Introduce an Optimal Pricing Strategy Using the Parameter of "Contingency Analysis" Neplan Software in the Power Market
Case Study (Azerbaijan Electricity Network)

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ABSTRACT

Overall price optimization strategy in the deregulated electricity market is one of the most important challenges for the participants, In this paper, we used Contingency Analysis Module of NEPLAN Software, a strategy of pricing to market participants is depicted.
Each of power plants according to their size and share of the Contingency Analysis should be considered in the price of its hour. In the second stage, each of the power plants and cross-border supplier required forecasts on price and load request for determined hours, that can be used Artificial Neural networks. Thus, an efficient integrated model of optimized pricing for participants in the power market is extracted. The result of this study in the Azerbaijan power network for the special day and hour checked and has been provided.

KEYWORDS: Power Market, Artificial Neural Networks, Contingency Analysis

1. INTRODUCTION

Due to the orientation, the entire trading world's energy in the power market, currently all enterprise energy trading, "on the Ministry of Energy" carried out in the power market. One of the major debates in this field for market participants, the categories of "Pricing" and "how to win" is in this competitive environment.

Contingencies are defined as potentially harmful disturbances that occur during the steady state operation of a power system [1].

Contingency analysis is the study of the outage of elements such as transmission lines, transformers and generators, and investigation of the resulting effects on line power flows and bus voltages of the remaining system. It represents an important tool to study the effect of elements outages in power system security during operation and planning. Contingencies referring to disturbances such as transmission element outages or generator outages may cause sudden and large changes in both the configuration and the state of the system.

Contingencies may result in severe violations of the operating constraints. Consequently, planning for contingencies forms an important aspect of secure operation [2].

So with the knowledge this fact, and given that in the restructured environment (Power Market) to predict, daily price CONTERAS and colleagues found the modified ARIMA model have been introduced for forecasting market price "next-day" [4]. Neural networks in load forecasting, much has been used [5]. Now also use this tool to forecast the short term electricity price. For example, RAMSY and colleagues combined method based on artificial neural networks and fuzzy logic by giving an example of a market in Wales and England has suggested [6]. SKZUTA as well has been used a three-layer neural network with back propagation error learning method, to predict the market price of electricity [7].

Now in this paper, by combining these two methods, first, identify the efficient cross-border supply lines and power plants for the specified hours in Azerbaijan network, and then use of artificial neural networks to predict the load and energy prices in the specified hours. Until Power Market participants, recognize their position at the desired hours (According to the proportion of their influence) in the power market. Finally, an optimal price strategy would be formulated.

2. Methodology
2.1 Contingency Analysis Studies

The most difficult methodological problem to cope within contingency analysis is the accuracy of the method and the speed of solution of the model used. The operator usually needs to know if the present operation of the system is secure and what will happen if a particular outage occurs. Operations personnel must recognize which line or generator outages will cause power flows or voltages to go out of their limits. In order to predict the effects of outages, contingency analysis technique is used. Contingency analysis procedures model a single equipment failure event, that is one line or one generator outage, or multiple equipment failure events, that is two transmission lines, a transmission line and a generator; one after another in sequence until all credible outages have been studied. For each outage tested, the contingency analysis procedure checks all power flows and voltage levels in the network against their respective limits [3].

2.2 Methods of Contingency Analysis

Methods based on AC power flow calculations are considered to be deterministic methods which are accurate compared to DC power flow methods.[1] The methods used for analyzing the contingencies are based on full AC load flow analysis are faster and accurate. And therefore the wide use of the network control center. Because the contingency alarms came too late for operators to act, they are worthless. Most operations control centers that use an AC power flow program for contingency analysis use either a

Newton-Raphson or the decoupled power flow. An algorithm under the AC load flow method will be used to ensure higher accuracy [2]. Since these algorithms has a good performance in terms of convergence speed and reliability in unfavorable conditions. Below is a brief description of these methods.

I.   Decoupled Load Flow

The Newton Raphson power flow equations in Jacobian form are represented by the following equation.

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} H & N \\ J & L \end{bmatrix} \begin{bmatrix} \Delta\delta \\ \frac{\Delta V}{V} \end{bmatrix} \tag{1}$$

$$H_{ik} = \frac{\partial P_i}{\partial \delta_k} \qquad N_m = \frac{\partial P_i}{\partial V_k} V_k \tag{2}$$

$$j_{km} = \frac{\partial Q_i}{\partial \delta_k} \qquad L_{km} = \frac{\partial Q_i}{\partial V_k} V_k$$

H, N, J and *L* are the sub-matrices of the Jacobian represented by Equation 2.

In a power system there is a strong dependence between injected real powers and bus voltage angles and between the injective reactive power and bus voltage magnitudes that is strong couplings between *P* and δ variables and between *Q* and */V/*. The coupling between *Q* and δ and *P* and */V/* is weak. Therefore the matrices *N* and *J* can be set to zero. Resulting linear equations reduce to

$$\Delta P_{(k-1)} = H_{(k-1)}\Delta\delta_k \tag{3}$$

$$\Delta Q_{(k-1)} = L_{(k-1)}\left[\frac{\Delta|V|}{|V|}\right] \tag{4}$$

The elements of *H* and *L* are given in Equation 2.

II.   Fast Decoupled Load Flow

In decoupled method the elements of Jacobian matrix *H* and *L* have to be calculated at each iteration which requires considerable computational time. For simplifying these calculations the following approximations described by equations 3, 4 and 5 are done to make these matrices constant

$$\cos\delta_{ik} = 1 \tag{5}$$

$$G_{ik}\sin\delta_{ik} << B_{ik} \tag{6}$$

$$Q_i << B_{ik}|V_i|^2 \tag{7}$$

Introducing these approximations the *H* and *L* matrices are obtained from equations 8 and 9.

$$H_{ik} = L_{ik} = -|V_i||V_k|B_{ik} \qquad i \neq k \tag{8}$$

$$H_{ii} = L_{ii} = |V_i|^2 B_{ii} \tag{9}$$

Dividing each equation by Vi and setting |Vj| = 1, fast decoupled load flow (FDLF) equations are given by equation 10 and 11.

$$\frac{\Delta P}{|V|} = B'\Delta\delta \tag{10}$$

$$\frac{\Delta Q}{|V|} = B''\Delta V \tag{11}$$

Where elements of *B'* and *B''* are obtained taking the negative of appropriate elements of *B* [1].

3. DISCUSSION

The programming of the above procedure for contingency analysis has been implemented in NEPLAN is fast decoupled load flow. And more a set of single and multiple contingencies are performed on Azerbaijan power network using full AC load flow analysis applying the simulation of lines and generator's outage.

3.1 simulation of line outage theory

The simulation of transmission line outage is carried out by the formulation of the corresponding admittance matrix. Assume that the line connected between buses m and n will be outage. The elements of the admittance [Y] matrix that will be affected are Y_{mn} ‹Y_{nn}‹Y_{mm} andY_{nm}, and the new values of those admittances for the (π) mode of representation of transmission lines will be given by:

$$Y'_{mm} = Y_{mm} - \frac{1}{(R_{mn}+jX_{mn})} - \frac{jB_{mn}}{2} \qquad (12)$$

$$Y'_{nm} = Y_{nn} - \frac{1}{(R_{nm}+jX_{nm})} - \frac{jB_{nm}}{2} \qquad (13)$$

$$Y'_{mn} = Y_{mn} - \frac{1}{(R_{mn}+jX_{mn})} = 0 \qquad (14)$$

$$Y'_{nm} = Y_{nm} - \frac{1}{(R_{nm}+jX_{nm})} = 0 \qquad (15)$$

Where:

Y'_{mm}, Y_{mm}; Self admittance at bus m post and pre-contingency.
Y'_{nm}, Y_{nn}; Self admittance at bus n post and pre-contingency.

Y'_{mn}, Y'_{nm}; Mutual admittance between bus m and n post contingency.
Y_{nm}, Y_{mn}; Mutual admittance between bus m and n pre-contingency.

4. SIMULATION OF GENERATING UNIT OUTAGE THEORY

This simulates mainly outage of one unit (or more) in a power station. Let the total generation for the station at bus (*m*) be P_{gm}, and assume that there exist identical (*g*) units, then:

$$P'_{gm} = P_{gm} - n\left(\frac{P_{gm}}{g}\right) \qquad (16)$$

Where:

P'_{gm}; Active power generated at bus m post the outage.
P_{gm}; Active power generated at bus m before the outage.
n; Number of outage generation units in the station.
$\frac{P_{gm}}{g}$; Active power generated at bus m per a generator unit [3].

4.1 Chosen powerful software for analysis of parameters (Outage) in the power market Azerbaijan electricity network.

Due to the analysis of networks with power market model, Extended Newton Raphson load flow model must be used. The most important reason is the Distributed slack.

That specify, load flow calculations based on "Distributed reference Node" should be done or not? Whereas we want to perform load flow in conventional networks, we choose the highest power unit as the slack Control, accepted their share.

NEPLAN software is the best software of this feature because its Background is based on the power market. In this study, Data analysis for Azerbaijan Network is done by

bus, and then the rests of the buses are selected PQ and PV; however, in the power market, we do not have a slack bus. And all of buses based on their role in the frequency

NEPLAN software. Figure .1 illustrates Azerbaijan Electricity Network Diagram in NEPLAN Software.

Figure.1. Azerbaijan Electricity Network Diagram in NEPLAN Software

Initially, by using the ability of "Contingency Analysis" NEPLAN software,

the most effective power plants and electricity import's lines are detected in the

Azerbaijan network. The results of these studies at 21:00 on 13/08/2012, is obtained as Table 1. Now with the sort of Contingency Analysis result based on intensity, we recognize that each case must be initially chosen and studied.

In this study, the data from the years 2010, 2011 and 2012 related to the Armenia feeder, to predict the initial "loads" and "price" the ANN[1] has been used. Figure (2, 3) illustrates comparison chart of "real" and "forecast" normal days of the week (Tuesday).

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[1] artificial neural networks

Table1. Results of Contingency Analysis power plants and power supplies of Azerbaijan cross border networks

Contingency analysis results NEPLAN®

	Contingency Element/Mode	Violated Element	Element Type	Area of viol. element	Zone of viol. element	Violation %	Base Case Value	Number of Violations
1	TURKIYE							9
2	TURKIYE	KHOY-132	Node	Area 1	Zone 1	112.53	108.75	
3	TURKIYE	URMIEH-20KV	Node	Area 1	Zone 1	111.42	108.39	
4	TURKIYE	URMIEH-132	Node	Area 1	Zone 1	111.33	108.25	
5	TURKIYE	ARAS	Node	Area 1	Zone 1	111.15	107.41	
6	TURKIYE	URMIEH-528	Node	Area 1	Zone 1	110.91	107.91	
7	TURKIYE	JOLFA	Node	Area 1	Zone 1	110.9	107.36	
8	TURKIYE	JOLFA230	Node	Area 1	Zone 1	110.74	106.84	
9	TURKIYE	khoy-543	Node	Area 1	Zone 1	110.18	106.22	
1	TURKIYE	BALANJ	Node	Area 1	Zone 1	110.14	107.05	
1	URMIEH-G15							1
1	URMIEH-G15	URMIEH-20KV	Node	Area 1	Zone 1	110.07	108.39	
1	Sabalan-G16							1
1	Sabalan-G16	URMIEH-20KV	Node	Area 1	Zone 1	110.13	108.39	
1	Sabalan-G14							1
1	Sabalan-G14	URMIEH-20KV	Node	Area 1	Zone 1	110.05	108.39	

The training and test ANN has been implemented of Matlab R2010a software. And the results obtained are as follows for Armenia feeders. Finally, network errors when testing for weekdays is as follows;
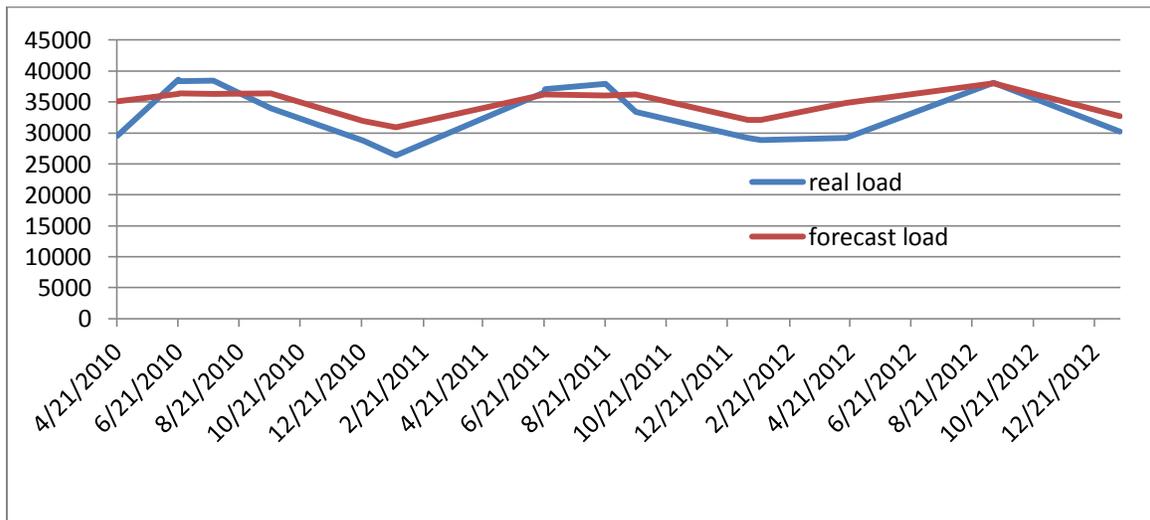
Figure.2. Comparison chart of "real load" and "forecast load" normal days of the week (Tuesday)

Figure.3. Comparison chart of the "real price" and "forecast price" normal days of the week (Tuesday)

Due to the similarity of accountability network to another day of the week, it does not seem necessary to provide the relevant diagrams.

Not that for data analysis load "daily peak load" and for price, data has been used "weighted mean price of the accepted day "is applicated. To achieve optimum results, day of the week is divided into four categories: Saturdays (the first working day of the week), Tuesday (normal day of the week), Thursday (the last day of the week) and Friday (holiday). And temperatures considered "The mean monthly maximum temperature" is selected for every month.

5. CONCLUSION

Then the most impact on power and electricity import's lines in Azerbaijan networks will be detected. And for this hour, energy imported from Armenia according to the network configurations and load demand is less important. And it should be considered in the price of its hour, that

energy supplier will be a winner in the power market. Therefore, the most effective power plants and electricity import's lines are respectively; Feed line from Turkey with the highest impact (112.53%), G15 URMIA Unit with impact (110.07%), G16 SABALAN unit with impact (110.13%) and G14 SABALAN units with impact (110.06%).

And each of power plants according to their size and share of the Contingency Analysis, and it should be considered in the price of its hour. In the second stage, each of the power plants and cross-border supplier required forecasts on price and load request for determined hours, that can be used neural networks. Note that if this method is good training, would be a good delivery, and using this approach presents a preliminary forecast, that will be completed our proposed strategy for the optimal electricity pricing formation.

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