Course on Integrated Waste Management for a Smart City
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Module 5
Lecture No 23
Waste Collection and Transport (Contd.)

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Okay welcome back so we are now in week 5, this is the third module of week 5 so we have been covering in this particular module if you remember in the last 2 videos we were looking at the collection system, before looking at the transportation system and as I mentioned you the collection and transportation part of municipal solid waste management is one of the most expensive part, so we will continue that discussion, will talk about the transfer station, I already showed you some uhh photograph of different transfer station pretty much around the world and uhh so what I will do is, in this particular video we will look at some of those we will look at basically economics of uhh whether we should say economics of waste transport I would rather put that way.

It is essentially to find out where we can whether we can go for a transfer station say if you are uhh in a small city or even if you think about Delhi or Bombay or Kolkata or Mumbai uhh sorry in Chennai, so even those cities as you can think of those cities as uhh combination of several small cities right there, so rather than taking the waste collected from a uhh like from one region and take it directly to the landfill just too far or we should take it to transfer station where we transfer this waste from the smaller trucks are the trailer truck and the bigger trailer truck goes to the landfill, so talk about that I will show you an example.

I will not solve the example completely I will tell you how to solve it I will not you to solve that example later on in the as part of the discussion board or maybe as a supplemental uhh material we will post the solution to this particular problem but right now I would go the problem, I will explain you how it is to be done and I will walk you to the steps you need to do the math I want you to work on this problem that is why I am not doing the entirely 100 percent.

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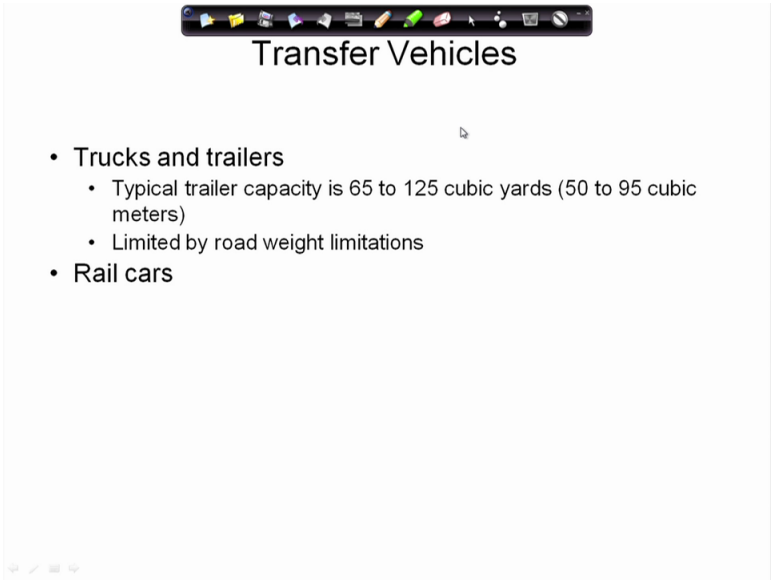

So let us get started, so in terms of transport vehicle there are different types of transfer vehicles that is being used trucks and trailers are used typically we have uhh trucks trailer is the bigger one uhh I showed you some pictures of waste being taken from a small trucks to the bigger trucks and then also from also the rails are used railways is used for transportation if you remember uhh that particular picture from Chile where from the transfer station they were taking to the landfill on a railroad, so those are also uhh used for transporting the garbage.

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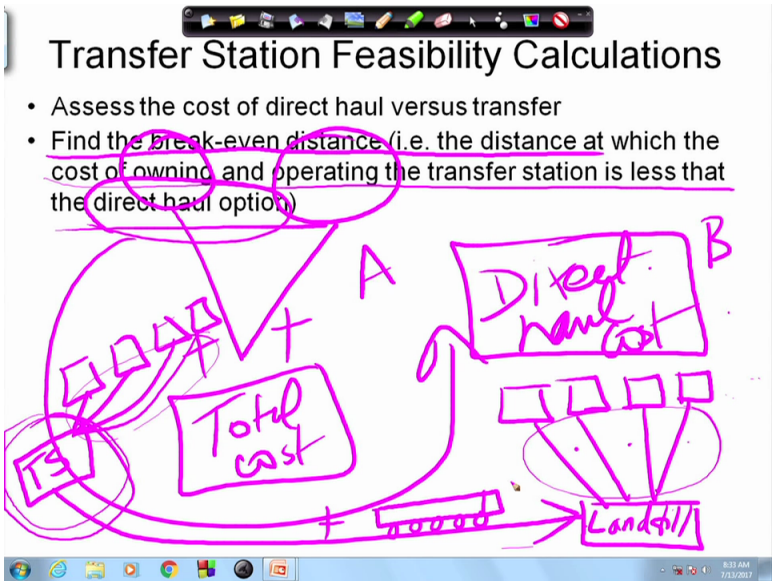

So in terms of the transfer station whether we should go for transfer station or not uhh we can do a we can assess the cost of direct haul versus transfer. When we say direct haul versus transfer means whether we should take a waste directly from the household collection which is collected in a truck, should be taken directly from their all the way to landfill or we should be take it to a transfer station.

In the Indian scenario what we see is mostly if you are in a high rise apartment kind of settings, you have the waste collected from your individual home by some person coming in the morning or collecting it and then they take it to just outskirts of that apartment complex and they have certain bins or they will have like a concrete uhh we call it Dhalo or it is basically a concrete bin like a bigger one and then you put all the garbage in there and uhh the truck comes and collected from that particular location.

So most of these trucks have the smaller truck, we do not see a huge truck going around the streets and especially in the residential area because it will not be able to navigate those streets, the streets are narrow and you do not have to who bring those big trucks because it is again, it consumes more petrol, more gasoline, more diesel. So what you need to do is uhh you have these smaller trucks getting collected then it goes to a uhh transfer station or if the landfill is nearby you can take you directly to the landfill.

So what is this particular problem? This particular example is trying to illustrate, as how to, how to find out, however you go about finding it out whether it is worth taking the smaller trucks to the landfill or whether it is worth to have a transfer station and then a transfer station

can be used as another uhh you can say a collection Centre or some sort of process and center as well because as you saw those pictures transfer station is not only used for collections uhh and transfer from one small vehicle to the bigger vehicle, there is also used to recover some of those recyclables which has been, which should not have been there I just made waste into the uhh the disposal stream that you try to pick it up at the transition as well.

So how we do that uhh it is essentially a engineering economics problem, you may have uhh than that economics, engineering economics course, even if you have not done it, if you just apply a common sense is pretty straightforward and then we will uhh show you the examples. So you are in terms what we do we try to find out, since if you remember what I have been talking about, I am saying that is the distance, whether the distance from the uhh this individual like residential area to the landfill or it is too far or too low that kinds of the side whether we should go for a transfer station on not.

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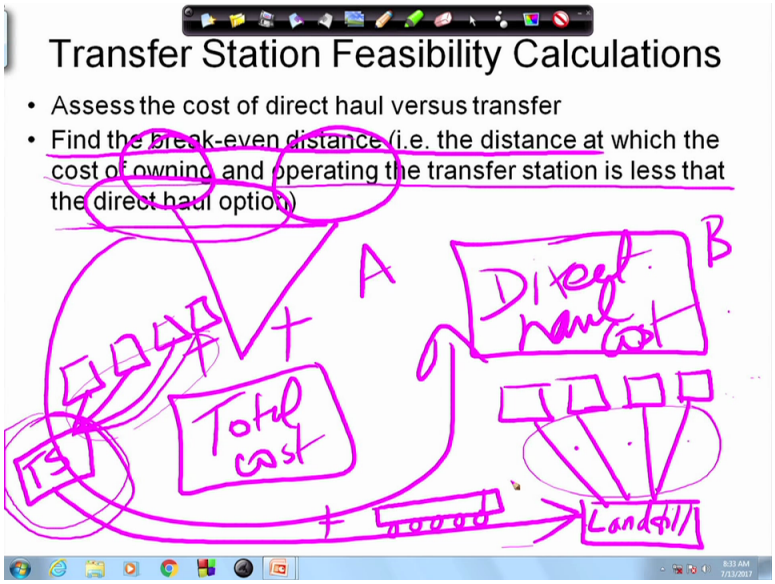

So in that case what is the important thing is the distance because there is a transportation cost, so what we are trying to do here is? We have to try to find the breakeven distance, so as you can see here we are trying to do this breakeven distance uhh we will that is find the breakeven distance that is the distance at which the cost of owning and operating the transfer station is less than the direct haul option. So we can make a transfer station and the cost of that, cost of owning and operating so there are 2 parts here, owning and operating.

What is owning? Owning means we have to build the transfer station, so there is a capital cost and when you have to operate means there is a regular operation and maintenance cost,

so we have to take it factor both, there is a one factor will come from here, one factor will come from here, you add up both these factors so that is what we will get our total cost showing up for the uhh are if you are doing it for the landfill. Similarly if you do the direct haul, if this is the direct haul option, if you do this direct haul option that also has a cost associated with that.

So you have a direct haul cost and this cost is what? This cost is what is the truck that is being used uhh we are taking this truck and then we are using this smaller trucks, so here we have there is small trucks from the different residential area and say if it is this is our landfill location these all these trucks are going to the landfill location. Here what we are trying to do, here we are trying to have for the transfer station you have these small trucks uhh I am not very good and uhh art, I never got good marks in my drawing class uhh so bear with me with that, so then you take it to a transfer station and from the transfer station this actually goes to the landfill.

So this is our landfill, so here in this case whatever is the cost is the cost this cost, plus this cost, plus this cost, plus this cost and there would be some more trucks and we can add them up all and that is the total cost from this transportation. Here one part is here, then we have a transfer station, we have to construct the transfer station which is not in this case in uhh say this is the option A and option B, so in option B which is the direct haul option, there is no transfer station, so transfer station cost is not included there, here we have a transfer station.

So we have to look at the cost of building the transfer station and also operating the transfer station and then you take this uhh things that goes transfer station to the landfill and here it goes in a bigger truck, it is like the big trailer truck rather than a small truck, so you have this truck which has several you may have seen wheel with several wheels and it goes over there. So that is just to illustrate the point, so this is a so we can do the direct haul versus this transfer station operation.

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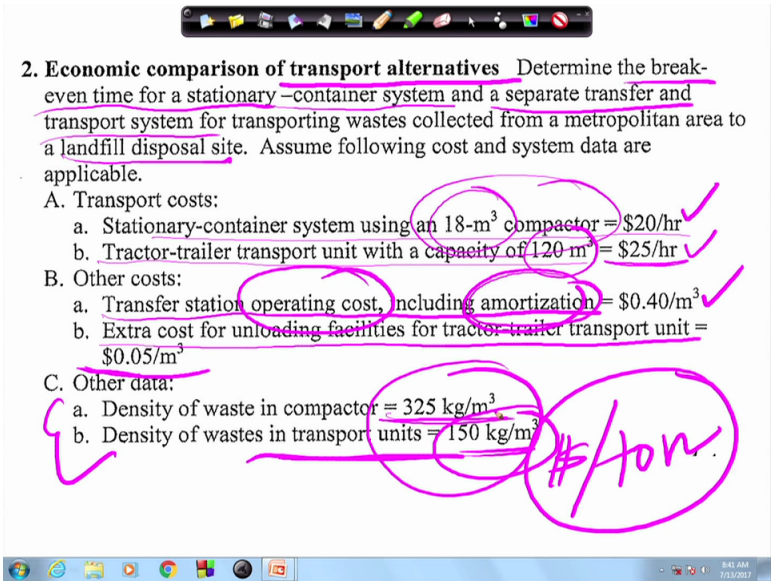

So let us look at one example of that uhh, how like how we do the math part of it. So you say if you have a scenario where we are trying to do the comparison of the transport alternatives, so as I was explaining you in the previous slide, this is essentially transport alternatives, so what are the alternatives. We are again I said that it will try to find out the breakeven because it is all depends on the distance, is not it. So we are trying to determine the breakeven, it is breakeven time or a stationary container system and a separate transfer and transport system, so stationary container means you are collecting the waste and taking it directly uhh to the landfill.

Or you have the separate transfer and transport system, so your taking this smaller truck to a transfer station and from the transition waste goes to a landfill disposal site. Now for different data has been given to us in terms of how much it cost in for the transport for stationary container system using over 18 meter cube compactor, those of the vehicles remember the had showed you some vehicles which were having uhh they had a compactor in the truck itself.

I told you that even in Kharagpur town uhh we saw some of these newer trucks coming up, many actually ULB's are buying those trucks, the trucks which has a compactor on the back and it tries to compact the garbage, so when it tries to compact the garbage what is it trying to do? So that it can store more garbage than a regular truck which does not have that compactor. So if you have this and the volume of the truck is 18 meter cube and for this if you are operating the truck uhh it cost dollar 20 per hour.

Now if you operate this tractor-trailer transport unit, if you have a tractor-trailer transport unit uhh and you operate that of course it is a bigger vehicle but the volume is much bigger as well it can take lot of waste in there. Since it is a bigger vehicle the cost is higher but not too high uhh in terms of if you look at the capacity uhh 20 to 25 which is what is 25 percent, yeah 25 percent hike in cost but if you look at the volume increase, it is much higher your almost what so almost nearly around 6 to 7 times yeah definitely more than 6 times.

So it is uhh you have that much fold increase capacity in terms of taking the waste in this in those transport units. So that is the cost for operating these 2 different types of trucks, the other cost like if you since if you want to operate it as a transport if you want to build a transfer station, so this is what it is talking over here, transfer station operating cost including amortization, amortization essentially what means it means it is the capital cost uhh it is basically a term for the mortgage, mortgage as you know when you take the loan from the hand that is called mortgage especially for the property, any property when you take the loan and that is called mortgage.

So you have uhh that is the layman term is called mortgage. Some of my economic friends may have different definition but we do not have to worry about that right now, so in terms of uhh transfer station we have to operate the transfer station, so there is a cost including for that part and then there is some to build the transfer station, so there is some cost associated with that, so for that is dollar 40 per metre cube.

So it is given per metre cube is in terms of since you are handling the volume of the garbage and then there is some extra cost uhh extra cost for unloading facilities for the tractor transfer unit because now you have to take the tractor transport unit, this is a huge truck uhh they have to be unloaded when it goes to the landfill site. So there is some extra cost associated with that as well and not too much 5 cents per metre cube and then the what are the other data given, so if you have seen here these volumes are given in metre cube and this volumes are also in metre cube and usually we are try to look at the rise in terms of dollar per tonne.

So if you trying to find dollar per tonne, this values are in metre cube, volume is given, so of course we need some density data, so we have density data has been provided to us, so that we can convert from volume masts and vice a versa, so density for waste in the compactor, compactor that is the smaller truck uhh 18 meter cube compactor. There you can see that it is 325 KG per metre cube, so it is pretty good uhh compaction. In transport unit in the big trailer transport unit it is 150, so it is much it is actually uhh much less compared to the compactor.

It is less because in the trailer and if you do not first of all you do not want to compact too much because if you want to if you compact too much. What is if you if we have looked at the transportation sector a little bit probably you know that there is a limitation of weight of any truck, when you are driving on the highway, if you are going on any highway, you see those weighing bridge in Hindi there is there was like Dharam Kanta. Uhh those Dharam Kanta or the weighing bridge places where you take you will say that the truck has to go at way and the truck needs to be weigh, so the truck needs to be weigh from time to time of course from the tax purposes.

Now with GST and all those some of those tax thing may change but there is another reason for weighing those trucks to find out it should not exceed the Department of transportation maximum load uhh and that is set for any kind of highway, so you do not want to heavy or truck going on that because our bridge our culverts and other things I have been designed for a certain way and if this becomes too much that will be uhh structure will have damage all they will be collapsed, there could be some accident, so to prevent that there is a there is a limit.

If you are civil engineer you know that or if you are an any kind of engineer or scientist you should have fair understanding and if you are designing something or a particular load and if you start operating it at much higher load of course the structure has a will have all the chances of failure after it passes through even usually we put the factor of safety there things if it goes beyond that it will start you start seeing things failing up.

So for that particular purpose uhh you see the transport transporter unit, first of all you do not want when you do not want it to be compact too much because the weight will be too high and the other thing is that if you compact too much it is a huge truck and then when you take into the landfill you have to again un-compact it that is again you are using loss of energy to un-compact so that is also not needed and so that is the reason why you see that the density is much less in the transporter unit as opposed to a compact unit. So this is the problem we have we have been given the cost for different things and we have been given some density information so that we can go from mass to volume and other.

Now we have to find out what is the breakeven time, now how will you go about it as I said early in the very beginning today that in this particular video I am not going to uhh give you the entire solution because I want you to work on this problem. We will give you the solution probably after couple of weeks uhh so that you can get some chance to work on it and I will

provide you the answer on the discussion board but at right now uhh I want you to work on this problem so that is why but I have kind of giving you this how to do this problem.

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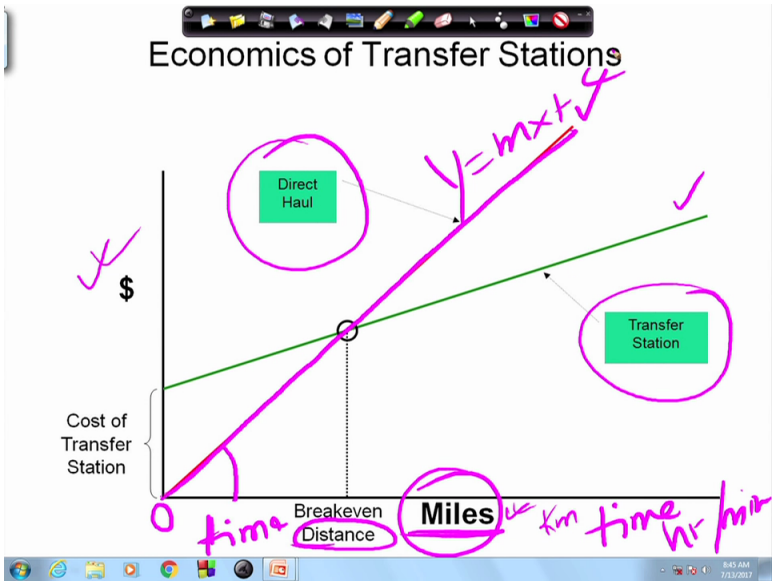

So let us look at what things you need to do, so you have to come up with essentially this graph which you are seeing over here, you have to come up with this graph, so now what is this graph, let us explain this graph so that, so if you remember there are as you can see here there are 2 lines uhh we have this red line and then we have this green line. Now this green line is for the transfer station option and this red line is for the direct haul option and we are plotting since breakeven distance was asked, so we are plotting it as dollar per miles. We can also put it at kilometre or anything in that way as well because that is not of you can put it in either way.

Now since the if you remember the previous slide uhh the information was provided as uhh like per hour and so we have to convert that in terms of uhh so distances per hour you can rather than using miles you can also use the time, so rather than using this mile, you can also use it in hours or minutes. Since the data has been provided in per hour, so if the data is provided for kilometre per mile we can use it as a mile as well. So there are different ways you can do it, so here so this breakeven distance or we can even have this breakeven time.

Now what is breakeven time, what do we mean by breakeven? Breakeven is the point is that 2 costs matches and if it goes beyond that, the cost factor changes as I will explain to you is particular video uhh particular graph right now. So what we are looking at this red line it starts basically at 0 0. Why it is start at 0 0? Because in terms of the transport cost, the cost as

the distance increases or as at time of travel increase, whether time of travel is 0 there is no cost associated with that.

When there is no uhh time of his 0 there is no cost as your factor as your taking your truck by 1 minute, 2 minutes, 3 minutes, 1 hour, 2 hours you are seeing a like a linear line going up and up and up based on that, so and uhh slope of this line kind of tells you at what was the rate of increase in cost unit of time or per unit of distance. So that is for the direct haul, it starts at 0, so that is pretty simple no problem and you have this equation, you already have the information in the uhh as part of the description of the problem, so you should be able to come up with is y is equal to mx plus c kind of a question for this particular line, so it is a line, so as you know the line has y is equal to mx plus c. So you can use that and you can come up with this particular kind of equations that.

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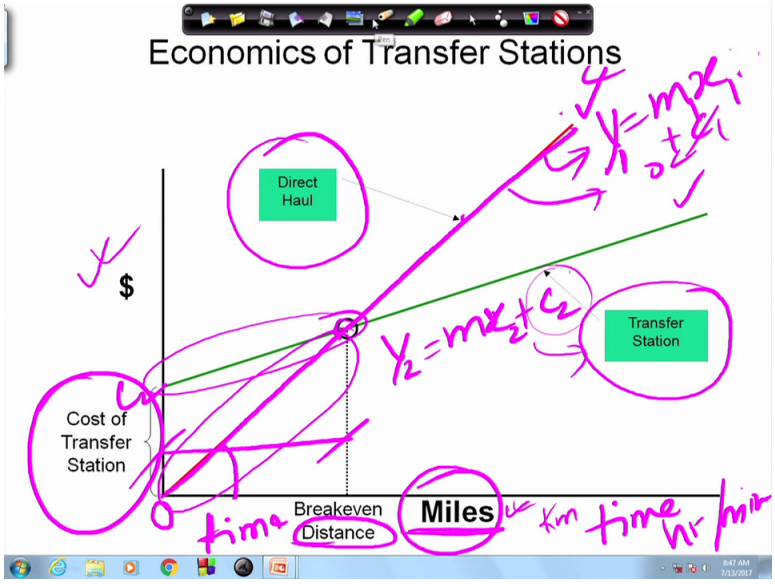

So now what is the other one, why the other one does not starts at 0 uhh some of you may already have figured it out. So if this is starting at 0 why the other one is not starting at 0 uhh the transfer station part, the reason for that is already kind of explain your, what is this? It is the cost of the transfer station because if we as I explained to you in the previous slide we are going for this transfer station option there is a cost to build the transfer station and there is a cost to operate the transfer station that cost has given over here.

So in this particular uhh I erase that and this particular one in this equation if y is say let us call it y1 is equal to m1x1 plus c1 and so if I am looking at this particular line, the value of c is what, value of c1 is 0. Okay let me put the c1 over here so that you can see more clearly.

Uhh y is equal to mx1 plus uhh plus c1. Now the c1 is 0 for this particular stuff but if you look at this particular say if you call it y2 is equal to mx 2 plus c2.

Now what is c2? c2 is this remember from your very basic uhh like a coordinate geometry or those things that you did, so here this is for the transfer station equation, this was for the direct haul equation. Here we have a c2 value and that is the cost of building and operating the transfer station, so that is why you start at are uhh the line starts at a value of dollar value equals to c2 and the time of the travel is still 0 because from this transition is taking to the landfill.

So you can do the uhh the equation for that wherever these 2 lines meet that is the breakpoint, now what does that means? So if you if the distance or if the time of travel is in this particular is in this duration where our cost of direct haul is actually less than cost of transfer uhh operating and building a transition, so that is the cost of this direct haul is less then this transfer station cost.

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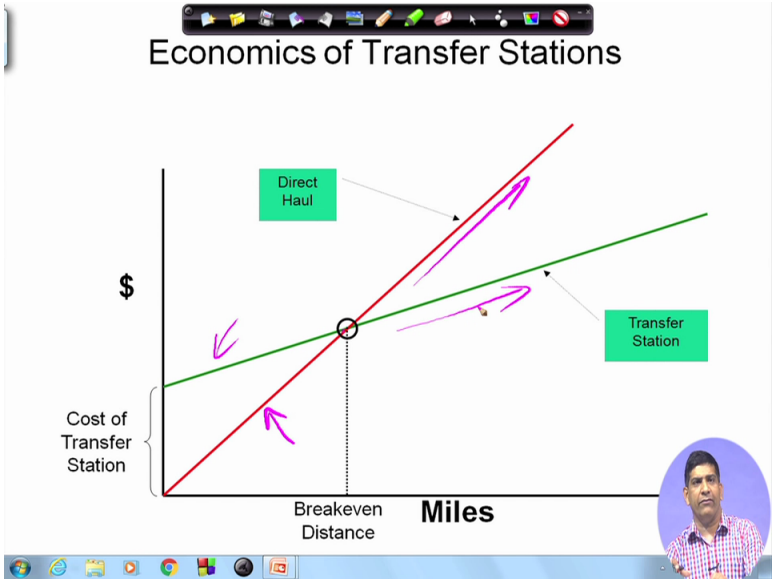

Now as you go further, so this is the like here as you can see that this coast line is higher, this coastline is higher than this coastline up to this particular point but as you process this particular thing actually the direct haul cost keeps on going up so direct haul cost is keeping on going up at the transfer station cost is actually is less now so as you can see that the dynamics changes after this this particular breakeven point or breakeven distance, breakeven time whatever way you put it.

So what I want you to do is I want you to look at uhh this is a very important and very interesting problem and this is one of the like whenever you look at the transfer station versus direct haul which is one of the choice that you need to make uhh so in that case, this actually becomes very important for you to do this kind of calculation and so the reason I am not going over line by line for each calculation as I will do for certain other problems in this particular week because I want you to solve it and I have kind of given you enough hint, so enough hint and enough directions do that.

So go ahead and solve it come up with these 2 equations the data has been provided you and come up with this breakeven time and then post it on discussion board that what they breakeven time you got so once we see that uhh I am giving you like almost 2 weeks to work on it, so if some of you are busy it should not take more than our to work on this problem but you just work on it and after the end of week 6 we will post the answer, so that you have the answer to this problem and then I will also make a solution and scan the solution and put the solution up there as well, so that is it is a very important concept we in terms of economics of transfer station.

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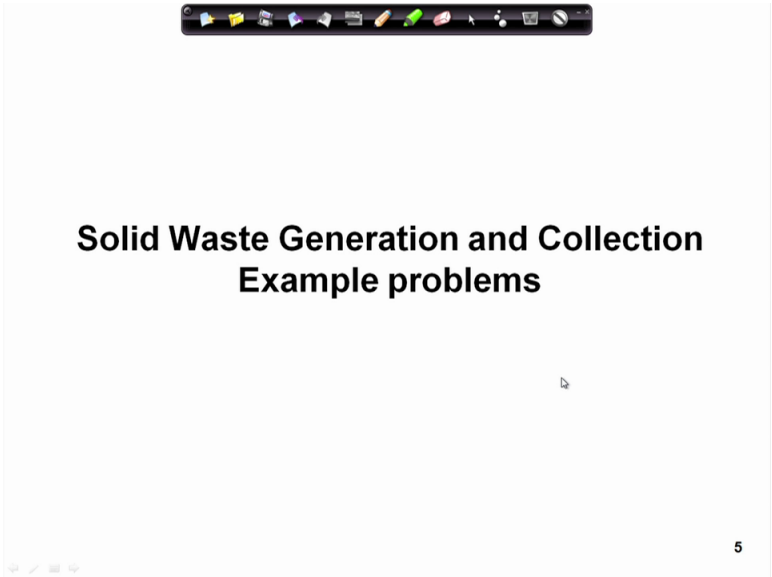

So we covered that and rest of this particular uhh in this video and the subsequent videos will try to look at some examples, so we will try to go over some examples we have covered some theory material this week, the previous week and so we will look at how those things are applied in the real world problem, so if you look at some generation and collection example problem, so let us look at these couple of problem in this video and then we will go to the other one at least let us look at one.

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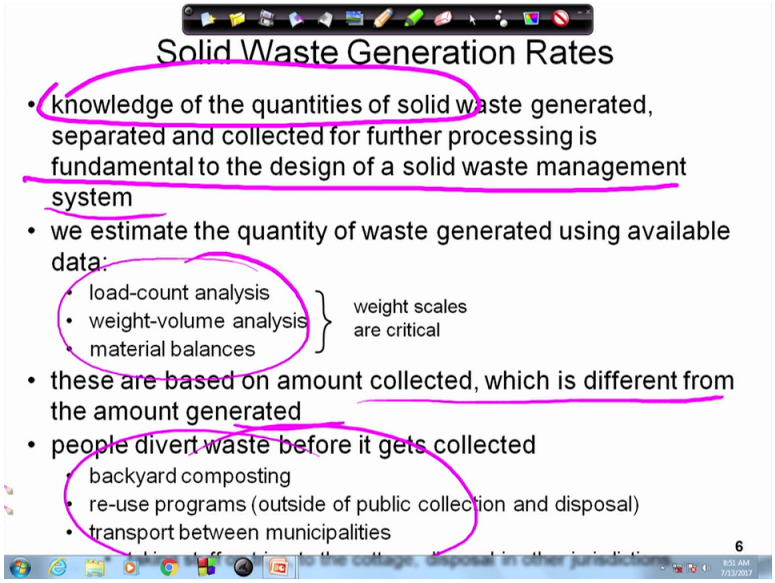

So one of the important thing we talked about earlier as well is finding out the solid waste generation rate because unless we know the generation rate, we cannot design our waste management system. So knowledge of the quantity of solid waste generation how much waste is being generated this is very important, so we need to find out how much waste is being generated, so in this method sorry I think I went to the next slide.

So it says knowledge of the quantity of solid waste is very important, so what it as I as I say over here it is kind of fundamental uhh it is fundamental to design of a solid waste management system costs unless we know how much waste is being produced, so how we do the waste, we use some load-count analysis, we do the weight-volume analysis, we do the material balance. So these are based on amount collected these are what is the amount that is collected we do not want to generated. People also divert some waste in terms of backyard composting, reuse programs and other things there as well, so there are some of those things are done.

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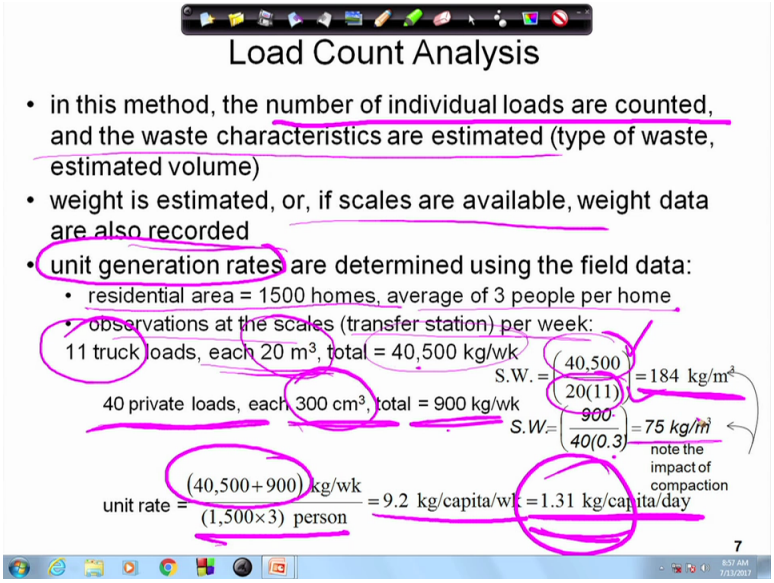

So I think I may have any kind of given part of this uhh stuff earlier, so in terms of the load count analysis what we do here is uhh we actually find out what is the number of individual loads are counted, so things getting disposed at uhh things being bought in to the disposal site. So we look at the number of individual loads are counted and the waste characteristics are estimated types of waste estimated value, we have the weight scales are available we will weigh the data, record the data.

So if you take one example of uhh wear unit generation rate calculation. What is your generation rate? Is to find out how much waste is produced per capita per day, it could be per day, per week, per month whatever but per person. So unit is basically to find out per person, so here if you have a residential area uhh, residential area 1500 homes, average of 3 people per home and so in the observation at the scale or at the transfer station per week what they found is that 11 truck load came every week each was 20 meter cube that is the volume of the truck, so total 40,500 KG per week based on the weight that was uhh what is coming into the transfer station.

Then there was 40 private loads, what are this private loads? People who could not was not at home or they live uhh little bit in semi-urban areas so their houses are not serviced because the houses are too far apart there, so they bring the garbage and drop it off at the transfer station, so for those private loads 300 centimetre cube, so people basically bringing that in their smaller truck or maybe at the back of the car and 900 KG per week coming there much smaller than that.

So in terms of the total unit rate is 40,500 coming from the trucks and 900 coming from the individual, so that is a total waste is produced and that particular area uhh per week, we so that much KG per week. Now the population is 1500 houses uhh 3 person per house so 1500 times 3 is the population. So this is the amount of waste produced this is the total population, so unit rate we can calculate as 9$, so if you do the maths add this up divided by 4500 and you will get 9$2 KG per capita per week so that is per weekday data and then you can divide it by another factor of 7 because that is what and you get 1$31 kg per capita per day.

So that is the amount of waste being produced and it is a it is not too high from where in specially in the Western sector. From the Indian context this number seems to be high uhh because our CPHEEO manual they suggest a figure of around 0$6 to 0$7 for the urban area as of now but with the advent of all this online shopping, packaged material lots of packaging will uhh you see I was is travelling by the plane few days back uhh yesterday and went during those uhh they bring you the food and after the for this and if you look at the packaging although you had the food but the most of the waste is lot of paper like sandwich came wrapped in a parafilm.

So there was a plastic that film plastic and then uhh like a fruity kind of juice so you have that container then you have a straw and then you had some spoon and other things packed those are all plastic spoons then have things packed in plastic uhh I would say small bag not really a bag but you probably get what I am talking about it is kind of uhh all you have spoons with tissue paper output and a small plastic stuff and that is that is again waste you have the napkin, paper napkin those plastic spoon folk and sometimes knife as well and what else have the straw and you have the uhh box in which it came uhh.

So usually if you have a smaller flight they serve you things in a box. So if you look at that they you may have the food and you did not waste any food the whole packaging itself looks the uhh significant and most of it is a very good calorific value material. So that is why what I am trying to say is that more and more of those kind of waste, those kinds of things are developed where we are using lots and lots of packaging.

Although right now we are at 0$6 or 0$7 KG per person per day as per the CPHEEO manual unfortunately we really do not have a very good data in terms of what is the real waste generation rate in the country or in different cities that kind of data we still do not have a reliable data on that but assuming that something around 0$7 because CPHEEO has done that calculation based on some stuff, so they come up with this data and so but this is the this is

how you get those unit generation rate and the other thing that has been shown is basically the density values.

So for this particular waste (())(31:38) the 20 meter cube truck, 11 trucks so this is the volume, so this is the mass upon volume so you see 184 KG per metre cube and this is uhh individual load, so this is mass divided by the volume 40 private loads, each 300 centimetre cube to that is 0$3 meter cube and then you get 75 KG per metre cube. So what is trying to illustrate here is if the individual loads are not compacted this truckloads are compacted you see that with the compaction you actually go almost nearly 2$5 times more weight can be put in to those trucks because some sort of compaction is happening.

So this is one example of how this information that we have been talking about gets applied, so we will look at some more examples like this in the next video and uhh we will carry forward this discussion and so this is uhh I hope you are enjoying the course and you can give us seeing the benefit practical application that is one of the major goal of this course because there are solid waste courses are offered, solid waste books are some books are available or a lot but the practicality aspect like how you will take this information and apply the field that is what I am trying to highlight in this particular course and I hope you are getting that, if you are not you are always welcome to put your comments, thoughts, questions whatever on discussion board will be more than happy to answer anything you have we are keeping a close eye on that again thank you and I will you can see in the next video.