



الشركة السعودية للكهرباء  
Saudi Electricity Company  
طاقة مثمرة

**Demand S**

**Electricity**

**Markets**

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# AGENDA

- ▶ INTRODUCTION
- ▶ OBJECTIVE ( BACKGROUND OF MY M.S RESEARCH)
- ▶ PROBLEM FORMULATION
- ▶ ANALYSIS AND RESULTS
- ▶ CONCLUSION

# INTRODUCTION

- ▶ Many countries have moved from vertically integrated environment and introduce competition in their power industry
- ▶ In vertically integrated systems, electricity price is usually regulated and customers are offered pre-determined tariffs.
- ▶ In competitive electricity markets, however, ISO determine the electricity price for specific intervals taking into account various economical and operational factors

# INTRODUCTION

- ▶ In many wholesale electricity markets, the demand-side is merely treated as a forecasted load to be served under all conditions.
- ▶ Likewise, end consumers in retail markets are rarely offered time-varying prices that reflect the underlying costs of serving the system load.
- ▶ Without active demand-side participation in closing the gap between the retail and wholesale markets, generators have less incentive to sell their capacities at true cost.
- ▶ This could lead to market failures in forms of price spikes, which is ultimately endured by the end consumers

*The challenge that remains is how to incorporate these demand responses into market design to achieve the efficient market performance*

# DEFINITION OF DEMAND-SIDE PARTICIPATION

*“Demand-Side Participation, refers to the mechanism for communicating prices between wholesale and retail electricity markets, with the immediate objective of achieving load changes, especially at high wholesale price periods”*

**Braithwaite and Eakin, 2002**

*“ Variations of retail consumers’ load from normal consumption patterns in response to changing electricity prices over time, or incentives given to consumers that are designed to induce less consumption during high wholesale price periods or when the reliability of the system is put at risk”*

**Goldman et al., 2005**

# BENEFITS OF DEMAND-SIDE PARTICIPATION

- ▶ Enhances market efficiency
- ▶ Cost reduction
- ▶ Enhances system reliability
- ▶ Potential environmental improvements
- ▶ Opportunities for risk management
- ▶ Customer service and choice
- ▶ Market power mitigation

# OBJECTIVES

- ▶ Study Different options of bidding strategies for Load serving entities (LSEs).
- ▶ Develop optimal bidding strategy for LSE with risk in pool-based double sided competitive electricity market.
- ▶ Study different scenarios of the developed strategic bidding

# What is Load Serving Entity?

# Definitions:

- ▶ *Load serving entities (LSEs) provide electric service to end-users. LSEs include the competitive retailers (CRs) that sell electricity at retail price in the competitive market.*

(ERCOT)

- ▶ *A load-serving entity (LSE) secures energy and transmission service (and related interconnected operations services) to serve the electrical demand and energy requirements of its end-use customers.*

(NERC)

- ▶ *Utilities, marketers or aggregators who provide electric power to a large number of end-use customers.*

(IEP)

# STRATEGIC BIDDING IN ELECTRICITY MARKETS

- ▶ Strategic bidding is the process by which participants in a market develop bids that aimed to achieving their performance goals.
  - ISO hope to achieve cost-minimizing function .
  - Market participant hope to maximize their profits.
- ▶ The bidding problem in electricity markets is related to pool trading in which the sealed auction is widely employed and power suppliers & large consumers are required to offer price and quantity bids to a market operator.
- ▶ The market operator then determines the winning bids and a uniform market-clearing price using a simple merit order dispatch procedure. While for contracted trades such as bilateral arrangements, a negotiation process between the two parties may be necessary

# BIDDING STRATEGIES APPROACHES

- ▶ Estimation of the MCP in the next trading period
- ▶ Game Theory based.
- ▶ Estimation of bidding behavior of the rivals participants

# PROPOSED METHODOLOGY

- ▶ The research considers a pool-based double-side competitive electricity market where both generation companies and load serving entities can bid in the markets.
- ▶ Optimal bidding strategy of single LSE will be developed considering Pay-As-Bid (PAB) settlement and step-wise bidding rules.
- ▶ Competitors in the market (Genco and other LSE), they will be model based on their historical data.
- ▶ The problem of building an optimal bidding strategy will be formulated as stochastic optimization.
- ▶ Apply Monte-Carlo simulation and Genetic Algorithm optimization tool.

# MATHEMATICAL FORMULATION

- Consider a system with :
  - 3 independent Gencos
  - 4 independent LSEs
- Market participants are allowed to bid up to 3 blocks in single time period.
- The bidding of LSE in single time period is as follows :
  - block quantity  $\Phi_{d,x}^j$  which equals the forecasted load at each period,
  - block price  $\phi_{d,x}^j$

Where  $j=1, 2, \dots$  and  $I_d$  represent the type of load.

## ► Profit of LSE:

Profit = Revenue - Cost

$$\pi = \underbrace{\alpha(\bar{\Phi}_{d,X})^T - \beta(\Phi_{d,X} - \bar{\Phi}_{d,X})^T}_{\text{Revenue}} - \underbrace{\varphi_{d,X}(\bar{\Phi}_{d,X})^T - f(\bar{P}_{DX})}_{\text{Cost}}$$

Where:

- $\alpha$  is the retail prices to end-consumers
- $\beta$  is the expense of the interrupted power to end consumers

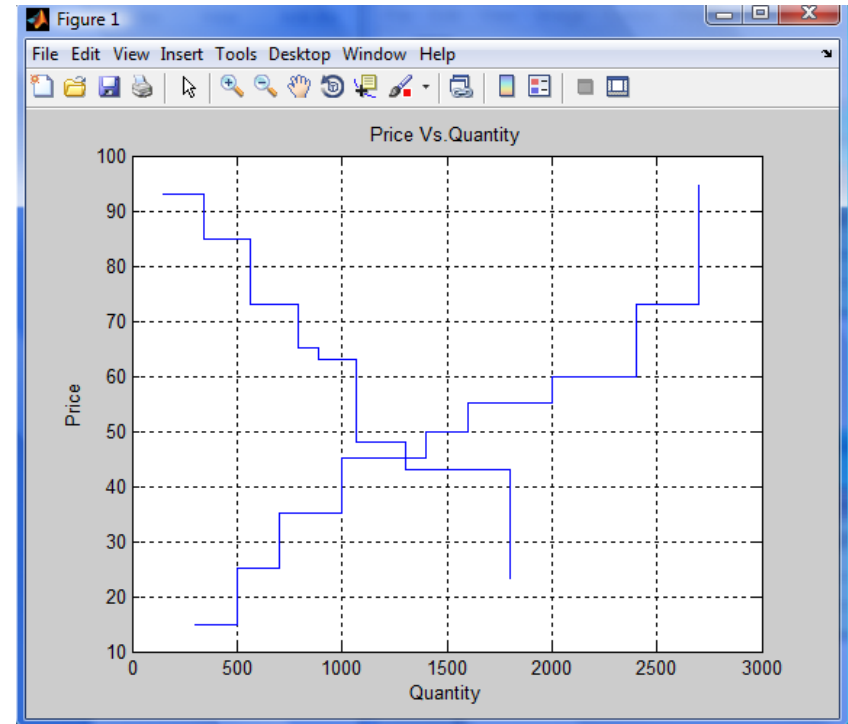
# Bidding Data For Rivals & Market Clearing Process

Parameter of GenCos Bidding

Genco	Block 1		Block 2		Block 3		Variance	
	$\mu(\text{qty})$	$\mu(\text{prc})$	$\mu(\text{qty})$	$\mu(\text{prc})$	$\mu(\text{qty})$	$\mu(\text{prc})$	$\sigma(\text{qty})$	$\sigma(\text{prc})$
1	300	15	200	35	400	50	5.5	2.5
2	200	25	300	45	400	60	5.5	2.5
3	200	55	400	73	300	95	5.5	2.5

Parameter of LSEs' Bidding

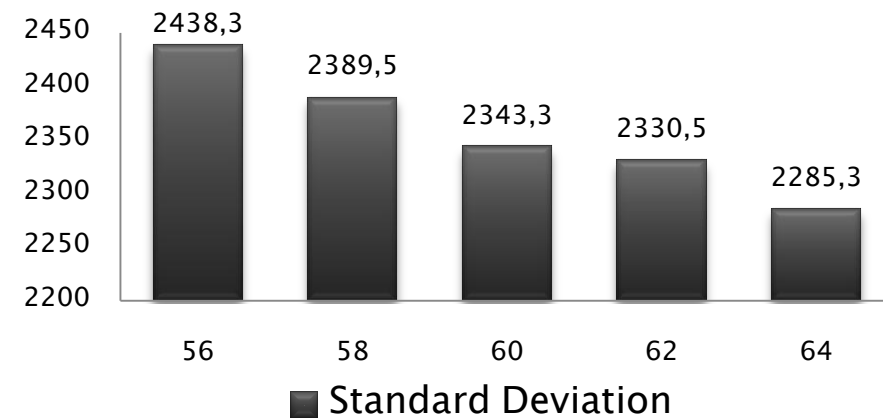
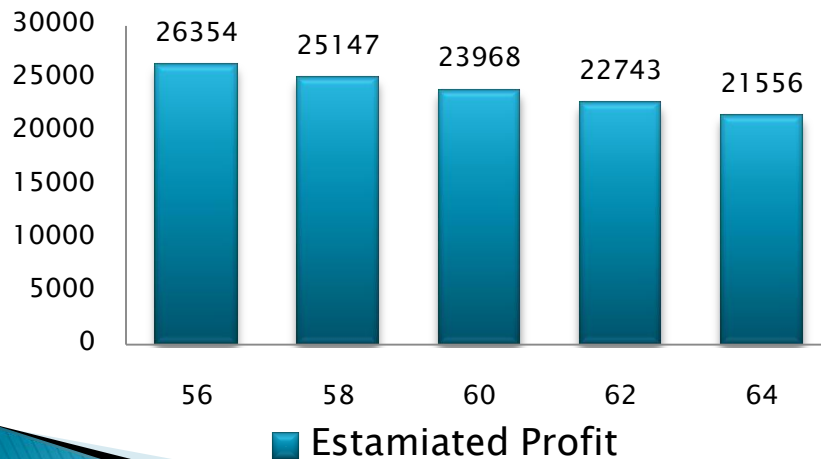
LSE	Block 1		Block 2		Block 3		Variance	
	$\mu(\text{qty})$	$\mu(\text{prc})$	$\mu(\text{qty})$	$\mu(\text{prc})$	$\mu(\text{qty})$	$\mu(\text{prc})$	$\sigma(\text{qty})$	$\sigma(\text{prc})$
1	100	63	300	43	200	23	5.5	2.5
2	190	85	230	65	180	48	5.5	2.5
3	150	93	220	73	230	43	5.5	2.5



# The impact of different bidding strategies on expectation profit and standard deviation

Bidding Price	Quantity	$\hat{E}(\pi)$	$D(\pi)$	KED
56	600	26354	2438.3	0.092521
58	600	25147	2389.5	0.095021
60	600	23968	2343.1	0.097768
62	600	22743	2330.8	0.102471
64	600	21556	2285.9	0.106017

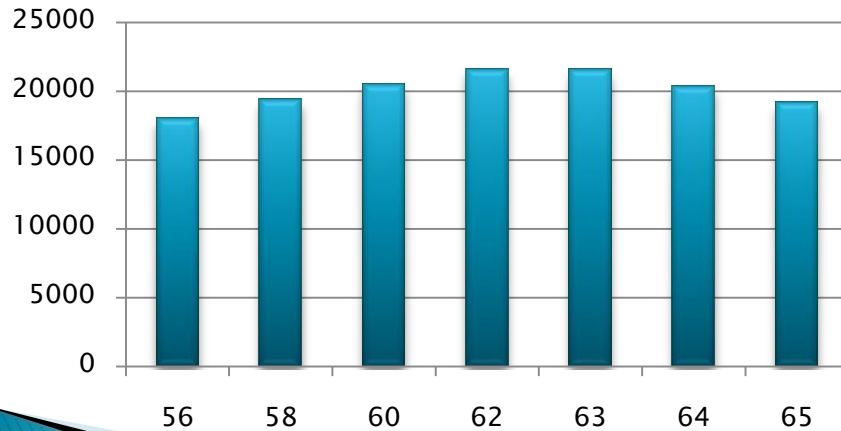
MCP	
Price	54.993\$
Quantity	1600 MW



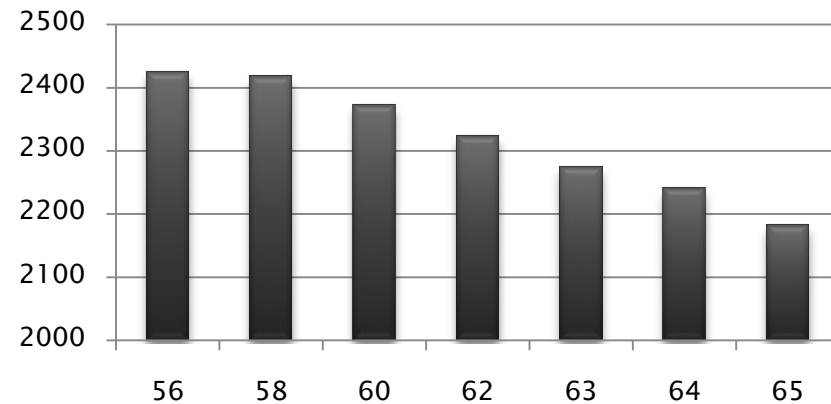
# The impact of different bidding participation of LSE X into the pool-market

MP					
Price	Quantity	Bidding Price	Quantity	$\hat{E}(\pi)$	$D(\pi)$
54.987	1600	56	530	17992	2424.7
55.169	1600	58	550	19357	2417.8
54.993	1600	60	570	20495	2372.3
55.231	1600	62	590	21555	2323.8
54.876	1600	63	600	21602	2273.9
55.45	1600	64	600	20355	2240.2
55.071	1600	65	600	19160	2181.9

$\hat{E}(\pi)$



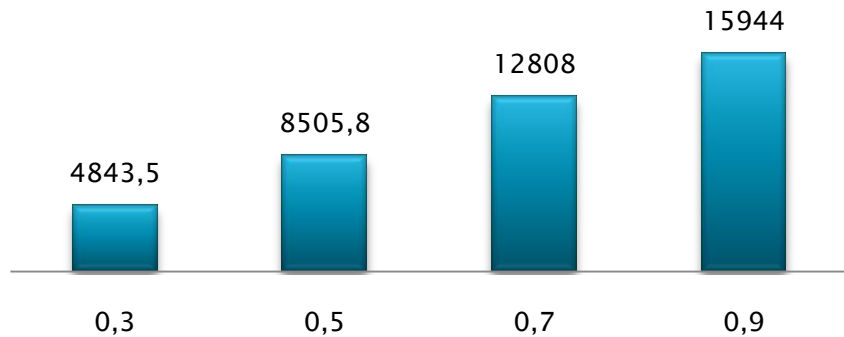
$D(\pi)$



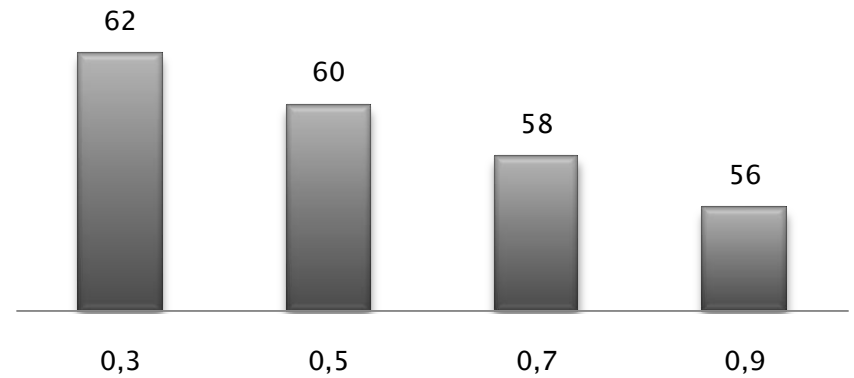
# The impact of different weighting factor on bidding strategies

	Bidding Blocks		Monte-Carlo simulation			
$\omega$	Quantity	Price	$\hat{E}(\pi)$	$D(\pi)$	$\psi$	KED
0.3	590	62	21604	2340.9	4843.5	0.108355
0.5	560	60	19355	2343	8505.8	0.121054
0.7	550	58	19327	2403	12808	0.124334
0.9	530	56	17988	2450	15944	0.136202

■ net profit vs. Risk

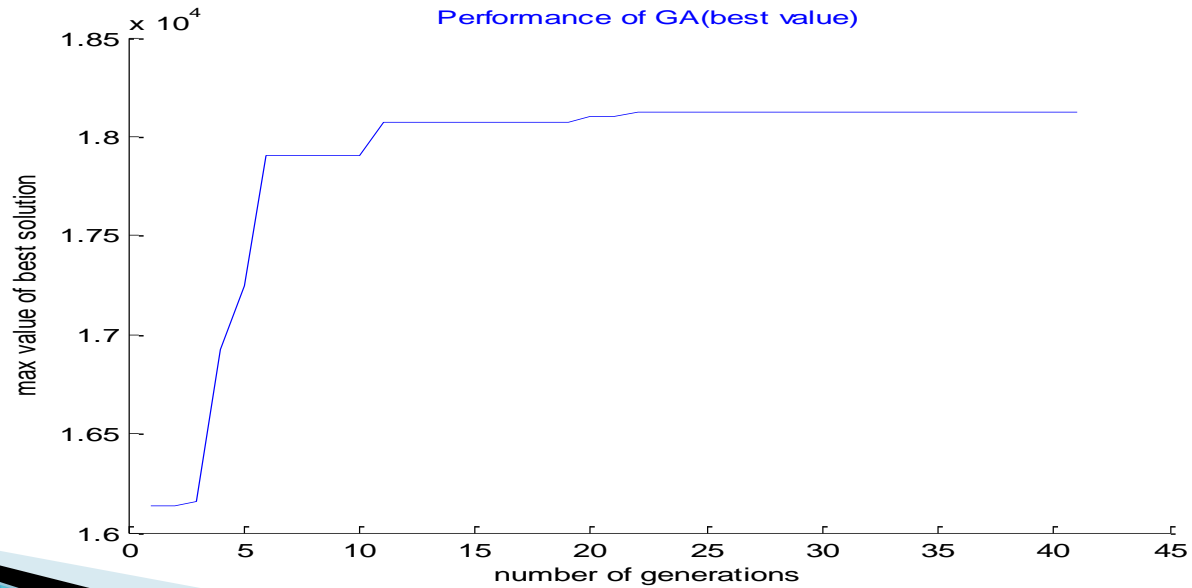


■ bidding vs. Risk



# Optimal Bidding for LSE

Optimal Bidding strategy by GA	
$\omega$	0.85817
Bidding Price	56.477
$E(\pi)$	20479
$D(\pi)$	2441
$\psi$	<b>17228</b>





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**THANK YOU**