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The Relationship Between Energy Consumption and Economic Growth: Evidence From A Structural Break Analysis For Turkey

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ABSTRACT: In this study the aim was to investigate empirically the role of energy consumption in economic growth for the Turkish economy. The data used include annual energy consumption and economic growth series from 1960 to 2008. We used aggregate as well as various disaggregate data on energy consumption, including, oil, electricity, coal and renewable energy. Our contribution is that we take a structural breaks modeling approach in this paper. In the literature, the Kejriwal cointegration test has not been applied to date. The main conclusion of the study was that Turkey's energy consumption and economic growth has a positive relationship varying quantity with structural breaks.

Keywords: Energy Consumption; Economic Growth; Cointegration with Structural Breaks; Turkey.
JEL Classifications: C22; O13; Q43

1. Introduction

Production and many consumption activities involve energy as a required input, making it a key source of economic growth. At the same time, economic growth may induce the use of more energy. However, with industrialization, energy in the production structure has been used extensively. With conventional energy sources used in this process, as the level of economic development increases, it is emerged in different types of energy. The stage of urbanization is closely related with the stage of industrialization.

The relationship between energy consumption and economic growth has been a well-studied topic in the field of energy economics because of the importance it has in present-day economies, ranging from developed economies to developing ones. Moreover, in addition to the increase in energy prices, the decrease in existing energy resources, the search for alternative energy resources and the use of these new resources also affect the relationship between energy and economic growth. The direction and level of the causal relationship play an important role in the determination of energy policies.

The question of whether there is a relationship between energy consumption and economic growth has attracted a great deal of research in the energy economics literature since the pioneering study of Kraft and Kraft (1978). To date, empirical findings have been mixed or conflicting with regard to causality. Findings obtained from studies vary according to whether the country studied is a developed or developing one, to difference in methods used in such studies, variables used in the model, variables used for the level and difference values and the data utilized. In addition, this inconsistency is related to differences in climatic conditions and energy consumption. Chontanawat et al. (2006) asserted that different results for different countries are not necessarily surprising given the many institutional, structural, and policy differences. For instance, according to Yoo (2006), the fact that there is no causal relationship between energy consumption and economic growth in Indonesia and Thailand results from the fact that electricity is mostly used for basic human needs and the remainder is used for economic activities in these countries.

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Morimoto and Hope (2004) reported that energy demand in Sri Lanka is mainly met by hydropower so that the electricity supply decreases drastically when the country is hit by serious droughts and this has led to a dramatic decline in its economic growth. In particular, serious droughts in 1996 meant that Sri Lanka experienced a severe power crisis that adversely affected the economy in 1996. Mahadevan and Asafu-Adjaye (2007) suggested that Nigeria and Venezuela do not exhibit a long-run relationship and it is possible that the political environment, as well as the high level of corruption in these economies, has blurred long-term economic behavior. Soytas and Sari (2006) proposed that the lack of consensus on the causal relationship between energy consumption and economic growth can be explained by economies having different energy sources and a different energy consumption pattern. Zhao et al. (2008) pointed out that countries are in very different stage of development and the development process may also have a significantly different impact on energy and economic growth relations, thus it may be unwise to expect consensus on the role of energy in economic growth. However, the lack of consensus for particular countries that have similar characteristics and are at the same stage of development is somewhat surprising. Masih and Masih (1997) proposed that this is primarily due to methodological differences in terms of the definition and specification of variables, the econometric techniques employed, and lag structures chosen. Zamani (2007) implied that since causality tests are sensitive to the time period and lag lengths, different results may be found for the same country. In the case of Taiwan, while Masih and Masih (1997) suggested the existence of a long-term relationship between energy consumption and economic growth by using the Johansen cointegration test and vector error correction model (VECM), Cheng and Lai (1997) indicated that the variables have no inherent co-movement tendency in the long-term. In this respect, Zhao et al. (2008) suggested that when a country is to be studied, both aggregated and disaggregated data with sufficiently long time periods should be examined.

The aim of this study is to re-examine the causal relationship between energy consumption and economic growth with structural breaks for the Turkish economy. The remainder of this paper is organized as follows: The next section presents a survey of the energy consumption-growth hypothesis. The third section introduces the data and methodology and the fourth section presents the empirical results of the study. The last section concludes the paper.

2. Literature Survey

The literature applied to demonstrate the relationship between energy consumption and economic growth has been synthesized into four testable hypotheses which include growth, conservation, feedback and neutrality. (Apergis and Payne, 2009; Abbasian et al. 2010; Fulei, 2010; Ozturk, 2010). The growth hypothesis claims that energy consumption has an important role in economic growth both as a direct input in the production process and indirectly as a complement to labor and capital inputs. Unidirectional causality from energy consumption to economic growth is consistent with the growth hypothesis. In other words, the economy is energy dependent and energy is a limiting factor to economic growth. In this case, energy conservation policies which reduce energy consumption may negatively affect economic growth or may cause poor economic performance. Some of the studies that found evidence of the growth hypothesis include the following: Yu and Choi (1985) for Finland, Masih and Masih (1997) for Taiwan and Thoma (2004) for the U.S.

The conservation hypothesis asserts that energy consumption is dictated by economic growth. If there is a unidirectional Granger-causality running from economic growth to energy consumption, this hypothesis is confirmed. If this is the case, it may be implied that energy conservation policies may be implemented with few adverse or no effects on economic growth (Paul and Bhattacharya, 2004). Cheng and Lai (1997) suggested that for newly industrializing countries in general, energy is an important factor in economic development. Production in industries such as manufacturing, construction and transportation demands a substantial amount of energy. Consequently, an increase in output influences energy consumption. Some of the studies that found evidence of the conservation hypothesis include the following: Kraft and Kraft (1978) for the U.S., Cheng and Lai (1997) for Taiwan, Aqeel and Butt (2001) for Pakistan, Hatemi and Irandoust (2005) for Sweden, Yong-Xiu, De-Zhi and Yan (2007) for Beijing, Zamani (2007) for Iran, Zhang and Cheng (2009) for China, Binh (2011) for Vietnam and Souhila and Kourbali (2012) for Algeria.

The neutrality hypothesis means that energy does not affect economic growth. In other words, any decrease or increase in energy consumption has no effect on economic growth. On the other hand, it is argued that since the cost of energy is a very small proportion of GDP, it is unlikely to have a significant impact; hence there is a “neutral impact of energy on growth” (Vlahinic-Dizdaravic and Zikovic, 2010). In addition to those specified, it has also been argued that the possible impact of energy use on growth will depend on the structure of the economy and the stage of economic growth of the country concerned (Ghali and Sakka, 2004; Mehrara, 2007). As the economy grows its production structure is likely to shift towards services, which are not energy intensive activities. Yu and Jin (1992) and Ozturk (2010) proposed that energy consumption is not correlated with economic growth, which means that neither conservative nor expansive policies in relation to energy consumption have any influence on economic growth. Some of the studies that found evidence of neutrality hypothesis include the following: Akarca and Long (1980) for the U.S., Yu and Hwang (1984) for the U.S., Yu and Jin (1992) for the U.S. and Payne (2009) for the U.S.

The feedback hypothesis, in which bidirectional causality exists, proposes that energy consumption and economic growth affect each other simultaneously and may serve as complements. In this case, policy makers should take into account the feedback effect of real GDP on energy consumption by implementing regulations to reduce energy use. Additionally, economic growth should be decoupled from energy consumption to avoid a negative impact on economic development resulting from a reduction in energy use. A shift from less efficient energy sources to more efficient and less polluting options may establish a stimulus rather than an obstacle to economic growth (Belke et al, 2010). Some of the studies that found evidence of the conservation hypothesis include the following: Hwang and Gum (1991) for Taiwan, Hondroyiannis, Lolos and Papapetrou (2002) for Greece, Paul and Bhattacharya (2004) for India, Ghali and El Sakka (2004) for Canada and Hou (2009) for China.

Table 1. Overview of previous studies for Turkey

Authors	Period	Variables	Methodology	Conclusion
Soytas, Sari and Ozdemir (2001)	1960-1995	-Real GDP, -Energy Consumption	-Johansen Cointegration Test, -VECM	$EC \rightarrow Y$
Altinay and Karagol (2005)	1950-2000	- Real GDP, -Electricity Consumption	-Dolado-Lutkepohl Causality, -Granger Causality	$Elec. \rightarrow Y$
Erdal, Erdal and Esengun (2008)	1970-2006	-Real GDP, - Primary Energy Consumption	-Johansen Cointegration Test, -Pair-wise Granger Causality	$EC \leftrightarrow Y$
Erbaykal (2008)	1970-2003	- Real Income, - Electricity Consumption, - Petroleum Consumption	-ARDL	$Elec., P \rightarrow Y$
Acaravcı (2010)	1968-2005	- Real GDP, - Electricity Consumption	-Johansen Cointegration Test, -Granger Causality	$Elec. \rightarrow Y$
Ozturk and Acaravci (2010)	1968-2005	-Real GDP, -Energy Consumption, -Carbon Emissions, -Employment Ratio	-ARDL -Granger Causality	*No Causality*
Kaplan, Ozturk and Kalyoncu (2011)	1971-2006	-Real GDP -Energy Consumption, -Real Energy Prices, -Capital, -labour	-Johansen Cointegration Test, -Granger Causality	$EC \leftrightarrow Y$
Acaravci and Ozturk (2012)	1968-2006	-Real GDP, -Electricity Consumption, Employment Ratio	-ARDL -Granger Causality	$Elec. \rightarrow Y$
Ozturk and Acaravcı (2012)	1960-2007	- Real Income, - Energy Consumption, -Carbon Emissions, -Openness -Financial Development	-ARDL -ECM	$EC \rightarrow Y$

Notes: E $\rightarrow$ Y (or Elec. $\rightarrow$ Y) denotes causality runs from energy consumption to income. E $\leftarrow$ Y (or Elec. $\leftarrow$ Y) denotes causality runs from income to energy consumption. E $\leftrightarrow$ Y (or Elec. $\leftrightarrow$ Y) denotes bi-directional causality between income and energy consumption.

As mentioned above, the survey also shows that previous studies on the causal relationship between energy consumption and GDP are somewhat contradictory in terms of the four hypotheses. Table 1 summarizes the earlier empirical findings between energy consumption and economic growth for Turkey.

As a result, the study of the issue in the Turkish case shows contradictory results in terms of the existence and direction of the relationship between energy consumption and economic growth. Thus, this subject is similar to the literature in the world and Turkey.

3. Data and Methodology

In this study we used aggregate as well as various disaggregate data on energy consumption, including oil, coal, and electricity. The variables used in the model are: GDP, real gross domestic product; ENERGY, total final energy consumption (ktoe); OIL, total final energy consumption of petroleum products (ktoe); COAL, total final energy consumption of coal and coal products (ktoe); ELEC, electricity in total final energy consumption (ktoe); and RENEW, combustible renewables and waste (ktoe). All variables are employed in their natural logarithmic form. Annual data from 1960 to 2008 were obtained from the International Energy Agency (IEA, 2010) CD-ROM; the International Monetary Fund and the International Financial Statistics (IMF-IFS, 2011) CD-ROM for Turkey.

Structural changes occurring in an economy alter the structural properties of data which are an indicator of the economy. The analysis of whether the structural changes at hand have an impact on the characteristics of a time series is carried out by testing whether there is a change in the average and trend of a series and whether the average and trend change the integration level of the series. This study is composed of two stages. In the first stage of analysis we apply the Lee-Strazicich unit root test with structural breaks. The second stage was introduced to determine whether there is a long-term relationship between the two variables by using the Kejriwal Structural Breaks Cointegration Test .

3.1. The Unit Root Test

Prior to the cointegration test with structural breaks, variables are taken into consideration as to whether or not they are stationary in the presence of structural breaks. Indeed, in the presence of a break under the null, researchers might incorrectly conclude that rejection of the null indicates evidence of a trend-stationary time series with breaks, when in fact the series is difference-stationary with breaks (Lee-Stazicicich, 2003). In order to examine the stationarity of each variable, we employ the Lee-Strazicich (LS) test to examine the possibility of a unit root among these variables**.**

The Lee-Strazicich test is based on the Lagrange Multiplier (LM) unit root test suggested by Schmidt and Phillips (1992). Following Perron (1989), there are two structural break models. These models are Model A which allows for a one-time change in level and model C which allows for a change in both the level and trend. In Lee-Strazicich tests, breaks are determined endogenously. The two-break LM unit root test statistic can be obtained by estimating

$$\Delta y_t = \delta' \Delta Z_t + \phi \tilde{S}_{t-1} + u_t \qquad \tilde{S}_t = y_t - \tilde{\Psi} - Z_t \tilde{S} \qquad t = 2,...T \tag{1}$$

The unit root null hypothesis is described by $(\phi = 0)$. According to the LM test statistics it is decided whether or not series are stationary with a structural break. The critical values of Model A and Model C were reported by Lee and Strazicich (2003).

3.2. The Cointegration Test

This study utilizes the newly proposed Kejriwal (2008) test to examine the cointegration relationship between energy consumption and economic growth. Kejriwal and Perron (2006) proposed a sequential procedure which permits consistent estimation of the number of breaks and derived the null hypothesis of no structural change in a general model which allows both I(0) and I(1) regressors as well as multiple breaks. Kejriwal and Perron (2008) also proposed a procedure that allows one to test the null hypothesis of, say, k changes, versus the alternative hypothesis of k + 1 changes. This test is defined as shown in Equation (2)

$$SEQ_T(k+1|k) = \max_{1\le j\le k+1} \sup_{\tau\in\wedge_{j,\in}} \left\{ \frac{A_T(k) - B_T(\tau,k)}{\hat{\sigma}^2_{k+1}} \right\} \quad (2)$$

where $A_T(k) = SSR_T(\widehat{T}_1,...,\widehat{T}_k)$, $B_T(\tau,k) = SSR_T(\widehat{T}_1,...,\widehat{T}_{j-1},\widehat{T}_j,...,T_K)$ and $\Lambda_{j,e} = \{\tau : \widehat{T}_{j-1} + (\widehat{T}_j - \widehat{T}_{j-1}) \in \le \tau \le \widehat{T}_j - (\widehat{T}_j - \widehat{T}_{j-1})\in\}$. $\widehat{\sigma}^2_{k+1}$ is a consistent estimator of the long-term variance under the null hypothesis. The procedure is applied as follows: first we test for zero versus one break; if a rejection occurs we test for one versus two breaks and so on until a non-rejection occurs. The number of breaks is estimated as the number of rejections (Kejrival, 2008). Thus, the model takes into account the variations in the regime and is defined as shown in Equation (3)

$$y_t = c_i + z'_t\beta_i + \sum_{j=-l_T} \Delta z'_{t-j}\Pi_j + u^*_t \qquad (T_{i-1} < t < T_i) \quad (3)$$

for $i = 1,...,k+1$, where k shows number of breaks, and z_t is a q vector of $I(1)$ regressor. The break dates are obtained using the dynamic programming algorithm proposed in Bai and Perron (2003). (Kejrival, 2008).

Kejriwal and Perron (2008, 2010) consider the following linear regression model with m breaks (m + 1 regimes):

$$y_t = c_j + z'_{ft}\delta_f + z'_{bt}\delta_{bj} + x'_{ft}\beta_f + x'_{bt}\beta_{bj} + u_t \qquad (t = T_{j-1}+1,...,T_j) \quad (4)$$

4. Emprical Results

4.1. The Unit Root Test Results

The test statistics of the LS unit root tests were obtained for five variables (ENERGY, OIL, ELEC, COAL, RENEW and GDP). The results of the unit root test are presented in Table 2.

Table 2. Lee and Strazicich Unit Root Tests Results

Variables	λ Value	Model	Lag	Break Date	Test Statistic	critical t value
ENERGY	$\lambda_1: 0.2$ $\lambda_2: 0.6$	A	0	1971 1998	-3.29	-3.84
		C	2	1973 1999	-5.15	-5.74
OIL	$\lambda_1: 0.2$ $\lambda_2: 0.8$	A	1	1979 1993	-0.85	-3.84
		C	1	1973 2000	-3.91	-5.71
ELEC	$\lambda_1: 0.2$ $\lambda_2: 0.8$	A	1	1980 1983	-1.53	-3.84
		C	3	1973 2002	-5.91*	-5.71
COAL	$\lambda_1: 0.4$ $\lambda_2: 0.6$	A	2	1979 1981	-4.50*	-3.84
		C	0	1970 1998	-6.45*	-5.67
RENEW	$\lambda_1: 0.2$ $\lambda_2: 0.6$	A	3	1992 1997	-1.84	-3.84
		C	4	1970 1989	-4.13	-5.74
GDP	$\lambda_1: 0.2$ $\lambda_2: 0.6$	A	2	1971 1993	-3.34	-3.84
		C	3	1970 1999	-5.08	-5.74

This table is based on the variables, the λ value, models A (two breaks in the intercept) and C (two breaks in the intercept and trend), optimal number of lagged, break date, test statistic and critical t values. In the table, (*) marks indicate that the null hypothesis was rejected; in other words, given a structural break the variables are stationary at the level. Critical t values are provided for the 5% significance level. As shown in Table 2, the results of the LS unit root tests for levels and first differences show that, ENERGY, OIL and GDP appear to be I (1) at the 5% level of significance except for ELEC and COAL. Therefore the unit root null cannot be rejected at the 5% level for the variables ENERGY, OIL, RENEW and GDP and the unit root null can be rejected at 5% level for the two variables ELEC and COAL. In the series break dates coincide with the crisis in Turkey and worldwide.

4.2. The Cointegration Test Results

The Kejriwal technique is applied to test for cointegration between the variables. This determines whether a long-term relationship exists between economic growth and energy consumption. This technique, the dates of structural breaks in the cointegration relationship, and the coefficients of the regime proposed a methodology that offers internally. To determine the number of breaks between variables three information criteria are used: LWZ, BIC and SEQ. Table 3 reports the results of the Kejriwal (2008) tests.

Table 3. Kejriwal Cointegration Tests Results

Models	Number of Breaks		
	LWZ	BIC	SEQ
(1) $GDP = f(ENERGY)$	1	2	1
(2) $GDP = f(OIL)$	2	3	1
(3) $GDP = f(ELEC)$	1	4	0
(4) $GDP = f(COAL)$	2	3	0
(5) $GDP = f(RENEW)$	3	3	0

Table 3 presents the results of the number of breaks selected by sequential (SEQ) with LWZ and BIC information criteria. For Turkey, none of the models are significant, indicating a stable cointegrating relationship. The sequential procedure selects no break for models (3), (4) and (5). Hovewer the sequential procedure selects a single break for models (1) and (2). The first of these criteria on the basis of SEQ criteria and then LWZ criteria is applied to the structural break cointegration tests. Kejriwal test results are evaluated by regimes as follows. The results of model (1) are shown in Table 4.

Table 4. $GDP = f(ENERGY)$ Model with Kejriwal Structural Break Cointegration Test Results

Break Date	Regime and Regime Period	Constant Coefficients and Standard Errors of the Regimes	Slope Coefficients and Standard Errors of the Regimes
1968	1. Regime (1960-1967)	-0.401(0.018)*	1.121(0.009)*
	2. Regime (1968-2008)	-0.115(0.142)	1.077(0.024)*

* indicates that the estimated coefficients are statistically significant.

As seen in Table 4, the break date of the model is the year 1968 and this year is before the oil crisis. In addition, the slope coefficient decreased after the first break. This situation weakened the relationship between ENERGY and GDP. In this model, the coefficients are significant except for the constant coefficient of the second regime.

As seen in Table 5, there is one break in this relationship in 1972. The oil crisis in the 1970s also influenced the nature of the relationship between energy and economic growth and after the crisis the link between oil consumption and economic growth further strengthened. This situation shows the important effect of the oil crisis on the economy. In this model, the coefficients are statistically significant.

Table 5. $GDP = f(OIL)$ Model with Kejriwal Structural Break Cointegration Test Results

Break Date	Regime and Regime Period	Constant Coefficients and Standard Errors of the Regimes	Slope Coefficients and Standard Errors of the Regimes
1972	1. Regime (1960-1971)	6.809(0.094)*	0.426(0.064)*
	2. Regime (1972-2008)	-0.495(0.188)*	1.201(0.231)*

* indicates that the estimated coefficients are statistically significant.

Table 6 presents the results of the $GDP = f(ELEC)$ model. According to these results, the cointegration relationship between GDP and the ELEC variable for the year 1997 was a structural break. The main feature of 1997 is that, the use of natural gas began to spread across the country and it increases the weight of natural gas consumption in electricity production. This situation is a factor that affected the nature of the relationship between electricity consumption and economic growth.

Table 6. $GDP = f(ELEC)$ Model with Kejriwal Structural Break Cointegration Test Results

Break Date	Regime and Regime Period	Constant Coefficients and Standard Errors of the Regimes	Slope Coefficients and Standard Errors of the Regimes
1997	1. Regime (1960-1996)	7.153(0.010)*	0.486(0.006)*
	2. Regime (1997-2008)	6.780(0.026)*	0.534(0.009)*

* indicates that the estimated coefficients are statistically significant.

Table 7 presents the $GDP = f(COAL)$ model with Kejriwal Structural Breaks Cointegration Test results. Coal consumption is important for Turkey's economy due to the fact that local production resources are available. For this reason it is important due to its relationship to economic growth. As Table 7 shows, there are two breaks in this relationship in 1989 and 1995. Both of these break dates are important for the Turkish economy. In addition, the year 1989 was the peak year of liberalization in Turkey and this year witnessed significant economic challenges. The year 1995 was one in which the results of the April 5, 1994 decisions were seen at the highest level. Until 1989 coal consumption was seen to affect economic growth negatively. These breaks are likely to result from ineffective coal production just for the sake of coal consumption. The relationship has been positive since the early 1990s. In fact, these years saw an increase in privatization application, and therefore can also be said to have increased efficiency in the production of coal. The slope ratio that emerged after the second break in 1995 is higher than the ratio in the two regimes. In other words, the strength of the relationship between economic growth and coal consumption increased overtime. Finally, the coefficients of the model are statistically significant except for the slope coefficient of the second regime.

Table 7. $GDP = f(COAL)$ Model with Kejriwal Structural Break Cointegration Test Results

Break Date	Regime and Regime Period	Constant Coefficients and Standard Errors of the Regimes	Slope Coefficients and Standard Errors of the Regimes
1989 1995	1. Regime (1960-1988)	15.506(0.081)*	-0.689(0.039)*
	2. Regime (1989-1994)	4.911(0.053)*	0.719(2.182)
	3. Regime (1995-2008)	3.855 (0.100)*	0.863(0.222)*

* indicates that the estimated coefficients are statistically significant.

As Table 8 shows, there are three breaks in this relationship in 1978, 1986 and 1992. Of these, 1978 is remarkable in terms of marking the second oil crisis. Due to the low level of the economy, it can be argued the relationship between economic growth and renewable energy sources was at a very strong level until that date. As economy improves, the relationship in question reduces and even turns negative. This findings makes more sense. Indeed, intensive consumption of combustible renewables and waste negatively affect economic growth due to the fact that their productivity is low and this energy resource has a negative effect on environment. Finally, the coefficients of the model are statistically significant except for the slope coefficient of the fourth regime.

Table 8. $GDP = f(RENEW)$ Model with Kejriwal Structural Break Cointegration Test Results

Break Date	Regime and Regime Period	Constant Coefficients and Standard Errors of the Regimes	Slope Coefficients and Standard Errors of the Regimes
1978 1986 1992	1. Regime (1960-1977)	-85.826(0.171)*	11.054(0.105)*
	2. Regime (1978-1985)	-3.037(0.126)*	1.553(0.126)*
	3. Regime (1986-1991)	32.953(19.757)*	-2.427(0.947)*
	4. Regime (1992-2008)	22.962 (2.319)*	-1.286(1.232)

* indicates that the estimated coefficients are statistically significant.

5. Conclusion

In this study, we tried to explain the causal relationship between energy consumption and economic growth with structural breaks for the Turkish economy. The main conclusion of the study is that, Turkey's energy consumption and economic growth showed a positive relationship, varying quantity with structural breaks. These breakpoints, which occurred, during the 1970s, oil crises, were parallel to the structural transformation in the 1980s to liberalization, the 1991 Gulf crisis, the recent crises in 1994 and 2001 and the spread of natural gas usage across the country in 1997. In general, the relations between the consumption of energy sub-indices (especially oil) and economic growth strengthened over the years, meaning the estimated coefficients increased. In this case the energy dependence of the economy has increased.

At least one of the two policies must be applied in Turkey to meet imports largely of energy resources. These policies will decrease dependency on external energy resources and decrease the dependency of economic growth on energy consumption. In order to reduce the dependency of economic growth on energy consumption; energy saving measures should be encouraged both in the industrial sector and in the housing sector; in addition the sectorial structure of the economy should be improved in a way that it consumes less energy while supporting economic growth.

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