Operation and Planning of Power Distribution Systems

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Lecture - 14
Different reliability indices with numerical examples

So, in my last lecture I started discussion on the reliability assessment of power distribution system ok. And the necessity of this type of assessment is also taught and I gave the definition of interruption outages and finally, I was talking about some of the reliability indices which electric utilities commonly use to assess the reliability of their networks ok.

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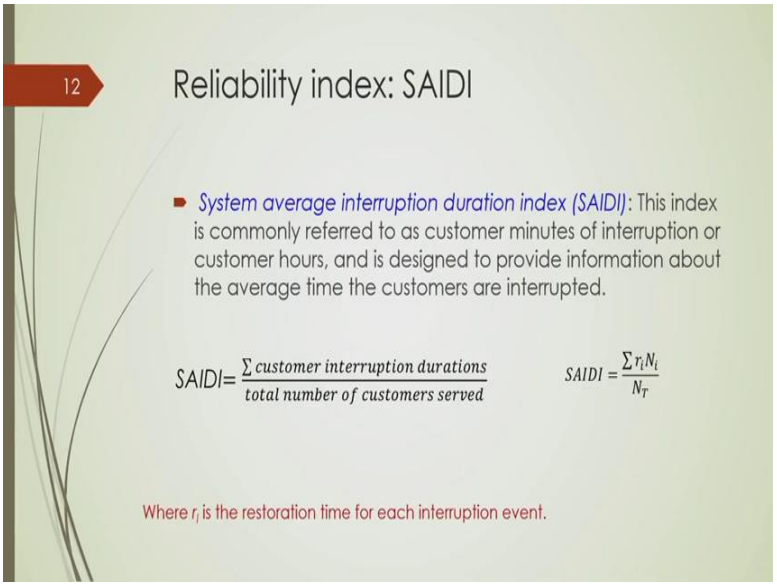

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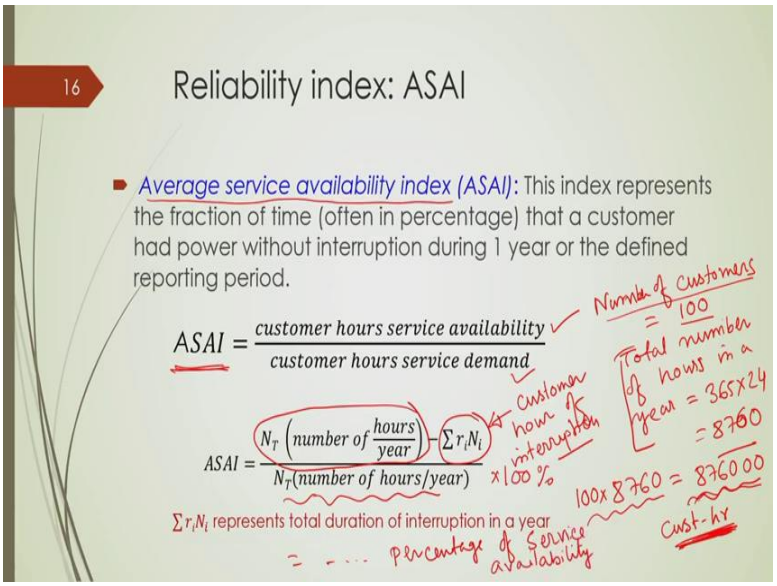

And I cover up to this reliability index in my last lecture that is average service availability index. So, it is essentially an index which gives the availability which provides the information of availability of the service to all the customers, that how much the whole system was available to all the customers and it is a ratio of customer's hour service availability to the customers hours service demand ok. So, as a customer everybody wants to have uninterruptable power.

And so, if we have number of customers equal to 100 and if we analyze this for a 1 year of period, so, the total number of hours for a year is total number of hours in a year is equal to 365 multiplied by 24 which is 8760. So, if your number of customers is equal to 100 and total numbers of hours in a year is 8760, under a particular distribution network, so, theoretically that service should be available to the all customers is 8760, i.e., 100 times of 8760 that is 876000 that many customer hours ok. So, this is the theoretically that much of serviceable availability we should have, but it is not practically possible to have that many customer hours of service availability. Why this is not possible? Because there would be some cases of interruptions ok.

And due to this interruption, I means, no utility can provide that much of customers hours of service availability. So, in order to assess that how much customers hours of service availability the utility can provide, we formulate this index ASAI which is called

Average Service Availability Index ok. So, here this one is the denominator of this index that how much customers hours of service demand that utility has ok.

And numerator is that much of, numerator is that this is nothing but the denominator of this index subtracted by how much customer hour is interrupted due to faults or outages. So, this is basically a customer hour of interruption ok. So, if you subtract to that customer hours of interruption from this customers hour of service demand or customer hours of service availability then whatever you will get that will be the numerator ok.

And denominator is that customer hours of service demand ok. And sometimes we you can convert this in a percentage and you multiply it 100 percent then whatever value you will be getting that much percentage of service availability the utility can provide; that much percentage of service availability the utility can provide ok. So, this I will explain in more detail in a numerical problem in the latter part of this lecture ok.

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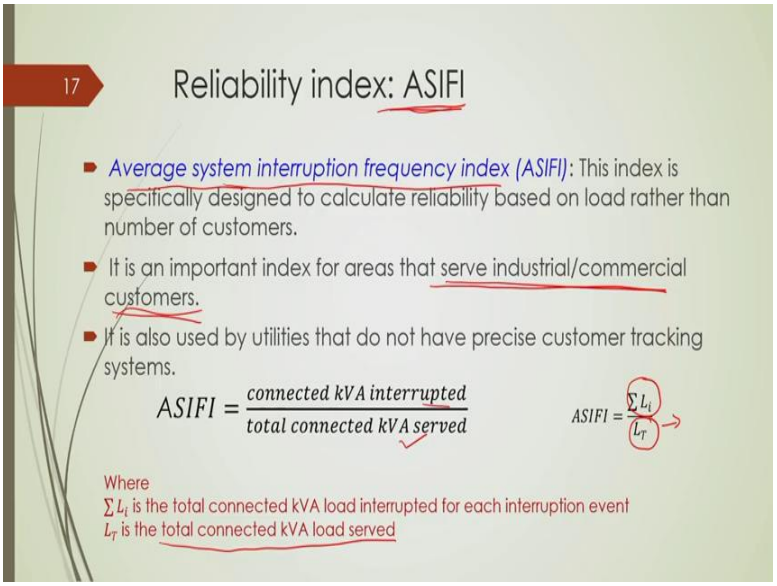

So, next we have another index called ASIFI; ASIFI is Average System Interruption Frequency Index, average system interruption frequency index. It is different from SAIFI ok; SAIFI was System Average Interruption Frequency Index, but here it is average system interruption frequency index ok.

Now, what is this? This is another index which is basically a ratio of connected kVA interrupted to the total connected kVA served. So, denominator is your total kVA

demand. So, this is total kVA demand or total connected kVA load served and numerator is the connected kVA interrupted. So, it gives a ratio of connected kVA interrupted, to the connected kVA served ok. So, you can eventually multiply it with 100 percent in order to get the percentage of kVA interrupted.

Or otherwise, this will give you a fraction of kVA interrupted to that much of kVA served ok. This is normally used for these industrial and commercial customers who experience much trouble for, who experience loss of business due to an interruption ok.

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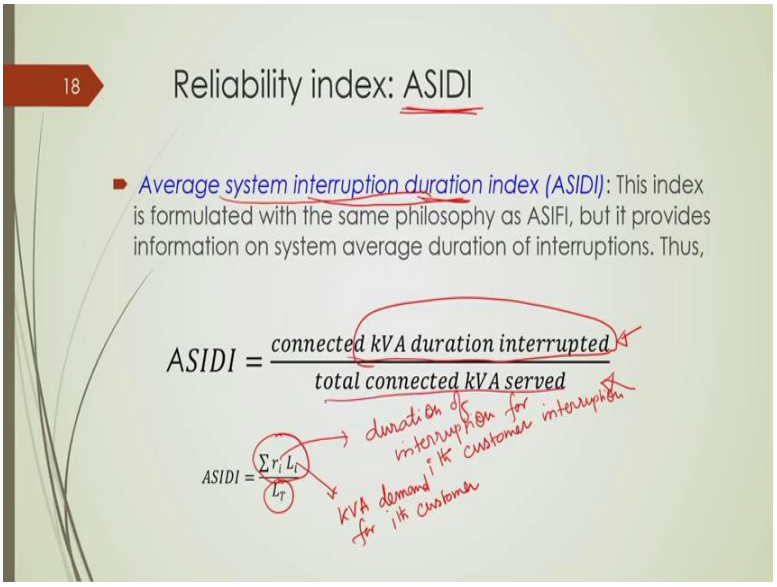

Now, similar to this ASIFI, we have another index which is called ASIDI; previously it was related to frequency, now it is related to the duration. So, ASIDI the full form is Average System Interruption Duration Index; this is different to SAIDI, this one gives you that ratio of connected kVA duration interrupted to the total connected kVA served. So, previously it was total kVA interrupted was formulated as ASIFI that gives you the frequency of interruption and here, since it is related to the duration of the interruption.

So, numerator is connected kVA duration interrupted, connected kVA duration interrupted. So, this is basically summation of r i multiplied by L i. Where r i is giving you the duration of interruption for ith customer, duration of interruption for ith interruption or ith customer interruption ith customer interruption and L i is the load demand of that particular customer. So, this is the kV A demand for ith customer.

And the denominator, it is the total connected kVA served, which is similar to the denominator of ASIFI, total connected kVA served ok.

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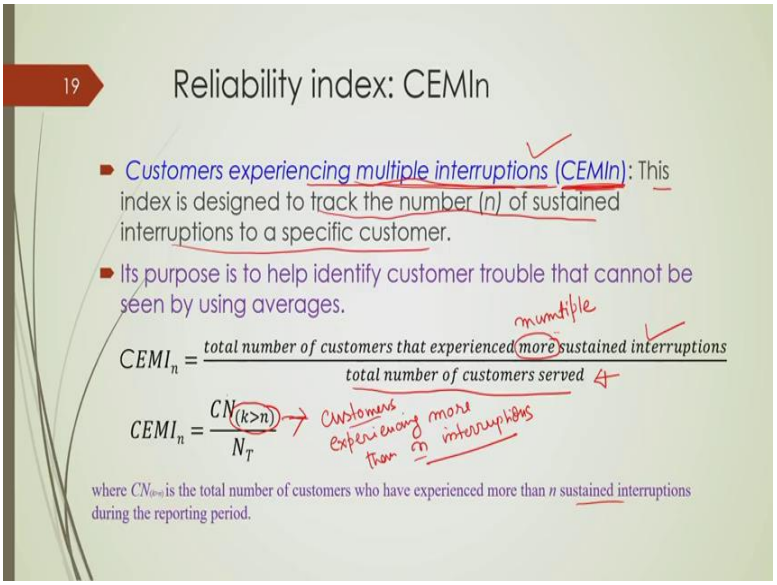

Now, next index is only for those customers which experience multiple interruptions ok. In fact, there are many indices which I talked about like SAIFI, SAIDI, the CAIFI, CAIDI and all. So, you may get some customers who get repeatedly interrupted ok.

Now, that means, you get multiple interruptions and their trouble is much more and in order to identify these, because SAIFI, SAIDI, CAIFI, CAIDI may not fully represent those things at least SAIFI, SAIDI cannot full cannot represent that who is customer is experiencing multiple interruption ok.

Now, here in order to consider that there is a new index called customers experiencing multiple interruptions that is acronym as CEMI small n ok. I n stands for this Interruption and CEM stands for Customer Experiencing Multiple interruption ok. So, this index is designed or formulated to track the number of sustained interruptions to a specific customer ok to identify that which customers get multiple interruptions. So, it is a ratio of a total number of customers that experience more sustained interruptions or multiple sustained interruptions to be more precise.

Multiple sustained interruption to be more precise and the denominator is total number of customers served, that is N T that denominator is same as that of the denominator of

SAIFI ok, alright. Now, here this CN then this terms k greater than n means though here we are counting those customers who experience more than n number of sustained interruptions. So, this is basically representing, this numerator is basically representing customers experiencing more than n interruptions ok.

So, k greater than n means this here we will count those customers who experience more than n numbers of interruptions ok, more than n number of interruption. So, this index is specifically formulated for identifying the customers or the number of times one customer or the fraction of the customers among all the customers who are experiencing multiple interruptions ok; n can be 2, n can be 3 or n can be any value depending upon that a utility preference that how many interruptions they want to catch ok.

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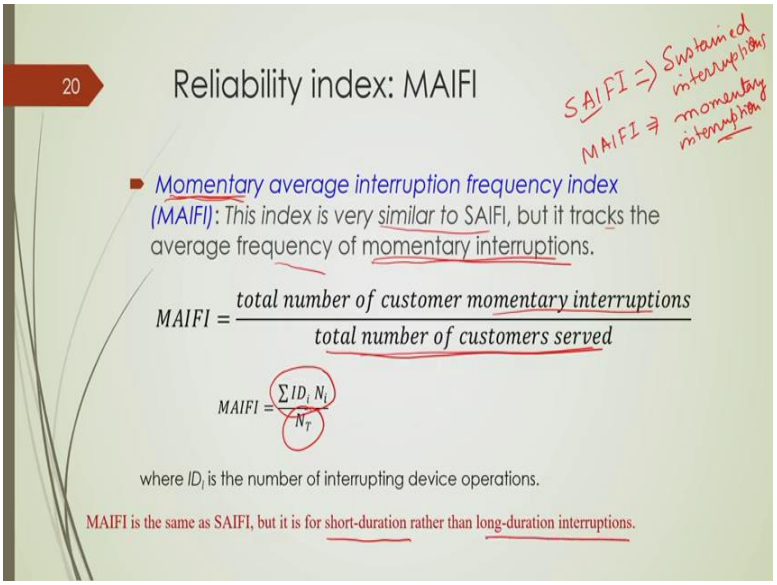

Now, there are some indices which are called momentary indices, which are for momentary interruptions. So, already I mentioned there are 3 types of indices usually formulated; one is called one group of indices is for sustained interruption. Another group of indices is formulated for momentary interruptions and another group of indices is formulated for load or energy based interrupts load and energy based indices ok.

Now, this I will talk about some few indices which will be in the category of momentary interruptions ok. Now, this index is similar to SAIFI, but it tracks the average frequency of momentary interruption. So, SAIFI is for; SAIFI is for; SAIFI is applicable for sustained interruption; that means, those interruptions which sustain few minutes or few

hours and MAIFI, this index is for momentary interruption. Momentary interruption means very short duration interruption which occurred for a fraction of second and so. So, this index is applicable for momentary interruption ok.

Now, what is this MAIFI? MAIFI is this denominator is same as that of SAIFI, that is total number of customer served that is N T and its numerator is total number of customers momentary interruptions ok. So, in SAIFI the numerator was total number of customers experience sustained interruption, here in MAIFI the numerator is total number of customers who experience momentary interruptions ok.

So, this is the only difference with SAIFI. So, it is used for short duration reliability problem. Whereas, you know SAIFI is used for long duration interruption to identify or to numerically represent long duration interruptions ok.

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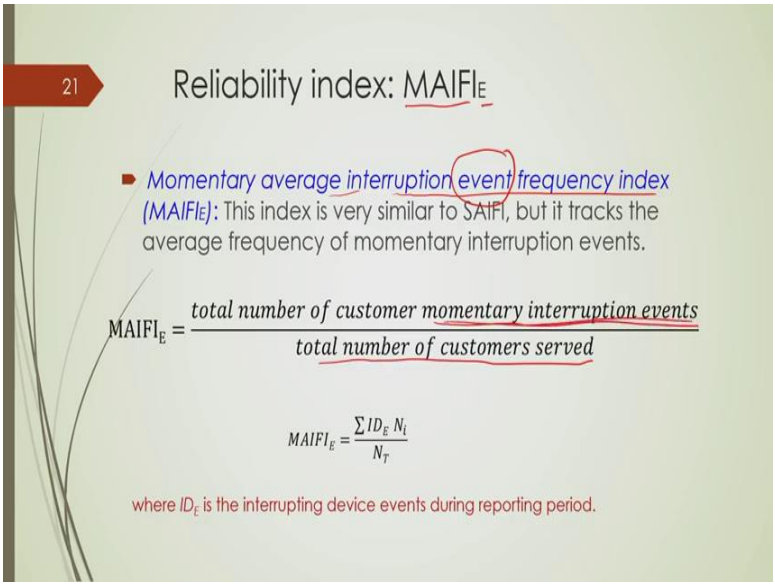

There is another index similar to MAIFI, it is called MAIFI E which is a Momentary Average Interruption Event Frequency Index. So, there is an additional term that is called event which is included here ok. So, here the denominator is same as that of MAIFI that is total number of customer served.

In fact, it is same as that of SAIFI as well, but the numerator is different; the numerator is total number of customers momentary interruption events; total number of customer momentary interruption events ok and that is what the difference is ok.

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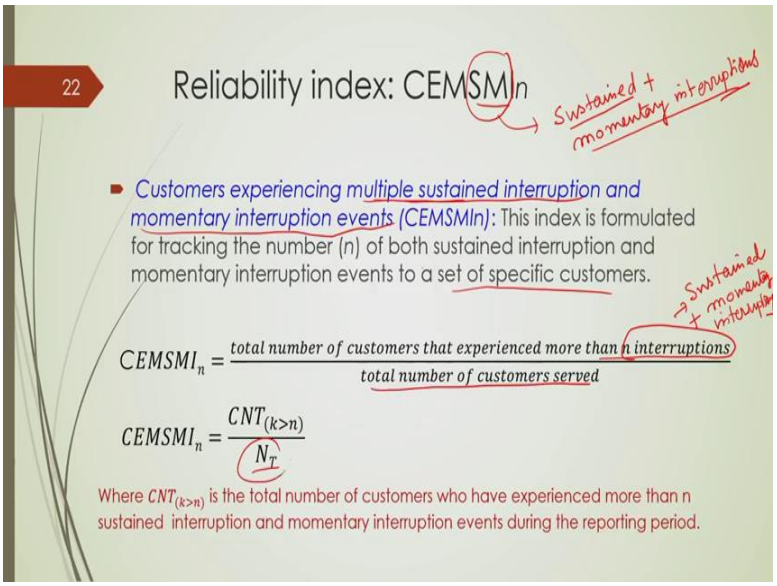

There is another index which is to for those customers who experience multiple sustained interruptions and momentary interruptions ok. So, this is for those customers who experience multiple sustained plus momentary interruptions and this index is formulated to track the number of both sustained and momentary interruption events to set a specific customer ok. So, similar to this CEMI n here only difference is it is CEMSMI n. So, SM stands for here it is Sustained plus Momentary interruption.

So, here this index is for sustained plus momentary interruptions ok. So, similar to CEMI n it is used for those customers who experience multiple interruptions; but in CEMI n it was only for those customers who experience multiple numbers of sustained interruptions. But here in CEMSMI n this index for those customers who experience multiple sustained as well as momentary interruptions ok.

Otherwise, both are similar. So, this numerator is total number of customers that experiences more than n number of interruptions which include sustained plus momentary interruptions; sustained plus momentary interruptions alright. And the denominator is same as that of total number of customer served as in case of CEMI n ok.

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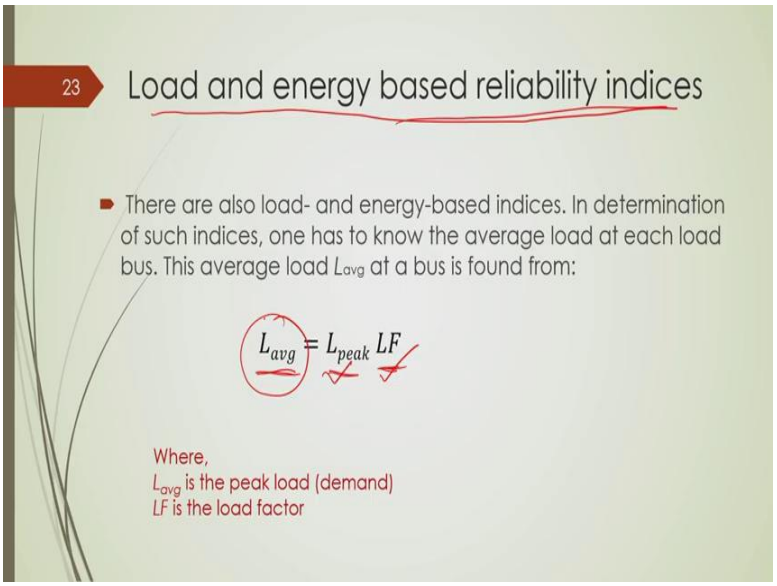

Now, next we will discuss some load or energy based reliability indices, which are very important to understand. Because, these indices are normally used for power distribution system planning ok, when we do plan a network we ensure that the planned network will have certain degree of reliability.

And because you know SAIFI, SAIDI all these are statistics based reliability indices and for a new network which we are planning to design we will definitely not get this type of statistics, its past statistic that how many interruptions will happen. So, those things we cannot predict ok.

So, in order to avoid this, indices gave certain reliability assessment capacity ok. Now, we have a number of load or energy based indices. Now in order to find this, let us first understand that we need the idea of average load; average load is nothing but peak load multiplied by load factor ok, because load factor we know it is a ratio of average load to the peak load. So, if you multiply peak load with load factor you will get the average load ok.

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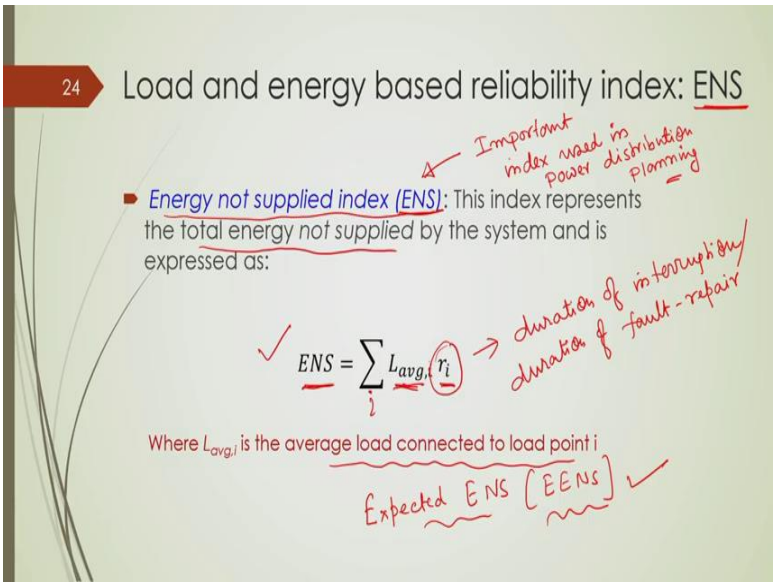

Now, this first index which is very very popular and it is used in many of the research papers, I will also show you in more detail whenever we will talk about power distribution system planning, that is called Energy Not Supplied that is ENS it is an important index used in power distribution system planning.

It is an important index used in power distribution planning so that we can predict that how much would be the reliability level of the planned network and this index gives you that how much of energy could not be supplied due to certain number of faults ok. So, this index is summation of average load multiplied by r i, where this r i is the duration of repair or duration of fault ok.

So, this r i stands for duration of interruption or you can call it as duration of fault repair or alternatively you call as duration of any kind of sustained fault ok. And if you multiply this with, L avg i which represents the average load connected to the load point I who are getting interrupted due to any kind of fault or interruption event ok. So, this basically aggregate, if you aggregate all then this will give you that much of energy not supplied ok.

I have some numerical example, to illustrate you in better manner ok. So, this is a very important index and sometimes in some research paper they used expected ENS, expected ENS; Expected Energy Not Supplied which is termed as EENS and this is an important indicator or reliability index which needs to be minimized so as to ensure a

degree of reliability for a planned network ok. This I will discuss in more detail in power distributions planning module ok.

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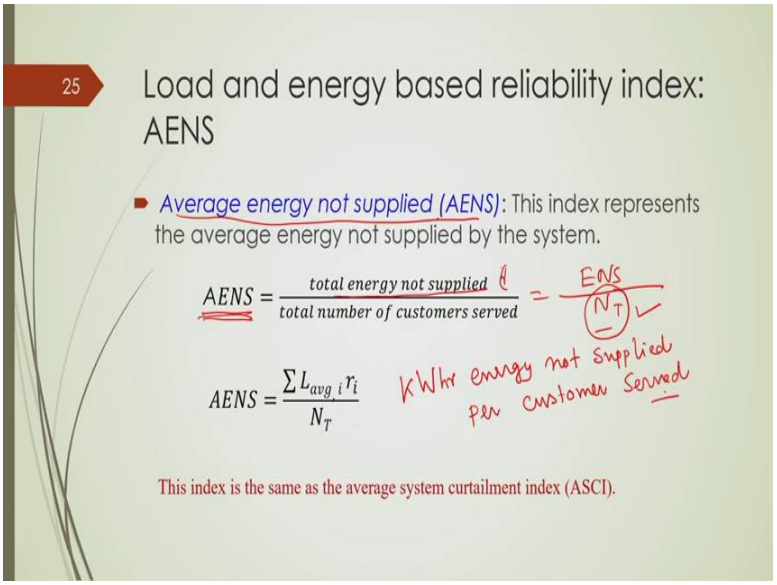

Now, we have two more indices related to this energy not supplied, that is ENS, one is called Average Energy Not Supplied where the numerator is the ENS itself, the total energy not supplied that is ENS, that is ENS and the denominator is total of number of customer served that is N T ok. So that means, this AENS is nothing but normalized form of ENS, where normalization is done with number of customer served; number of customer served ok.

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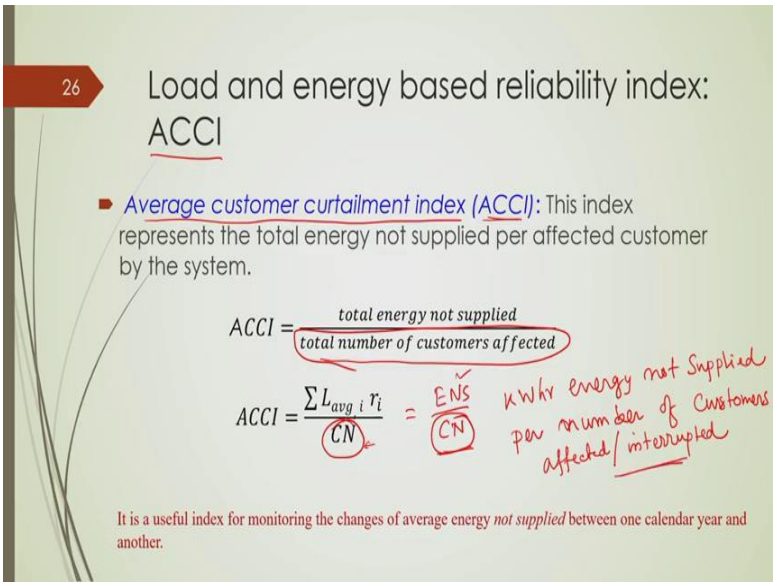

And there is another index called ACCI which is called Average Customer Curtailment Index which is similar to this previous one, i.e., AENS, but which also used to normalize that energy not supplied, but the normalization is done in different way. So, here normalization is done by with number of customers.

And this AENS is basically representing that much of energy is not supplied, but number of customers served. So, if you write the unit of this AENS. So, this will be kilowatt hour of energy not served, energy not served or not supplied per customer served ok. Now, in ACCI the unit would be, since the normalization is done with number of customers affected and as I already mentioned number of customers affected is represented by CN, where basically we exclude those, we will not exclude, but rather we will consider those customers who experience multiple interruptions by only once. We will not consider multiple times for those customers who experience multiple interruptions ok. So, of course, CN is much lower than the number of customers served and also it is lower than the numbers of customers interruptions ok.

So, if you normalize this ENS with CN and CN is the same quantity which is used as the denominator of CAIFI, that you have seen and same amount of customers not total number of customers affected or total number of customers interrupted will be also used here to normalize ENS and that index would be called customers average curtailment index ok.

So, here the unit of this index can be written as kilowatt hour of energy not supplied or not served per unit of per number of customers affected or interrupted; affected or interrupted ok. So, here ENS is normalized with a different quantity than AENS that is the only difference ok. Now we discussed many indices, reliability indices, let us find out how to determine those indices numerically.

With what sort of information we need to gather or a utility needs to gather so that they can compute these indices effectively ok.

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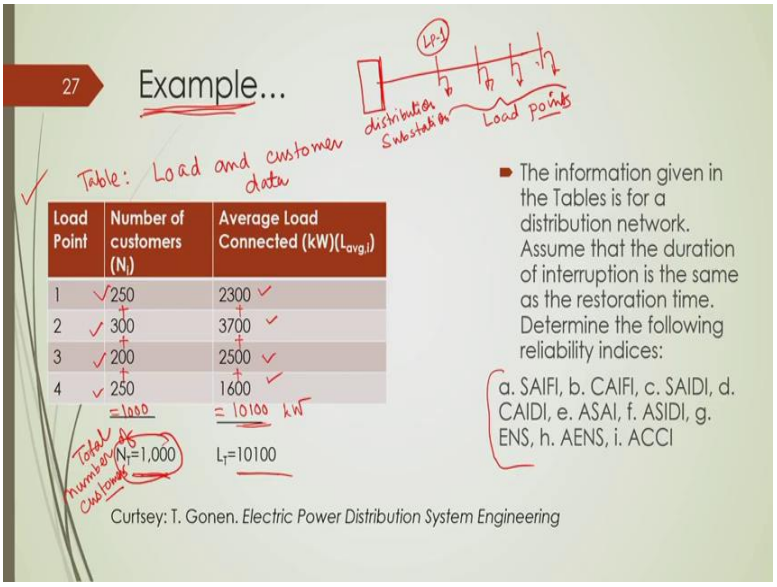

So, this example give you the idea, there are two ideas that you will get: one is how to compute those indices; with a given data set also it gives a idea that what are the data need to be tabulated; what are the data need to be tabulated in order to compute these indices ok. So, this one needs to understand clearly ok. So, look at this table; look at this table; this table does not give you any data related to interruption; this tables give you only load and customer data, load and customer data ok.

Now, this table gives you load and customer data. Now, if you look at these 3 columns of this table, column 1 is for load points it gives you there are 4 load points under a distribution feeder or under a distribution network ok. So, you can assume that this is suppose a distribution substation and we have one feeder where we have 4 number of loading points like this, 4 number of loading points. So, these are the load points which

are connected to a distribution transformer, and then it is connected to the number of customers.

And it is mentioned that how many customers are connected to each of the load point. So, for load point 1, so this is, suppose load point 1, we have 250 number of customers connected. An average load connected load is also given that is 2300 kilowatt; 2300 kilowatt. Similarly for load point 1, this is the number of customers.

So, that is 300 number of customers are connected with this load point 2 and the average connected load is 3700. Similarly, these are the data part load point 3 and load point 4 and corresponding average load connected ok, average load connected. Now, if you sum up this second column of this table then you will get total number of customers served by this particular distribution feeder.

So, this gives you total number of customers ok. So, this is given as 1000 which is nothing but obtaining by adding this 250, 300, 200, 250, which gives you 1000 alright; 250, 250, 500 and this 300, 200, 500; 500, 500 if you add you will get 1000. Similarly, this average load connected to the whole feeder you can get just by adding this average load connected to each of the load points, which is 2300 plus 3700 plus 2500 plus you know 1600 which gives you 10100 ok. So, this 2300 if you add 3700 this will give you 6000 and 2500 and 1600 if you add, we will get 4100. So, result is 10100 kilowatt of average load ok. And you are supposed to determine some of the indices given over here, but with this information, we cannot certainly determine these indices, we need more information. What information are given, let us see?

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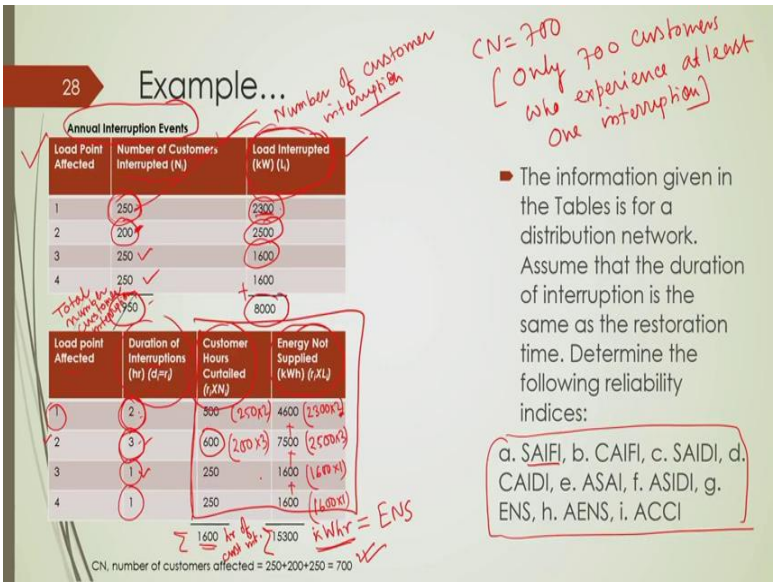

This table gives you the annual interruption events; so, annual interruption events. So, here again column 1 and column 2 are same that is number of loading points and no, column 2 is different. So, column two is basically giving you number of customers interruption, this is that many customer interruptions took place ok. So, although we have 250 customers there is an event of 250 customer interruptions ok; that means, that does not mean that all the 250 customers are interrupted, because it may so happen that one customer is interrupted multiple times.

So, this 250 gives you number of customers interruption. So, this is basically number of customer interruption, is not the number of customers interrupted or number of customers affected, but it gives you number of customers interruption; customer interruption ok. Similarly, at load point 2 there is a event of 200 number of customers interruptions.

Similarly, for load point 3 and load point 4 is given. And if you sum up all these things which gives you 950, so, this 950 is the total number of customers interruption. So, this gives you total number of customer interruption ok; total number of customer interruption ok. Similarly, this column gives you how much load is interrupted due to those customer interruptions and if you add all these things this gives you total number of load interrupted ok.

And as an extension of the same table, we also have the information of duration of interruption which is required to compute those indices which are related to the duration of interruption; for example, SAIDI, CAIDI and so on. So, the duration of interruption is given that for load point 1, there is duration of 2 hours of interruption, for load point 2 there is an event of 3 hours of interruption, for load point 3 there is a 1 hour of interruption and load point 4 there is an event of 1 hour of interruption ok.

Now, you need to find out with this information, I think one needs to calculate or one needs to compute all these indices which are given over here; all these indices are possible to calculate part of this table ok. We do not need anything; only thing is that we need information, that is what is CN. CN is the number of customers affected excluding by considering that those customers who experience multiple interruptions; we consider this ok and that number will be less than number of customer interruption and that number will be of course less than the number of customers served. This CN is given as 700 which means that we have only 700 customers who experience at least one interruption ok.

So, we have 700 number of customers who experience at least one interruption ok. Now, with this 3 column of annual interruption event, we can find out customers hours of curtailment which is required for duration based index. This is very simple, you know the duration of the interruption and you know the number of customers interrupted; you simply multiply. So, you will get all these customers hour curtailed that gives you that many customers hours are curtailed ok.

So, this 500 we get if you multiply 250 with 2. So, this 500 is because of 250 multiplied by 2. Similarly, this 600 we will get it from multiplying 200 with 3. So, because at load point 2, there are 200 number of customers interruption events and the duration was of 3 hours. So, this gives you 200 multiplied by 3 which is 600 and so on. So, if you sum up all these things then whatever you will get that is that much hour of customer interruption which occur ok.

So, this gives you that many hour of customer interruption. Similarly, you can also find out energy not supplied ok. So, how to find out this energy not supplied? We know this average load interrupted. That is 2300 and if you multiply with this duration of this interruption, then you will get energy not supplied at load point 1. So, this 4600 from

2300 multiplied by 2 which is this; 2 is the duration of the interruption and 2300 gives you how much load was interrupted at load point 2 or due to the interruption at load point 1 ok.

Similarly, this 2500 if you multiply with this duration event that is 3 then we will get 7500 and similarly this 1600 is duration event is already 1 that is 1600 multiplied by 1 and 1600 multiplied by 1. So, if you sum up all this, then whatever you will get? You will get that is the value of energy not supplied. So, that much of kilowatt hour of energy is not supplied.

So, this is the ENS that you can get ok. Now, let us see that how we find out those indices ok. So, these are two tables, these two columns of this table can be obtained from this 3 tables given ok. We do not need to have this information, but only we need to have this information of number of customers interruptions; we also need the information of how much load was interrupted due to this interruption event and what was the duration of this interruption.

With these 3 data sets, you can compute this ENS; you can compute all these indices possible and also we know that number of customers is 1000 and the average load connected was 10100 ok.

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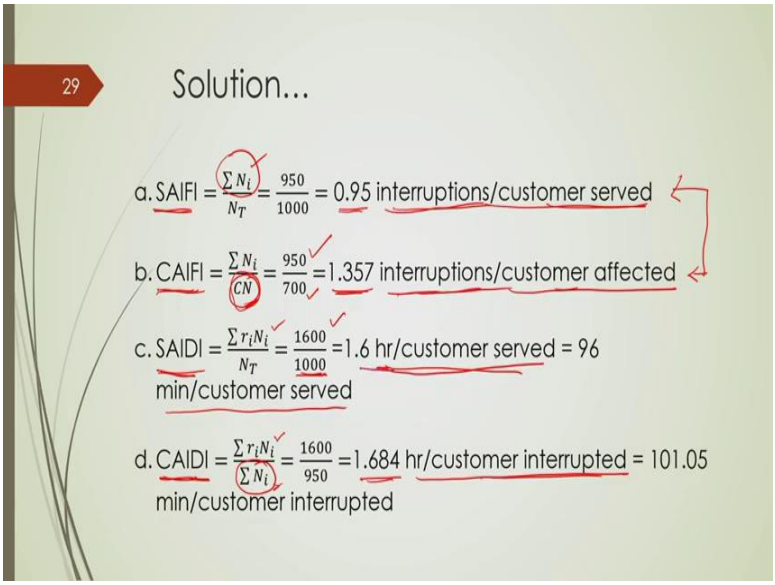

Now, in order to find out SAIFI, SAIFI is the ratio of total number of customers interruptions to the total number of customers served. So, total number of customers interruptions already we got 950 that is this 950 divided by total number of customer served which is 1000. So, it gives you 950 divided by 1000 which is equal to 0.95; look at this unit. This unit is sometime very important; the unit of SAIFI is that many interruptions per customer served; that many interruptions per customer served.

Similarly, CAIFI that is a customer average interruption frequency index whose difference with this SAIFI that denominator is different, here denominator is number of customers affected, not the customer number of customers served ok. And we all already know number of customers affected is 700; number of customers affected is 700. So, we know the numerator is same as that of SAIFI, that is 950 and denominator is 700.

So, it is 1.957 number of interruptions per customers affected; look at this difference of the unit of this you know SAIFI and CAIFI. So, in one case it was that many interruptions per customer served and for CAIFI it is that many interruptions customer interruptions per customers affected or customers interrupted so; obviously, CAIFI is higher because CN is lower, it gives you only that many customers who got at least 1 interruption ok..

Now, let us find out two duration indices, one is SAIDI another is CAIDI ok. In SAIDI, that is system average interruption duration index, the numerator was total hours of customers load curtailment, which you can eventually get from this value total number of customers load curtailment which is given as 1600 ok. So, that is the numerator of this SAIDI. And the denominator is that many customers served which is similar to SAIFI ok. So, the unit of this is that much of hour per customer served or you can convert it to minute; 1.6 hr per customer served corresponds to 95 minutes of per customer severed ok. But in CAIDI that is Customer Average Interruption Duration Index numerator is same as that of SAIDI that is 1600 and denominator is that many customers interruptions ok. So, this was this is basically the numerator of SAIFI or CAIFI, as well ok. So, it is a ratio of 1600 by 950, so, which is 1.684 hour; look at this unit again hour per customer interrupted ok, or hour per that much of customers interruptions ok, whereas, in SAIDI it was that much hour of customer served.

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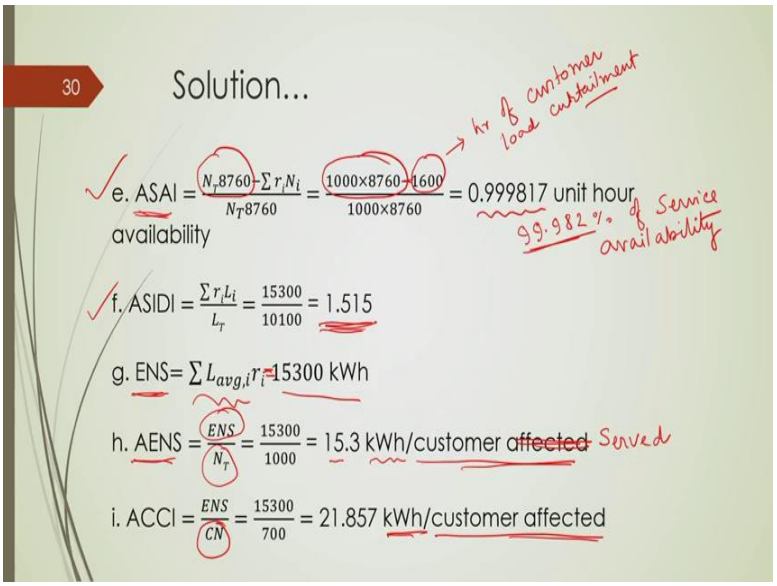

Now, ASAI is Average Service Availability Index, as I said, which gives you that how much service was available. So, as I said, the numerator is first number of customers multiplied by number of hours in a year. So, here ASAI is computed in a year, but eventually it can be computed also in a span of 2 years or 3 years or for a given reporting period ok. So, since our total number of customer is 1000, so, this N T multiplied by 8760, which is that much of customers hour demand we have for this particular system.

And now if you subtract with this duration of this interruption or the hour of customers load curtailment which is equal to 1600, this one, then the numerator will give you that much of hour service which was given uninterrupted to all customers. So, this 1600 is the that many hours of customer load curtailment or interruption you can call ok.

So, if you subtract this with 1000 multiplied by 8760 you will get this factor and if you multiply this with 100 percent then this will give you 99.982 percent of service availability ok. So, this gives you 99.982 percent of service availability ok. Now, we will calculate ASIDI, which is nothing but you know kVA interrupted to the kVA served.

So, kVA interrupted you can find out already this that much of energy is not served that is ENS that is kVA interrupted 15300 and kVA demand is 10100. So, this is a unit less index which gives you, if you multiply it with 100, you can get that much percentage of kVA served with in relation to that much of kVA demand ok. Now, ENS that is energy not supplied only we computed as this should be equal to 15300 kilowatt hour ok.

This one is already calculated here ok. Now, AENS that is average energy not supplied; here the numerator is ENS which is normalized with number of customers that is 1000. So, its unit is that much of kilowatt hour per customers not affected, it should be customer served ok. So, AENS, the unit would be that much hour kilowatt hour per customer served and ACCI, its denominator is only difference. So, its unit will be that much of kilowatt hour per customer affected ok.

So, this gives you all these values of all these indices and this also gives you what are the information you should have in order to compute those indices.

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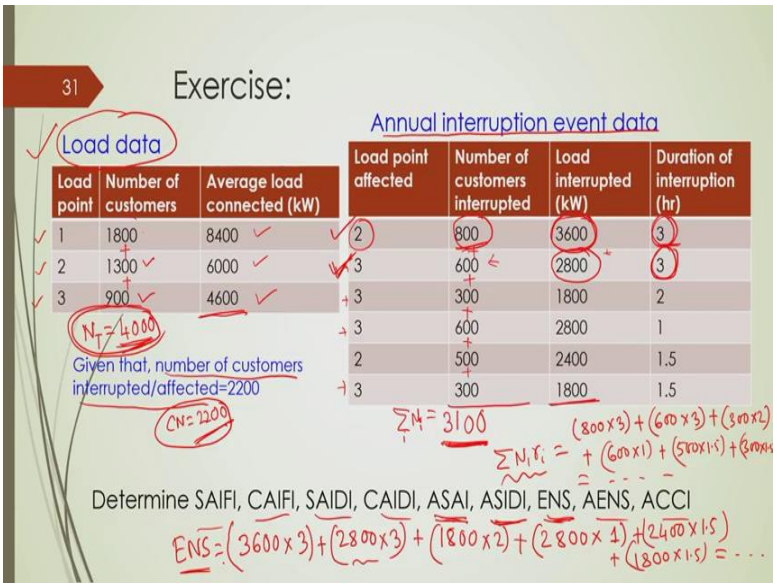

Now, we have another example, we have another example which I kept as an exercise for you to do ok. So, I can help you to give a hint to let you know how to proceed this. So, this exercise is similar to previous one; here this table gives you load data ok; here it is mentioned that we have 3 load points that is load point 1, load point 2, load point 3. And at load point 1, we have 1800 customers connected; at load point 2, we have 13600 customers connected and at load point 3 we have 900 customers connected.

Similarly, this average load connected to each of the load points are also given, this 8400, 6000 and 4600 for load point 1, 2 and 3, respectively ok. So, you can find out this value of N T which gives you total number of customer served just by summing up all these three 1800 plus 1300 plus 900.

So, if you sum up this 1800 to plus 1300 this will give you 3100, if you sum up with 900 this will give you 4000. So, we have total 4000 customers for this particular system and this average load connected information is also given. Now, there is another table which gives you annual interruption event data ok; annual interruption event data.

So, there are 6 set of events; there are 6 set of events. In event 1, load point 2 was affected which causes 800 numbers of customers interruptions ok; which causes 800 numbers of customers interruptions ok. And number of load interruptions was 3600 and the duration of the event was 3 hour so as the other event. So, you can see load point 3, it experiences multiple interruption events.

And load point 2 experience, in fact, load point 2 experiences 2 numbers of interruption events and load point 3 experiences you know 4 number of this interruption events. And correspondingly number of customers interrupted, number of amount of load interrupted and the duration of the event, this information are given to us ok.

Now the question is how do we calculate? Or how do we compute these indices like SAIFI, CAIFI, SAIDI, CAIDI, ASAI, ASIDI, ENS, AENS, ACCI, similar to this previous problem? Ok and one information is given that number of customers interrupted or affected is 2200; that means, CN is equal to 2200 alright; CN is equal to 2200, because you know this CN and N T these are the two information which we require to normalize all these indices.

Most of the indices are normalized with either CN or N T; that means, they are computed as that much per customer served or that much per customers affected or interrupted ok. Now, how do we calculate SAIFI? In order to calculate SAIFI, you need the information of how many number of customers interruption events were ok. So, you sum up all these values 800, 600, 300, 900, 600, 500 and 300.

Then, whatever the value will come that will give you N i; summation of N i with for all i ok. So, here there is an event of this. There are 6 events and for each event this number of customers interruptions are given. So, if you sum up let us see what is that value this is 0, this is also 0, 3, 5, 8, 14, 17, 23 and 8 that is 3, 31. So, that many customers interruptions took place ok.

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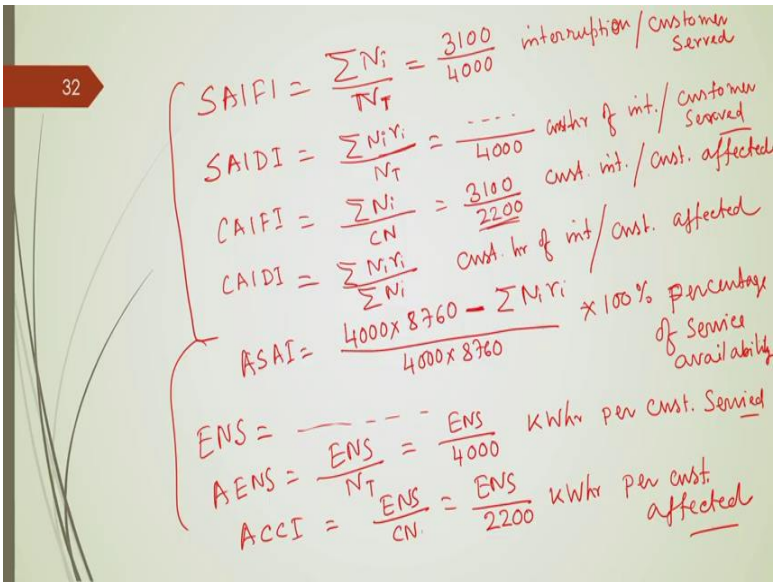

So, as we know SAIFI is equal to; SAIFI is equal to system average interruption frequency index is equal to summation of N i divided by N T which is number of customer served. So, we know that summation of N i is equal to 3100 and number of customers served is 4000. So, we can write it as 3100 divided by 4000 that many interruption per customer served per customer served ok.

Similarly, how do you calculate SAIDI? So, SAIDI, as you know, it is a duration index. So, the numerator is you know that number of customers durations curtailed and the denominator is same as that of SAIFI that is N T. So, we know that denominator is 4000 and this number of customers you know interruptions you can find out by multiplying that number of customers interrupted to the duration of the interruption and add.

So, in order to find out this N i r i, we calculate this by number of customers with the duration of this interruption. So, this is 800 multiplied by 3. So, this will give you the duration for the first interruption event plus 600 multiplied by 3; this will give you the second interruption event. So, first, second over; now third is 300 multiplied by 2, 4th is 600 multiplied by 1. 5th is 500 multiplied by 1.5, and 6th is 300 multiplied by 1.5 ok. Then, whatever the value would be, that would be the numerator of SAIDI ok. And the denominator is off course, known to us that is 4000. So, if you put this value, then we will get that many of hours of interruption per customer served hours of interruption, interruption; I write in short form int per customer. Or, it could be made more precise

that much customer hours of interruption; customer hours of interruption per customer served. So, you can compute it; you try it by yourself. So, only calculation is required. Now, we have two customer based indices; one is called CAIFI; another is called CAIDI ok. So, for CAIFI, the only difference its SAIFI is the denominator is different, so here denominator is CN numerator is N i summation of N i.

So, numerator will be 3100, denominator will be this CN, value is given to us that is 2200. So, we write it 3100/2200, that many customer interruptions per customers affected, alright. Now, CAIDI, we know it is a ratio of SAIDI and SAIFI. So, numerator is summation of N i r i and the denominator is N i, customers hours of interruption, customer hours of interruption per customer affected ok.

So, we compute these four indices, which are related to sustained interruptions ok. Now, let us see what are (Refer Time: 55:14), taken we need to find out ASAI, ASAI is simply this average service availability index. So, we know that the total number of customer is 4000. So, this should be ASAI is equal to total number of customer multiplied by a given time period, let us consider the time period of 8760.

That many customers hour of supplies required that 4000 multiplied by 8760, but it is not possible to provide that much of customer hours of service. So, you deduct that how much you know customers this was the load curtailed was there and that is eventually this N i multiplied by r i. So, if you deduct its then you will get, if you multiply it with 100 percent then we will get that much of percentage of service availability ok.

Now similarly, you can compute this ASIDI, ASIDI this you can find out that how much load was interrupted by summing up this to the how much load demand or connected load demand it has. Similarly, ENS is already computed; no, ENS you need to compute, ENS is not computed here. So, let us see how to compute this ENS that is energy not supplied. So, energy not supplied, it is better to compute over here because all these data are in this slide. So, ENS would be equal to how much load interruption took place multiplied by total duration of this interruption. So, this will be equal to 3600 multiplied by 3 plus 2800 multiplied by 3, that means, for the second event the duration of interruption was 3 hour and the load interrupted was 2800 so we multiply this; and then, similarly for third event we have this load interruption of a 1800 multiplied by duration of 2 hours. Similarly, for fourth event there was an event of 2800, 2800 kilowatt of load

interruption and the event duration of 1 hour. Similarly, fourth one 2400 multiplied by 1.5 plus; 1800 multiplied by 1.5 so whatever we will get that will be ENS, ok.

Now, once you compute the ENS. So, ENS is computed; you can compute. So, ENS is already computed, you can compute AENS just by normalizing ENS with this number of customers served. So, that is you know ENS divided by 4000. So, you give the unit is kilowatt hour per customer served.

So, that much of energy not supplied per customer served and this last this index that is ACCI, we normalize ENS with CN that is the number of customers affected ok. So, only difference is the how it is normalized. So, this will be ENS divided by this CN is given as 2200 that is 2200. So, unit would be that many kilowatt hour per, we should not use this symbol because we are using per so that kilowatt hour per customer affected or interrupted alright. So, in this way, you can compute all these indices. So, with this example, you should have an idea that first of all how to compute these indices. And secondly, what sort of data one needs to record; the utility needs to record corresponding to a particular fault event so that the utility can compute those indices ok.

So, I will basically stop at this point today.