Commodity Derivatives and Risk Management
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Week-11
Lecture 51
Electricity Trading in Day Ahead Market (DAM)

Welcome to the 51st lecture on Commodity Derivatives and Risk Management. And today we will continue with our discussion related to Electricity Trading in Day Ahead Market or Dam Market. Please recall that in the previous session we had discussed that the spot trading of electricity happens in any one of the three commodity or electricity exchanges in India. And as far as the India is concerned the total Indian territory is divided into 13 locations or 30 regions which are popularly known as N1 into A1, A2 and so on so forth. And a day is divided into 96 blocks of 15 minutes each and based on the demand supply for every 15-minute block a cut off price and volume are determined for electricity trading. Please note that in the case of a spot trading of electricity buyers and sellers will be giving both buy volume and buy price and sellers will also be giving the amount of electricity they would like to sell at different prices. And when we are talking about the double sided anonymous close bidding auction double sided means both buyers and sellers will be giving both buy and sell price as well as buy quantity as well as sell quantity. So, a buyer will be giving buy quantity, buy price, seller will give sell quantity and sell price and anonymous means they would not know who is bidding what amount. So, that is what the anonymous comes to the picture and close bidding means again nobody would know what amount of price and quantity bid has been done by each of the members. And once this demand supply bidding volume bidding quantity is received by the exchange, the exchange proceeds with arriving equilibrium price which is known as your market clearing price and market clearing volume. And as we discussed in the previous session let us take some numerical examples to understand the market clearing price and the market clearing volume. Please see that this particular image shows the way the market clearing volume and market clearing prices arrived. Let us say on the t minus 1 day for every time block of 15 minutes buyers and sellers from different areas please note that all 13 areas buy and sell volume for a given 15-minute block is going to be used to arrive at the supply demand curve. All of us have done economic subject in which we have seen that supply demand interacting with each other that is a basic economics 101 diagram what all of us get to see that the supply curve and demand curve interact with each other to arrive at the equilibrium price and equilibrium quantity. Exactly the same process is done here of course, in a textbook you will get to see the equilibrium, or the demand and supply curve will be in a straight-line form in reality the demand supply curve is ever in a straight-line form. So, as you can see from this particular diagram the

supply of electricity for all sellers for a given time block of 15 minutes. So, this particular block which I have this particular image which I have taken from the India energy exchange as you can see this corresponds to the 9.45 AM to 10 AM block. So, different buyers and sellers have given price bid as well as quantity bid for a given 15-minute block and the total supply and demand curve has been arrived at as you can see this x axis is the megawatt hour which is your quantity, and the y axis is your INR per megawatt hour. So, that is basically price and as you can see as the price increases the quantity supplied is increasing, the red line indicates your supply curve. So, as the price is increasing y axis you have price as price is increasing the quantities supplied by the sellers or generation companies is increasing and exactly the reverse is happening as you can see as the price is decreasing the demand quantity demanded is increasing at a 10,000 rupees per megawatt hour the total quantity demanded is lesser as compared to let us say the when the price is about 1,000 rupees per megawatt hour. So, this supply demand interaction curves this equilibrium price is arrived and that price and that quantity is known as your market clearing volume and market clearing price. From this particular diagram please note that the market clearing volume is 5,872.59-megawatt hour of electricity and what is the equilibrium price or what is the market clearing price market clearing price is 2001 rupees per megawatt hour and this again this table also I have collected from the India energy exchange the source of this particular table and the diagram is given here in this web link. Of course, this diagram and this data will be changing from day to day or time to time, you can visit India energy exchange to understand more detail related to how the supply and demand curve looks for 15 minutes time block in a given year. And as you can see as the price increases total supply or sale quantity is increasing, please see that at the at some price range between 0 to 1,000 the total supply is about 5,130.4. Please note that the exchange does not actually share the actual data, it is not possible for the exchange also to share the actual data they have clubbed it in a manner just to give a representation of it. So, some bidders who are interested to sale at a price anywhere between 0 to 1,000 rupees are willing to sell quantity to the tune of 5,130.4-megawatt hour. Similarly, different buyers are given their indication to buy electricity at a different price point as you can see at the lowest price point the total amount of electricity demanded is very high. Also, I would want all of you to take note that this is not the actual supply demand, this is the cumulative supply and demand. As you can see 6,675.4 is higher than 6,652.8 and so on so forth and similarly you have 6,532 is higher than 5,130.4. So, this supply demand curve is not the actual supply demand for a one particular buyer or seller this is the cumulative detail. In fact, we will take numerical examples simple small example to understand how in real life this particular supply demand curve can be generated. Similarly, just to give an example how the supply demand curve looks different at a different time of the day I have again taken a snapshot of the supply demand curve from the India Energy Exchange at a different time point. As you can see this particular snapshot is related to the supply demand curve

from midnight to 12 midnight to 12.15 AM. So, as you can see the supply demand curve again the supply curve is in red and the demand curve is in blue and the supply demand curve the shape and size of the supply demand curve has changed significantly because the quantity demanded or price at which the electricity demanded or price at which electricity supplied is significantly differs at the time which is 12 o'clock in the midnight to 12.15 vis-a-vis 9 o'clock in the morning to 9.30 in the morning to 9.45 in the morning. So, as you can see that the supply demand curve for 12 to 12 midnight is different, and this supply interaction supply demand interaction curve is significantly different from 9.45 AM to 10 AM block given in the previous slide and please note that each of this price what we are seeing that is known as the system price for the block of 15 minutes. Let me repeat here the MCP or market clearing price are also known as the system price for the given time block. Again, for a given date just to show the variation of MCP for different time blocks I have taken the data from India energy exchange. As you can see from midnight 12 AM to 12.15 AM the market clearing price is 10,000 and the market clearing price has fallen to about 2001 rupees for 9.45 AM to 10 AM. So, this goes on to indicate that depending upon the supply demand curve the price at which electricity is going to be transacted will vary from time block to time block. Now, again the same thing which I have same two images which I discussed in the previous two slide I have just put side by side. So, that you get a clear picture related to the supply demand curve at two different time points on a given day and again the way I had already mentioned this supply demand curve is related to the cumulative supply demand curve at different price points. Now, let us take a small numerical example to understand how exactly one would go about deriving the supply demand curve and the actual equilibrium price and equilibrium quantity which are nothing but your market clearing price and market clearing volume. Let us take a simplistic situation where you have let us say 6 buyers of electricity and they are willing to buy different quantity of electricity at different price point to make our life easier I have assumed that they can bid at a multiple of 0.25. In reality, they can bid at any price point, but to make our explanation little simpler, I have taken that these buyers will be able to bid any quantity, but they will be able to bid at a price point of multiple of 0.25 and the minimum price range is 2.25 and the maximum price range is 4.75 that is an assumption which I have taken. However, as you can see there are only 6 buyers interested in buying different quantities at different buy price and there are about 8 sellers these are the bidder means both it can be buyer and seller. So, it is a sell bid. So, the sell bidders have given different quantity again at different price point. So, this is the starting point. So, on t minus 1 day at India energy exchange or for that matter at HPX or PXIL, buyers and sellers will be giving these kinds of data. So, this is your anonymous double sided close bid process. So, nobody will know what the other person is giving at what price point. So, closed bid and anonymous I explained double sided means both buyers will be giving buy quantity and buy price sellers will be giving sell quantity and sell price. Now once the exchange receives this data point exchange

goes about generating the supply demand curve or the cumulative supply and demand. So, the first point in generating cumulative supply demand is to arrange the prices. Let us understand how exactly this is done from the buyer's point of view. Let us say let us say the maximum price at which buyers can bid is 4.75, but please note that no buyer is willing to pay a high price of 4.75. So, what is the buy volume at 4.75? It is 0 and what is the cumulative buy volume at 4.75? It is again 0. Similarly, there is no buy bid for 4.5. So, the buy volume as well as cumulative buy volume remains 0. Now let's come to 4.25. So, the total amount of electricity which a particular trader or a distribution company wants to buy is 1,600 units and at a price of 4.25 rupees per unit. So, total cumulative buy volume is going to be 1,600 and let us come to the next point. Let us say 4. At price point of 4, a buyer wants to buy 400 units and cumulative unit is becoming 2,500. And why are we accumulating in this manner in the sense that if somebody is willing to buy at 4.25, then that same party will be very happy to buy at 4 rupees. So, that is why we are accumulating the total demand in this manner. Similarly, let us take a case of let us say the price point 3. At a price point 3, total demand is for 1,000 units. So, the cumulative unit comes to 11,500 units and at 2.75, there is no demand, and the cumulative buy volume remains the same. That means, up to the price point 3, if the total demand is 11,500, at the price point 2.75, the total demand is also going to be 11,500 because the same set of people who are willing to buy at a price more than 3 or more than 3, they would also be very happy to buy at a price of 2.75. In this manner, as you can see, the cumulative buy volume will be calculated at different price points. Please note that these are the common price points. We are not calculating the buy cumulative buy volume for only the price points which have been bid by the buyers. So, we identify the common price points at every price point, we find out what is going to be the cumulative buy volume. And exactly the same process is done for generating cumulative sales volume. However, the logic is a little different. We start with the lowest price in this case it is 2.25. So, the total quantity of electricity which sellers want to sell at a price of 2.25 is 0. There is nobody who is willing to sell at this low price. Now let us come to 2.5. In that case the total amount of electricity where one generation company or one electricity producer company is willing to sell is at 800 units at a price point of 2.5. So, cumulative volume is going to be 800. Now let us come to the next point that is 2.75 demand is 2,000, demand to sell electricity is 2,000. So, cumulative volume is coming to 2,800 and the logic is that if a generation company if an electricity producer is willing to sell it at 2.5, he or that company will be very happy to sell at 2.75. Hence the cumulative volume at 2.75 rupees is going to be some total of the earlier sales volume plus the volume at 2.75. So, in this manner the total cumulative sales volume will be calculated at different price points. So, this is the beginning process which is, or the first process done by the exchange. Please note that this is the actual bid which will be coming from the buyers and sellers of electricity. Based on the buyers and sellers' electricity the bid price and bid volume and cumulative buy volumes as well as sell price and cumulative sell volume will

be arranged by the exchange. The concept I have explained in this block, now let us move to the actual identification of the equilibrium price. Now once we do that, we identify what is going to be the cumulative buy volume at different price points and cumulative sell volume at different price points. And when we plan this diagram, as you can see you, I am sure all of you will be able to now see this particular diagram which is a very basic diagram in terms of supply demand curve. And please note that in this case I have done in the y axis sorry x axis the price and in the y axis this is the total volume demanded. And as you can see, as the price increases but volume goes down people are not willing to pay a very high price to buy electricity. And similarly, when the price increases sell volume increases sellers are very happy to sell electricity at a very high price. So, as you can see the buy and sell volume buy and sell curve is demand supply curve is interacting at this point in time. So, this interaction point is going to help us in identification what is going to be the market clearing price and the market clearing volume. And I would like to give a thumb rule related to what would be the price for what would be the price for market clearing price. As you can see, when you are sorting the price or when you are arranging the price from the lowest price to the highest price up to some point cumulative buy volume is going to be more than the cumulative sell volume. As you can see up to 3.25 price point the cumulative buy volume is 10,500 and cumulative sell volume is 4,000. At a price point of 3.5 cumulative buy volume is 2,500 and cumulative sell volume is 7000. So, this is the price this this will give us an indication of what is going to be the equilibrium price. So, equilibrium price will range somewhere between 3.25 to 3.5. So, this is basically a thumb rule to understand what would be the price range within which the equilibrium price will be falling, but we have to actually use some other methodology to identify what is going to be the equilibrium price and the equilibrium volume. Please note that this particular from this particular diagram I have just taken a slice of this diagram which I have explained here. So, this x1, y1 and x2, y2 indicates your supply curve and x3, y3, x4, y4 is your demand curve. So, sorry x1, y1 and x2, y2 is your demand curve and x3, y3 and x4, y4 is your supply curve. So, obviously, we have to find out what is the coordinate of a x and y. We know x1, y1, we know x2, y2, we know x4, y4 and we know x3, y3. So, the coordinates of these 4 points are known to us we have to find out what is going to be the coordinate for x and y. So, as you can see x1 y1 is nothing, but 3.25 and 10,000. So, x1, y1 relates to the price of 3.25 and the cumulative volume of 10,000. Similarly, to other coordinates for other coordinates I have given the x and y value. Now we will be using the interpolation formula to arrive at the equilibrium quantity and equilibrium price. So, the linear interpolation formula is mentioned here, and it is just a simple math. It is just a simple math and based on this linear interpolation formula you, as you can see x is your 3.39. You have to solve this basically you have to use a pen paper to solve this particular these two equations to arrive at the values of x and y. And x stands at 3.39 and y stands at 6,020. So, that means, the equilibrium market clearing price is 3.39 and total volume of electricity which can be transacted is your

6,020. Now coming to another interpretation of this x and y or market clearing price and market clearing volume is that any seller who has bid a price less than 3.39. Please note that any seller who has who is operating in this range if any seller who has bid a price less than 3.39 will be able to sell. Basically, a buyer, a buyer who is a buyer who has bid a price higher than 3.39 will be able to buy. So, you will have let us say any buyer who is operating in this range who is willing to pay a price higher than 3.39 will be able to buy electricity. And let us say a seller who is really interested in selling electricity at 10 rupees per unit will not be able to sell. Please note that in this particular example we have only taken a price point up to 4.75. Suppose we add a price of 10 rupees, somebody is demanded at some amount, then we will not be able to that particular seller will not be able to sell electricity because it is charging it is interested to receive a very high price. Similarly let us say a buyer who wants to bid at a very low price suppose a buyer wants to say that why am I going to pay a very high price let me be very guarded and quote a very low price. So, if a buyer is quoting a very low price, then the chance that the order matching at that price will not happen and in that sense the buyer will not be able to buy electricity at that price point. So, obviously, a seller who has bid at a price which is less than the equilibrium price will be able to sell and a buyer who has bid at a price which is more than the equilibrium price will be able to buy electricity. Now with this the exchange goes on to identify or report what is going to be the market clearing price or the market clearing volume for that 15-minute block. So, as I had as I had discussed that for 12 O' clock in the midnight to 1,215 midnight as you can see the exchange reports 10,000 as the market clearing price and what is the market clearing volume market clearing volume is 6,984 units. So, this is the first step which the exchange does an electricity exchange does. So, though on t minus 1before 1 pm all buyers and sellers will be giving buy bid and sell bid they will be sending that detail to the exchange in an anonymous manner. Exchange will do the cumulative buy and sell demand generation process arrive at the equilibrium price of MCB and its MCP calculation that is market clearing volume calculation and market clearing price calculation. So, for that time block please note that 6984 is the market clearing, 6,984-megawatt hour electricity is the market clearing volume at a price of 10,000 rupees per megawatt hour. So, please note that this process gets completed by 1 pm in d minus 1. So, though the buyers and sellers will be giving their bid the exchange will be doing the market clearing process identification MA of MCP and MCP by 1 p m. And as we discussed this price of 10,000 rupees megawatt hour and 6984 of megawatt hour MCP and MCP are known as unconstrained MCP and MCB. Let me repeat this price and the equilibrium volume is known as the unconstrained price or unconstrained volume. Now once this process is done the exchange will contact NLDC and exchange will contact RLDC, SLDC etcetera to check whether transmission capacity for transacting 6,984 units of electricity is available at that point in time. Please note that spot trading of electricity is not the only electricity which is getting transacted in a grid. You have long term power purchase agreement; you have short term power purchase

agreement. So, different buyers and sellers are different buyers withdrawing electricity, different electricity generation companies are injecting electricity to the grid at that point in time. So, whether the availability of enough grid capacity is there at that point in time to transact this market clearing volume or not. And that cannot be done by the exchanges that is done through the dispatch centers. Please recall that in the previous session we did discuss very briefly the role of NLDC, RLDC and SLDCs. So, this dispatch center will check whether there exists any congestion in the grid or not and that information will be coming to the exchange platform by 2 p.m. And if there is no constraint then exchange will inform all buyers and seller all buyers and sellers whose bid has been accepted that yes, your bid has been accepted and tomorrow at the designated time that is 12 o clock in the midnight to 1,215 a.m. you please release this amount of electricity. So, that information will be given in exchange to the buyers and sellers of the electricity. Now if there is not enough space or grid capacity is there, exchange undertakes a process which is known as a market splitting process. So, the exchange then will proceed with another process which is known as your congestion management or market splitting process. And let us say based on the available grid capacity the exchange identifies, or exchange comes to know that only 6402 units could be transacted. Now from these 6,402 units the exchange will start the process of congestion management or market splitting and we will be discussing more about this process of congestion management and market splitting in the next session. Now with this I will end today's session on the day ahead market or spot electricity spot trading of electricity using your day ahead market. Let me summarize what I discussed. So, in a day ahead market one day prior to the actual transaction of electricity actual transmission of electricity the buyers and sellers the generation companies as well as the power distribution companies' discounts will be giving buy and sell bid for different blocks 15 minutes block. And they will be informing also the to the exchange at which point they would like to they would like to inject electricity, or their customers are going to withdraw the electricity. Please note that in real life the bid will come not only for the price and quantity they will also be an area associated with that particular bid. So, which we have not discussed till now. So, the buy and sell volume buy price as well as sell price as well as the area in which the generation company will be injecting the electricity or distribution companies' customer will be withdrawing electricity that information will be coming. Now the exchange will ignore the area information and will only consider the buy and sell price and buy and send volume to arrive at the MCP and MCV. And it will proceed to check whether grid congestion is there or not. If there is no grid congestion, then it will inform the parties and the parties will be the buyers and sellers or distribution companies and electricity producer companies will be generating electricity or withdrawing the electricity by that amount at the designated time in the next day. But if there is congestion the exchange will start something called congestion management or market splitting, that aspect of market

splitting, we will be discussing in greater detail in the next session. Again, I eagerly look forward to interacting with all of you in the next session. Thanking all of you.