions for actually planning on building. So, this is one of the strategies which we employ at the right at the beginning of our like our building designing at the concept stage and the design guidelines stage only. Yeah and topographical effect as I stated earlier.

(Refer Slide Time: 26:37)



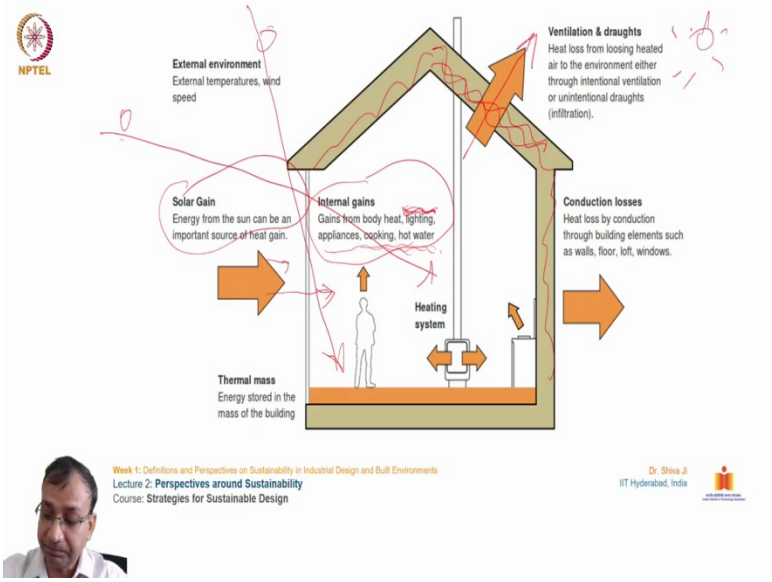
And for actually facilitating actually an efficient flow of like light heat and ventilation we have like our doors and windows. So, we have actually n number of like a solutions already existing

with us like how we can facilitate. So, based on the width and height of these louvers which are coming at the vertical line as the horizontal members the perforations and these are pergolas, we can actually control the intake of light.

So, in the summer actually Sun comes at the top and then winter it goes little lateral other downside. So, the penetration of Sun becomes like a more in the winter and it reduces in the summer. So, we can actually use this the width of this actually unit over here to control how much of like a sunlight I want inside the interior of the space.

So, this can be controlled over here and of course with the number of fence in there like a windows and if you want to carry the sunlight till inside like a interior of our, deeper inside where there is like a, the deeper spaces. So, there this kind of like any (())(27:47) ceilings can be used where we carry actually light inside where like spaces through like a highly like a reflective like using surfaces.

(Refer Slide Time: 27:57)



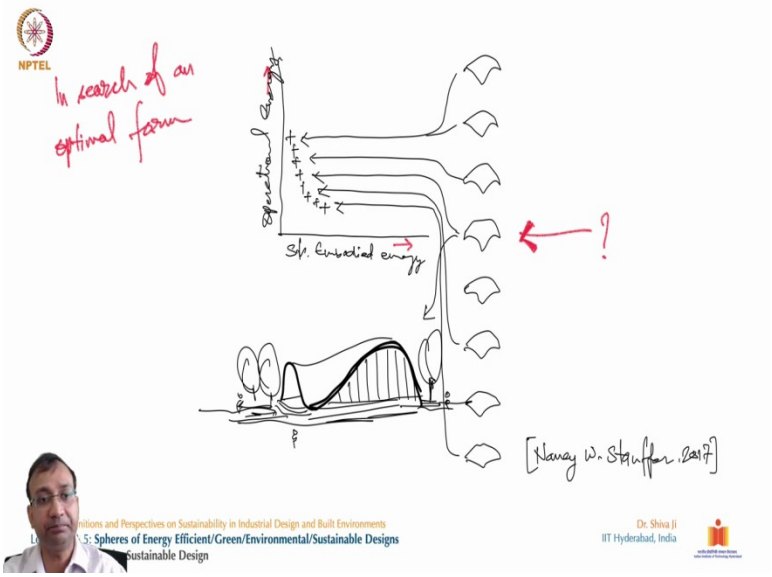
So, these are actually techniques through which we can make it like efficient use of like a lighting and heating in the buildings and here as you see, I think we have seen in the previous slide. So, how this material actually behaves, in like a certain like atmosphere, so how it reacts, how it kind of responds to the surrounding. So, if it is like a hotter outside if it is like a colder outside.

So, how this material which is like used over here, in this actually building surface depending upon the location of the Sun and this thing behaves. So, that is actually an illustration given over here. So, the ventilation and droughts can be actually you know controlled from using like a such like applicable materials and internal gains if you see over here, the gains from the body heat because humans as a we also produce like a heat inside the like a species and there is a load from like a lighting also lighting also creates some heat load.

Appliances they produce heat, cooking and other like hot water activities and other activities also like electrical activities, they actually generate. Even like our computers and TVs they also generate some amount of heat and they contribute in the overall like a heating like in a interior environment and of course obviously there is like a solar gain. So, we actually based on these calculation like how much of solar gain is going to be in like a which month.

Because, if it is like a summer then the inclination of like a Sun is like this distance and if it is winter, then that penetration of Sun is going to be a little higher. So, how we are going to control actually this thing. So, depending upon this actually we can design our like a buildings and windows and fenestration.

(Refer Slide Time: 29:47)



This is one actually example. So, this shows actually the efficiency on like a two parameters. You can see here one y and x dimensions. So, this talks about like a structural embodied energy on the x axis and on the y axis it talks about operational energy. So, like this one is taken at the

time of fabrication and manufacturing and the first one is taken at the time of during the operation stage as we have discussed.

Because, the operations period is going to be quite longer than the time of the, at time of the fabrication of it. So, both of these are like an important a huge amount of energy is invested in the time of like a fabrication, also manufacturing also and a huge amount of energy invested in the operations. So, we must have a balance of these, so these cross sections, these across points as you can see, these are the reserves actually observed from the different types of these roofing forms and you know that the geometry of this roofing.

So, there are a variety of geometric forms even to like this actually design and calculation is more and then optimized actually form is selected with this one to go ahead for the construction of it and in in the graph if you see this is here right here. So, this is kind of a, you can see an interplay of like a permutation and combination. Where we choose actually a number which actually responds to both of the aspects, because both of those aspects are very important and should be actually taken care of.

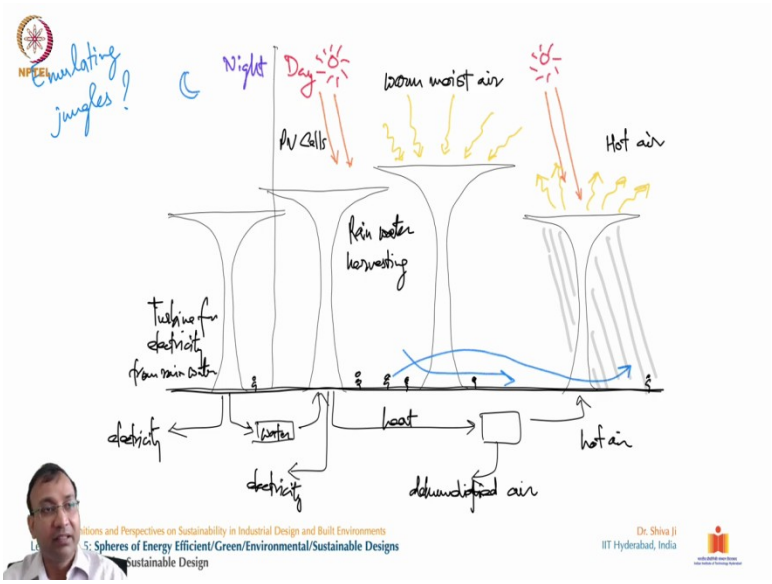
(Refer Slide Time: 31:30)

So, I would like to show like a one case example over here. So, you may be aware of actually are some of you may have been to this place also, this has become a recent actually a tourist spot in the city of Singapore. Where they have actually created an urban forest kind of actually structure.

So, this is supported by you can see some of these a tree like structures, which are like a completely manmade.

So, we will see, you can see these people walking over here on the, this like a footpath and there is like an over the air like this bridges there. So, people are actually can walk in on top of these trees in the middle of this height of these trees or the top of these like a natural trees and they are going to have actually view of this area, this has actually water bodies and fountains and several other interesting stuff in the vicinity. You can see these creative actually shaped buildings also on the left hand, right side. So, this is a place in a very posh area very bustling area of the Singapore city.

(Refer Slide Time: 32:42)



So, let us see what is the, what are the actually features and characteristics of actually this urban forest and how it behaves in a differently in the day and the night. So, if you see here, so with the Sun, it has actually photovoltaic cell actually and panels planted on top of it, they actually obviously they receive to be Sun energy and they produce actually electricity. So, with that electricity, it actually sustains its own you know electrical needs to run actually this whole unit.

So, it has actually solar thermal collectors and at the bottom in the underground level, you can see over here. So, the energy generated and collected is stored over here and then it is further distributed or maybe even supply to the grid. So, depending upon this, so they have actually all of these processes kept in the subsurface actually area and at top they have they have actually

even these are moist air actually intake this thing and with the help of these moisture in the air, they actually with the help of condensation, they collect water.

So, this water they use for, of course they collect water in the rain as well as these moist air because this is situated in our like ocean area, oceanic area. So, this is a very high like humid area, humid regions it falls in. So, there is a lot of like, water content in the air and that is how they actually harvest water from these are trapping this air, this moist air in the filters and hear in this last one, if you see this hot air is pushed back again to the atmosphere.

So, they have this surface also such, so that it reflects actually the major portion of the light which is received over here. So, there is, this reflects light and in turn it creates a shaded area on the ground, you see this here, this shaded area. So, it creates a comfortable actually shaded area on the ground, what is done by the tress also they create a shaded area on the ground. They actually receive the sunlight, they do the photosensitive activity.

So, on the same actually principle, this unit actually is undertaking several activities of the heating the water and electricity generation and gathering water droplets from the like a moist air and several activities and in turn they are creating like a sheets on the ground. And on the night side if you see on this shaded area, the turbines there are some you know small size like a turbines kept.

They also create a electricity from like a water shifting from energy generating the need for the usability in the nighttime. So, whenever there is moment of water which is collected on the top over here, they have like a of small sized actually turbines installed in the stem of this unit and that falling water actually falls on the fins of those turbines and turbines run and they actually generate energy.

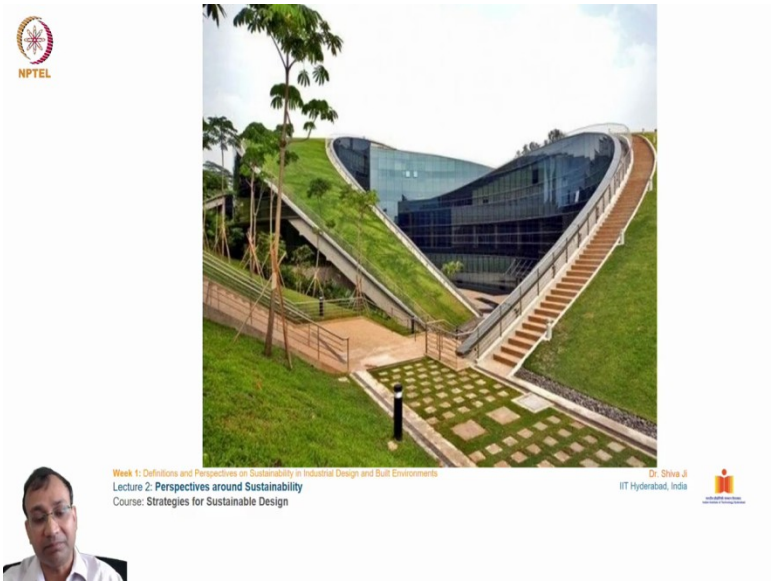
So, this actually garden this urban forest is one of the beautiful examples of like the future is going to look like in the coming times. So, in one of the next lectures, we will be discussing the future of the habitation, how the habitation is going to look like in the future. So, it is really going to be one of the amazing and interesting actually insights like how we can actually conclude how we can infer from the nature how we can take insight from the nature and emulate them in our designs.

(Refer Slide Time: 36:24)

Yeah, so you can see more closer pictures over here, these surfaces are completely adorned with the these leafy vegetation and creepers and bushes and trees and stuff. So actually, these greener bodies, they absorb heat. For example, you can go back in your home and then the next, like a daytime, you can experience, you touch a building surface in the Sun and you touch a wooden surface in the Sun, you touch a plastic surface in the Sun, you touch a metal surface in the Sun, and you touch a plant which is exposed to the Sun.

You will feel different actually, you know, the amounts of heat what they are holding. Though, they are actually receiving the same amount of like a Sun's heat and energy, but how much they are, how they are maintaining this actually balanced like a plants, how do they still keep their temperature, their surface temperatures low is really an amazing fact as compared to that if we see our buildings, they actually get heat up very fast and if you touch a building surface in the Sun, well, you cannot hold it for a long time. Because it is so hot enough.

(Refer Slide Time: 37:37)



Yeah, and there are several other examples from across the world in terms of like a design and efforts being made by designers and architects and engineers from across the world to minimize that actually surface heat, they are using the same natural materials to minimize that the surface heat. So, of course, if this building was using like a conventional like roofing, like for example, like tiles and concrete or brick or anything. It was definitely going to be much hotter than what it has now.

It has like a grass cover, it has like a Earth material, the soil kept on top of it and there is a grass actually growing on top of it. So obviously, it is going to be cooler. So, how it is going to help in the energy saving like exercises, it is going to exert very little actually heat load on the building surface, the building volume inside the actually that building and in turn, that will save a lot of energy.

(Refer Slide Time: 38:34)

Yeah, so if we now relate these efforts with the, your UN SDGs point, which we discussed earlier. So, which are those is the UN SDGs point which are relevant for, the efficient building design for like energy efficiency for their like a sustainability, for their being environment friendly and all that. So, these many like we have these sets of SDGs you can see on this slide over here, they are directly related with the building design.

Sustainable building design, which actually takes care of like a certain (())(39:06) these many like of UNSDGs directly. So, the first one is the number three, which talks about good health and well being. So, obviously buildings are the actually manmade objects in which we spend most of our lives. Whether it is like a, it is our home or our office or our like a factory or maybe a cinema hall or recreational place or maybe railway stations, all of these actually things are buildings.

So, we spent a sizable number of our like a, like hours per day inside the buildings. So, feeling like a good and feeling comforted inside these buildings becomes very important. The next one affordable and clean energy as we spoken of saving energy through these buildings is very important, decent work and economic growth, because these buildings are the actual drivers of economy growth. Because, in them actually we conduct our like enterprising activities and we produce actually (())(40:04).

The ninth one industry and innovation and infrastructure, this is also directly related with the building activities, sustainable cities and communities. So, obviously, a group of like the, such structures and buildings, they form a community that form actually a social life. For example, a set of apartments, they actually constitute a society and those number of like a n number of like society, they form actually, maybe of our sector of the city and then there are n number of like sector sectors, collectively they form into a city.

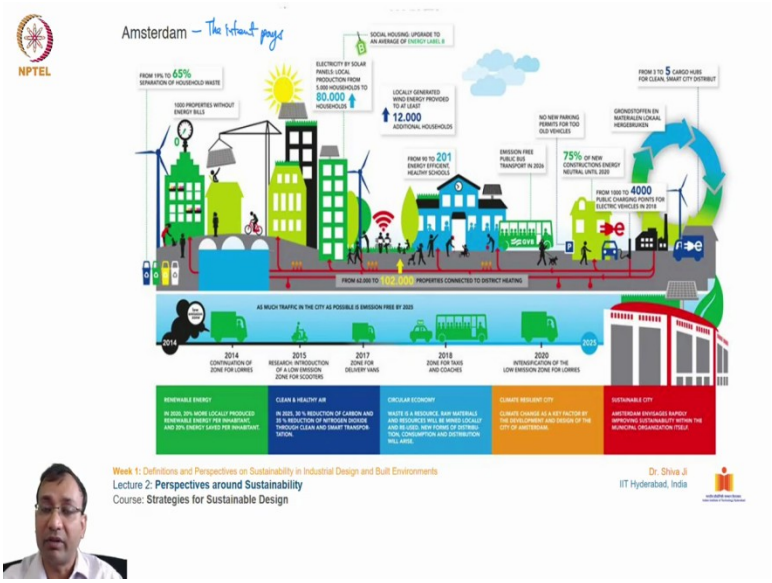
So, buildings are the actually unit of that bigger block, but we call this as a city and the next one response consumption and production of course, buildings consume a lot of energy and material and resources. So, we must minimize them and climate action. So, of course, the buildings are like as we discussed earlier, they are the kind of like organisms, which consume energy which exert activity based they live actually, they die one day.

So, they actually contribute a lot to the environment. So, how this climate action can be controlled. So, this is they are actually directly related to there also and life on the land, of course, most of our buildings are on the land. So, they actually impair they actually create a lot of impact on the land itself and obviously, this can be achieved only with a good cooperation and all.

Because even for, for designing and for construction of a building, n number of like experts and people are involved, we need a financer we need a like a manager, we need an architect, we need a contractor, we need a lot of like a manpower to construct that building, we need a lot of engineers to monitor and design that building for their structure and several other like building services.

A lot of like an n number of people and of course, we need the users who are going to live in there. Of course, we need the people who will be maintaining them. Of course, we need people who will be going to dispose them off when the building actually comes to the end of its lifecycle. So, all of these actually efforts and of course we need those people who will be supplying services to that city. For example, like energy, water, sanitation services and all. So, obviously collective actually, effort is going to help in any activist scenario.

(Refer Slide Time: 42:14)



So, well I do not talk much about this slide, but I will give you a hint I am talking about the city of like Amsterdam over here. Like how Amsterdam has come up to in a leading position for the other cities and other countries of the world to like, you know, emulate is like a really like a praiseworthy.

As we discussed earlier, they actually gave a lot of emphasis on the pedestrian movement, cycling and clean energy resources, the recycling of the waste, they do not try to produce even a single household actually they tried minimizing there waste generation on a daily basis and all that.

So, there is a lot of consistent and persistent effort in terms of all of these aspects and that is how you actually as Amsterdam has come with level of after like a so many years and it is worth actually praising. So, as a like a homework or an assignment just like an assignment to you maybe you can go back and search more for like Amsterdam and what are the latest sustainable activities they have promoted over the time?

(Refer Slide Time: 43:18)

And for like any green office these are the UNSDGs who are directly environment involved good health and well being and clean energy, infrastructure and this we have discussed in the previous one. But this is specific to the office constructions.

(Refer Slide Time: 43:35)

Well, there are some interesting insights from an examples and case studies from across the world. Well of course, you may be aware of GRIHA and LEED and there are (())(43:46), BREEAM, there are many more actually sustainability assessment rating tools from across the

world. Which actually try to assess buildings or evaluate buildings or rate them on like a systematic parameters.

So there are several actually, efforts being made from all different agencies to design their buildings, in correspond to the, these guidelines. So, there actually work starts right from the conception and the idea generation and the design development of the building itself. As you can see over here in this building, you can see these wooden planks they are arranged in such an interesting fashion, so of course, it has become a piece of like an aesthetical value.

But at the same time, it is serving some other functional purposes also, first of all, it is creating an air buffer I am sure you can understand that. So, by this crisscrossing actually does the puzzle kind of like a structure it is trapping air into it and it is kind of restricting the air movement on the surface of this building and you know air is an insulator material. So, in turn, this is going to restrict the direct falling of the Sun on the surface of the building on the interior of the building on the glass surfaces.

At the same time, it is going to create at least a buffer or air temperature buffer between the outside and the inside. So, see like how like a smart it is to use such a like a piece of like a work to have some multipurpose functions. So, apart from being just an aesthetic it has some functional value also and as the lead rating suggests for like this particular pose it, this is like a Japan house building from like Sao Paulo.

So, this has actually received lead Platinum rating in this latest year of like 2020. So, this is really one of the very good examples, maybe you can go back and search for more details, more such examples from across the world.

(Refer Slide Time: 45:43)

So, how these buildings can be actually made a made into a green buildings. So, there are several efforts several lecture on the corrective measures which can be taken in the different components different parts of the building. So, you can see in this slide over here, starting from the top, it has like a windmills it has like a solar panel, it has like a green terrace garden on top of it, well terraced garden is an activity is a strategy which reduces the overall the heat component of the because all of these building surfaces in the concrete and brick and other materials, they trap they generate heat.

They trap heat, they trap heat and they actually radiate heat in the night time. So, overall all in the n number of buildings situated in any given like a city overall they create like a phenomena of like a UHIE, Urban Heat Island Effect. So, collectively, they radiate heat in the other times of the day also and they become kind of the, the whole city becomes like a very, the heat trapping actually entity.

So, compared to the temperature prevailing temperature in the countryside, the temperature inside the cities will always be higher, because of this phenomena and this actually feature of like creating the terrace gardens on the top of the buildings is certainly going to have the impact on the minimizing actually that heat in actually overall heat in a city. So, that is one of the strategies which we should apply in our designs to minimize the heat energy requirements of the building as well as reducing the UHIE contribution to the whole city.

And there are several other like efforts which we can actually make you can like a rainwater like a collection, you need rainwater harvesting. Because the rainwater is one of the biggest actually sources of like you know fresh water potable water. So, how well we can transfer it back in the ground. For all the like groundwater recharge or maybe you can utilize for like a other sources, in some places like in the northeast, like I have lived in, like different parts of the Northeast.

So, there I have seen like some examples, I myself have survived on for like a few years on the like rain harvested like a water, even for drinking even for kitchen, even for like all of other activities, because there is no ground water, because it, the whole place is situated on such a hilly terrain where it is very difficult to make a bore and take the underground water. So, rainwater is supply is the only supply which is easily available on free of cost.

So, you have you are setting the design for the roof rainwater collection and you have your unit to store that water and filter it and utilize it. So, those actually techniques can be installed in all of other building obviously Government of India has introduced and made it mandatory to have all government buildings and institutions and campuses to have rainwater harvesting system and yeah, and of course thermal , allowing plentiful natural light inside the actually, using actually energy efficient luminous and other electrical appliances.

So, you can see there are efforts being made in naming and interiors, even in the energy consumption part and even living or non toxic lead materials and substances, so that there should not be any VOC, Volatile Organic Compounds, emissions of the gas and such fumes inside the interiors which may hamper with the overall, the human comfort and well being. So, these many firsts, there are several more you can explore more. We will be talking more of these in the coming slides.

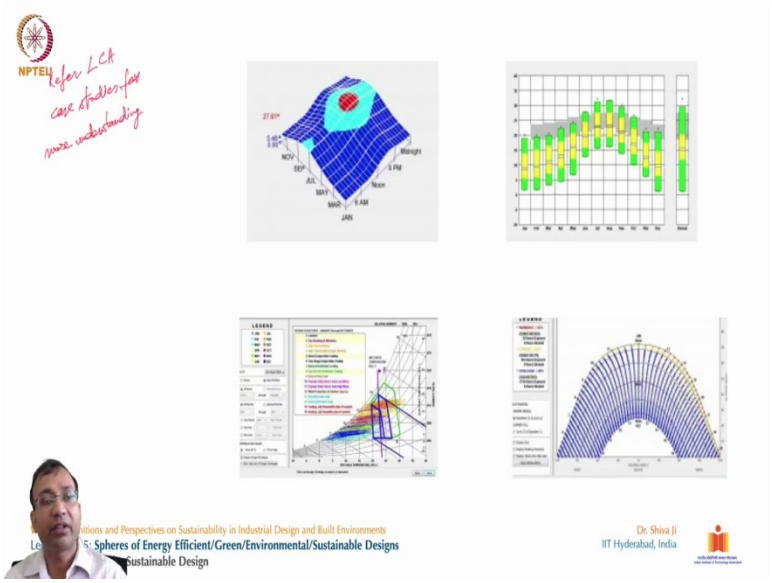
(Refer Slide Time: 49: 25)

So, here if you see you know, there is an interesting relationship of a building with the society and the surrounding like how a building is related with the like it's surrounding. So, for example, like we get the supplies and resources from the like a trees and other like natural entities, these bushes and plants they actually help in creating a living, habitable living environment.

There is again a factor of like a social justice also like how our society, how the people are empowered? How we are sourcing local and healthy food? How we can reduce the, the indirect emission by not using so much of like the resources which are sourced from like a faraway places or different other countries?

Lifecycle assessment of the different like objects and using like a local transportation and again and the energies plus atmosphere relationship. So, any building is related with, of course, next to it, the next infrastructure and that infrastructure is directly related with the ecology of that place.

(Refer Slide Time: 50:35)

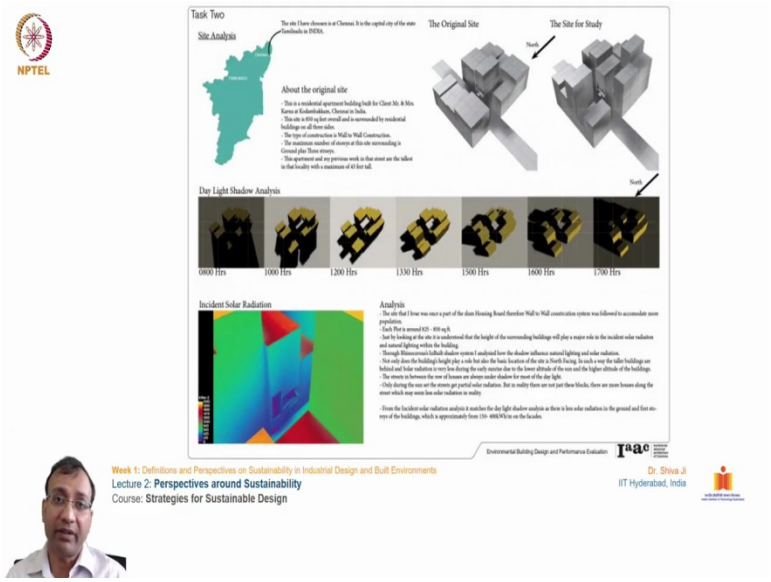


So, there are some actually exercises which are done for calculating like a lifecycle analysis of like products and buildings. So, how much of energy they actually consume, while they were like a constructed while they were like a used and while the when they were actually discarded and disposed. So, this analysis we will do more in detail in the coming lectures, but you can look for it into more details like the how these kind of efforts are being utilized the from the design itself. So, some actually this is actually climate analysis map of Chennai, the city of Chennai in Tamil Nadu.

(Refer Slide Time: 51:17)

So, here they have actually given this wind wheel analysis. This windrose diagram and there is a temperature actually map for the entire year. So, how much it ranges and what is the actually range and what is the prevailing wind direction. So, based on this actually these are the guidelines which we follow for designing our buildings.

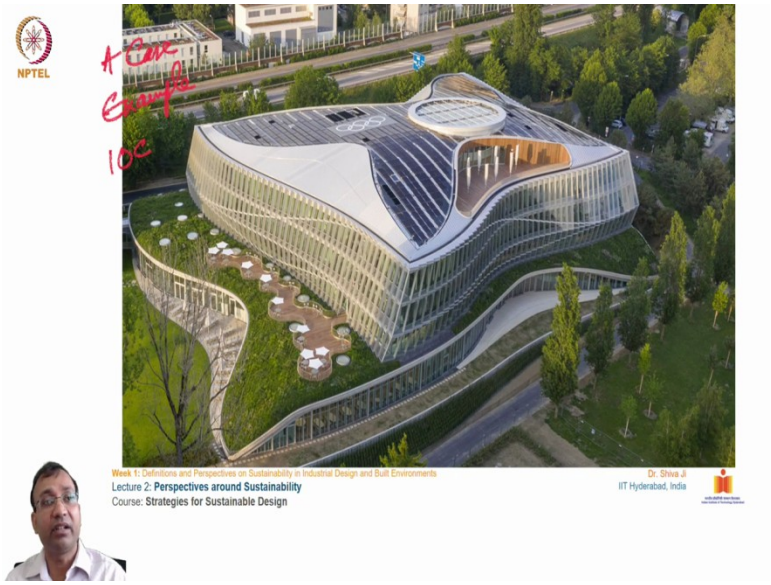
(Refer Slide Time: 51:33)



And of course, with the help of like recent technological advancements of the softwares and tools, we can have some simulation basic results also how our designs are going to be have in

certain circumstances, in certain climates at what time of the day? etc, how much of your light intake heat intake and what supplies? And accordingly we can modify our designs, we can improve our designs.

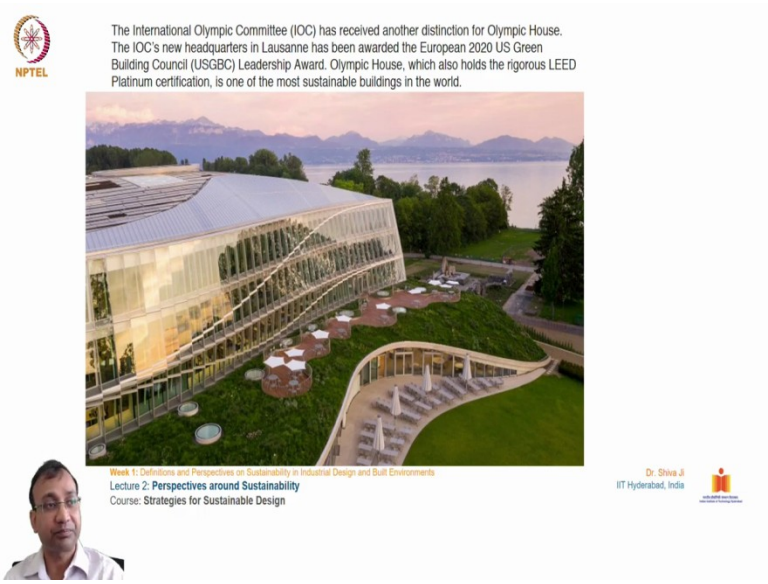
(Refer Slide Time: 51:58)



So, I will show some actually case studies some very good examples, which are actually commendable for their effort from like different places. So, this is a building of like IOC, International Olympics like this thing and so you see this as a very strange kind of design, but this is strangeness design is devised from the rain or like a simulation because the at what time of the year?

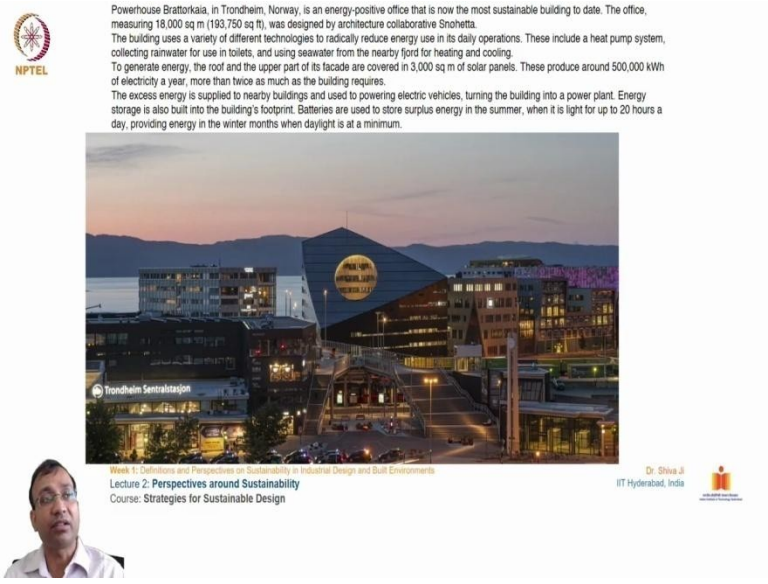
At what time of the day? How much of Sun intake? How much of lighting intake is needed? In which portion of the building? And now accordingly the surface of the building the surface, which you are seeing is tapering and waving off like that. Is actually designed a with that actually calculation in mind and this is one of the most efficient actually designs in the recent times.

(Refer Slide Time: 52:49)



You can see actually the picture from other angles. So, on the ground floor, if you see, there is a continuity of this grass surface from the ground floor of this building. So, you see these windows and doors are lined up on the side of it on top of that there is a grass and actually soil and some seating arrangement are there. So, in order to minimize actually that heat gain on the paved hardcore actually paved surfaces and tiles, this was actually, this arrangement was made.

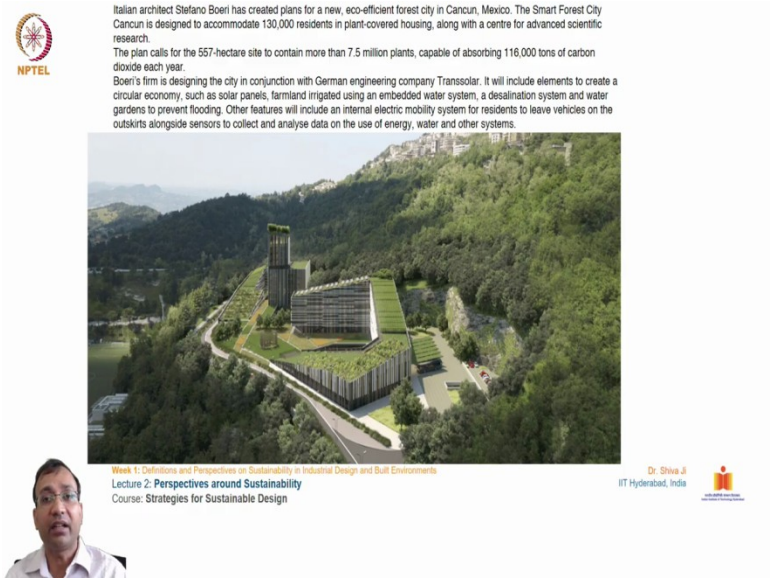
(Refer Slide Time: 53:21)



So, maybe you can look for more details more such examples from across the world. Like this is an example from like a Norway. So, this is the energy positive office. So, like this is the most sustainable actually such a kind of a building which was the designed in the recent times and well the statistics you can read over here.

But it actually employs like a photovoltaic cells and it generates its own like a of course 100 percent of power rather it supplies to the grid also and they store energy this electricity power for the using in the other time of the year and the month when there is a little water, a little actually Sun. So, this is an amazing actually extremely strategy, where we can store energy to use into some other months also. Not just in the other time of the day, but in the other month also. This is a one of the very praiseworthy interior design in the recent times.

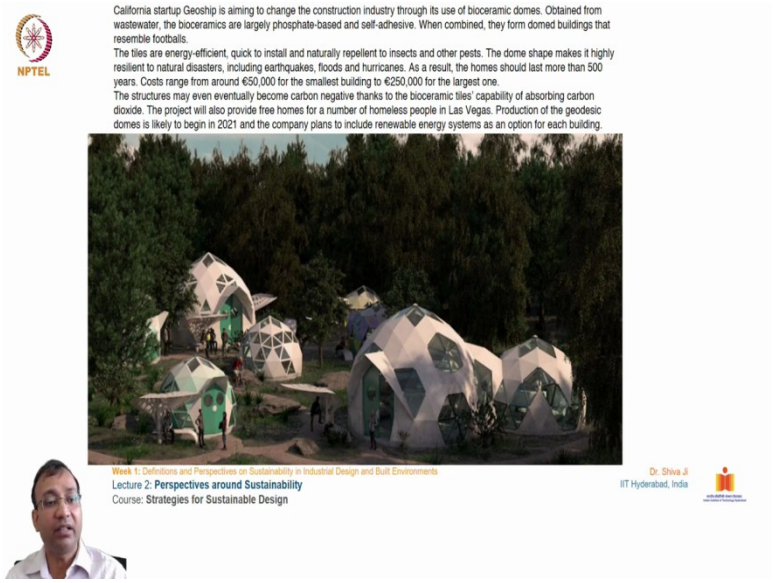
(Refer Slide Time: 54:20)



So, this is from this design is from Mexico. So, this is a next to situated next to a forest. So, they have actually designed this Smart Forest City. So, this actually accommodates around 130000 residents in plant covered housing. So, this is a, this portion actually is a part of this whole actually scheme.

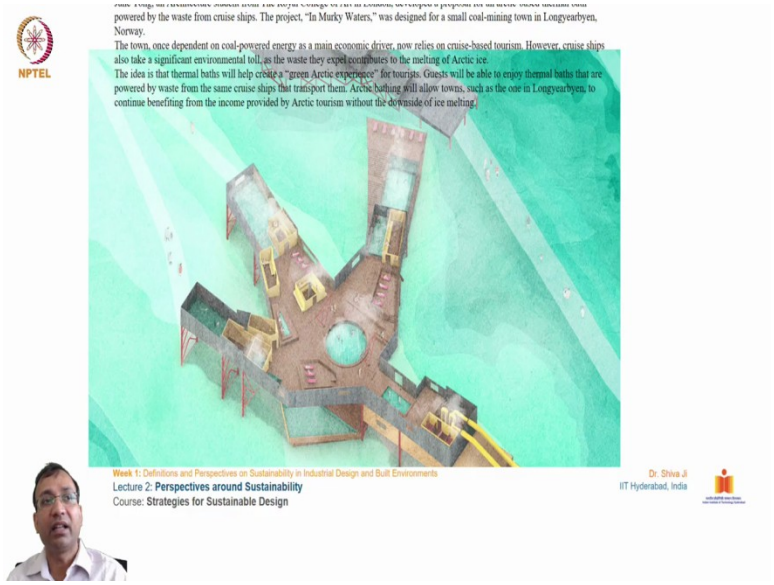
So, this is, with scheme actually they have tried to go as close to the nature as possible. So, you can see these terrace gardening and fins on the surface of the building and strategic actually the orientation and form of the building is such that so that it allows actually the light heat and visibility outside.

(Refer Slide Time: 55:08)



This is one actually example in a very unusual form. So, it allows actually heat even from the roof as you can see, so that in order to minimize the dependence on, the electrical lighting as much as possible and you can see the costing and all other details are given over here like how much it has saved on the regular construction. Like materials and energy consumption.

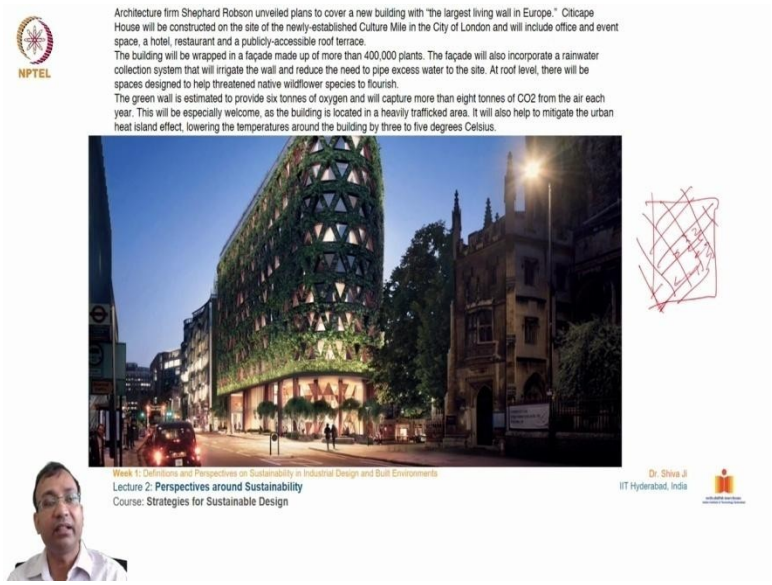
(Refer Slide Time: 55:35)



This is one is actually the concept actually design. So, this utilizes the tidal waves to generate energy. So, I suppose this is still at the conceptual stage, but it has been won an award, a prestigious award and for it is like how to utilize like the existing actually the natural energy

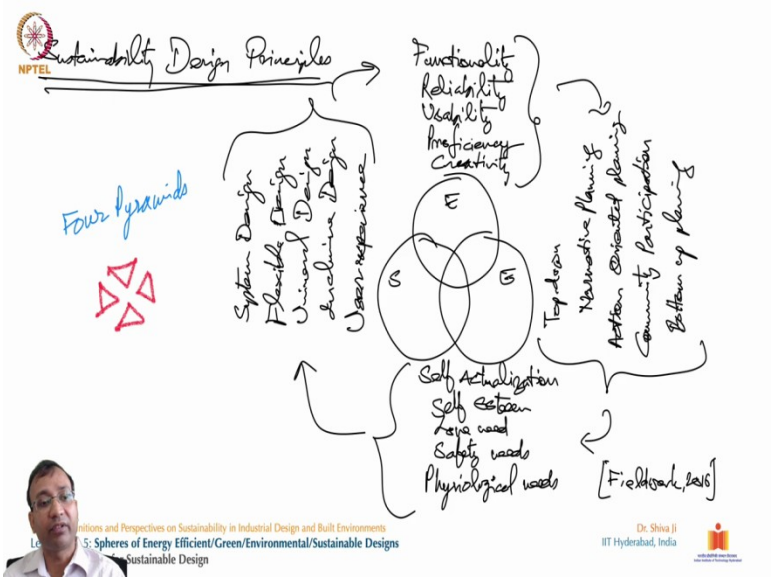
sources which are present on the site. So, this was actually created next to an oil rig and there was a lot of like, ocean waves surfing from the bottom of this actually structure. So, accordingly actually they have utilized to you know to trap a lot of you know tidal wave energy and turning into the electrical energy.

(Refer Slide Time: 56:18)



And here in this one, you can see the grass surfaces and vegetation is wrapping around the building. Obviously, in overall sense actually minimizing the heat load on the top of the, on the surface of this building by being a present everywhere, so this is creating a kind of a you know, the comfortable like ear chambers on the surface of the building. The overall heat actually load on this building reduce significantly.

(Refer Slide Time: 56:50)



So, as we have seen in the previous slides, so there is always a kind of an effort on like a certain base. So, there are if you see integrated urban planning, design and sustainable design principle. So, there are four pyramids, which are coming to form a bigger structure. So, you can see these four pyramids over here separately. So, the first when we talk about the basics, so the function of the building, function of the design must always be taken care of, because that building or that design is not actually going to succeed if it is not following its function.

So, the function liability usability proficiency and creativity comes the last at the pinnacle, but it contributes also the most. In the system design principle on the left hand you see it starts from there, flexible design principle, universal design principal, inclusive design principle, user experience.

So, these are all should be part of the overall like a design effort and in the bottom when you see it starts from the like a Maslow's principle you may be all aware of how it corresponds to this Maslow's principle, Maslow's pyramid also like physiological needs safety needs, love needs, a self-esteem and self-actualization, when we take on reflecting on our life and the overall life and productivity.

On the right hand side, it starts from the bottom of planning approach, then it goes to community participation, because no design can succeed without the participation of its people. The next one

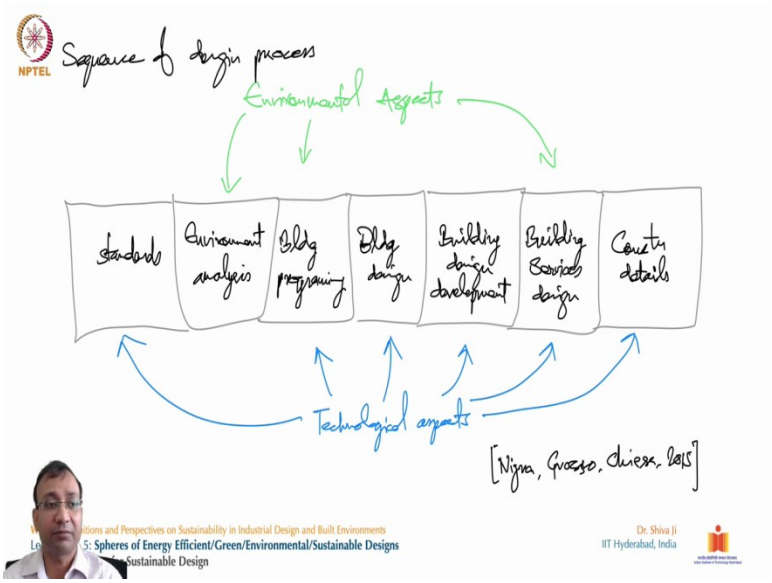
action oriented planning. Normative planning and then advocacy and top down planning. So, they are like are interrelated. So, these actually four pyramids are coming into the common confluence of the three aspects of sustainability. So, these three colored circles you see on the on the top of these four pyramids.

So, these four actually parameters are conferencing into the sustainability. So, this is the approach actually given by this fieldwork in 2016. So, this is one of the actually insights which I thought of like a sharing with you how the design can be part of the bigger the perspective from the light life.

(Refer Slide Time: 59:03)

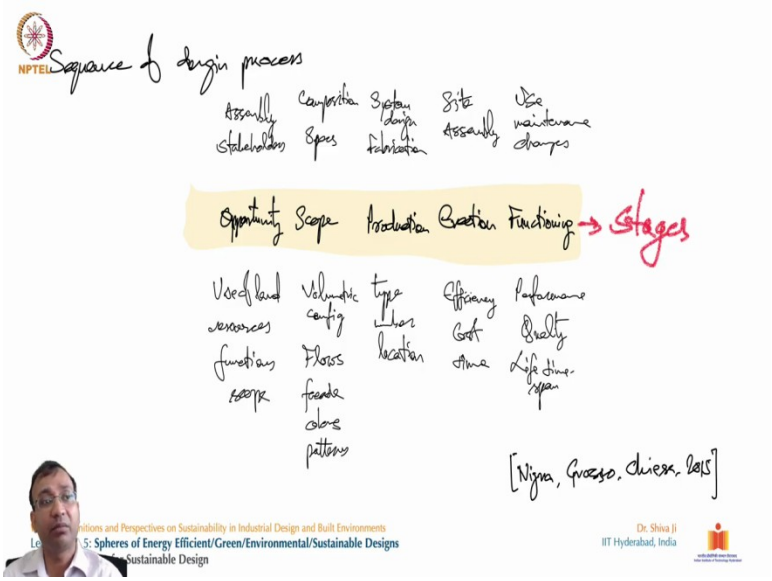
And there are various domains inside these ESE aspects, we will discuss about these in the coming lectures.

(Refer Slide Time: 59:13)



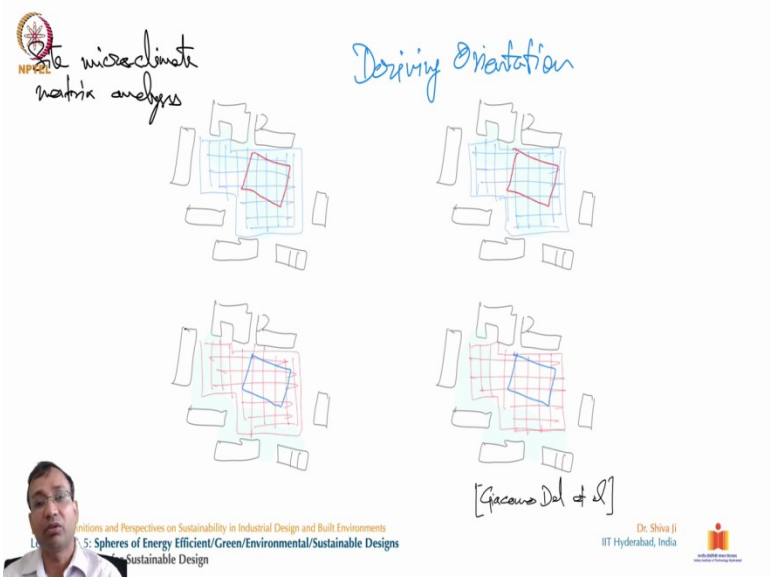
And how like environmental aspects are integrated, how in that technological aspects are interrelated and as you can see over here and in a kind of an integrative like a ways, this is all connected with each other and this is how actually the life of a building or the whole design process actually evolves. So, from the beginning you will see the client briefing, standard, analysis and programming then the design part and the development part and services part, construction part and then comes the other like end of the life stages part and all.

(Refer Slide Time: 59:50)



Yeah, so, there are different actually stages, the sequence is given over here of the design process of the sustainability and how it evolves.

(Refer Slide Time: 59:59)



And some examples like as we discussed in the previously like a how the orientation of the building blocks should be kept and how the simulation and analysis tools are helping these days. So, this is the one actually here researcher has given this actually figure which talks about like, how about the like a winter valuation or how about the summer valuation and what are the values and the different actually, places of the site, so they have actually created a grid and based on that grid actually, they concluding then this should be the best location for the of building form.

(Refer Slide Time: 60:37)

And in 3D if you see like a how the building form can be, further bifurcated and defragmented, like a smaller forms. To facilitate of course, the functionality as we saw in those pyramids and of course, the technicality part of it energy saving part of it and satisfying actually all of those parameters, which are sustainable building actually searched. So, with this, we have come to the end of today's lecture. Thank you very much!