Urban Service Planning
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Lecture 57
Street Lighting

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Welcome back in lecture 57, we will talk about street lighting services, the different concepts that we will cover around roads and street lighting, different types of light sources, then we will talk about standards for street lighting in India. Then, we will talk about design principles for road and street lighting, then certain recommendations for lighting, then energy efficient street lighting, energy conservation, equipment selection, maintenance and monitoring. And then we will talk about certain case studies and different keys stakeholders who are who are involved in energy efficient lighting projects that are being undertaken in India and finally, IoT based smart LEDs best street lighting system.

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So, road and street lighting is has two parts to it. One is of course, the technical part that is selection a particular luminaire or selection of particular lighting levels or you know, calculation for different lighting levels and all. So, we will talk about that, but mostly we are focused on the overall process of roads and street lighting certain standards.

And also, we will talk mostly about how we need to improve street lighting in India, and particularly in regards to conversion of to energy efficient lighting so that we can save energy and so on. So, it is one of the as you know, street lighting is one of the most important and expensive responsibilities of the city. And around 10 to 38 percent of the total energy bill in typical cities worldwide goes for street lighting.

Now, so that means that if we can save on this particular energy, we will also be able to save on lot of money as well. And also, the other aspects of street lighting is the reason we provide street lighting is because the primary reason is for safety. That means if a street is well lighted, or if an urban area is well lighted, then of course, we feel more safer. And of course, the number of crimes and all is directly correlated with the kind of street lighting that is present in an urban area.

Then the cost savings that we can do. Usually this is an expensive affair, because not only it is the capital costs, but also, we need to run the street lighting operations throughout the year that leads to a lot of energy bills. So, if we can reduce a lot of cost in street lighting, in that case, we can actually expand to new areas to provide street light and also in many low income and other underserved areas, which are currently they are in an urban area.

So, in Indian cities, we see that major roads are lighted, but many minor roads or certain areas of the cities are not lighted. So, if we can improve on energy efficiency of the existing system, the savings would be actually used to expand the lighting network in other parts of the city. So, around in India, we have got around total 35 million streetlights roughly rough estimate which is around and it consumes around 1.5 percent of the total energy required of the country, so that is a huge amount of energy that could be saved by improving upon the streetlights.

And Bureau of Energy Efficiency as per Central Electricity Authority statistics states that the gross energy consumption for public lighting in India comes to around 6131 million kilowatt hours. Now, this currently government of India is working on the Street Lighting National Program, which wants to replace the different conventional streetlights with smart and energy efficient LED streetlights and rough estimate is around 21 million streetlights with LED would be eventually replaced it will be replaced by these 21 million streetlights with LED lights and this project is executed by the Energy Efficiency Services of India.

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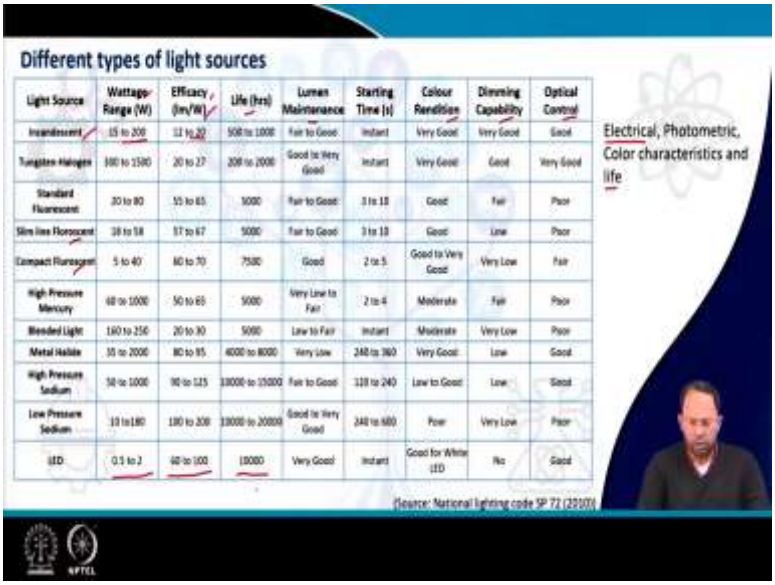

Now, this is a list of the different kinds of light sources that we usually use in urban areas starting with incandescent light. So, this is the basic you know the older light sources now we are replacing them with different other kinds of light particularly fluorescent light and there are different types of fluorescent light usually we are in India we are replacing them with T5 fluorescent lights and so T5 actually T is for tubular the shape of the light and this 5 is for the what is the you know the width of this particular light and so on.

The diameter or the size of that particular light, now these are the different kinds of light the applications are different like for example, we some applications require a lot of light the power the total amount of light should be more in others, we want the quality of the light to be better and so on. So, you can see that we considered when we select a particular light or luminaire that means, the total overall lighting fixture the total unit in that case we considered electrical properties of the light that is around what kind of power it consumes that you can measure it in Watts, then we consider also the efficacy of the light that means, how much light is produced per watt or per power of light per unit of power of light which is given by this lm by W luminescence by watt.

Then life hours of the, then we talk about the life of this, if the life hours is more then it does not requires replacement pretty often, lumen maintenance that means, how good the quality of light or the amount of light remains throughout the lifecycle of this slide. If it fails down then of course, we have to replace it, then starting time in case it goes up how much time it takes take to again come back, then suppose there is a power cut immediately after power cut when power comes how long again it takes to for the light to come back, colour rendition how good things look under this particular light, dimming capability, optical control, these are different parameters.

So, you can see that while incandescent light the wattage range is around 15 to 200 and efficacy is around 12 to 20 whereas for LED it comes to around 60 to 100 or and the wattage range is very very low and the total life hours of LED is also very high. So, you can understand if I can replace incandescent lights with LED lights, of course, we will improve not on the cost, but also on the overall maintenance of this lights as well.

So, but there are certain positives and negatives for all this light. So, these are considered while selecting which particular light source would be better for a particular application. So, we will discuss that how we are going to improve upon different light sources and so on in the later part of this lecture.

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So, coming to the standards for street lighting in India, we usually refer to three standards, one is the IS 1944 which was actually prepared during 1981 Code of Practice for Lighting of Public Thoroughfares. So, this talks about how do we should design lighting system for different roads and all and it talks about the basic principles the lighting for main roads, secondary roads, and also other urban roads as well.

So, it also talks about intersections as add grade and you know and different grade separating intersections as well. Now, in addition to that, it talks about design and choice of equipment, siting and appearance and lighting criteria for different areas. Now, this is just for public thoroughfares, whereas the current code which is prepared by the Bureau of Indian standards, this is the national lighting code SP 72.

This is the lighting code, which is pretty elaborate, and it covers different aspects of lighting in urban areas. So, it is not only about thoroughfares but for different, you know different applications in urban areas. So, it talks about its specifies the different regulatory practices. In addition, it talks about minimum lighting levels, quantity and safety parameters to protect the interest of public that is what is the minimum amount of light required to for the, safety of the people and what based on what people would actually be comfortable with.

So, based on those lighting standards have been created. And it also talks about lighting products and methods of lighting design and installation overall. And it covers different kinds of lighting for example, it talks about interior illumination inside buildings of different kinds of buildings, exterior illumination, in urban areas, so you can understand being when you are

designing lighting systems in an urban area, it is not only just for roads, but also for other areas as well.

For example, industrial areas, what sort of lighting should be given security lighting, decorative lighting, suppose you want to light up a monument or a park or a garden, what sort of lighting needs to be provided? Then utility areas such as docks and harbours, railways, airport, aprons, then sports stadium, mass rapid transit systems, hazardous areas then road lighting, energy efficient, then how do I replace current lighting with energy efficient lighting, what should be the way we should measure it? So, those are covered over here daylighting for buildings and emergency lighting and maintenance. So, these are the different aspects covered in this national lighting code. And you can just download it and you can take a look and it is a very nice document which gives you a details of what sort of lighting systems or lighting standard should be adopted in India.

Finally, we have the Bureau of Energy Efficiency Guidelines for energy efficient street lighting. So, this talks about practical, gives us practical guidance on how we should convert standard lighting to energy efficient street lighting. And for that it also specifies different kinds of street lighting poles specifications, their mountings how we should mount different kinds of streetlights and finally, energy efficient practices such as dimming and recommended dimming of lights at different times of the different times based on illumination levels, based on the different road types and so on.

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So, talking about the design principles for road and street lighting, first of all, we have to look into energy savings, so, we can choose efficient technologies and designs which leads to

energy savings, then comes the capital cost, now capital cost is a one-time investment cost, but after that, there is regular maintenance and also operating costs.

Now, where the capital cost could be determined based on what sort of light we are using and also what spacing we are giving between the lights and where we are placing them on are replacing them on both sides of the road or on one side of the road and so on. Then maintenance cost of the light it depends on the life of the lamp and also how often these are placed because the mode amount of poles you use the maintenance cost will be higher, you have to clean the lights, you have to replace certain kinds of faults. So, that increases the maintenance cost.

Then reduce glare and improve visibility. So, this is more about the quality of the light. So, that means the watt lamp or luminaire you are selecting that actually plays a role, then achieving security through light, so adequate levels of lighting should be provided it should be a provide safety to motorists, cyclists and pedestrians.

So, motorists require certain types of light, cyclists and pedestrians who are primarily at the side of the road, along pedestrian pathways or bicycle tracks, they require other kinds of lighting systems. So, overall the visibility of the roads not only does not matter, it is also the road as well as the surrounding. So, we have a parameter called surrounds, which measures that what proportion or what ratio of light is also reaching the surrounds, surrounding areas of that particular road, because you just cannot light the road the surroundings if you light then you can see that if somebody is willing to cross or there is a stray animal, all these things needs to be looked at.

So, other than that the pedestrians, cyclists they should be able to look at road signs, it should be give a visual comfort to the driver. So, we should ensure that. Now, the lighting pattern along the road in what way you are providing light should also give improved traffic guidance that means in which direction the road is curving, so the shape of the road identity.

So, it should help us in identifying the bends and the curves as well as if there is a change in the road width or if there are obstacles we should be able to immediately detect it. So, it is not only just about the lighting levels, but also in the way we arrange the lighting poles and all along the road edges and all that also gives us an idea about what sort of lighting is provident.

Then continuous and uniform lighting, that lighting also should be very uniform that means along a particular length of a road, the lighting levels should be uniform all throughout. So,

there are also certain measures called for uniformity, longitudinal uniformity, then there is other forms of uniformity as well. So, it talks about that in a stretch of road, the lighting levels should be uniform throughout and at the same point of time within a road itself within that particular road there also should be uniformity towards its width as well.

So, overall lighting should give pleasant environment and overall if I provide lighting in an urban area, usually it leads to also it could be related with economic development of that area as well. Now, a few parameters that we should be concerned with one is the luminescence level of the light. So, luminescence level means the amount of light finally reaching your eyes reaching a user's eyes and that gives us the luminescence level and usually it is candela per meter square. And this is based on the light distribution of luminaires that we are using, the luminous flux of the lamps, the geometry of the installation and the reflection properties of the road surface. So, all this influences the luminance level that we are able to achieve.

Then illuminations level is actually how when the light falls on a plane surface like the road surface, what sort of illuminance is happens so that is another parameter, illuminance uniformity that means overall uniformity, longitudinal uniformity and surround ratios. We have mentioned longitudinal uniformity, how uniform is the lighting level throughout the length of a road, then surround ratio is what sort of lighting is there for the surrounding areas.

So, all this comes under illuminance uniformity, then degree of glare limitation suddenly there is a bright source of light it can blind you or it may you know make everything else less visible. So, degree of glare limitations should be also considered. And finally, the lighting should give visual guidance such as the location of poles, different lamp colours, we can vary the lamp colours to add a signify certain changes and use of high masts in case of intersections and all we go for high masts lighting greater than 20 meter, which actually helps us to give uniform you know lighting all throughout and if I put multiple poles at different grids it usually creates confusion.

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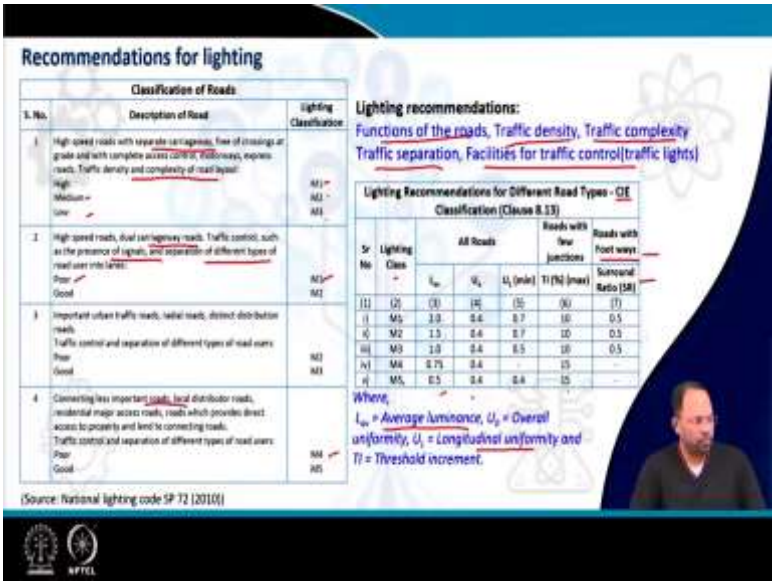

Now, these are standard charts which are provided in the code. So, for different categories of roads or different classifications of roads like road like separate carriageways, or expressways. Here, you can see that based on traffic density and the complexity of the road layout, if it is very high, medium or low traffic density or complexity, then lighting classification are given as M1, M2, M3 and so on.

Now, if the road is a dual carriageway road traffic control is there like presence of signal separation of different types of road users into different lanes, like there are pedestrian pathways bicycle tracks, then there are multiple lanes and there are high occupancy vehicle lanes and other sorts of lanes.

Then if the segregation in lanes is poor, then we go for M1 if it is good we go for M2, same way we are having other roads like less important roads, local distributor roads, we can go for M4 and M5. Now, these are CIE lighting recommendations based on CIE classification. And you can see that based on the functions of the road, traffic density, traffic complexity, traffic separation facilities for traffic control, we determine what sort of lighting levels should be important.

So, here you see the lighting class is given M1 M2 to M5 as per over here, you have seen that. So, multiple parameters are measured one is Lav, which is average luminescence that should be there. So, that values are given in this is 2, 1.5, 1 for the. So, as you see that the more or lesser important the road is the value is less and the this is candela per meter square. So, this is luminescence. Then U0 is the overall uniformity of that particular lighting level, UL is a longitudinal uniformity and TI is the threshold increment like roads with few

junctions and then this roads with footways you can see the surrounding ratio as you can see there are pedestrian pathways. So, the surround ratio has to be in more and this and in case of junctions the threshold is also it varies for different categories of road.

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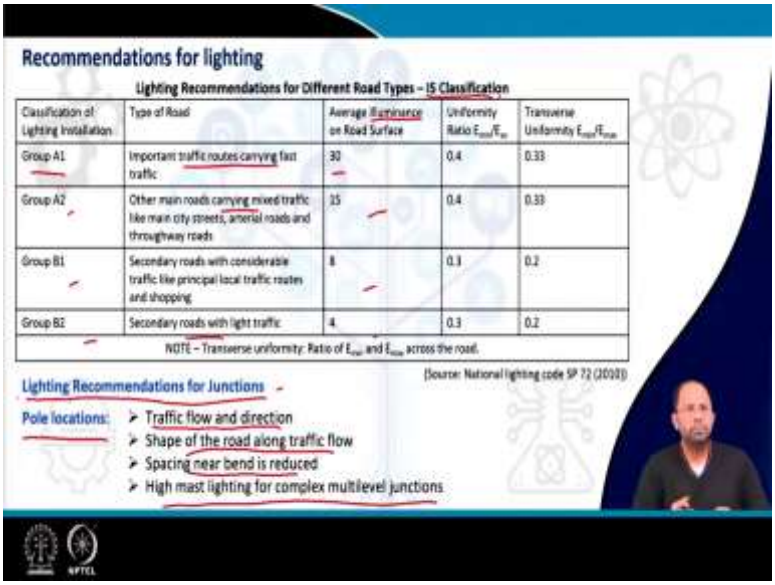

Now, for based on IS classification, there is another way to classify the different kinds of road, then for example, important traffic routes getting fast traffic it falls under Group A1 here the lighting level is given in form of illuminance instead of luminescence luminance, so illuminance is in lux. So, you as you can see this value is 30 lux and uniformity ratio is also given which is 0.4 and transverse uniformity is 0.33.

So, these are similar to you know the other uniformities that we discussed. So, one is transverse across the road and the other is longitudinal that we discussed earlier. So, overall you can see we have group A1 A2 B1 B2, B2 as secondary roads B1 as secondary roads with considerable traffic A2 are other main roads getting mixed traffic like city main streets and so on. So, accordingly the luminescence levels vary.

Now, similarly, there are lighting recommendation levels for junctions which are more or less similar to the roads as well but certain considerations for high mass lighting and all these things come for junctions. So, anyway we are not focusing too much on the technical recommendations part because that is where illumination engineers or illumination specialist will come and actually determine what sort of lighting levels will be determined, but what we are focused on is we understand these different concepts so that when we replace this with when we create plans for upgrading the lighting system and all, so then we can make the right decisions.

Now, the poll locations are also important. So, along with the lighting quality of the lighting levels, the poll, how we organize the polls, that is also important. So, it depends on the traffic flow and direction. So, as I was saying that when there is a bend we should give the polls in such a way so that it can show us that the light that the street is bending.

Shape of the road along traffic flow spacing near like for example in the bends, the spacing between the poles are reduced, then high mass lighting for complex multi-level junction. So, these are the different considerations of what alternative is better, which not only improves the lighting level but also visual clarity or guidance to the travel to the pedestrians, guidance to the vehicle users and so on.

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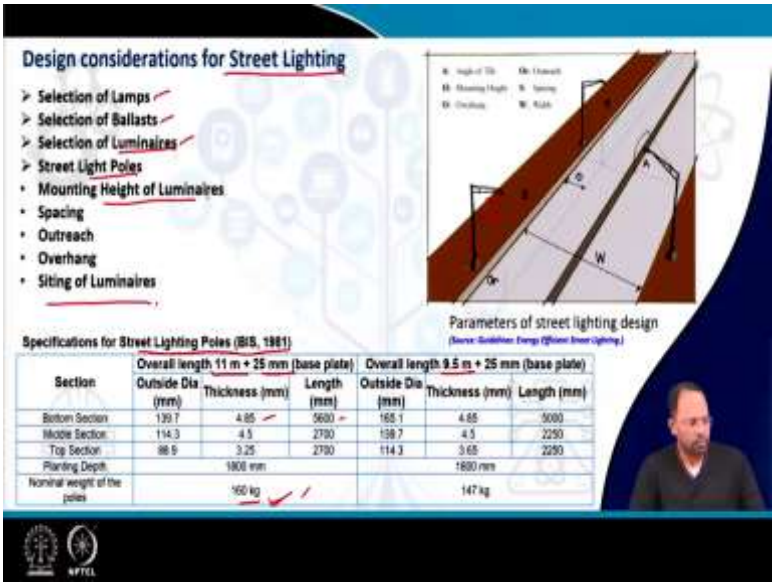

Now, the overall design considerations for street lighting, it involves selection of the lamps, selection of the ballasts, these are electronic or electromagnetic components which determines how much electricity power could go into the lamp, so that there is uniform lighting and all. Then selection of luminaires that is the final unit that entire package of the light as well as the housing and everything is that luminaire

So, this overall package of this, what should the design of that, then the streetlight poles, the design of the poles against streetlight poles have got different parameters to consider like mounting height of the luminaire at what height we are putting the luminaire, spacing between gap between the poles, outreach that is an outreach and overhang, overhang is how much it is hanging into the street, if it is too long, then what happens the light does not reach the cars and all this and that can create accidents over outreach is basically the distance between the center of this particular pole and the center of the luminaire.

So, this is the outreach, this is particularly of concern for aesthetic concerns, architectural concerns and so on. And then sighting of the luminaire that means that where should I place the lights and so on. So, these are all the different aspects that should be covered. So, the specifications of streetlighting poles are given in BIS 1981 as you can see that there are 11 meter poles with a 25 mm baseplate or 9.5 meter poles.

So, you can see the diameter that we are usually using and the thickness of those particular poles and the length of the poles and so on. And overall you can see the planting depth as well as the weight of the poles. So, these are important why? Because as you can see based on the weight sometimes the cost is determined, based on material or as well as the weight of the pole.

And sometimes there are a lot of accidents that happen along the streets and many times these poles are damaged because of accidents and this has to be replaced. So, all these parameters comes into play in determining what is the cost of replacement as well as you know repairing as well as removing the pole from one location to another.

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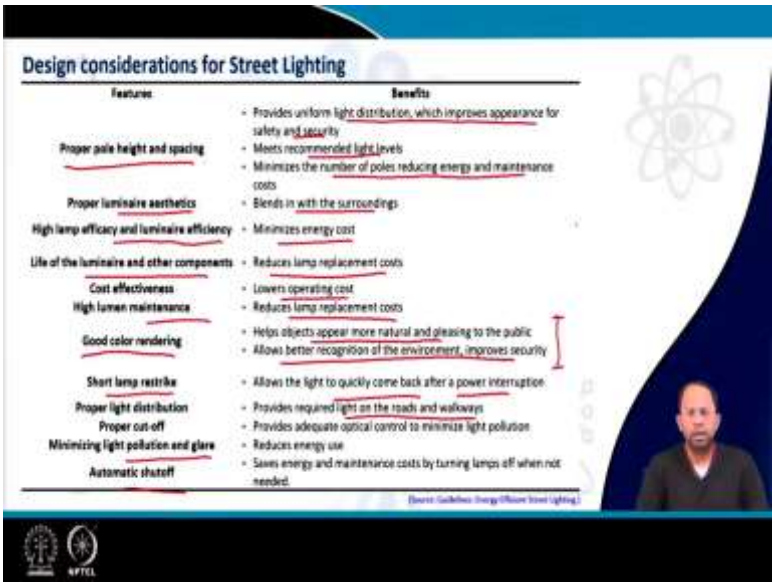

Then just summarizing whatever we have learnt. So, proper pole height and spacing is important. It provides uniform light distribution which improves the appearance of safety and security, meets recommended light levels, minimizes number of poles reducing energy and maintenance cost, then proper luminaire aesthetics, so that it blends into the surroundings looks nice, high lamp efficacy and luminaire efficiency minimizes the overall energy cost, life of luminaire and other components reduces lamp replacement cost, cost effectiveness, lower operating costs, high lumen maintenance, reduces lamp replacement cost.

Because if the lumen levels remains stable all throughout its life then of course we do not have to replace it, but if it falls down drastically in the middle of its life, then we have to replace it because maybe we would not compromise on the light levels, this lighting levels. Good colour rendering allows better recognition of environment improved security helps objects appear more natural and pleasing.

So, these are more aesthetic aspects then short lamp restrike that is how once the light goes out after power interruption how quickly the light can come back, proper light distribution provides required light on roads and walkways, proper cut off, minimizing light for pollution and glare, automatic shutoff so that we can use timers and all these things. So, all these different aspects are considered while we design street lighting system or we designed replacement for street lighting system with energy efficient equipment.

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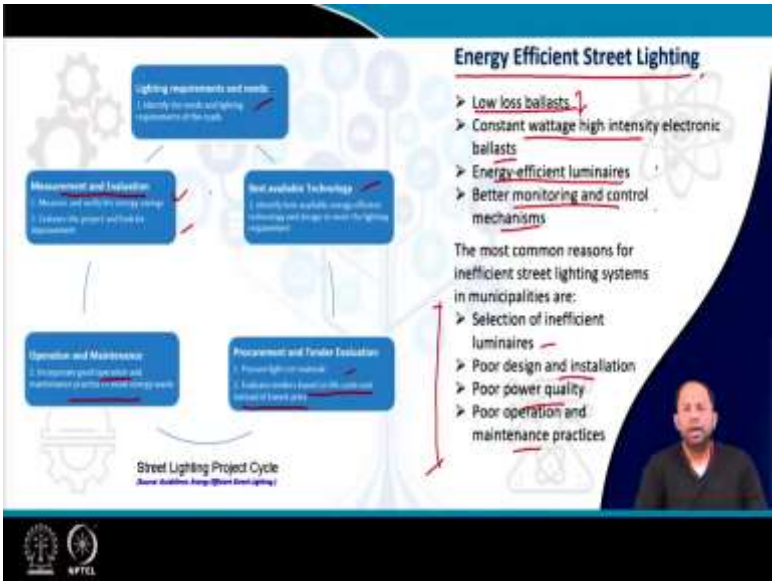

So, for energy efficient street lighting, this is you know these projects are going on in urban areas in today's context. So, usually we will go with low loss ballast that means the electronic component that controls the supply of electricity and other aspects in a luminaire we will go in such a case that we there is less loss of energy over here, then constant wattage high intensity electronic ballast is preferred and then instead of electromagnetic ballast, then energy efficient luminaires better monitoring and control mechanism.

So, we have to improve upon all these different aspects not only one in all aspects and the common reason for inefficient lighting are selection of inefficient luminaire, poor design and installation, poor power quality, poor operational maintenance practices. So, we have to be careful about all these different aspects.

Now, if I just go with the project cycle, so of course we have to choose the best available technology we have to first identify that what sort of lighting is required for what purpose we are using that light. First, we determined that for that we have to do proper audits and all and then once we do the tender, the tender can be just on based on the cost of the light of the material that we are procuring, but it also has to consider the overall lifecycle cost instead of the lowest price. Otherwise, what happens because we will buy something which is the cost low but in overall maintenance cost would be high or maybe the operating cost will be even higher.

Then finally, we have to have a good operation and maintenance practice or strategy. And finally, we have to measure that what actual improvement is happening because of this replacement. So, if I do not measure and evaluate properly with proper baselines, that what was earlier energy consumption now, we are what we are consuming, then probably the overall replacement project would be a failure. So, this is very important as well. So, this is how we go about with the energy efficient street lighting projects or selection of energy efficient street lighting for current lights, lighting systems.

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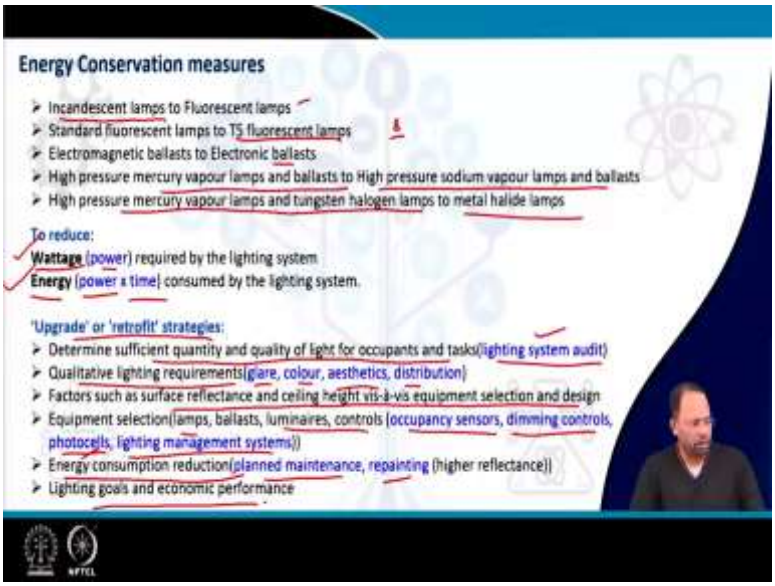

So, certain strategies which are listed in the National code, for example, first of all we should convert incandescent lights to fluorescent lamps, this is the first step, now standard if there are already standard fluorescent lamps we can improve them to T5 fluorescent lamps. Some people also choose other ones but T5 is recommended. T5 is again tubular lamps. And the ratio is you know, if the it is 5 parts, it is 5 by 8 inch diameter, then you take a 5 inch diameter something in the ratio would be 5, something like that.

And then electromagnetic ballasts to electronic ballast, then high pressure mercury vapor lamps and ballasts to high pressure sodium vapor lamps and ballast, then high pressure mercury vapor lamps and tungsten halogen lamps to metal halide lamps. So, these are the basic strategies that you can follow, but of course, you required experts to give actual to do that proper selection of the lighting system or the lighting luminaire.

Now, our goal is to reduce two things one is to reduce the overall wattage that is the power consumption, this is and the other is to reduce the overall energy, energy is power multiplied by time. So, we reduce both wattage as well as energy for a system, then only we can achieve better efficiency. So, some of the upgrade or retrofit strategies that we can adopt to determine sufficient quantity and quality of light for occupants and tasks.

So, this is the first step which is also known as the lighting system audit, then qualitative lighting requirements needs to be determined like how much glare, what kind of colour rendition properties, aesthetics of the luminaire distribution, how many so, all these things play a role, factors such as surface reflectance and ceiling height, we service equipment selection and design.

So, overall this also is important, then equipment selection involves lamps, ballasts, luminaire control. So, lamps and ballasts are definitely part but luminaire control is like based on occupancy sensors of a particular room the light will turn up or occupancies instead of a road the light will turn up, dimming controls, we can dim the lights at different times of the day, photocells then lighting management system. So, overall that lighting management system is like recording at different conditions we can sense what kind of lighting is there based on that we can do control the lighting of this particular luminaire and so on.

So, and then recording the data and so on. So, this overall management system is there. And then we can of course have solar lights and also this part is also important, then energy consumption reduction by planned maintenance and repainting. So, if I clean the lights, then the lighting output improves, if I replace certain you know certain components and all at certain intervals, then probably the overall energy efficiency will improve so, this is also important. And finally, the overall lighting goals and economic purpose performance also needs to be understood.

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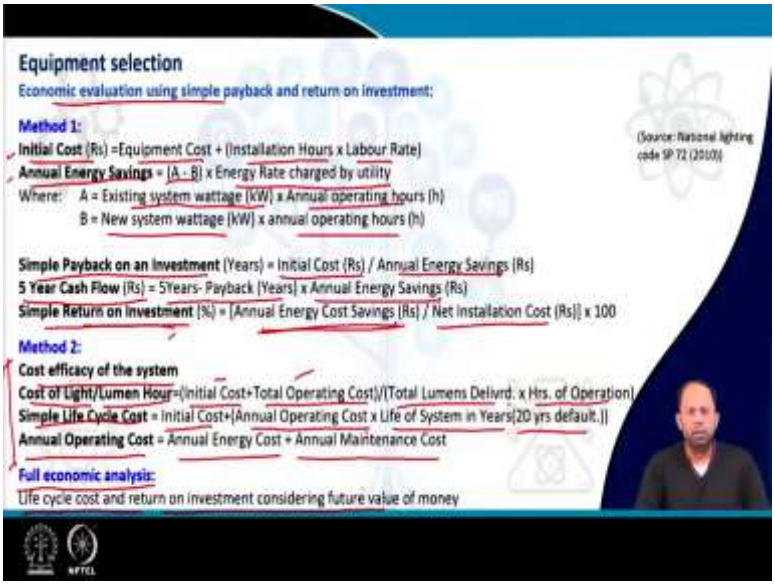

So, how do I choose the right equipment when we are doing this kind of projects of energy efficiency improvement. So, we do economic evaluation, and there are different methods to it. The first method is we just do a very basic calculation of we determine what is the initial cost that is equipment cost, there is a capital cost plus the installation cost and of course which is installation hours multiplied by labour rate.

Now, the overall annual energy savings is computed by A minus B where A is existing system wattage into annual operating hours. So, this is kilowatt hours, and B is the new system wattage into annual operating hours, we expect that the earliest system was more so that is why A minus B. So, multiplied by the energy rate charged by the utility company.

So, that means per hour energy rate multiplied by energy savings, which is calculated by A minus B and we get the overall annual energy savings. Now, this is initial cost, this is annual energy savings, how do I determine the overall benefit and all? First we can determine the simple payback on an investment in a number of years.

That means this is the overall initial cost that I have to invest and every year I am saving this much money. So, I will be able to recover my investment, which is initial cost divided by annual energy savings. Now, the other way to other measure these 5 year cash flow that is the total amount of money invested in money coming in. So, usually, it is the 5 years or whatever years of payback, that you are considering multiplied by annual energy savings, that will give you an estimate of savings all throughout this you know, this particular period.

Then simple return on investment, which is annual energies, savings cost savings divided by net installation cost into 100. So, that is a what percentage of money we are recovering every year. So, that is simple return on investment. Now, the second method is to look into the overall cost efficacy of the system, instead of just the amount of money that we are investing and when we are recovering.

So, here we look into cost of light divided by lumen hour. So, that means what is the amount of money we are investing divided by the hour. So, which includes initial cost of the light plus total operating cost divided by total lumens delivered into hours of operation. So, that means for per unit amount of light delivered, what is the amount of investment I have done.

So, this is initial cost and total operating costs divided by total lumens delivered divided into multiple into hours of operation. Now, simple life cycle cost in this particular case would be initial cost plus annual operating cost, which is basically we are expanding the total operating cost into annual operating cost into life system, life of the light system that we are now putting in.

So, by default it is 20 years, but based on the actual selection of actual luminaire or actual lighting system that we are choosing this value can vary. So, annual operating cost is equal to the annual energy cost plus the annual maintenance cost. So, overall this can be utilized. So, this is the second method in which we can also compare between two or multiple systems and we can choose the best system which should be used to replace that current system.

Now, in addition, we can go for more elaborate economic analysis. So, instead of going with this, we can look into the overall lifecycle cost of a particular system or a particular technology that we are using now and also and return on investment considering even the future value of money. So, that is unnecessarily complicating the calculations to come to a more you know, elaborate calculation to say which one is system is better. So, either you can go with any one of this method to come to a decision that the equipment that you are using to replace the current equipment would be better or not.

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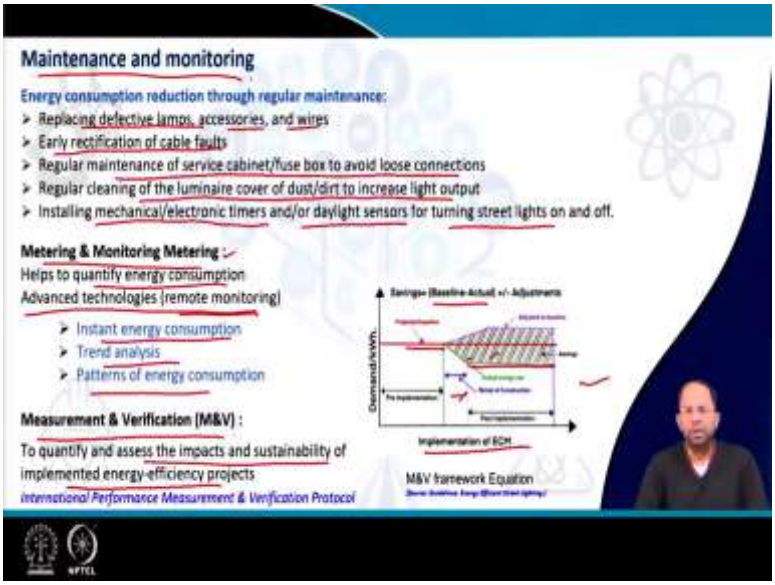

So, finally the third the final part is maintenance and monitoring. So, overall energy consumption can be reduced via regular maintenance. And here we can replace defective lamps, accessories and wires, at certain intervals, we can early rectification of cable faults, regular maintenance of service cabinet fuse box to avoid loose connections, regular cleaning of luminaire cover for dust and dirt to increase the light output, so that you know the overall lighting system is fine, installation of mechanical electronic timers or daylight sensors for turning street lights on and off. Instead of using manual input we use this automatic system so that it becomes much more efficient.

So, usually we do metering and monitoring to determine how much amount of energy is being consumed. So, to quantify energy consumption, we do metering of streetlights as well. And usually this bill is paid by the ULB. So, they have to do meter because they need to keep records of how much money we are paying to the electricity company.

And sometimes we can do advanced technologies such as IoT and other systems where we can do remote monitoring of when the lighting system is getting on when it is off, and we can do some predictions as well. And we can also determine what amount of energy is being consumed. We can do some trend analysis of energy consumption during different seasons.

And finally, we can find these patterns of energy consumption which can help us to design more efficient overall energy management or this lighting management systems. So, this measurement and verification is once we are doing a lighting project and all we have to really quantify and assess the impacts of the sustainability of implemented energy efficient projects.

So, that is why we can do this kind of frameworks where we you can see that this was the current baseline that is the before change, this is what the amount of energy that was consumed, and this and then then there is a period when change happens and then finally, the value comes down. And this we have to determine by the savings which is the shaded area. So, this is how we can actually determine like savings is equal to baseline minus actual plus minus the adjustment that also happens.

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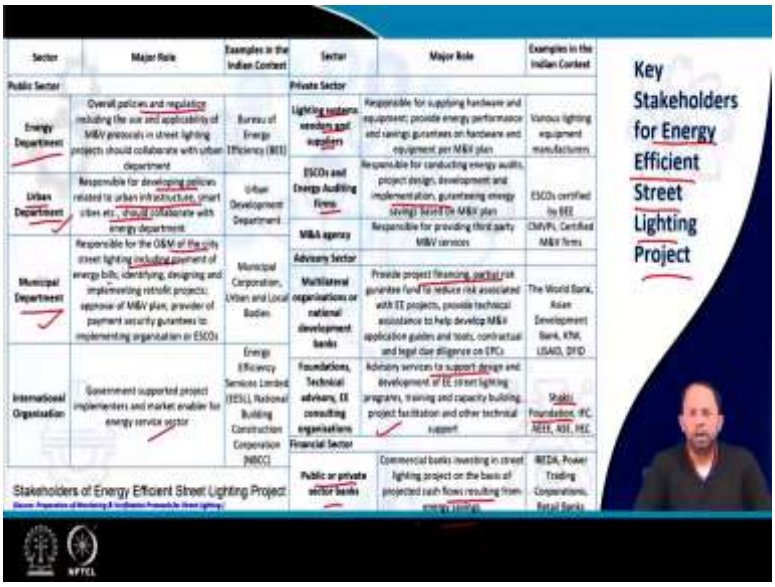

So, coming to the key stakeholders for energy efficient street lighting projects, so I will just go in broad aspects, the Energy Department, which creates the policies and regulations and also the different the urban department which is responsible for developing policies related to urban infrastructure, smart cities, and which stretches should be changed in all those different aspects.

And all the policies on what sort of lighting should be utilized, what should be the funding structure, all these things are determined by the urban department, the municipal department is actually responsible for street lighting and operation and maintenance. So, they are the ones paying the electricity bills, so they identify and the final project stretches and all these things, and they identify all the other aspects and the final selection is done by the municipal department.

Now, international organizations as always, they provide funding support or technological support or technical support as well. Now, in the private sector light, the lighting systems are vendors and supplies are there who will provide the different options for different technologies that could be utilized, then energy auditing firms can give us ideas about the

overall project design, the development and implementation strategy, what sort of savings would be done, so they can actually do that.

Then other third party M and V services providers could be there, then advisory sectors could be the different financial partners, then there could be some technical support, NGOs and all like Shakti foundation and all these NGOs actually can help us in designing the overall programs for change and so on. So, this is where urban planning comes into the picture. And finally, the private and public sector banks, which will fund this entire project based on amount of energy savings and cash flows that happens for these kind of projects.

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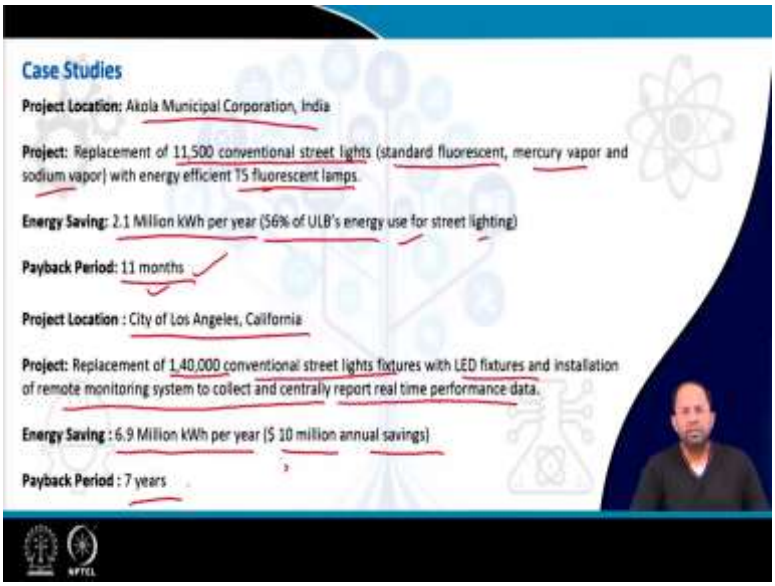

So finally, coming to a case study, first we will discuss Akola Municipal Corporation in India, where around 11,500 conventional streetlights, were replaced. And with energy efficient T5 fluorescent lamps that light replaced were standard fluorescent, mercury vapor and sodium vapor lamps were replaced with T5 fluorescent lamps.

The energy saving estimated was around 2.1 million-kilowatt hour per year, which is around 56 percent of the ULBs will be selling, so if the ULB will be was paying around 10 crores for lighting, it lighting bill would come down to even something around 5 to 6 crores. So, you can understand the amount of energy savings that will have the amount of cost savings that will this will result in, the overall payback for the period is 11 months that means we are recovering the entire cost or project cost within 11 months of implementation of that project.

The second project is city where replacement project was held in California in Los Angeles, where 1,40,000 conventional streetlights were replaced with LED fixtures, and it was also

fitted with remote monitoring systems to collect and centrally report real time performance data. So, this is where IoT systems comes in. So, overall energy savings was 6.9 million kilowatt per hour, and this led to around 10-dollar million annual savings, so you can understand. So, in this case, the savings was one third roughly so you can understand the cost would be 3 million improvement would be something around 3 million dollars. And the payback period in this case was determined as 7 years.

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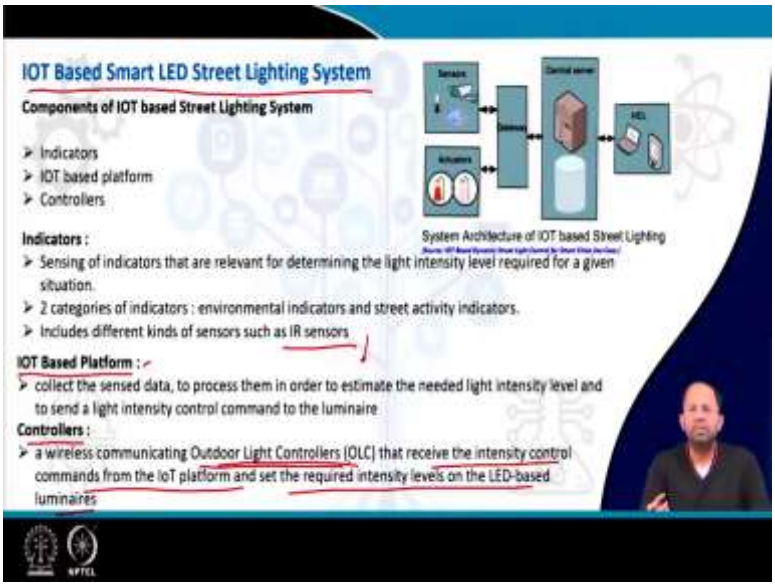

Now, finally, coming to smart lighting systems, like this is a case study of IoT based LED street lighting system. So, this is where you have to understand that there are different sensors, which will sense the suppose I want to turn on a particular light, I will turn on when there is occupancy of the road, or when certain the level of illumination actually goes down. And we will turn on the lights. So, we have to have certain sensors.

So, one could be a sensor which detects the amount of light in ambient light, the other sensor could detect the movement. So, we can go for IR sensors for determining movement, we can determine some sort of ambient light sensors as well. So, these sorts of sensors record a sense the surrounding environment. And based on that it sends information to an IoT based platform, which is a microcontroller. It is basically you can say it is a small system where it is a computer system, or it has got a microcontroller, it can make decisions it is a smart system, where all this data coming from the sensors is processed, and then analysed.

And then based on that based on the algorithms based on the firmware that is written in that microcontroller. Or the program that is written in that microcontroller, it can take smart decisions that if this is the elimination level, this should be the amount of we should turn on

this this light or this should be the dimming level. So, all these things that determined there in the microcontroller.

So, that is the IoT platform it also IoT platform is not only the decision-making part, but also receiving of data and then transmitting of data all these things are part of the IoT platform. So, this data could be sent to the central servers as well over a GPRS connection or over a and then the location there could be a GPS chip embedded, which gives us location of that particular pole and then there are controllers that is we want to do something.

So, that means once the data is there, we take a decision. Now, we want to take a decision like turning on a light. So, there are outdoor light controllers, we can call them sometimes we use actuators like if I want to turn a motor we will use actuator or we have outdoor light controller in this particular case, which actually can receive the intensity control command from the IoT platform and set the required intensity level of the lead-based luminaire. So, this is how IoT platform actually increases cost of goods but at the same point of time, make the entire system intelligent so that we can save a lot on energy as well.

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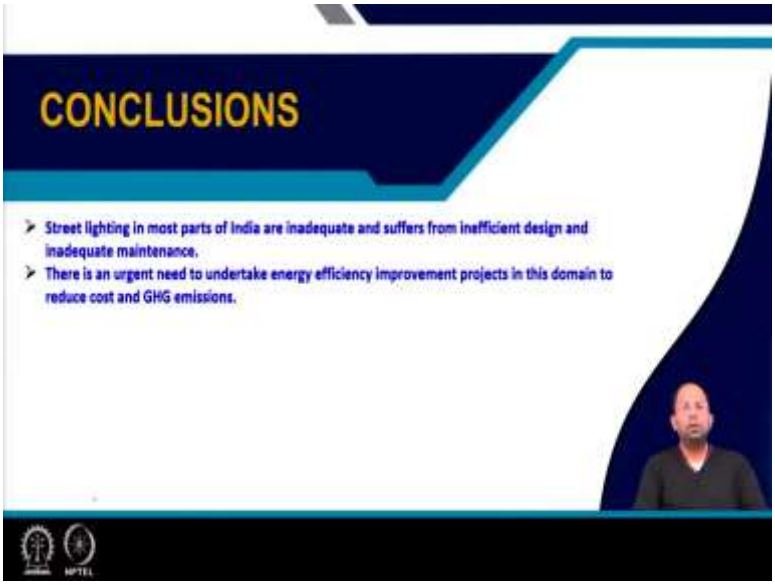

These are some of the references that you can study. To conclude, street lighting in most parts of India are inadequate and suffers from inefficient design and inadequate maintenance and there is an urgent need to undertake energy efficiency improvement projects in this domain to reduce the overall cost and greenhouse gas emissions. Thank you.