Electrical Distribution System Analysis

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Lecture – 05
Load Allocation in a Distribution System

Students welcome to this 5th lecture of the course Electrical Distribution System Analysis. Topic of the today's lecture is Load Allocation in a Distribution System. Before going to the load allocation we will see what we have seen in the last lecture.

So, we have started with nature of loads, we have seen load course those are basically daily, yearly monthly load course. Then we have seen load duration course, then we have seen various factors which are basically demand factor, load factor, diversity factor and utilization factor.

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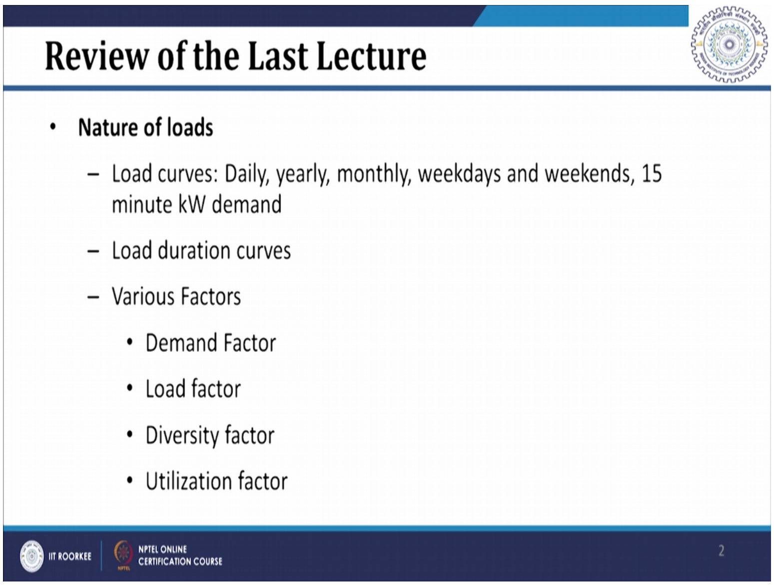

And we have seen that all these factors are important from the point of view of utility. Out of these load factor and diversity factor is very important. So, utility want to improve all those factor means, load factor they want to make it as close to unity has possible and diversity factor they want to make has high has possible.

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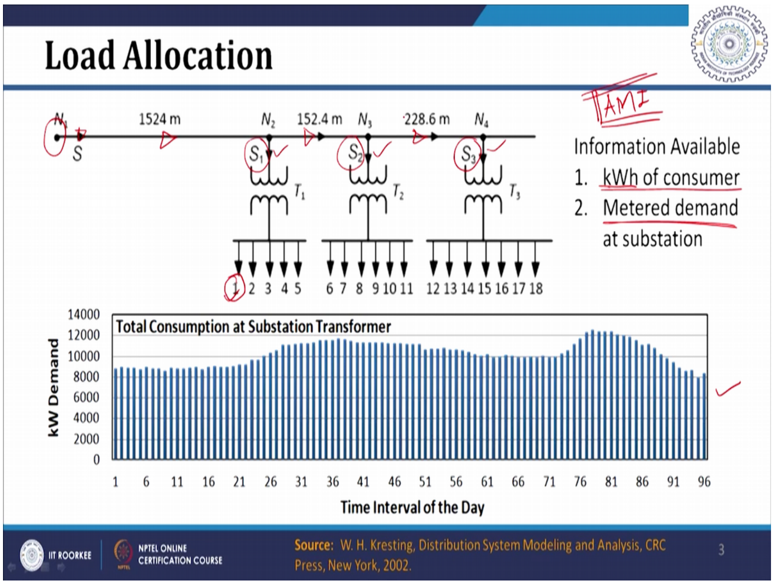

Now, we will see what is called has load allocation. Whenever, we are doing some kind of analysis like load flow analysis or short circuit analysis or any other analysis; like we want to place the distributed generation, we want to place the capacitor or you want to do the volt or optimization we want values of load in the distribution system.

Means so, if you see this distribution system for the analysis purpose it is generally then up to distribution transformer level. All these analysis are basically avoided up to consumer level so, most of the analysis people do up to distribution transformer level.

So, for this analysis we want to load till your distribution transformer level. So, basically if you want to do the analysis so, we want this load S 1 S 2 S 3 which are actually flowing through the distribution transformer. But if you see the measurement which are available in distribution system they are limited. What we know as the measurements in a distribution system, if your advanced metering structure is available then many measurements of the consumers they are available with their consumption patterns.

But most of the system in the world or most of the systems in the world they are not yet provided with advanced making infrastructure, because of that there are only limited measurements are available to predict these load. The measurements available are nothing, but these kilowatt hour consumption of the consumer which is nothing, but the consumption of each consumer. For say monthly, daily, weekly or yearly that we know from the billing data of the consumer or billing information of the consumer.

So, kilo watt hour for consumption of the consumer for particular period we know from billing information. Other thing which we know is actually metered demand at substation. Generally, actually these substations will be provided with meter for measurement of power which is going out of this substation and feeding these distribution transformers.

This measured demand or meter demand at substation which is available into this form. Now, by knowing this data that is kilo watt hour consumption of customers and this metered demand at substation we want to find out this S 1 S 2 S 3 which are basically, load allocated to distribution transformer or may be want to calculate how much power is flowing through these feeder section. So, these this is nothing, but your load allocation problem.

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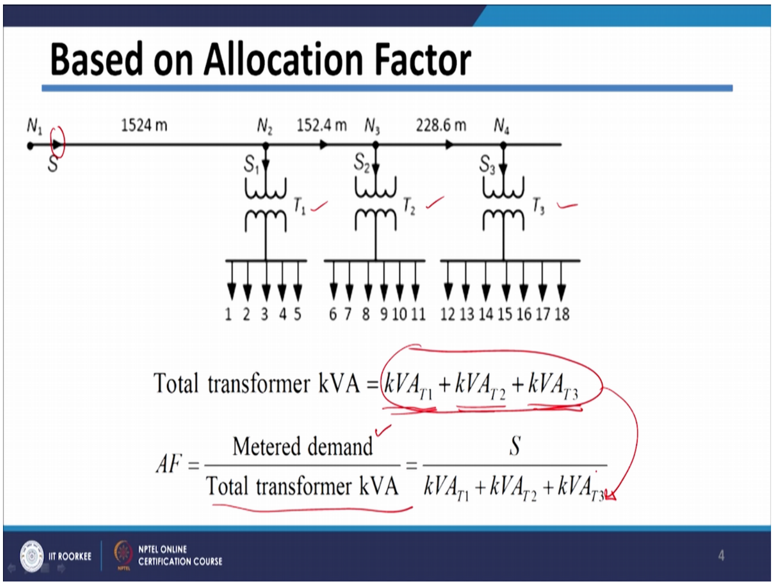

There are many methods and nowadays if you see the literature people of proposed many methods, which are based on sophisticated optimization algorithm. However, since limited information is available there are few algorithms which we are going to see they are basically simple algorithm; using which we can allocate them the load. Means, we can allocate load to the distribution transformers.

The first method is actually based on allocation factor which is very simplest method, but it will not give very accurate distribution of load or they should very accurate allocation of the load over the distribution transformer. But some estimate of the load will get on a distribution transformer that is based on allocation factor. In this case allocation factor is defined as your meter demand at substation divided by total transformer kVA; kVA.

Now, this total transformer kVA is nothing, but additions of rating kVA ratings of each of the transformer. So, in this case since I have shown three-transformer this is nothing, but addition of kVA ratings of all these three-transformers. In that case then allocation factor will be equal to your meter demand means the demand which you are measuring it here; which may be in kilowatt our kVA divided by total transformer kVA which we have calculated here nothing, but addition of capacities of all transformer.

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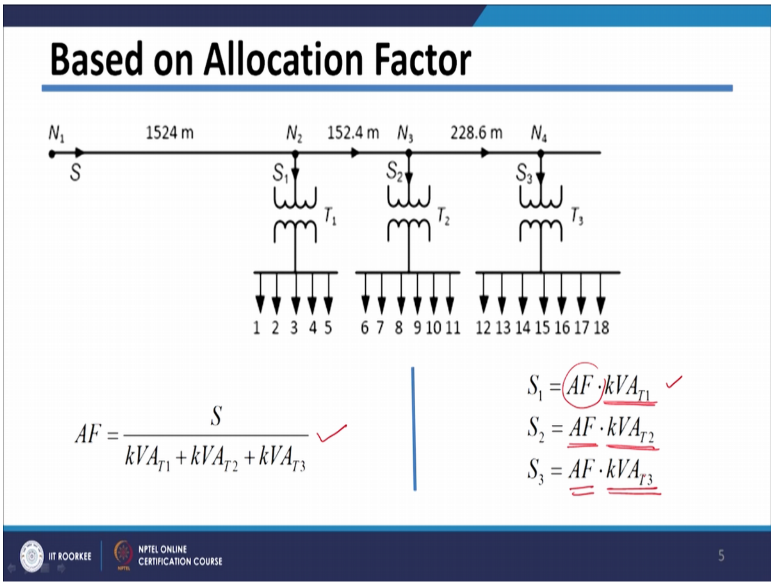

And based on this allocation factor we divide our load or we allocate our load among the distribution transformer. And it is simplest method once you get the allocation factor which is defined on the last slide; we can get the load on transformer T 1 which is basically S 1 which is just allocation factor multiplied by kVA rating of transformer T 1.

Similarly, S 2 will be equal to allocation factor multiplied by kVA rating of transformer T 2 and then S 3 will be equal to allocation factor multiplied by kVA rationing of transformer 3 T T 3. So, you can see that it is very simplest kind of method which is available for distributing the load or allocating the load among the distribution transformer.

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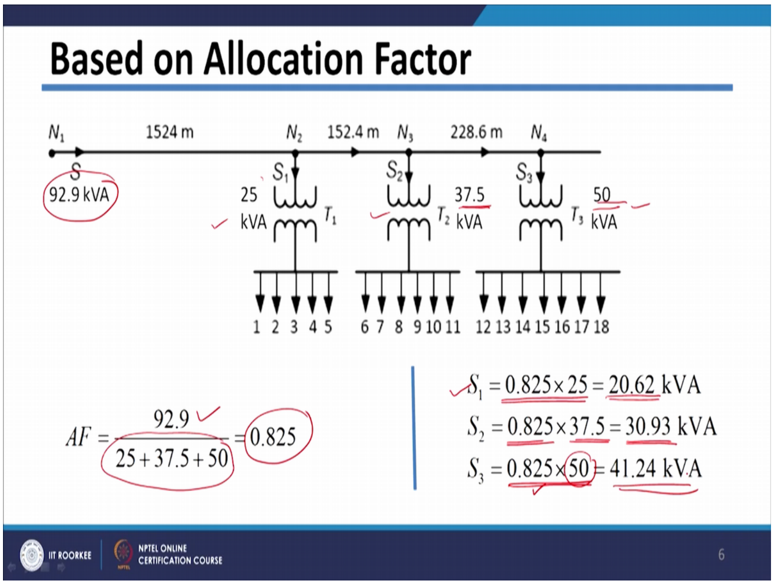

So, if you take one example it is since, it is very simplest method simple example is available. Say you are having this metered demand at substation which is 92.9 kVA and which we want to divide among these a distribution transformer. Now, allocation factor can be easily calculated. It will be total meter demand divided by kV ratings of of the transformers which is 25 37.5 and 50 kVA.

So, you are allocation factor in that case it will be 0.825 and if you calculate then based on allocation factor the load allocated to transformer 1 will be S 1 which is basically allocation factor multiplied by kV rating. So, load on transformer S 1 will be 20.62. Similarly, you can calculate for S 2 which is allocation factor multiplied by rating of transformer T 2, which will be 30.93. And S 3 which is load on transformer 3 which will be allocation factor multiplied by kVA rating of data, how much will give you load allocated to that particular transformer. So, this is actually a little bit approximate method which is based on allocation factor.

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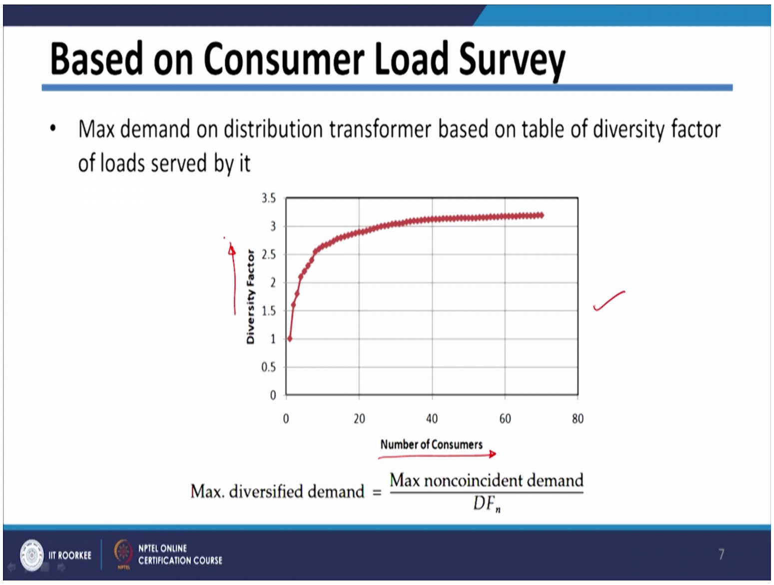

Now, if you want to further improve the accuracy of allocation based on the measurements which are available; in that case we need to carry out some kind of consumer load surveys. So, consumer load surveys are carried out to find out your diversity factor graph, which I have explained in last lecture which is plotted like I shown it here, which basically number of consumers which are plotted on x axis versus your diversity factor which is plotted on y axis.

And this diversity factor curve we can get it from consumer surveys. Means we have to put maximum demand meters at different consumer premises and you have to get their consumption pattern. And based on those consumption patterns and maximum demand meter which are placed for different number of consumers we can get these curves.

So, this kind of survey can be carried out for few number of consumers. Suppose you are having lakhs of consumers in your distribution system, you can select say 100 consumers and for those 100 consumers we can carry out this load survey to calculate the diversity factor.

So, to carry out this first say energy meter will be placed or maximum demand meter will be placed for 1 consumer, then 2 consumer, 3 consumers, 4 consumers. And like that if you go on increasing the number of consumers and parallely if you measure their individual consumptions or individual maximum demands; as well as diversity diversified maximum demands we can get this diversity factor curve.

So, this curve can be available from consumer surveys. Then one more curve which can be available from similar kind of consumer surveys; which is basically we plotted on this particular slide.

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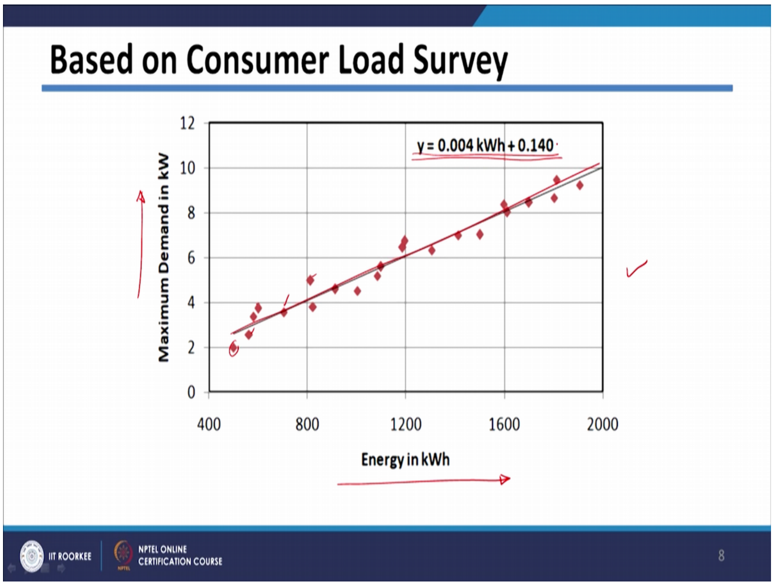

If you observe this on x axis we have plotted energy consumption in kilowatt hour and on y axis we have plotted maxim demand in kilowatt.

So, this curves tells us energy consumption versus maximum demand. This again we have got from say consumer service. So, in this case we have done the consumer survey by measuring their maximum demand and energy consumption; for say 25 consumers. And these dots basically shows their maximum demand versus energy consumption or energy consumption versus maximum demand.

Ah. So, if you can observe these are the dots which are basically taken from the consumer surveys. And if you fit the line between these points I will get actually linear curve, which will basically tell us for those consumer groups we can have energy and kilowatt together. And these two graphs can be used to get the proper estimation of load allocation on distribution transformer.

Now, let us see how can we use these two graphs to do the load allocation in distribution system over the distribution transformers.

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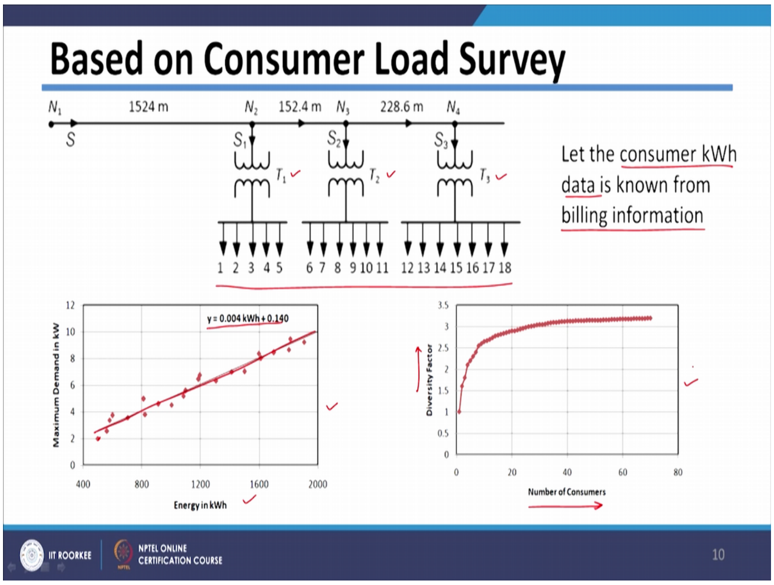

So, as we discussed we have got these two curves from load surveys. One is basically kilowatt maximum demand versus energy consumed in kilowatt hour. And we say this which are basically calculated based on load surveys and these dot indicate the load survey results of particular consumer. And we have filled the curve between these points to get the equation of linear curve which is given by this expression here.

Similar load survey will be carried out to calculate the diversity factor versus your number of consumers. Now, let us see how we can use these curves to get the load allocation in distribution system. So, here I have considered typical distribution systems. A distribution system, where there are three-transformers T 1 T 2 and T 3 and there are a number of consumers are connected to this distribution transformer.

Ah Let us see we know the kilowatt hour consumption of these consumer means we have billing information of these consumers. So, we have three things one is this graph, another is this graph and third is billing information of each consumer. Now, let us say you are having this distribution system with three-transformers and number of consumers.

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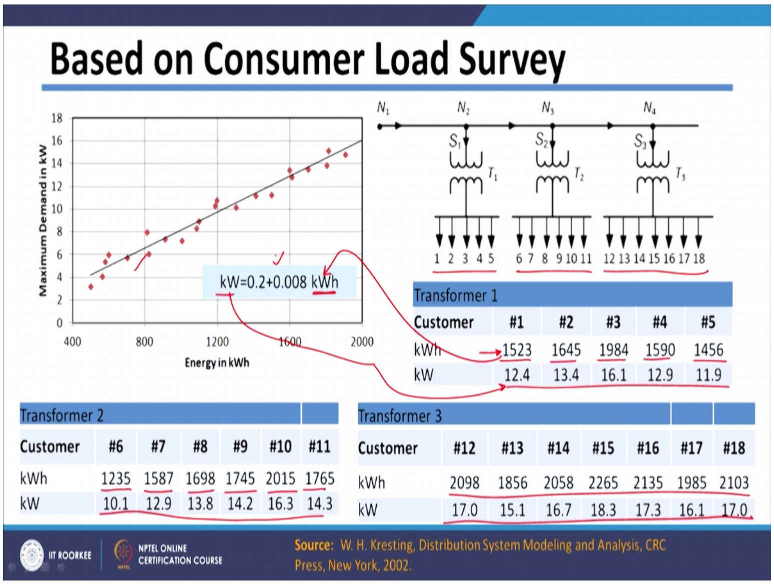

So, in this case there are 5 number of consumers on transformer T 1, 6 number of consumers on transformer T 2 and 7 number of consumers on transformer T 3. So, total 18 consumers are there and we have billing information of those consumers for same month. So, this is kilowatt hour consumption of each of these consumers which are connected to transformer 1 which for say monthly consumption.

Similarly, for transformer 2 the consumption of each consumer is represented here and similarly on transformer 3. Now, from this consumption we can get approximate maximum kilowatt demand for each consumer using your load survey. So, load service already carried out and from this load survey we have got this relation here; which indicate kilowatt maximum demand will be equal to 0.2 plus 0.008 kilowatt hour.

So, if you can put these kilowatt hours into this expression it will give me maximum kilowatt demand for each of the consumer. So, for each consumer I can get maximum kilowatt demand by putting the kilowatt hour into this expression. So, this is how I can calculate maximum kilowatt demand for each consumer. So, these are nothing, but maxim kilowatt demands for all the consumers calculated using load survey equation which is this.

So, once you call once you get these maximum kilowatt demands for all the consumers; now we can get maximum diversified demand on say transformer T 1.

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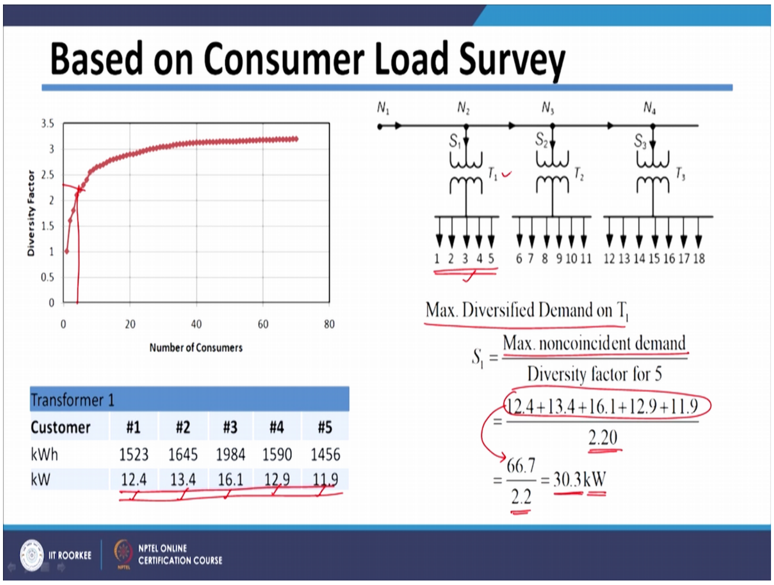

So, transformer T 1 these 5 consumers are connected and we know maximum demand of each consumer which you have got in last slide. So, these are the maximum demands of each of the consumer. Then maximum diversified demand on transformer T 1 is defined as maximum non-coincident demand divided by diversity factor for 5. Because, there are 5 consumers who is to get the diversity factor for 5 and maximum non-coincident demand will be nothing, but addition of individual demands of each of the consumer. So, it will be addition of all these maximum demands of each consumer will give me total maximum non-coincident demand on the transformer.

So, this will be nothing, but maximum non-coincident demand on a transformer divided by diversity of factor for 5. So, we can get the diversity factor for 5 using this graph here which comes around 2.2. And addition of this is 66.7 divided by 2.2 will give me 30.3 kilowatt. So, maximum diversified demand on this transformer T 1 is 30.3 kilowatt.

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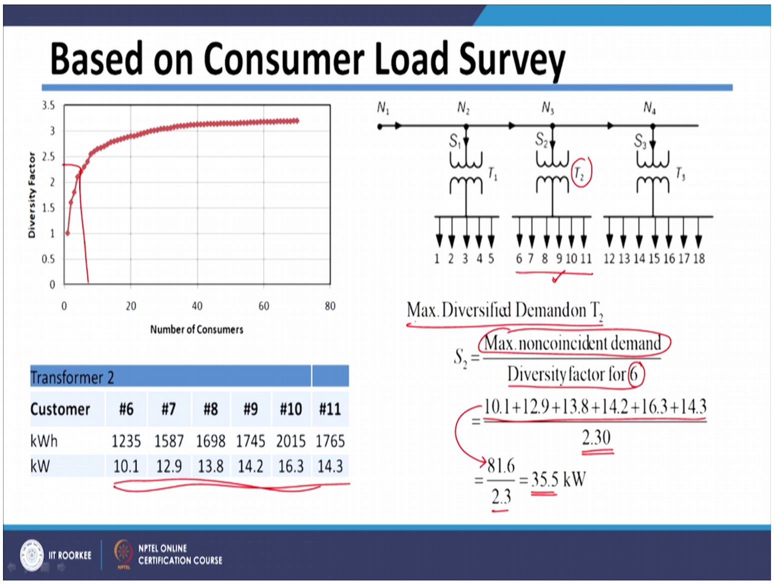

Similarly, we can get for transformer T 2. So, for transformer T 2 these 6 consumers are connected we have their maximum kilowatt demand individual maximum kilowatt demand. So, therefore, maximum non-coincident demand is nothing, but addition of individuals maximum demands. So, these are the individual maximum demands. So, addition of this gives a maximum non-coincident demand and transformer; divided by diversity factor for 5 because, there are 6 diversity factor for 6 because there are 6 consumers connected to this transformer.

So, if you calculate for 6 consumers we can get 2.3. So, here the addition of this is 81.6 divided by 2.3. So, maximum non-coincident or maximum diversify demands on T 2 is 35.5 kilowatt. So, here on this transform of T 2 the maximum diversify demand is 35.5 kilowatt.

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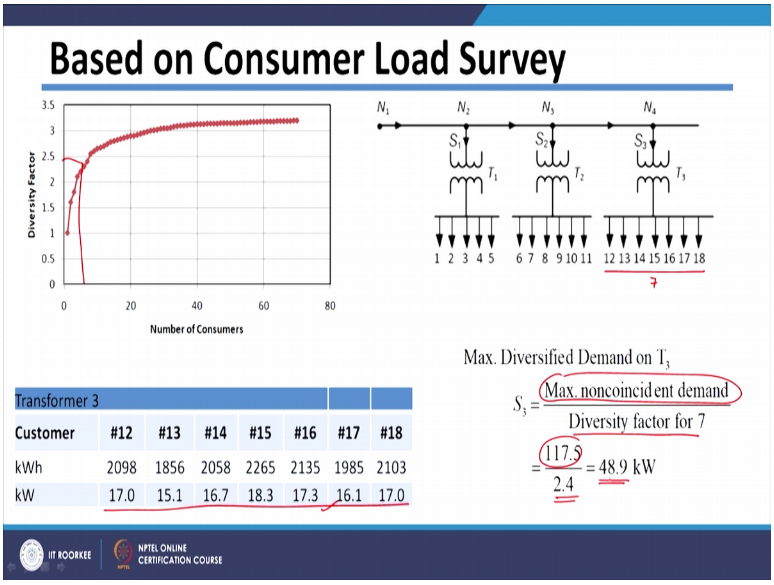

Similarly, on transformer T 3 you are having this 7 consumers which are connected; these are maximum individual demands an addition of this is nothing, but maximum non-coincident and demand. So, if you add them together you will get 117.5 and then you have to get the diversity factor for 7 because there are 7 consumers from this transformer. And from this graph again we can get diversity factor for 7 which comes around 2.4. So, 117.5 divided by 2.4 so, it is 48.9 kilowatt.

So, maximum diversified demand on transformer T 3 will be 48.9 kilowatt. Now, let us say we are interested in calculating maximum diversified demands on feeder sections.

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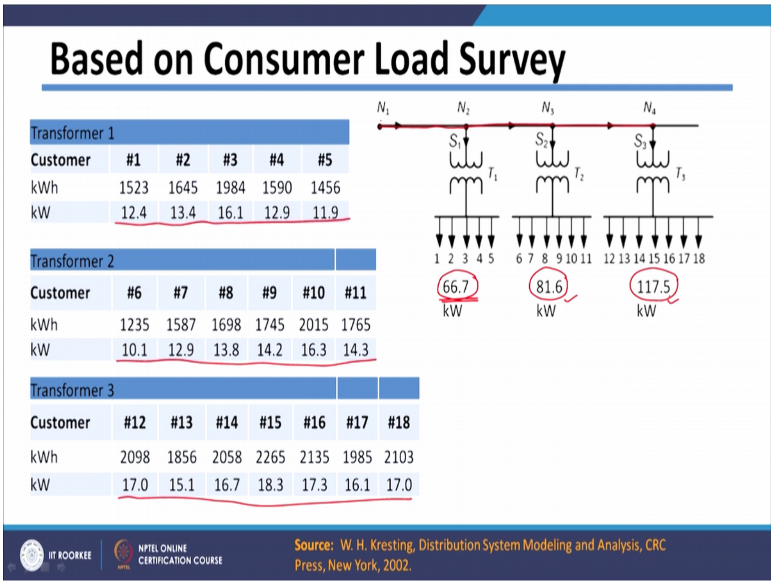

So, there are three feeder section one is from N 1 to N 2, N 2 to N 3 and N N 3 to N 4. And we have seen that the non-coincident maximum demands on transformers on transformer T 1 it is 66.7, which is nothing, but addition of maximum demands of all the consumers, which are connected to transformer T 1. For transformer T 2 it is it is 81.6 means nothing, but addition of all the consumers connected to transform T 2 these addition of individual maximum points.

Similarly, on transformer T 3 it will be addition of individual maximum demands of all the consumers which are connected to transform of T 3. So, they are 66.7 on transformer T 1, 81.6 on transform on T 2 and 117.5 on transformer T 3.

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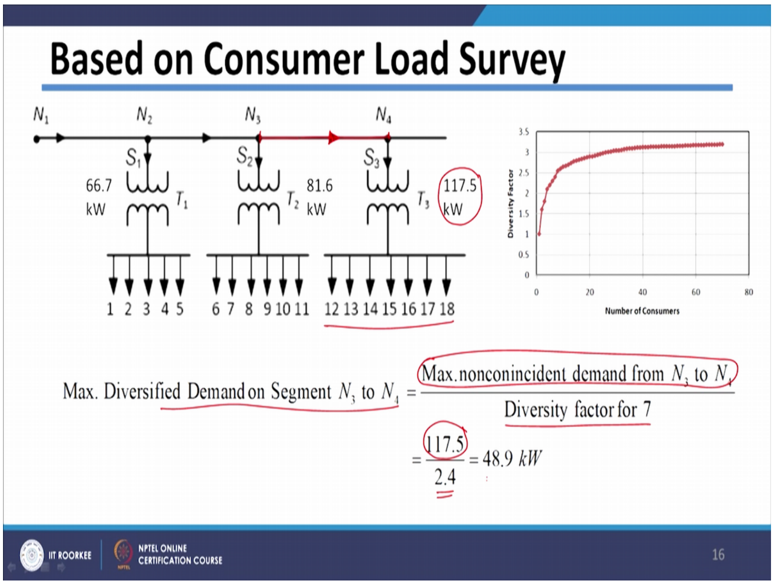

Let us say we are interested in calculating maximum diversify demand on say feeder section from N 3 to N 4. So, in this case we can write maximum diversify demand on segment between N 3 to N 4. So, we have to see what is maximum non-coincident demand from N 3 to N 4. So, we have seen that non-coincident demand on transformer T 3 is 117.5.

This same non-coincident demand is flowing from this speeder section. So, that is why the maximum non-coincident demand on this speeder section will be 117.5 and then diversity factor for 7 because there are 7 consumers connected and we have seen that this diversity factor is 2.4. So, in this case the maximum diversity diversifies demand on segment N 3 to N 4 is 48.9 kilowatt.

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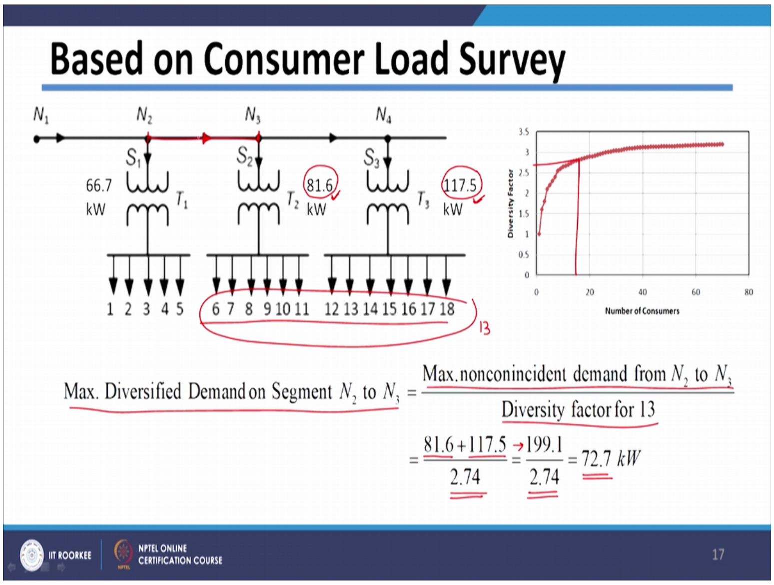

In case of segment between N 2 to N 3, we have to consider non-coincident demands on two transformers that is transformer T 2 and transformer T 3. So, total non-coincident demand on feeder section N 2 to N 3 will be nothing or, but addition of these two non-coincident demands.

So, when we are calculating maximum diversify demand on segment N 2 to N 3 or to consider maxim non-coincident demand from N 2 to N 3 which is basically due to these two transformers. When transformer give 81.6, another transformer give 117.5 divided by a diversity factor for 13; because total number of consumers connected beyond the point N 3 is 13. So, all these consumer 13 so, we can get the diversity factor for 13 which comes around 2.74. So, in this case this addition is 109 199.1 divided by 2.74 which is 72.7 kilowatt.

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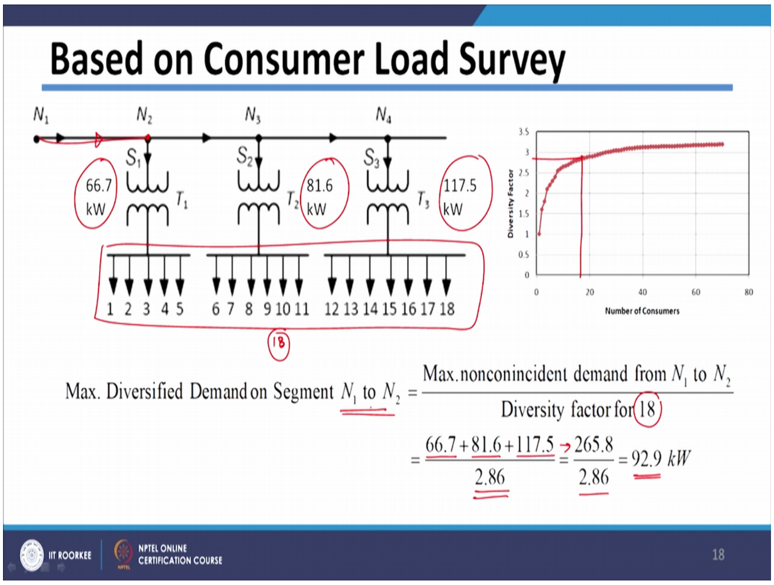

So, in this section the maximum diversified demand is 72.7 kilowatt. Similarly, on section between N 1 to N 2 so, in this case you can say all the consumers are connected. So, total number of consumers beyond this point they are total 18 consumers and it has maximum non-coincident demand of all the three transformers. So, from here to here the maximum non-coincident demand is nothing, but addition of all the three transformer maximum non-coincident demands.

So, maximum non-coincident demand transform T 1 is 66.7, on T 2 it is 81.6 and from on T 3 it is 117.5. And diversity factor for 18, we can get it from this graph which comes around 2.86. Then the addition is 265.8 divided by 2.86 which comes around 92.9 kilowatt. So, this is nothing, but maximum diversified demand on segment N 1 to N 2.

So, this is how you can get maximum diversified demands on feeder section. So, this is nothing, but your load survey method to get the load allocation on distribution transformers as well as on feeder section. And then there is third method, where the load allocation is done based on transformer load management survey.

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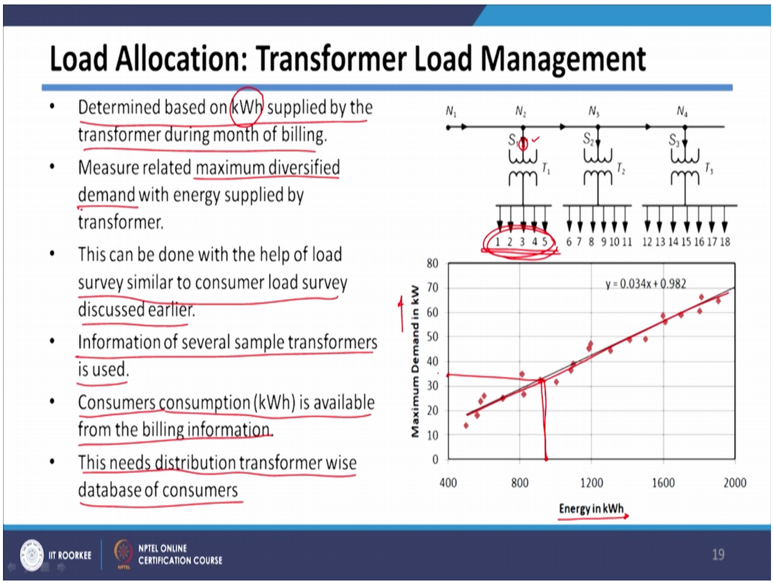

These surveys are similar to your consumer surveys. However, in this case surveys are carried out on distribution transformers. So, in this case the kilowatt hour supplied by transformer during billing months, they are calculating from billing information. So, we know that how much kilowatt hour energy is supplied, by that particular transformer.

And we are putting the meter to make a meter to major maximum diversified demand on that particular transformer. So, we can put some meter here to measure how much is the maximum diversify demand which is flowing through this particular transformer. So, this can be done with the help of load surveys similar to consumer load survey as discussed earlier.

So, in this case we can do the load surveys on a transformer to get kilowatt hour supplied by that transformer versus maximum demand which is flowing through this transformer. And if there are say 100's of transformer in your system, you can select few transformers say 25, 30 or 50 transformers and you can do the surveys on these 50 transformers. So, that we can get graph similar to this which tells me the energy supplied with by this transformer, which we can get from the billing data of the consumers.

And maximum kilowatt demand on this transformer which we can get it from demand meter, which you are putting on particular transformer. And then after plotting this data we can feed the linear curve so, that we can calculate kilowatt demand from nh consumer. So, once you have this curve we can calculate from this load survey, we can calculate maximum demand for any transformer if you know kilowatt hour supplied by this that particular transformer. And that kilowatt kilowatt hour supplied by that transformer will be available from billing data of the consumers which are connected to that particular transformer.

So, in this case information of several sample transformation transformers is used, we need to calculate on several transformers. The consumer consumption kilowatt hour is available from billing information and this needs distribution transformer wise database of consumer. Because we need to know how much kilowatt hour energy is actually supplied by that particular transformer, then only we can get the maximum demand of this particular transformer using this graph.

So, once you know kilowatt hour energy supplied with this transformer from that energy I can get its maximum demand and that can be used as a load applied on that particular transformer. So, this method is based on transformer load management survey.

So, in summary of this lecture we have seen load allocation to the distribution system ah. So, basically that load is allocated at distribution transformer level or sometimes it may be needed for feeder section level and we have seen three methods.

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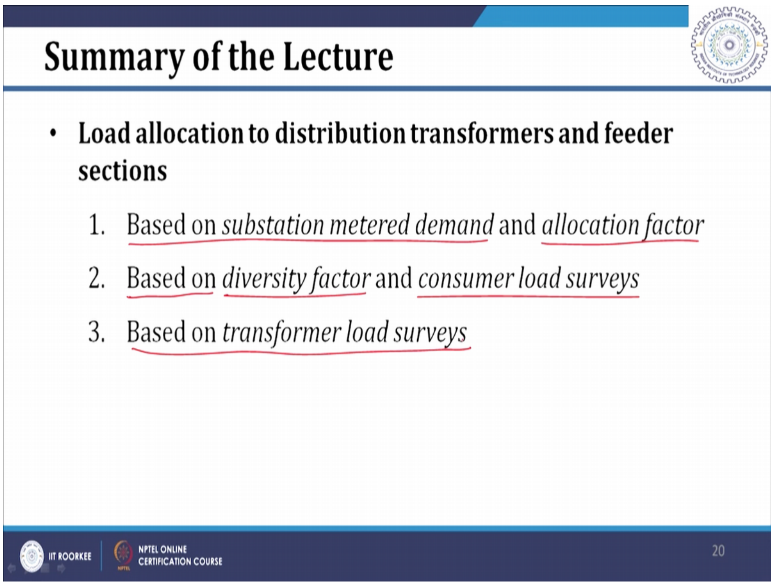

First method is based on substation metered demand and allocation factor. Second method is based on load surveys, those load surveys are basically diversity factor and consumer load surveys. And third method is based on transformer load management surveys or transformer load service.

So, here we have seen how loads are allocated on distribution transformer level, in distribution system or feeder level in distribution system.