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SYSTEM DYNAMIC MODELLING OF TURKISH ELECTRICITY MARKET

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ABSTRACT

This study includes current situation of Turkey electricity market, deregulation of electricity market of well-known countries and system dynamic models of electricity in UK. In last section, evaluation of Turkey electricity situation with using system dynamic models of UK (EMM model) could be found. This study assumes there should be a pool in Turkey electricity market as other countries electricity market which we have examined. Data that obtained in last section in different cases prove this proposal.

Also, there is a section for calculation of well-known countries electricity prices with using special system dynamic modelling programme, different formulae and methods. Comparison of each countries electricity prices obtained data and real data are also found in this section.

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1. INTRODUCTION

During the 1990s fundamental change has gripped the heretofore monopolistic industry of electricity generation and supply. Until the 1980's, electricity was seen as a natural monopoly, and in most cases was publicly owned in Europe and privately owned in the US. This changed when Chile, Norway and the UK became the first countries to create competition in the electricity generation sector. The US, Australia, most of South America, and many other countries in Europe are currently in various stages of design or operation of similarly restructured electricity markets. [9]

Energy has always been one of the major issues that have to be evaluated carefully for the governments. Power production, particularly electric generation is a main necessity for the public, therefore all the governments main duty is serving the needs of the people that they govern. With the recent privatization era, updated regulation structures have been developed especially in the way of enabling private entities involvement to the various phases of the operations regarding energy generation. [13]

Power market deregulation has come farthest in the countries where it started. Norway's power market has expanded to encompass its Nordic neighbors - Sweden, Finland and Denmark - tied together by the Nordic power exchange Nord Pool. The United Kingdom has its own Pool, which has achieved many of the same goals although problems in the way the exchange works have slowed down the pace of reform. Both the Nordic countries and the United Kingdom now allow all consumers to choose who supplies their power, achieving competition within this sector.[4]

Mork suggested that developments in energy markets are finally turning towards the biggest energy market of all: electricity. Every continent in the world is contemplating some kind of deregulation of electricity markets. The immediate concern is usually to end monopoly control and bring prices down for business and end-users.[5]

The electricity market in the Northern European countries, Finland, Sweden and Norway, has encountered a fundamental change since the beginning of the 1990s. The previously regulated and monopolistic electricity industry has been deregulated and a free electricity market has been created through legislative actions. The Finnish electricity market was deregulated by the Electricity Market Act, which has been in effect as of 1st June 1995. The Act includes prerequisites for competition in power generation, foreign trade, and power sales, so that the electricity market can function efficiently. It also establishes clear rules for the grid business, which operates in a position of a natural monopoly. The business areas open to competition now have a separate accounting from those in a monopoly position. [4]

Furthermore, there is an impact of deregulation on electricity prices. Russel has argued that The deregulation of electrical utilities has a substantial impact on the cost of commercial electricity. Where they have allowed utilities free market competition, prices have fallen by as much as 30 per cent. Internationally, deregulation has occurred in several countries in South America and in Great Britain. Changing the structure of electricity delivery has enhanced deregulation in both locations.[6]

US experience is the best example of impact on electricity. In US the average monthly industrial electricity bill nationwide in 1994 under a regulated environment was $6,859.93. If they fully deregulated the market for electricity, that electricity bill would have fallen to $5,067.08. That represents a saving of more than 26 per cent. These savings are in line with what occurred in the UK under full deregulation and in New Hampshire under partial deregulation. Several states, including California, Massachusetts, and Texas, are projecting that they will fully deregulate by the year 2000. Current legislation is pending in the US Congress that would cause national deregulation. [3]

Before deregulation, companies generated, transmitted, and sold at retail electricity in a given geographical region. This “natural monopoly” existed in theory to keep costs down by preventing duplication of services. As companies service areas began to overlap, they created nationwide transmission grids. These grids provided access to each other’s generation particularly in high demand situations. After deregulation, companies had to choose whether to be generators, transmitters, or retailers of electricity. Because the grid connected all generators on one end and all retail users on the other, the division into three separate companies provided both competition and better efficiencies that forced prices down.[3]

2. MODELS FOR EVALUATING ELECTRICITY PRICES

Electricity prices are different in each well known countries these prices are shown in Table 1. [12]. We suggested that these variation are formed by countries electricity production, consumption, export and import data (Table 2 [10]). Also, GNP, GNP per capita, inflation rate affect electricity prices of countries. The data for 20 countries are listed on Table 3. [10]. All of these variables are used for methods for evaluating electricity prices.

Table 1: Electricity prices (c/kWh) of 20 countries[12]

	Australia	Austria	Belgium	Canada	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Japan	Norway	Portugal	Spain	Sweden	Switzerland	UK	USA	Turkey
Ind. Prices	4,6	8,1	6,8	3,8	6,7	5,6	6,0	10,0	5,9	6,6	11,0	16,0	3,5	10,0	7,9	3,5	10,0	7,0	4,0	8,4
House. prices	7,9	16,6	20,3	6,0	20,4	10,2	16,7	20,4	11,5	13,2	17,0	23,0	8,5	16,0	19,0	10,0	14,0	13,0	7,8	8,6

Table 2: Population, GNP and Inflation rate of 20 countries[10]

Countries	Population (2000)	GNP (1999) (billion $)	GNP per capita	Inflation rate (1999)	Countries	Population (2000)	GNP (1999) (billion $)	GNP per capita	Inflatio n rate (1999)
Australia	19.169.083	$416	$22.200	%1,80	Italy	57.634.327	$1.212	$21.400	%1,70
Austria	8.131.111	$191	$23.400	%0,50	Japan	126.549.976	$2.950	$23.400	-%0,80
Belgium	10.241.506	$243	$23.900	%1,00	Norway	4.481.162	$111	$25.100	%2,80
Canada	31.281.092	$722	$23.300	%1,70	Portugal	10.048.232	$151	$15.300	%2,40
Denmark	5.336.394	$128	$23.800	%2,50	Spain	39.996.671	$678	$17.300	%2,30
Finland	5.167.486	$109	$21.000	%1,00	Sweden	8.873.052	$184	$20.700	%0,40
France	59.329.691	$1.373	$23.300	%0,50	Switzerland	7.262.372	$197	$27.100	%1,00
Germany	82.797.408	$1.864	$22.700	%0,80	Turkey	65.666.677	$409	$6.200	%65,00
Greece	10.601.527	$149	$13.900	%2,60	UK	59.511.464	$1.290	$21.800	%2,30
Ireland	3.797.257	$74	$20.300	%2,20	USA	275.562.673	$9.255	$33.900	%2,20

Table 3: Electricity production, consumption, import and export data of 20 countries [10]

	Electricity production (billion kWh) (1998)	Electricity production by source				Electricity consumption (billion kWh) (1998)	Electricity exports (billion kWh) (1998)	Electricity imports (billion kWh) (1998)
		Fossil fuel	Hydro	Nuclear	Other			
Australia	186	%89,85	%8,35	%0	%1,80	173	0,0	0,0
Austria	56	%31,46	%65,92	%0	%2,62	52	10,5	10,3
Belgium	79	%42,48	%0,49	%55,72	%1,31	75	6,4	7,8
Canada	551	%27,18	%59,77	%12,25	%0,80	485	39,5	11,7
Denmark	40	%90,80	%0,07	%0,00	%9,13	33	7,1	2,7
Finland	75	%41,62	%19,59	%27,59	%11,20	79	0,3	9,6
France	481	%10,77	%12,45	%76,24	%0,54	389	62,0	4,0
Germany	525	%65,77	%3,20	%29,06	%1,97	488	39,1	38,6
Greece	44	%8,26	%91,24	%0,00	%0,50	42	0,9	2,5
Ireland	20	%94,12	%4,63	%0,00	%1,25	18	0,1	0,2
Italy	243	%80,22	%17,30	%0,00	%2,48	267	0,9	41,6
Japan	996	%56,68	%8,99	%31,93	%2,40	926	0,0	0,0
Norway	115	%0,58	%99,16	%0,00	%0,26	111	4,4	8,0
Portugal	39	%63,14	%33,46	%0,00	%3,40	36	3,7	4,0
Spain	179	%48,23	%19,16	%31,23	%1,38	170	5,6	9,0
Sweden	157	%6,09	%46,49	%45,16	%2,26	135	16,8	6,1
Switzerland	61	%3,74	%54,29	%40,18	%1,79	51	29,6	23,6
Turkey	117	%69,40	%30,50	%0,00	%0,10	119	0,2	2,3
UK	343	%68,24	%1,49	%28,48	%1,79	331	0,2	12,6
USA	3.620	%70,34	%8,96	%18,61	%2,09	3.365	12,8	39,5

In 1st method initially we determine gain that is obtained by electricity production and sales. Obtained gain for each country approximately 2% of each country GNP. Gain is also calculated by electricity production, consumption, import and export rates and prices of each country. In this approach, we assume that electricity consumption and export costs are equal to average electricity prices. Also, we accept electricity production and electricity import costs are equal to half of the average electricity prices.

Formula (1) is given below:

[(El. Prod + El. Import) * (1/2) El. Prices] - [(El. Cons.+ El. Export)* El. Prices] = GNP*0.018*(1-inflation rate) (1)

Results of this formula reach average electricity prices of countries and see computed values and real values of electricity prices are very similar in some countries. Results of the real electricity prices and computed electricity prices graph and influence diagram of 1st method are shown in Figure 1 & 2. Influence diagram in Figure 2 is also used in special system dynamic model programme.

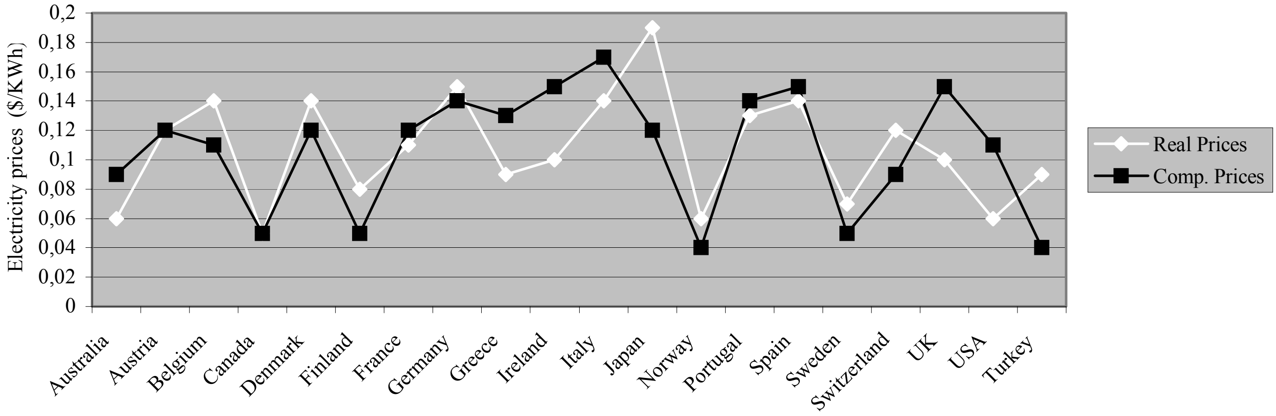

Figure 1 Graph of real and computed electricity prices of 20 coutries

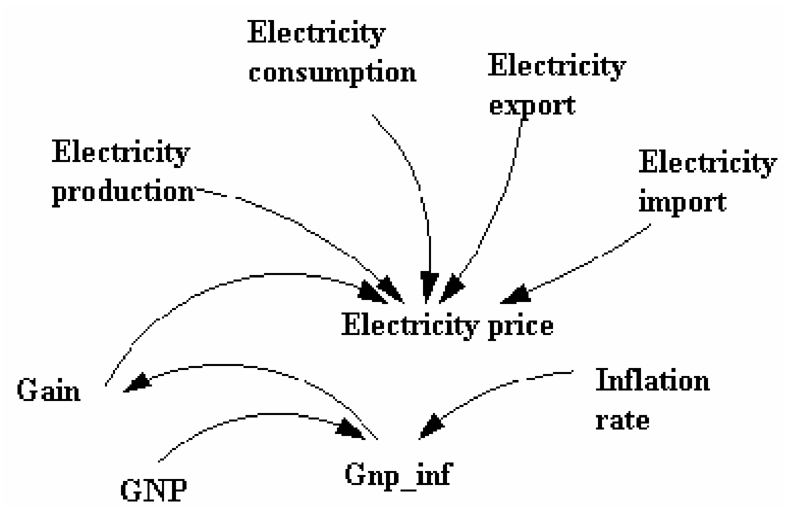

Figure 2 Influence diagram of 1st method

In 2nd approach first, we determine electricity production costs of each country. For this reason, costs of production electricity in each power plant have to be known. These costs are taken to be:

Fossil fuel: 4 c/kWh

Hydro: 3 c/kWh

Nuclear: 10 c/kWh

Other: 5 c/kWh

From these values annual electricity production cost of each country is found. Each countries gain should be found from electricity sale (70% profit accepted). Result of gain over electricity consumption gives average electricity prices.

Formula (2) is given below;

[(El. Prod. from foss.) * 4 + (El. Prod. from hydr.) * 3 + (El. Prod. from nucl.) * 10 + (El. Prod. from other) * 5] * 1.7 = El. Consumption * El. Prices (2)

Results of this formula reach average electricity prices of countries and see computed values are generally between countries industry and household prices.

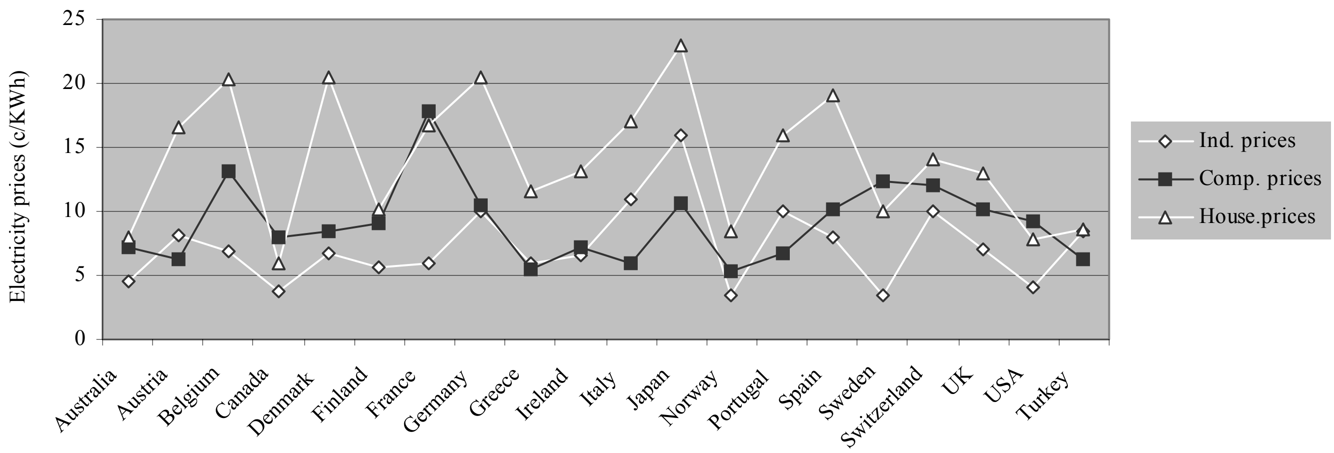

Figure 2 Graph of real and computed electricity prices of 20 coutries

In 3rd approach first, we determine annual electricity consumption per capita it is equal to electricity consumption of country divided by population. Then, apply inflation rate to GNP per capita. Finally, division of electricity consumption per capita to GNP per capita with inflation gives how much electricity prices (c/kWh) should people pay. But this value is not valid, because people give approximately 3% of their annual gain to electricity. So, obtained electricity prices multiplied by 0.03 and reach computed values.

Formula (3) is given below;

GNP Per capita * (1-inflation rate) * 0.03 = (electricity consumption / population) * Electricity prices (3)

Results of this formula reach average electricity prices of countries and see computed values are generally between countries industry and household prices that values are shown in Figure 3

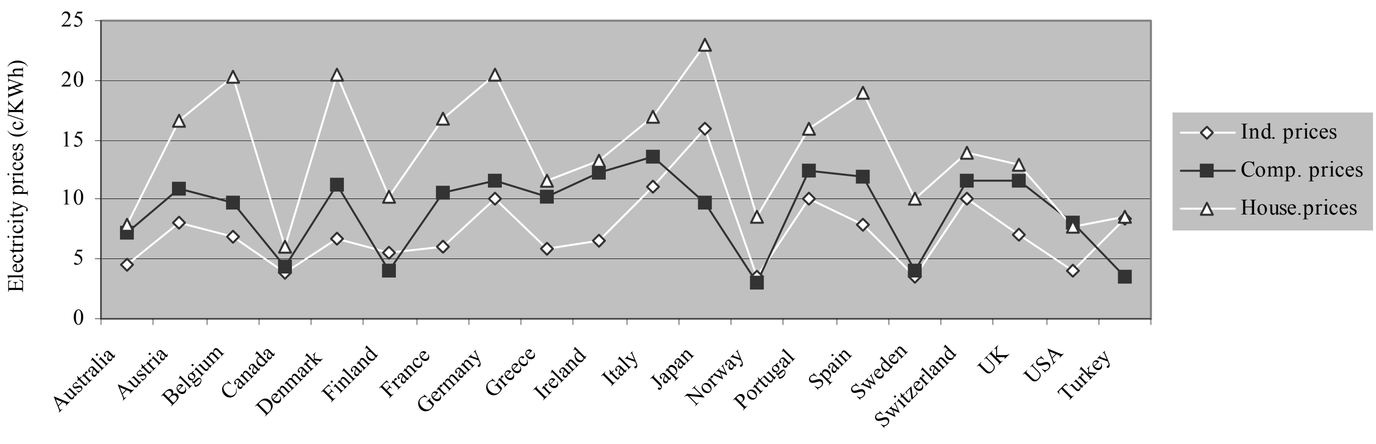

Figure 3 Graph of real and computed electricity prices of 20 coutries

3. SYSTEM DYNAMIC MODELLING OF UK ELECTRICITY MARKET

Ford suggested that system dynamics has been used extensively to aid in resource planning in the electric power industry. Many applications constitute a major body of work that has proven useful to large and small power companies as well as to government agencies at the local, state and federal level. The work has been performed by utility analysts, government planners, consultants and academics.[1]

Since 1989, the electricity industry in the UK has undergone two radical changes: privatisation and introduction of competition. [11] In the process, it was fundamental to separate the monopoly elements of the business (transmission and distribution), from those elements, which would be subject to competition (generation and supply). [9]

Under restructuring in UK, Central Electricity Generation Board (Trans.& Gen.) was split into 4 parts, National power & Powergen (Gen.) divided fossil-fired power station, Nuclear Electric (Gen.) kept all nuclear generation plant and the ownership and operation of the transmission system were transferred to the newly created National Grid Company (NGC), which was given a specific remit to facilitate competition. [9]

NGC was given the responsibility for ensuring secure dispatch of generation and the operation of a daily power pool. The power-pool became the market place for buying and selling electricity between generators and suppliers. All customers have the freedom to choose their supplier. All the major generating companies are required to sell the electricity they produce into an open commodity market known as the Pool.[11]

Each generating unit has to declare by 10 am each day its availability to the market, together with the price at which it is prepared to generate, for each and every half hour of the following day. The units are then called to generate by the NGC in ascending order of price. The most expensive unit used establishes the system marginal price (SMP) Set by valuing the small possibility that electricity supply is disrupted (loss of load- LOLP) given the amount of generation capacity available. The regulator assesses and sets the value for loss of load (VOLL). The following equation shows how Pool Purchase Price is calculated.[11]

Pool Purchase Price = SMP + [LOLP * (VOLL - SMP)]

Figure 4 provides an overview of the electricity system in the UK showing both the flow of electricity and contract arrangements.

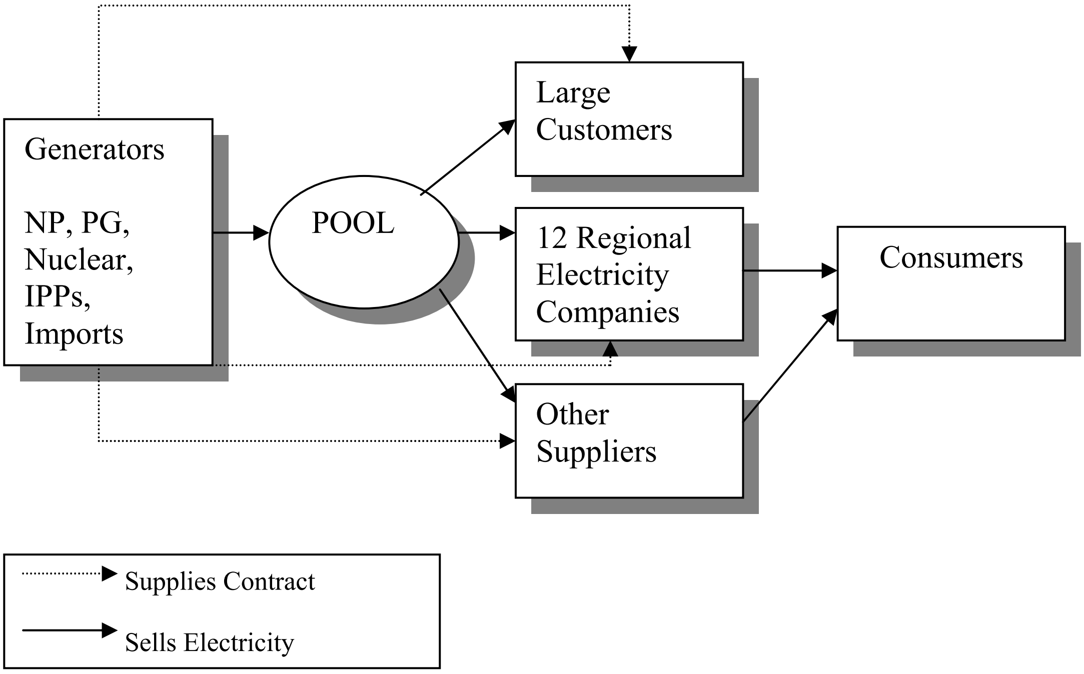

Figure 4 Electricity pool of UK.

The Electricity Markets Microworld is a computer simulation of a deregulated electricity market. The situation that players are faced with at the start of the simulation is a market that has recently been opened to competition. The incumbent generator, that had the monopoly of generation before deregulation, now faces competition from a number of new independent power producers (IPPs). These companies have entered with relatively cheap plants known as combined cycle gas turbines (CCGTs) that are powered by natural gas. A regulator oversees the operation of the market. The user of the microworld can select the role of the Incumbent, a New Entrant or the Regulator, set targets, define strategies, and test them running the simulation over a number of years.[11]

Figure 5 shows the structure of the default decision-making process of the two generators is given. When the market price rises, the forecast profitability of new CCGT plants increases, which is used as a signal to build new capacity. The capacity decision rules of the Incumbent and Independents differ. The capacity investment decision of the *Independents* is influenced by the market share of the *Incumbent,* with their ability to build new capacity increasing as the market share of the Incumbent increases. This rule was chosen to model the effect that was observed in the England and Wales market, where distribution companies subsidised new entrants in an attempt to break the dominant position of the incumbent generator. The Incumbent's new investment decision is influenced by its profits as it will not be able borrow money to build new capacity if their existing plant is loosing money.[11]

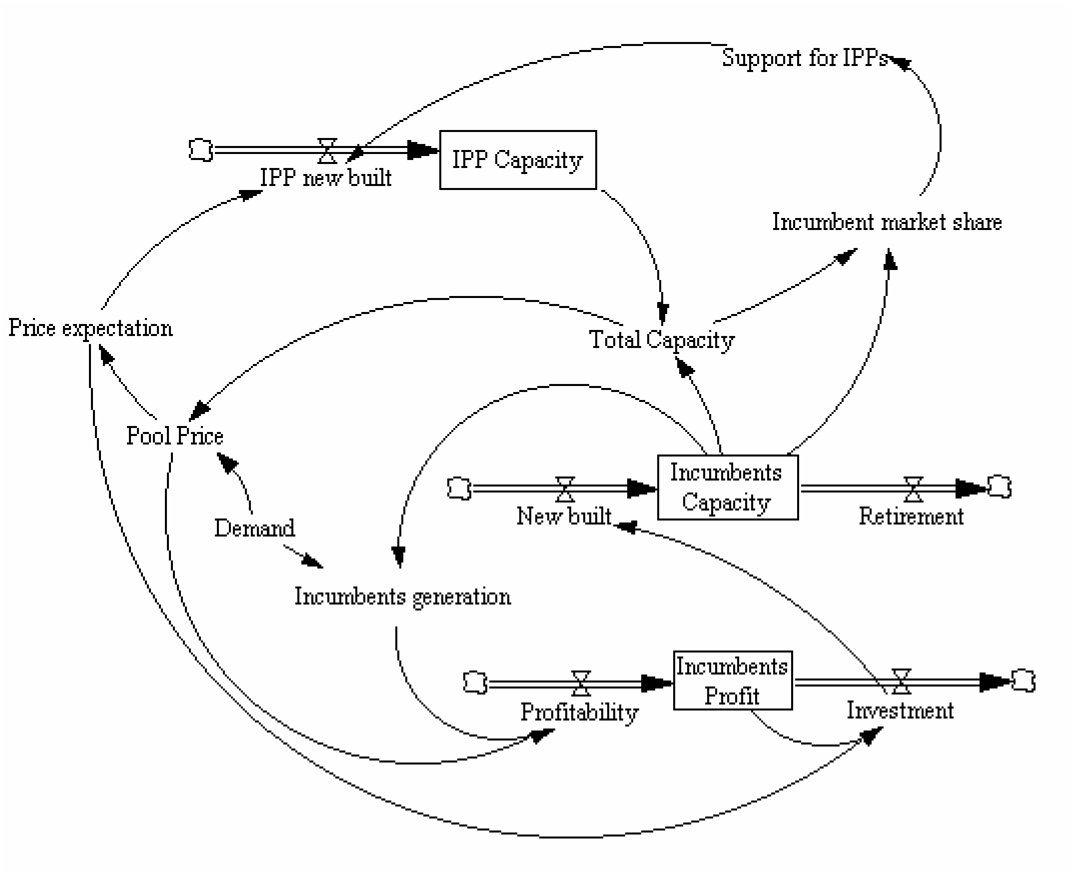

Figure 5 Stock and flow diagram of the investment decison [11]

Generators also have to decide how to price the generating capacity that they own. The short-term implications of the bidding decision for any generator are described in the following influence diagram.(Figure 6)[9]

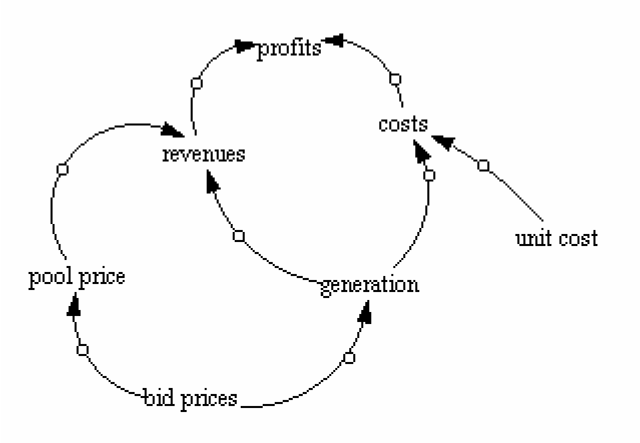

Figure 6 Influence diagram of bidding strategy [9]

Formulae:

Formulae which are obtained from Figure 5 & 6 should be like that. They are not strictly true, but they are close to real equations.

Revenues: Pool price * Incumbent generation (\$/period)

Incumbent Profit: Revenues - Investment (\$)

Investment: Price expectation - Incumbent profit (\$/period)

New Built: Investment / (CCGT construction Cost) (MW/period)

Incumbent Capacity: Incumbent Capacity + New built - Retirement (MW)

Retirement: Constant (MW)

Incumbent Generation: If Demand ≤ Incumbent capacity , (Demand), (Incumbent Capacity) (MWh/period)

Demand: Constant (MWh/period)

Total capacity: Incumbent Capacity + IPPs Capacity (MW)

Incumbent market share: Incumbent capacity / Total capacity

Support for IPPs: If incumbent market share ≤ 0.5 , (0.09-0.06*Inc. market share), (0.12)

Pool Price: SMP + [LOLP * (VOLL - SMP)] (\$/MWh)

LOLP	VOLL	LOLP : Loss of load price
0,018	-0,2	VOLL : Value of loss of load
0,016	-0,15	SMP : System marginal price
0,007	-0,1	VOLL = (Total Capacity - Demand) / Total Capacity
0,004	-0,05	
0,002	0	
0,0015	0,05	
0,001	0,1	
0	0,15	

Price Expectation : Pool price * Total capacity ($/period)

IPP new built: (Price expectation * support for IPPs) / (CCGT constr. cost) (MW/period)

IPP capacity: IPP new built + IPP capacity (MW)

4. EMM MODEL WITH TURKISH DATA

Table 4. shows total capacities and total production amount of each type of power plants. These values are determined by using tables on appendix pages.

Table 4 Power plants capacities and their production amounts.

	Total Capacity (MW)	Average (GWh)	Definite (GWh)
Total	27.519	146.823	136.817
Total (hydro)	11.939	43.207	33.202
Total (diesel)	230	751	751
Total (coal)	817	5.403	5.403
Total (lignite)	7.552	48.630	48.630
Total (LPG)	34	255	255
Total (fuel-oil)	1.207	7.584	7.584
Total (CCGT)	5.693	40.686	40.686
Total (wind)	8,7	40,5	39,5
Total (other)	38,8	267,5	267,5

Table 5 demonstrates Turkey power plants and their capacities which is obtained by tables on appendix pages. Power plants variable costs, fixed costs availability and plant life are also determined in Table 4.2 [12] . In this Table TEAS power plants (hydro, CCGT, coal and oil) are shown as an Incumbent and the other power plants (ÇEAŞ, Trakya Elk., Ova Elk., ENDA, Ayen Enerji, KEPEZ, Bilgin Elk., Berdan, Alaçatı......) are demonstrated as an IPPs (independent power producer) (hydro and CCGT). New entrant (hydro and CCGT) capacities are not determined now, capacity values are tried on next section with applying system dynamic model.

Table 5. Turkey power plants used in our model.

Generator	Plant Type	Capacity	Var. Cost	Fix Cost	Availability	Plant Life (year)
Incumbent	CCGT	4500	22,5	30	0,85	40
Incumbent	Coal 1	5000	18	45	0,8	40
Incumbent	Coal 2	3500	21	45	0,8	40
Incumbent	Hydro 1	6000	12	15	0,8	40
Incumbent	Hydro 2	5000	12	15	0,75	40
Incumbent	Oil	1500	45	30	0,8	40
IPPs	Hydro	1000	12	15	0,8	40
IPPs	CCGT	1500	22,5	30	0,85	40
New Entrant	Hydro	**	12	15	0,8	40
New Entrant	CCGT	**	22,5	30	0,85	40

Table 6 shows assumed Turkey electricity demand data(we do not know Turkey electricity peak demand data it is assumption). Also initial demand, annual demand growth, incumbent initial cash & debt & fixed assets are determined in Table 6. New entrant initial cash will be tried when applying model.

Table 6 Turkey electricity demand data

% Peak Demand	hours	% Peak Demand	hours	initial peak	Incumbent initial
100	76	59	474,5	demand in MW	fixed assets(million $)
97	148,5	56	552,5	24.000	8000
93	148,5	53	552,5		
89	217	50	467,5	Annual Demand	Incumbent initial
86	217	47	467,5	Growth (%)	debt
84	234,5	44	442,5	4,5	0
81	234,5	42	400		
79	349	40	350	New Entrant initial	Incumbent initial
75	349	37	316	Cash (m$)	cash (million $)
71	498	33	182	***	800
69	498	31	88		
67	490	29	11	CCGT Construction	
64	490	26	5,5	Time	
61	474,5			2 years	

Figure 7 below shows Turkey electricity pool. In here, generators (Incumbent, IPPs, New entrant..) produces electricity and all generated electricity are collected in a pool and distrubuted to suppliers than suppliers sells electricity to consumers.

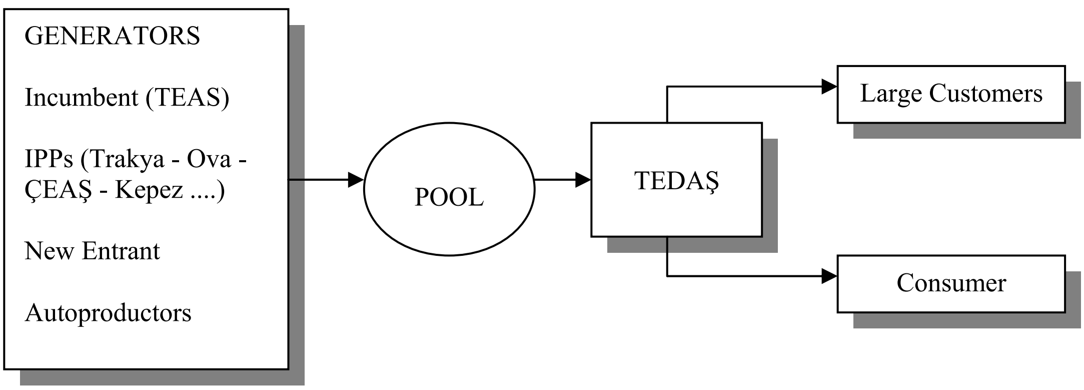

Figure 7 Turkey Electricity pool

We try different values on new entrant initial capacity [(hydro:400, CCGT:500), (hydro:500, CCGT:750)] in each cases. Also, we try different value of capacity ordered in each period (eg. Incumbent: 100MW, IPPs: 100MW, New Entrant: 25MW...) and bidding prices for incumbent and IPPs power plants in each case. We reach different results with applying EMM model that is described in section 3 with Turkish data on Table 5 & Table 6. Goals of each cases (we could not show all cases because there are 27 case, cases results are demonstrated on conclusion part) are reach mimimum pool price, no shortage and approximate total demand values in 2010(Table 10).

In Table 7 we demonstrates one of cases initial values. From those initial values we reach some results in 2010(Table 8). Also, we have changed initial data and reach different results. All of those obtained data are shown in Table 8.

Table 7 Initial data of Case 5

Run #		5		
Incumbent			Capacity of New Entrant Hydro (MW)	500
Bidding price	Difference from SMP	%0	Capacity of New Entrant CCGT (MW)	750
Capacity (MW)	Order every period (OEP)	100	New Entrant Initial Cash (million $)	500
IPPs				
Bidding price	Difference from SMP	%0	Starting year	2002
Capacity (MW)	Order every period (OEP)	100	Ending year	2010
New entrant			No of period in a year	12
Bidding price	Difference from SMP	%0		
Capacity (MW)	Order every period (OEP)	25		

Table 8 Case 5 and different decisions given on Case 5 results

	Decisions	Excess capacity in 2010	Pool Price ($/MWh) in 2010	Market share (%) in 2010			Total Capacity (MW) in 2010
				Incumbent	IPPs	New Entrant	
1	Case 5 Results	%1	22,5	76	18	6	43.704
2	If Incumbent capacity is 110MW OEP instead of 100MW OEP	%2	22,4	77	17	6	44.547
3	If Incumbent capacity is 120MW OEP instead of 100MW OEP	%4	22,5	77	17	6	45.389
4	If New Entrant capacity is 30MW OEP instead of 25MW OEP	%1	22,6	76	18	6	44.125
5	If New Entrant capacity is 40MW OEP instead of 25MW OEP	%3	22,5	75	17	8	44.968
6	If Incumbent bid price %10 instead of %0	%1	23,5	57	33	10	43.704
7	If both Incumbent & IPPs bid price %10 instead of %0	%1	24,5	72	16	12	43.704
8	If Incumbent & IPPs bid price %10 and new entrant bid price %5 instead of %0	%1	24,8	73	16	11	43.704

5. Conclusion

In this project, we examined countries electricity market restructuring and see there should be an electricity pool in electricity market. UK electricity model influenced us, so we use pool in our cases. Also we examine system dynamic model of UK. We use UK EMM model in 3rd section. In 2nd section we try to estimate electricity prices of countries with applying different formulas. In here, we see countries electricity prices is effected with electricity production, consumption, export and import values. Population, GNP, GNP Per capita, inflation rate values are also affect electricity prices.

In section four, we study EMM model with Turkish data. First, we decide capacities of each type of power plants and demand values. In cases parts different capacities are used for new entrant capacity and reach different results at the end of the our model. These results are:

1. **Pool price is between 22 - 25 $/MWh in the year of 2010 & 21 - 23 $/MWh in the year of 2002**

Pool price is generators production prices. We know 1999 generators production prices[7] (Table 8). But we couldn't say anything about electricity pool price of 2010 because we couldn't estimate what will be $/TL rates. But, according to average electricity production cost ($/MWh) the prices of electriciy is decreased. In Table 9 obtained pool prices from the cases in the year of 2010 are shown.

Table 8 Generator production prices in the year of 1999 [7]

Month		$ rates	average cost ($/MWh)
January	1999	315.220	35,2
February	1999	332.200	35,0
March	1999	352.405	34,6
April	1999	369.155	34,7
May	1999	390.248	34,6
June	1999	406.594	34,9
July	1999	421.362	35,3
August	1999	427.988	37,2
September	1999	445.089	38,2
October	1999	460.603	39,4
November	1999	479.621	40,5
December	1999	516.150	40,2

Table 9 Obtained pool price value ($/MWh) in the year of 2010

Cases	Pool price in 2010 ($/MWh)	Cases	Pool price in 2010 ($/MWh)	Cases	Pool price in 2010 ($/MWh)
Case 1	23	Case 3	22,6	Case 5	22,5
Case 1 disc. 2	22,5	Case 3 disc. 2	22,5	Case 5 disc. 2	22,4
Case 1 disc. 3	22,3	Case 3 disc. 3	22,4	Case 5 disc. 3	22,5
Case 1 disc. 4	22,6	Case 3 disc. 4	22,6	Case 5 disc. 4	22,6
Case 1 disc. 5	22,7	Case 3 disc. 5	22,5	Case 5 disc. 5	22,5
Case 1 disc. 6	24,1	Case 3 disc. 6	23,6	Case 5 disc. 6	23,5
Case 1 disc. 7	25,2	Case 3 disc. 7	24,6	Case 5 disc. 7	24,5
Case 1 disc. 8	25,3	Case 3 disc. 8	24,7	Case 5 disc. 8	24,8
Case 2	23,8	Case 4	24,5	Case 6	23,5

2. Electricity capacity is between 43,000- 47,000 (MW) in the year of 2010.

According to result of our cases we say "there will be no electricity shortage also, there will be an excess capacity in the year of 2010". We know approximate electricity value in 2010 (Table 10) [8]. Obtained total capacity value (MW) from the cases in year 2010 is shown on Table 11. There is little difference between obtained total capacity and approximate total capacity values

Table 10 Approximate total capacity values in next years [8]

Years	Approximate demand (MW)
2002	24.000
2003	26.240
2004	28.657
2005	31.295
2006	33.851
2007	36.615
2008	39.605
2009	42.839
2010	46.338

Table 11 Obtained Electricity capacity (MW) in the year of 2010

Cases	Total Capacity in 2010 (MW)	Cases	Total Capacity in 2010 (MW)	Cases	Total Capacity in 2010 (MW)
Case 1	43.194	Case 3	43.374	Case 5	43.704
Case 1 disc. 2	44.037	Case 3 disc. 2	44.217	Case 5 disc. 2	44.547
Case 1 disc. 3	44.879	Case 3 disc. 3	45.059	Case 5 disc. 3	45.389
Case 1 disc. 4	43.615	Case 3 disc. 4	43.795	Case 5 disc. 4	44.125
Case 1 disc. 5	44.458	Case 3 disc. 5	44.717	Case 5 disc. 5	44.968
Case 1 disc. 6	43.194	Case 3 disc. 6	43.374	Case 5 disc. 6	43.704
Case 1 disc. 7	43.194	Case 3 disc. 7	43.374	Case 5 disc. 7	43.704
Case 1 disc. 8	43.194	Case 3 disc. 8	43.374	Case 5 disc. 8	43.704
Case 2	46.480	Case 4	46.624	Case 6	47.032

3. Electricity market with pool system supports private sector.

Market share of Incumbent power plant (TEAS) is %91 and market share of IPPs power plant (Independent power plants) is %9 in the year of 2000 (Table 12). According to our cases results Incumbent market share decreases to about %70 and IPPs market share increases approximately %30 in the year of 2010. Obtained market share values from cases part in the year of 2010 is shown on Table 13

Table 12 Incumbent & IPPs market share in 2000

Generator	Plant Type	Capacity (MW)
Incumbent	CCGT	4500
Incumbent	Coal 1	5000
Incumbent	Coal 2	3500
Incumbent	Hydro 1	6000
Incumbent	Hydro 2	5000
Incumbent	Oil	1500
IPPs	Hydro	1000
IPPs	CCGT	1500

Incumbent market share
%91
IPPs market share
%9

Table 13 Obtained Market share values in 2010

Cases	Market Share of Incumbent in 2010	Market Share of IPPs in 2010	Market Share of New Entrant in 2010
Case 1	%77	%18	%5
Case 1 disc. 2	%77	%18	%5
Case 1 disc. 3	%78	%17	%5
Case 1 disc. 4	%76	%18	%6
Case 1 disc. 5	%75	%18	%7
Case 1 disc. 6	%58	%33	%9
Case 1 disc. 7	%73	%16	%11
Case 1 disc. 8	%74	%16	%10
Case 2	%61	%28	%11
Case 3	%77	%18	%5
Case 3 disc. 2	%77	%18	%5
Case 3 disc. 3	%78	%17	%5
Case 3 disc. 4	%76	%18	%6
Case 3 disc. 5	%75	%18	%7
Case 3 disc. 6	%58	%33	%9
Case 3 disc. 7	%73	%16	%11
Case 3 disc. 8	%74	%16	%10
Case 4	%73	%16	%11
Case 5	%76	%18	%6
Case 5 disc. 2	%77	%17	%6
Case 5 disc. 3	%77	%17	%6
Case 5 disc. 4	%76	%18	%6
Case 5 disc. 5	%75	%17	%8
Case 5 disc. 6	%57	%33	%10
Case 5 disc. 7	%72	%16	%12
Case 5 disc. 8	%73	%16	%11
Case 6	%72	%15	%13

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APPENDIX

Table A1 Turkey Power Plants & Capacities (ordered by total capacity) [2],[7],[12]

	Company	Type	Power Plant Name	Place	Total Capacity (MW)	Average (GWh)	Definite (GWh)
1	TEAŞ	Hydro	ATATÜRK	Ş.URFA	2405	8900	7400
2	TEAŞ	Hydro	KARAKAYA	DİYARBAKIR	1800	7500	6800
3	TEAŞ	CCGT	BURSA	BURSA	1432	10024	10024
4	TEAŞ	Lignite	AFŞİN-ELBİSTAN	K.MARAŞ	1360	8840	8840
5	TEAŞ	CCGT	AMBARLI KÇ(CC)	İSTANBUL	1350,9	8780	8780
6	TEAŞ	Hydro	KEBAN	ELAZIĞ	1330	6600	5820
7	TEAŞ	Lignite	HAMİTABAT KÇ	KIRKLARELİ	1200	7800	7800
8	TEAŞ	Lignite	SOMA B	MANİSA	990	6435	6435
9	TEAŞ	Hydro	ALTINKAYA	SAMSUN	702	1632	1236
10	TEAŞ	Hydro	BİRECİK	Ş.URFA	672	2516	2516
11	TEAŞ	Lignite	KEMERKÖY I,II,III	MUĞLA	630	4095	4095
12	TEAŞ	Lignite	YATAĞAN	MUĞLA	630	4100	4100
13	TEAŞ	Fuel-oil	AMBARLI	İSTANBUL	630	4100	4100
14	TEAŞ	Lignite	ÇAYIRHAN1,2,3,4	ANKARA	620	4030	4030
15	TEAŞ	Lignite	SEYİTÖMER	KÜTAHYA	600	3900	3900
16	TEAŞ	Hydro	OYMAPINAR	ANTALYA	540	1620	482
N	ÇEAŞ	Hydro	BERKE	ADANA	510.75	1700	
17	TRAKYA ELK.	CCGT	UNİMAR	TEKİRDAĞ	504	3780	3780
18	TEAŞ	Hydro	H.UĞURLU	SAMSUN	500	1217	820
19	TRAKYA ELK.	CCGT	ENRON	TEKİRDAĞ	498,7	3740,3	3740,3
20	TEAŞ	Lignite	YENİKÖY	MUĞLA	420	2730	2730
21	TEAŞ	Lignite	TUNÇBİLEK B	KÜTAHYA	300	1950	1950
22	TEAŞ	Lignite	KANGAL	SİVAS	300	1950	1950
23	TEAŞ	Coal	ÇATALAĞZI	ZONGULDAK	300	1950	1950
24	ÇEAŞ	Hydro	SIR	K.MARAŞ	283,5	725	408
25	TEAŞ	Hydro	GÖKÇEKAYA	ESKİŞEHİR	278,4	562	460
26	OVA ELEKTRİK	CCGT	OVA	KOCAELİ	253,4	1900,5	1900,5
27	Otoprodüktör	Coal	İSDEMİR	HATAY	220	1650	1650
28	TEAŞ	Lignite	ORHANELİ	BURSA	210	1365	1365
29	TEAŞ	Hydro	BATMAN	BATMAN	198	483	483
30	TEAŞ	Hydro	KARKAMIŞ	GAZİANTEP	189	652	652
31	DOĞA ELK.	CCGT	ESENYURTI,II,III,IV	İSTANBUL	188,5	1413,8	1413,8
32	TEAŞ	Diesel	ALİAĞA GT+GÇ	İZMİR	180	540	540
33	Otoprodüktör	CCGT	BİS ENERJİ	BURSA	174	1305	1305
34	TEAŞ	Hydro	ÖZLÜCE	BİNGÖL	170	414	290
35	TEAŞ	Hydro	ÇATALAN	ADANA	168,9	596	270
36	TEAŞ	Hydro	SARIYAR	SAMSUN	160	300	228
37	TEAŞ	Hydro	GEZENDE	İÇEL	159,3	528	130
38	Otoprodüktör	Fuel-oil	PETKİM ALİAĞA	İZMİR	140	1050	1050
39	TEAŞ	Hydro	ASLANTAŞ	ADANA	138	569	360
40	Otoprodüktör	CCGT	ENTEK	BURSA	129,9	974,3	974,3
41	TEAŞ	Lignite	TUNÇBİLEK A	KÜTAHYA	129	840	840
42	TEAŞ	Hydro	HİRFANLI	KIRŞEHİR	128	400	178
43	Otoprodüktör	CCGT	AK ENERJİ(BOZÜYÜK)	BİLECİK	127	952,5	952,5
44	TEAŞ	Hydro	MENZELET	K.MARAŞ	124	515	435
45	Otoprodüktör	CCGT	ÇOLAKOĞLU MET.	İSTANBUL	123,4	987,2	987,2

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	Company	Type	Power Plant Name	Place	Total Capacity (MW)	Average (GWh)	Definite (GWh)
46	TEAŞ	Hydro	KILIÇKAYA	SİVAS	120	332	277
47	EN-DA	Hydro	GÖNEN	BALIKESİR	110,6	47	35
48	TEAŞ	Hydro	DİCLE	DİYARAKIR	110	298	298
49	Otoprodüktör	CCGT	AK NERJİ(ÇRKEZKÖY)	TEKİRDAĞ	98	784	784
50	TEAŞ	Hydro	KIRALKIZI	DİYARBAKIR	94	146	111
51	TEAŞ	Hydro	KÖKLÜCE	TOKAT	90	588	343
52	AYEN ENERJİ	Hydro	ÇAMLICA	KAYSERİ	84	429	243
53	Otoprodüktör	CCGT	ZORLU ENERJİ	BURSA	77,5	581,3	581,3
54	Otoprodüktör	CCGT	ERDEMİR	ZONGULDAK	77	577,5	577,5
55	TEAŞ	Hydro	KESİKKÖPRÜ	ANKARA	76	250	110
56	TEAŞ	Hydro	S.UĞURLU	ADANA	76	273	206
57	TEAŞ	Hydro	DOĞANKENT I.II	GİRESUN	70,8	314	62
58	ÇEAŞ	Hydro	KADINCIK I	İÇEL	70	345	190
59	TEAŞ	Hydro	DEMİRKÖPRÜ	MANİSA	69	193	78
60	TEAŞ	Hydro	ADIGÜZEL	DENİZLİ	62	280	15
61	ÇEAŞ	Hydro	SEYHAN I	ADANA	60	350	109
62	Otoprodüktör	CCGT	AK ENERJİ(YALOVA)	YALOVA	59,5	446,3	446,3
63	Otoprodüktör	CCGT	ZORLU ENERJİ	KIRKLARELİ	56,7	425,3	425,3
64	TEAŞ	Hydro	DERBENT	SAMSUN	56,4	257	201
65	Otoprodüktör	CCGT	BOSEN	BURSA	56	420	420
66	ÇEAŞ	Hydro	KADINCIK II	İÇEL	56	320	200
67	TEAŞ	Hydro	KAPULUKAYA	KIRIKKALE	54	190	150
68	TEAŞ	Hydro	KOVADA II	ISPARTA	51,2	222	121
69	TEAŞ	Fuel-oil	HOPA	ARTVİN	50	200	200
70	Otoprodüktör	Coal	ERDEMİR	ZONGULDAK	50	375	375
71	TEAŞ	Hydro	KEMER	AYDIN	48	143	62
72	KEPEZ	Hydro	MANAVGAT	ANTALYA	48	220	40
73	KEPEZ	Hydro	KARACAÖREN II	BURDUR	47,2	206	110
74	Otoprodüktör	Fuel-oil	TÜPRAŞ RAFİNERİ	KOCAELİ	45	242,3	242,3
75	TEAŞ	Fuel-oil	PS3-SİLOPİ(MOBİL)	Ş.URFA	44,1	330,8	330,8
76	TEAŞ	Lignite	SOMA A	MANİSA	44	290	290
77	Otoprodüktör	Fuel-oil	TÜPRAŞ RAFİNERİ	İZMİR	44	330	330
78	Otoprodüktör	Coal	ATAER ENERJİ	İZMİR	43,2	324	324
79	Otoprodüktör	CCGT	BİL ENERJİ	ANKARA	41	307,5	307,5
80	Otoprodüktör	CCGT	ENERJİSA	KOCAELİ	40	320	320
81	Otoprodüktör	CCGT	NUH ÇİMENTO	KOCAELİ	38,4	288	288
82	TEAŞ	Hydro	YENİCE	ERZİNCAN	37,89	21	21
83	Otoprodüktör	CCGT	ESKİŞEHİR SAN.ODASI	ESKİŞEHİR	37	296	296
84	Otoprodüktör	Coal	KARDEMİR	KARABÜK	35	190	190
85	TEAŞ	Hydro	KARACAÖREN I	BURDUR	32	142	84
86	Otoprodüktör	CCGT	CAMIŞ ELEK(TRAKYA)	KIRKLARELİ	31	232,5	232,5
87	BİLGİN ELK.	Hydro	HAZAR I-II	ELAZIĞ	30,1	192	24
88	Otoprodüktör	Fuel-oil	ÇİNKUR	KAYSERİ	30	150	150
89	TEAŞ	Hydro	ALMUS	TOKAT	27	99	39
90	KEPEZ	Hydro	KEPEZ I	ANTALYA	26,4	169	130
91	TEAŞ	Hydro	TORTUM	ERZURUM	26,2	100	85
92	Otoprodüktör	Coal	SEKA DALAMAN	MUĞLA	26,2	196,5	196,5
93	Otoprodüktör	CCGT	PRELLİ	KOCAELİ	24,5	183,7	183,7
94	TEAŞ	Fuel-oil	VAN(MOBİL SNT)	VAN	24	180	180
95	Otoprodüktör	Fuel-oil	TÜPRAŞ OA.RAFİNERİ	KIRIKKALE	24	180	180

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	Company	Type	Power Plant Name	Place	Total Capacity (MW)	Average (GWh)	Definite (GWh)
96	TEAŞ	Hydro	KUZGUN	ERZURUM	22,65	3	0
97	Otoprodüktör	Coal	SEKA AKDENİZ	İÇEL	20	50	50
98	Otoprodüktör	CCGT	MODERN ENERJİ	TEKİRDAĞ	20	150	150
99	Otoprodüktör	CCGT	KARTONSAN	KOCAELİ	19,8	148,5	148,5
100	Otoprodüktör	Fuel-oil	SEKA İZMİT	KOCAELİ	18	90	90
101	Otoprodüktör	CCGT	STARWOOD	BURSA	17,3	129,8	129,8
102	TEAŞ	Hydro	ÇAYKÖY	ISPARTA	17	36	0
103	FETHİYE	Hydro	FETHİYE	MUĞLA	16,5	90	27
104	ÇAYKÖY	Hydro	AKSU	BURDUR	16	36	35
105	TEAŞ	Hydro	ÇILDIR	ARDAHAN	15,36	67	56
106	TEAŞ	Hydro	İKİZDERE	RİZE	15,12	100	65
107	TEAŞ	Other	DENİZLİ	DENİZLİ	15	90	90
108	TEAŞ	Hydro	BEYKÖY	ESKİŞEHİR	15	87	87
109	TEAŞ	Hydro	TERCAN	ANKARA	15	51	28
110	TEAŞ	Diesel	ENGİL GT	VAN	15	90	90
111	TEAŞ	Hydro	ÇAĞÇAĞ III	MARDİN	14,4	42	42
112	Otoprodüktör	Lignite	ILĞIN ŞEKER	KONYA	14,4	36	36
113	Otoprodüktör	Fuel-oil	DENİZLİ ÇİMENTO	DENİZLİ	13,9	104,3	104,3
114	Otoprodüktör	CCGT	EGE BİRLEŞİK ENERJİ	İZMİR	13	97,5	97,5
115	Otoprodüktör	Fuel-oil	KONYA ŞEKER	KONYA	12,8	32	32
116	Otoprodüktör	Coal	AFYON ŞEKER	AFYON	12,8	32	32
117	Otoprodüktör	Coal	TURHAL ŞEKER	TOKAT	12,8	32	32
118	Otoprodüktör	CCGT	ESKİŞEHİR ŞEKER	ESKİŞEHİR	12,8	32	32
119	TEAŞ	Hydro	TOHMA-MEDİK	MALATYA	12,5	59	59
120		Hydro	TOHMA-MEDİK	MALATYA	12,5	59	0
121	Otoprodüktör	CCGT	YALOVA ELYAF	İSTANBUL	12,3	92,3	92,3
122	Otoprodüktör	Fuel-oil	ETİ ALİMİNYUM	KONYA	12	60	60
123	Otoprodüktör	CCGT	CAMIŞ ELK(ÇAYIROV)	KOCAELİ	12	90	90
124	Otoprodüktör	CCGT	CAMIŞ ELEK(TOPKAPI)	İSTANBUL	12	90	90
125	Otoprodüktör	CCGT	ŞAHİNLER	TEKİRDAĞ	12	96	96
126	TEAŞ	Diesel	HAKKARİ(MOBİL)	HAKKARİ	11,1	83,3	83,3
127	TEAŞ	Hydro	GÖKSU	KARAMAN	10,8	65	58
128	Otoprodüktör	Coal	BANDIRMA BORAKS	BALIKESİR	10,7	80,3	80,3
129	TEAŞ	Hydro	YERKÖPRÜ		10,56	70	70
130	Otoprodüktör	Coal	ADAPAZARI ŞEKER	SAKARYA	10,4	26	26
131	Otoprodüktör	Fuel-oil	TÜPRAŞ RAFİNERİ	BATMAN	10,3	28,3	28,3
132	Otoprodüktör	Lignite	SUSURLUK ŞEKER	BALIKESİR	10,2	25,5	25,5
133	Otoprodüktör	Lignite	BOR ŞEKER	NİGDE	10,1	25,2	25,2
134	Otoprodüktör	Other	BAĞFAŞ	BALIKESİR	10	75	75
135	Otoprodüktör	LPG	ORTA ANADOLU MEN.	KAYSERİ	10	75	75
136	Otoprodüktör	Fuel-oil	POLİNAS	MANİSA	10	75	75
137	Otoprodüktör	Coal	AKÇA TEKSTİL	DENİZLİ	10	75	75
138	Otoprodüktör	Coal	SEKA ÇAYCUMA	ZONGULDAK	10	75	75
139	BERDAN	Hydro	BERDAN	İÇEL	10	48	10
140	Otoprodüktör	Coal	BURDUR ŞEKER	BURDUR	9,7	24,2	24,2
141	Otoprodüktör	LPG	GOODYEAR	SAKARYA	9,6	72	72
142	Otoprodüktör	Lignite	ELBİSTAN ŞEKER	K.MARAŞ	9,6	24	24
143	Otoprodüktör	Lignite	EREĞLİ ŞEKER	KONYA	9,6	24	24
144	Otoprodüktör	Lignite	ÇARŞAMBA ŞEKER	SAMSUN	9,6	24	24
145	Otoprodüktör	Fuel-oil	AĞRI ŞEKER	AĞRI	9,6	24	24