Strategies for Sustainable Design
Professor Dr. Shiva Ji
Department of Mathematics
Indian Institute of Technology, Hyderabad
Lecture - 13
Reliance and Dependence of Building Design on Energy

Hello everyone, we will discuss about reliance and dependence of building design on energy, how energy is in our buildings and how much saving can be done and how much is consumed by which area, which particular component of the building. So, we will see one by one.

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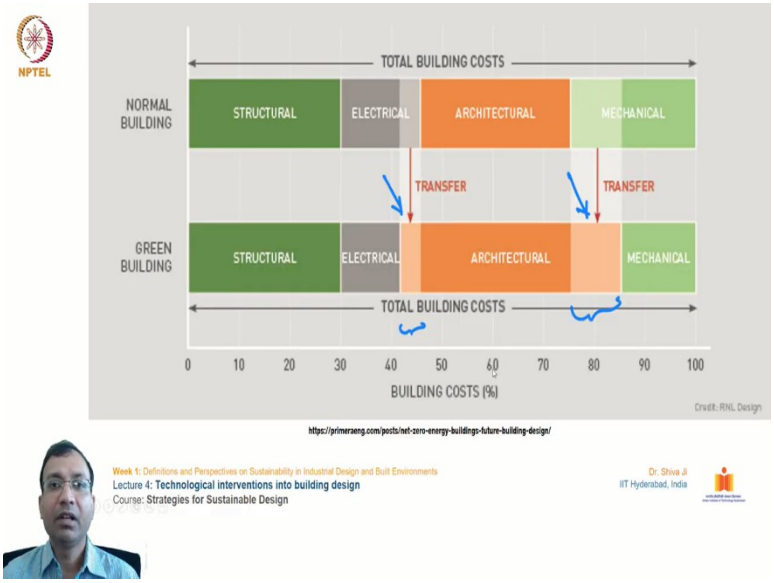

So, if you see this particular table over here. So, this talks about the total cost invested in any given building. In normal condition and what happens in the green building condition on the lower colour, band you can see. So, the top one it talks about the total building cost is divided into 100 percent. So, almost 30 percent is taking by the structural systems.

Almost 15 percent is taken by the electrical systems. Almost 30 percent is again taken by the architectural systems and rest of the 25 percent is taken by almost all mechanical systems. So, in that if we go for any such a measures of this, green building, efficient measures. So, the percentage what we see saved from electricity and in the mechanical consumption is significant.

So, as we can see, the transfer, which happens from electrical to the architectural aspects. So, the cost gets reduced by 5 percent, almost 5 percent over here. And in the mechanical portion it gets a reduction of approx 10 percent. So, overall what we can see in the savings over here is up to 15 percent. So, 15 percent I think is not a small volume.

And if we consider to same thing for almost every building, if we turn out regular buildings, our normal buildings into green buildings. So, at least 15 percent of efficiency, 15 percent of improvement can be made on the costing. So, for any investor, for the any financier who is putting in his wealth for the construction of normal building, from normal to a green building, then he is observing he or she is observing 15 percent benefit.

So, that benefit on the monitory terms is huge, 15 percent is a very good cut. So, how the building costs can be reduced through going for green design principle? So this is given from this table over here.

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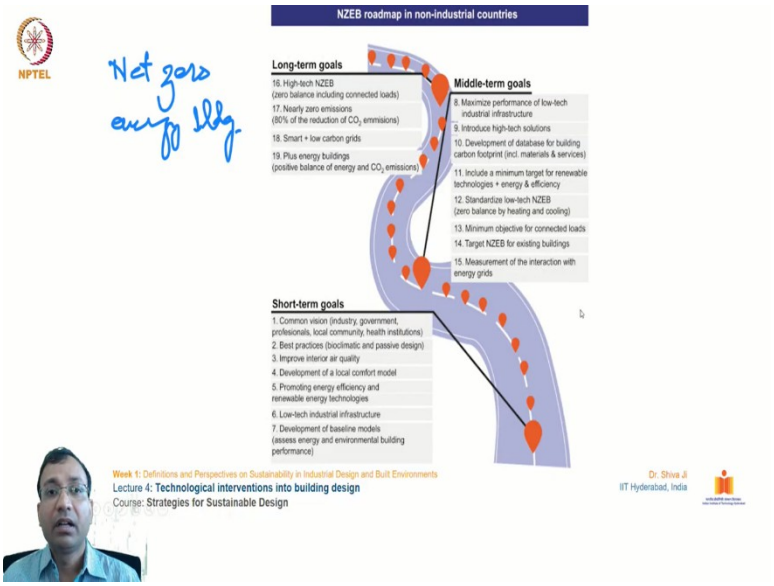

So, how these green things can be achieved, so we have discussed earlier net zero energy buildings are the one concepts, where a building can go independent of the normal national grid or state grid and generate its own power for meeting its own demands. So if we see non-industrialized, non-industrial countries like ours, which are still not in the league of the advanced countries. So, how these efforts can result in to some advantages.

So, let us see if there are long term goals, if there are middle term goals and if there are short term goals. So, how this whole phenomena will unravel, that we will see over here, so let us start with the bottom one, short term goals. So, with the common vision of the industry, government professionals, local community, you know, the other institutions. So, this can be said the best practices, such as bio, climatic and passive designs.

Those strategies can be involved in the building designed to reduce the, first of all, the consumption of the electricity in any given building, so that the overall requirement of the power

remains under a check. The third one: Improving interior air quality so the efficiency, first of all, of the occupants or the inhabitants of that building will improve and the overall load on air conditioning or improving the air quality will also get minimized. The fourth one: Development of a local comfort model. So, generally we follow a tools and graphs and the given standards which run at the national level.

But this is needed some intervention to generate and to create such parameters at the local level so that we have the model of the local comfort level, how much of the region is needed, how much of the region is going to be there in the temperature in the thermal rain, how much in the humidity, how much in the precipitation, how much in the wind speed, wind velocity?

So, accordingly we can take care of. So it is making our buildings suitable and relevant in any given local condition. The microclimate, what we call as. So, a particular state in India generally has one or two types of climates. So, in that climate also there are smaller areas, which follows certain kind of microclimates.

So, we should have templates, we should have standards, we should have the data to meet such microclimate conditions so that the buildings can also be designed accordingly to maximize the local conditions of the climate. The next one, promotion promoting energy efficiency and renewable energy technologies will evolve, of course, it is a proven fact these days if we promoted non-renewable energy and if you if we promote renewable energy sources.

So, of course, the renewable energy sources are infinite. They can be harvested as long as we want okay, they are not going to last plus. They do not have the bad kind of after effects and side effects. They do not have much impression of the pollution or the CO2 emissions or any sorts of emission. So, of course they are cleaner than the conventional non-renewable energy sources.

So, these techniques, these technologies can be employed in our buildings. The next one talks about the low tech industrial infrastructure, so very high technology, industrial infrastructure takes a lot of investment, lot of cost. It needs to maybe import several technology, several equipment and tools from faraway places.

So, why not to go ahead with the low tech technology, which is local, which is reasonable in nature, and utilize that itself on the site. The seventh one talks about development of baseline models, so assess energy and environmental building performance. So, if we create one based model or a based case for one building, which gives us an optimal performance on energy harvesting and energy utilization, so that model can be emulated in that micro climatic region.

So, that we become as a role model, that we give a lot of data in terms of how to go about how to detailer these buildings. What are the materials to be used, what are the forms to be forward, how to handle with the orientation, how to handle the sizing and scale of the building. So, all of these strategies will become handily available for the local architects and designers and engineers to implement in their projects.

Let us see, what are the mid-term goals for achieving such efficiency? So, this one talks about maximizing performance of low tech industrial infrastructure. So, the low tech infrastructure, what we spoke on the previous one. It talks about maximizing the performance so that we can make maximum use of such a facility, which is readily available in the nearby region in that particular given region.

The next one talks about introduce high tech solutions. So, even if we are falling low tech industry, infrastructure, but we can go for high tech solution, the high technological solution, because importing the technology from elsewhere is not going to cost us in terms of resource consumption so we can utilize the resources from the local doc.

Still, we can import that the high end technology from elsewhere. So, the technology itself can be imported from elsewhere. And by using the local means and in the materials and resources available, we can maximize benefit. So, that is the purpose over here. The tenth one talks about development of database for building carbon footprints such as materials and services.

So, how much carbon footprint these individual components are exerting. For example, the construction materials such as bricks you know steel, glass, you know the tiles, several other paints you know other partition materials or the fibers, the boards, et cetrea. There are several types of binder's you know other components.

So, all of these put together as well as the materials which are utilized for building services such as leads fire, you know water supply, sanitation, you know plumbing. So, all of these materials can be divided into their unique components and can be assessed for creating database of building carbon footprint. So, how much carbon is being emitted from one unit is building. So, that can be developed as a standard case model.

How much carbon is being emitted from one unit is building. So, that can be developed as a standard case model. The next talks about include a minimum target for renewable technologies, plus energy and efficiency. So, at least every project should set a target of utilizing renewable technology, renewable energy, because only with the help of that target.

The team can strive for achieving the target and we can achieve some success in that. The next one talks about standardized low tech net zero energy building. So, zero balance by heating and cooling. So, how we can minimize the differences, so how we can maximize the uses of and the temperatures or the, you know, the resources available right outside the building.

So, the overall balance remains as close to zero as possible. So, that is the purpose. So, how these, the natural phenomena can be employed in the design of the building, the 13th one talks about minimum objective for connected loads. So, the connected loads should be kept at minimum. So, the design load, if it is lower, so the overall planning for the energy consumption will always be always lower.

So, we should work out the entities and the artefacts and the articles which consume lesser energy. The 14th one talks about a target net zero energy building for existing buildings. So, even we can employ this energy to energy building concept even then existing buildings. So, why not to go and redesign the power infrastructure, the power requirement of these buildings and arrange for energy generation on site itself?

So, that could be a mid-term feasible plan where this can be implemented in a shorter span of few years okay and the building can be taken over from the main grid to the local this micro grid or the on site itself. And 15th one talks about measurement of the interaction with the energy grids.

So, the connection from the main grid also should be there in case buildings falls short of the power requirement, or if you generate a surplus, energy that can be given back to the regional or national grid. Let us move to the long term goal how these goals may help us achieve the target of energy building adoption in Indian context.

So, this one talks about high tech net zero energy buildings so the again at going for the long term investment. If you are talking about then the high tech high tech, high level technology adoption will be more fruitful in the longer terms because that will be more effective, more optimized , solutions can be achieved through this. So, the next one talks about nearly zero emissions, so the 80 percent of the reduction of CO2 emissions.

So, while going to net zero energy building we can minimize on operational cost and operational CO2 emissions, which happen out of coal based power plants, the hydrocarbon based power plant, gas based power plants. So, at least we can register huge percentage of saving in terms of emission. So, that should be target for long term plan for net zero energy buildings.

The 18th one talks about smart plus low carbon grids. So, we should go for smart, what are the smart grids? You can maybe Google separately and understand, but these are the power arrangements where we work in tandem with the other regional grids also. And wherever there is a surplus or deficiency of power supply, the other neighbouring grids comes to the rescue and supplies and maintains the overall balance at the national level.

So we can device integrating with the smart grid to maximize the efficiency. The last one talks about plus energy buildings. So, positive, balance of energy and CO2 emissions. So, there should be a balance plan in the overall energy consumptions, overall emissions from that building. So, this is long term planning can help establish this relationships. So, the overall impact of the building can be minimized.

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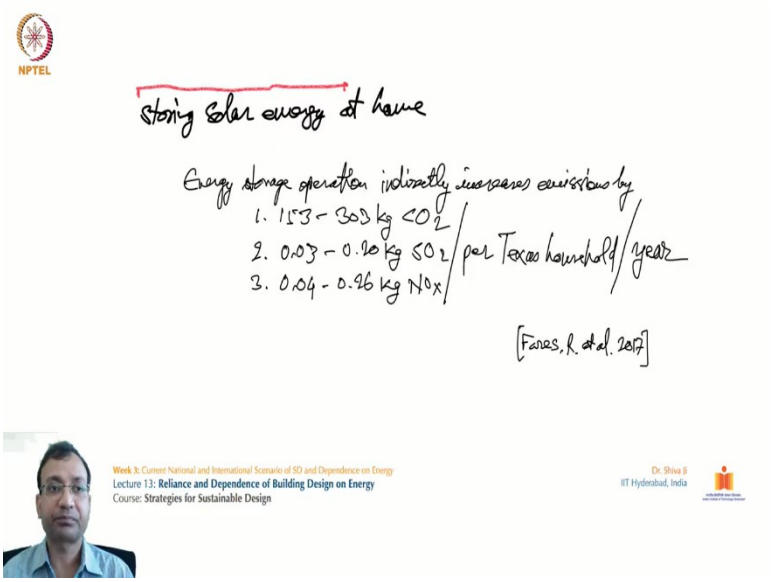

So, how this can be done, like storing solar energy in the home? So, there is one paper which talks about such stuff. I would to bring you to your kind knowledge right over here. There has been a growing interest in using energy storage to capture solar energy for later use in the homes, to reduce reliance on the traditional utility because solar energy is available in the daytime only.

So, how can we make use of it in the night times and the other times of the day when the sun goes down and sun, the availability of the sun becomes lesser? So, however few studies have critically assessed the trade-off associated with storing solar energy rather than sending it to the utility grid, as is typically in order today.

Here we show that typical battery system could reduce peak power demand by 8 to 32 percent and reduce peak power injections by 5 to 42 percent, depending upon how it operates. However,

storage inefficiencies increase in annual energy consumption by 324 to 521 kilowatt hours per household on average. For a little more storage Operation indirectly increases emission by 153 to 303kg CO2.

So as we can see the CO2 you know S02 and other nitrous oxide per Texas household annually. So, this study was conducted in the state of Texas, in the U.S.A. So, how this can be done? So advising this storage facility at the household level itself so that the dependence and then sending the power back to the national grid okay can be also reduced.

So, the power of storage can take place at the unit level of the unit house level only so that it can be used even at the later tanks. Thus the home energy storage would not automatically reduce emissions or energy consumption unless it directly enables renewable energy. So, this is the kind of a provision being advised here by the researcher.

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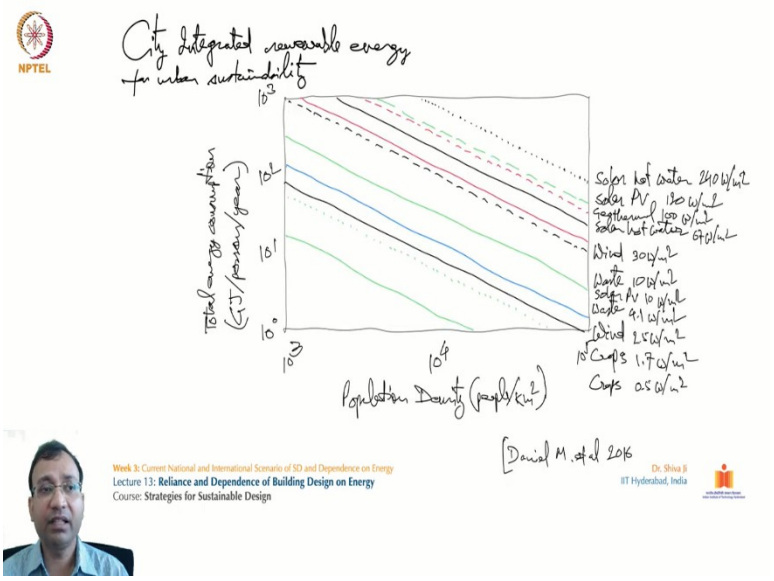

Let us see how this happens at the city integrated renewable energy for urban system. So, here we can see the different components of a building which consume how much of power in the different times of the year. So, there are ly two charts given over here the total final energy consumption. And the total transport energy per capita. So, that the lower end talks about the per capita, and the above one talks about the total final energy consumption.

So, as you can see on the top, the table A the figure A, talks about the solar hot water. This is the largest volume over there, the 240 watt at thermal per meter square. So, this is total energy consumption by hot water, facilities and only if you see there are several other. So, how this can

be met, this demand by the supplier groups? So, at the bottom, you can see there are some indicators are given with the help of the colour codes and the population sizes.

So, solar photovoltaic cells are able to generate 120 watt per meter square and geothermal up to 100 watts per meter square. And similarly, there are these how much is wind generates, how much of units generate? So, this is given along with the consumption of points also how much is consumed by the crops and other units. And the second figure you can see over here. This talks about the per capita consumptions.

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So, how this building management system, the building automation, can help to achieve such efficient system, which we are talking about? So, in this one, if you see we have seen this slide earlier, also this is most detailed one over here. It talks about installing HVAC Maintenance Services. It is talks about installing fire detection and alarm systems. It talks about security and control system.

It talks about digital surveillance system. It talks about intrusion detection systems. Okay. So, with these systems there we can achieve number of automations in the buildings. So, these automations will help not just in the security and maintenance. These automations will help us even minimizing the energy load and the resource consumption in our buildings.

So, by installing lighting control and retrofitting solutions, we can minimize the energy load. We can install smoke control systems so we can install indoor air quality checks. So, with that we can switch on and off and we can keep running our air filters and other solutions for indoor air quality.

We can install water management information systems we can install energy management information system we can have our own onsite technical team and service, service team which will keep on moving and reporting such activities and with. If there is any need they can keep on rectifying that. So, and there are several other also new technologies being employed or being used in the building facilities, you can see over here.

They are environmental control systems, they are the checks for mechanical maintenance and retrofitting system, they are assel locator. There are systems for enterprise system integration where all of these systems individually can be integrated into one system and can be monitored from there. So, such automation systems can be employed to improve the energy efficiency part.

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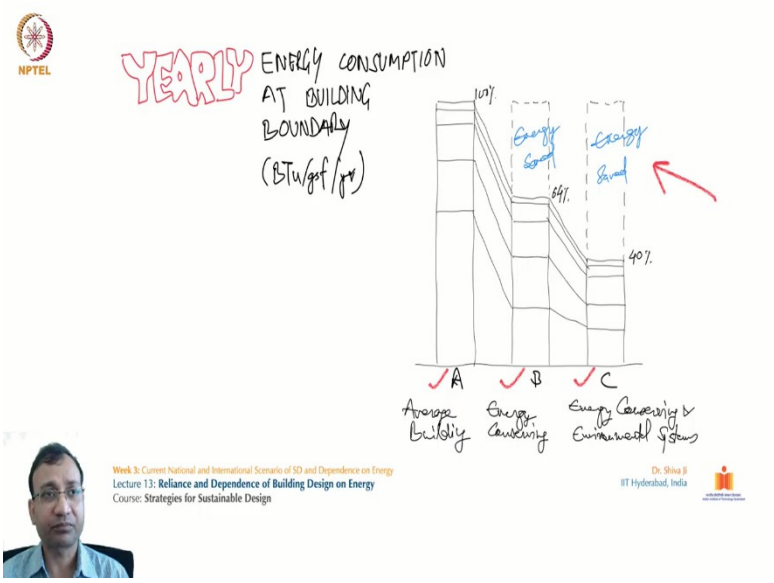

Let us see how much of energy is consumed by a normal average household and a building which is design for conserving electricity. And that the see, you can see in this one the building which you can see consumes energy construction as well as in the environmental systems. So, we can see I think this is quite evident from here in the case A if you see.

If this building is consuming the 100 percent of whatever this amount the volume of this, the amount of energy they are consuming, if it is 100 percent. so from this base case of A. So, if you are moving to the case B, energy conserving construction. So, in this such construction system, we can save power by up to, the consumption has reduced to up to 64 percent of the base case.

So, that is huge reduction. That is almost more than one third of saving, which is done. So, that is the kind of impact on the energy consumption while maintaining, while going for energy

conserving construction systems and if you examine the case C, the third one. In this one , the system is, system follows energy conserving construction and environmental systems.

So, in this it is observed, the energy consumption has stood only at 40 percent. That means there is a saving possibility of 60 percent, which has happened over here. So, it is huge amount of saving, which has happened over here, even in this, you can see the largest consumer of this energy has remain domestic hot water system and then the cooling and then the office equipment, hand pumps, lighting and then comes the heating.

So, this is the pattern which is there in the building. This is from, I think, the United Kingdom. But, yes, I think it is mostly true in most of the countries and the in the colder countries. They work more for the heating of the building in our kind of countries. We work more for the cooling of the building. But the saving, if you see the overall, remains almost significant, very significant.

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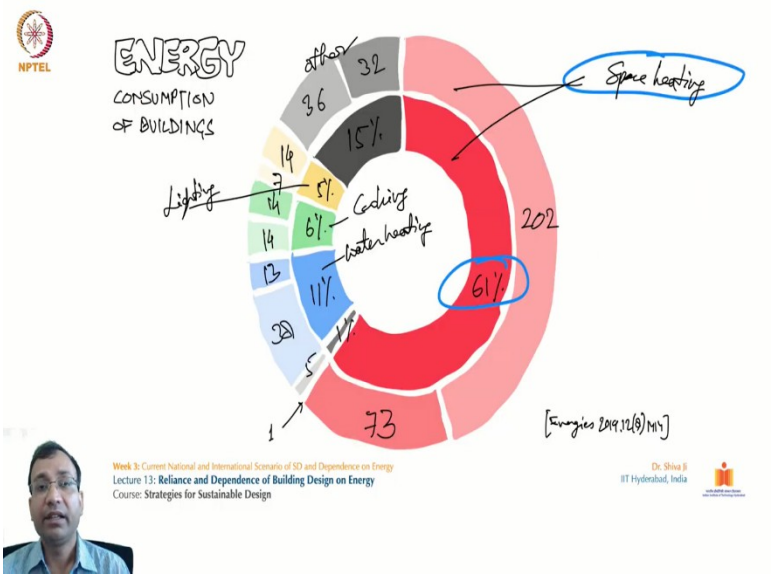

Here, if you see the single largest consumer, one component in the building is the space heating. This we have seen earlier also so this space heating takes around 61 percent of the energy consumed in the building, then the cooling and then water heating, cooking, lighting, they all have their respective shares. So, we can see from here.

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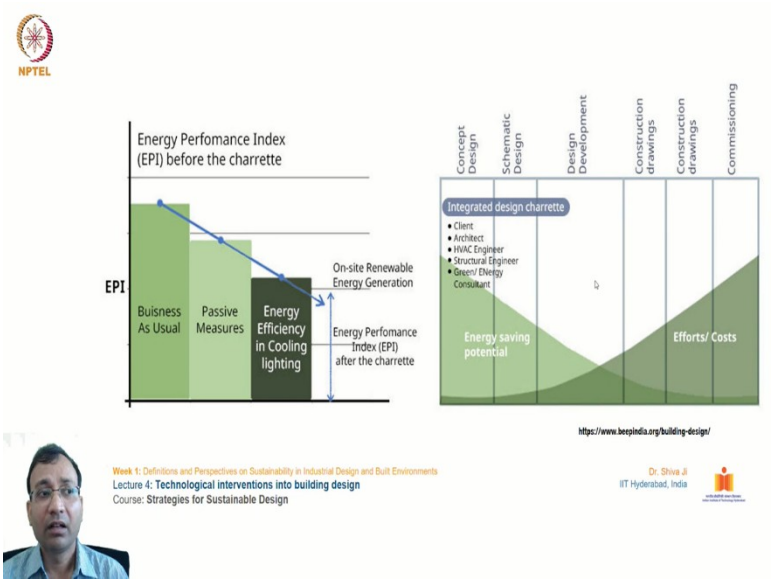

And how in this figure we can see Energy Performance Index EPI before and in the second one, we can see how it has helped with the different stage wise, if you see stage wise of the designing and construction of these buildings. So, how these efforts and costs maximize the gains? So, in the first one, in this energy performance index, if you see the normal if you goal and normally as usual, so it is stands at one point.

And the moment we take passive measures, it gets down and it gets down even further when we go for efficient, energy efficient cooling systems and cooling you know the lighting and et cetera. So, there is a significant drop in terms of you know the performance of energy in that particular building and how it changes as we progress through our concept design through systematic design and the design development.

So, if you see by integrating different stakeholders. And taking energy saving measures. So, the efforts and cost can come down.

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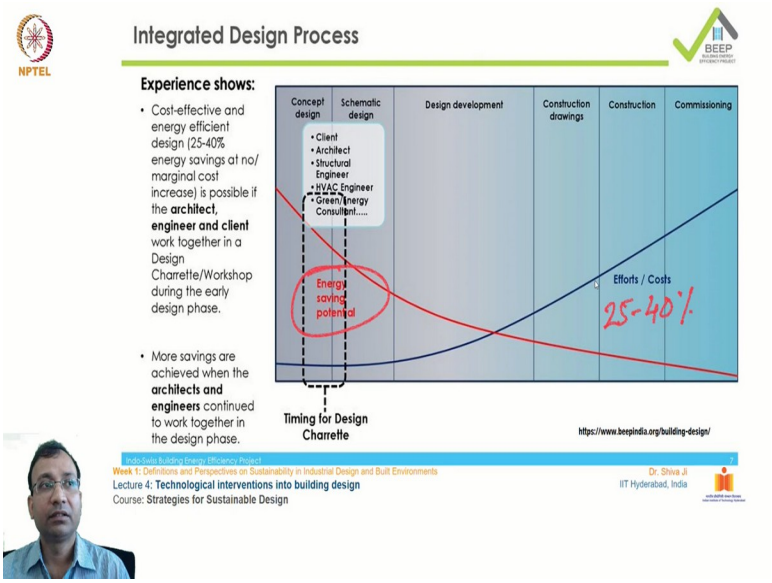

The similar integrated design process is given over here, also from the concept design to schematic design to the design development up to the commissioning. There is always this potential. It is shown over here is the 25 to 40 percent of you know the seven potential is observed in this one. So, there is a huge potential for you know energy conservation and reduction of the overall impact.

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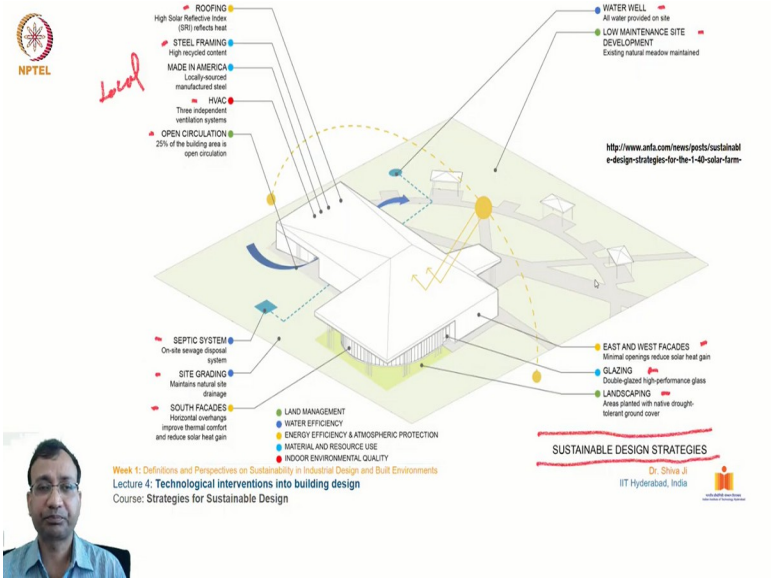

And water, what are those places where this strategic interventions can be made? So, really good component wise in this building, illustrations. So, the roofing of course, we can use high solar reflective index, material that which reflects the heat in the outer side and which does not heats

up the building. So, the overall cooling of the building requirement will be lesser. Then there will be steel framing, steel is one of the highly recyclable materials.

So, the steel can be used, which can be recycled after the lifecycle of this material is over. And then locally sourced material, locally manufactured materials can be utilized to improve on the indirect emissions part. HVAC systems well, these can be installed in an integrated manner so that they can take care of the heating, cooling and ventilation purposes.

Open circulation that is also can be given so that the open areas can take use of prevailing wind directions of that particular site. And there is no much work needed to improve the efficiency of them on the cooling part. Septic systems can be installed on the site you know site gridding. , material on a natural side of the topsoil can be maintained.

The drainage can be provided in such a way so which prevents the soil erosion, which prevents the the damaging the top layer of the soil which is the fertile one that can be used for growth of the grass and other plants. South facade can be utilized for better thermal comfort in this thing, because in the south, sun goes almost vertical.

And this site can be utilized for it is strategic purposes. And on the top side, if you see water will fall water requirements on the site or well with this point is subjective, it depends on the local administration and the mandates by the civic authorities. So, depending upon the local administrative laws, this point can be undertaken.

Low maintenance site development. So, the site itself should be designed in such a way so that the low maintenance, low mechanical or external maintenance is needed. And that the facade directions, the directions of the site and the building can be taken care of to design the form and the material application in those directions.

Glazing also can be used for depending upon the direction. If it is the harder side then the double glazing can be used, if it is north side, then maybe a single glazing will also suffice. And obviously with the help of the landscaping, the overall ambiance and the overall UHI can be reduced significantly by adopting these design strategies over here.

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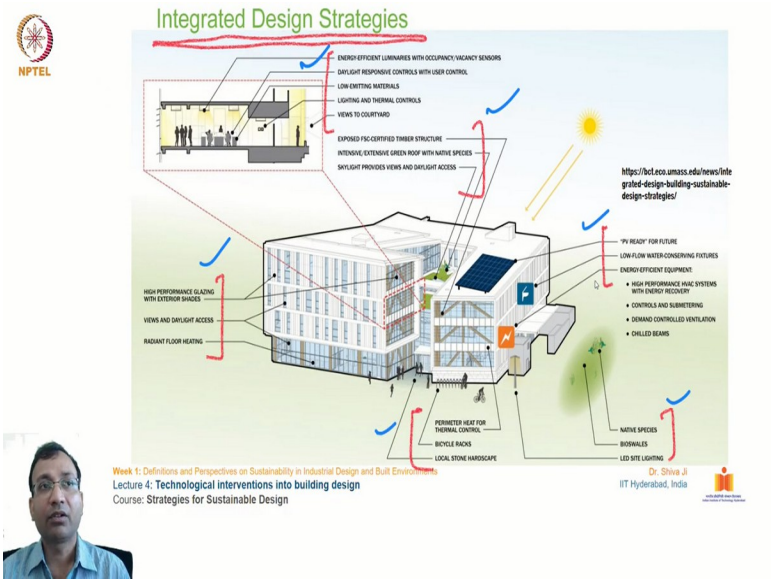

So, these are integrated designs, Strategies , they are given some more over here in an very control building like a mall, maybe in a hospital, maybe a school or college. So, how these energy efficient, like a luminous, they can be utilized and low emitting materials can be utilized. Lighting and thermal controls can be given and views can be given even in the in the inside of the building, in the courtyard areas where people can have look to the nice ambient external site.

And the structure can be used with the steel or maybe even timber, as in this sketch it is they have used the certified harvested timber. So, that comes from the managed forests. And this is one of the sustainable practices being adopted in the different countries and economies these days and making use of the skylight to have access to the natural sunlight in the daytime.

And having , High-Performance, glazing with the external shades. And at least providing some view okay to the outside and utilizing radiant floor heating or cooling depending upon the climate and location. So, such strategies can be utilized for bringing in efficiency. And of course, utilizing the photovoltaic solar cells and water harvesting, rainwater harvesting units, energy efficient equipment to utilization of these things can be increased for strategic in design inputs in the design of these buildings.

And lastly, I would to mention over here, even promoting the native species of plants and bushes and trees should also be encouraged because they consume optimized amount of water and they require little maintenance because they are habitual. They are native to that place. So, a little maintenance will be required compared to those species, which is brought from some other regional location.

So, resulting in to , the better efficiency and resource optimization the water is the one commodity requires to maintain landscaping. So, by using a natural and local species of these flora over here, we can minimize the water consumption using biofuels so that the rainwater and storm water remains on the site for some time, and percolates to the lower strata and then and then using LED based lighting systems. Using public transportation, promoting individual cycles and such things are part of the overall strategy to improve the efficiency.

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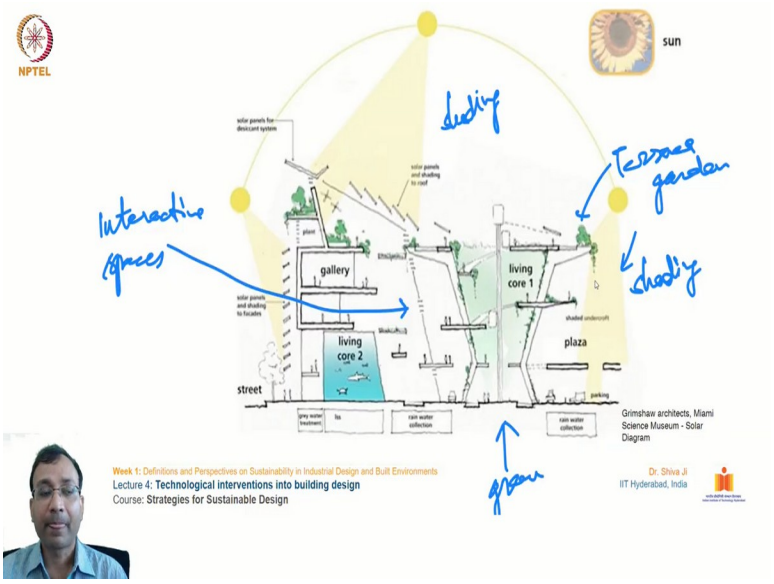

As you can see in this cross section over here of this building, the designer has the architect has utilized the orientation of the sun to maximize the solar gain on the solar panels, as well as reducing the solar gain in the inside of the spaces so that it does not get too heated. At the same time, they have utilized this courtyard designed to create corridors and walking areas along with some greener facilities.

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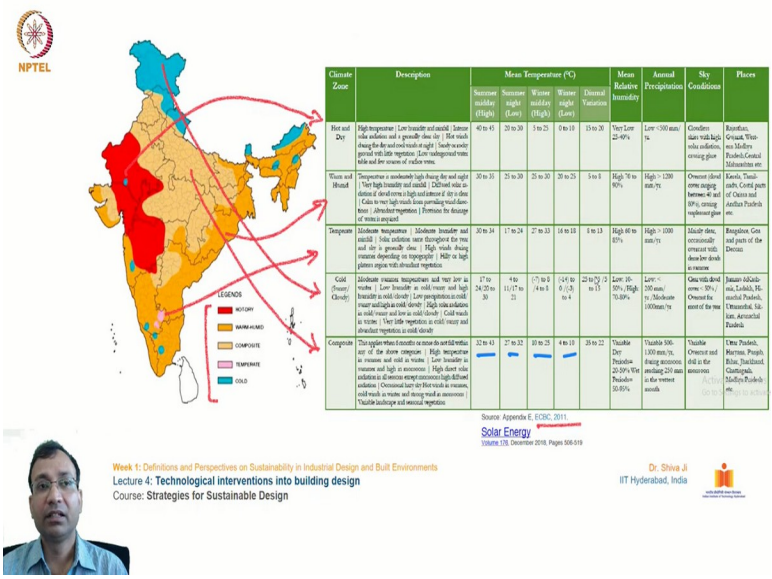

Climate Zone	Description	Mean Temperature (°C)					Mean Relative Humidity	Annual Precipitation	Sky Conditions	Places
		Summer midday (High)	Summer night (Low)	Winter midday (High)	Winter night (Low)	Diurnal Variation				
Hot and Dry	High temperature | Low humidity and rainfall | Intense solar radiation and a generally clear sky | Hot winds during the day and cool winds at night | Sandy or rocky ground with little vegetation | Low underground water table and few sources of surface water.	40 to 45	20 to 30	5 to 25	0 to 10	15 to 20	Very Low 25-40%	Low <500 mm/ yr.	Cloudless skies with high solar radiation, causing glare	Rajasthan, Gujarat, Western Madhya Pradesh,Central Maharashtra etc.
Warm and Humid	Temperature is moderately high during day and night | Very high humidity and rainfall | Diffused solar radiation as cloud cover is high and intense if sky is clear. | Calm to very high winds from prevailing wind direction | Abundant vegetation | Provision for drainage of water is required.	30 to 35	25 to 30	25 to 30	20 to 25	5 to 8	High 70 to 90%	High > 1200 mm/yr.	Overcast (cloud cover ranging between 40 and 80%), causing unpleasant glare	Kerala, Tamilnadu, Costal parts of Orissa and Andhra Pradesh etc.
Temperate	Moderate temperature | Moderate humidity and rainfall | Solar radiation same throughout the year and sky is generally clear | High winds during summer depending on topography | Hilly or high plateau region with abundant vegetation	30 to 34	17 to 24	27 to 33	14 to 18	8 to 13	High 60 to 85%	High > 1000 mm/yr.	Mainly clear, occasionally overcast with dense low clouds in summer	Bangalore, Goa and parts of the Deccan
Cold (Sunny/ Cloudy)	Moderate summer temperature and very low in winter | Low humidity as cold/sunny and high humidity in cold/cloudy | Low precipitation in cold/sunny and high in cold/cloudy | High solar radiation in cold/sunny and low in cold/cloudy | Cold winds in winter | Very little vegetation in cold/sunny and abundant vegetation in cold/cloudy	17 to 24/ 25 to 30	4 to 11/ 7 to 21	(-7) to 0 /4 to 8	(-14) to 0 /-3 to 4	25 to 29 /2 to 13	Low: 10-50% ; High: 70-80%	Low: < 200 mm/ yr. /Moderate 1000mm/yr.	Clear with cloud cover < 50% / Overcast for most of the year	Jammu &Kashmir, Ladakh, Himachal Pradesh, Uttaranchal, Sikkim, Arunachal Pradesh
Composite	This applies when 6 months or more do not fall within any of the above categories | High temperature in summer and mild in winter. | Low humidity in summer and high in monsoon | High direct solar radiation in all seasons except monsoon; high diffused radiation | Occasional hail in Hot winds in summer, cold winds in winter and strong winds in monsoon | Variable landscape and seasonal vegetation	32 to 43	27 to 32	10 to 25	4 to 10	16 to 22	Variable Dry Periods= 20-30% Wet Periods= 50-85%	Variable 500-1300 mm/yr, during monsoon, reaching 250 mm in the wettest month	Variable Overcast and dull in the monsoon	Uttar Pradesh, Haryana, Punjab, Bihar, Jharkhand, Chattisgarh, Madhya Pradesh etc.

So, in context of India, this is source from ECBC what they recommend for different major climatic zones of India. So, India is majorly divided into five climatic regions, hot and dry, warm and humid, temperate, cool and composite. So, you can see over here the description of these climatic zones are given and mean temperatures are given in the summer okay and winter.

And the diurnal variation is also given and with the help of this data, the temperature chart and the relative humidity chart and the sky conditions and the wind conditions. Our designs, we can improve on these. So, this is this chart becomes a basis for our planning our strategies for designs in these various climatic conditions.

So, even for more detailed micro climatic conditions, as we have discussed in the previous slide, so we should focus on developing those micro climatic charts and data sets for better optimization for suiting these buildings on given a location. Because even in these climatic zones, there are several variations of your locally from one place to another.

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Similar kind of efforts in this sketch also over here to improve on the overall performance of the it does in consumption in the building. So, there are several such techniques which can be employed. As you can see in this particular sketch, there is a huge amount of greenery given even in the lower floors of this building to minimize the heat load and increase the air ventilation improve the air quality and give a better experience to its inhabitants.

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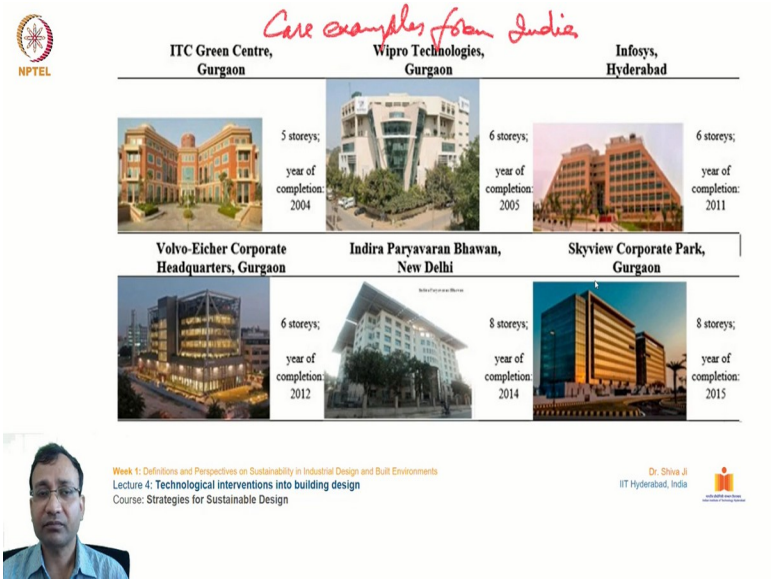

There are some examples from India on efficient buildings, which have been completed in the recent years, in the last one decade or so. And these buildings have become a kind of a landmark for other architects and designers to follow. So, some of these I would to mention over here, this ITC green centre from Gurgaon and Wipro Technologies, the building from Gurgaon and Infosys

from Hyderabad. And this is Volvo Eicher corporate headquarters from Gurgaon. And the last one is also Skyview Corporate from Gurgaon.

And then the second last you can see is the Indira Paryavaran Bhavan from New Delhi, which I had mentioned. This is the net zero energy building of India. So, these buildings are worth taking inspiration from to how to design modern buildings in the given context, taking help of the energy saving, minimizing on the resources and overall in the overall sense, serving the purposes of sustainability. Thank you, everyone!