Commodity Derivatives and Risk Management
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Lecture 52
Spot & Derivatives in Electricity (System Price & Area Clearing Price)

Welcome to the 52nd lecture on Commodity Derivatives and Risk Management and we will be discussing Derivatives and Risk Management, and we will continue with our discussion related to various aspects of spot and derivatives market related to electricity. And in the previous session we had discussed about system price and area clearing price very briefly, but today we will be focusing more on how the system price and area clearing price will be arrived. And going forward we will also be discussing various aspects related to spot trading of electricity, other dimensions of spot trading of electricity and also derivative contracts related to that electricity. Now, just as a recap what we discussed in the previous session, please recall that the price equilibrium price and equilibrium volume which is known as a MCP and MCV that is your market clearing price and market clearing volume is arrived from the actual buyer and sellers' price and quantity bid. Once the buyers and sellers give the price and quantity bid, the exchange prepares a MCV and MCP determination schedule by generating cumulative buy volume and cumulative sales volume. In fact, in the previous session this particular slide we discussed in significant detail. However, just as a recap I will take you through little bit on this this discussion related to MCP and MCV. As you can see the price at which buyers want to buy different volume of electricity is arranged from the lowest price to the highest price and for each price range we identify what is going to be the cumulative buy volume and what is the cumulative sale volume and obviously, our buy and sale demand curve is and from the interaction point we arrive at the equilibrium price and the equilibrium volume. And here I would like to draw your attention to some interesting observation, please note that as the price increases up to some point some price point cumulative buy volume is going to be more than the cumulative sales volume, but beyond that price point the cumulative sales volume is going to be more than the cumulative buy volume. For example, up to the price point of 3.25 cumulative sales volume is 10,500 and cumulative buy volume is 4,000 or let me let me refresh that is cumulative buy volume is 10500 and cumulative sales volume is 4,000, but the moment we go to the next price point which is 3.5 the relationship changes that is in this case cumulative buy volume is less than the cumulative sales volume. So, that gives us an indication that the equilibrium price will lie somewhere between 3.25 to 3.5 and we use this linear interpolation formula to arrive at the equilibrium price and the equilibrium volume, in this case the equilibrium price is 3.39 rupees and equilibrium volume is 6,020. So, this is how exchanges go about

identifying the system price for a given time block of 15 minutes. This part also we discussed nevertheless I will also take another couple of minutes to recapitulate what we discussed in the previous session. Please note that from 12 o'clock midnight to 12.15, the market clearing price is 10,000 rupees per megawatt hour and the market clearing volume is 6,984-megawatt hour. Please note that this is the actual data which I have taken from a commodity exchange from India energy exchange to be precise. Now, based on the auction data, market clearing price of 10,000 and market clearing volume of 6,984 is arrived for the midnight to 12.15. And please note that this process gets completed by 1 p.m. on d minus 1. Please note that on day d electricity will be derived electricity will be transacted. So, all this process of identification of price is happening on d minus 1 that is one day prior to the actual delivery date. And these 10,000 rupees per megawatt hour and 6,984-megawatt hour are your unconstrained in nature these are known as your unconstrained MCP and unconstrained MCV. Now, once this process is done the commodity exchange contacts NLDC, NLDC in turn contacts RLDC and SLDC to check whether this 6,984-megawatt electricity can be transacted at the designated time of 12 a.m. in the night to 12.15 a.m. Now, the power exchange will be informed by the NLDC whether the grid congestion is there or not. If grid congestion is not there the exchange will inform all parties that yes you are supposed to deliver electricity and obviously, through the clearing house of the exchange the buyers will be transferring money to the sellers on ah t plus 2 days of the actual delivery of electricity. But in case there is constraint then the power exchange is going to proceed with the constraint MCV calculation and area wise price. A different price will be calculated which is known as your area clearing price and constraint MCV will also be a found out. Please note that for the 12 O'clock to midnight ah 12.15, the RLDC informs or NLDC informs India energy exchange though the market clearing volume is 6,984-megawatt hour, but actual based on the grid capacity 6,402 units can be actually delivered. So, with this the exchange now comes to know that we have to proceed with another set of activities for arriving at the constraint MCV and area wise clearing price. And this process of arriving at a different quantity and a different price is known as your congestion management or market splitting. So, as we ah inform ah just now we discussed that the available transmission capacity is the actual volume which can be transacted which is 6402 units. Now with this let us understand how the exchange will go about identifying area clearing price. Now please note that this table which again I have taken from India energy exchange as you can see the market clearing price is 10,000 rupees, but for some specific area as you can see the market clearing price remains 10,000 and some areas like S1, S2, S3 market clearing price is reduced. So, these 10,000 for A1 will be known as the area clearing price for A1. Similarly, 5,719 is going to be known as the area clearing price for S1, while the 10,000 rupees this MCP will be known as the system price for that given day for the time period of midnight 12 AM to 12.15 AM. Similarly on the same day please note that in a about an hour later the MCP is 6,511 for the time period 1 AM in the night to 1.15 AM

and please note that the area clearing price for S1, S2, S3 is 4,993 while the area clearing price for remaining 12 remaining 9 locations is 9,800. So, how exchange goes about deciding different area clearing prices and as you can see a price or an area will have a lesser price if it will be treated as a surplus area and an area will be treated as a deficit if it is a deficit area in the sense a surplus area the sell bid volume is going to be higher than the buy bid volume. So, because there is a sell bid volume that is more than the buy bid volume the exchange will reduce the price to arrive at the equilibrium quantity. Similarly, an area which will be treated as a deficit area will be in in that case the bid volume will be sell bid volume will be lesser than the buy bid volume. So, the number of sellers or the quantity of electricity to be sold from that area is much lesser than the number of a quantity of electricity to be bought hence it will be treated as a deficit area. Now, let us take some numerical examples or some hypothetical to example to understand how the exchange will go about deciding different area prices for surplus area as well as deficit area. This particular diagram shows the calculation or area clearing price calculation for surplus area as well as deficit area. Let us take a hypothetical example in which in an electricity market there are only two areas, that is area S and area D exist for a given 15-minute block. Now, based on the demand supply of area S and area D the exchange will go ahead and identify P0 as the unconstrained market clearing price and Q0 as the unconstrained market clearing volume. Now, with this the exchange goes to RLDC, NLDC and the RLDC, NLDC says that no Q0 quantity of electricity cannot be transacted because there is grid condition. Now, with this information the exchange will now go ahead and decide or determine the different clearing prices for both area S and area D. Now, based on the demand and supply for area S it will again determine the equilibrium point. As you can see area S is a surplus area and the equilibrium point is at a price which is let us name it as a PL that is price low, and this low price is as compared to your P0. P0 is your both market area S and area D equilibrium volume that is P0, and Plow is the equilibrium price for the surplus area. And how do we know that this area is a surplus area? Please note that at the P0 quantity P0 price the sale quantity is greater than the buy quantity. So, if we are to find out what is going to be the total sale quantity at P0 as you can see the sale quantity will be somewhere here x axis is Q ah that is quantity. So, the sale quantity is somewhere here and buy quantity is here. So, the sale quantity is higher than the buy quantity. So, at an equilibrium price of P0 hence the exchange is going to reduce the equilibrium price which is P low to arrive at the different quantity. Similarly, for the other area that is area D as you can see the equilibrium will be arrived at a price point which is higher than P0 let us name it as a PH. And how do we know that this particular area is a deficit area because at a price of P0 as you can see the sale quantity the interaction points the sale quantity is much lesser compared to a buy quantity. So, this is how the exchange is going to decide a different area clearing price. The market clearing price is P0 which is unconstrained in nature and this PL and PH are your market are your area clearing prices which will be based on the supply demand ah supply

demand for both areas depending upon the grid congestion and how much of electricity can be transacted in the or exchange period. For exchange in the in the grid. The same concept I have taken ah through some numerical examples to explain the process of arriving at a different price. Please recall that there are for area S there are different sellers there are different buyers for area D there are different sellers, different buyers. Let us say we have common price point 1 to 14 just random some prices I have taken for each price there will be different quantity which will be did by different sellers and buyers. So, from here please note that the exchange will go ahead and prepare a cumulative demand supply situation. And that cumulative demand supply situation as you can see the in a based on the explanation that at some price point cumulative buy volume is going to be more than the cumulative less volume and at the next price point the buy volume is going to be less than the ah sell volume. So, based on this understanding, as you can see the equilibrium price for the market as a whole is going to be somewhere between 9 and 10. Now, let us come to area S and area D. Please note that area S is a surplus area why are we telling area S is a surplus area as you can see total quantity to be sold in area S is 1,255 while the total quantity demanded to be bought at area S is 475. So, obviously, area S is a surplus area and exactly the surplus is happening. So, the sale quantity is less in area D while buy quantity is more. So, obviously, you have a deficit area. Now, as you can see the cumulative when we are merging the buy sale demand irrespective of which area buy or sell demand is coming our equilibrium price will be somewhere between 9 and 10, but when we are doing the equilibrium price calculation for area S the equilibrium price is going to be somewhere between 7 and 8. Similarly, for area D the equilibrium price is going to be somewhere from 10 to 11. So, this clearly indicates that depending upon the deficit or supply area your ah or our area clearing price is going to be different. So, the same exercise or same numbers I have plotted here in ah in excel as you can see for the common area the ah the average equilibrium price is going to be somewhere between 9 and 10. And in the case of your surplus area the equilibrium price is going to be somewhere between 7 and 8 and in case of a deficit area the equilibrium price is going to be somewhere between 10 and 11. So, this is how the exchange goes about identifying or calculating the different area clearing price. So, which is different than the market clearing price if there is any kind of grid congestion exist. Again, revisiting the previous slide which we discussed a couple of minutes ago. So, you have the market clearing price for the given 15 minutes block that is midnight 12 am to 12.15 am the market clearing price is 10,000 and for different areas you have price could be 10,000 or price could be less than 10,000. And in another situation, you have the market clearing price for some areas is much higher compared to the equilibrium price of 6,511 and for some areas you have the equilibrium price or area clearing price is less than 6,511. Now with this once this process is done by the exchange the exchange will inform once again whether this particular amount of electricity can now be transacted and this process will be done through ah confirmation with NLDC, RLDC, SLDC. And once this

body is confirmed that yes, this amount of constraint amount of electricity can be transacted the exchange will inform the buyers and seller on day d that at the designated hour or designated 15 minutes block electricity will be delivered to the grid. Please note that in addition to this Indian companies buying and selling Indian generation company, power generation company and distribution companies using India energy exchange to transact electricity. Now, we have operators from Nepal and Bhutan who have started participating in the India energy exchange market with the availability of grid connection. Now India has a grid connection with the Nepal and Bhutan. So, the power producers and distribution companies are ah contributing to the ah buy sale quantity and they are able to utilize the exchange platform to participate in the day ahead market. In addition to the day ahead market India energy exchange also offers real time market. So, in real time market exactly the same process of arriving at the day ahead market is the repeated and the ah auction is done an auction is done in every half an hour ah with electricity to be delivered after four-time block. So, that is one hour later. So, when we are talking about the real time market the auction is done half an hour ah every half an hour and electricity is done after a four-time blocks that is about an hour later electricity is ah delivered. So, these are the example these examples what I discussed day ahead market and real time ah market are examples of the spot trading of the electricity. Please note that when we are talking about the spot trading of electricity it does not mean over the counter in a normal over the counter transaction, we give something and in return we get money from the counter party. In the case of electricity, the price negotiation gets done d minus 1 and actual delivery of the underlying happens on the day d. And in the case of a real-time market the price decision is happen happens about an hour ago and the actual delivery of electricity happens an hour later. Now, let us understand some interesting aspects related to the process of market splitting and that interesting aspect is related to the congestion fee. Now, let us say we revisit our example of two areas. Let us say in for a given fifteen-minute block we have only two areas, area S and area D area S is the surplus area and area D is your deficit area. Let us say the P 0 that is the market clearing price is 5,000 rupees per megawatt hour that is your market clearing price. Exchange goes ahead and identifies your P low and P high and let us say P low is going to be 4,430. So, that is going to be applicable for the area, which is a surplus area and P high obviously, this 5,500 is ah the price applicable to the deficit area. Now, let us say in area S total supply quantity is 100 units and total demand quantity is 60 units hence area S is a surplus area and area D is going to be a deficit area because supply is only 35 units and demand is for 80 units. Now, when the grid connection is available between S and D what will happen 40 units of surplus area from area S will be supplied to area D. So, now, in that case area D will have a 75 units electricity to be delivered these 75 units will come from 35 units which is being generated at some power generation company located in area D and rest 40 units is coming from power generation company which are located in a separate area that is your area S. Now, once the electricity is generated or once the electricity is

generated and distributed in the grid and the distribution companies' customers withdraw the electricity the payment has to be made. So, now, let us come to understand how much of the receipt of area A suppliers are going to happen. Please note that area S suppliers have supplied 60 units of electricity to distribution companies which are at area S and 40 unit they have supplied to area D. So, for the 60 units they are going to receive 4430 per unit for 60 unit please note that the P low is 4430. So, obviously, they are going to get 4430 units. Now for the remaining 60 units sorry remaining 40 units these people are going to the suppliers are going to receive 4,430 units. Please note that all suppliers if they belong to area S, they are going to get 4,430 units. So, they are going to get 4,430 units for the first 60 units to be delivered to distribution companies operating at area S. Now the remaining 40 units, they are also going to get 4,430 units, but please note that the buyers who are operating from area D, who have taken electricity which is supplied from suppliers operating at area S. So, those buyers are going to give 5,500 per unit. So, buyers will be giving 5500 rupees per unit while sellers will be receiving 4,430 rupees per unit. Now, whatever the difference that will go to CERC that is your central electricity regulatory commission. So, as a regulator these 42,800 rupees is going to be given to the CERC as a congestion fee. Please note that the exchanges do not earn anything other than providing a platform and for every unit of electricity is the order matching is happening they will be getting certain commissions. So, whatever is the congestion fee that will go to the CERC as you can see the CERC regulation on congestion fee and charges this particular again detail I have taken from the CERC website. So, CERC website indicates that congestion amount arising from the difference in the market price of different regions as a consequence of market splitting in power exchanges. The congestion amounts shall be maintained in a separate account by the power exchange which shall be transferred to the power system development fund in a manner as specified in the central electricity regulatory Commission regulation 2019. So, this is a very interesting aspect related to the spot trading of the ah spot trading of electricity which is not applicable to any other commodity. In case of any other commodity, whatever the sellers give to the buyers, buyers receive that amount of money. But in this case, there is going to be a difference between what sellers receive and what buyers pay and that amount of money is deposited with the CERC. In this context let us understand another interesting aspect called financial transmission right. Please note that the physical transmission rights or firm transmission rights allow a party to transmit electricity between two points in a grid. So, a generation company will have certain right to ah transmit electricity in a grid, but financial transmission right are the rights to the accumulated congestion fund. So, how exactly does this financial transmission right ah concept works? Please note that the FTRs are auctioned by the power exchange or electricity regulator. Please note that the congestion fee gets deposited with the electricity regulator. Now and in that case the electricity regulator may auction the financial transmission right. For example, let us say a power exchange or electricity regulator can

auction the FTR between the S1 to E1 region of India for a period of 9 AM to 10 AM for 1 year. So, whatever the congestion fund which is getting deposited in the congestion fund for congestion arising for S1 to E1 region on any given day for 9 AM to 10 AM for the 1 year is going to be the financial transmission right. So, to whom the exchange or the regulator is going to award this financial transmission right, the highest bidder is awarded the FTRs, and the highest bidder pays the bid amount to the regulator. And the accumulated congestion fee throughout the year whatever is going to be the congestion fee for the S1 to E1 region for the time period 4-time blocks that from 9 AM to 10 AM over the 1 year that is going to be the earning of the FTR holder. Obviously, the bidder or the FTR holder would be expecting the actual congestion fund to be higher than the bid amount. In fact, if you recall we had discussed something about streaming deals with respect to mining companies. Mining companies receive an upfront fee amount and in return for paying some amount of gold or silver to the counterparty. Exactly the same thing is being done here. In this process the regulator receives upfront amount which they used to develop the electricity infrastructure in a in an economy and basically, they are monetizing the congestion fund, and they receive upfront amount from the highest bidder and give the financial transmission right to the highest bidder. With this we will end our discussion. So, to summarize we discussed the concept related to the how area clearing price is going to be arrived which is completely different than the how market clearing price is going to be arrived. And with this we also discussed related to how the exchanges or how the regulators generate the congestion fee and how the regulator monetizes the congestion fee by auctioning it through a process of creating financial transmission rights. With this we will end today's discussion. We will discuss the remaining part of the electricity trading in the next session. As usual I eagerly look forward to interacting with all of you in the next session.