Strategies for Sustainable Design
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Lecture 12
Built Environment and Energy Consumption

Hello everyone, in this lecture, we will talk about built environment and energy consumption.

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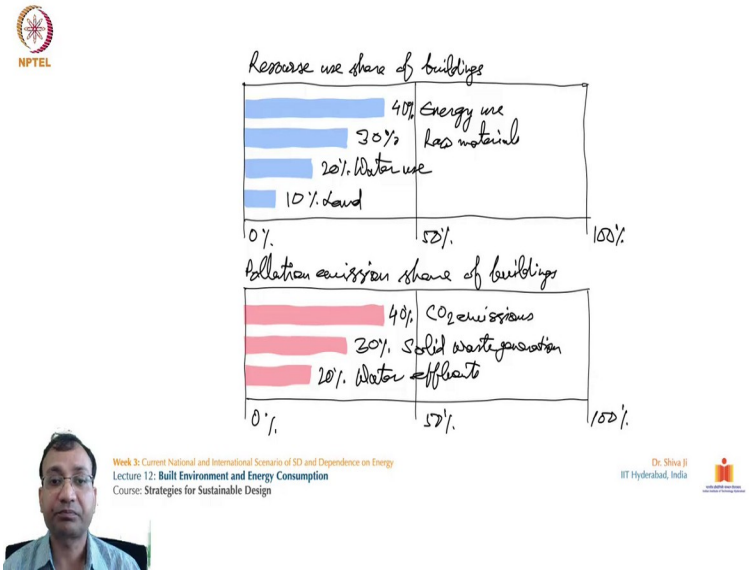

So, if you see this table, it talks about the share of the built environment and their respective resource uses. So, the resource uses a different resources such as like energy, raw materials, water, land, they are actually bifurcated, like how much the build environment, the buildings are consuming actually.

So, the first table actually talks about and it carries 40 percent of the energy use. So, as I have stated earlier the buildings are the single largest actually consumers of the total world energy and they consume approximately 40 percent of the total World Energy, even more than the industrial sector okay, even more than any other sector.

So, these are the largest consumer, so if there is a saving of any fraction of also percent saving, so the overall resultant saving in terms of volume will be tremendous. And the second actually is the raw materials used by buildings. So, that is the resting at around 30 percent okay water usage

around like 20 percent and land uses around 10 percent. So, we can see like the total land whatever is available for like our uses these days.

So, this is occupied by buildings alone, by percentage of like 10 percent and the water, whatever water we are consuming actually these days the buildings take total of around 20 percent of that and raw materials what we consume, like what buildings consume, for like construction material, for their like operations, for the lack of maintenance. So, all of that put together it consumes around like 30 percent of their raw materials uses, which is huge.

So, in terms of resource and energy consumption, the buildings are one of the largest consumers in all of the sector actually combined. And the second actually table talks about the share of the built environment at pollution emission. So, here if you see like the CO2 emissions also happen, which are caused by like the buildings is at the rate of 40 percent, which is very huge.

And the second one is solid waste generation by like buildings and it stands at the rate of like 30 percent and water, effluents 20 percent. So, these also like the by-products of any building such as like emissions, such as waste generation such as like effluents and other like toxic materials and exhaust coming out of the buildings as a resultant of like, several processes, such as like air conditioning, and there are several like actually compound based actually finishing materials which are being used these days.

Like volatile organic compounds, VOCs we used in the finishing materials such as lacquer and paints, you know, and several like other liquid treated like wood materials, there are several types of like adhesives and resins are also being used, there are several types of the treatment materials used in flooring system such as like epoxy. So, all of these have actually a huge environmental impact. So as a emission if you see buildings are also responsible for very high emissions in terms of like toxic materials and gases.

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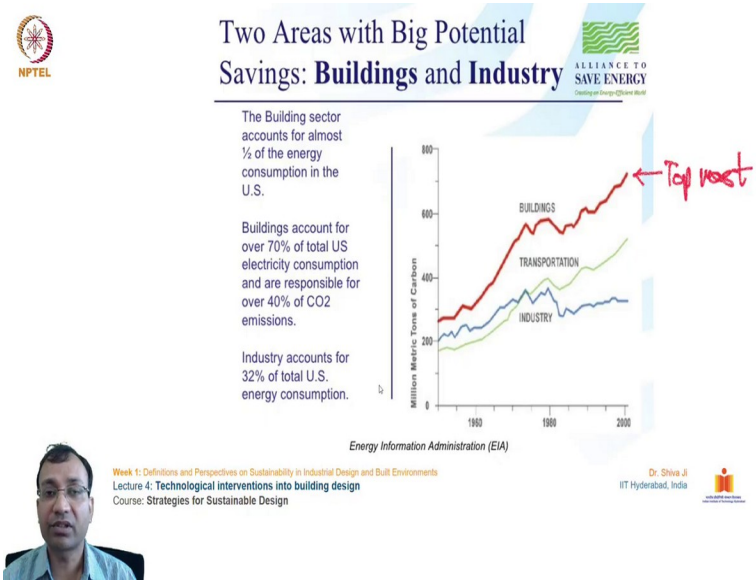

So, two big areas like you know, for the potential of saving, if you see, so it is very evident from the previous slide, like buildings are largest consumer of like resources and energy and they are the largest emitters also. So, in tune if you see from the like opportunity perspective as a designer as an architect and as an engineer, I am sure you will see, there is a huge scope also, there is a huge potential also further saving from on all of these actually factors.

So, if you see like buildings are standing compared to other like industrial sectors, like for example, like industry and transportation, buildings are coming at the top. So, as a resultant, we can see there is a huge scope of like potential for like an improvement also in terms of like optimizing on energy uses, energy consumption on the parameters of sustainable, like, resourcing of the materials and the raw materials which are required for the buildings for the building environment, actually, these days.

And if you see the numbers given on the left side of this actually illustration, so it talks about the building sector accounts for almost half of the energy consumption in the United States. So this is just an example from one country, well United States of America is one of the advanced countries, and there the contribution of like an energy to serving actually buildings alone is by almost 50 percent, which is tremendous.

The second one, buildings account for over 70 percent of total US electricity consumption and are responsible for over 40 percent of co2 emissions okay. So, the total like electricity consumed okay off that actually 70 percent is taken by the buildings alone over here and the last one industry accounts for 32 percent of total US energy consumption.

So, the industry even though like industries are like very critical and important for the actually manufacturing and other like processing of legal stuff, but industry is still lagging behind the buildings that mean buildings are actually far outrun the resource consumption and energy consumption. So, in itself, it is evident like there is a huge scope in terms of like improvement on the like resource consumption and energy in the buildings.

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So, here if you see what could be the benefits okay for like the buildings and the building's owners and the occupants and the civic bodies and the political like administrative like agencies like to furthering improvement of such efforts okay. So, it is given at the three scales like one individual like building scale and at second at the district scale like an urban scale and the third one is at the city scale.

So, what could be the benefits if you see like, if we work for the building efficiency? And on site actually power generation if we work for the stories of that on site per generated power, for the consumption like on the later times, okay. So, what could be the benefit? So, the common ones

are listed over here the most efficient actually resource use, manage resources consume, reduce costs actually of far like energy and other resources, reduced like resource use of course, and received reduced demand and the electricity grid, because taking actually power from electricity grid actually exerts a lot of impact and pressure on the overall system, because that power has to be generated somewhere and transported to your like place.

So, in the transportation itself, there is a huge percentage of that power, it gets lost, it depends on the length or distance, but yes, there is always a certain percentage of like that power that which gets lost in the transmission. So, by generating power on site, we can reduce our dependence on the grid. And secondly, we can reduce the, we can almost like nullify the losses happening in the transmission of the power from one place to another and we can go independent of the grid to have to generate our own like electricity and reduce stormwater enter, infrastructure needs.

So like in such disastrous situation, situations of like disaster of flooding and so, so, there could be benefits in such scenarios also and what can happen at the district level, at the local urban scale level. So, if we regulate the heating and cooling of these buildings if you regulate the transportation efficiency in that over area encouraging pedestrian and the movement on like cycles, if we minimize the personal vehicles if we promote public transport.

And if he if we actually devised micro grid, so, micro grids are like arrangements, okay, which serve actually for smaller area, very focused area for example, maybe one neighbourhood. So, there could be power generation plants such as solar photovoltaic actually cell based or there could be wind farms, okay, there could be tidal energy harvesting farms, okay. So, these smaller units can provide electrical electricity for like smaller areas.

For example, maybe I had an area of like maybe a 200 acres, 500 acres or even maybe 1000 acres. So, like this actually policies these days being promoted in the government institutions such as the IITs and IIMs to generate their own actual electricity on campus. So, these chilly campuses are being facilitated with the power generation plants. So, at least a significant percentage of their power requirement they are meeting through actually these needs okay.

So, this is a normal initiative actually taken from the governmental agencies to improve actually and implement (())(9:18) microgrids. So, what could be the benefits of like such scenario as you

can see over here on site resource management, production and storage, so that the centralized power plant units that dependence on such units will actually reduce, so we can have actually distributed actually economic model, which we will discuss more in detail in lens chapter.

So, those kind of actually distributed economic models can be implemented on site to site, there could be local aggregation of demand like how much power is required on a particular line location, so that can be assessed properly and more accurately than actually covering a bigger area. So those kind of like of accurate forecast also can be actually can be created to generate power and meet that demand.

Improve resource distribution and improve performance and resilience - So, of course, since this unit is going to work at the local level, so, the resource distribution, the resource actually requirement for like this unit can be taken like locally without like interference from a farther like a faraway places. So, this will actually improve the performance of the local level and the resilience of that actually locality. So, resilience is very important for survival in any eventuality kind of conditions.

So, this is very important because if this works properly, then the place in itself will become actually independent of the other places. So, if something goes wrong for example, like in this globalized economy, if one country faces a difficult situation in this economic like a system, so the all other countries also gets affected. So, that is actually the repercussion of such a such a system where everybody can agree like an institution become so, dependent on the other that if something goes wrong with one the everyone gets collapsed.

So, we should actually go independent of such like a system we should develop that resilience. So, this is the reason actually resilience will become very important in today's time to actually generate that resilience at the local level. And what will happen at the city scale, if you see this illustration it talks about improving on the transportation from personalized to public, in improving on like cycling, improving on battery powered like vehicles and then the compact development.

So, the compact developments by that means, like the development in a very like an efficient manner. So, the more number of actually output can be actually created in a smaller areas to

optimize on the space, to optimize on the land. And then the next feature which we are talking at the city level is of the mixed use of the buildings. So, the buildings can be made of the (()) (12:08) use, they can be used for like you know extended hours, extended duration of the day or night.

So, that the resource which is like invested so much in that building can be utilized for you know, more amount of time for example, any school if it is running their classes. So, what is happening in this building or a space after the school hours, well, that building is closed for those times. So, is there any way to optimize, to make use of that space for like multipurpose like activities. So, why not such initiatives can be taken care of?

So, what could be the benefits in such like scenarios, so avoiding like our increased legal infrastructure costs, okay, avoiding health cost, because, if people are fit enough, if people are taking care of their own individual like health, the health of their family, if they are taking public transportation if they are cycling, if they are walking, jogging.

So, obviously, it will result into an improved like health condition, which will in turn like exert lesser impact if you actually demand lesser actually car cost investment from the like the health sector, it will reduce the need of several kind of services which are not required that much, which are not critical in nature. So, at least we can avoid those type of like services, and of course, the lower energy demand and related emissions from public infrastructure.

So, since the public like infrastructure, okay, will have like, better actually capacity to solve the people. So, the per person actually emission will get reduced significantly.

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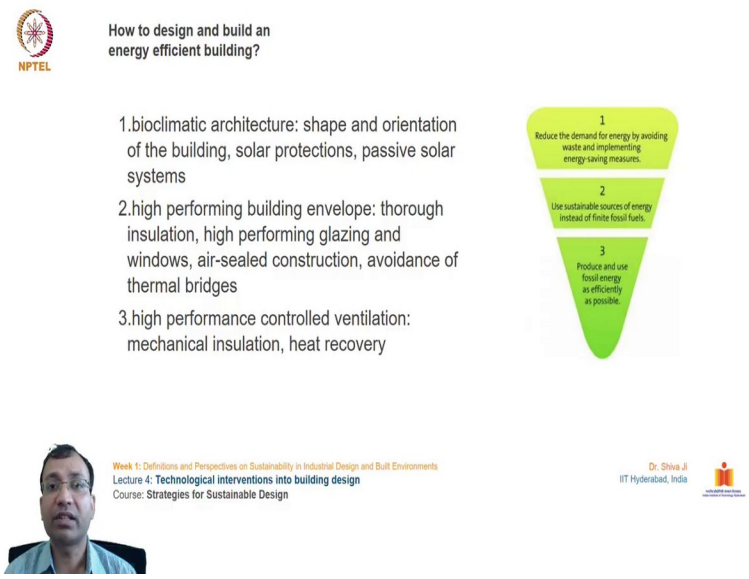

Okay, next, if you see over here, how to design and build an energy efficient building. Well, this slide we have discussed earlier, but I have kept it here again, to remind you like how we can go in the approach. So, the first approach actually talks about reducing the demand. The second one talks about actually using the renewable resources and avoiding actually non-renewable resources. And the third one, even if we need to, like use such resources, we must use them with much efficiency as much as possible.

So, on the left-hand side, you can see what are the strategies for employing such in the designs of our like buildings and other products. So, using the concept of bioclimatic architecture, so the shape orientation of the building you know, solar protections, you know, passive solar systems can be installed okay in the building to take advantage take the maximum advantage of the solar like, you know, their direction, the solar availability of sun and actually prevailing winds and all of these things and even the topological actually characteristic and topography.

The second, high performing building envelope, thorough installation should be there so that to minimize the actually in losses, high performing glazing and windows air sealed construction, avoidance of thermal bridges, the third one high performance controlled ventilation, mechanical insulation, heat recovery.

So, heat recovery is also one of the options which several projects are using these days, where they are actually recovering heat from like services if there is a heating maybe a heating actually mechanism installed in a building or if there is a cooling mechanism installed in that building. So, the energy which was invested for cooling that particular air should be harvested back as much as possible, if there is a like any fresh air change or any like such activity, so the cool air can be diverted if it is exiting that building.

So, that cool air can be diverted to like other like ancillary activities. So, that is actually purpose with this to maximize the uses of the energy invested in any component of the building.

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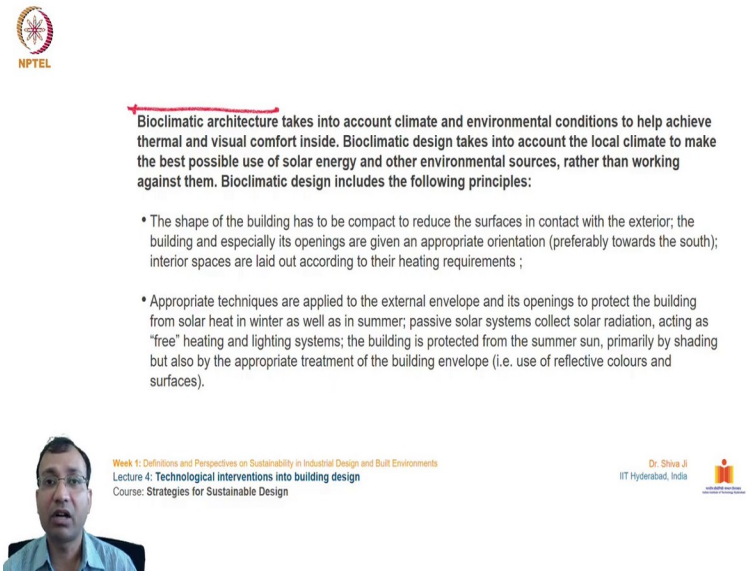

So, how like this bioclimatic we can take use of this, actually. So, I will quickly explain this topic over here, it takes account of the climate and environmental conditions to help like achieve thermal and visual comfort inside, bio climatic design actually takes into account the local climate to make the best possible use of solar energy and other environmental sources rather than working against them.

So, bioclimatic design includes the following principles. So, there are two principal I will explain briefly, the shape of the building has to be compact to reduce the surface in contact with the exterior of the building, the surrounding of the building, the building and especially its openings are given an appropriate orientation preferably towards the south, interior spaces are laid out

according to their heating requirements, though actually, these directions will vary depending upon the location of that site and that the building across the planet.

So, then from the northern hemisphere to the southern hemisphere, the orientations may completely go opposite. So, we have to actually take care of such calculations depending upon the location on the globe. The second one - Appropriate techniques are applied to the external envelope and its openings to protect the building from solar heat in winter as well as in the summer, passive solar systems collect actually solar radiation acting as free heating and lighting systems.

The building is protected from the summer sun, primarily by shading, but also by appropriate treatment of the building envelop, the use of reflective color and surfaces. For example, if we do not want much heat gain from the sun in the summer months, so we should use actually reflective materials to reflect back the heat quotient of the sun's rays okay and in winter if we want that heat to come inside then maybe we can we can use you know suggestive materials which allow actually heat retention in the building.

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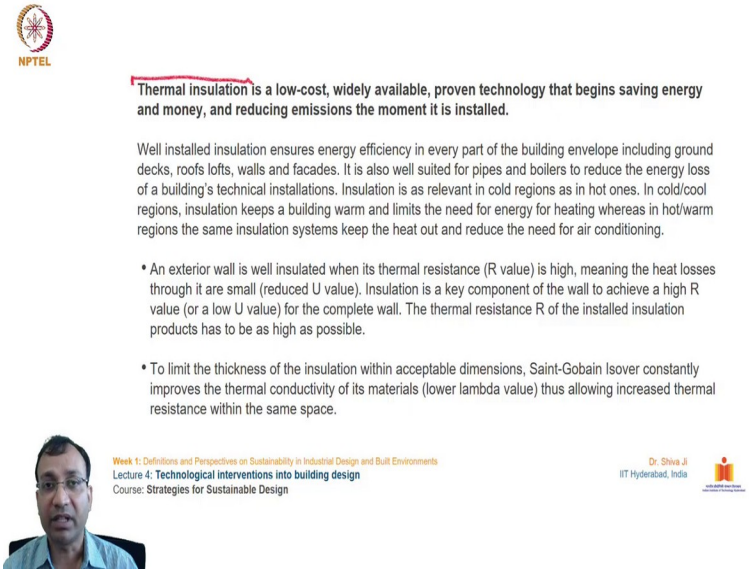

Similarly in the thermal insulation, so, thermal insulation, it is a low cost widely available proven technology that begins actually saving energy and money, it reduces actually emissions because it helps actually the system in an indirect way, it is minimizing, it is reducing the actually losses

which are happening in the process of actually heating or cooling. So, this insulation is very important to improve the overall efficiency because a major portion of around like an energy gets lost just because of actually weaker actually insulations.

So, well insulated, like insulation in the building and energy efficiency in every part of the building. So, how this can be done, you see there are two points over here and exterior wall is well insulated when its thermal resistance the R value is high, meaning the heat losses through it are small reduced U value, insulation is a key component of the wall to achieve a high R value for the complete wall, the thermal resistance are of the installed insulation products has to be as high as possible.

So, as you see like every material has certain thermal resistance, for example, brick we generally use concrete, we use wooden panels, we use like the stone materials okay, we use timber, we use these days we are using like an aluminium, we are using steel, mild steel we are using like glass. So, every these like materials they have some R values which is thermal resistance.

So, how appropriately this property of this thermal resistance can be applied to reduce the heat intake in the summer months and to increase the heat intake in the winter months, which is fitting for like northern hemisphere can be actually made use of. So, this is the actually strategy based on the property of the material, we can actually apply.

The second one talks about to limit the thickness of the insulation within acceptable dimensions like there are some companies like Saint Gobain, so they have actually launched some glass materials, which have the lower R values as compared to the conventional like glasses so which helps in turn minimizing actually heat loss. So, these glasses actually are called reflective glasses. So, they actually reduce the heat component in the sunlight okay. And as a resultant the air conditioning load on any space is like minimized significantly.

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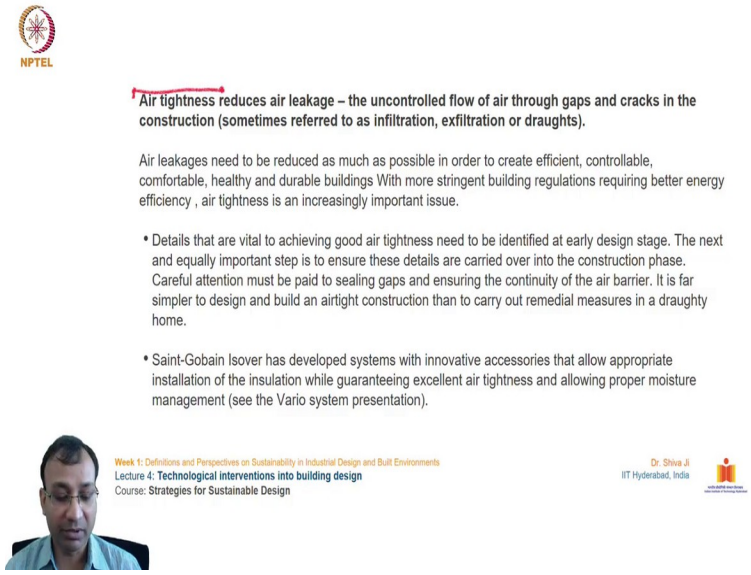

The next one I would like to talk about here is the air tightness. So, this also like with the conviction okay there may be the actually loss of the energy from like inside to outside or from outside to inside. So, how would this air tightness also we can ensure maximum efficiency on the like energy systems. So, this is also one of the, a part of the like overall strategy to actually apply this air tightness to use this air tightness to minimize the actually losses by convection.

So, this actually reduces or minimizes or breaks actually air leakages happening anywhere in our like ducts or anywhere from the interior spaces to the outside. So, it checks actually the gaps, cracks in the building okay or the construction or the interior spaces or even in the false ceiling in the windows and the doors to maximize the actually effect of the invested energy.

So, how this can be done, the details that are vital to achieving good air tightness need to be identified at the early design stage. The next and equally important step is to ensure these details are carried over into the construction phase, careful attention must be paid to sealing gaps and ensuring the continuity of the air barrier, it is far simpler to design and build an airtight construction than to carry out remedial measures okay afterwards because the remedial measures actually may not actually work properly.

So, it is always recommended to go for such details at the time of the design itself. The second one talks about from a particular company like Saint Gobain. So, there is one actually model they

have launched Isover has developed system with the innovative accessories that allow appropriate installation of the insulation while guaranteeing excellent air tightness and allowing lack of proper moisture management.

So, see like how different companies, the private companies are also coming to the rescue of the cause of ecological like you know balance. So, saving energy, saving resources must become motto of each and every like organization whether it is government or private or every like a manufacturing unit to serve the overall purpose of like you know bringing like energy efficiency and efficiency overall in the resource connection.

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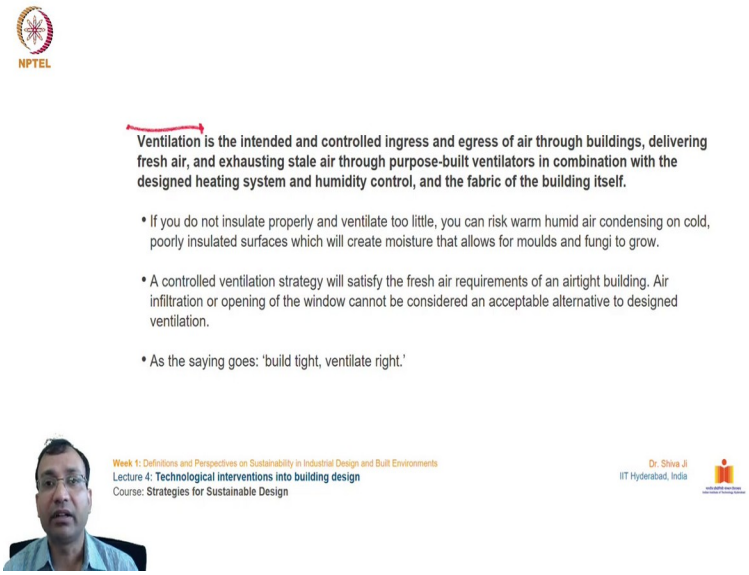

The next one he talks about here is the ventilation So, the how the ventilation can be controlled okay for bringing fresh air for cooling it for bringing it to the desired temperature. So, if you do not insulate properly and ventilate too little you can risk warm humid air condensation on the cool poorly insulated surfaces like we observed generally in the humid months okay, sometimes you observe like condensation and water droplets forming.

So, this this because of the bad actually installation processes which were carried out at the time of the fabrication or the manufacturing of that actually. So, we have to check such actually things which actually in turn will further give rise to the you know the growth of like mold and fungi in the interior spaces and which can further actually cause damages to the health of the occupants.

The next one it talks about a control ventilation strategy will satisfy the fresh air requirements of an airtight building, air infiltration or opening of the window cannot be considered an acceptable alternative to the design ventilation okay, the last one as the saying goes build tight, ventilate right.

So, this is very important like the whole system of the building should be actually airtight completely, so that the intended actually resource consumption and the energy consumptions can be achieved. So, it is very important to take care of these smaller details at the time of the construction only because it will be very difficult to rectify them once the construction is over.

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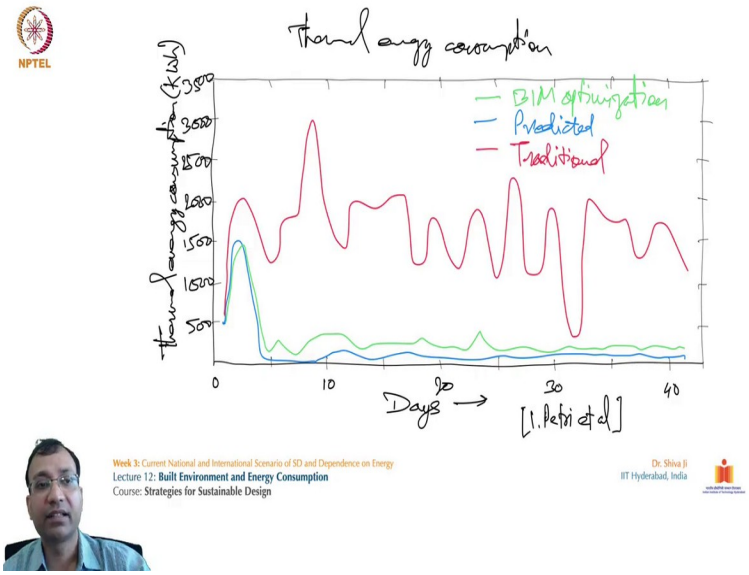

So, if you see like the overall what is the thermal energy consumption pattern. So, this red lines are represented by traditional optimization thermal energy conjunction, the blue one talks about predicted thermal energy consumption and the green one is the building information modeling optimization thermal energy consumption.

So, what happens in the traditional like optimization method, what happens when we like predicted and what happens when we take help of BIM model, actually consumption pattern. So, these are the latest tools and softwares and mechanisms such as building information modeling, they have added quite a lot to the like energy efficiency and managing any like enterprise

managing like any building or the built environment efficiently for like resource consumption or for the like an operational resource consumption for such as like energy.

So, energy is one of the actually components, which are building uses as long as it is functional. So, you can see this red line which is traditional optimization thermal energy consumption, which is always like in the higher scales. So, if you see like in the observation was done over range of 40 days over 40 days.

So, how it has actually faired in these actually in the traditional way and how this can be like taken care of by going for predictive models and how BIM has actually finally resulted with the help of all of these methods. So by employing actually such methods such as like insulation and air tightening and all that, so, how this has resulted as effectively. So, it is quite less than what is being used in the traditional like systems.

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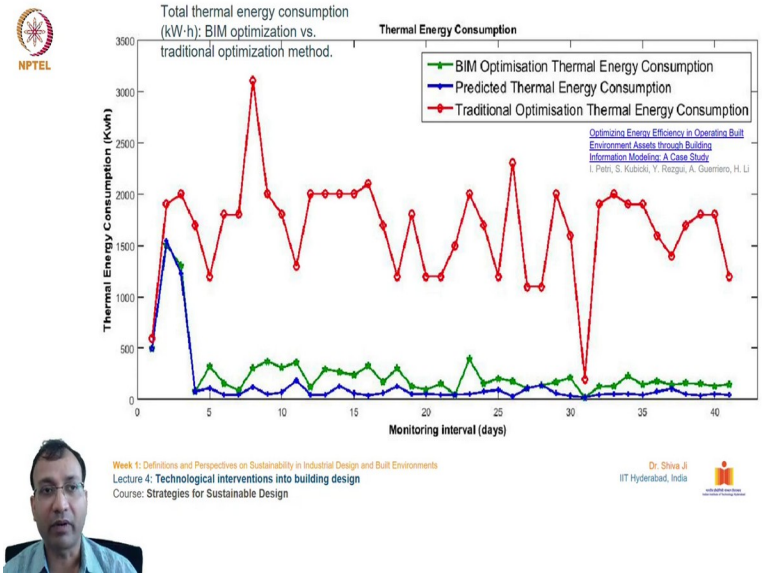

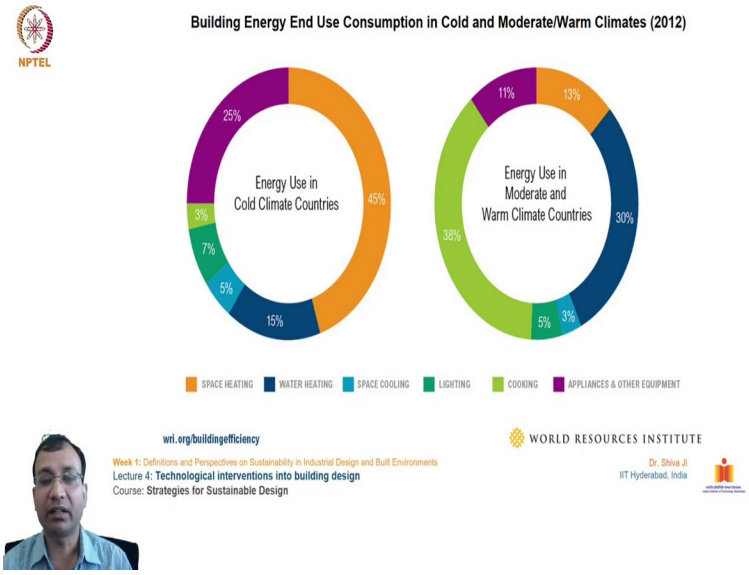

So, we can see over here like the effects which BIM rated, BIM model actually structure can provide, here this chart, I think, we are coming towards the end of this lecture. So, this chart actually provides the building energy like end use conjunction in cold and moderate or warm climate. So, this is from a year like 2012. So, the first actually circle talks about around 45 percent for heating spaces, so the energy used in the cold climate countries so, that on the right side, it talks about the energy used in the warm countries.

So, the colder countries 45 percent of the energy is used in heating their spaces, which is the largest actually component among all of these The next one is the water heating because these places the water gets frozen it becomes ice and the building services actually cannot run the water supplies and the sanitation cannot function. So, in these actually places there are provisions to keep heating the water on the regular basis.

So, they did not freeze it in the pipes. So, these two are actually taking like almost like 55 to 60 percent of the total like energy requirement of a building and on contrary to that, if you see on the right side. So, this one when we see so, here like the cooling becomes very important, so traditionally if you see like these buildings which are in the warmer like countries, so the space cooling is requires only requires only 3 percent.

So, compared to like the counterparts from colder country, so this is very little, but on contrary we have some other observations like 38 percent of the energy is used in the cooking which is

the highest in these countries and the 30 percent energy is used for water heating. So, water heating for like several purposes for like kitchen use, for the bathroom use and several other and space heating is required only 13 percent, 11 percent is required for like appliances and other equipment and 5 percent is for lighting.

So, I think lightning remains more or less I think closer to each other in the both of the actually context from 5 percent to 7 percent, but space cooling also relatively is lower in both of these from 3 percent to 5 percent, but this heating actually is changing quite a much and in this scenario on the right hand under warmer countries, we are seeing this actually range of like these cooking requirements, which are very high up to 38 percent.

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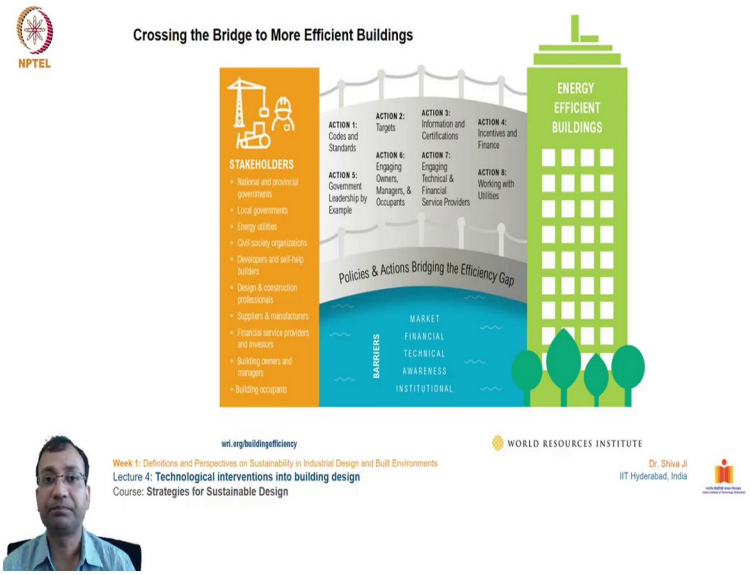

So, how like these the most efficient actually, buildings can be actually achieved? So there are some like action points, which are actually prepared from this World Resources Institute. So, we will discuss one by one. So, the stakeholders are listed on the left side. So this talks about national and provincial governments because they frame the policies, they are actually the top most bodies to create rules and regulation and laws.

And local governments which enforce actually local laws and optimize actually resources and energy utilities, civic society, actually organizations and bodies such as municipal organizations, developers and self-help builders, design and construction professional like you and me,

suppliers and manufacturers, financial service providers and investors, building owners and managers and of course, the last one is very important building occupants, because they are the ones they are the people who are going to use these buildings over a long period of time.

So, during the operation stage, they are actually involvement and interest and their actually intention matters the most. So what could be the like action points over here, so to prepare actually codes and standards, fix some targets like for resource optimization for the like energy consumption and all, the third one information and certification to go for actually such information distribution actually systems where these things, these targets can be actually achieved and giving like incentive and financial like help to these stakeholders.

For example, like manufacturers if they are creating compliant products. So they, their production must be incentivizes the power generation for like our site if a building is going for like (())(30:30) energy kind of concept, then these enterprises are these buildings also should be like incentivizes to promote like independent power generation system with the help of micro grid and all. The action five suggests like government leadership by example.

So, the government, the regulating bodies must first to produce actually such examples by actually modifying or by having such like efficient buildings of their own use, like as we saw in the Indira Paryavaran Bhawan, so Ministry of Renewable Resources actually constructed the India's first net zero energy building in New Delhi, which is situated in the Lodi Colony area. So, that building actually generated its own power rather it generated surplus power and it is supplied to the local grid over there.

So, that is one example actually set by the government institution itself, which is quite actually healthy example for the others to follow. The sixth one talks about engaging owners, managers and occupants. So, this actually awareness of these stakeholders is very important, because generally they are the ones who are going to use these buildings, they actually maintain these buildings, they take care of the upkeepment. So, their awareness and information actually is very important, so that they can take care of the loopholes.

The second one - Engaging technical and financial service providers and the last one working with the utilities. So, by this actually the help of these strategic actually action points we can see

over here we can work for you know, optimization of the buildings for making them like our most energy efficient buildings. So, this is actually the bridge which is proposed over here. So, from stakeholders as to the result of like energy efficient building, this is the way we can actually lead for actually this desired actually situation.

Well some barriers are there, but they can be actually taken care of, barriers such as market. So market, does the market have like such supply such materials in like abundance, are there like financial services available the financing available for erecting actually such efforts, are the technical, technical like advantages and merits available, technical knowledge available to meet actually these targets?

Is there awareness in the local stakeholders, are they aware of the possible efforts, which can bring some results to this project? And are there like institutions to support actually such activities? With this I would like to bring the end to this discussion. Thank you, everyone.