Proposing a Model Based on Decision Framework of Retailer for Optimizing the Profit of Retailer's Company in Electricity Market

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***Abstract*—Retailers provide electricity to those consumers that do not participate directly in the electricity markets. Retailers do not generally own production units and they purchase the electricity to be supplied to their clients through bilateral contracts, in the futures market, and in the pool.**

The objective of a retailer is to maximize the profit it obtains from selling to its customers. Its profit margin is generally narrow as it should buy as cheap as possible to provide its clients with the lowest possible prices; otherwise these clients may change retailer. Marketers play the same role as retailers but may also intermediate between producers and retailers. The retailer must cope with uncertain pool prices and client demands, as well as the possibility that clients might choose a different supplier if the selling price offered by the retailer is not sufficiently competitive.

Keywords-Electricity retailer, Electricity Market, Optimization, Decision framework, Retailer, Retailers' profit

I. INTRODUCTION

A Retail Electric Provider (REP) sells electric energy to retail customers in the areas where the sale of electricity is open to retail competition. A REP buys wholesale electricity, delivery service, and related services, prices electricity for customers, and seeks customers to buy electricity at retail . The retail side of electricity involves the final sale of power from an electricity provider to an end-use consumer. These sales range from the service for a large manufacturing facility to small businesses and to individual households.

In every state, regardless of whether they allow retail competition or not, supply for end-use customers is obtained either through the open, competitive wholesale market, from utility-owned rate-based (cost-plus) generation, or some combination of the two. The activity carried out by a retailer consists in buying energy from the electricity markets for selling it afterwards to consumers or other retailers at a fixed price. Thus, the profit gained by a retailer comes from the difference between the revenue from selling to consumers (its clients) and the cost of purchasing in the electricity markets. Retailers are also responsible for purchasing electricity in the wholesale market .

II. LITERATURE REVIEW

The restructuring of the electric sector has led to the conversion from a vertically integrated structure and Retailers have emerged as fundamental agents within this new framework[1]. For markets to work, there must be an active client (demand) side in which customers react to changing the prices [2,3]. Allowing consumers to face the underlying variability in electricity costs can promote economic efficiency that will increase reliability of the system. In [4] talked about Retailers' settlement obligations for wholesale power costs based on consumers' load-profiled consumption and some stochastic planning for retailers. In[5] the authors talk about a policy that forces all consumers to choose among electricity suppliers and products. In [6], 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. According to many researches , all retailers suffer from volatile demand and wholesale prices.

III. RETAIL COMPETITION CONCEPT

The push to deregulate generation was clearly predicated on reducing the cost of generation which accounts for nearly one half the cost of power. Wholesale competition could save a lot of money; retail competition needs a different rationale. When the costs of the electricity industry are analyzed, they are traditionally divided into three major categories: generation, transmission, and distribution-retail is not mentioned. Retail costs could be cut in half, and no one would notice as they are only a small fraction of distribution costs[7].

Generally, a retailer buys wholesale power, signs up retail customers, and sends out bills. Although an individual retailer may manage to purchase power cheaply, on average a retailer will pay the average cost of wholesale power. Also, there is no reason to believe that competition on the demand side of this market will reduce the cost on the supply side. There may be room to cut billing costs, but there are other motives at work in the push for retail competition.

retail competition can only lower wholesale costs by reducing the market power of wholesalers. But market power on the supply side of the wholesale market would normally be reduced by an increase in competition on the supply side, not by increased competition on the buyer's (retailer's) side. In fact more competition on the buyers' side means less monopsony power to counteract the monopoly power of the suppliers.

The impetus for retail competition comes primarily from two sources: those who believe they can profit by being retailers, and big commercial and industrial customers. Some of them believe they are smarter or more desirable customers and so can cut a better deal on their own[4][8].

A. Impact of Choosing a Retailer Company

Retail choice appears to have the following impacts on innovative service offerings:

1) Retail choice is extending the market penetration of dynamic pricing programs that reflect power system conditions. All other things equal, this improves the efficiency of use of power system resources, lowers the average costs of producing power, and tends to improve resource adequacy[3].

2) Retail choice promotes renewable resources. To the extent that this raises the market penetration of intermittent resources such as wind and solar, it may raise resource adequacy issues because of the non-dispatchability of such resources[1][3].

3) Retail choice has not generally promoted smart metering.

B. Impact of Retail Choosing on Customer Prices

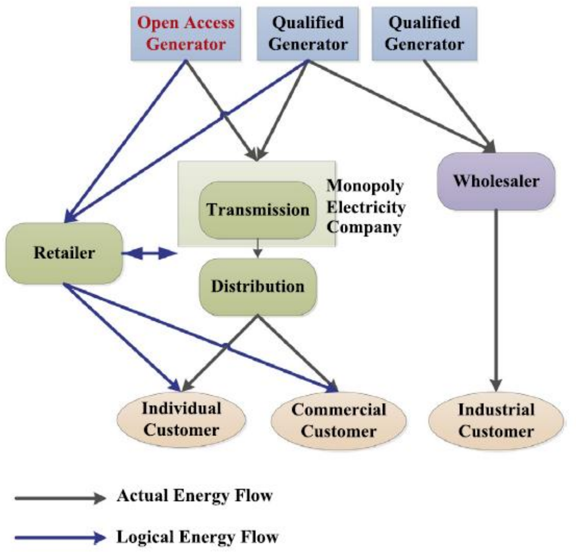
1) Retail choice states, from the beginning of retail choice up to the present, have had retail prices persistently higher than those in other states, with the price gap varying over time with changes in fuel prices and other factors[4]. The overall trend has been toward a lower price gap, though that is at least partly due to the happenstance of natural gas prices being low at the present time.

2) Retail electricity prices in retail choice states vary more immediately with current fuel prices and other market factors than do retail prices in other states, and are therefore less stable than retail prices in other states.

3) Retail electricity prices in retail choice states vary by location in a manner that mimics locational variations in wholesale electricity market prices. Abbreviations and Acronyms[8].

C. The nature of pricing between Retailer in electricity

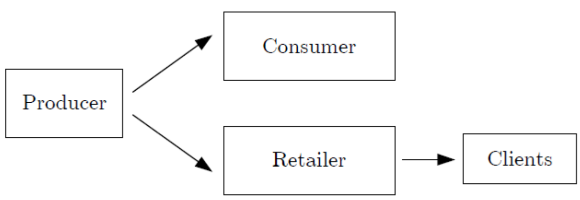
Putting aside regulatory intervention for the moment, Now, this question will be asked; what form would the introduction of retail competition be likely to take in electricity? It would be natural for such competition initially to focus mainly on price, for at least two reasons: First, for the reasons given in many researches, electricity is broadly homogeneous and the scope for adjusting the quality of the electricity itself is severely limited, at least in the short term[9-10]. Second, a key function of retail competition is to set retail prices, that is to moderate the process of price formation in the market. That process has been suppressed or distorted by government policies in all countries over the last fifty years or more. The obvious consequence of removing such government or regulatory constraints is to set the market's price formation process into action. Fig(1) shows the retail competition



Fig(1): Retail competition

It is necessary to say that, Producers sign bilateral contracts with consumers or retailers. Consumers buy energy for their own consumption, while retailers buy energy to supply their clients' demands.

Consumers deal directly with producers while retailers' clients deal with producers through their retailers. The arrows in this figure indicate the flow of energy. Fig(2) shows how bilateral contracts take place[4][8][10]:



Fig(2): Schematic of Bilateral Contracting of electricity

Before beginning the optimization problem, defining two kinds of electricity market for the conception of the problem is necessary:

IV. RESEARCH METHODOLOGY

A. Pool Market

The pool comprises a day-ahead market and several shorter-term markets known as adjustment markets. It also includes the balancing market that ensures the real-time balance between supply and demand.

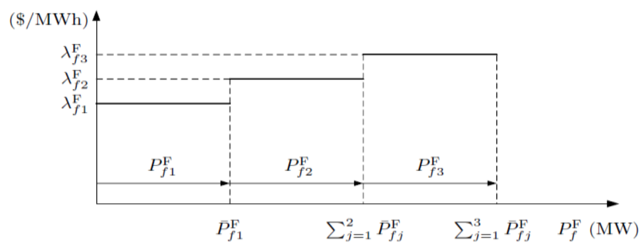
The energy traded in the pool is mostly negotiated in the day-ahead market, while adjustment markets are used to make adjustments to the energy cleared in the day-ahead market[1][5]

B. Future Market

A futures market is an auction market in which participants buy and sell physical or financial products for delivery on a specified future date. These products are called derivatives or derivative products. futures markets are useful if the price of electricity is highly uncertain in the pool, which is the case in pool-based electricity markets.

Typically, a retailer participates in the futures market to acquire part of the electricity that it sells to its clients. The main advantage of this market is that it allows the retailer to buy energy at a fixed price prior to its selling.

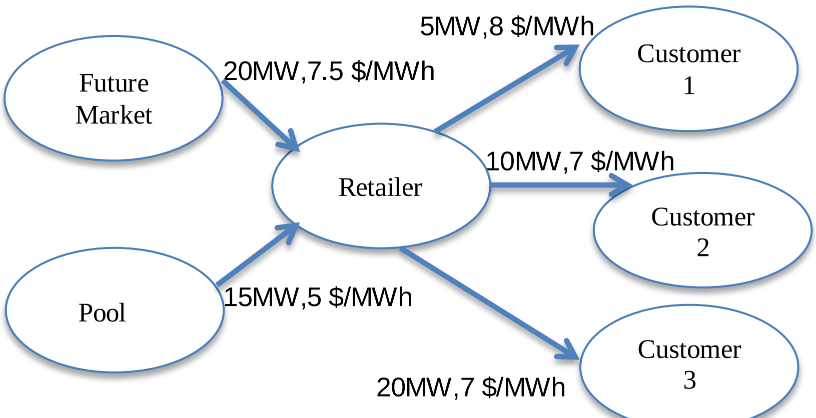
Fig (3) shows an example of a forward contracting curve with three blocks. The contract price is represented in the y-axis, while the power purchased from the contract is indicated in the x-axis. We assume that the retailer participates in the futures market only purchasing electricity. Observe that the number of blocks in the forward contracting curve should be tailored to the considered problem[3][6].



Fig(3): Forward contract buying curve

V. *MODEL FEATURE*

We consider the situation faced by a retailer described in Fig(4)



Fig(4): Retailer Problem

A. Expected Profit

The profit of the retailer is equal to the revenue obtained from selling electricity to clients minus the ne cost of trading in the pool and minus the cost of forward contracting. The final profit attained by the retailer depends on the actual realizations of the stochastic processes (pool prices and client demands). The profit in scenario ω is mathematically expressed as:

The expected profit expressed in (1) includes the revenue from selling to clients, the net cost of pool trading, and the cost of energy purchasing through forward contracts, respectively.

$$\sum_{t=1}^{N_T}\left(\sum_{e=1}^{N_E} R^R_{et\omega} - C^P_{t\omega} - C^F_t\right) = \sum_{t=1}^{N_T}\left(\sum_{e=1}^{N_E}\sum_{i=1}^{N_I}\lambda^R_{ei}\,\bar{E}^R_{eti\omega} - \lambda^P_{t\omega}E^p_{t\omega}\sum_{f\in F_t}\sum_{j=1}^{N_J}\lambda^F_{fj}P^F_{fj}d_t\right), \forall\boldsymbol{\omega}. \quad (1)$$

where:

N_T : represents the number of time periods

$R^R_{et\omega}$: Revenue obtained by the retailer from selling to client group e in period t and scenario ω ($).

C^F_t Cost of purchasing from forward contracts in period t ($).

$C^P_{t\omega}$ Cost of purchasing from the pool in period t and scenario ω ($).

λ^F_{fj} Price of block j of the forward contracting curve of forward contract f ($/MWh).

d_t Duration of period t (h).

P^F_{fj} Power contracted from block j of forward contracting curve of forward contract f (MW).

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:

$$\sum_{\boldsymbol{\omega}=1}^{\boldsymbol{N_\Omega}}\boldsymbol{\pi_\omega}\sum_{t=1}^{N_T}\left(\sum_{e=1}^{N_E} R^R_{et\omega} - C^P_{t\omega} - C^F_t\right) \quad (2)$$

By considering equation (1) & (2) and fig(3):

the retailer purchases in the futures market and the pool 20 and 15MW at prices 7.5 and $5/MWh, respectively. Likewise, the retailer sells 5, 10, and 20MW at prices 8, 7, and $7/MWh to consumers 1, 2, and 3, respectively.

The purchase cost paid by the retailer is equal to: 20MW×$7.5/MWh + 15MW×$5/MWh = $225/h.

On the other hand, the revenue obtained by the retailer is 5MW×$8/MWh + 10MW×$7/MWh + 20MW×$7/MWh = $250/h.

Therefore, the profit achieved by the retailer in this case is 250 – 225 = $25/h.

VI. Decision Framework

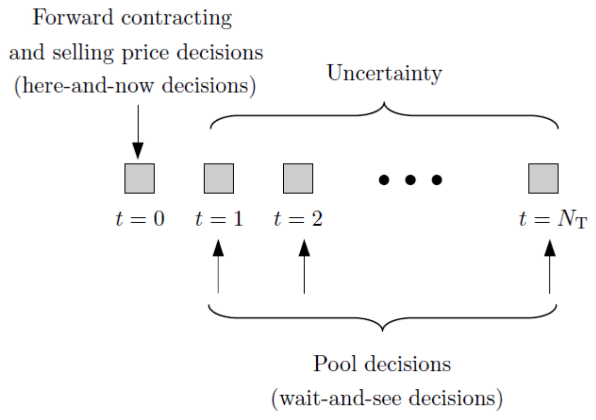
From a retailer point of view we can distinguish between medium-term and short-term decisions. The configuration of the futures market portfolio and the determination of the selling price offered to the clients are medium-term decisions, while the transactions in the pool are decided in the short-run. Medium-term decisions are made at the beginning of the planning horizon, whereas short-time decisions are made throughout it.

The main difference between these two kinds of decisions lies in the degree of uncertainty revealed at the moment of the decision making[8][11].

In order to make optimal decisions for forward contracts and selling prices a year ahead, this procedure is repeated at the beginning of each month.

The decision framework of the problem organized in this paper is illustrated in Fig (5)

The parameter N_T represents the number of time periods in the planning horizon. Note that the time periods are not necessarily hours[11].



Fig(5): Decision framework for a retailer

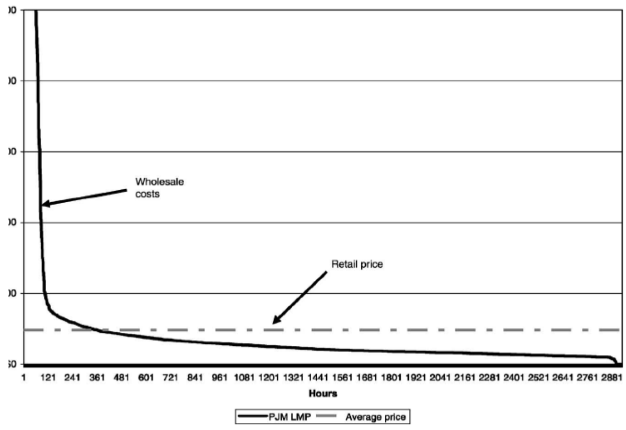
B. Two-stage decision framework

Consider a single year planning horizon. The retailer has to determine the selling price for a set of clients. Four quarterly forward contracts, each spanning one of the four quarters of the year, and an annual contract are available for the retailer in the futures market. Additionally, the retailer trades in the pool either purchasing or selling electricity[12]. The decision framework for the retailer is as follows:

1. At the beginning of the year, the retailer fixes the selling price offered to the clients and decides which quarterly and annual forward contracts to sign for the whole planning horizon[5].

2. For each realization of the pool prices of the year, the retailer decides the amount of energy to be traded each hour in the pool[2][5].

Fig(6) Shows the changing of the price for wholesale and retail market:



Fig(6)- Diagram of changing of the price for retail and wholesale market

VIII. Conclusion

This paper presents a stochastic programming model that allows an electricity retailer to determine its medium-term forward contract portfolio and to offer optimal selling prices to clients. To procure the electric energy to be sold to its clients, a retailer copes with two main challenges: while buying, it faces uncertain pool prices; while selling, it faces the uncertainty of client demand and the fact that clients may select a different retailer if selling prices are not competitive enough. The influence of the retailer on the futures market is explicitly taken into account through forward contracting curves. The proposed modeling framework is flexible enough to accommodate a variety of features characterizing both retailers and trading floors.

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