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ANALYZING THE RETAILER'S PROFIT IN ELECTRICITY MARKET BASED ON CONSUMER'S BEHAVIOR

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ABSTRACT

Due to exchange costs, only huge consumers select direct buy from wholesale market. Most small and medium consumers, buy energy from retail market (this market has bought electricity from wholesale market). In this model, the "wires" activities of distribution companies are normally separated from their retail activities; because these companies no longer have the local monopoly for providing electricity in the area they cover. Thus, in this model the exclusive function is only related to constructing and exploiting the transmission and distribution network. Retailers are essential for small consumers, because small consumers buy electric energy from a retailer and hire a connection from their local distribution company. Contribution of small consumers in the market is not beyond the selection of a retailer between all the retailers, and also they do not have an active role like big consumers through direct buy from the market.

KEYWORDS: Electricity market, Demand response, Retailer, Random planning

INTRODUCTION

Before the beginning of competence in electrical industry and in a major part of the twentieth century, it was not feasible for the buyers and the consumers to freely choose the marketer in electrical industry. These consumers had to buy electricity from the company which had the monopoly of electricity distribution in their area. Structure of some of these companies was vertical, that is they were committed to produce electricity, transfer electricity from plants to load centers and distribute energy among consumers. In some other countries, the company which consumers bought energy from, were only responsible for distributing and selling energy in their local area. In a deregulated environment, consumers with considerable consumption volume employ necessary sensitivities to predict amount of consumption or the suitable price to preserve the financial resources. But such behavior is not necessary for small consumers and they prefer buying on a fixed tariff basis. Thus, retailer's roles will cover the empty space between wholesale markets and small consumers. In between, demand response programs in the performance of electricity market and consumer's contribution and energy producer companies are of great importance.

Demand response (DR) programs include methods for managing the demand which changes the customer's consumption caused by price. It should be said that some of these programs were used in conventional electricity system in the form of multi-tariff counters. Economists believe that changing the prices is a proper method for motivating the consumers to consume electricity optimally. Such pricing causes long term changes and short term changes in load consumption pattern. In long term, high price of electricity will lead to energy saving, if there is a great difference between tariffs of peak hours and low load hours, consumers will be motivated to install energy storing devices so that they can prevent consuming energy in peak hours that the electricity price is high. In general, demand response is defined as the small consumer's contribution in electricity market, their being faced with instantaneous prices of the market and being responsive to it. Price of electricity is more integrated in the worlds, but in Iran a few of the consumers are aware of the real price of electricity, thus there is no inspiring factor for the consumers to contribute in the market and adapt their consumption with production, network and price of electricity. This paper aims to achieve a model for maximizing the retailer's profit by considering the demand response. In this regard, deregulation of power systems, transactions and behaviors in the electricity market are investigated which are of great importance. The results are also analyzed in GAMS.

LITERATURE REVIEW

In the recent decade, several researches relevant to electricity retailer, demand response, electricity market and their relations are done. In [1], profit and risk of a retailer company which are obtained from future contracts, call option and wholesale market are investigated simultaneously. In [2], a model is proposed, based on which retailer companies can contribute in competitive market of other retailers along with distributed generation and energy storage systems. In [3], strategies and policies of manufacturers and energy buyers in the electricity market is investigated, in this reference we investigate the household consumers' behavior in the electricity market. In [4] all problems which a retailer might face in the electricity market is investigates and has proposed some examples from the world's electricity market. In [5], a proper and relevant model for exact investigation of the retailer market, relation between programs based on demand response price, equipment introduction, standards and new strategies for smart measurement are proposed and approaches for preserving consumers' information in the competitive model of the retailer are introduced. In [6], retailer's profit is optimized by considering the sale price to be fixed and the demand to be specified at the retailer's side, in this reference, implementing demand response programs are performed simply and based on load relocation, in [7] demand response program is investigated in particular, in addition the uncertainty of the program and its impact on the electricity market is investigated, in this reference consumer's attraction and its impact on consumption management is also studied. In [8] a set comprising retailer and power plant are investigated, such that this plant provides consumer's demands and sells the remaining of its production in the wholesale market. In [9], a model is proposed to program and formulate demand response in the deregulated power system, in this model, transaction market associated with demand response and its mechanism in the presence of electricity market's actors are investigated. In [10] all points, mechanisms and strategies of the power system based on forming the electricity market and presence of different actors in this market are investigated, the main objective of this article is to propose approaches for optimizing manufacturer's profit and optimizing social welfare of the consumer.

THEORETICAL BASIS OF RESEARCH

3-1 Types of Electricity Market

1) In terms of commodity, electricity market can be divided into the following categories:

1. Energy market
2. Ancillary service
3. Transmission

Energy market: transaction market related to consumption power, is called energy market, electricity transactions in the energy exchange is the transactions of apparent power.
Ancillary services: is the reactive power market and reservation services, capacity and other services which are required for preserving the apparent power of a network.
Transmission market: in this market, electrical energy services are exchanges.
2)In terms of time, electricity markets can be divided into the following categories:

1. Forward market
2. Day-ahead market
3. Real-time market

Forward market: forward contract is a contract in which buyer and seller agree on the delivery time in the future and the price. This type of market has been recently established in Iran's Exchange.
Day-ahead market: in most electricity markets, production and consumption of the next day is planned, this market is also called sale day market.
Real-time market: regarding the changes at load's side, production's side and balancing the intervals, it is necessary to establish a market for intervals less than 1 hour which is called Real-time market[11].

3-2 History of Establishing Retailer Companies in Electricity Market

In many countries, deregulation has moved from competition in production section to creating competition in retailer section. In Norway, customers were allowed to choose a supplier to provide their electricity in 1993, and all obstacles for the consumers to access retailers were eliminated gradually. Some years after Norway, Sweden and Finland started competition in retailer level, such that at the end of 1998 a complete competition was carried out in three countries at retailer level[10][11].

3-3 Objectives and Process of the Retailer Market

1. Consumers freedom in choosing the service provider companies
2. Creating competition in the market and increasing the quality of the services
3. Decreasing the prices proposed by the retailers and thus preserving the consumers' interests
4. Eliminating price control regulations and scanning the market by deregulation executives
5. Increasing retailer market's share through better service and proposing more suitable prices
6. Opposing the environmental challenges by retailers by means of technologies which are consistent with environment and encouraging the consumers and rewarding them for using the electricity produced by clean technologies[3][5].

3-4- The Relationship between Retailer, Demand Response and Consumption Management

Each retailer faces two types of contracts: buying and selling energy contracts; usually part of buying and selling energy through instantaneous energy, where there are a lot of price fluctuations. On the other hand, the retailer is committed to provide the variable energy of its consumers.

While the retailer faces load fluctuations and price, consumers who face fixed price of electricity show less sensitivity towards the price changes in the wholesale market. Since increasing the consumer's sensitivity will be followed by advantages like decreasing the production cost, decreasing authority in the market, decreasing the costs paid by the consumers. Applying methods which increase the consumers' sensitivity could be advantageous both for the total system and the consumer[8]. In order to solve this problem and increase the consumers' sensitivity, pricing models which vary with time like real time pricing, time use pricing, critical-peak pricing and … are proposed.

The main objective of these pricings is summarized as following:

1. Retailer price which reflects the wholesale market's fluctuations to the final consumers so that they pay based on the real value of electricity in different times of the day.
2. encouraging the consumers to change working hours of the high consumption devices to non-peak hours to decrease their own costs and help decrease the peak to medium load ratio[9].

by regarding all things describe above, real time pricing (RTP) of electricity provides natural transmission of price signals from real-time market to small consumers. While real time pricing, consumers face hour prices which change daily and they decide based on these prices. In addition, real time pricing eliminates the risk of buying electricity which the retailer or the local distribution company might face due to buying from the wholesale market or the unstable instantaneous prices and selling it with fixed price. Also, employing instantaneous pricing transfers price risk from the retailer or the local distribution company to the final consumer[2][9].

MATERIALS AND METHODS

4-1 Necessity of Retailers in the Electricity Market

In many countries, deregulation has moved from creating competition in the production section to creating competition at the retailer level. The fact is that emphasizing on competition in production without creating competition in the consumption environment cannot create all competition advantages in the electricity market and might result in instability of the prices and strengthening the market strength of the manufacturers. Investigating the deregulation process in England, Norway and Canada shows that these markets have problems providing stable services and stable prices which is mainly due to authority of the manufacturers' market, incomplete mechanism of exchange (incompleteness of the market on demand side), lack of motivation for creating sensitivity to price of electricity in consumers[1].

One of the ways through which the consumers can contribute in the market is aggregating small consumers and forming institutions called retailers which can contribute in the market as a buyer on one hand and sell electricity to small consumers through direct contracts on the other hand.

Figure (1) shows the areas related to activity of a retailer:

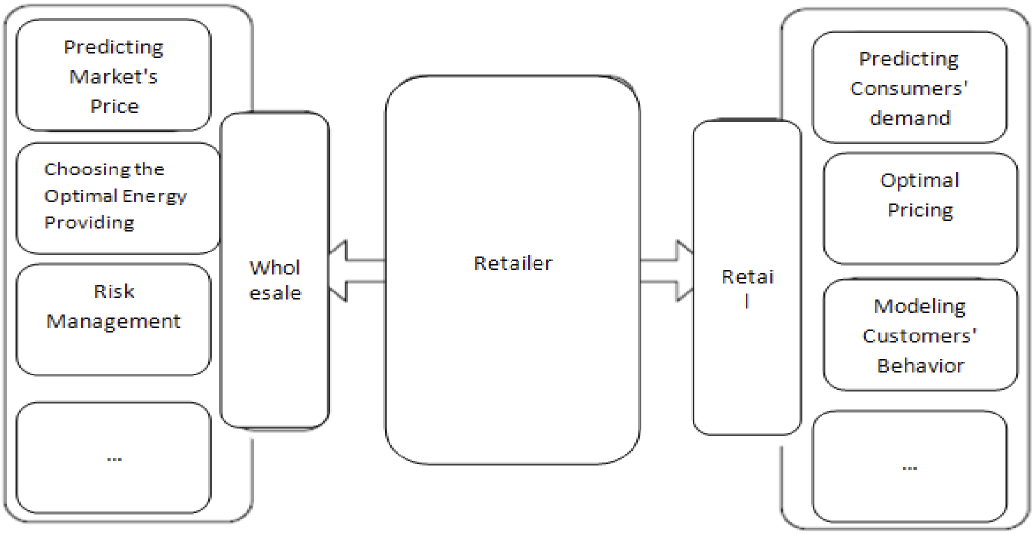

Figure (1)- Areas related to Retailer's Activities in the Electricity Market

4-1 Main Activities of Retailer Companies

Some of the duties of a retailer company in the electricity market are as follows:
1. estimating the customers
2. recognizing the customers
3. Electricity pricing
4. Predicting the electricity price
5. risk management

4-2 Necessity of Performing Demand Response Programs

In some times of a year, consumption power of a system increases significantly, in such situations without considering the demand response, manufacturing capacity increases to provide the required power and storage of these hours. While installation cost of plant units is very high and takes time. By conducting demand response programs, consumption in peak hours can be reduced by those consumers who can reduce their consumption and lots of extra costs for increasing the production capacity in short time will decrease.

Regarding the above discussion, advantages of demand response for the network and the consumer are as follows:
1) Preventing the increase in prices
2) Helping to fix the prices in the electricity market
3) Decrease in the price of electricity in the wholesale and retailer electricity market
4) increasing credit and authority of the retailer market
5) decreasing the risk of retailers

Some advantage of demand response for the network are as follows:
1) decreasing the investment and exploitation costs
2) feasibility of using maximum power from the available plants
3) increasing reliability
4) helping the load's curve to become smooth

PROBLEM FORMULATION AND RESEARCH METHODOLOGY

5-1 Notation

The Notation Used throughout retailer's problem is shown below:

Indices and Numbers:

e Index of client groups, running from 1 to N_E.
f Index of forward contracts, running from 1 to N_F.

J Index of blocks in the forward contracting curves, running from 1 to N_J.
I Index of blocks in the price-quota curves, running from 1 to N_I.
t Index of time periods, running from 1 to N_T.
ω Index of scenarios, running from 1 N_Ω

Real, Binary and Random Variables:

C_t^F Cost of purchasing from forward contracts in period t ($).
$C_{t\omega}^P$ Cost of purchasing from the pool in period t and scenario ω ($).
$E_{t\omega}^P$ Energy traded in the pool in period t and scenario ω (MWh).
P_f^F Power contracted from forward contract f (MW).
P_{fj}^F Power contracted from block j of forward contracting curve of forward contract f (MW).
$R_{et\omega}^R$ Revenue obtained by the retailer from selling to client group e in period t and scenario ω ($).
λ_e^R Selling price offered by the retailer to client group e ($/MWh).
λ_{ei}^R Selling price associated with block i of the price-quota curve of client group e ($/MWh),Limited($\bar{\lambda}_{ei}^R$)
ξ Auxiliary variable used to calculate the CVaR ($).
η_ω Auxiliary variable related to scenario ω used to calculate the CVaR ($).
v_{ei} 0/1 variable that is equal to 1 if the selling price offered by the retailer to client group e belongs to block I of the price quota curve, being 0 otherwise.
λ_t^P Random variable modeling the price of energy in the pool in period t ($/MWh). $\lambda_{t\omega}^P$represents the realization of this random variable in scenario ω.
d_t Duration of period t (h).
E_t^{PC} Energy contracted prior to the beginning of the planning horizon that is used in period t (MWh).
E_{etiw}^R Energy associated with block i of the price-quota curve of client group e in period t and scenario(MWh).
$\bar{P}_{fj}^F$ Upper limit of the power contracted from block j of the forward contracting curve of forward contract f (MW).
λ_{fj}^F Price of block j of the forward contracting curve of forward contract f ($/MWh).
α Confidence level used in the calculation of the CVaR.
β Weighting factor used to materialize the tradeoff between expected profit and CVaR.
π_ω Probability of occurrence of scenario ω.

5-2 Energy Balance

At first, for balancing the electrical energy of the retailer in each time period and scenario, the following equation is presented:

$$\sum_{e=1}^{N_E} E_{etw}^R = E_{tw}^p + \sum_{f\in F_t} P_f^F d_t + E_t^{pc}, \forall t, \forall \boldsymbol{\omega}, \qquad (1)$$

In the above equation:

E_t^{pc}:is a part of energy which has been exchanged before.

The above equation states that the retailer should consider the difference between consumers' demand and the amount energy bought from the bilateral contract with the company in the Pool market to define this amount.

5-3 Expected Profit

Retailer's profit in the electricity market can be states as follows[12][13]:

difference between the revenue obtained from selling electricity to customers and the companies' costs in Pool contracts and buying energy from bilateral contracts, therefore the final profits depends on random and stochastic prices of Pool and customers' demands[14-17]. Accordingly if we want to define the retailer's profit, we have:

$$\sum_{t=1}^{N_T}\left(\sum_{e=1}^{N_E} R_{et\omega}^R - C_{t\omega}^P - C_t^F\right)=$$

$$\sum_{t=1}^{N_T}\left(\sum_{e=1}^{N_E}\sum_{i=1}^{N_I} \lambda_{ei}^R \bar{E}_{eti\omega}^R - \lambda_{t\omega}^P E_{t\omega}^p - \sum_{f\in F_t}\sum_{j=1}^{N_J} \lambda_{fj}^F P_{fj}^F d_t\right), \forall \boldsymbol{\omega}. \qquad (2)$$

In calculating the retailer's profit, it is important to consider the event probability of the scenario, thus the expected profit for the retailer can be stated as follows[18][19]:

$$\sum_{\omega=1}^{N_\Omega} \pi_\omega \sum_{t=1}^{N_T} (\sum_{e=1}^{N_E} R_{et\omega}^R - C_{t\omega}^P - C_t^F) \qquad (3)$$

5-4 Modeling Retailer's Risk

For modeling the retailer's risk, Cvar is used[20]:

$$CVar = Maximize_{\xi,new} \quad \xi - \frac{1}{1-\alpha}\sum_{\omega=1}^{N} \pi_\omega \eta_\omega \ :$$

$$\xi - \sum_{t=1}^{N_T}\left(\sum_{e=1}^{N_E} R_{etw}^R - C_{tw}^P - C_t^F\right) \le \eta_\omega, \forall\omega \qquad (4)$$

$$\eta_\omega \ge 0, \ \forall\omega \qquad (5)$$

5-5 Constraints and Objective Function of the Problem

$$Maximize_{P_{fj}^F, \lambda_{ei}^R, v_{ei}, E_{tw}^P, \xi, \eta_w}$$

$$\sum_{w=1}^{N} \pi_w \sum_{t=1}^{N_T}\left(\sum_{e=1}^{N_E}\sum_{i=1}^{N_I} \lambda_{ei}^R E_{etiw}^R - \lambda_{tw}^P E_{tw}^P - \sum_{f\in Ft}\sum_{j=1}^{N_J} \lambda_{fj}^F P_{fj}^F d_t\right) + \beta(\xi - \frac{1}{1-\alpha}\sum_{\omega=1}^{N} \pi_\omega \eta_\omega) \qquad (6)$$

$$0 \le P_{fj}^F \le \bar{P}_{fj}^F, \forall f, \forall j \qquad (7)$$

$$\bar{\lambda}_{ei}^R v_{ei} \le \lambda_{ei}^R \le \bar{\lambda}_{ei}^R v_{ci}, \forall e, \forall i \qquad (8)$$

$$\sum_{i=1}^{Ni} v_{ei} = 1, \forall e \qquad (9)$$

$$\sum_{e=1}^{N_E}\sum_{i=1}^{N_I} \bar{E}_{etiw}^R v_{ei} = E_{tw}^p + \sum_{f\in Ft} P_f^F d_t + E_t^{PC}, \forall t, \forall w \qquad (10)$$

$$\xi - \sum_{t=1}^{N_T}\left(\sum_{e=1}^{N_E}\sum_{i=1}^{N_I} \lambda_{ei}^R E_{etiw}^R - \lambda_{tw}^P E_{tw}^P - \sum_{f\in Ft}\sum_{j=1}^{N_J} \lambda_{fj}^F P_{fj}^F d_t\right) \le \eta_w, \forall w \quad (11)$$

$$v_{ei} \in \{0,1\}, \forall e, \forall i \qquad (12)$$

$$\eta_w \ge 0, \forall w \qquad (13)$$

The objective function (6) comprises two terms: i) the expected profit and ii) the CVaR multiplied by the weighting factor β. The factor β models the tradeoff between expected profit and CVaR .

Constraints (7) bound the power contracted from each block of the forward contracting curve of each contract. Constraints (8)-(9) identify the block of the price-quota curve associated with each selling price . Constraints (10) impose the electric energy balance in each period and scenario . Constraints (11) are used to compute the CVaR. Finally, (12) and (13) constitute variable declarations.

DATA AND SIMULATION RESULTS

According to table (1), data pertaining to two contracts of retailing in the electricity market for two time periods are shown in hours.

Table (1)- forward contracting curve data

(MW) P^F_{f2}	(MW) P^F_{f1}	λ^F_{f2} ($/MWhour)	λ^F_{f1} ($/MWhour)	*Time period*	*Contract*
20	***20***	***69.3***	***66***	***1-2***	***1***
20	***20***	***70.35***	***67***	***1-2***	***2***

In addition, the data concerning the electrical energy demand and POOL prices for different scenarios are given in Tables (2) and (3).

Table (2)- Electrical Energy Demand

Demand in Period 2 (MWhour)	*Demand in Period 1 (MWhour)*	*Scenario*
325	***350***	***1***
335	***365***	***2***
345	***375***	***3***
340	***360***	***4***

Table (3)- POOL Price

POOL price in Period 2 ($/MWhour)	*POOL price in Period 1 ($/MWhour)*	*Scenario*
52	***60***	***1***
55	***65***	***2***
68	***74***	***3***
61	***70***	***4***

In addition, the response given by the customers against the retailer's proposed prices are shown in Figure (2).

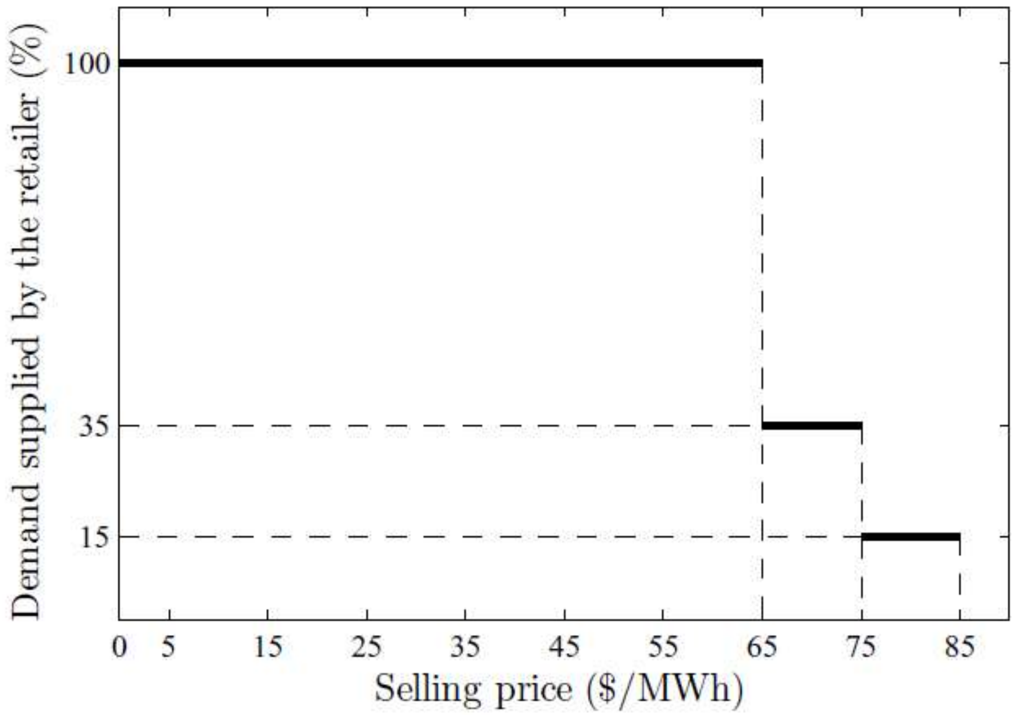

Figure (2)- Diagram of the Provided Demands of the Customers by the Retailer versus Selling Price(price-quota curve)

The results are obtained from GAMS and CPLEX[21], thus according to Figure (2), it can be said that if the selling price is less than 65 $/MWhour, the retailer will provide 100% of the customer's demand, if the selling price is between 65 to 75 $/MWhour, retailer can provide 35% of the customer's demand, similarly if the selling price is between 75 to 85 $/MWhour, the retailer can only provide 15% of the customer's demand and if the selling price is more than 85$/MWhour, the retailer cannot provide the customer's demand at all. α is considered 0.95.
Some of the simulation results including the expected profit, standard deviation of profit and CvaR are presented in Table (4) for different values of β. For β=0, maximum expected profit for the retailer and maximum risk are obtained.

Table (4)- Retailer's Expected Profit, Standard Deviation and CVar

CvaR ($)	***Standard Deviation of Profit ($)***	***Expected Profit ($)***	***β***
976.50	***1482.62***	***3017.58***	***0***
1176.50	***1229.07***	***2870.92***	***1***
1858.50	***105.30***	***2007.42***	***2***
1883.75	***28.59***	***1903.96***	***100***

According to the information of table (4) the relation between the retailer's expected profit with profit's standard deviation and CVar are shown in Figures (3) and (4) respectively.

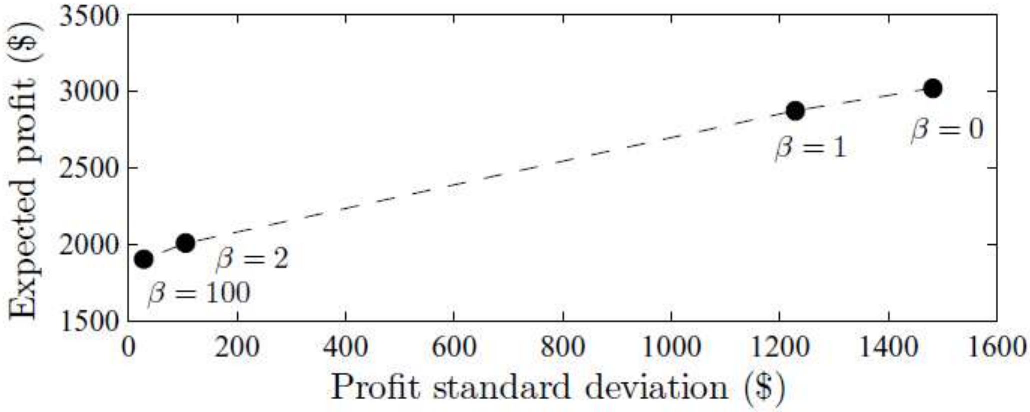

Figure (3)- Expected Profit vesus standard deivation of profit

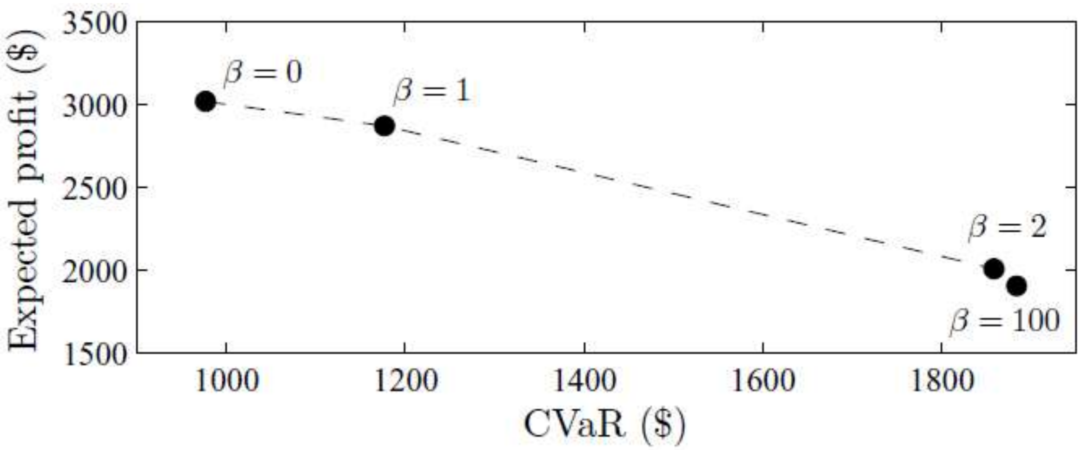

Figure (4)- Expected Profit versus CVar

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A sectional of GAMS codes Shown in this part:

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SETS
W          Scenarios /w1 * w4/
T          Periods /t1 * t2/
F          Forward contracts /f1 * f2/
E          Client groups /e1 * e1/
J          Blocks in the forward contracting curve /j1 * j2/
I          Blocks in the piece-quota curve /i1 * i3/
Ft(F,T)    Forward contracts available in period t;

Ft(F,T)=yes;

SCALARS
lambdaRmax      Maximum selling price /120/
lambdaRmin      Minimum selling price /20/
beta            Weighting factor /0/
alpha           Confidence level /0.95/;

PARAMETERS

EPC(T)          Energy previously contracted
ED(T,E,W)       Stochastic demand of the clients
ER(T,E,I,W)     Stochastic demand supplied by the retailer
d(T)            Duration in hours of every period t
prob(W)         Scenario probability;

TABLE lambdaF(F,J) Price of the forward contracting blocks
j1      j2
f1    66.00    69.30
f2    67.00    70.35;

TABLE PFmax(F,J) Upper limit of the forward contracting blocks
j1      j2
f1    20       20
f2    20       20;

TABLE k(I,E) Demand supplied in each price-quota curve block (per unit)

e1
i1        1.00
i2        0.35
i3        0.15;

TABLE lambdaRI(I,E) Price of each price-quota curve block
e1
i1         65.0
i2         75.0
i3          85.0;

TABLE lambdaP(W,T) Pool prices
t1     t2
w1      60     52
w2      65     55
w3      74     68
w4     70     61;
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CONCLUSION

This paper has proposed a model for defining a price for the participants from the retailing point of view in the electricity market. The proposed model is carried out in GAMS as an optimizing problem. Although buying from the wholesale market will be followed by significant profit for the retailer but because of high price fluctuations it is necessary that the retailer endures a high risk. This model is based on the random nature of the prices and risk. In general, by proposing this model, the retailer will convince the consumer to decrease buying from the POOL price-based electricity market. The uncertainty in POOL prices and unspecified price attraction for the consumer that the retailer faces were considered in this paper. In this paper, retailer's risk is well modeled by using CvaR. Based on the simulation results it can be concluded that by distributing the load and relocating the load by the consumer and applying demand response programs, retailer's profit increases and the cost paid by the consumer will decrease. This conclusion that the retailing competition makes the energy providers more effective in addition to create new opportunities for the active consumers can also be denied. In future researches, conducting plans with different time periods as the main approach and factor for retailer's decision making can be studied.

REFERENCES

1. A.Hatami, H.Seifi, and M.K.Sheikh-El-Eslami, “A Stochastic-Based Decision-Making Framework for an Electricity Retailer: Time-of-Use Pricing and Electricity Portfolio Optimization,” IEEE Trans. Power Syst., vol. 26, No. 4, Nov. 2011.
2. Mohammad Ali FotouhiGhazvini , Pedro Faria, Sergio Ramos, Hugo Morais, Zita Vale, “Incentive-based demand response programs designed by asset-light retail electricity providers for the day-ahead market,” Energy, p.p 1-14, 2015.
3. Yingkui Yang, “Understanding household switching behavior in the retail electricity market,” Energy Policy, vol69, p.p406-414, 2014.
4. Christophe Defeuilley, “Retail competition in electricity markets,” Energy Policy, vol37, p.p377-386, 2009.
5. MungyuBae, Hwantae Kim, Eugene Kim, Albert Yongjoon Chung, Hwangnam Kim, Jae HyungRoh, “Toward electricity retail competition: Survey and case study on technical infrastructure for advanced electricity market system,” Applied Energy, vol133,p.p252-273, 2014.
6. S.Nojavan, B.Mohammadi-Ivatloo, and K.Zare, “Optimal bidding strategy of electricity retailers using robust optimization approach considering time-of-use rate demand response programs under market price uncertainties,” IET Generation, Transmission & Distribution, Oct. 2014.
7. Jianping He, Lin Cai, , Peng Cheng and Jialu Fan, “Optimal Investment for Retail Company in Electricity Market,” IEEE Trans. Industrial Informatics, vol. 11, No. 5, Oct 2015.
8. M.Kazemi, B.Mohammadi-Ivatloo and M.Ehsan, “Risk-Constrained Strategic Bidding of GenCos Considering Demand Response,” IEEE Trans. Power Syst., vol. 30, June 2014.
9. DuyThanh Nguyen, Michael Negnevitsky and Martin de Groot, “Market-Based Demand Response Scheduling in a Deregulated Environment,” IEEE Trans. Smart Grid, vol4, No. 4, Dec2013.
10. D. Kirschen and G. Strbac, “Fundamentals of Power System Economics,”New York: Wiley, 2004.
11. Gang Li; Fengfeng Huang; T. C. Edwin Cheng and Ping Ji, “Competition Between Manufacturer's Online Customization Channel and Conventional Retailer,” IEEE Trans. Engineering Management., vol62, 2015.
12. S. Jalal Kazempour; Antonio J. Conejo and Carlos Ruiz, “ Strategic Bidding for a Large Consumer,” IEEE Trans. Power Syst., vol30, 2015.
13. Qipeng P. Zheng; Jianhui Wang and Andrew L. Liu, “Stochastic Optimization for Unit Commitment—A Review,” IEEE Trans. Powe Syst., vol30, 2015.
14. H. Heitsch and W. Römisch, “Scenario tree modeling for multistage stochastic programs,” Math. Program., vol. 118, no. 2, pp. 371–406, May 2009.
15. “Market operator of the Iberian electricity market,” OMEL, 2013 [Online]. Available: http://www.omel.es
16. “Forward and futures market operator of the Iberian electricity market,” OMIP, 2013 [Online]. Available: http://www.omip.pt
17. E. F. Bompard, G. Abrate, R. Napoli, and B.Wan, “Multi-agent models for consumer choice and retailer strategies in the competitive electricity market,” Int. J. Emerg. Elect. Power Syst., vol. 8, no. 2, Jan. 2007, art. 4.
18. J. R. Birge and F. Louveaux, Introduction to Stochastic Programming. New York: Springer-Verlag, 1997.

19. A. J. Conejo, R. García-Bertrand, M. Carrión, A. Caballero, and A. de Andrés, "Optimal involvement in futures markets of a power producer," IEEE Trans. Power Syst., vol. 23, no. 2, pp. 703–711, May 2008.
20. R. T. Rockafellar and S. Uryasev, "Conditional value-at risk for general loss distributions," J. Bank. Finan., vol. 26, no. 7, pp. 1443–1471, 2002.
21. R. E. Rosenthal, GAMS—A User's Guide, GAMS Development Corporation. Washington, DC, USA, 2008.