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Optimal Bidding Strategies of GENCOs in Day-Ahead Energy and Spinning Reserve Markets Based on Hybrid GA-Heuristic Optimization Algorithm

Momammad Esmaeil Nazari*, Morteza Mohammadi Ardehali

Energy System Laboratory, Center of Excellence on Power Systems, Department of Electrical Engineering, Amirkabir University of Technology, Tehran, Iran. menazari@aut.ac.ir, ardehali@aut.ac.ir

Abstract

In an electricity market, every generation company (GENCO) attempts to maximize profit according to other participants bidding behaviors and power systems operating conditions. The goal of this study is to examine the optimal bidding strategy problem for GENCOs in energy and spinning reserve markets based on a hybrid GA-heuristic optimization algorithm. The heuristic optimization algorithm used in this study is successfully applied for validation and, it is determined that the heuristic optimization algorithm improves profits of a GENCO by 4.15-47.95% and 20.84-31.30% in single-sided and double-sided auctions, respectively.

Keywords: Bidding strategy, Energy market, Genetic algorithm, Heuristic optimization, Spinning reserve market
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1. Introduction

Electricity has evolved into a distributed commodity and, in an electricity market for energy and spinning reserve, generation companies (GENCOs) attempt to maximize their own profits according to other participants bidding behaviors and power systems operating conditions [1]. There are numerous studies on the optimal bidding strategy problem, as outlined next.

A new bidding strategy formulation for day-ahead energy and spinning reserve markets based on evolutionary programming is developed and examined by Attaviriyanupap et al. [1], where the bidding parameters are initialized randomly and selection and competition techniques are used to update the bidding parameters. However, in that study, the suggested evolutionary programming (EP) and sequential quadratic programming (SQP) arrive at maximum profits in more than 2000 iterations.

The optimization of the bidding strategy problem is examined using genetic algorithm (GA) by Wen and David [2], where two different bidding schemes have been suggested for each hour, and bidding strategy in the day-ahead energy and spinning reserve markets is developed.

Optimal bidding strategy with considerations for market power and transmission constraints is examined based on GA by Badri [3, 4], where a mixed integer linear programming is employed to solve the optimal bidding strategy problem.

Li and Shahidehpour examine a transmission constrained bidding strategy of GENCOs using the primal-dual interior point method (PDIPM), where the proposed methodology employs the supply function equilibrium for modeling a GENCO bidding strategy [5].

Bidding strategy of thermal generation units (TGUs) in competitive electricity market with consideration for their reliability is studied by Soleymani et al., where general algebraic modeling system (GAMS) is used to solve the bidding strategy problem for a six-bus network [6]. In another study, Soleymani uses particle swarm optimization (PSO) and simulated annealing (SA) to optimize the bidding strategy problem for an IEEE thirty nine-bus network [7].

Optimal bidding strategy in oligopoly markets considering bilateral contracts and transmission constraints is discussed by Badri et al., where PDIPM is used [8].

Similar studies for solving the optimal bidding strategy problem with considerations for transmission constraints are presented by Refs. [9, 10], where the models are implemented in GAMS.

Based on literature review, all relevant studies solve the transmission-constrained bidding strategy problem of GENCOs participating in energy market without considerations for spinning reserve market.

The goal of this study is to examine the optimal bidding strategy problem for GENCOs in energy and spinning reserve markets based on a hybrid GA-heuristic optimization algorithm. Accordingly, the novelty of this study includes development of a newly heuristic optimization algorithm to solve bidding strategy problem and the simulation results are compared with EP and SQP methods used by Ref. [1].

The remainder of this study is presented as follows. Section II formulates the optimal bidding strategy problem and Section III explains the development of the proposed heuristic optimization algorithm. . In Section IV, the proposed optimization algorithm is applied and the simulation results are analyzed. Finally, in Section V, conclusion remarks along with recommendations are given.

2. Problem Formulation

In this section, the problem formulation for bidding strategy is presented. It is noted that all variables and parameters are defined in Ref. [14].

A) *Day-ahead energy market*

Suppose a GENCO has *N* TGUs with second-order generation cost functions as

$$f(P(i,t)) = a_i P^2(i,t) + b_i P(i,t) + c_i \tag{1}$$

The *MCP* is determined by the derivative of cost function

$$\partial f(P(i,t))/\partial P(i,t) = \rho(i,t) = 2a_i P(i,t) + b_i \tag{2}$$

where $\rho(i,t)$ is an initial bidding point of TGU i^{th} owner.

In this study, non-negative parameters (α_{jt}, β_{jt}) are used by GENCO jth at hour t and, the bidding price is

$$\rho_{jt} = \alpha_{jt} + \beta_{jt} TP_{jt} \tag{3}$$

As the profit of TGU i^{th} in energy market is

$$PF(i,t) = \rho_{jt} P(i,t) - f\left(P(i,t)\right) = -a_i P^2(i,t) + \left(\rho_{jt} - b_i\right) P(i,t) - c_i \tag{4}$$

and to achieve positive profit of TGU i^{th}

$$\rho_{jt} > b_i. \tag{5}$$

B) *Single-sided auction*

Under the single-sided auction scheme, only GENCOs are allowed to bid. Next, MCP_t and TP_{jt} are calculated for N_s GENCOs

$$MCP_t = \alpha_{jt} + \beta_{jt} TP_{jt} \quad j = 1,...,N_s \tag{6}$$

$$PD_t = \sum_{j=1}^{N_s} TP_{jt} \tag{7}$$

then,

$$MCP_t = \left(\sum_{j=1}^{N_s} \alpha_{jt} / \beta_{jt} + PD_t \right) / \sum_{j=1}^{N_s} 1/\beta_{jt} \tag{8}$$

$$TP_{jt} = \left(MCP_t - \alpha_{jt} \right) / \beta_{jt} \tag{9}$$

$$TP_{j\min} \le TP_{jt} \le TP_{j\max} \tag{10}$$

If $TP_{jt} < TP_{j\min}$, then $TP_{jt} = 0$ and the relevant GENCO is removed from the problem as a non-competitive participant for that hour. Also, if $TP_{jt} > TP_{j\max}$, $TP_{jt} = TP_{j\max}$.

C) *Double-sided auction*

When large consumers are permitted to bid in the energy market, a double-sided auction is used and, large consumers are required to submit a monotonically decreasing bid curve ($\phi_{kt} - \varphi_{kt} TL_{kt}$) to the ISO [1]. As in single-sided auction, MCP_t and TP_{jt} are calculated as

$$MCP_t = \left(\sum_{j=1}^{N_s} \alpha_{jt} / \beta_{jt} + \sum_{k=1}^{N_c} \phi_{kt} / \varphi_{kt} + PD_t \right). / \left(\sum_{j=1}^{N_s} 1/\beta_{jt} + \sum_{k=1}^{N_c} 1/\varphi_{kt} \right) \tag{11}$$

$$TL_{kt} = \left(\phi_{kt} - MCP_t \right) / \varphi_{kt} \tag{12}$$

$$TL_{k\min} \le TL_{kt} \le TL_{k\max} \tag{13}$$

Similar to the single-sided auction, if $TL_{kt} < TL_{k\min}$, then $TL_{kt} = 0$ and the relevant consumer is removed from the problem as a non-competitive participant for that hour. Also, if $TL_{kt} \ge TL_{k\max}$, $TL_{kt} = TL_{k\max}$.

D) *Spinning reserve auction*

The spinning reserve is categorized in ancillary services. In this study, it is assumed that there are separate auctions for spinning reserve for GENCOs to participate in and, the successful bidders are paid a capacity reservation payment.

In this section, spinning reserve bidding strategy is modeled with and without considerations for uncertainty.

Non-negative parameters (γ_{jt}, η_{jt}) are bid for spinning reserve by a GENCO jth at hour t and, therefore, the bidding price of GENCO jth for spinning reserve is

$$\rho_{jt}^{r} = \gamma_{jt} + re\eta_{jt} \quad (14)$$

As a single purchaser, the ISO selects spinning reserve bids from GENCOs with the objective of minimizing cost. Therefore, the ISO must consider energy and spinning reserve and then selects the lowest cost spinning reserve providers based on this information. Therefore, the objective function of ISO is given by

$$\min \sum_{j=1}^{N_s} RP_t TR_{jt} \quad (15)$$

subject to

$$\sum_{j=1}^{N_s} TR_{jt} \geq R(t) \quad (16)$$

$$TR_{jt} \leq TR_{j\max} \quad (17)$$

$$TR_{j\max} = \sum_{i=1}^{N} I(i,t) P_{\max}(i) - TP_{jt} \quad (18)$$

The spinning reserve price is then equal to the highest $(\gamma_j + re\eta_j)$ of the successful bidders.

E) *Objective function of GENCO*

The bidding parameters for every GENCO are selected to maximize its profit based on the forecasted demand. In energy and spinning reserve markets, a series of 24 auctions is conducted and cleared simultaneously and separately. Price-based unit commitment (PBUC) problem must be solved for GENCO to reach maximum profit along with determination of α_{jt}, β_{jt}, γ_{jt}, η_{jt}. The objective function for PBUC problem is

$$\max \{ PF = RV - TC \} \quad (19)$$

$$RV = \sum_{t=1}^{T} MCP_t TP_{jt} + RP_t TR_{jt} \quad (20)$$

$$TC = \sum_{t=1}^{T} \sum_{i=1}^{N} (1 - re(t)) f\left(P(i,t)\right) \quad (21)$$

$$+ re(t) \left(f\left(P(i,t) + R(i,t)\right)\right)$$

$$+ SU(i,t) I(i,t) \left(1 - I(i,t-1)\right)$$

and

$$SU(i,t) \quad (22)$$

$$= \begin{cases} HSC(i) & T^{off}(i,t) \leq CST(i) + MDT(i) \\ CSC(\mathrm{i}) & T^{off}(i,t) > CST(i) + MDT(i) \end{cases}$$

$$I(i,0) = IS(i) \quad (23)$$

Note that $IS(i) > 0$ if TGU i^{th} has been on before first time period and $IS(i) < 0$ if TGU i^{th} has been off before first time period.

The following constraints must be met by GENCO j^{th}

$$\sum_{i=1}^{N} P(i,t) = TP_{jt} \quad (24)$$

$$P_{\min}(i) I(i,t) \leq P(i,t) \leq P_{\max}(i) \quad (25)$$

$$\sum_{i=1}^{N} R(i,t) = TR_{jt} \quad (26)$$

$$T^{on}(i,t) \geq MUT(i) \quad (27)$$

$$T^{off}(i,t) \geq MDT(i) \quad (28)$$

3. Optimization Methodology

In this section, the novel heuristic optimization algorithm developed for optimal bidding strategy is presented

A) Single-sided auctions

The procedure of optimal bidding strategy under single-sided auction is

1. The initial bidding parameters of GENCO must be determined while the revenue is maximized. It means that GENCO jth attempts to maximize its TP at maximum possible MCP.

$$\max \{ MCP_t TP_{1t} \} \quad (29)$$

$$MCP_t = \left(\sum_{j=1}^{Ns} \alpha_{jt} / \beta_{jt} + PD_t \right) / \sum_{j=1}^{Ns} 1/\beta_{jt} \quad (30)$$

$$= \left(\alpha_{1t} + A_t \beta_{1t} \right) / \left(1 + B_t \beta_{1t} \right)$$

$$TP_{1t} = \left(MCP_t - \alpha_{1t} \right) / \beta_{1t} \quad (31)$$

$$= \left(A_t - \alpha_{1t} B_t \right) / \left(1 + B_t \beta_{1t} \right)$$

where

$$A_t = \sum_{j=2}^{Ns} \alpha_{jt} / \beta_{jt} + PD_t \quad (32)$$

$$B_t = \sum_{j=2}^{Ns} 1/\beta_{jt} \quad (33)$$

To find α_{1t}, β_{1t}, the GA is used, where initial population=20 and crossover rate is at 80% and, convergence is reached when fitness function (FF) tolerance is lower than 10^{-6}.

2. After determining α_{1t}, β_{1t}, other parameters such as $TP_{1t}, TP_{2t}, TP_{3t}$, and MCP_t are calculated based on Eqs. (30) and (31).

3. The PBUC problem of GENCO with considerations for calculated MCP_t and TP_{1t} is solved using the heuristic optimization algorithm developed in [11-13].

In this step, $RP(t)$ is set as maximum possible value,

$$RP(t) = \max\{(\gamma_2 + re\eta_2),(\gamma_3 + re\eta_3)\} \quad (34)$$

then $P(i,t)$ and $R(i,t)$ is calculated. Also, TR_{1t} is calculated by

$$TR_{1t} = \sum_{i=1}^{N} P_{\max}(i)I(i,t) - \sum_{i=1}^{N} P(i,t)I(i,t) \quad (35)$$

(a) If

$$TR_{1t} = R(t) \quad (36)$$

it is necessary for GENCO to bid lower γ_1 and η_1 as compared with other GENCOs to overcome in spinning reserve auction as $R(t)$. So, $R(t)$ is only awarded to GENCO and therefore $RP(t)$ equals to spinning reserve bidding price of GENCO

$$RP(t) = \gamma_1 + re(t)\eta_1 \quad (37)$$

(b) If

$$0 < TR_{1t} \le R(t) \quad (38)$$

it is necessary for GENCO to bid lower γ_1 and η_1 as compared with other GENCOs to overcome in spinning reserve auction as TR_{1t}. So, another GENCO with higher spinning reserve bidding price than GENCO wins $R(t) - TR_{1t}$ and $RP(t)$ equals to

$$RP(t) = \min\{(\gamma_2 + re(t)\eta_2),(\gamma_3 + re(t)\eta_3)\} \quad (39)$$

(c) If

$$TR_{1t} = 0 \quad (40)$$

therefore, it is necessary for GENCO to bid higher γ_1 and η_1 as compared with other GENCOs. The spinning reserve price is then equal to

$$RP(t) = \min\{(\gamma_2 + re(t)\eta_2),(\gamma_3 + re(t)\eta_3)\} \quad (41)$$

4. Due to shutting down some TGUs in step 3, TP_{1t} will reduce to TP_{1t-new}. So, following optimization problem is solved using GA to find new α_{1t}, β_{1t}

$$\max\{MCP_t = (\alpha_{1t} + A_t\beta_{1t})/(1 + B_t\beta_{1t})\} \quad (42)$$

subject to

$$TP_{1t} = (A_t - \alpha_{1t}B_t)/(1 + B_t\beta_{1t}) = TP_{1t-new} \quad (43)$$

After determining α_{1t}, β_{1t}, other parameters such as $TP_{1t}, TP_{2t}, TP_{3t}$, and MCP_t are calculated.

5. Steps 3 and 4 are repeated until the bidding strategy of GENCO is not changed. Then, profit of GENCO is calculated and other parameters of other GENCOs are determined.

B) Double-sided auctions

The procedure of optimal bidding strategy for double-sided auction is similar to single-sided auction, however,

$$A_t = \sum_{j=2}^{Ns} \alpha_{jt} / \beta_{jt} + PD_t + \sum_{m=1}^{Nc} \phi_{mt} / \varphi_{mt} \quad (44)$$

$$B_t = \sum_{j=2}^{Ns} 1/\beta_{jt} + \sum_{m=1}^{Nc} 1/\varphi_{mt} \quad (45)$$

4. Simulation Results

The optimal bidding strategy problem for various power systems is solved to verify the efficiency of the heuristic optimization algorithm developed in this study and, the simulation results are presented in this section.

It is noted that to achieve positive profit of TGU i^{th}, MCP_t must be greater than b_i. Then $\alpha_{1t} \ge 16$ and $\beta_{1t} \ge 0.01$ for GENCO.

In this case, the simulation results of bidding strategy of GENCO are presented. It is assumed that GENCO has 10 TGUs [1] to participate in the energy and spinning reserve auctions with two other GENCOs in a single-sided auction and also with two other large consumers in a double-sided auction. The probability that the spinning reserve is called in real time is set at 5%. To maintain the power system reliability, adequate spinning reserve is required and, in this study, the spinning reserve is 10% of the power systems demands [1]. All required data for GENCOs and power system studied is available in [1].

A) Single-sided auctions

In Table I, initial TGUs output powers and corresponding profits of GENCO are shown. It is observed that, some profits are negative (highlighted cells) and the committed TGUs with negative profit must be off. Then, final TGUs output powers of GENCO are shown in Table II.

Also, bidding parameters of GENCO, energy and spinning reserve market prices, and power awarded to GENCO are shown in Table III. Comparison of profits for GENCO and improvements achieved by the heuristic optimization algorithm of this study are given in Table IV, where it is shown that profit is improved by 4.15-47.95% in single-sided auction mode, as compared with those reported by Ref. [1].

B) Double-sided auctions

In this case, two large consumers participate in the energy market. Comparison of profits for GENCO and improvements achieved by the heuristic optimization algorithm of this study are given in Table IV, where it is shown that profit is improved by 20.84-31.30% in double-sided auction mode, as compared with those reported by Ref. [1].

Also, bidding parameters of GENCO, energy and spinning reserve market prices, and power awarded to GENCO are shown in Table V.

5. Conclusion

In this study, a heuristic optimization algorithm for solving the optimal bidding strategy problem for GENCOs in energy and spinning reserve markets is developed. By definition of a new *FF* based on a deterministic approach, the proposed heuristic optimization algorithm arrives at higher economic profit for GENCO, as compared with those found in the literature. The heuristic optimization algorithm is successfully examined for optimal bidding strategy problem in energy and spinning reserve markets. For future works, renewable energy resources could be added to optimal bidding strategy problem.

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Table.1.
Initial TGUs output powers and corresponding profits of GENCO in single-sided auction

hr	***TGU***																			
	Output power (MW)										***Profit ($)***									
	1	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
1	413	0	0	0	0	0	0	0	0	0	544	0	0	0	0	0	0	0	0	0
2	431	0	0	0	0	0	0	0	0	0	684	0	0	0	0	0	0	0	0	0
3	392	0	0	0	0	0	0	0	0	0	385	0	0	0	0	0	0	0	0	0
4	447	150	0	0	0	0	0	0	0	0	1487	-271	0	0	0	0	0	0	0	0
5	455	224	0	0	0	0	0	0	0	0	1901	252	0	0	0	0	0	0	0	0
6	455	221	0	0	0	0	0	0	0	0	1890	230	0	0	0	0	0	0	0	0
7	455	287	0	0	0	0	0	0	0	0	2187	770	0	0	0	0	0	0	0	0
8	455	449	0	0	25	0	0	0	0	0	3039	2570	0	0	-313	0	0	0	0	0
9	455	455	0	0	48	0	0	0	0	0	3169	2747	0	0	-177	0	0	0	0	0
10	455	455	0	130	146	0	0	0	0	0	4209	3787	0	761	656	0	0	0	0	0
11	455	455	130	130	155	20	0	0	0	0	4932	4510	936	967	965	-229	0	0	0	0
12	455	455	130	130	156	20	0	0	0	0	4938	4516	938	969	975	-229	0	0	0	0
13	455	455	130	130	162	80	0	0	0	0	5239	4818	1024	1055	1134	771		0	0	0
14	455	455	130	130	116	0	0	0	0	0	4662	4240	859	890	558	0	0	0	0	0
15	455	455	130	130	54	0	0	0	0	0	4382	3960	779	810	-1	0	0	0	0	0
16	455	455	130	130	162	0	83	0	0	0	5249	4828	1027	1058	1137	0	1328	0	0	0
17	455	455	130	130	162	80	85	55	55	49	6349	5927	1341	1372	1529	408	-76	-307	-381	-440
18	455	455	130	130	162	80	85	55	55	55	6823	6401	1476	1508	1698	492	13	-250	-323	-356
19	455	455	130	130	162	80	85	55	55	55	7491	7070	1667	1699	1936	609	137	-169	-243	-275
20	455	455	130	130	162	80	85	55	55	55	6626	6204	1420	1451	1628	457	-24	-274	-347	-379
21	455	455	130	130	162	80	36	55	0	0	5649	5227	1141	1172	1280	285	-363	-392	0	0
22	455	455	130	130	87	0	0	0	0	0	4533	4112	822	853	292	0	0	0	0	0
23	455	321	0	0	0	0	0	0	0	0	2341	1082	0	0	0	0	0	0	0	0
24	455	181	0	0	0	0	0	0	0	0	1706	-58	0	0	0	0	0	0	0	0

Table.2.
Final TGUs output powers of GENCO in single-sided auction

hr	***TGUs output power (MW)***									
	1	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
1	263	150	0	0	0	0	0	0	0	0
2	281	150	0	0	0	0	0	0	0	0
3	242	150	0	0	0	0	0	0	0	0
4	297	150	0	0	0	0	0	0	0	0
5	455	224	0	0	0	0	0	0	0	0
6	455	221	0	0	0	0	0	0	0	0
7	455	287	0	0	0	0	0	0	0	0
8	455	449	0	0	0	0	0	0	0	0
9	455	455	0	0	0	0	0	0	0	0
10	455	455	0	130	146	0	0	0	0	0
11	455	455	130	130	155	0	0	0	0	0
12	455	455	130	130	156	0	0	0	0	0
13	455	455	130	130	162	0	0	0	0	0
14	455	455	130	130	116	0	0	0	0	0
15	455	455	130	105	25	0	0	0	0	0
16	455	455	130	130	162	58	0	0	0	0
17	455	455	130	130	162	80	0	0	0	0
18	455	455	130	130	162	80	0	0	0	0
19	455	455	130	130	162	80	0	0	0	0
20	455	455	130	130	162	80	0	0	0	0
21	455	455	130	130	162	80	0	0	0	0
22	455	455	130	130	87	0	0	0	0	0
23	455	321	0	0	0	0	0	0	0	0
24	455	0	0	0	0	0	0	0	0	0

Table.3.
Bidding parameters of GENCO, energy and spinning reserve market prices, and power awarded to GENCO in single-sided auction

hr	α (\$/MWh)	β (\$/(MWh)^2)	γ (\$/MWh)	η (\$/MWh)	*MCP* (\$/MWh)	*RP* (\$/MWh)	TP_1 (MW)	TR_1 (MW)
1	16.00	0.0100	1.31	89	20.13	5.76	413	81
2	16.00	0.0100	1.89	93	20.30	6.54	430	79
3	16.00	0.0100	2.87	93	19.91	7.52	391	71
4	16.00	0.0170	2.87	81	23.62	6.92	448	100
5	16.00	0.0100	2.78	93	22.78	7.43	678	112
6	16.00	0.0100	1.99	87	22.76	6.34	676	114
7	16.00	0.0100	3.65	87	23.41	8.00	741	128
8	16.00	0.0105	4.78	79	25.50	10.00	905	6
9	16.00	0.0110	5.65	79	26.00	10.00	909	0
10	16.00	0.0100	5.89	73	27.86	9.70	1186	16
11	16.00	0.0103	6.53	69	29.64	10.29	1324	7
12	16.00	0.0103	7.29	83	29.65	11.70	1325	6
13	16.00	0.0111	7.29	79	30.81	11.70	1334	0
14	16.00	0.0100	7.99	65	28.85	11.60	1285	46
15	16.00	0.0108	7.19	65	28.65	10.70	1172	152
16	16.00	0.0103	8.39	59	30.33	11.94	1391	22
17	16.00	0.0130	8.99	65	34.39	12.40	1415	0
18	16.00	0.0141	8.99	65	35.94	12.70	1414	0
19	16.00	0.0160	8.99	65	38.57	13.60	1411	0
20	16.00	0.0137	9.67	67	35.33	14.03	1411	0
21	16.00	0.0110	7.89	69	31.58	11.65	1416	0
22	16.00	0.0100	6.63	73	28.57	10.70	1257	75
23	16.00	0.0100	5.09	79	23.75	9.04	775	132
24	16.00	0.0188	4.44	79	24.57	9.10	456	0

Table.4.
Comparison of profits for GENCO and improvements achieved by the heuristic optimization algorithm of this study as compared with those from Ref. [1]

Auction	***Profit***				
	This study ($)	***EP [1] ($)***	***Improvements (%)***	***SQP [1] ($)***	***Improvements (%)***
Single-sided	226,330	217,317	4.15	152,976	47.95
Double-sided	374,110	309,597	20.84	284,922	31.30

Table.5.
Bidding parameters of GENCO , energy and spinning reserve market prices, and power awarded to GENCO in double-sided auction

hr	α ($/MWh)	β ($/(MWh)^2)	γ ($/MWh)	η ($/MWh)	*MCP* ($/MWh)	*RP* ($/MWh)	TP_1 (MW)	TR_1 (MW)
1	16.000	0.010	1.31	89	23.51	5.76	751	81
2	16.000	0.010	1.89	93	23.76	6.54	776	79
3	16.000	0.010	2.87	93	23.91	7.52	791	71
4	16.000	0.010	2.87	81	25.44	6.92	906	4
5	16.000	0.010	2.78	93	26.34	7.79	1034	38
6	16.000	0.010	1.99	87	26.29	7.80	1029	43
7	16.000	0.010	3.65	87	26.64	9.30	1064	7
8	16.000	0.010	4.78	79	28.42	10.00	1242	89
9	16.001	0.011	5.65	79	31.42	10.00	1412	0
10	33.590	0.012	5.89	73	33.59	9.70	1412	0
11	35.110	0.014	6.53	69	35.11	10.29	1412	0
12	33.830	0.013	7.29	83	33.83	11.70	1412	0
13	36.350	0.010	7.29	79	36.35	11.70	1412	0
14	35.410	0.010	7.99	65	35.41	11.60	1412	0
15	32.380	0.010	7.19	65	32.38	10.70	1412	0
16	20.750	0.010	8.39	59	35.72	12.10	1497	0
17	40.070	0.010	8.99	65	40.07	13.65	1497	0
18	25.366	0.010	8.99	65	40.89	13.30	1552	0
19	16.953	0.010	8.99	65	43.10	15.92	1607	0
20	40.790	0.016	9.67	67	40.79	14.40	1497	0
21	35.410	0.010	7.89	69	35.41	11.65	1497	0
22	32.180	0.011	6.63	73	32.18	10.70	1412	0
23	16.000	0.010	5.09	79	27.14	9.90	1114	88
24	16.000	0.010	4.44	79	26.26	9.10	751	46