Economic Operation and Control of Power System

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Week - 07

Lecture – 32

Very good morning and welcome you all to the NPTEL course on Economic Operation and Control of Power Systems. I am very sure that you must have enjoyed my previous lecture where we talked about locational marginal costing, multi-area transactions and the benefit that we get due to interconnection and interchange of energy. And today we will be talking about multiple utility interchange and mostly we will be focusing on willing of power from different resources. Now phenomenon that take place with multiple utility interchange is popularly known as Wheeling That means you wish to wheel energy from one area to other using different utilities facilities. Now wheeling is the use of some parties transmission system for the benefit of other parties because I am an energy owner, I do have five power plants and I do have another industry which is located 500 kilometers away. So I wish that my own energy need to be used at my industry location but I do not have transmission corridor.

So I have to use someone's transmission corridor to exchange my own power and that is possible through wheeling. And the power not necessarily move as you desire because it depends on system conditions and the line constraints. It occurs on an AC interconnection that contains more than two utilities more popularly two different parties. Whenever transaction take place if there are only two parties there is no third party to perform the wheeling here.

Now we will just concentrate on one very interesting example which has been very detailed in the textbook on Wood and Wollenberg. Wheeling and the problem of parallel path. Now consider the example which has been shown in the diagram 32.1 that is basically six locations A, B, C, D, E, F. Suppose area A and C negotiate to sell 100 megawatt through A to C.

That means there is a negotiation between two different parties that means C is ready to buy 100 megawatt from A and A is ready to sell 100 megawatt to C. So to me that could be an industry in this zone. And there could be a generation at location number A. So this fellow gentleman who generate power instead of selling to the grid or the utility the gentleman at A is interested to sell power to a consumer situated at location C. Now area A will increase its schedule net interchange by 100 megawatt because whatever the earlier energy exchange that is coming through A will now increase by 100 megawatt.

And C will reduce its net interchange scheduled by the same amount. Assuming there is no losses in the system so you basically increase this by 100 and reduce this by 100. So this is consumed and that is being generated. Now the generation in A will increase by 100 megawatt sell and that in C will decrease by the 100 megawatt purchase. That is what numerically we add and reduce will lead to sell and purchases.

Now in the figure 32.2 we source the resulting changes in the power flow because of increase in 100 megawatt and reduction in 100 megawatt. And as you could see now this at this location we have increased 100 megawatt and this 100 megawatt has now flown this way 50 that way 50. Now this 50 is divided into 25, 25 and 25 and this both merge to 50 and moving to 50 and finally C got 100 megawatt as an additional energy. And A has penetrated 100 megawatt.

Note that not all the transaction flows over the direct interconnection between the two systems. Initially we thought that the 100 megawatt will flow in this line because we are talking about the transaction between A to C. But in reality that is not happening. Even though I wish to exchange power between Jaipur and Ahmedabad of X megawatt it is not necessarily the tie line connected or the interconnection between Rajasthan and Ahmedabad will carry that X megawatt transaction between Jaipur and Ahmedabad. But it may go through some other path and may enter to Ahmedabad through Bombay or Pune.

It is possible. Am I right? So A is selling 100 megawatt to C but all the other interconnected areas are affected. So it is not mandatory that if there is an energy exchange that is between A to C only this corridor is going to get disturbed but all the other corridors got disturbed because of one transaction. Is it clear? That means we can conclude that the energy which has been wheeled through different corridors to reach to C to satisfy the transaction of 100 megawatt between A to C and that is clearly known as wheeling. The number of possibilities for transaction is very large because this is a very simple example of six areas or six buses but practically any country for example India which is very very big and very difficult to identify how the whole transaction got disturbed.

So if you introduce an interchange of energy or an exchange of energy into existing optimal power flow or a load flow you will experience each and every line will experience a different power flow now. That means because of the transaction the power flow in each and every corridor oscillates because of the new transaction. The number of possibilities for transaction is very very large and the power flow pattern that results depends on the configuration and the purchase cell combination plus the schedule in all of the systems. As an example in United States various arrangements have been worked out between the utilities in different regions to facilitate inter-utility transactions that involve wheeling. This past arrangement should generally ignore flow over parallel pass where the two systems were contiguous and owned sufficient transmission capacity to permit the transfer.

Difficulties arise when willing increases power losses in the intervening systems and when the parallel path flow utilize capacity that is needed by wheeling utility. Now what exactly happens when you carry out a transaction there are two challenges. One that may increase the system loss that is one and probably there are many parallel path flow that really is supposed to be utilized by wheeling being utilized by its own loop flow that takes place within your network. Now increased transmission losses may be supplied by the seller so that the purchaser in a transmission receives the net power that was purchased. For example if I am purchasing 100 megawatt and that leads to a loss of actually 10 megawatt then the seller will inject 110 megawatt so that I get at least 100.

The other arrangement could be the seller will give 100 megawatt and the purchaser will get 90 megawatt accommodating the losses. But in general the seller take the responsibility to adjust the losses that is being caused or created due to the transaction. In other cases the transaction cost may include a payment to the wheeling utility to compensate it for the incremental losses. The relief of third party network element loading caused by wheeling is a more difficult problem to resolve. If it is a situation that involves overloading a third party system on a recurring basis the utilities engaged in the transaction may be required to seize the transfer or pay for additional equipment.

Loop flows and arrangements for parallel path compensation become more important as the demand for transmission capacity increases at a faster rate than actual capability does. This is the situation in most developed countries. New high voltage transmission facilities are become more difficult to construct that we all know. Another unresolved issue has to do with the participation of organizations that are basically consumers. Should they be allowed access to the power transmission network so that they can arrange for energy supplies from non-local resources.

In the deregulated natural gas industry in the United States especially this has already been implemented. Now when the expansion of phase angle regulating PAR transformers, flexible AC transmission devices back to back HVDC links and long distance HVDC links enable more control and more flexible. So these are the devices which can control the power flow in a network. For example if the line is getting X mega watt of power they can increase to 2X or 3X depending upon those flexible devices are being engaged in those corridors. A HVDC system is presently proposed to overlay the present AC system within United States corridors.

Even in India many HVDC corridors are in project mode now. European Indians and China have also planned for extension of the HVDC system to make sure that the AC system is able to accommodate more renewable energy sources which are currently coming up. So if you look into the Indian network today we have also created a green corridor now which is responsible to accommodate all the renewable powers which are available which has never been planned before 50 years. So due to the new presence of renewable energy sources we need to have new corridors to evacuate all the energies that are presently available to me either in desert areas or maybe in coastal areas due to wind energy availability. So wheeling is inherent if utilities can contract beyond immediate connections as implemented in the system especially the western half of the United States through the Western Electricity Coordinating Council and similar kind of structures is also available in Europe, China, India and most of the developed nations today.

East coast interchange was only between interconnected immediate neighbors. However, the density of the transmission system and the lack of flow control has shown that wheeling is inherent also in the eastern half of the United States. So wheeling is a quite common phenomena in North America and however in a market shape actually the other Asian and European countries also concentrating on such kind of energy exchange like other states. Once power systems are interconnected with all the immediate neighboring systems this may mean that one system will have interchange power being bought and sold simultaneously with several neighbors. In this case the price for the interchange must be set while taking account of the other interchanges.

Dear students you will be happy to know there are two exchanges currently operational in this country and in India we do have two exchanges which carry out and accommodate different wheeling as well as sell and purchase of power between two different entities. For example, if one system were to sell interchange power to two neighboring system in sequence it would probably quote a higher price for the second sell since the first sell would have raised its incremental cost in the beginning. In the other hand, if the selling utility was a member of a power pool the sell price might be set by the power and energy pricing portions of the pool agreement to be at a level such that the seller receive the cost of the generation for the sell plus one half the total saving of all the purchases. In this case assuming that a pool control center exists the sell prices would be computed by this center and would differ from the prices under multiple interchange contracts. The order in which the interchange transaction agreements are made is very very important in costing the interchange where there is no central pool dispatching offices.

Such analysis is required by federal and state agencies in most of the nations. For example, consider a three party transaction COA locates power and energy in COC and makes an arrangement with an intervening system of COB. So there is a case between A to C and there is intermediate agency at B point for transaction. So then COC sells to COB and COB sells to COA. The price level to COA may be set as the cost of COC generation plus the willing charges of COB plus one half of COA savings.

It may also be set at COB net cost plus one half of COA savings will be the final cost. So price is a matter of negotiation in this type of transactions when prior agreement on pricing policies are absent. Often utility companies will enter into interchange agreements that give the amount and schedule of the interchange power but leave the final price out instead of agreeing on the price. The contract specifies that the system will operate with the interchange and then decide on its cost after it has taken place because you will get a clarity how much the incremental cost would behave after you physically extend the transaction. By doing so, the system can use the actual load on the system and the actual unit commitment schedules rather than the predicted load and committed schedules.

Even when the price has been negotiated prior to the interchange, just assume that you agree to a price without any practical exchange of energy, utilities will many times wish to verify the economic gains projected by the performing after the fact production cost. Sequence of calculation impacts is long and subject to interpretation if the contracts are not all inclusive procedures. Assumptions on relative cost and fuel must be avoided as well as assumed cost of transmission system use. Power systems are often interconnected with many neighboring systems and interchange may be carried out with each one when carrying out the after the fact production cost, the operations offices must be careful to duplicate the order of the interchange agreements. When several two party interchange agreements are made, the pricing must follow the proper sequence.

The central dispatch of a pool can avoid this problem by developing a single cost rate for every transaction that takes place in the given interval. So thank you all for your attention and we covered wheeling very nicely today and most likely we will talk about a pool market model when we meet next time. Thank you..