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Forecasting the primary energy demand in Turkey and analysis of cyclic patterns

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Abstract

The planning and estimation of future energy demand via modern statistical methods have been officially used in Turkey since 1984. However, almost all previous forecasts proved significantly higher than actual observations because of several reasons discussed here. The cycle analysis, which is a semi-statistical technique that makes use of any cyclicity in the historical data of annual additional amounts of energy demand, appears to give better results than the other techniques for forecasting energy demand in Turkey. This method suggests that the energy demand will be around 130 million toe in 2010. This figure is very close to the estimates obtained by the Winter's exponential smoothing method. To increase the scientific validity of the method, it should be applied in other similar countries. © 2001 Elsevier Science Ltd. All rights reserved.

Keywords: Forecasting; Energy demand; Cyclic patterns; Turkey

1. Introduction

Despite the fact that the developing countries consume only a small share of the world's commercial energy, and energy is usually a small segment of the nations' economy, energy demand of the developing countries increases more rapidly than that of the developed countries [1,2]. The primary goal of the developing countries' energy sectors is, therefore, to provide sustainable, reliable, affordable and, if possible, clean energy supply, sufficient for the industrial and

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public needs to be able to keep up industrialization with living standards. Medium and long term energy demand forecasts, based primarily on a realistic estimate of targeted economic growth and social development of the country in the future, are prerequisites to reach this goal. For this reason, forecasting and, in particular, examining the balance between energy supply–demand and energy–economy interactions have always had its practitioners, especially in the developing countries [3].

However, all projections, whether fairly simple or sophisticated and econometric, usually give similar results for the near future but differ greatly over longer periods of time [4]. Unexpected events usually undermine the assumptions on which most were based [5]. For instance, long term oil demand forecasting was pursued rather less enthusiastically than once was the case, owing to the destructive effect of the oil price shocks of 1973 and 1979.

Another important issue that should be considered in forecasting energy demand is the energy prices. It has been claimed that if prices had not risen, energy demands would have grown at about the same rate as the GNP, which is usually not the case [6]. However, low prices, generally associated with the long term domestic availability of energy, result in intense energy use and vice versa [7]. On the other hand, any increase in energy demand usually is accompanied by depleting domestic natural resources and lowering economic growth, primarily by increasing costs.

Similar to several other developing countries, Turkey's major aim has been to modernize the country in a system of mixed economy, giving more emphasis on private enterprises since the free market reform measures taken in the early 1980s. The national energy policy developed by the MENR (Ministry of Energy and Natural Resources of Turkey), as summarized by Bir in 1984 [8], has almost been the same since then. However, despite all efforts, Turkey is severely faced with an energy dilemma, basically because of high energy demand and limited natural energy resources.

The purpose of this paper is, therefore, to review and analyze the already existing forecasts for future primary energy demand and show that the analysis of cyclic patterns in historical curves can be used in forecasting in Turkey. Such efforts are expected to play a vital role in determining the energy strategy of the country.

Unless otherwise stated, data is obtained from the following sources throughout the paper: (1) yearly energy reports, statistical data and proceedings of the energy congresses of Turkey, published by the WEC TNC (World Energy Council, Turkish National Committee), since 1953 and (2) several publications by the MENR the SPO (State Planning Organization of Turkey), and the State Institute of Statistics of Turkey (SIS).

2. A general outlook of energy and socio-economics

Turkey is one of the largest countries in Europe, covering an area of 779,452 km^2. 97% of her land lies in Asia, whereas only 3% lies in Europe. Since the population has been determined as 62.8 million in the 1997 census, the average population density is about 80 persons per square kilometer. However, the three biggest cities, İstanbul, Ankara and İzmir, are inhabited by nearly one quarter of the country's population. The annual rate of increase in population varied from a minimum of 1.059% in 1945 to a maximum of 2.775% in 1960.

Although the country produces and consumes all kinds of energy resources, imports supply more than 60% of the energy requirement of Turkey. In 1999, primary energy consumption was

76.6 million toe, while production was 27.1 million toe, and only 35% of demand was met by domestic sources. The energy demand will depend on imported energy in the coming future, more than at present, for instance, 72% in 2010 and 76% in 2020 [9].

The rate of increase of energy demand is traditionally high, varying from a minimum of −5.73% in 1979 to a maximum of 11.59% in 1972, with an average of 5.12% in the period between 1951 and 1999. The rate of increase in electricity demand is even higher than this, varying from a minimum of 3.9% in 1999 to a maximum of 18.4% in 1976, with an average of 9.52% in the period between 1970 and 1999. The economic growth of Turkey has also been rapid, resulting in a GDP growth rate that varies from a minimum of −6.4% in 1999 to a maximum of 12.8% in 1951, with an average of 5.2% in the same period. The World Bank recorded, in 2000, that Turkey had a GNP of $200.5 billion (1998 US dollars), ranking 22nd, and a GDP per capita of $3160, ranking 89th in the world in 1998 [10].

Economic growth resulted in energy consumption per capita increasing from about 150 koe (kilogram of oil equivalent) in 1923 to 1190 koe in 1999. Among other parameters that measure energy–economy interactions, the average energy intensity and coefficient of elasticity of Turkey between 1990 and 1999 are 0.31 and 1.19, respectively. They are typical for middle to low income countries, as shown several times previously [11–13], but these figures are expected to increase until a certain GDP per capita level has been reached.

Turkey's energy system is based primarily on fossil fuels. The fossil fuels' share in overall energy consumption of the country increased from 36.4% (2.5 million toe) in 1950 to 86.7% (66.4 million toe) in 1999. The annual rate of increase of this share was much higher before the 1973–1978 oil crises period than after the shocks. On the other hand, the use of non-commercial sources, such as wood and animal or plant wastes, that are traditionally high, decreased to about 8.9% in 1999. The remaining 4.4% is hydro, geothermal and solar energy.

3. History and review of the previous forecasts

Although some discrete efforts for the application of mathematical modeling to simulate the Turkish national energy system were made during the late 1970s [14–17], the official use of such methods in energy planning and national policy making by the Ministry was realized only after 1984 [18]. The forecasts made before 1984 were simply based on various best fit curves by the SPO in 1966, 1967, 1972, 1977 and 1979 and by the MENR in 1973, 1975, 1977 and 1978 [18,19]. These forecasts consistently predicted much higher values than the consumption that actually occurred.

The year 1984 has been a milestone, not only for the Turkish economy but also for energy planning and estimation of future energy demands by applying modern econometric techniques (Fig. 1). The World Bank recommended the MENR use the simulation model MAED (model for analysis of energy demand) and WASP III (Wien automatic system planning), which were originally developed by the IAEA (International atomic energy agency), for determination of the general energy and electricity demands, respectively [18–21]. MAED is used to forecast the medium and long term energy demand, considering the relationships between several factors that affect the social, economical and technological system of the country [19,20,22]. The WASP has used MAED's results to develop the optimal production–investment plans [21].

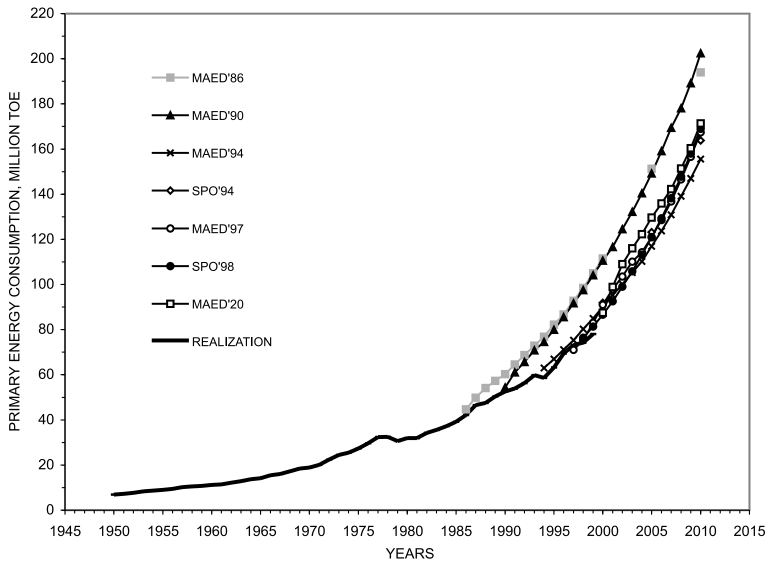

Fig. 1. Important MAED applications and some projections by the SPO and realization in Turkey between the 1950–2010 years.

The first effort to include socio-economic data into energy modeling, before MAED, had, in fact, been made by the MENR in 1984. Three scenarios were developed in this model. The first one was pessimistic, assuming no change in the existing energy policy; the second one was optimistic, assuming significant radical changes; and the third one, which was also used in the fifth five year development plan by the SPO, was more realistic than the others.

Several authors developed other econometric models. A model called MOCEP (multiple objective clean electricity production) analyzed the power plant capacity in 2004 [23]. The energy demand model called EFOM-12 C Mark I, that was developed by the Commission of the European Communities in 1984, was applied to Turkey for the period between 1981 and 1985 [24]. Kouris' correlation models were applied for forecasting the primary and secondary energy demands in Turkey for the period between 1970 and 1992 [25]. The BALANCE [26] and IMPACT [27] models were used in the context of ENPEP (energy and power evaluation program) for the long term supply and demand projections. In the most recent models, a special emphasis was given on the energy–economy environmental interactions [28,29].

Two of the note worthy models were officially developed by the SPO [30] and by the SIS [18] (Fig. 1). The SPO econometrically modeled the sectoral energy demands for different consumer groups. These groups were separated into subgroups, and mathematical models for each consumer group were developed by regression analysis. Comparing the correlation coefficient values, the best models were then chosen. The SIS, on the other hand, investigated the relationship of several demographic and economic parameters with primary energy demand to develop a model by using the Durbin–Watson statistical test. Both models, in which the most meaningful relationship of energy demand was found to be with GDP, reached results similar to those in MAED'97.

4. Analysis of MAED applications

Although several versions were prepared for various purposes, MAED was basically applied five times in 1986, 1990, 1994, 1997 and 2000 in Turkey (Fig. 1). The projections differ from each other considerably, but the earlier MAED applications (1986 and 1990) are closer to each other than the later applications (1994, 1997 and 2000). The MAED's later applications estimated similar figures to two projections by the SPO.

The rate of success of MAED applications is studied by plotting the deviation of the prediction from realization in million toe in Fig. 2. The deviations range between 2.497 and 26.883 million toe for the 1986–1999 years in MAED'86, between 1.724 and 25.968 million toe for the 1990–1999 years in MAED'90, between 4.295 and 6.939 million toe for the 1994–1999 years in MAED'94 and between −2.200 and 4.972 million toe for the 1997–1999 years in MAED'97. For 1999, however, MAED'86 estimated 34%, MAED'90 estimated 33%, MAED'94 estimated 9% and MAED'97 estimated 6% more than the realization. This shows that MAED applications also give similar results for the near future but differ greatly over longer periods of time, as frequently observed in the world (see also Ref. [4]).

The demographic and economic parameters for the future, which are used in MAED applications, are estimated by the SPO. However, the SPO's estimates are usually more like "targets", significantly influenced by the governments' policies rather than "forecasts" determined scientifically. Another problem with the estimates is that they are usually based on inadequate data of the past. For instance, the demographic data is available only for ten census years since 1950, and the absence of a set of economic parameters with prices fixed at a single year makes the comparisons difficult.

These problems cause the deviations of the data used in MAED applications to reach to about double that of the realizations. For instance, for the periods between the 1985–1990, 1990–1995 and 1995–2000 years, MAED used the GNP growth rates of 6.0–7.0%, 7.0–8.0% and 7.0–7.5% in

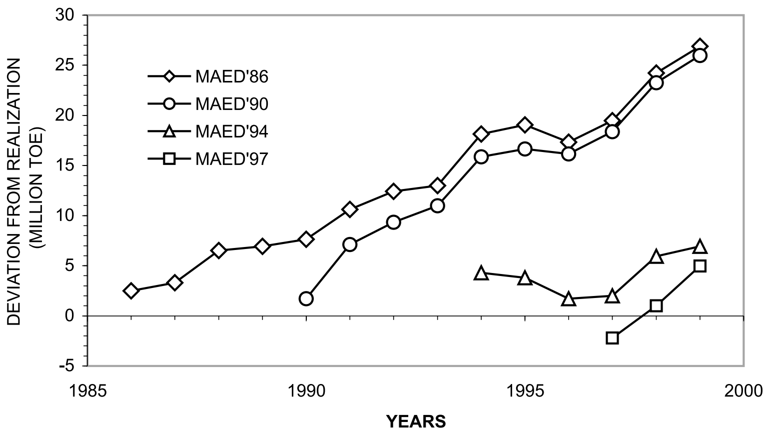

Fig. 2. Deviations from realization in the MAED applications between the 1986–1999 years.

Table 1
Demographic and economic data for each census year

	1950	1955	1960	1965	1970	1975	1980	1985	1990	1997
Population (million)										
Total	20.947	24.064	27.754	31.391	35.605	40.347	44.736	50.664	56.473	62.865
12 + Labor force	14.333	15.983	18.171	20.538	23.280	26.945	30.539	35.339	40.783	43.054
15 + Labor force	12.928	14.589	16.327	18.242	20.726	24.017	27.303	31.654	36.727	38.297
Employment	9.092	11.660	12.501	13.557	15.118	17.098	18.522	20.556	23.381	24.669
Urban	5.244	6.927	8.859	10.805	13.691	16.869	19.645	26.865	33.326	40.882
GNP (billion TL)										
Total	10.826	15.917	19.929	25.413	34.468	46.275	50.869	63.989	84.591	114.874
Industry	1.421	2.341	3.121	4.921	6.039	9.514	10.424	15.116	21.872	32.336
Services	4.974	7.608	9.330	12.650	17.832	25.444	28.157	36.476	48.972	67.987
Energy consumption (million toe)										
Total	6.922	8.966	11.208	14.204	18.849	27.381	31.913	39.167	52.632	73.257
Commercial	2.524	3.967	5.320	8.318	12.876	20.598	24.231	31.417	45.425	66.237

1986; 6.4%, 6.8% and 6.2% in 1990; and 5.7%, 4.8% and 6.0% in 1994, respectively [19,20,22], but the realizations for the same periods have been around 4%, 3% and 4%, respectively.

In addition to the failure in successfully estimating the data used in MAED applications, the effectiveness of the "critical" parameters in determining the future energy consumption has not been questioned properly. Therefore, in this study, the answer to this question is first investigated statistically.

The World Energy Council (p. 40) noted that "the main parameters driving energy demand are not independent; demography, economic growth, environment, energy intensity and technology are part of an intricate fabric of individual behavior and investment..." [7]. In MAED applications, the demographic data consist of total population, labour force (12 and 15 years over populations), employed population, and rural/urban population, whereas the economic data consists of GDP and its sectoral distribution, such as industry and services (Table 1).

The correlation coefficients between the dependent variable (total energy consumption) and independent variables (regressors) are calculated to vary between 0.920 and 1.000. This shows that an almost perfect relationship exists, not only between the variables, but also between the regressors themselves. Therefore, multiple regression analysis could not be applied to our data due to harmful multi-colinearity [31].

Since the individual effects of all these regressors on the independent variable are more or less the same (Table 2), a simple regression (trend) model seems to be the most reasonable technique for prediction of the future energy demand. Otherwise, forecasting in the multiple regression approach would be an additional source of errors. After applying various time series methods, including prediction and smoothing, and comparing their mean square errors [32], it is found that the Winters' exponential smoothing method is the best one, giving the best fit model of the observed data (Fig. 3). This method estimates the energy demand of Turkey to be 79.66 million toe in 2000, 102.56 million toe in 2005 and 130.50 million toe in 2010.

Table 2
Coefficients of simple linear regression model for predicting total energy consumption

Predictor	R-square	*F*	t	Significance level
Year	0.906	77.500	8.803	0.000
Total population	0.945	137.074	11.708	0.000
12 + Labor force	0.940	125.871	11.219	0.000
15 + Labor force	0.938	120.455	10.975	0.000
Employment	0.925	99.306	9.965	0.000
Urban population	0.986	564.966	23.769	0.000
Total GNP	0.998	4093.621	63.981	0.000
Industry	0.992	1026.405	32.038	0.000
Services	0.999	9506.399	97.501	0.000
Commercial energy consumption	0.999	5679.064	75.360	0.000

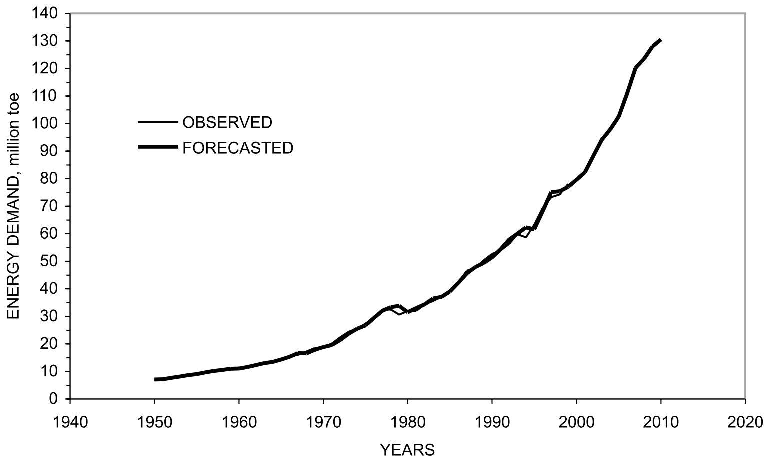

Fig. 3. Observed and forecasted curves estimated by Winter's exponential smoothing method for the 1950–2010 years.

5. Analysis of cyclic patterns in primary energy consumption and GDP trends

5.1. Total amounts

The historical curves of the total amount of primary energy consumption in million toe and of total amount of GDP in billion Turkish Liras (TL) at 1987 prices for the period between 1950 and 1999 can be subdivided into three gradually increasing segments, which are separated by two "unusual events" (Fig. 4). These events seem to be the decreases in both curves, which occur in 1979 and 1994 randomly, rather than periodically. It is known that a revealing feature of the primary energy trends of the world's market economies is the impact of two oil shocks in April 1979 and in September 1980 [30]. In Turkey, however, a well marked demand reduction also occurred in 1994 as a result of local economic crisis.

The energy demand first increases from 6.922 million toe in 1950 to 32.511 million toe in 1978. Then, following a decrease to 30.648 million toe in 1979, it increases again to 59.845 million toe in

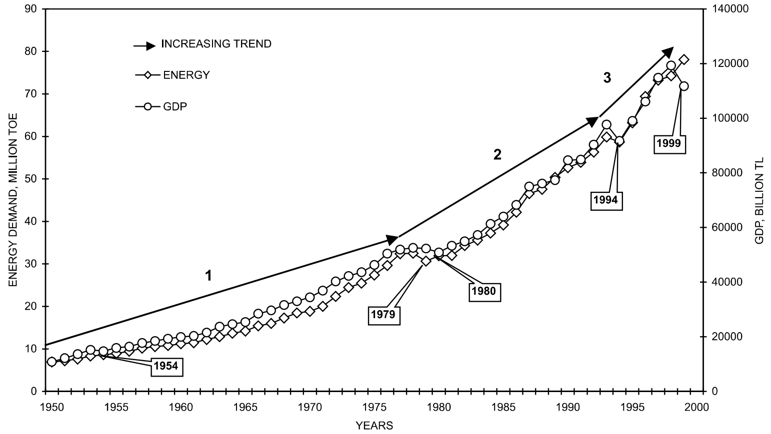

Fig. 4. Total amounts of energy demand and GDP curves for the 1950–1999 years.

1993, forming the second segment. The second decrease from 59.845 to 58.675 million toe occurs between 1993 and 1994. The third segment continues until 78.07 million toe in 1999. Although decreases in GDP occur five times in 1954, 1979, 1980, 1994 and 1999, the threefold separation is also meaningful for GDP. The first segment occurs between 10,826.9 billion TL in 1950 and 52,582.2 billion TL in 1978, the second segment occurs between 50,869.9 billion TL in 1980 and 97,676.6 billion TL in 1993 and the third segment occurs between 91,733.0 TL in 1994 to 111,684.0 billion TL in 1999.

5.2. Rate of changes

The rates of change in energy demand and GDP do not correlate with each other as well as the total amounts. The formula of the regression line between them is $y = 0.4172x + 3.0486$ with a determination coefficient of only 0.2999. In energy demand, the annual rate of change varies from -5.7% in 1979 to 11.6% in 1972, with an average of 5.1% for the period between 1950 and 1999 (Fig. 5). The annual rate of change of GDP varies from -6.1% in 1994 to 12.8% in 1951, with an average of 5.2% for the same period. The two period moving average curves on the frequency histograms show that comparatively uniform and unimodal distributions occur in energy demand and in GDP. The only exceptions are the minimum values in both.

The historical curve of rate of change in energy demand shows that the rates become negative only two times, one is -5.7% in 1979 and the other is -2.0% in 1994 (Fig. 6). Besides these two decreases, the minimum and maximum rates of increases occur as 0.238% in 1981 and 11.586% in 1972, respectively. On the other hand, the rate of GDP change becomes negative five times in the history of the country. The first one is -3.0% in 1954, the second one is -0.5% in 1979, the third one is -2.8% in 1980, the fourth one is -6.1% in 1994 and the last one is -6.4% in 1999. Besides the negative values, the minimum and maximum rates of increases are 0.3% in 1991 and 12.8% in 1951, respectively.

A total of 27 increases and 21 decreases in the rates of change in energy demand and of 22 increases and 26 decreases in GDP are recorded over the successive years. The rates of change in

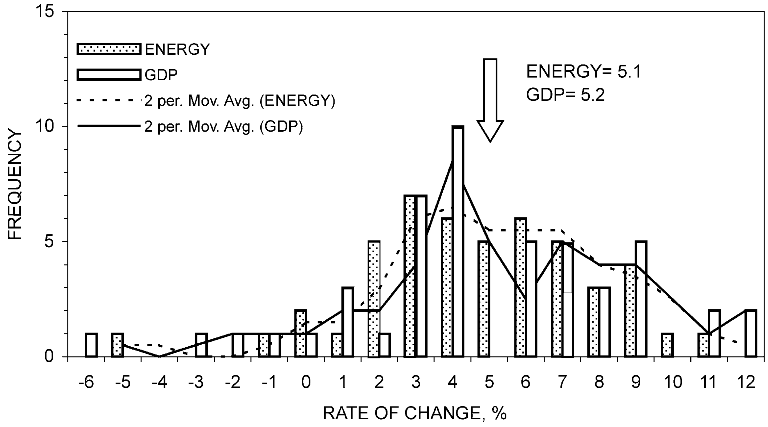

Fig. 5. Frequency histograms of rates of energy demand and GDP. Two period moving averages are shown on the bars. Arrow shows the averages.

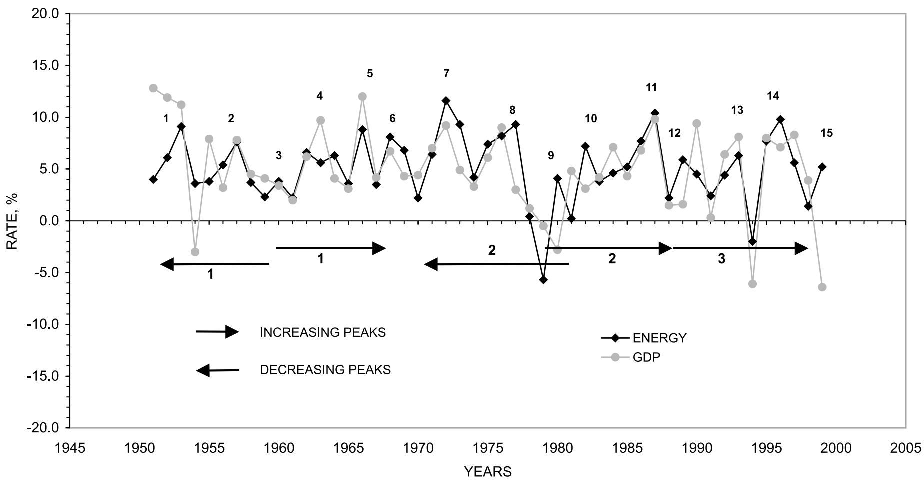

Fig. 6. Rates of change of energy demand and GDP curve for the 1950–1999 years.

energy demand and GDP increase together 16 times, decrease together 15 times and one increases while the other decreases 17 times. This means that they both respond similarly only 31 out of 48 times during 49 years between the 1951–1999 period.

The above data shows that rate increases are more consistent in energy demand than in GDP. In energy demand, the most successful years are the 1983–1987 period, in which the rates of increase changed gradually from 3.763% to 10.413% five years in a row. An increase in four successive years is recorded between the 1974–1977 years from 4.173% to 9.309%. In GDP, however, increases are recorded in a maximum of four successive years between the 1969–1972 years.

The increases or decreases in the rate of change in energy demand form fifteen recognizable peaks, of which six also occur at the same year in GDP. By studying the trends in three successive peaks in energy demand, it is found that the increasing trend occurs three times between the peaks

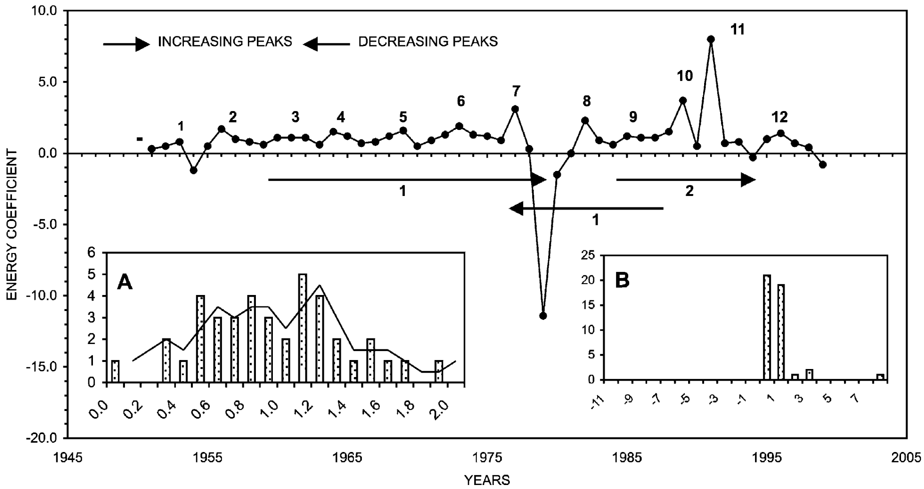

Fig. 7. Energy coefficient curve for the 1950–1999 years. The frequency histograms of 40 values between 0.0 and 2.0 (A) and of 44 positive values between 0.0 and 8.0 (B) are given in the lower graphs.

3–5, the peaks 9–11 and the peaks 12–14, and the decreasing trend occurs two times between the peaks 1–3 and the peaks 7–9. The increasing or decreasing trends seem to be distributed randomly.

5.3. Energy coefficient

The ratio of energy consumption rate/GDP rate, known as the energy coefficient, is one of the best parameters to indicate the energy/economy interaction. The frequency histogram of 40 out of 44 energy coefficient values shows that they have a relatively uniform and unimodal distribution and are in the range between 0.004 and 1.9 with a mean of 1.04 (Fig. 7). However, excluding the values of the five crisis years of 1954, 1979, 1980, 1994 and 1999, the range of the 44 energy coefficients becomes 0.04 and 8.0 with a mean of 1.2. These figures confirm the fact that an increase of 1% in GDP requires a 1.5% increase in energy use in an economy undergoing industrialization and a 0.5% increase in the mature industrialized economy [33].

Two increasing and one decreasing trends occur in the successive energy coefficient peaks. The peaks 3–7 and the peaks 9–11 form the increasing trends, whereas the decreasing trend consists of the peaks 7–9. These trends also seem to be distributed randomly.

5.4. Additional amounts

The historical trends of the amounts added annually to the primary energy demand and GDP are also investigated. The additional amounts of energy demand in million toe and of GDP in billion TL (in 1987) do not correlate well with each other (Fig. 8). The regression line has a formula of $y = 0.0003x + 0.8646$ with a determination coefficient of 0.3203. However, the peaks, especially of energy demand are aligned perfectly following a systematically increasing cyclic pattern.

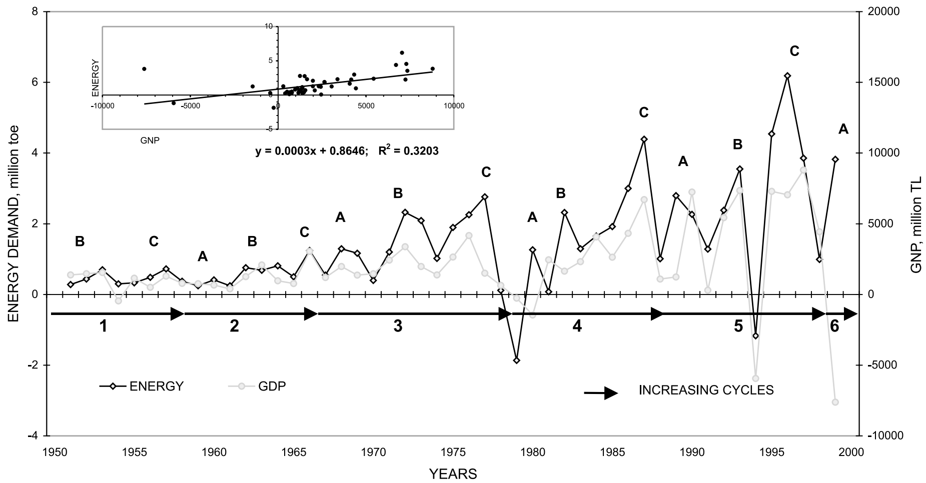

Fig. 8. Analysis of cyclic pattern in the additional amount of energy demand curve between the 1950–1999 years. The frequency histogram is given in the upper left graph.

Fifteen peaks, of which nine also occur in GDP in the historical curve of energy demand, are determined. These peaks are orderly aligned forming six repeated cycles (Fig. 8). Two of the cycles are not complete (the cycle 1 that ends in 1959 and the cycle 6 that starts in 1998), whereas the others are complete (the cycles 2–4). The complete cycles occur between 1959 and 1967, 1967 and 1979, 1979 and 1988, and 1988 and 1998. The time duration of the complete cycles ranges between 8 and 12 years with a mean of 9.5 years.

Each cycle is composed of three increasing successive peaks (A, B and C), the last one being always the biggest (Table 3). The biggest peaks of the cycles 1 through 5 occur in 1957 (1C), 1966 (2C), 1977 (3C), 1987 (4C) and 1996 (5C). The time intervals between these five peaks are 9, 11, 10 and 9 years, respectively. Therefore, the average duration of each cycle can safely be taken as 10 years. Using the pattern that occurred in the past can make forecasting easier, assuming that similar behavior will occur in the future. Therefore, the next biggest peak of cycle 6 (6C) can be estimated to occur in 2006.

The estimation of this peak's value is, however, not as easy as estimation of its time because of sharp changes between the peaks 1966 (2C) and 1977 (3C). For this, only the peaks 1977 (3C),

Table 3
Time and value of the smallest (A), medium (B) and biggest (C) peaks in the complete cycles

	Cycle 2	Cycle 3	Cycle 4	Cycle 5
A	1960 (0.413)	1968 (1.290)	1980 (1.265)	1989 (2.795)
B	1964 (0.809)	1972 (2.323)	1982 (2.317)	1993 (3.547)
C	1966 (1.244)	1977 (2.759)	1987 (4.391)	1996 (6.187)

Table 4
Total amounts of energy demand in million toe for the decade between 2000 and 2010, estimated by cycle analysis and Winters' exponential smoothing method

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Winters' method	79.66	82.29	88.34	94.10	97.88	102.56	110.88	120.22	123.53	127.99	130.50
Cycle analysis	80.77	81.97	84.97	90.9	91.69	99.69	110.07	118.07	123.07	125.07	131.44

1987 (4C) and 1996 (5C) are used in estimating the value of the peak in 2006 (6C). Calculating the best fit power and exponential trend lines can do this, since both have a correlation coefficient of 0.997 and estimates that are the closest values to the realizations. The peak of 2006 is estimated to be 10.39 million toe in power and 10.37 million toe in exponential trend lines with an average of 10.38 million toe.

Similarly, by using the smallest peaks in 1989 (5A) and 1999 (6A) and the medium peaks in 1982 (4B) and 1993 (5B), the medium peak of the cycle 6 (6B) is found to occur as 5.12 million toe in 2003 and the smallest peak of the cycle 7 (7B) as 6.37 million toe in 2010. Therefore, the energy demand of Turkey can be estimated to be 80.77 million toe in 2000, 99.69 million toe in 2005 and 131.44 million toe in 2010 (Table 4). Although the total amounts per each year differ slightly from the estimates by the Winters' exponential smoothing method [32], the values in the year 2010 are very close to each other. Using the values obtained by the cycle analysis of additional amounts, Fig. 9 completes the graphs of the total amount and rate. However, these figures should be considered as representing a "suppressed" demand environment and "optimistic" scenarios should be developed for better performances.

6. Concluding remarks

Forecasting, especially in energy demand, is usually considered an art, not a science [34], therefore some variations are to be expected, depending on the modeller's interpretation of one or another of the underlying relationships. Although forecasts of future energy consumption in many countries (e.g. Dorf, 1978, for the USA [34]) have traditionally turned out to be low, those in Turkey, frequently far off the mark, consistently predicted much higher values than actually occurred.

Two different historical curves are conventionally used in the world to examine the evolution of a country's energy demand through time. These are: (1) the amount of annual energy consumption and (2) the annual rate of change of energy consumption. However, neither of them provides a clear understanding of the country's yearly performance in developing her energy demand capacity. The first one emphasizes the level that is reached through time, and the previous year's performance is more reflected, obscuring how much is added per year in the second one. It is here found that the additional amount of energy consumption per year gives much better results for energy demand performance analysis than the total amounts and the rates. This is mainly because the additional amounts reflect the capability to consume and to meet it by production or import.

Several statistical methods are applied to such historical curves to estimate the future by examining the past, the simplest one being the best fit curves obtained by regression analysis.

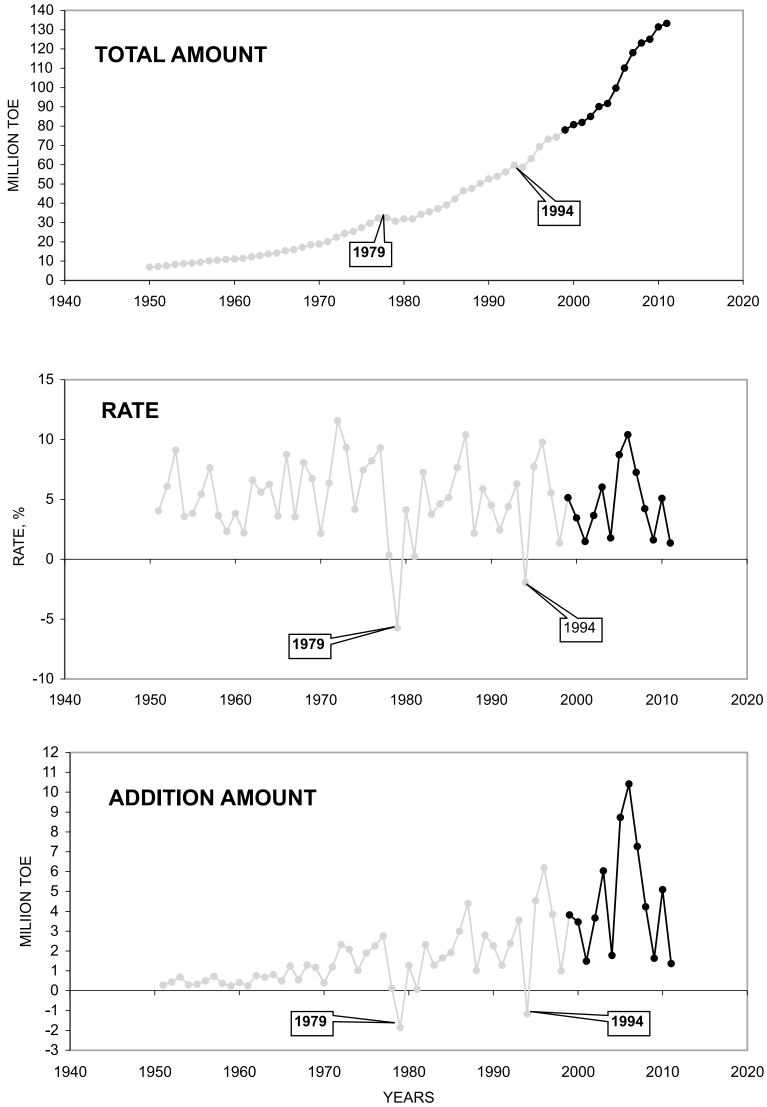

Fig. 9. Total amount, rate of change and additional amount of energy demand for the 1950–2010 years.

Among the complicated methods, history matching, auto correlation, filtering, time trend analysis etc. are also used. In this study, however, a method, which is commonly applied in geology to interpret and correlate well logs, fossil distribution curves or various sedimentological parameter curves is found to give better results than the complicated models for forecasts in developing countries as Turkey. The method simply includes examining the already existing trend for any cyclicity and, if a cyclic pattern exists, using the pattern for estimation of the future trend. The major assumption made in the analysis of the cyclic patterns can be summarized as "the past may be the key to the future", which means the events that occurred in the past will occur in similar manner in the future.

However, some catastrophic events may also occur, and it is always very difficult to foresee such "unexpected" events. For instance, the environmental absorptive capacity for pollutants and greenhouse gases, which are the ultimate constraints on fossil fuels [35,36], might also affect the future energy demand in Turkey similar to the other countries.

Another important factor affecting the energy demand in the world is the prices of energy. Although it has been noted that the primary energy consumption seems not to have been affected significantly by any increase in energy prices in Turkey [25], rapid changes in energy prices might be expected to affect energy consumption especially in energy importing countries.

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