Sustainable Transport System
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Lecture 51
Case Study-II: Mass Rapid Transit (MRT) Systems

Hello friends, you may recall our last interaction on a BRTS, Bus Rapid Transit System in that we studied the success story of Bogota, BRTS system and then some limitations and failures of Delhi BRTS and the success story of Ahmedabad BRTS, today we will discuss about Mass Rapid Transit systems and for that, we will study the success story of Delhi Metro as a case study.

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So, means the introduction will be there little bit about Mass Rapid Transportation system and then case studies will be focused only on Delhi Metro, but various aspects will be considered like, what were the timeline, how it was implemented and planned, then various policies which has affected or influenced the growth of Delhi Metro and then very good initiatives or green initiatives, which has made this Delhi Metro as a wonderful case study all over the world and then the integration with the rapid Metro of Gurgaon which is small town, now a big town in the earlier it was a very small town, but now a lot of MNCs offices are there, so it is in NCR that is National Capital Region and this is the town of Haryana, but just at the border of Delhi.

So, the rapid Metro Gurgaon how it was integrated with Delhi Metro and then some challenges means, not all things are very good, but there are certain limitations or challenges or lessons to learn, so those things will be there and ultimately, we will conclude this lecture.

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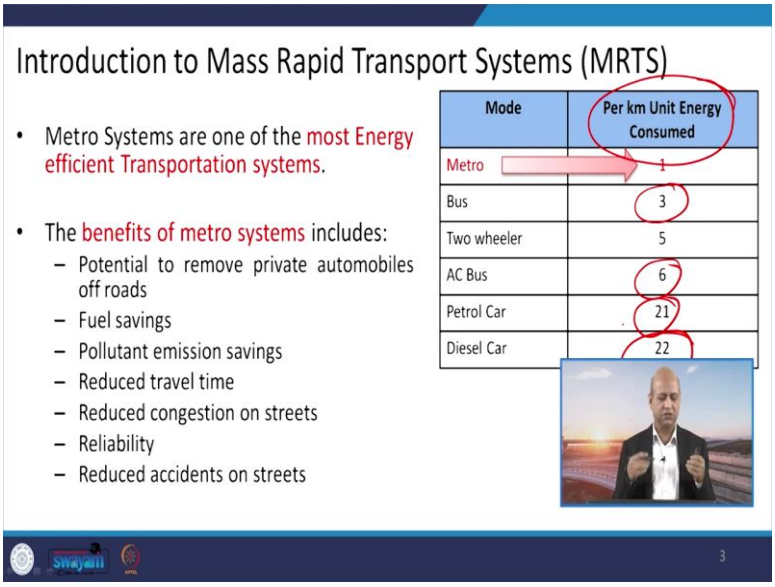

So, when we talk about this brief introduction of Metro system, basically we will focus upon energy consumption and then the emissions means, exhaust emissions which are avoided by metro system, now very small indicator which is very good indicator you can see like per kilometre unit energy consumption.

So, in moving one kilometre how much energy is consumed by a system like, Metro consumes if 1 unit and bus consumes 3 units, thrice, 2 wheelers 5 units, AC bus 6 units petrol car 21 times and diesel car 22 times, so that means metro is the most energy efficient transportation system in comparison of these other vehicular transportation systems, so there are various benefits in the sense because, it removes the need of privately owned vehicles when we shift from that sector to Delhi this metro system or MRTS and then emission saving in the sense means, those emissions are avoided which were otherwise when we ride the bus or car, fuel saving is a lot and then reliability because the complete system is dedicated corridor there is no other chances of delaying except some in a very rare case, but that is again means from the reliability aspect this is one of the wonderful system and accidents which you can see on the roads and streets there are no chances of such accidents in the metro system.

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So, you can see this one pictorial representation of Delhi Metro, which is the case study for today, so at various places it is elevated at some places it is underground, so this is a mixed kind of in different phases this Delhi Metro was built.

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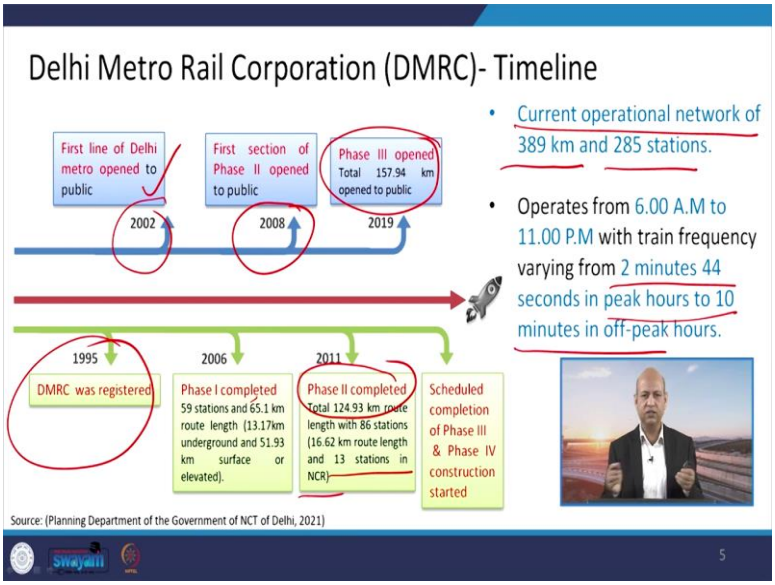

In 1995 this was registered DNRC that is Delhi Metro Rail Corporation the timeline is represented here, in 2002 this first line of Delhi Metro was open for public, in 2006 the phase one was completed and around 59 stations were covered and 65 kilometre route length was achieved by this phase 1, in 2008 first section of phase 2 was opened, in 2011 phase towards completed and it could cover around 125 kilometre metres stretch or the route and 13 stations

were in the NCR means outside Delhi, but in National Capital Region and then in 2019 this phase 3 was opened total around 158 kilometre and this was open for public.

So, now this phase 4 is going on and you can see the total network current operational network is around 389 kilometre means approximately 400 kilometre with 285 stations and it runs from 6 am in the morning to 11pm in the night and during peak hours when a lot of people are travelling then the frequency is quite high every 2 minutes and 44 second 1 train is there 1 and in non peak hours around 10 minutes is the gap of these Metro trains. But, that is not a huge gap you can have your next train, if you just miss the first one.

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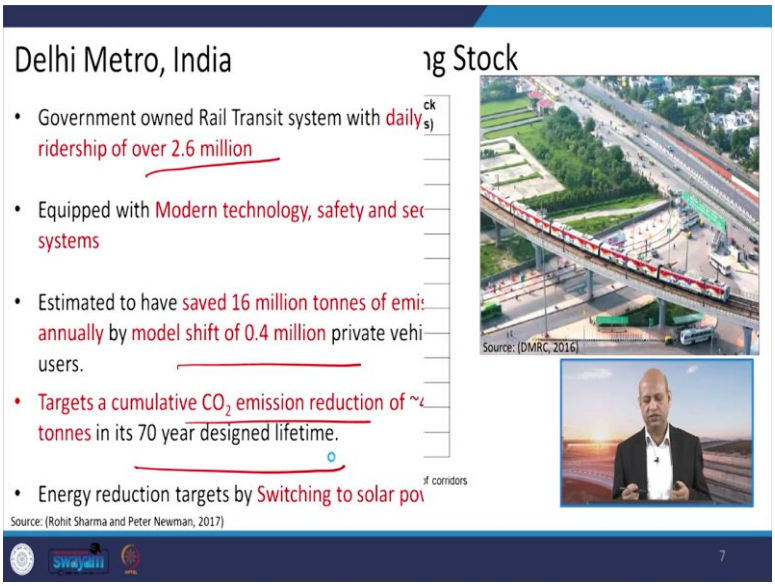

The ridership is very large like 2.6 million people daily using this Delhi Metro and it is equipped with very high reliable technology of modern days in terms of safety and security systems and then, if you see in terms of emissions 60 million tonnes of emissions annually it is reducing, because of modal shift of around 0.4 million private vehicles, so that kind of emissions saving is there or avoidance is there well target of cumulative CO2 emissions reduction around 4.8 1 million tonnes in its 70 year design lifetime, so this is estimated figure and solar power is also being inbuilt or integrated in the whole system, so that it can have the renewable resources integration and that way further reduction in emissions.

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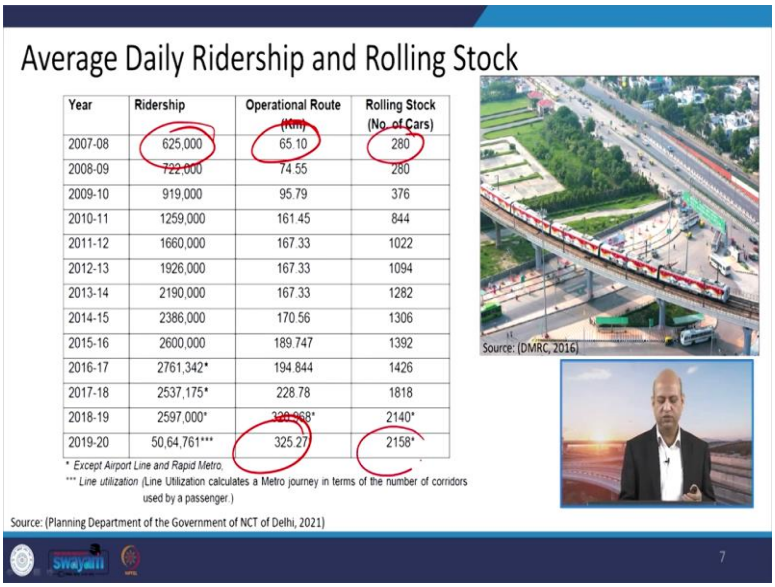

You see the ridership increase from 2007 to 2019, so around 625,000 riders it was initially, but in 2007, but now it is 50,100,000 or 51,000 you can say operation route from 65 kilometres to around 325 kilometre stretch is covered and the coaches or cars earlier it was 280 and now it is around more than 2100, so the growth you can visualise with these numbers plus the ridership is increasing every year from 2002 to 2015.

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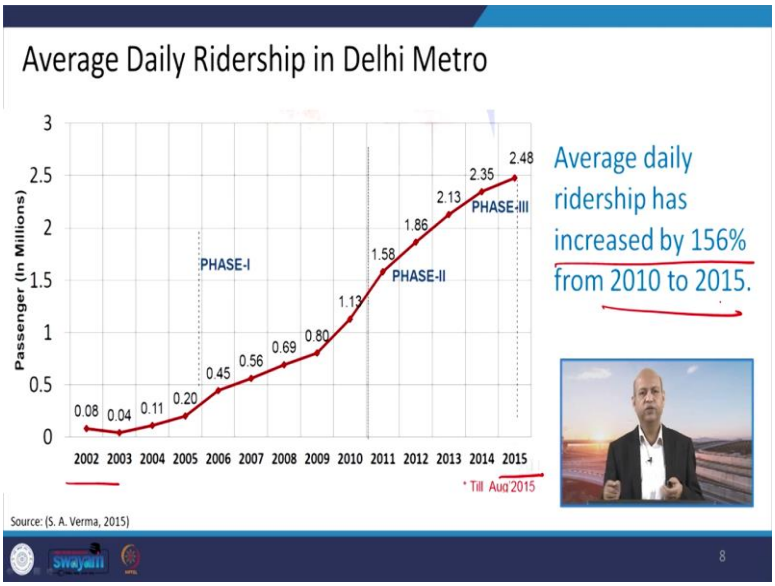

If you see the graph is always increasing, that means the people are feeling incentive to ride the metro, because of its comfort level because of its efficiency, because it reduces time to

travel from one point to another and its completely air conditioned and wonderfully equipped, so that way people like to use it, so it has increased around 156 % in between 2010 to 2015.

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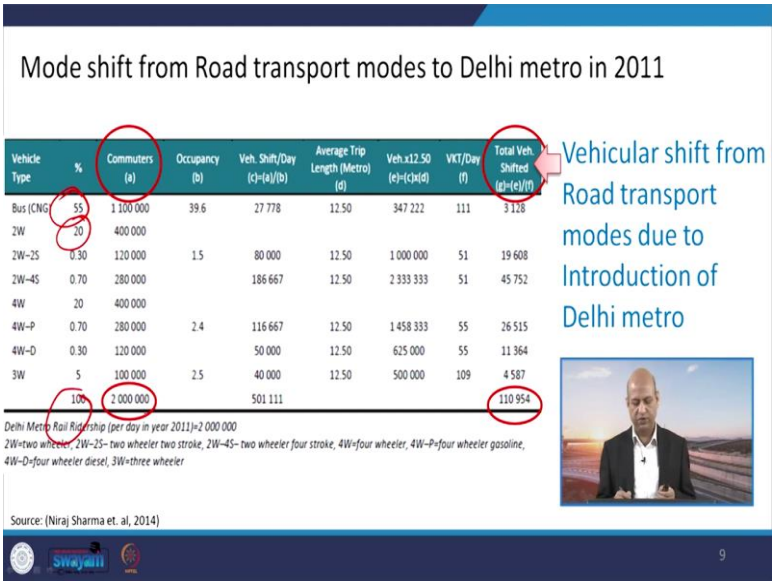

When you see the mode shift from road transport modes to Delhi Metro in 2011, so again you can see the total 2 million commuters were shifted towards Metro from like 55 % people were from buses and then 20 % from two wheelers, so that way the total 100 % the figure was around 2 million, so this is the growth story, but the 2011 figure itself says that it has been very popular.

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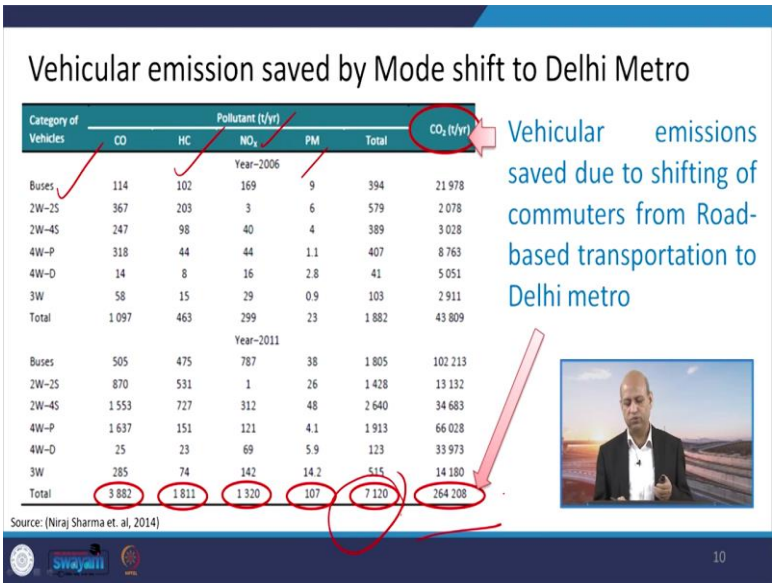

If you see the vehicular emissions saved by mode shift, because when we are going from fossil fuel based road traffic to Delhi Metro, then naturally we are reducing the exhaust emissions, because Delhi Metro is run by electricity although as I narrated in one lecture that people argue that electricity is also produced by fossil fuels by coal power plants, but as I said because the vehicular pollution is in the range of our breathing process, so that way the health benefits are much more because the stack emissions get diluted when they reach to the ground level, so compression is not so straight anyway, if you see the CO reduction from different categories of vehicles like buses, etc., so around 3882 tonnes per year saving of CO.

Similarly, hydrocarbons or NOx emissions particulate matters, so total is around 7000 tonnes per year reduction in the emissions of air pollutants, if you focus on greenhouse gas emissions or you can say carbon dioxide CO2 tonne per year, so you see the huge figure over around 265,000 around means it is to 264, but it may be around 265,000 estimated figure it is there is not where absolute value, so those emissions have been avoided because of this Metro, what are the different policies which have been integrated to make it very popular.

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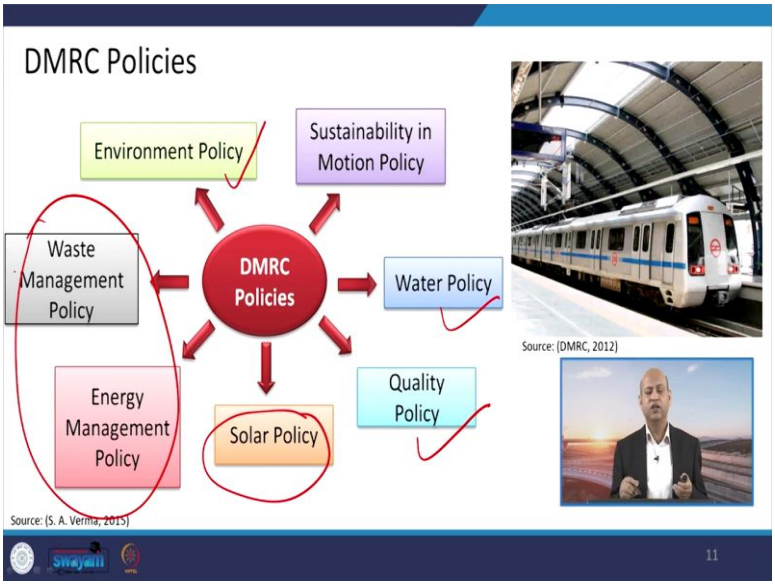

Because, environment policies there, how to make it environment friendly we will see different aspects later on then sustainability in motion policy, again the reliability and punctuality all those things, water policy we will see that how recycled water is being used and how it is really using the wastewater treatment through, wastewater treatment plants etc., quality policy, the quality control is there in terms of comfort level as well as our timings, solar policy means solar energy is being integrated an energy management policy means

several kinds of energy sources even waste energy resources are there, so the waste management and energy resources are being integrated, so that way this DMRC policies is wonderfully linked to each other to make it a sustainable case study for transportation systems.

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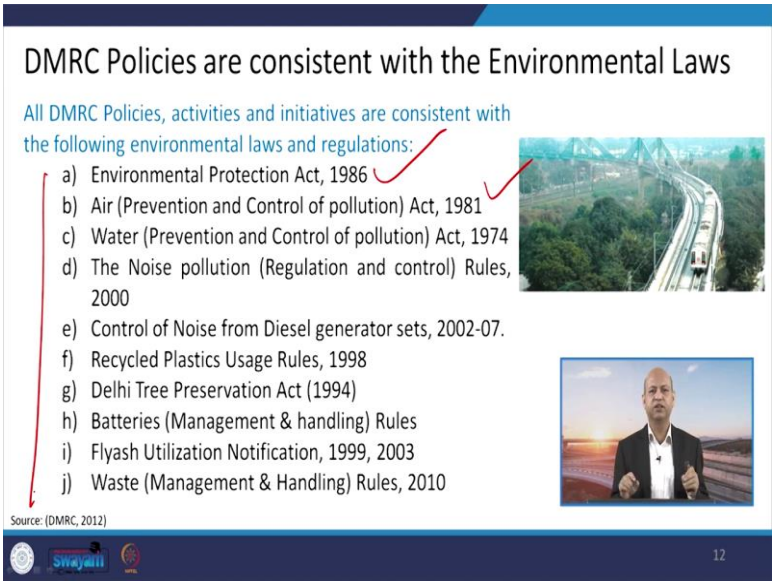

If you see this DMRC policies in terms of the environment, it follows all the rules and regulations or environmental laws of the land, so whether it is environmental protection Act 1986 or Air Pollution Act of 1981, so all these environment related acts and regulations have been properly integrated and implemented in the management system of DMRC.

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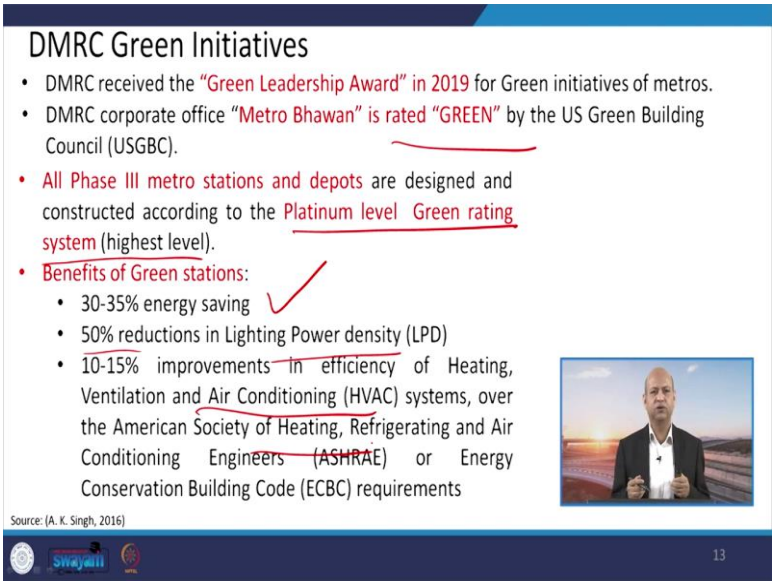

If you see this green Leadership Award of 2009, which was given to Delhi Metro, because of its very various initiatives for green environment and saving energy, then this Metro Bhawan was rated this big office complex as green by the US Green Building council so that means, you can see it systems best practices of the world have been implemented in the management of DMRC.

And then you can see this platinum level green rating system for all construction activities of Metro Station reports have been integrated and 30 to 35 % energy saving in all green stations which have been built, so this have been the part of planning and execution, 50 % reduction in lighting power density, all these benefits means whether it is lighting or energy or air conditioning system or heating system, all things have been designed as per the best practices of green energy or green rating or green leadership practices.

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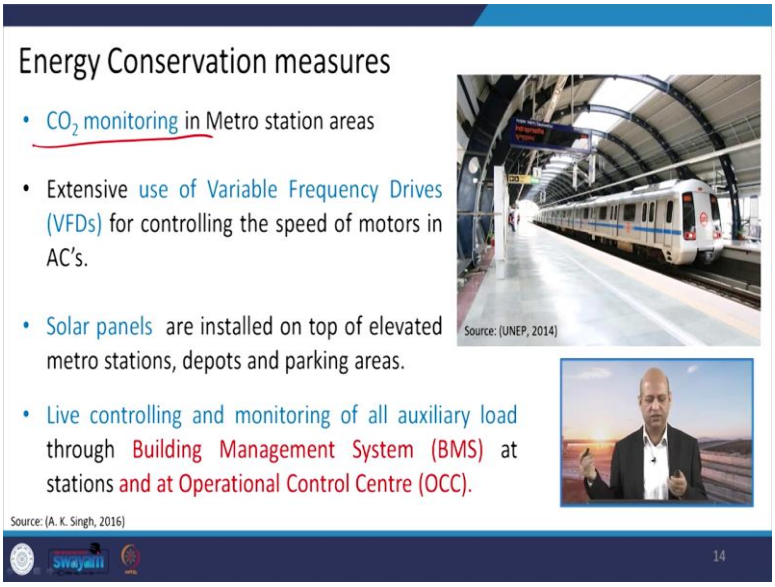

Energy conservation measures have been in place like CO2 monitoring at Metro stations areas automatic systems are there which measure the CO2 levels, so that it should not increase beyond certain level and there are ways to control it, then there are air conditioning systems and solar panels are also there plus there is management of air flux between underground in tunnels and how this Metro goes and then there is push up the air from behind and it adds to the fresh air.

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This green initiative if you compare this kind of scenario earlier when all these fossil fuel waste vehicular categories or vehicular these automobiles etc, they are burning lot of fuels and they are emitting a lot of whether air pollutants or greenhouse gases, but this is quite clean, there is no exhaust emissions of course, there may be little bit some like wheel, abrasion and friction very minute quantity, but in comparison to this is kind of negligible and there is the reduction of pollution around 6.3 lakh tonnes per year has been estimated with this claim development.

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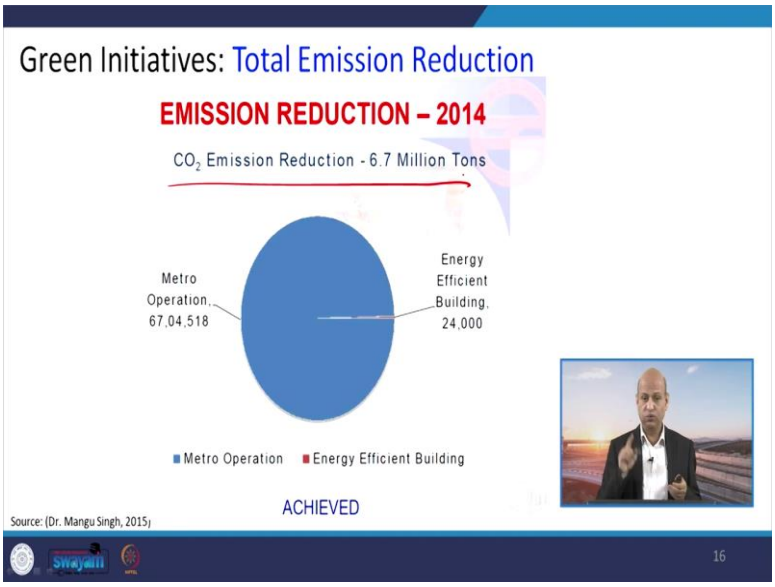

If you see the total scenario then the CO2 emission reduction has been estimated around 6.7 million tonnes reduction that has been achieved, in 2014 this estimated figure is, so that is the reduction.

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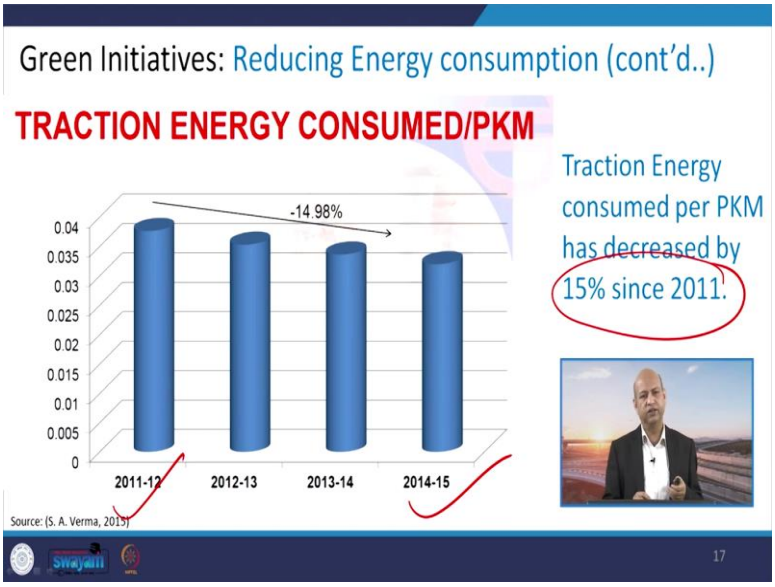

And then traction energy consumed per passenger kilometre, so this is also reducing from 2011 to 2014 if you see, so those traction in energy consumed has been like 50 % reduction with respect to 2011, so those practices have been implemented to achieve these targets.

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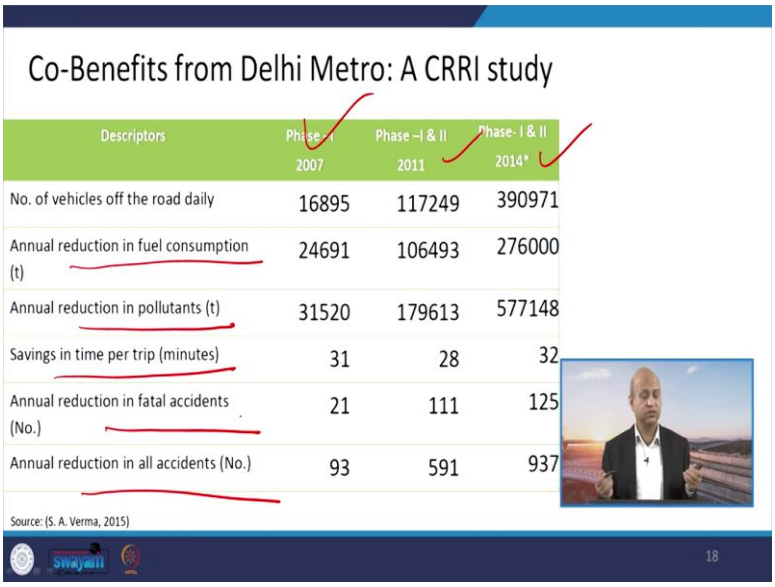

There are several CO-Benefits also CO-benefits means, when some additional benefits become automatically without aiming for that for example, if this annual reduction in fuel consumption, because this is working on electric cars, so in phase 1 this much of reduction is there phase 2 and phase 6, so it is reduction in fuel consumption is increasing in every phase, then reduction in pollutants or the trip or time saving, reduction in fatal accidents means these are just outcomes of this better or safer system in terms of Metro or MRTS in comparison to the road transport system, so these are reduction in accidents or reduction in fatal accidents all those have been increasing from 1 phase to another one, so this is a success story of CO-benefits.

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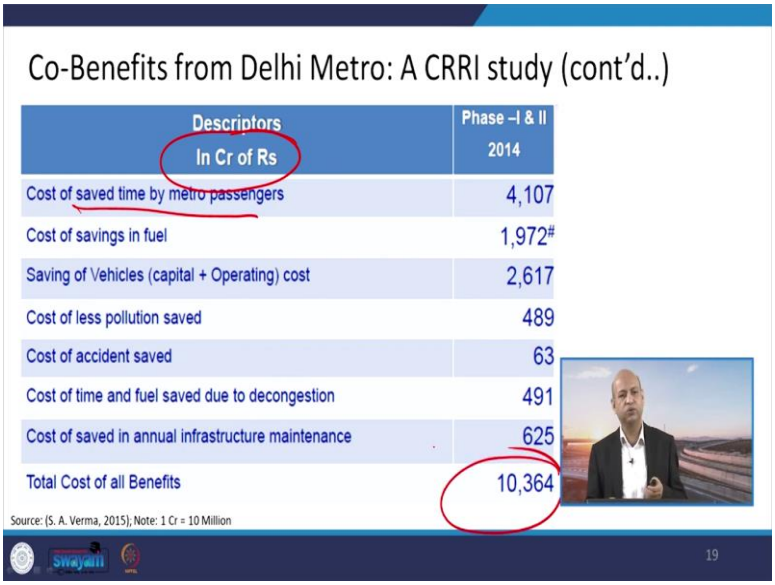

Also, if you see that save time, so that much if you convert it into crores of rupees one crore is 10 million, so if you compare different activities, so the total benefit is around 10 crore or 100 million, so that is a huge benefit, if you see in terms of monetary gains.

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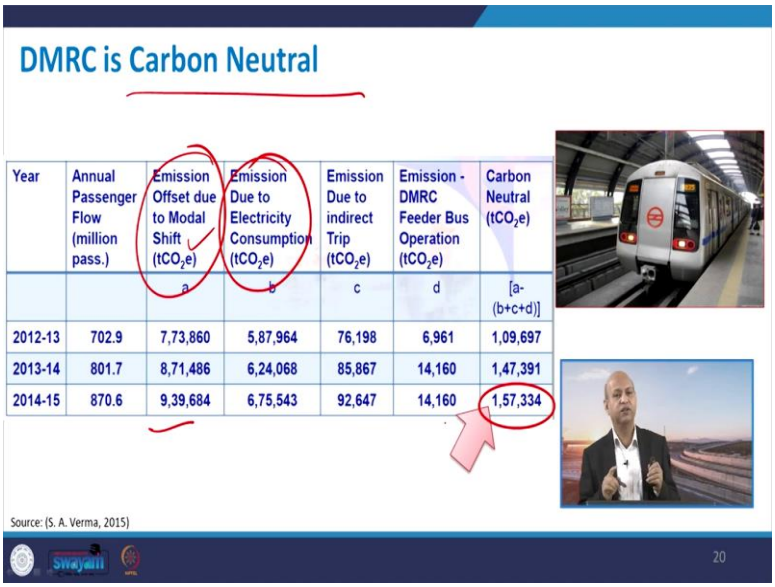

This is the carbon neutral, carbon neutral means there is no addition of carbon emissions because of Metro running on the rails for example, this is the emission offset due to modal shift, so this is more than the emission due to electricity consumption, as I said that some people argue that electricity is also being produced by some fossil fuel, but if you are deriving electric energy by solar panels or maybe from hydro power generated electricity if you are buying then you are not adding to emissions of carbon, so that is the thing you can see that net reduction is there of carbon emissions, so it is not adding to the carbon emissions.

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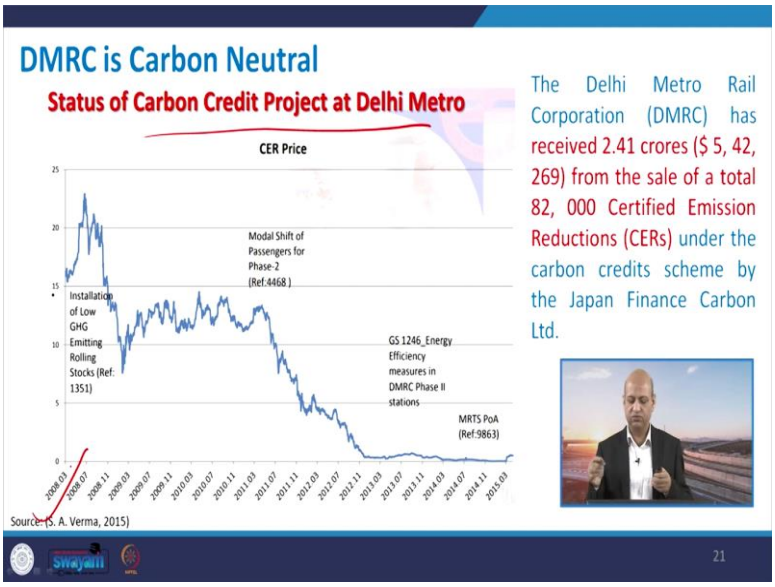

In the same sense carbon credit project have been implemented from very earlier years of 2008 and several crores of rupees saving have been achieved by this particular example.

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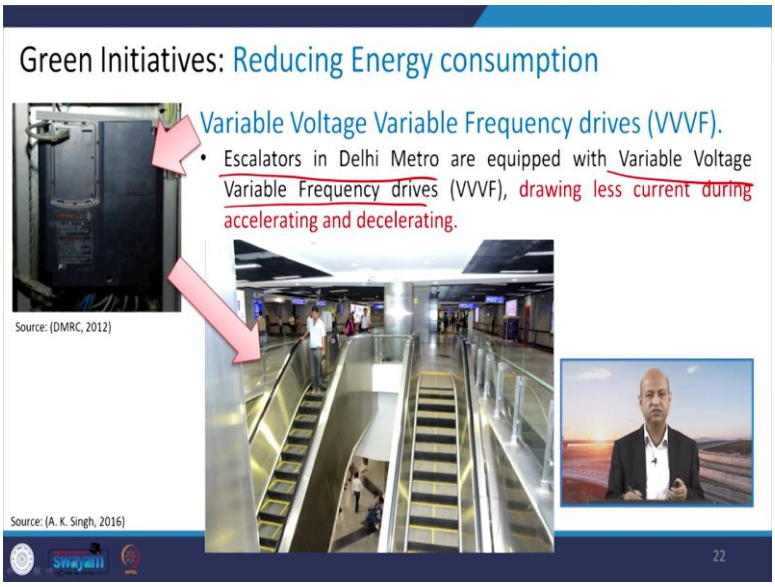

Then, there are other initiatives like energy consumption related these issues in the escalators, so they are having variable voltage frequency drive kind of equipments, which uses optimization of energy consumption in these escalators, so that way it is very energy efficient.

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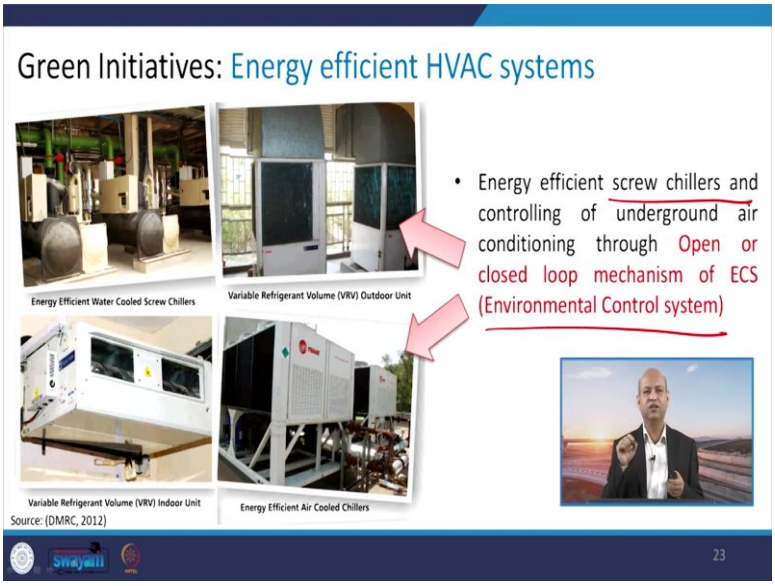

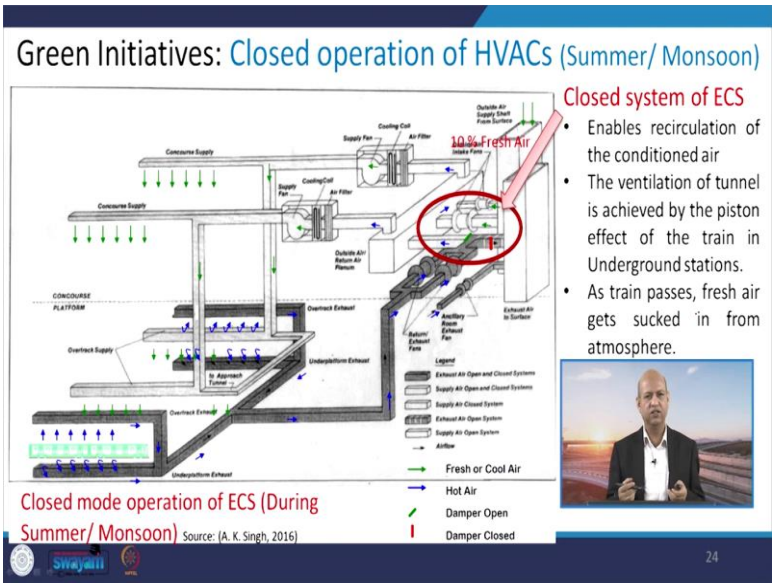

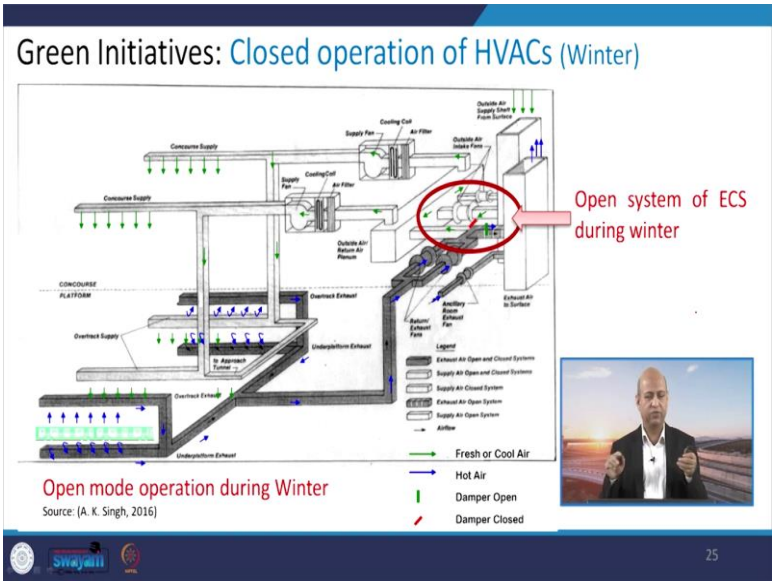

And then if you see the these air conditioning and although systems, so environmental control system is there and they monitor every kind of thing whether it is moisture level or humidity or thermal and the controlling system automatically it starts some equipment to get the fasciae or it starts to add to the heating processes, if like in winter if some at some pockets temperature goes down.

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In solar power plants have been added in this particular deports and the stations, so the roofs have been converted into with solar panels a lot of energy is being produced by these initiatives.

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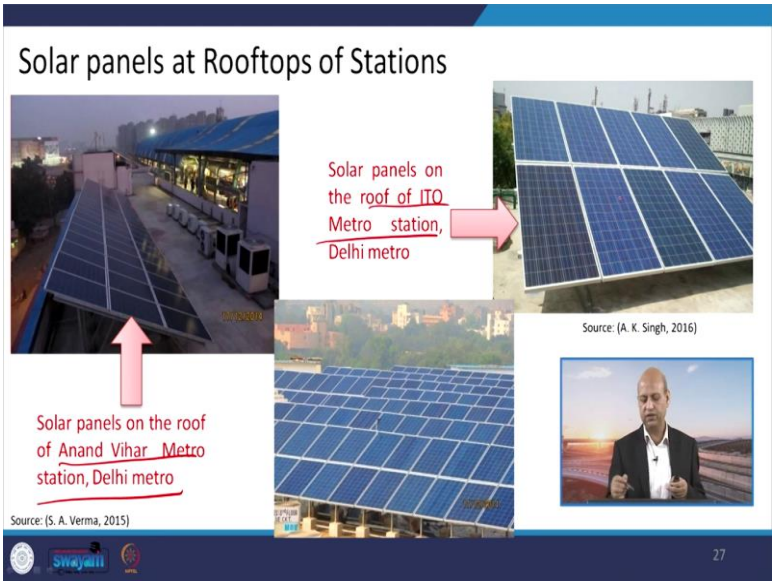

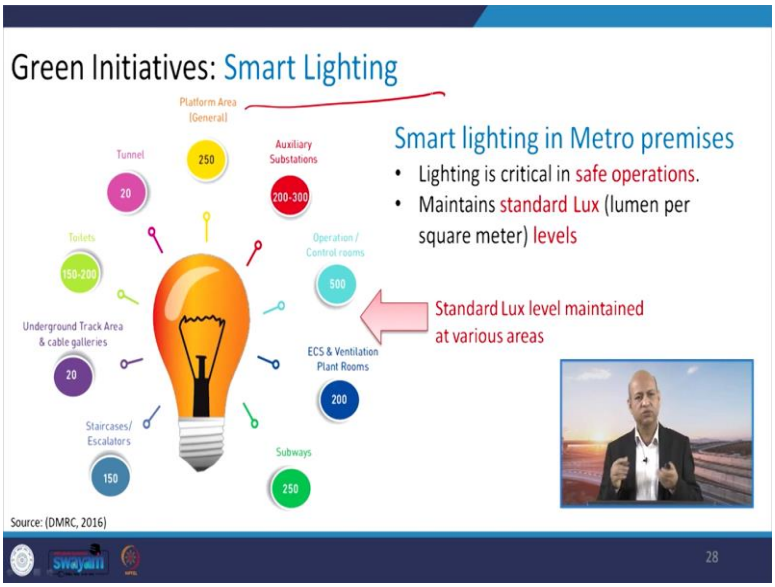

You can see Anand Vihar Metro station this is the photograph of that and this ITO Metro station again these there so everywhere means those buildings and wherever they have got the opportunity they have used this solar panels to generate the electricity and Smart Lighting have been implemented, so the saving of energy as well as means were how much illumination is needed, so that way good software have been implemented to have the right quantity of the light or illumination of the light, so see this smart LED lights have been used, so very less amount of power consumption but very good lit area is their lighting.

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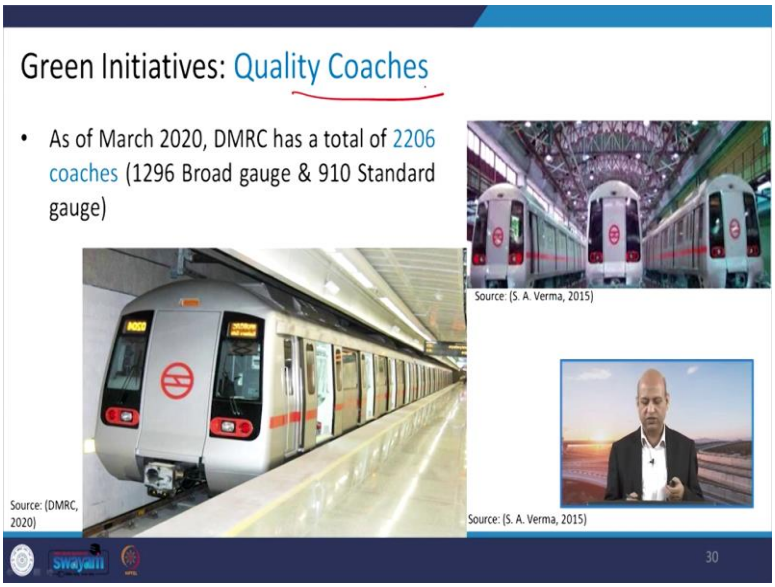

And then quality coaches, because comfort levels should be there for people to travel, so these are the quality coaches which have been used in this DMRC system and there are landscaping and paved flooring means the aesthetic value has also been added there are like water harvesting all those things have been integrated with each other, so see these look so beautiful Monday house metro station, so means people feel very good when they approach the station, so otherwise you see when we go to the bus station, it is so crowded and you do not feel good, so those kind of infrastructure facilities really motivate you to go to using this particular system.

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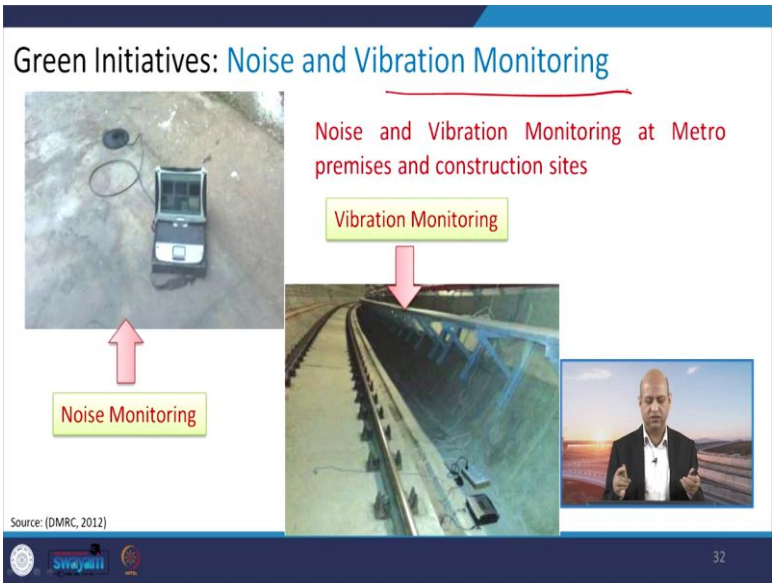

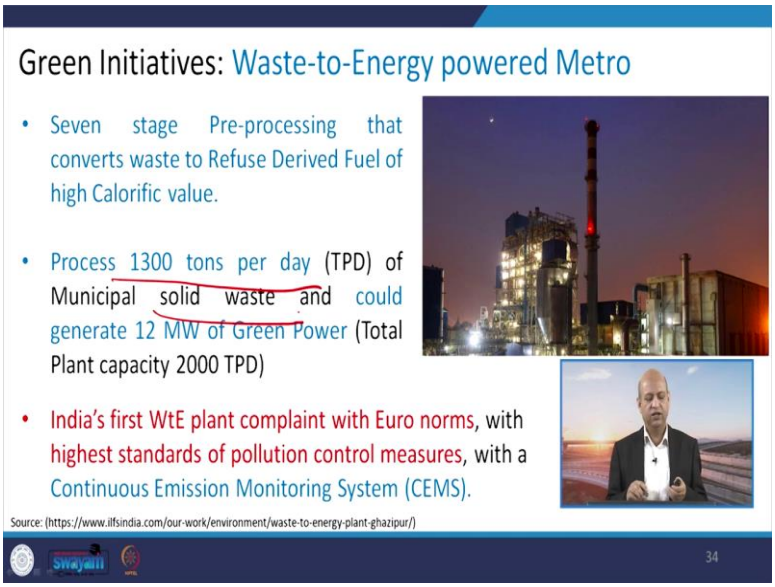

Then noise and vibration monitoring equipments are also there, so that can control the speed and other issues which affect the noise and vibrations, of course this is wonderful example of waste to energy powered Metro this is the first in India this particular plant which uses waste material to produce energy as per its calorific value, so in this slide it has been given these figures like 1300 tonnes per day of municipal solid waste it is being burnt and converted into energy plus there are equipments which control the air pollution, exhaust emissions from the STPs, so it is completely clean system, it is not like that, it is burning and then emissions are going into the atmosphere it is not like that, so good controlling of air pollutants system is there and that way, this is a green initiative, because it is converting waste into energy, so that way it is a green initiative you can call it.

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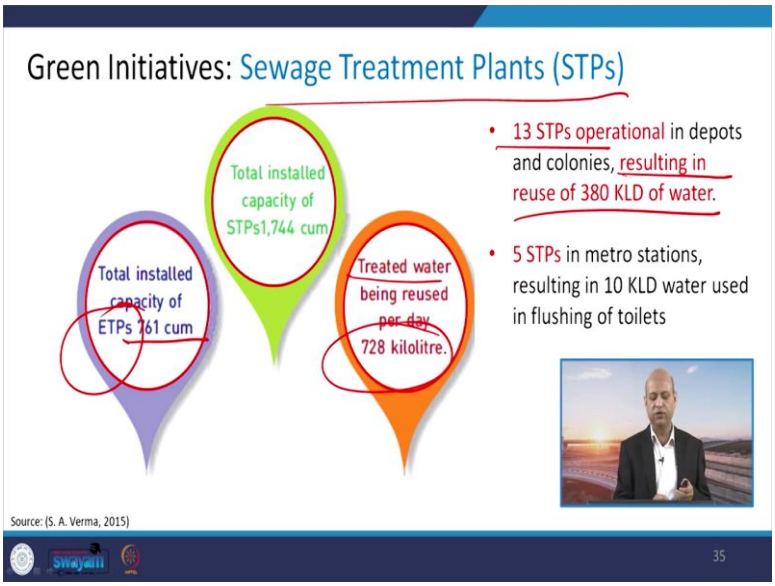

Then sewage statement plants are there, so 13 STPs or sewage statement plants are there, so as a result, they are using around 380 kilolitre per day of the water, so that is a wonderful achievement in that way. Effluent treatment plants are also there around 761 cubic metre of capacity and similarly treated water being reused per day around 728 kilo litres, so those are the things which make it towards environment friendly approach.

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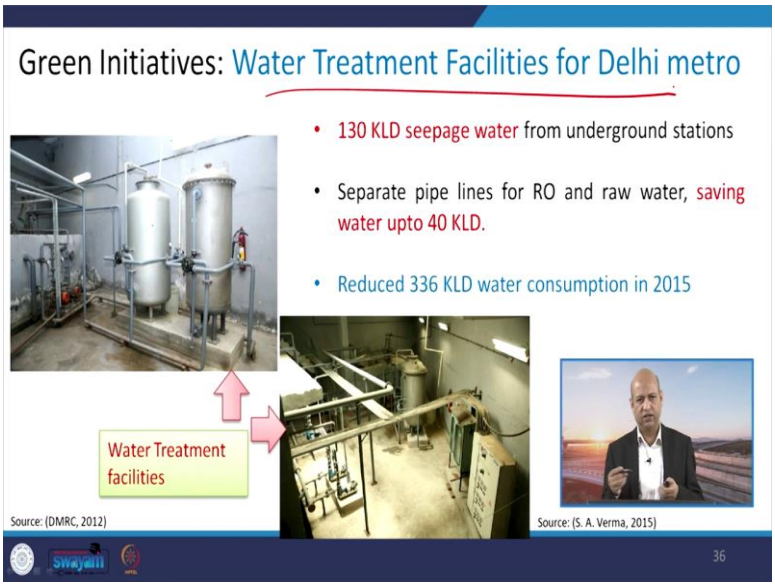

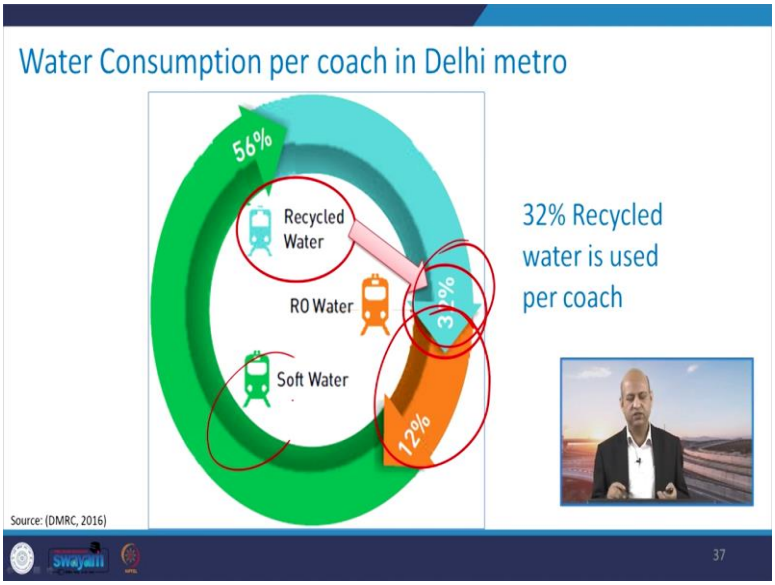

Water treatment facilities, so in underground, there are some seepage some water losses, so those are collected and they are treated and they are reused in the system, so RO system is there plus this seepage water is again made proper to circulate, so that this picture shows how much water is being recycled 32 % of the recycled water is being used it is a big quantity in

fact 32 % is not less and this much only our water is being used and the 56 percent is the soft water, so that way optimization in water usage has been achieved.

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Waste management, another example is like they are a lot of good or other things which are sometimes wasted or outdated, so the DMRC has set up a carpentry workshop to use that discarded wooden furniture and they again try to make some useful things, for example, some bends by disused wood waste and then organic waste converter is also there that can process the organic waste of the DMRC and it can be taken from the canteen or depots and then maybe manure etc., and for kitchen garden those kinds of waste material has been converted into compost or fertiliser, so it is again used for gardening purposes, so that you can see the recycling of lot of things are going on in DMRC that is a big achievement.

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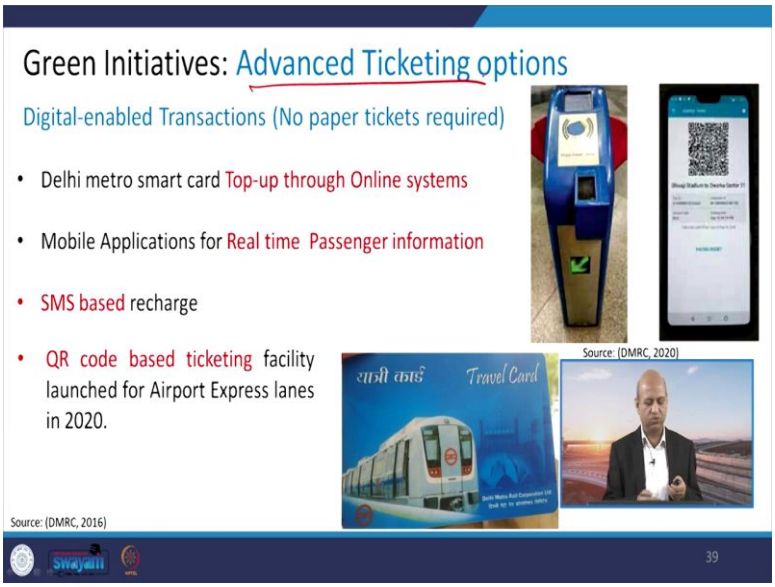

Also ticketing options of advanced nature, like you can use your mobile or these cards, etc., so there is no use of paper tickets and that way you are saving the trees, so that is again environment friendly approach and SMS or QR code kind of technological applications have been integrated with ticketing and travelling from one place to another.

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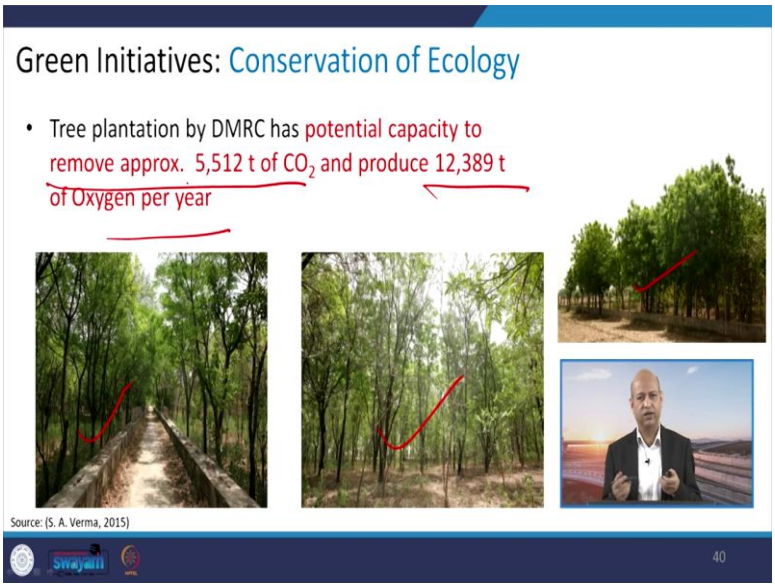

Then DMRC has also invested a lot for conservation of ecology, so it has planted a lot of trees and they produce around 12,000 tonne of the oxygen per year and they remove around 5000 tonne of the CO2 means, because it is a sink CO2 is used by plants as for producing their own food and they also give oxygen so that way a lot of plantation activities has been

funded by DMRC, so that is again a wonderful initiative in terms of the environmental protection.

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Last minute connectivity or last mile connectivity related, facility is or infrastructure have also been taken care of by Delhi Metro, so around 149 low floor versus and 25 standard floor versus have been used for this last mile connectivity, so that people do not feel, now or to wait for some other automobile to go from metro station to the destination then, there are initiatives like bicycle facility at certain locations around 18 lots of bicycle facility are there, you can just hire the bicycle and you can drop it at another station, so that way means it is

like benefit to the health as well as there is no emissions, so this non motorised vehicle categories have been integrated with Delhi Metro system, that is wonderful example.

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Similarly, e-bicycles are also there e-rickshaws are also there, so all those multi modal integration have been achieved in metro stations to facilitate the passengers, so e-rickshaws out there and then charging stations are also there, so that they do not need to go here and there and they get opportunity to charge their e-rickshaws batteries very conveniently.

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Then again, if you see the cleanliness and comfort level, so there was a survey and on the basis of that survey, it was known that information during travel, that is the very good means, first trend people say that this is the best, category or best practice or best aspect of this Delhi Metro system, then cleanliness of course, all these are of high rate, but if you rank in relative, so cleanliness is the second and the real time service is around the third rank, but they are of very good quality, only the comparison of these three variables are there plus there are certain coaches or cars which are dedicated to women passengers, so for their convenience for their safety, there are dedicated cars only for women, so this kind of facility is also in its Metro there.

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If you see the safety measure, so again control system is there and they constantly monitor automatic systems are there of any kind of deviation from protocol, so all kinds of possibilities are there will not be any kind of fatal accidents the metro will stop automatically, you might have read sometimes in newspapers that, there was power breakdown because of some unknown region and then Metro got stopped and there was, but some backup power, so that comfort level was not reduced for the passengers.

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Plus, there are some Mock drills, if something happened, because accidents are accidents, they do not come with the warning, so if somehow if those kinds of things happen then how to rescue the people, so those kinds of Mock drills are also conducted by DMRC time to time.

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Then, there is the integration of rapid Metro Gurgaon as I said and this is around 6-kilometre elevated mass transit network and it is operational since 2013 wonderful part is that it is managed by privately owned agency and that way the integration of this Delhi Metro Corporation and that Gurgaon's rapid railway system is there.

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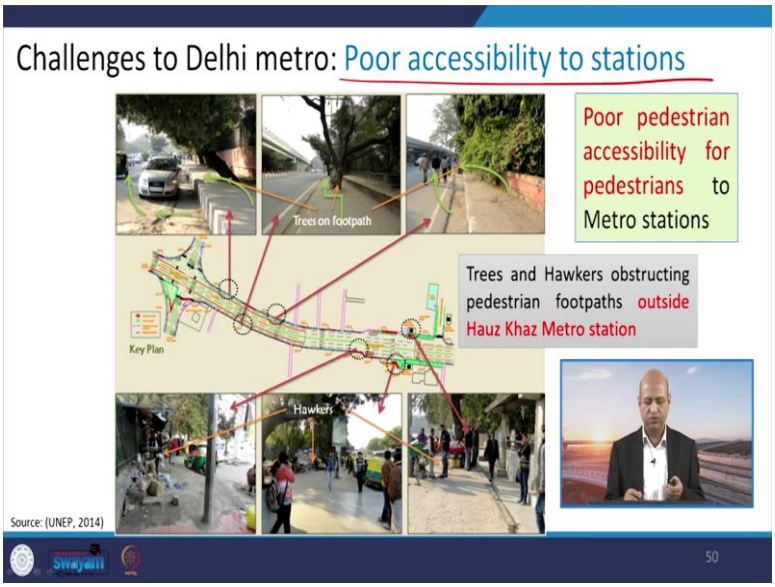

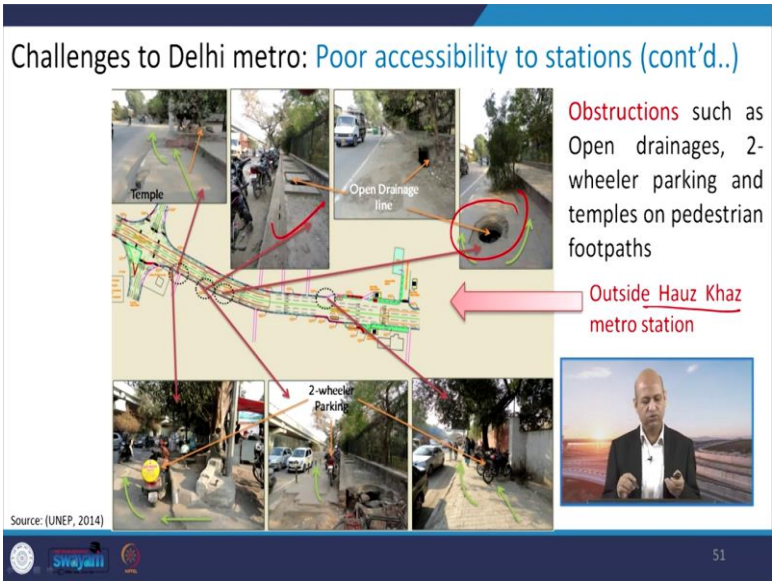

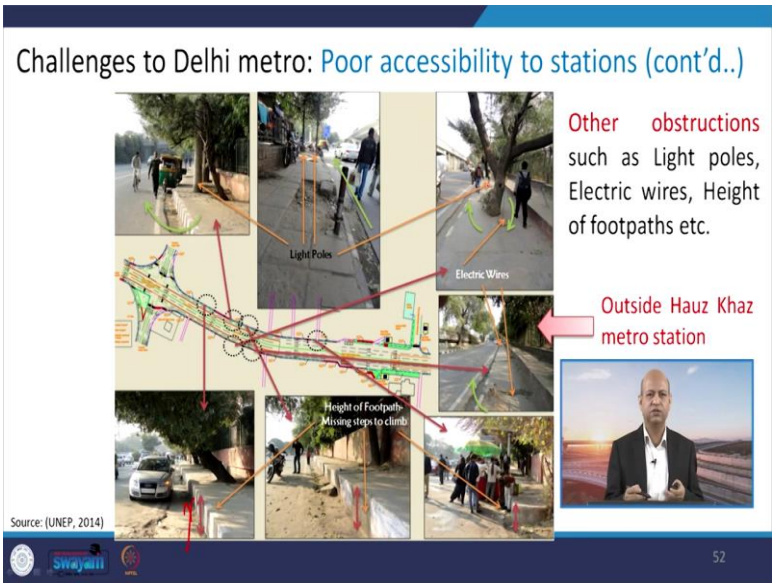

Then, there are certain challenges, because poor accessibility related things have been observed and people have complained, so as a kind of challenge or as a kind of scope for improvement I would like to share with you like at certain places you can find that like there are hawkers and mobility is not, so good in that sense you can even see these, like outside the Hauz Khaz some pictures have been taken open drainage and the potholes and then there is a huge gap between this platform walking pedestrian and the level, so those things are there and they should be taken care of these, see the height without one more step it is very difficult to climb this kind of footpath, so and then there are trees in between.

So, again if somebody nowadays people have you ever heard of reading something, text messages, etc., and there may be a chance of hitting this tree, so when Metro is planting so many trees, maybe they can take permission from the forest department to remove or to

transfer this tree from one place to another, so that the safety aspects are met for the passengers and people. Similarly, other pictorial representation are given, like these kind of these are the note good footpaths and these broken tiles or maintenance is not good on accessible roads.

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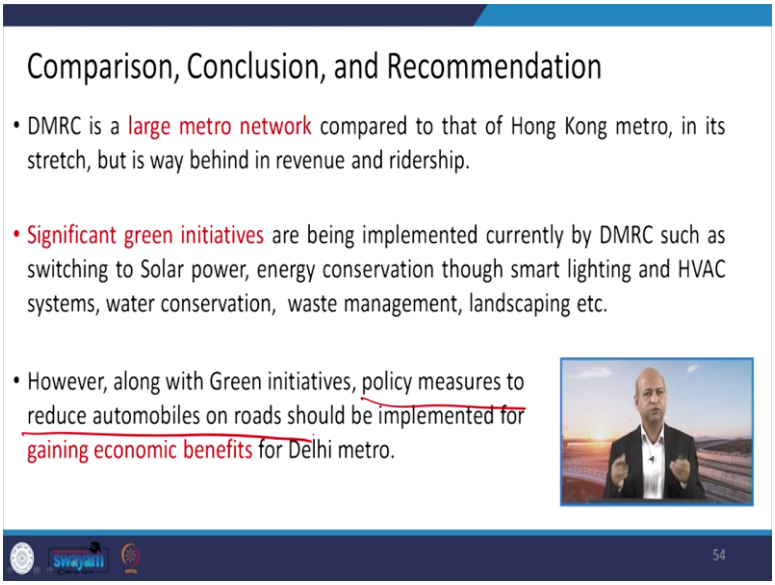

So, those are the challenges where scope is there for the good improvement and I hope in near future these things will be addressed properly, so if we compare our DMRC with the Hong Kong Metro, then I mean there is a lot of scope to improve in terms of ridership or revenue generation, we are far behind from Hong Kong Metro.

But significant green initiatives really bring this DMRC at the forefront as a very good example of environment friendly or sustainability aspects integration into the whole system, and if we want to recommend something, then we can say that some economic benefits can be taken into account and those should be transferred to improve the system plus more automobiles and those policies should be that the usage of automobiles should be reduced in that way those policies should be implemented and those amenities which are not at par with the expectation of the people, those should be improved timely.

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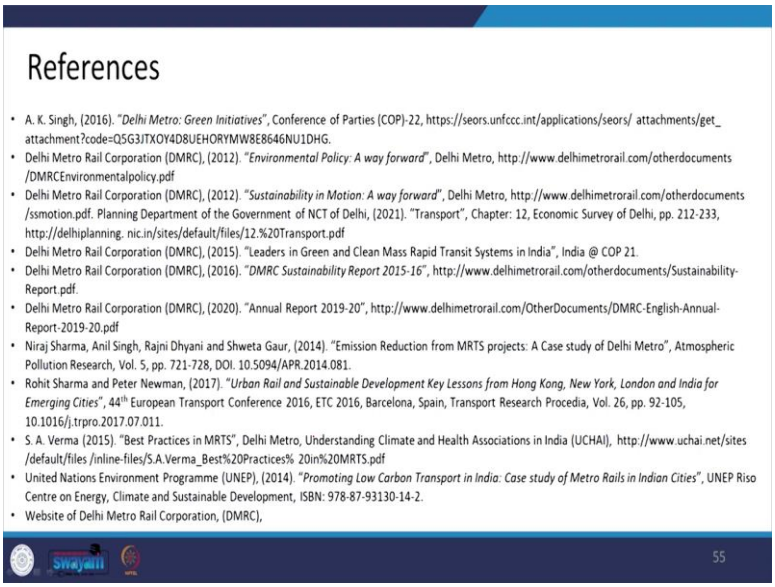

So, that is all for today and this is the list of references, so anyone of you if you want to know more about certain aspect you can go to references and visit those reference to gain more knowledge and thank you for your kind attention and this is means we have completed two case studies, earlier one was on Bus Rapid Transport System BRTS and this is mass rapid transport system with the success story of Delhi Metro Corporation. Thank you again.