Commodity Derivatives and Risk Management
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Week-11
Lecture 53
Spot & Derivatives in Electricity (Green DAM, Duck Curve, Dark/Spark Spread)

Welcome to the 53rd lecture on Commodity Derivatives and Risk Management. And today we will also continue with our discussion related to the spot and derivatives market in electricity. Today we will be discussing Green Day Ahead Market, the concept of DUCK curve as well as futures contract on electricity specifically with respect to dark spread and spark spread. Please note that in the previous session we had discussed how exchanges go about identifying the market clearing price and the market clearing volume with respect to conventional energy sources in the day ahead market. In addition to the conventional energy sources, green day ahead market for electricity the same process is done by the commodity exchanges or power exchanges. And as we know the green electricity is generated through solar or hydro or wind power sources. And the clearing of the green dam mark is, or green dam prices first takes place at the power exchanges before the conventional dam is done. So, for example, a particular green energy producer is interested to buy or sell electricity that particular producer will be giving a price bid as well as there are many counterparties, many distribution companies, many industrial installations who are very keen on now buying green electricity. So, these are the people who will be giving their price bid. The producers of solar, wind and hydro generation capacity they will be also giving a price bid. Exactly the price bid of supply demand will be arrived, and that process will be done first by the power exchange. So, the clearing of the green dam will take place first followed by the conventional day ahead market. And if a particular green energy producer's order could not be executed for example, a particular green energy producer has given a very high price and the order execution the price did not match hence the order did not get executed. In that case that particular green energy producer can revise that bid and submit the same electricity for to be traded as a conventional day ahead market. And please note that in a conventional day ahead market, various types of orders can be placed for different time blocks. We had discussed extensively how a particular trader has given an order for a time block let us say 12 O' clock in the midnight to 1,215 in the midnight. But it need not necessarily be the fact that one particular producer or distribution company will bid for only one particular 15 minutes block. Normally they bid for a continuous stretch of time and this continuous stretch of time bidding is popularly known as let us say FBA that is firm based 24 hours. Suppose an electricity producer is interested to use 24 hours to deliver electricity for every 15-minute block that particular producer will be able to give a price bid for the 24

hours at one block rather than giving 15 minutes block. Similarly, a distribution company who is interested to buy electricity let us say at a peak hour which is your 5 hours starting from 6 O'clock in the evening till night 11 O'clock. So, that particular distribution company can give a price bid for all 5 hours at one go. So, 5 hours into 4 please note that in India the buyers and sellers have to give a price bid for every 15-minute block. So, 5 into 4 so, 24 hour 24 15 minutes block a particular distribution company can give a same price order. So, these are your standard contract terms which are available in any power exchange. So, FNT is your firm night, FDY is your firm day and FPK is your firm peak. And the same standard process of order matching will be done by the exchange. So, this contract though may sound a little different, there is no different process with respect to the order matching. Now in India we also have a term ahead market it is basically a forward market. Please note that in the term ahead market buyers and sellers will be bidding for electricity to be delivered at a future date with the negotiation done at a current date. For example, on 12th June 2023 for September 2023 delivery month the discovered price is 6,500 per megawatt hour. Again, this particular table I have taken from the India energy exchange website as you can see different auction dates are mentioned here. So, on this auction date of 12th June different buyers and sellers have given have bided different amount of buy and sell amount. And the total price discovered is 6,500 and delivery month is your September 23rd. So, similarly for different months you have the different price bidding buy and sell bidding has been done and the different prices have been discovered for different months. And please note that the bidding is much earlier, 2 to 3 months earlier. So, bidding is done on 12th June for power to be delivered in the whole month period of September 2023. Of course, the time of the day all these details will be available in the detail contract details this is just a snapshot which indicates how the term ahead market works in Indian context. And exactly the same way of price discovery is done the buyer seller bidding will be put into cumulative buy bid and cumulative sell bid and the price will be discovered and that information will be given to the buyers and the sellers. And in addition to the term ahead market in Indian exchanges reverse auction is also currently being done in case of a reverse auction. Please note that the exchanges are offering a reverse auction platform in which a buyer can conduct and solicit bids from the seller for buying electricity at a specified period in future. So, as you can see this particular table again, I have taken from the India energy exchange website. You have the buyer Uttarakhand Power Corporation Limited. It has started an auction process on 21st June 2023. So, it wants to buy 15-megawatt hour of electricity and minimum it wants to buy in a 5 megawatt of electricity and the delivery dates will be from 6th July 2023 to 31st July 2023. So, about 26 days in the month of July which is to be to be delivered and the auction is done on 21st June 2023. So, this detail is the auction process. So, this company Uttarakhand Power Company Limited will be informing the India energy exchange that create an auction portal for me and India energy exchange will start the auction process as you can see. The result of the reverse auction

done on 22nd June 2023 on that day 9 sellers wanted to participate. The price at which the L1 price discovered is 5.19 rupees per kilowatt hour and this L1 party one in intense to buy intense to sell 25-megawatt hour of electricity. Similarly, the next party which is a L2 that party has bided at a 5.2 rupees per kilowatt hour. So, obviously, this particular table shows how the order matching has happened for Uttarakhand Power Corporation India Limited which is interested to buy 50-megawatt hours of electricity from a specific date that is 6 July to 31st July. So, this kind of reverse auction process is also being facilitated by the ah power exchanges in India. In this context I would like to share a very interesting development which has happened in Indian market very recently that is known as the concept of market coupling. So, please note that India has three power exchanges that is India energy exchange, power exchange of India limited and Hindustan power exchange. Currently India energy exchange has a larger market share in terms of different types of electricity ah being traded in this particular exchange platform. And on a given day the MCP, MCV and area clearing price, that is market clearing price, market clearing volume and area clearing prices etcetera are determined by the respective exchanges. Hence the MCP and MCV price varies significantly from exchanges to exchange. For example, if buyers and sellers are giving a price bid at a IEX and another set of buyers and sellers are giving price bid at PXIL for the same time block on a same day the market clearing price and area clearing prices could be significantly different than the India energy exchange. However, recently CERC has approved the market coupling process. So, what exactly the market coupling indicates? Under the market coupling buy and sell bids from all power exchanges for a given 15-minute block will be aggregated to arrive at the MCP, ACP and MCV. So, this is going to be a significant game changer in Indian energy Indian power exchange market. And in this process, this is going to lead to a better price discovery and the price at which buyers and sellers are buying and selling electricity will be much more competitive. When three market buy and sell sorry three exchanges buy and sell volume will be used to arrive at the market clearing price as well as market clearing volume. So, this is a very significant development which has happened very recently. In this context of electricity there is a very interesting aspect which is happening of late that is known as your duck curve in electricity. Please note that electricity generation can be done from conventional sources as well as non-conventional sources such as renewable ah sources. And out of the non-conventional sources solar electricity generation is increasing at a much higher rate as compared to wind or solar wind or hydro electricity generation. A significant portion of renewable energy or green energy comes from solar power solar power generation capacities. And as more and more solar units are coming to the trading platform or a grid that to only during the daytime. So, the amount of conventional energy getting traded or transmitted in a grid is reducing in the daytime. And this phenomenon is known as a duck curve. So, what exactly does it mean that the demand for conventional energy is going to be much higher late in the night when there is no sunlight. And as sunlight is available and how and as the green

energy gets transmitted to the grid the demand for conventional energy goes down. In fact, it has now touched the level of 0 that is during peak day some days this demand for conventional energy that is electricity generated from coal or natural gas is almost practically becoming 0. And all of a sudden as the sun goes down the demand for electricity conventional from conventional sources picks up in an expansion manner. Now, this is the concept of Duck curve, please note that this particular article I have taken from this particular image I have taken from an article by US government which is titled as solar capacity grows Duck curves are getting deeper in California. So, this is an article which is available I would like to. So, the source of this particular article link it is a very interesting article related to how that ah the intensity of the Duck curve is increasing over the years as you can see the duck curve this is this lighter line to 2015 the shape of the Duck curve was like this, but by 2022 as you can see the Duck curve has really depend. And why Duck curve should be of any discussion point? Please note that the creation of Duck curve is creating a lot of challenge to the electricity grid. In fact, the first challenge is grid stress. So, the extremes to swing in the demand for electricity from conventional power plants from midday to the late evening when energy demand is very high, but solar generation has dropped off means that the conventional power plants such as natural gas fired plants or coal fired plants must quickly ramp up electricity production to meet the consumer demand. And this rapid ramp up makes it more difficult for grid operators to match the grid supply with the grid demand in real time. So, this is creating a major challenge for grid operators right now because the conventional power electricity producers have to quickly reduce the generation capacity as well as quickly ramp up the generation capacity. So, during the early morning they have to stop generating electricity and in the evening time they have to quickly ramp up the electricity so that the customer demand can be met. And please note that the electricity cannot be stored. So, whatever electricity is being produced by any producer has to be released to the grid to be consumed. So, the grid has to have that kind of flexible management skill or flexible management system to accommodate such swing in the conventional energy production. So, that is creating a lot of grid stress. So, this is also something which is not applicable only in Indian in USA market we are also started seeing the same kind of phenomenon in the Indian market. So, I have just taken 2 random days ah electricity prices system prices for 96 blocks 24 hours in a given block is divided into 4, 15 minutes block. So, 96 data points for 2 random days I have taken as you can see India has also started experiencing the price during the ah conventional energy price during the midday is ah going down as compared to the price discovered through energy exchanges during the evening ah late evening or early morning time. So, as I mentioned that with the availability of solar power mid-day prices are significantly lower for any other time of the day that is when we are talking about the price, we are talking about the conventional energy prices conventional day ahead energy prices. So, in the sense electricity prices exhibit a very clear seasonal pattern and there are some calendar impacts or calendar effects associated

with electricity. So, these are known as your month of the year effect day of the week effect or time of the week time of the day effect. So, what are these calendar effects? So, the month of the year effect shows that the monthly average price for summer months will be higher. Similarly, the day of the week effect will indicate that weekend prices will be much lower compared to the weekdays because many industries will not be operating on weekends manufacturing units are stopped on weekends. So, obviously, weekend prices will be much lower compared to the weekdays and time of the day as we have seen early morning prices are normally lower than the peak evening hour prices and peak evening prices will always be higher on a given day. So, when we are modeling or when we are ah discussing or forecasting spot prices of electricity, we have to ah look into the price of the green energy price or as well as the calendar effects that is month of the year effect day of the week effect and the time of the day effect to model or forecast the spot price. Now, coming to the futures and options on ah electricity as well as swap contracts on electricity please note that as of now in India we do not have any derivative contracts ah standard futures and option contracts on electricity. We have companies entering into lot of swap contracts which are bilateral contracts with each other and many exchanges all over the world offer derivative products on electricity futures and option contracts are offered unlike ah Indian power exchanges because government of India has not allowed any derivative trading in ah in electricity as of now. Of course, we have forward market as we discussed that term ahead market where buyers and sellers are negotiating for delivering electricity 3 months 4 months into the future. So, that market is available, but a typical futures or option contract is not currently available in Indian market and most of the exchanges all over the world offer derivative products and electricity and normally the underlying is the system price for a given time block. For example, a futures contract could be the average system price from 11 am to 3 pm. So, the underlying of an electricity futures contract will be system price for a given time block ah in a given day. There could also be futures contract on area clearing price for a given time block for example, area average clearing price for S1 area for 11 am to 3 pm. Exchanges list various kinds of futures and option contracts and various combinations of the system price and area clearing price for different time blocks on a given day. Of course, trading depends on ah how many people are interested to hedge the price risk or how many speculators who are interested to enter into contracts on different ah futures and option contracts. Now, coming to Chicago Mercantile Exchange which offers futures contracts on many ah electricity products for example, ah I have just taken two contract details. So, PJM AEP Dayton hub real time peak calendar day 5 megawatt futures. So, this is an example of a futures contract and please note that AEP Dayton hub is a region the way we have discussed about S1, S2, A3, A2 etcetera. So, AEP Dayton is a region in the USA and ah the pick calendar day will be the underlying time period and the underlying contract size is 5-megawatt hour. Similarly, you have PJM Northern Illinois have 5 megawatts pick calendar month real time LMP futures. So, there are many combinations

of many different types of futures available at electricity futures available at CME. If you are interested to understand the contract specification who buys who sells this electricity futures contract, I would again urge that you please visit the Chicago Mercantile Exchange ah you will be able to understand the contract specification and the buyers and sellers of those contracts. And many companies enter into swap contracts to mitigate ah electricity prices. So, here I have given some examples of who could be the ah buy who could be the swap counter parties and who would take whether what kind of a swap position whether one would be a seller of a swap or a buyer of a swap. For example, let us say an electricity generator will be selling electricity at the spot price yes. So, the electricity generator will be selling electricity at the spot price and receiving a floating spot price. So, what is the fear of this particular generator? The fear of a generator is going to be that the electricity price is going to go down. In fact, if you recall we had discussed on a given day price can range for 15 different 15 minutes block price can reach from 10,000 rupees per megawatt hour to 2,000 rupees per megawatt hour. So, electricity generators here is that price is going to go down and that particular generator can enter into swap contract with a counter party where it will be a seller of a swap and it will be paying floating rate and receiving the fixed price. Similarly, different distributors will be depending upon the nature of the business, they will either be the seller of the swap or a buyer of the swap. This particular table is very self-explanatory. I do not want to go into the explanation related to this swap contracts in detail. In fact, in the earlier sessions we have discussed about various types of swaps when somebody when a company will be a seller of a swap or when a company is going to be the buyer of a swap we have discussed extensively. Just to summarize let us say one end user big commercial user who is a buyer of electricity that particular company is fearing that the price is going to go up. So, it will always be a buyer of a swap and it will be paying fixed and receiving floating from the counter party. And in this context, I have used the word PPA. So, that will be your long term power purchase agreement which are entered by electricity generators and distributors. In this context list understand very interesting futures contract which are known as your crack spread and spark spread. A spread is basically the price of output minus the price of input. As you can see spark spread is the price of electricity per megawatt hour minus the price of natural gas into the heat rate. So, spark spread is the spread when electricity producer uses natural gas to generate electricity. Similarly dark spread is the spread or the benefit a particular electricity producer will be getting when the electricity is being generated by using the coal. With respect to this spark spread and dark spread we also have a concept called a heat rate. Please note that the heat rate for coal or natural gas it is measured by the amount of energy which is measured in terms of British thermal unit that is amount of BTU energy is required to produce 1 kilowatt hour of electricity. And please note that heat rate is the energy input needed to produce 1 unit of output. The higher the heat rate, the lower the efficiency of generation company. Please note that the heat rate will vary from one generation company to power generation

company to another power generation company. In fact, heat rate may vary for a single company, but two different power generation stations. And this heat rate will vary from power plant to power plant depending upon what kind of input is going into the power generation system. For example, a coal fired plant a thermal power plant though if the coal has higher ash content it will lead to a higher heat rate higher heat rate means lower efficiency. If the coal has moisture it will lead to a higher heat rate. If the plants are older, it will have a higher heat rate. Similarly, for natural gas fired electricity generation plants depending upon the composition of methane ethane and propane in the natural gas the heat content will also vary. Please note that this particular table shows the heat rate for different power generation companies. Let us say you have A and B which uses coal input C and D use natural gas as input. And obviously, as you can see this coal generation company B uses lesser energy to generate 1 kilowatt hour of electricity. Obviously, generation B company is going to be an efficient company as compared to generation A company. Now coming to the crack spread and spark spread futures contract. Please note that a generator companies a power producer companies' gross profit is nothing, but the spark spread or a dark spread. So, profit which gross profit a power generation company is going to earn is going to be the price of the electricity minus the price of the input that is price of the coal or price of the natural gas. And if a generation company is expecting that its spread is going to go down. So, when the spread is going to go down if the electricity prices are going to go down while the coal or natural gas price is going to go up. So, this is the fear of the power generation company that is the output price will go down it will sell electricity at a much lesser price while the input cost that is coal price or natural price will go up. So, if a generation company is fearing that its spread is going to go down it will mitigate the risk by entering into long futures contract on coal or natural gas simultaneously it will also enter into short futures contract on electricity. So, it is fearing that the price of electricity is going to go down. So, it will enter into a futures contract short futures contract on electricity it will simultaneously enter into long futures contract on coal and natural gas. So, basically it will be entering into a short futures contract on dark or spark spread. So, the electricity generation companies' risk will be mitigated when the particular company enters into a short futures contract on dark or spark spread. So, when we are talking about long or short futures position with respect to spark or dark spread, please note that the short position will sell the futures contract on electricity and simultaneously it will be buying the futures contract on the input in this case I have also only mentioned the natural gas it could be natural gas or coal. So, a hedger a generation company as a risk hedger will take a short position on the spark or dark spread. Obviously, the counter party position will be taken by a speculator. So, with this we will end our discussion related to all things related to electricity as well as electricity spot and futures contract as I stated that in India, we do not have a market for derivative contracts. However, significant amount of spot trading is happening in Indian market as far as the electricity is concerned. So, with this we will end today's session and

I eagerly look forward to interacting with all of you in the next session in which we will be discussing more about the carbon spot market and carbon credit and derivative markets in carbon. So, thank you all of you.