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SYSTEM DYNAMIC MODELING OF ENERGY NEEDS AND INVESTMENTS IN TURKEY, FORESIGHT OF 2023 AND POLICY IMPLICATIONS

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LIST OF ABBREVIATIONS

ASTEC	Japanese Science and Technology Agency
CEO	Chief executive officer
DSS	Decision Support System
GDPM	Goal Directed Project Management
GDSS	Group Decision Support Systems
GNP	Gross national product
IAEA	International Atomic Energy Agency
IRP	Integrated resource planning
KPSO	Knowledge-people-system-organization
KTEP	Kilo tons equivalent of petroleum (unit of energy)
LCP	Least-cost planning
MAED	Model for the Analysis of Energy Demand
MCDM	Multi criteria decision making
NISTEP	Japanese National Institute of Science and Technology Policy
OPEC	Organization of Petroleum Exporting Countries
SPO	State Planning Organization
TUSIAD	Turkish Industrialists and Businessmen Association
UnIG	University-Industry-Government
WASP	Wien Automatic System Planning

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ABSTRACT

There is an ineffective resource allocation in energy sector, causing energy cuts during critical times. Although there is vast amount of energy gap between supply and consumption, officials postpone capacity investments in energy sector.

This research seeks the solution for energy investment decisions to be effective than the past ones. System dynamics tool has been used to model the national energy system, testing new concepts about the decision mechanisms in energy investments. Knowledge about the investing sector has been indexed in order to view the resulting behavior of the system. Delphi technique is used as a tool for setting scenarios for the simulation of the model. Delphi technique is applied to participants over the Internet to speed up the session times. The research has demonstrated that the investment decisions in energy sector is affected by various forces, possibly not visible who are used to linear thinking and reasoning.

A further contribution of this work is development an energy-economy model, taking into consideration about all the interactions and behavior of the entire system.

Keywords : Energy policy, strategic planning, system dynamics, foresight, Delphi.

ÖZET

Ulusal enerji sektöründe verimsiz kaynak tahsisleri nedeniyle, kritik dönemlere rastlayan enerji kesintileri ve yetersizlikleri yaşanmaktadır. Ulusal enerji üretimi ile talep arasında oldukça büyük bir oranda açık olmasına rağmen, hala kapasite artırımı sağlayacak yatırımlar ertelenmektedir.

Bu çalışma, enerji yatırım kararlarının etkinliğini artırmak amacı ile yeni çözümler aramak üzere odaklanmıştır. Ulusal enerji sektörü literatüründe henüz bulunmayan, sistem dinamiği yaklaşımı kullanılarak, ulusal enerji sistemi modeli oluşturulmuş, yatırım ve politika kararlarının nedensel döngülerinin etkileri incelenmiştir. Enerji yatırım kararlarının ardındaki yeterli karar destek birikimi endekslenerek modele dahil edilmiş ve değişimlerinin sisteme etkileri analiz edilmiştir. Uzgörü araçlarından Delphi metodolojisi kullanılarak, sektörün 2023 yılına dek beklentileri tespit edilmeye çalışılmış, bunlar simülasyona senaryo olacak şekilde düzenlenmiştir. Uzgörü çalışmasını literatürdeki geleneksel yöntemlerden ileri taşıyarak, veritabanı uygulamaları ve İnternet üzerinden yürütmek üzere gerekli altyapı hazırlanarak kullanılmıştır. Çalışmanın sonucunda, enerji sektöründe yatırım politikalarını belirlemede kullanılabilecek, oyun mimarisinde bir model geliştirilmiştir. Karar verici, sektördeki temel politika değişkenlerinin girdileri ile oynayarak, sonuçları 50 yıllık bir perspektif için alabilir ve bu sonuçlara göre karar verebilir.

Bu çalışmanın devamında uzgörü çalışması, geliştirilen altyapı kullanılarak, daha geniş kitleleri kapsayacak şekilde uygulanabilir. Sistem dinamik model, enerji sektörünün ekonomi ile olan ilişkilerini de kapsayarak daha hassas sonuçlar üretebilecek hale getirilebilir.

1 . ENERGY POLICY PLANNING

1.1 Introduction

The motivation of this study results from the rapid change in the manufacturing sector's energy needs in Turkey and worldwide shift from conventional to renewable energy resources.

Investments in energy industry has not been managed properly so that demand and supply has not balanced, which cause ineffective resource allocation. Although there is vast amount of energy gap between production and consumption, energy utility construction postpone declarations and energy saving policy announcements appear on press. In other words, although it is accepted that Turkish Republic has a great potential and a positive acceleration to develop and flourish, recent energy investment and regulation decisions are going to force a recession in that sector.

In the new millennium, all countries want to lead others technologically and become advantageous by the help of their technological superiority. Maintaining technological superiority is expensive. So, all countries must find innovative ways to conduct its research to maintain technological superiority. A University-Industry-Government (Turkish Department of Energy) (UnIG) collaboration is a promising innovative approach that can help the country's level of technological superiority. UnIG collaboration is a tool to achieve this national goal. (Özkan, 1999)

In past two decades, business environment achieved lots of changes by the help of new ways of strategic planning and information technology. Because of these changes, manufacturing sector's energy needs has grown up with acceleration more than the energy production investments. In result of those achievements, business environment is in search of new ways to supply its energy needs against conventional energy resources, because fossil oriented energy resources are depleting.

1.2 Description of Research

This study is for decision makers of energy sector, because it will propose a model focused on the energy resources and energy needs of Turkey in coming 20 years.

1.2.1 Title

The title of this thesis is, **System Dynamic Modeling of Energy Needs and Investments In Turkey, Foresight of 2023 and Policy Implications**.

1.2.2 Purpose

The purpose of this study is to propose decision tools for Turkey's energy sector considering future production needs. Study will include a foresight project to identify and assess important issues and developments in the energy supply/demand sectors, and a system dynamics model to emphasize major investment and decision mistakes.

1.2.3 Scope of the study

The research will be focused on the foresight of upcoming technological improvements of producing and transporting, distributing and using energy. Using basic past data and the results of the foresight, strategic energy investment decisions will be discussed from a system dynamics point of view.

1.2.4 Hypothesis

The hypothesis which will be examined in this study is;

Conventional energy utility investment models are lacking of feedback mechanisms. A new way of modeling on energy production sector will be more sensitive to understand the results of investment decisions.

1.3 Methodology

The research reported here has been regarded as a complete project, and Goal Directed Project Management (GDPM) (Andersen, Grude, Haug, 1996) methodology used for carrying out the phases. In order to recover from conventional decision mistakes, strategic planners and decision makers should consider the feedback effects of the decisions. System dynamics methodology has been used to emphasize these effects. Because of the existence of numerous variables and interactions to handle, system dynamics seem to be the most proper approach for modeling. For either to propose a group decision support technique or to state the relationships between variables of the model, Delphi technique has been carried out via a specially designed web site and a specially constructed e-mail discussing group.

1.3.1 System dynamics as a methodology

Our lives are filled with events: birthday parties, graduations, job starts, product launches, retirements, arguments, agreements and storms. Because of their prevalence, events tend to fill our discussions. In terms of understanding our world, however, events turn out to have limited usefulness. These limitations are well recognized in the physical sciences. If a teacher were to stand in front of a class and drop a piece of chalk and ask the class "why did the chalk hit the ground?" the response, "because you let go of it" would generate a chuckle and quickly be dismissed. If, however, you were to put the same student into a suit and ask of her "why did stock prices fall?" the response "because the Federal Reserve announced that it was increasing interest rates" would be considered serious and correct.

One step back from events is the idea of behavior patterns. A behavior pattern is something that connects together a long series of events over time. The American Revolution was an event. The extent of suppression, resentment and taxation in the decades preceding the revolution were patterns of behavior. Once you step away from events and begin considering patterns of behavior questions such as "what caused..." are given a different and much deeper meaning. We are no longer searching for an event that precedes or corresponded with another event. Rather we are looking for sources of pressure and imbalance that cause things to change.

Structure is the set of physical and information interconnections that generate behavior. Inventory is the accumulation of production less shipments. Workforce changes with hires and attrition and hiring is based on the targeting of production to meet demand and correct inventory imbalances. The result of this is that the inventory level moves up and down (behavior) and we now have so many inventories that we are not profitable and the CEO has been fired (an event). Structure determines behavior and events are snapshots of that behavior.

The event — behavior — structure distinction is an important tool for understanding and working with problems. Ultimately, successful policies and interventions need to be changes to structure, so that behavior is improved and bad events become less frequent.

System dynamics provide us with tools to represent structure, and understand how it determines behavior. (Vensim Simulation Software Help Manual v3.0)

1.3.2 Goal directed project management (Andersen, Grude, Haug, 1996)

In today's business environment, there has been a dramatic increase in the use of project management in many areas. Since the concept of project management was introduced, there has been an interest in improving the tools and techniques for management of one-time management.

As a result of technological advancement, and sophisticated customer demands and competitive pressure, companies need to continuously improve their product and service or bring new products or services to the market as soon as possible. Rather than only a few ongoing projects, companies are dealing with large numbers of ongoing projects. So, today for being successful in these all ongoing projects, it is useful to determine mutual language. This language is Goal Directed Project Management approach.

GDPM is a new project management methodology developed by E. Andersen, K.V. Grude, and T. Haug. It contains procedures and tools, which support project management. GDPM shows how to organize resources in an organizationally complex situation. GDPM provides to determine goals, and break each goal down into controllable sub-goals. Lastly, GDPM provides monitoring all activities to achieve the main goal.

Goal Directed Project Management is a new methodology for managing projects successfully. Project management with special emphasis on human and organizational sides of the projects is important for both public organizations and private companies, if they desire to achieve their goals. As for sustained and measurable improvement, GDPM starts with a business or organizational goal and directs the whole management process towards the achievement of that goal. GDPM, in its central focus on developing understanding, involvement and commitment amongst those involved, is a key ingredient in managing successful and lasting change.

Goal directed project management provides the philosophy to direct changes towards a predefined goal. The concentration on intermediate and final results (milestones) ensures the effectiveness of the project. The characteristics include;

1. Clear formulation of objectives, split up into sub-goals,
2. Result oriented objectives,
3. Description of required changes relating to People, System and Organization goals,
4. Focus not only on planning, but also on managing,
5. Providing the simplest possible information regarding the plan as well as the control and the organization of the project.

The project manager not only focuses on changes in the technical aspect (System Implementation) but also on changes in aspect such as People and Organization (Business Improvement). By describing responsibilities and roles at each level, task allocation becomes more apparent to each party, resulting in more effective communication. This leads to full integration within organization.

1.3.2.1 People – system – organization - knowledge concept

The greater part of project literature concerns technical projects, such as construction of bridges, roads, airports or oil platforms. But there should be a broader perspective for project management. KPSO stands for people, system, organization and knowledge. KPSO projects are projects where development of a "system" (a physical product or object), and development of "people" (Members or customers of that organization.), "organizations" (Which produce procedures.) and "knowledge" (will occur simultaneously. This can be called as KPSO way of thinking in project management.

The KPSO concept emphasizes the importance of balancing all four elements, knowledge, people, system and organization. "S" stands for technical aspects of the project. It often represents what we can "touch and feel" in the project. For example, in a construction project, the new building is the "S". The most common failing in project work is to focus too strongly on the technical content.

In typical organizational development projects the situation is reverse. These are only concerned with developing people in the organization and relationships between them. There is not enough emphasis on developing systems (e.g. routines and procedures) that will support the changes required in the organization. KPSO projects are projects where the result should be a composite "product"; goals should be achieved in all "P", "S" and "O".

One of the most important and characteristic aspect of project work is the extent to which people involved in the project (who will use the results are invited to participate in the work. One extreme is the "purely specialist project", the other extreme is the "purely process-oriented project".

In purely specialist projects all the work is performed by specialists without any form of cooperation or consultation with the end users. There is no place for user cooperation. In purely process-oriented projects, on the contrary everyone is encouraged to become involved and the project is allowed to be dominated by whatever problems and possibilities the participants see as being most important at any given time. The process itself determines the progress of the project.

All KPSO projects are "mixed" projects. They contain elements both from the process-oriented approach and from the specialist project.

1.3.3 Delphi, a group decision support methodology

There are a number of important foresight tools that can be used in the main foresight stage of a technological project. International experience has demonstrated that the choice of the methodology is not a critical issue, and there is no single preferred technique for foresight.

An important component of foresight is to define expected and possible futures for science and technology developments through exercises that focus on technology forecasts. One technique widely used for this is the Delphi survey approach. This technique is a specialized methodology of technology assessment that obtained quantitative and qualitative data. Delphi surveys allow groups of experts to be consulted on a range of possible future developments in their respective fields. The questions include such issues as the expected time of realization of the development, and demand and supply variables connected with the development such as ranking of importance, and other factors including technical, institutional, cultural, cost and funding constraints, or the need for international collaboration etc.

RAND in the US first designed Delphi technique in the late 1940s for military purposes. It originated as a method for obtaining expert opinion by a structured communication process. Its use in technology forecasting became public in the early 1960s. (ASTEC)

1.3.4 Research methods

Literature review, Internet survey, exploratory interviews, technical consultation, web based modeling instructions (for Vensim software) and Delphi questionnaire methods has been used.

1.3.4.1 Literature review

There are quite a lot of books, articles, papers, conferences, and dissertations about energy investment modeling. But there is limited number of works on system dynamic modeling of Turkish energy sector. Literature review is the second chapter of this thesis. It is explained in Chapter II.

1.3.4.2 Internet survey

Search engines such as AltaVista, Yahoo, Excite, Web Crawler etc., electronic libraries such as SweatsNet and Citation Index CDs from Bogazici University Library has been used to obtain data about energy planning and system dynamics is used as internet survey. And plenty of data about energy planning and system dynamics has been obtained. These data are also available in Chapter II.

1.3.4.3 Questionnaire

Delphi technique has been used to aid determining relationships between variables of the system dynamics model. In order to speed up the sessions, web based surveying and groupwide e-mail communication techniques have been used. Application techniques and the results of the questionnaire will be explained in Chapter IV.

1.3.5 Software

Vensim v3.0 PLE has been used for system dynamics modeling and simulation. Microsoft Office tools (Excel, Word, PowerPoint and Access) and FrontPage Express has been used to carry out the works of Delphi survey, edit the thesis and prepare the presentations of the research.

MORN v2.0 has been used to collect and classify the literature survey data. MORN is a knowledge base system applied as an information infrastructure of the research project whose members (present members of MRG) are residing in different parts of country. The system is an object-based system where concept indexes, external and internal links can be attached to multimedia objects to visualize the steps of research activities, concepts and their relationship.

1.4 Definition of Terms

1.4.1 System Thinking

A system is a group of interacting, interrelated or interdependent components that form a complex and unified whole. A system's components can be physical objects that can be touched, such as the various parts that make up a car. The components can also be intangible, such as processes; relationships, company policies; information flows; interpersonal interactions and internal states of mind such as feelings, values and beliefs.

The body is a good example for system. Within the body, the circulatory system delivers oxygen, nutrients, hormones and antibodies produced by other systems and carries waste to the excretory system. The circulatory system is made up of the heart, veins and arteries, blood and a host of supporting elements. All of these components interact to carry out their purpose within the larger system, the entire body (Anderson and Johnson, 1997).

System thinking is a school of thought that focuses on recognizing the interconnection between the parts of a system synthesizing them into a unified view of the whole. System thinking can be a valuable tool at the outset of a system dynamics study. It can help bring together the people necessary to the success of the system dynamics study and can get them in a frame of mind that is open to new ideas (Richardson and Pugh, 1996).

1.4.2 System Dynamics, Defined

System dynamics is the field of study that includes a methodology for constructing computer simulation to achieve better understanding of social and corporate systems. It draws on organizational studies, behavioral decision theory, and engineering to provide a theoretical and empirical base for structuring the relationship in complex systems. System dynamics is the rigorous study of organizational problems, from a holistic or systemic perspective, using the principles of feedback and simulation.

System dynamics offers a source of direct and immediate feedback for students to test assumptions their mental models of reality through the use of computer simulation. Computer simulation is the imitation of system behavior through numerical calculations performed by a computer on a system dynamics model. A system dynamics model is the representation of the structure of a system. Once a system dynamics model is constructed and the initial conditions are specified, a computer can simulate the behavior of the different model variables over time (Arslan, 1999).

The science of "System Dynamics" was invented at Massachusetts Institute of Technology by Jay W. Forrester in the 1960's and has grow to world-wide acceptance as a powerful tool for modeling the behavior of complex systems. Professor Forrester recognized the need for a better way of testing new ideas about social systems, in the same way people can test ideas in engineering. Systems dynamics allows people to make their understanding of social systems explicit and improve them in the same way that people can use engineering principles to make explicit and improve their understanding of mechanical systems. The system dynamics methodology uses computer simulation to relate the structure of a system to its behavior over time (Arslan, 1999).

1.4.3 Decision Support Systems (DSS)

As Murray (1999) argues, DSS help business decision-makers solve unstructured problems. Although they appear to be used primarily by business managers at the moment, everyone in the knowledge-based organizations needs to make decisions based on an increasingly complex set of information variables. Delphi as a DSS and Group Decision Support technique will be introduced in depth later in this chapter.

1.4.4 Web-based DSS

The web opens up a host of new opportunities (and problems) for the use of DSS (Dennis, 1999). It is a computerized system that delivers decision support information or decision support tools to a manager or business analyst using a *"thin-client"* Web browser like Netscape Navigator or Internet Explorer.

The computer server that is hosting the DSS application is linked to the user's computer by a network with the TCP/IP protocol. Web provides universal access. Dennis (1999) indicates that once the DSS and communication software have been installed, it is truly simply to access a Web server on your local area network, a Web server elsewhere in your building, or a Web server anywhere in the world. The software makes no distinction where you are in relation to the server, something that is not possible with traditional LAN-based products.

In many organizations, a Web-based DSS is synonymous with an enterprise-wide DSS that is supporting large groups of managers in a networked client-server environment with a specialized data warehouse as part of the DSS architecture.

1.4.5 Models

A model is a generalized description of a decision environment. Sauter (1997) uses three different dimensions to describe models; representation, time dimension, and methodology dimension (complete enumeration, algorithmic, heuristic, simulations, and analytical).

1.4.6 Group Decision Support Systems (GDSS)

Since 1988, GDSS research has been reported in a number of articles and conference proceedings. (See George, et al., 1990, for a summary up to 1988. Other, more recent, examples include: Gallupe, et al., 1991; Aiken, 1992; Poole & Holmes, 1993; Scott & Easton, 1996)
As reported in these sources, GDSS is an interactive, computer-based system that facilitates solution of unstructured problems by a set of decision-makers working together as a group. DeSanctis & Gallupe (1987) originally defined a GDSS as a system that combines communication, computing, and decision support technologies to facilitate formulation and solution of unstructured problems by a group of people. According to

Milam & Vanjani (1995) whatever term is used, a GDSS today can be defined as a computer-based system that supports groups of people engaged in a common task and that provides an interface to a shared environment. A GDSS is a computer-based "social technology" (Turrof & Hiltz, 1993).

GDSS represents a hybrid technology, combining DSS and groupware technologies. It should have the components of a DSS as described previously. A typical GDSS consists of networked computer terminals, with a terminal for each group member. Group members interact electronically through communication of text-, graphics-, video-, or voice-based information or through a combination of electronic and face-to-face interaction. (Sosik & Avolio, 1998) As such, GDSS consist of hardware, software, and procedures for facilitating the generation and evaluation of alternatives as well as features for facilitating to improve group dynamics. Numerous prototypes GDSS have been developed, and several have come to market. (Ozkan, 1999)

2 . EXISTING STUDIES

2.1 Chapter Summary

This chapter discusses the problem that is stated in the previous chapter, and its solutions proposed by different individuals working in this field. Two main approaches will be examined, namely system dynamics and Delphi methodology as a foresight tool. Both approaches serve as decision support systems for clients. The author is going to test combining the results of the Delphi survey with the scenarios that will be implemented to the system dynamics model.

2.2 Review of Energy Planning Models

Any activity requires energy. Life is a sort of activity itself. Something which takes a great place in our life and which is quite limited in conventional terms must have an importance as a resource. Energy is one of the most important issues that can be considered in that place. Rising prices and depleting resources force us to reduce the usage and raise the effectiveness of resource consumption.

Turkey is an energy importing country. Because of that, she is vulnerable to oscillating energy prices and different interrelations. In order to satisfy the energy demand with a tolerable price, keeping national economic growth on a desired level, policy makers should decide on the right capacity order on the right time interval and on the right resource type. Decision on which primary resource will be used at which portion at what time in producing energy is a challenging question for energy policy makers. In following paragraphs, different methods, which have been used to aid decision makers of the energy sector, will be discussed. At first, it will be helpful to examine the national policy planning efforts. Further, different techniques about planning and modeling of energy sector will be discussed.

2.2.1 National Energy Planning Models

Turkish national energy policy planning studies vary in different fields. In order to understand the current problem, it is essential to classify and analyze the past work on this field. Prof. Dr. Kavrakoğlu from Boğaziçi University of Istanbul has carried out major work in the field. Also, there are significant works about energy planning from Tırıs, Kılıç and Keçecioğlu. These studies are discussed in the following parts.

2.2.1.1 Energy Systems Analysis

His latest publication about energy systems analysis contains major research reports and articles, which he carried out between 1975 and 1988 (Kavrakoğlu, 1988). He analyzes energy systems planning from different approaches. These can be listed as follows:

a. Basic physical concepts and the criteria involved in energy systems.

In this section, Kavrakoğlu discusses the rational criteria for energy utilization problem, thermodynamics of energy conservation and a systems approach to energy conservation progressively.

b. Electricity power system at the national level.

Articles in this section analyze the decision processes on a combination of alternative resources to produce electricity regarding economics to be balanced against long term risks and environmental factors.

c. National energy systems.

It is stated that the most challenging part of the series is to construct a model of a given economy because of the high degree of the integration and various substitution of resources.

d. Global petroleum market.

Kavrakoğlu develops a price estimation model of OPEC petroleum market in this article.

e. Review of the field of energy modeling and analysis.

This section consists of review articles of energy modeling and policy analysis.

2.2.1.2 Energy Models in National Development Plans

Tırıs analyzes National Development Plans of State Planning Organization (SPO) and proposes a model for long-term production and consumption forecasting in his MS Thesis (Tırıs, 1990).

Tıns reports that two kinds of forecasting models has been used for national energy planning activities. These are aggregate and disaggregate models. He states that aggregate models use comparatively less data, however depend on historical correlations and do not give the chance to update the parameters while the systems change. Disaggregate models have the capability to change the parameters but need quite much data including social, demographic, economic and technological compounds. Also it is stated that scenario building with these models supplies the user with flexible analysis.

It is reported in Tıns' thesis that Ministry of Energy and Natural Resources has been using a disaggregate model, which was proposed by World Bank and International Atomic Energy Agency (IAEA), Model for the Analysis of Energy Demand (MAED) since 1984. MAED uses functions for each energy consuming sub sector and computes a quantity of energy demand. The demand then is used as an input for Wien Automatic System Planning (WASP) model to find out the optimum supply for the sector. Tıns notes the importance and unavailability of reliable data for these type of models in developing countries like Turkey.

It is observed that national policy planning models use of a linear thinking generation which has no benefit to the sector. It is a fact that the energy demand and supply sectors are affecting each other in a dynamic manner rather than the structures used above. The resulting failures of such planning activities, which are mainly prepared by SPO will be discussed in the forthcoming parts.

2.2.1.3 An MCDM Model for Evaluation of the Future Profile of Alternative Resources

Tıns, has proposed a multi criteria decision making model (MCDM) for evaluation the future profile of alternative energy resource consumption of Turkey as a PhD Thesis. He develops a model for deciding the supply profile of the national energy sector under four distinct criteria. Each criteria is a unique supply choice about energy production shares. First criteria (in fact a scenario) takes the exact resource supply shares of Ministry of Energy and Natural Resources. The second one is an alternative energy emphasized scenario, the third one is a Nuclear ant the last one is a fossil energy emphasized scenario. He analyzes the future profile of energy supply under these criteria or scenarios and concludes with the resulting calculations. (Tıns, 1992)

It is clear that there is no casual relation between the supply and demand sectors of the model. Demand is computed or forecasted in different calculations and then put in another model for calculating the supply. It is an important question that whether the real life is going like that.

2.2.1.4 A Multiobjective Approach to Energy Planning Problem

Kılıç has put forward a multiobjective approach to energy planning problem by considering energy, economy and environmental relationships and constraints. (Kılıç, 1996) She uses multi criteria decision making methodology to find out the optimum energy production strategy considering the environmental constraints.

Although the subject and main idea is about the environmental issues in energy production, the research again lacks the interference between the demand and supply sectors. Since the difference in any kind of energy demand profile will affect the energy supply configuration in time.

2.2.1.5 Solar Energy in Turkey's Strategic Energy Planning

In his PhD Thesis, Keçecioğlu has used statistical analysis methods to state the relation between the variables of energy system in Turkey. Variables were chosen from recent reports on strategic energy planning works. Extrapolations has been derived from the regression equations, which were found in previous analyses. Conventional macro results have been stated in the conclusion of the report.

This research also uses linear algorithms to see what is going to happen in the near future, but does not consider the relations between the sectoral variables of energy economy.

2.2.1.6 Prime Ministry State Planning Organization's Programs

Plan 8, covering years 2001-2005, has been issued recently. All national plans from 1 to 8 have broad statements about implications but do not have any theoretical structure. There is statistical forecasting more than investment and project planning in the texts. Additionally, there are significant errors about the forecasting results of each forthcoming planning period. These errors vary between the range of –66 and +80 %. It is obvious that there is a vital problem in the methodology of foresight techniques of SPO in energy sector. Clear addressing to each existing or planned project owners of energy sector is needed to take place in the plans. There is a problem in reaching, analyzing and developing the decision and foresight models used in planning energy investments. SPO should share planning and forecasting models with universities and practitioners in order to have dynamic and up to date planning. Detailed analyses of periodical development plans of energy sector can be found in Appendix-A.

2.2.2 Turkish Scientific Research Council (TÜBİTAK)

TÜBİTAK has two reports about strategic planning of energy technologies. The first one is about Turkish energy policy; second one is about strategic technologic management about energy based on the 1997 Kyoto Protocol. The first report put some principles about energy production and consumption. The missing thing is that there is not any action plan or even a flow chart to implement these principles. None of the statements have an address to implement. The second report is a translation. Also this report is lacking the structure of a conventional strategic technology management methodology. (Betz, 1994)

2.2.3 Evaluation of Turkey's Energy Strategy

Turkish Industrialists and Businessmen Association (TÜSİAD) had Prof. Dr. Ültanır prepare this report to evaluate current energy policies. (TÜSİAD, 1998) This report has a detailed structure that covers current status of energy sector, resource reserves, potential development fields, simulation and forecasting information up to year 2025. Unfortunately, there is no information about the simulation or forecasting methodology. One significant case contains regression analysis and a forecasting data of 25 years, which is rather informal. This report also does not have a valid structure of strategic technology planning methodology. (Betz, 1994)

2.2.4 Lacking Common Piece In The Models

It has long been acknowledged that people seeking to solve a problem often make it worse. Our policies may create unanticipated side effects. Our attempts to stabilize the system may destabilize it. Our decisions may provoke reactions by others seeking to restore the balance we upset. Forrester (1971) calls such phenomena the "counterintuitive behavior of social systems". These unexpected dynamics often lead to policy resistance, the tendency for interventions to be delayed, diluted or defeated by the response of the system to the intervention itself (Sterman, 2000). The lacking pieces in the systems, which are explained above that tempt to stabilize or restore the system, are feedback mechanisms. Linear approaches to systems analysis incline to ignore important feedback effects. These effects are widely discussed in Sterman's recent work.

System Dynamics is a method to analyze the system as a whole containing the feedback mechanisms. It is a method to enhance learning in complex systems. Just as an airline uses flight simulators to help pilots learn, system dynamics is, partly, a method for developing management flight simulators, often computer simulation models, to help us learn about dynamic complexity, understand the sources of policy resistance and design more effective policies. (Sterman, 2000)

2.2.4.1 System Dynamics and Energy Policy Analysis

The history of system dynamics applied to energy models can be traced back to the early 1970s when research at MIT and Dartmouth was primary concerned with world dynamics. This included factors such as the limits of economic and population growth, depletion of resources and pollution (Forrester, 1971; Meadows et al., 1972). Separate studies soon followed to examine the evolution of energy resources. One of the first large energy models was COAL2, created for the U.S. government (Naill, 1977, 1992; Naill et al., 1992). This model was the basis for another model, FOSSIL2, which has played an important part in U.S. energy planning since the late 1970s. There have been a number of other studies of the U.S. energy system, including policy evaluation (Ford, 1983), investment and uncertainty (Ford, 1985), and conservation (Ford and Bull, 1989). Other studies have included broad aspects of the energy system (Sterman, 1983) and the effect of external agents on utility performance (Geraghty and Lyneis, 1985), and evaluation of whole utility systems (Lyneis, 1994); a petroleum life-cycle model was also developed by Davidsen and co-authors (Davidsen et. al., 1990).

A number of models have been developed to investigate parts of the European electricity industry, among them a model of inter-fuel substitution in the OECD countries (Moxennes, 1990). In the U.K., models have been used to investigate issues related to privatization of the electricity industry (Bunn and Larsen, 1992, 1994; Bunn, Larsen and Vlakos, 1993). Possible applications to the French system were explored (Roche, 1989), whilst a model developed for Eastern Europe combines both econometrics and system dynamics (Backus, 1994). Outside Europe there have also been a number of studies using system dynamics: in Argentina (Rego, 1989), Colombia (Dyner, Smith and Pena, 1993), India (Chowdhurg and

Sahu, 1992), and New Zealand (Bodger and May, 1992). Furthermore, the recently edited volume by Bunn and Larsen (1997) also includes a number of SD applications to the energy sector at large. (Bunn, Dyner and Larsen, 1997)

It will be helpful to examine two of the models mentioned above, in order to clarify the need to investigate the feedback loops. The first is the PhD thesis of Prof. Sterman. Second one is a professional system dynamics application for energy planning.

2.2.4.1.1 Energy Transition and the Economy

Prof. Dr. Sterman discusses the then current energy planning models and proposes a new model regarding the feedback mechanisms in the sectors of the economy. As discussed above, energy is one of the main inputs of national economy. Sterman anticipates that the energy resource transition would lead to an economic crisis if no measures were taken prior the event. He has a theory of transition that during industrial era of the United States, main energy input resource shifted from wood to coal and then to fossil fuel within 1850 and 1980. The transition of wood, coal and fossil fuel is explained in Figure 2-1 (Naill, 1977).

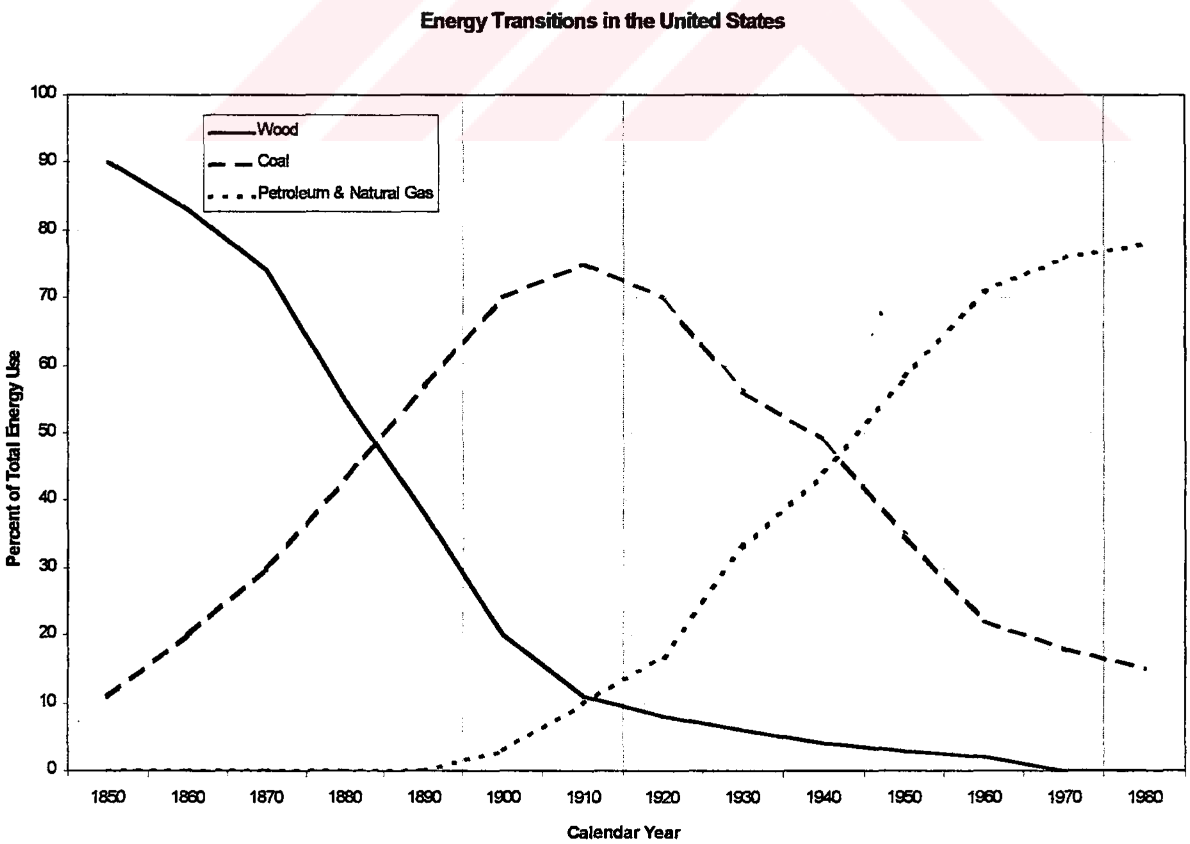

Figure 2.1 Energy resource transitions in the U.S. (Sterman, 1981)

During the new transition from petroleum and natural gas to alternative energy resources, Prof. Sterman aims to investigate and identify the structural mechanisms and disequilibrium dynamics that might prevent a smooth energy transition, explore their sensitivity to major uncertainties, and begin the analysis of policies to mitigate any that appear important. It is emphasized that the purpose was not to forecast energy use or the rate of economic growth, nor was it to predict that there would or would not be an energy-induced depression sometime in the 1990's.

2.2.4.1.2 Energy 2020

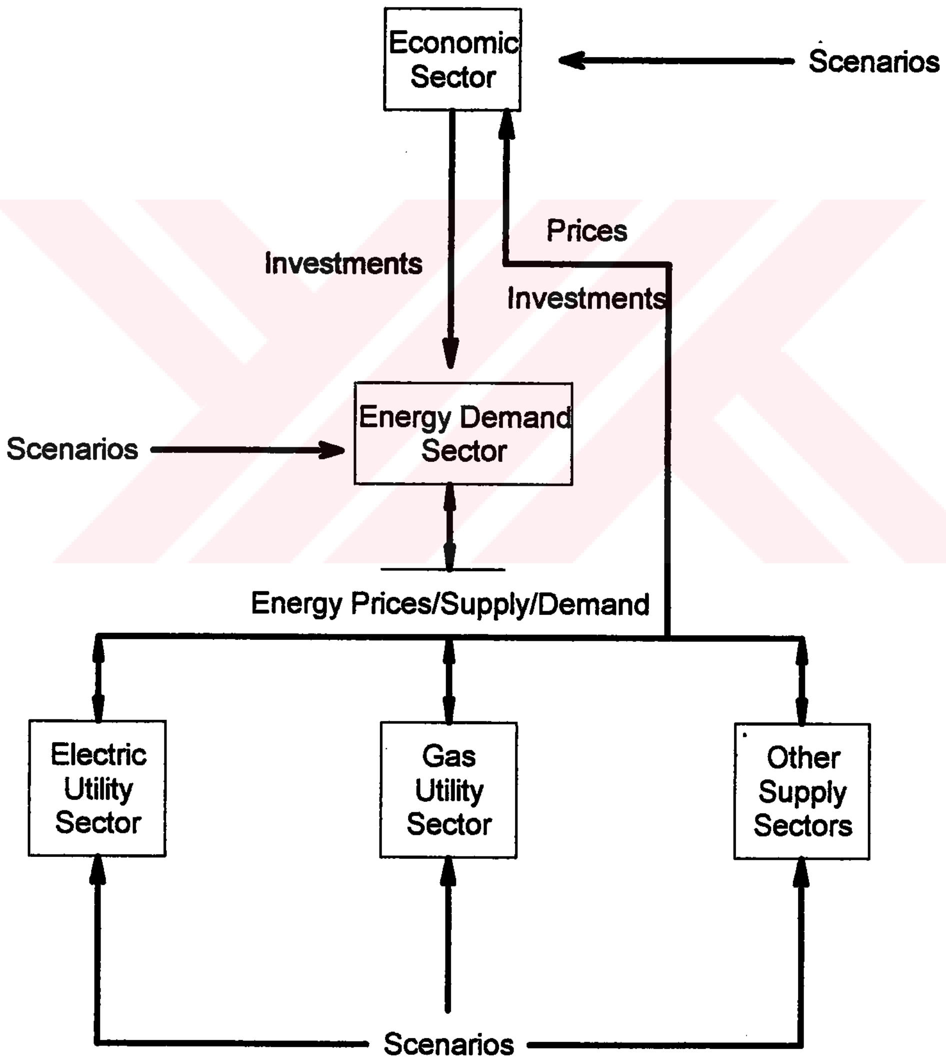

Figure 2.2 Overview of Energy 2020 Model

The main idea in the documentation of the professional energy policy planning software, Energy 2020 is "The only certainty in the energy business is uncertainty." The claim is that the model developed has a comprehensive structure capable of utilize a wide range of energy resources and simulate entire energy-economy relations. This provides the client to examine the interactions and feedback loops in potential problem areas.

Survival under these uncertain conditions requires rapid adaptation to hard-to-anticipate futures as they become reality. In an attempt to help utilities develop the flexibility they need, integrated resource planning (IRP) is now required for electric utilities in over twenty-five states and is gaining favor as a means of addressing the new competitive environment in the natural gas industry. For the most part, IRP is an extension of the least-cost planning (LCP) utilities now strives to do. IRP is supposed to incorporate more of both the supply and demand uncertainty surrounding utility markets. However, proposing a base case and only one or two additional scenarios - hardly a comprehensive representation of possible futures, usually performs both LCP and IRP. The utility's supply-planning, forecasting, DSM planning, finance, and rate departments iterate their detailed models in round-robin fashion, hand carrying their outputs between models, until an acceptable set of results are generated. The procedure is cumbersome, time consuming, prone to errors and much information is lost as output is moved from one model to another. It is a substantial undertaking, involving many staff members and scheduling and it generates an enormous amount of data. Yet it still only addresses a severely limited fraction of future outcomes. This time and staff intensive process does not encourage the "what if" analysis that so often leads to fruitful research and policy decisions under highly uncertain conditions. It offers no easy mechanism to test out ideas or try out strategies under a variety of potential futures.

Energy 2020 provides this missing mechanism, allowing planners to generate and compare "what if" scenarios in hours, not weeks. Energy 2020 encourages planners to think creatively and exhaustively about the future by removing much of the drudgery associated with planning and policy development. (Backus, Amlin and Freeman, 1993)

Energy 2020 is a complete commercial software package for industrial or governmental clients. It is the culmination process of a model development process that began in 1972. A special system dynamics modeling language PROMULA has been used to construct the model.

2.3 Foresight in Technology Management

The definition of foresight in Merriam-Webster Online Dictionary is:

a. An act or the power of foreseeing: prescience,

b. Provident care: prudence,

c. An act of looking forward (Merriam-Webster Dictionary, 2000).

Another resource defines foresight as, "Foresight is the ability to see what is likely to happen in the future, and the practice of taking this into consideration when you do things." (Collins, 1998)

Foresight is a very broad concept. Foresight is about perceiving the future and taking account of it. The motivation for undertaking foresight is therefore to make us better prepared for the future, and to help us shape the future by developing effective and realistic strategies.

Foresight also refers to the growing field of science and technology (S&T) or research foresight. This field seeks to use various types of information about prospective scientific, technological and other developments as inputs to decisions on priorities and research directions. It seeks to factor-in possible economic, social and environmental contexts to S&T investment decisions. It focuses attention on both the possible implications of

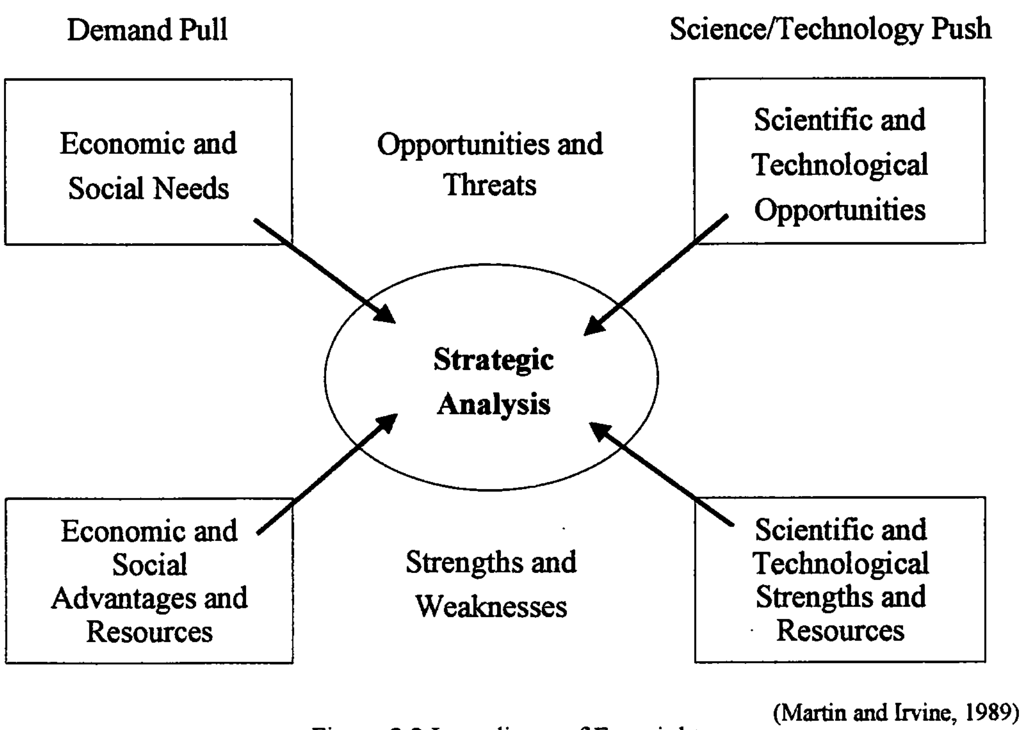

Figure 2.3 Ingredients of Foresight

prospective S&T developments for policy, and the implications of policy for prospective developments in S&T.

This approach has been encapsulated in Figure 2-3, which presents what are considered to be the essential ingredients of a foresight exercise (Martin and Irvine, 1989). Most notably, foresight is a strategic analysis. It uses information from both science and technology push (ie. technological forecasts) and social and economic demand-pull (ie. market trends and potential needs). Foresight considers opportunities, threats, strengths and weaknesses. It is an exercise in judgment.

Foresight is an area of experimentation. It has clear application in planning for strategic research and technology development. Martin and Irvine suggested that the scope for formal foresight techniques is greatest in evaluating on-going socio-economic needs for research, that is in strategic fields linked to industrial technologies or R&D aiming to meet longer term challenges in areas like health or the physical environment. From this view it is particularly useful for public sector strategic research organizations and industry.

Many of the methods of foresight had their origins in technological forecasting and assessment. This field developed its modern form in the 1950s and 1960s through work in Rand Corporation for the US defense sector on Delphi surveys and scenario analysis (eg. Herman Kahn). Such forecasting tools have subsequently been taken up by private companies, such as Royal Dutch/Shell (eg Pierre Wack), and by government agencies such as the Japanese Science and Technology Agency. (ASTEC)

2.3.1 Delphi

An important component of foresight is to define expected and possible futures for science and technology developments through exercises that focus on 'technology forecasts'. One technique widely used for this is the Delphi survey approach. This technique is a specialized methodology of technology assessment, which obtained quantitative and qualitative data.

Delphi surveys allow groups of experts to be consulted on a range of possible future developments in their respective fields. The questions include such issues as the expected time of realization of the development, and demand and supply variables connected with the development such as ranking of importance, and other factors including technical, institutional, cultural, cost and funding constraints, or the need for international collaboration etc. An example of the appearance of a Delphi survey question is shown in Table 2-1.

Table 2.1 Sample Delphi form

İsim:			Tek seçim				Tek seçim				Tek seçim							Çoklu seçim					Tek seçim						Çoklu seçim							Metin	Metin	Metin
Enerji			Uzmanlık Derecesi				Olayın 2023'teki hayat kalitesine etkisi				Olayın ilk olarak gerçekleşeceği zaman aralığı							İşbirliği yapılması gereken ülkeler					Türkiye'nin rekabet durumu						Gerçekleşmeye yönelik engeller							Konunun Ar-Ge projesini ne kadar bütçe ile kotarırdınız?	Sizce bu gelişmenin ülke ekonomisine getireceği kazanç/tasarruf ne kadar olabilir?	Yorumlarınız/ Alternatif Tezler
																							ArGe kabiliyeti		Ürün ve Hizmet sunumu kabiliyeti		Pazarlama kabiliyeti											
Alt KONU	Sıra No	OLAY	Yüksek	Orta	Düşük	yok	zarar verici	etkisiz	yararlı	çok yararlı	2001 - 2005	2006 - 2010	2011 - 2015	2016 - 2020	2020 - 2023	2023'den sonra	asla	Gerek yok	Komşular	Avrupa Birliği	Diğer Türk Cumhuriyetleri	ABD	Lider	Takipçi	Lider	Takipçi	Lider	Takipçi	Sosyal/Etik Kabul Görme	Teknolojik Yapılabilirlik	Finansman eksikliği	Ekonomik Yapılabilirlik	Mevzuat	Politik Tercihler	Eğitilmiş İnsan Gücü			
Keşif, Üretim ve İkmal	1	Hidrokarbonların uzaktan tespit edilişinin, arama işlemlerinde standart ticari bir teknik haline gelmesi.																																				
	2	3 Boyutlu sismik araştırmalardan elde edilen tüm bilgilerin analiz edilebilmesi ve ticari açıdan yorumlanmasında kullanılan ileri teknolojilerin geliştirilmesi.																																				
	3	Petrol ve petrolgazı sondaj çalışmaları maliyetini %50 indirmek (örneğin sondaj kuyusu ilerisinde bulunan kaya oluşumlarının on-line olarak sürekli ölçülmesi, sarmal sondaj boruları ve diğer techizat).																																				
	4	Yüksek basınçlı, yüksek ısılı petrol-gaz yataklarından yaygın şekilde istifade edilmesi.																																				
	5	Derin sularda (>1000m) ve şiddetli ortamlarda bulunan petrol ve gaz yataklarından yaygın olarak istifade edilmesi.																																				
	6	Uygun modelleme ve fiziksel-kimyasal uygulamalarla yataklardaki ekonomik açıdan çıkarılabilecek petrol miktarının %50 artırılması.																																				
	7	Petrol yataklarından verimin arttırılması için mikrobik açıdan zenginleştirilmiş çıkarma tekniklerinin ticari açıdan kullanılması.																																				
	8	Çok safhalı, iyi-akış tipi taşımacılığın 200 km. ve fazlası mesafede ve 3000 m.'ye kadar olan su derinliğinde ticari açıdan kullanılması.																																				
	9	Halen kullanılmakta olan deniz platformlarının ana maliyetinin %50 indirilmesi.																																				
	10	Uzak bölgelerden (örneğin. pazardan birkaç bin km. uzaktaki bölgelere) boru hattıyla doğalgaz taşınması veya LDG gibi sistemlere alternatif olan sistemlerin kullanımı.																																				
Üretim ve İkmal	11	Neft ve katrandan yaygın şekilde istifade edilmesi.																																				
	12	İleri otomasyon ve robot kullanımının; ekonomi, emniyet ve ince maden duvarlarında ve tehlikeli bölgelerde kullanım kabiliyeti açısından, yüksek duvarlı kömür çıkarma faaliyetlerinde standart birer teçhizat olması.																																				

RAND in the US first designed the Delphi technique in the late 1940s for military purposes. It originated as a method for obtaining expert opinion by a structured communication process. Its use in technology forecasting became public in the early 1960s.

Delphi has four main characteristics: anonymity (no physical contact between participants), iteration (several rounds), controlled feedback (the results of the previous round are provided to respondents), and a statistical presentation of the group response (average and spread).

Typically, the main steps in a Delphi survey are:

a. The establishment of a working group, and if necessary other expert groups, to explore an issue area and nominate a series of questions or 'Topic Statements' for the survey;

b. A 'Round 1' survey is prepared and circulated by post to the panel(s) of selected experts;

c. Replies are analyzed and a 'Round 2' survey is conducted, this includes information from Round 1, eg average realization time, importance etc. This gives the opportunity for respondents to re-evaluate their response to the first round in the light of the views of others, and those whose replies fall outside the normal range are invited to state their reasons;

d. Further Rounds for additional clarification may be employed if thought necessary;

e. Finally the information is then summarized and presented with an average value with some measure of dispersion, and analyzed by expert groups and individuals etc.

Japan, in particular, has considerable experience in such forecasts. Perhaps the best-known exercises are those of the Science and Technology Agency (STA), conducted through the National Institute of Science and Technology Policy (NISTEP), which have been carried out every five years since 1971. These surveys aim to outline trends in innovation to contribute to government policy and planning, and to provide private enterprises with information relevant to their own research and development. The fifth survey (1991) was repeated in Germany and an extensive comparison of results yielded many insights

(NISTEP FhGISI, 1994). These included the remarkable similarity in general expectations, illustrating the global nature of information transfer on many of the topic statements, and intriguing differences in expectations between Germany and Japan, including for example a generally higher confidence in the resources of Germany in developing basic research knowledge without the need for international collaboration. Delphi also formed key components of the UK technology foresight program through sector-based panel. A survey has also recently been conducted in France.

The Delphi technique has a number of advantages. It allows for both narrow and wide-ranging views of long-term future trends in technology. The Japanese surveys illustrate the latter, and have been characterized as 'holistic' covering a very broad range of fields – the fifth conducted in 1991 obtained views on over 1100 developments. Delphi used for specific fields is illustrated by the experience of UK sector panels. The Delphi method is also particularly suited to long time frames over 10 years, and the NISTEP surveys have used a 30-year time frame. The process allows the gathering of views from a very large number of people. In this way it can not only achieve better statistical reliability but also promote the process benefits of the '5Cs', especially 'consensus'. Delphi allows respondents to change their minds on topics without being personally identified, and it gives those with firm views an ability to stick by them. As the recent use by Germany of the Japanese Delphi questionnaire illustrates, essentially the same Delphi surveys can be applied in different countries – with the proviso that some topic statements with local relevance will require modification. This suggests that international collaboration on Delphi surveys will become more frequent in coming years as the international and global character of science and technology becomes more pronounced (Bourke and Butler, 1995a). For small nations participation in such surveys might provide a glimpse of the expectations of the technological leading edge.

A key disadvantage is that large-scale Delphi surveys can be costly and time consuming, and these expenses cannot be avoided. (ASTEC)

Carrying the application on a web-based DSS can prevent the disadvantages of Delphi discussed above. This will close the time and distance gap between the participants of the survey and boost up the entire process.

3 . MODEL STRUCTURE

3.1 Chapter Summary

The analysis of energy-economy interactions presented in the following chapters is based on a simulation model of the national energy sector.

This chapter represents the scope and boundary of the model, describes its structure, and discusses the values or the major parameters and equations. In order to set scenarios for the model, Delphi as a foresight tool will be applied to the participants related to energy sector. Delphi survey structure will be explained in the last part of the chapter.

3.2 Overview of the Approach

System dynamics method is used for simulation of dynamic systems. An attempt has been made to represent the consumption trends of each economic sector at the macro-level of national economy. Main energy relationships in the economy and the decision processes used by the consumers in the system are included. The model represents both the physical structure of the energy demand (the stock and flow networks of energy resources) and the energy type choice structure of the various consumers.

Sterman has used system dynamics in modeling U.S.A.'s energy-economy interactions. He explains why system dynamics is useful in political planning activities:

By modeling the decision-making of the actors in the system and the delays, constraints, and inadequate information that often confound them, the macro-level dynamics of the economy emerge naturally out of the interaction of the components of the system. Because such models provide a rich behavioral description of the economy firmly rooted in managerial practice, they are particularly well suited for examining the dynamic effects of policy initiatives. (Sterman, 1981)

3.3 Model Overview and Boundaries

The model represents the national energy demand system and energy production. There are six major sectors as shown in Figure 3.1:

a. Residential,

b. Office (business),

c. Industrial,

d. Transportation,

e. Agricultural energy demand

f. Production of energy.

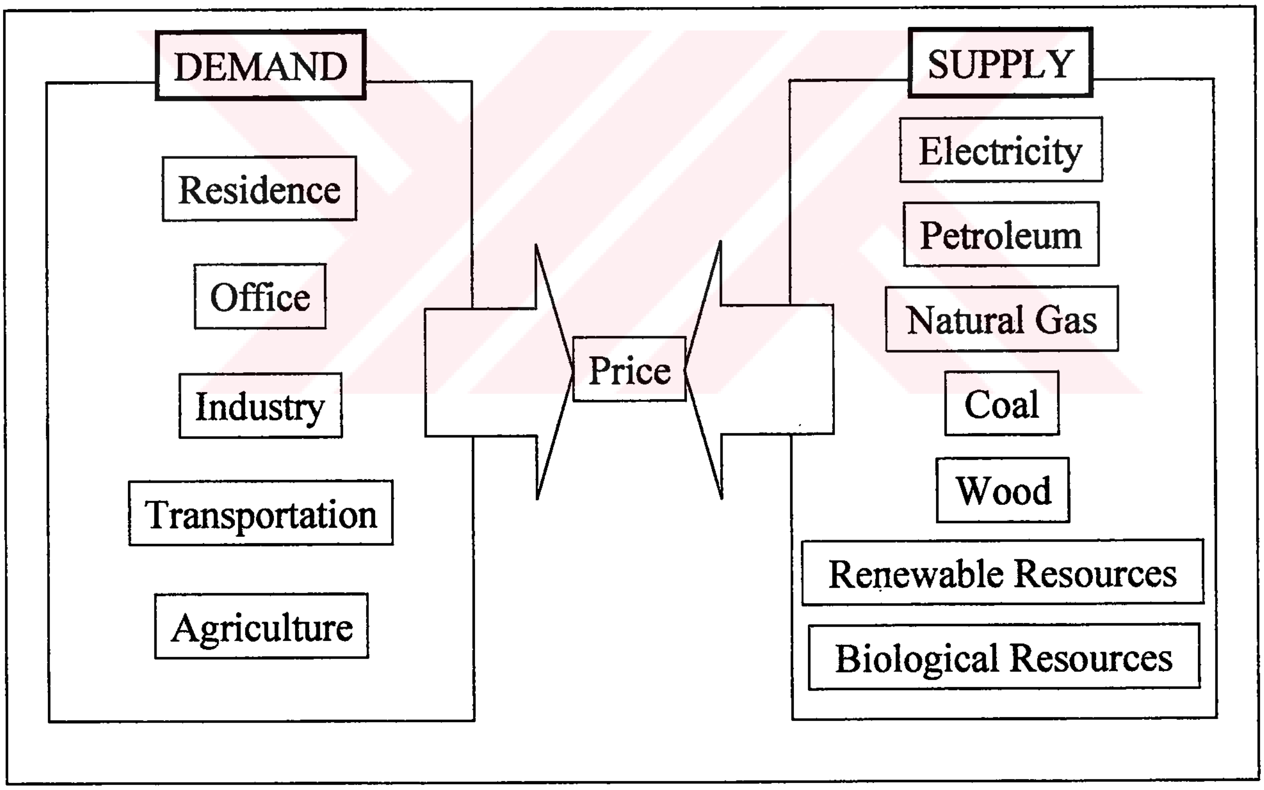

Figure 3.1 Model overview

Model structure is derived from the available data about energy sector. The historical data, which gathered from mainly three resources, force the modeler to construct demand and energy production sectors parallel to the data structure. It is disturbing that some conflicts between different data resources occur. During such occasions, most meaningful data has been used in the model. The data used in the model is listed as Appendix-B.

The residential sector consists of two parts:

- Heating devices of any kind

  Cookers, water heaters, stoves, air conditioners, etc.

- Only electricity consuming devices

  Television sets, video players, personal computers, lighting equipment, etc.

Since the energy consuming behavior is similar to residential sector, office sector has been designed similar to residence. There are two components of energy demand in office sector, electrical appliances and heating devices.

Industry sector consumes energy during manufacturing, which are electricity, petroleum, natural gas, hard coal, and lignite. Because of the availability constraints about industrial energy consumption data, no sub sectors are included in the model. Transport sector has been modeled as a function of vehicle population and fuel consumption per vehicle. Similarly, agriculture sector uses petroleum products and electricity. The consumption of resources has been modeled in agriculture sector.

The model boundary diagram (Figure 3.2) divides the major variables into those endogenous to the model and those exogenous to the model. The Figure 3.2 includes the major concepts excluded from the model.

Endogenous variables include the major energy consumption sectors mentioned above. There are also price change rates, total and fractional energy demands of each sector, energy production and imports for each energy resource.

The exogenous variables represent variables unlikely to be influenced by the system (such as population); variables representing specific policy levers the model user wishes to test (such as energy policies); and variables such as technological progress and OPEC prices, which is coupling to the economy.

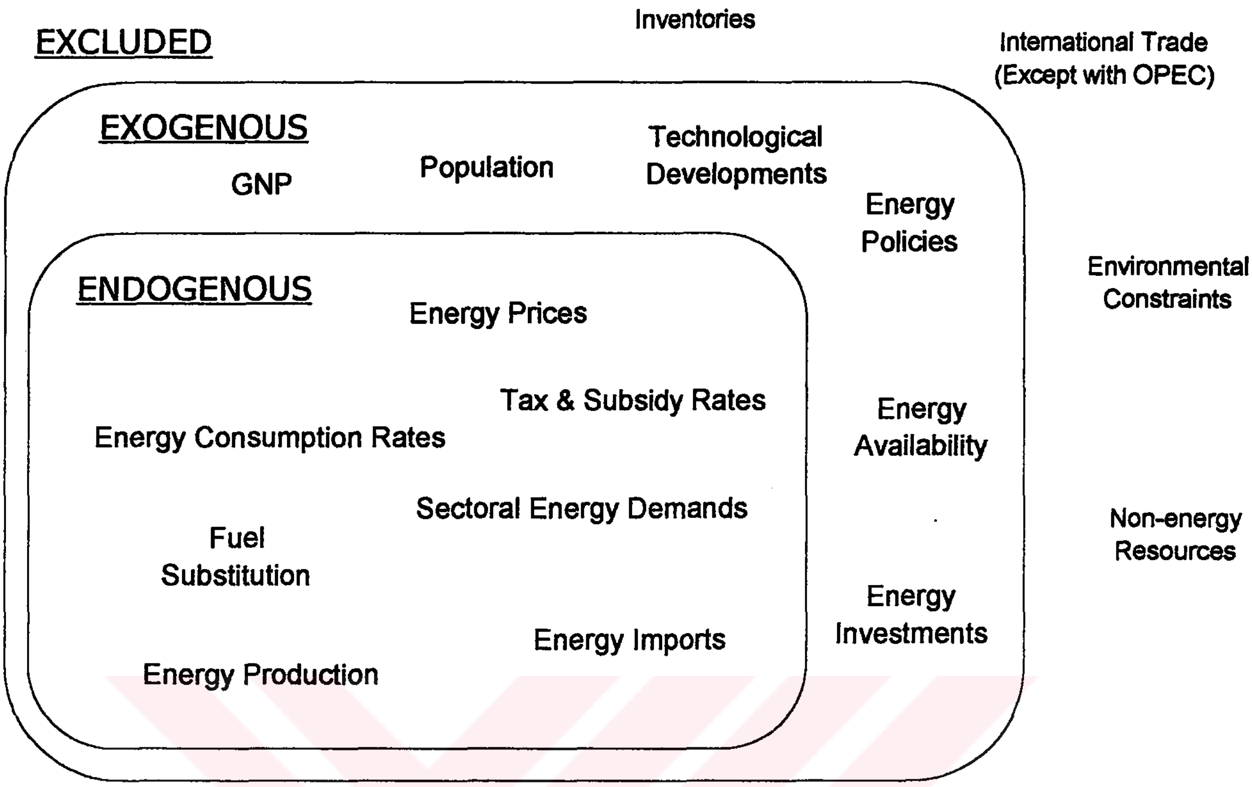

Figure 3.2 Model boundary diagram

The concepts and issues excluded from consideration are of particular interest since they define the boundaries of the model and suggest further research areas on this field.

3.4 Model Architecture

It will be useful to begin from demand sector, as it is the main sector in the model. Figure 3.3 summarizes the relationships between the demand sub-sectors and energy production sectors. Different from the past studies on energy sector, the author tries to merge two major sectors, supply and demand of energy. Since the shift in demand or supply will directly affect a change in the general behavior, model should consist the two major parts. Demand in each economic sector grows parallel to GNP and population. Change in energy demand of each sector, choose a fraction of energy resource to meet the energy needs. The fraction of each energy resource for economic sectors is decided under the effects of difference between the supply and demand and price policy effects.

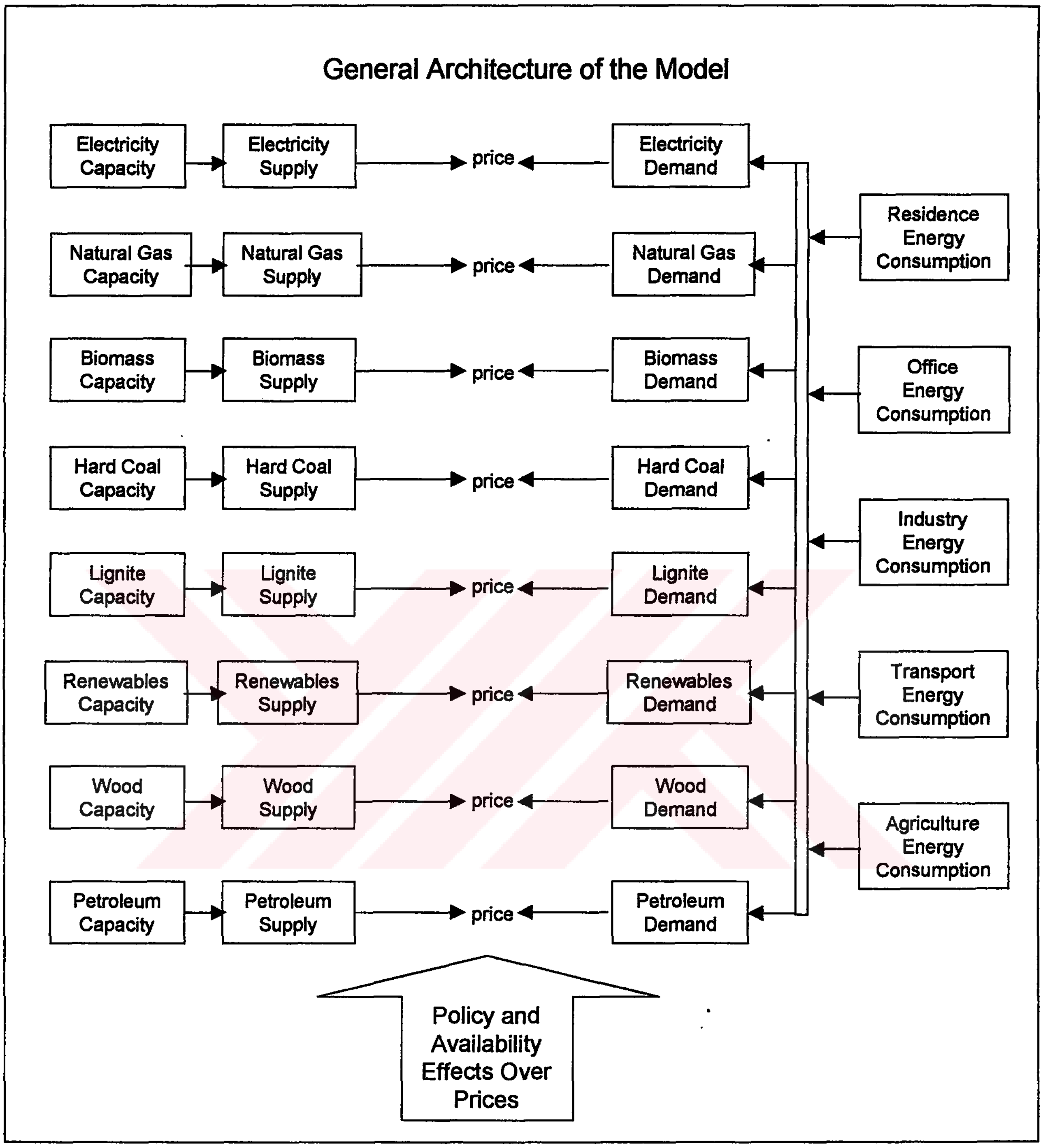

Figure 3.3 General architecture of the model

3.4.1 Population and GNP sector

Population and GNP sector consists of population, GNP, household and urban population. Following paragraphs demonstrate the structure and equations of the sector.

Population is a calculated with an integral function. Initial population value is the real value of 1975 population of Turkey. Later, a growth function reveals the projected population values up to end of the simulation. Population is calculated with the following equation:

$$population = initial\ population + \int population\ growth\ dt$$

$$(population\ unit : 10^6\ individuals) \qquad (3.1)$$

Where variable population growth is a function of population and population growth rate. Unit of population in equation 3.1 is "millions". Population growth rate has been driven from the regression analysis of population growth rate time series, where

$$population\ growth\ rate = 0.587 - 0.000286 * Time \qquad (3.2)$$

Variable "Time" is year. Coefficients of the equation are the results of regression analysis. R^2 value for the population growth regression is 0.999. The detailed results of the regression analysis can be found in Appendix-C.

Population growth is projected parallel to National Statistics Institute projections and can be differentiated according to altering scenarios by changing constant *pSlope* in the model. Population has a positive effect on energy demand levels, since every individual have to use some kind of energy to live his/her life. The fractions of the energy types depend on the location of the residence, but energy consumption is a must for everyone.

Similar to population, GNP has a parallel structure in the model. It is also possible to vary the GNP growth rate to test energy demand values. Unlike to population's effects, GNP growth has some kind of balancing effect on energy demand of different sectors, since GNP growth is a sign of technological development. It is a common fact that new technologies consume less energy. GNP is calculated using the following equation:

$$GNP = initial\ GNP + \int gnpGrowth\ dt \qquad (GNP\ unit: 10^9\ TL) \qquad (3.3)$$

Here, variable "gnpGrowth" is calculated from the function,

$$gnpGrowth = 1.60459 - 0.000786468 * Time \qquad (3.4)$$

Equation 3.4 is the result of regression analysis of GNP growth over time. Analysis shows that the R^2 has a value of 0.0698. The reinforcing and balancing effects of population and GNP over energy consumption rates are demonstrated explicitly by statistical analysis reports in Appendix-C.

Household is calculated with the following equation:

$$household = 4628.32 + 21.5513 * GNP \quad (units) \tag{3.5}$$

The regression statistics state that there is a significant relationship between GNP and household quantity. R^2 value of the regression is 0.9592.

Urban population has also a significant relationship between national population. We can observe the resulting equation in the following

$$Urban\ population = -12.6814 + 0.7735 * population \tag{3.7}$$

R^2 value of the regression analysis is 0.9818.

3.4.2 Residence Sector

Energy consumption of residence sector depends upon the exogenous variables, which are population, gross national production (GNP), average household size. Residence sector's energy consumption is examined in two sub sectors. One of them is electricity consuming appliances sub sector, which has no alternative energy resource switch to. Latter one is heating appliances sub sector, which has alternative resources to select. Electricity consumption of residence sector is computed from total household population and average electricity consumption per house. Average electricity consumption of household is under affect of technological development.

The relations analyzed above can be simply put into model as Figure 3.4:

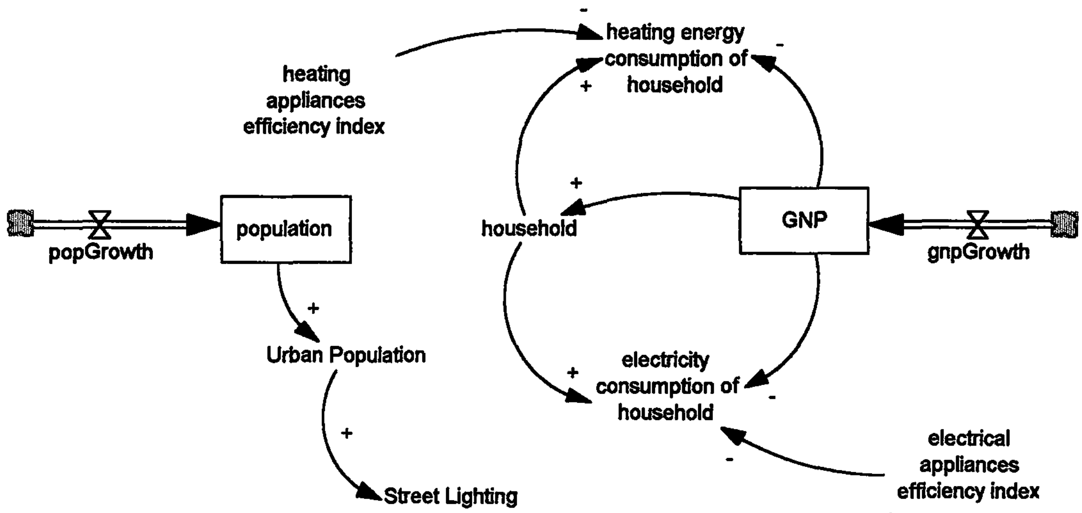

Figure 3.4 Effects of population and GNP

Since electrical appliances use only electricity, energy consumption of this sector affects directly only "Residential Electricity Demand" variable in the model. Residential heating energy consumption has some different relationships from electrical appliances. Such as, heating has various energy resources and consumers have a chance to make a selection about cooking or space heating between them. Figure 3.5 demonstrates the relationship between these resources and residential consumers.

Household affects household electrical appliance energy consumption. Electrical energy demand per household is derived from GNP, as follows:

*household electricity demand = -1.14587e-05 + 2.66551e-007 * GNP* (3.6)

*(household electricity demand unit: Kilo Tons Equivalent Petroleum **KTEP** of energy per household per year)*

R^2 value of the regression is 0.9829.

Same as electricity consumption, heating energy consumption has a strong relation with GNP growth. The regression equation can be written like this:

*household heating energy demand = 4581.0637 + 38.5728 * GNP* (3.7)

3.4.3 Office sector

Main inputs for office energy consumption are office population and electricity consumption per office. Office population is calculated with the regression equation as follows:

$$office\ population = 1311.3587 + 24.7349 * GNP \qquad (3.8)$$

R^2 value of the regression analysis is 0.9454.

Electricity consumption per office is calculated with the following equation:

$$electricity\ demand\ per\ office = -62056.4048 + 1764.2753 * GNP$$

$$(electricity\ demand\ per\ office\ unit:\ KTEP\ per\ year) \qquad (3.9)$$

R^2 value for the regression analysis of electricity demand per office vs. GNP is 0.8550.

Office sector is mostly similar to residence sector in terms of energy consumption, except water heating and cooking demand is not as much as residence. Office electricity consumption equation is as follows:

$$office\ elec.\ consumption = office\ population * electricity\ demand\ per\ office \qquad (3.10)$$

$$(office\ electricity\ consumption\ unit:\ KTEP\ per\ year)$$

In equation 3.8, variable office population contains both governmental and private office population. Since there is not sufficient data about office heating energy consumption, residential behavior has been used in office heating part, except the office population.

3.4.4 Industry sector

Industry has a lot of sub sectors in real life. Mining, food, textile, chemical, iron and steel industries are a few examples for these. Unfortunately, there is only electrical energy consumption data is available as time series for different sectors of industry. It is decided that the model should exclude the sub sectors in order to eliminate biased results.

Five types of energy are used in industry sector. These are electricity, lignite, hard coal, natural gas and petroleum. General industrial energy demand is dependent to GNP. Industrial energy demand changes according to GNP. According to some price change effects and demand elasticitys, energy choices differ in time as energy prices change. These price change effects will be discussed in the following paragraphs. From the price and demand elasticity functions, fractional share occurs between the energy types. According to exogenous elasticity constants, reactions may vary over price changes.

Total energy demand of industry is calculated with the following equation:

*Industrial Energy Demand = 2416.77 + 51.2917 * GNP* (3.11)

(Industrial Energy Demand unit: KTEP per year)

R^2 value is 0.9834 according to the regression analysis. Details can be observed in Appendix-C.

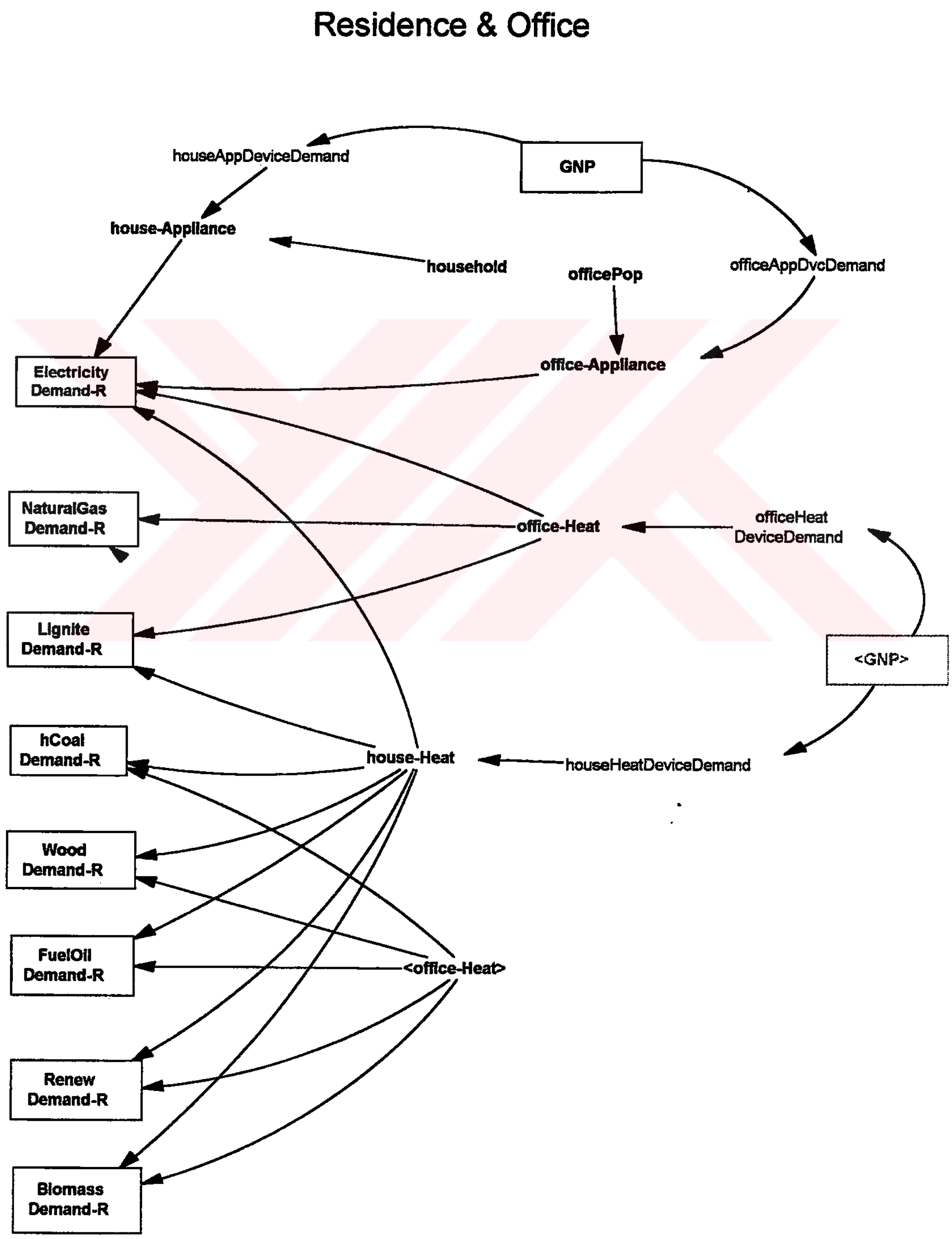

Figure 3.5 Residential and office energy demand structure

3.4.5 Agriculture sector

Agriculture sector is developing constantly according to GNP. This change has been projected to end of the simulation. Agriculture sector has a simple structure as shown in Figure 3.6. GNP growth affects the rate of energy consumption of agricultural sector. Electricity and petroleum products are used in this sector. Both of these energy demands change depending upon the development of agriculture sector and GNP. Resulting demands from this sector create a sum from different sectors in the model.

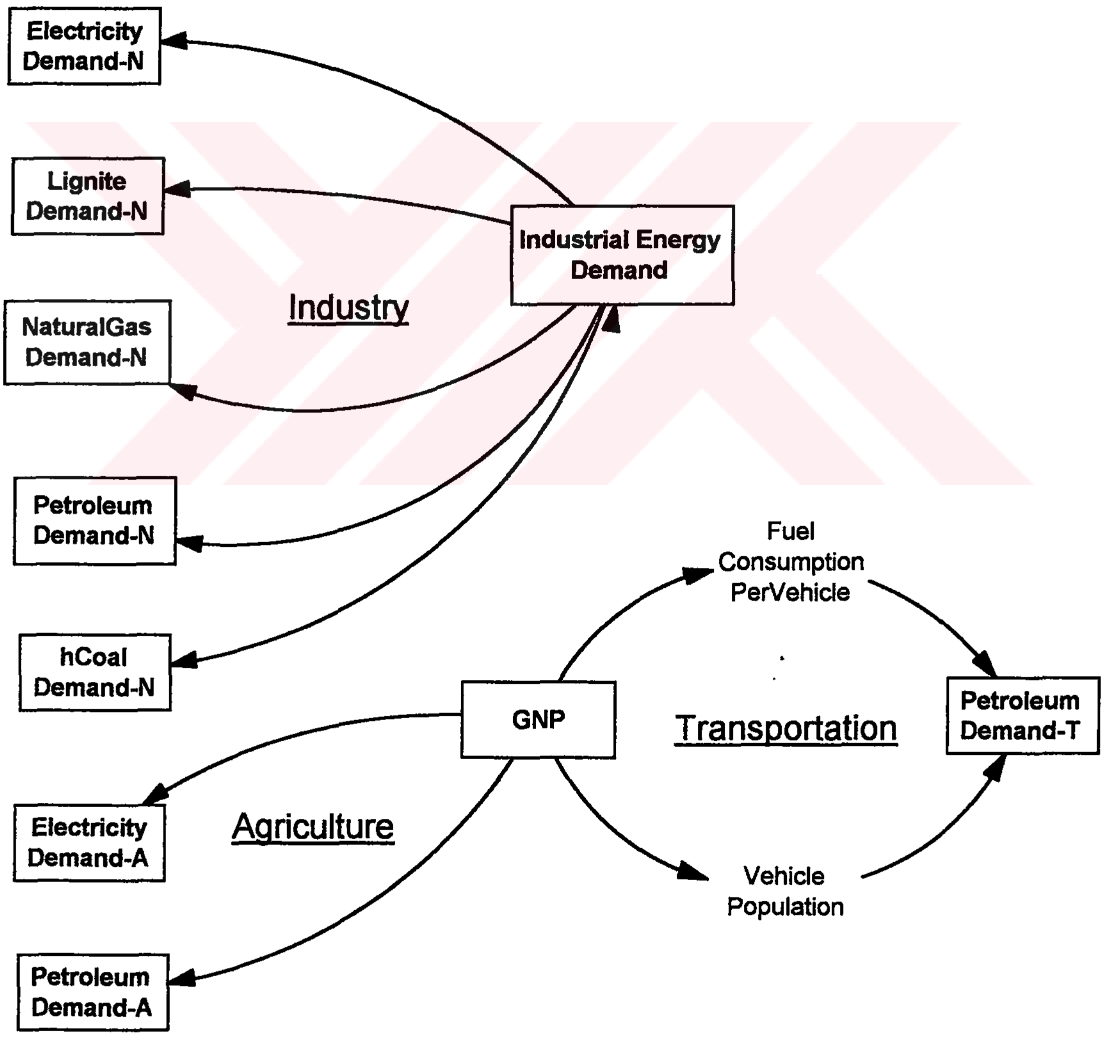

Figure 3.6 Industry, transport and agriculture sectors

Equations of the agriculture sector are:

electricity demand of agriculture $= -50.51 + 2 * GNP$ (3.12)

(electricity demand of agriculture unit: KTEP per year)

fuel demand of agriculture $= -266.07 + 7.0243 * GNP$ (3.13)

(fuel demand of agriculture unit: KTEP per year)

Regression analysis results show that the R^2 values of electricity and fuel demands of agriculture are 0.8267 and 0.9644 respectively.

3.4.6 Transportation sector

Transportation sector's fuel consumption is dependent to GNP as seen in the model. This sector's total consumption is a function of average fuel consumption of a vehicle and vehicle population in Turkey.

vehicle population $= -1.15695e{+}006 + 15320.7 * GNP$ (3.14)

fuel consumption per vehicle $= 0.0278 * (Time - 1957)^{-0.6542}$ (3.15)

(fuel consumption per vehicle unit: KTEP per year)

Statistical analysis results show that the R^2 values of vehicle population and fuel consumption per vehicle equations are 0.9542 and 0.8909 respectively. Relationships of transportation sector can be viewed in Figure 3.6.

3.4.7 Energy supply sectors

There are ten supply sectors in the model, namely

a. Hydro-electricity

b. Thermo-electricity

c. Petroleum

d. Natural Gas

e. Lignite

This variable is a linking variable to demand sector in order to compute the capacity cap of the sector.

*TargetConstructionInProcess = AnticipatedRetiringCapacity **

ConstructionTime (3.23)

This is an auxiliary variable for calculation of capacity gap. It is derived from retiring capacity.

AnticipatedRetiringCapacity = Smooth (RetiringCapacity, TimeToAnticipateRetiringCapacity) (3.24)

Recognition delay function of the retiring capacity, in Vensim syntax. *RetiringCapacity* is recognized by the system after *TimeToAnticipateRetiringCapacity.* As a natural behavior, retiring capacity information flow to the capacity ordering system is delayed with this function.

TimeToAnticipateRetiringCapacity = 1 (3.25)

$Capacity = DesiredCapacity_{t0} + \int (FinishingConstruction - RetiringCapacity)\, dt$ (3.26)

Major level variable, which differs in according to the "desired level" and "awareness index".

RetiringCapacity = 100 (3.27)

FinishingConstruction = ConstructionInProcess / ConstructionTime (3.28)

ConstructionTime = 3 (3.29)

$ConstructionInProcess = \int (StartingConstruction - FinishingConstruction)\, dt$ (3.30)

Failing to keep track of what is in process means that organizations will over order. They will keep investing for the same amount of capacity until it is reached; rather than realizing the order has been placed even though it hasn't shown up yet. This is the main mistake that people make in playing the Beer Distribution Game of system dynamics (Sterman, 1992). Here in this model, this structure is also included in the simulation. An index variable of "knowledge of in process construction" is added. Maximum value of the index, 1 means that the investor or the policy maker is completely aware of the capacity in the construction process and will not over order. The minimum value of the index, 0 means that the policy maker does not have any information about the capacity in the construction process.

Therefore, is able to order the same capacity gap until it is reached the desired level. Figure 3.8 demonstrates the actual capacity difference between these occasions. In addition to the basic structure, capacity constraints of each sector have been put into each one.

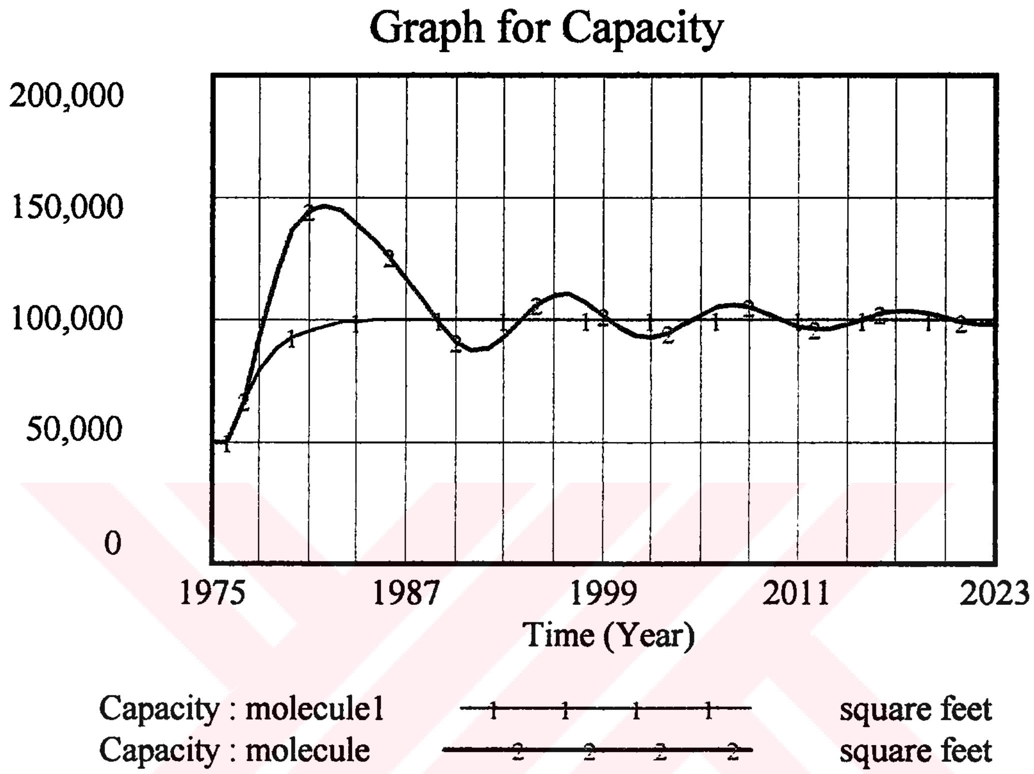

Figure 3.8 Graph for awareness index changes

Figure 3.8 demonstrates the actual capacity levels of two different intelligence index values. Initial level of capacity is 50,000 units. Desired capacity level is 100,000 units. First curve is the result of a perfect intelligence level of investment. Second curve is the result of a poor intelligence level of investment. Poor intelligence levels cause excess and insufficient levels of energy production capacity.

3.4.7.1 Electricity supply sector

As the basic structure and formulation has been explained above, it is time to put the differences of each energy supply sector. Electricity is produced in three sectors, namely hydro-electricity, thermo-electricity and renewable-electricity sectors. Each sector's generating structure is similar to each other, but capacity limitations differ. There are capacity constraints for each type of electricity generating resources. These constraints are gathered from databases of Ministry of Energy and Natural Resources.

In electricity supply sector, it is interesting that the energy produced or imported, does not totally consumed by the national energy network. An average of 13% electricity over gross production is lost on the transmission network. The author needed to include such a variable into the model as "networkEfficiency-Electricity".

There is also a capacity utilization factor for electricity power plants, as a value of 46%. Some of the energy is used up by the generation system with a percentage of 6%, it is included in the model as "GenerationEfficiency-Electricity" The variables mentioned above are all rates applied to the stock variable of "Electricity Capacity" as seen in the Figure 3.9

3.4.7.2 Petroleum supply sector

Petroleum supply sector means the petroleum extracting and refining capacity. Capacity demonstrated in the model is the refinery output capacity. All liquid fuel consumption is considered in crude oil units (KTEP), except the heating demand of residence and office. Fuel-oil consumption is added to total petroleum demand, from residential and office sectors. Petroleum supply sector has a similar structure to electricity supply sector. Natural petroleum reserves are considered as a constraint for local petroleum extraction capacity. There is also an import constraint in order to introduce the international availability of petroleum to the model.

3.4.7.3 Natural gas supply sector

Natural gas supply depends on the import of natural gas mainly. Natural gas supply sector contains both local extraction and import capacity. Constants are altered as necessary to fit the original behavior. Natural gas demand is the sum of residential, office and industrial natural gas demand. This variable is transferred to NG-Desired Capacity in the supply sector. The other end of the loop, NG capacity is used in the price change calculations.

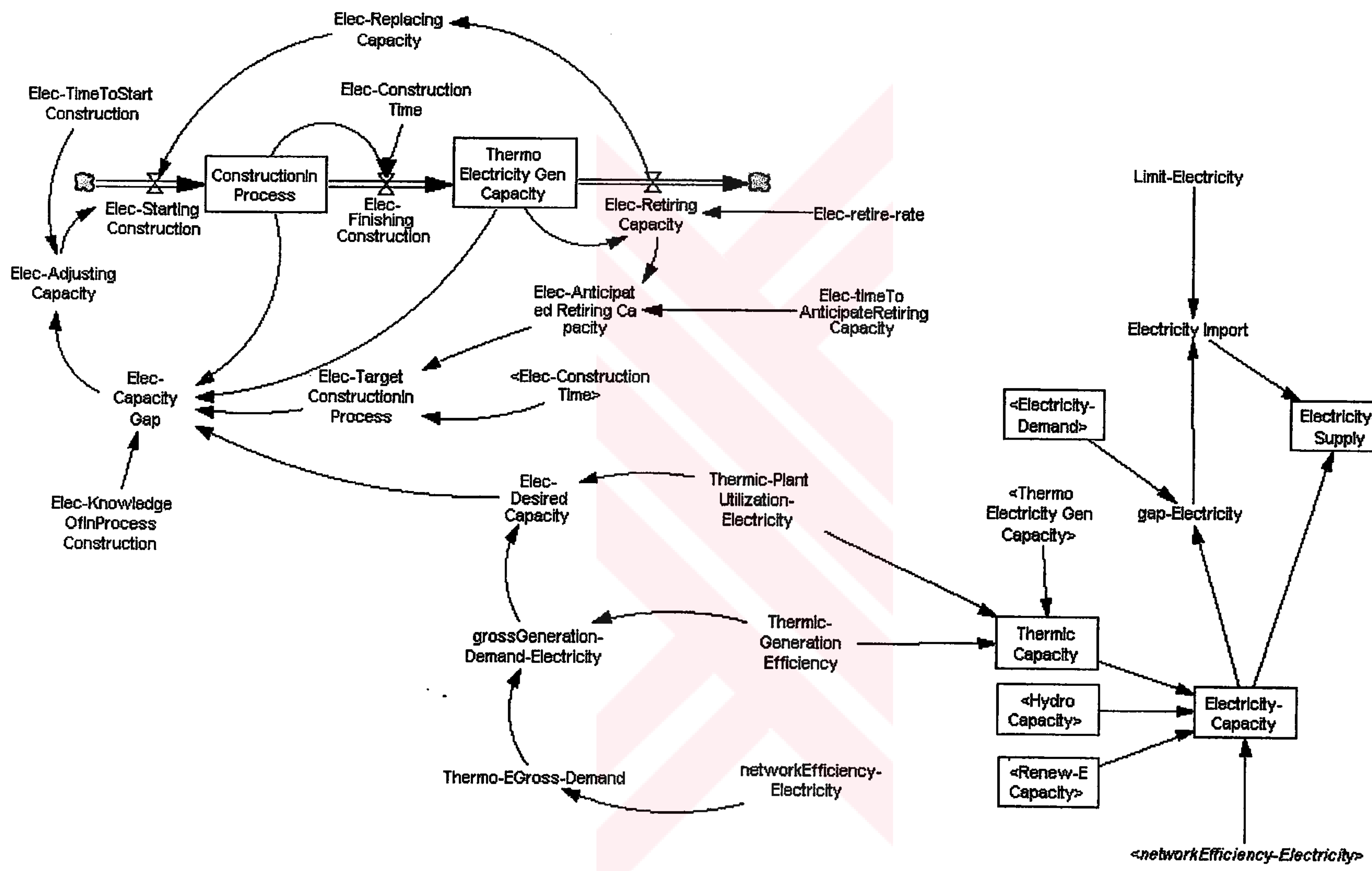

Figure 3.9 Thermo-electricity supply sector

3.4.7.4 Hard coal supply sector

Hard coal sector has a similar structure to basic molecule but the initialization values are different. There is local extraction capacity constraint in the model to set the available hard coal limits to the model. Hard coal demand is the sum of residential and industrial hard coal demands, which is an input to the supply sector as an hCoalDesiredCapacity variable. Output of the sector's interactions is transferred to price sector as hCoal Capacity.

3.4.7.5 Lignite supply sector

Lignite demand is the sum of residential, office use and industrial lignite energy demands. Local lignite reserves are set as extraction constraints. In the flow of lignite demand information, lignite supply capacity changes in time. The supply capacity value is used in calculation of price changes as other supply sectors.

3.4.7.6 Wood supply sector

Wood sector has no difference from the basic supply sector. There is an input from demand sectors, a capacity constraint and an output to price sector. In order to realize the capacity limit for wood, a capacity constraint is added to the molecule. The capacity construction time for wood sector symbolizes the tree rising time. It is rather high in wood sector.

3.4.7.7 Biomass supply sector

Biomass is organic residues of animals and plants. Although biomass is a primitive energy resource, depleting conventional fossil energy resources force consumers to find new energy resources like biomass. Biomass sector has the same generic structure and constraints.

3.4.7.8 Renewable energy resources supply sectors

Renewable resources are considered in two parts, which are electricity producing renewable resources and heat producing renewable resources. Renewable resources contain solar, wind and geothermal energy. Each part of the sector constitutes a unique supply structure and has been modeled as different sectors.

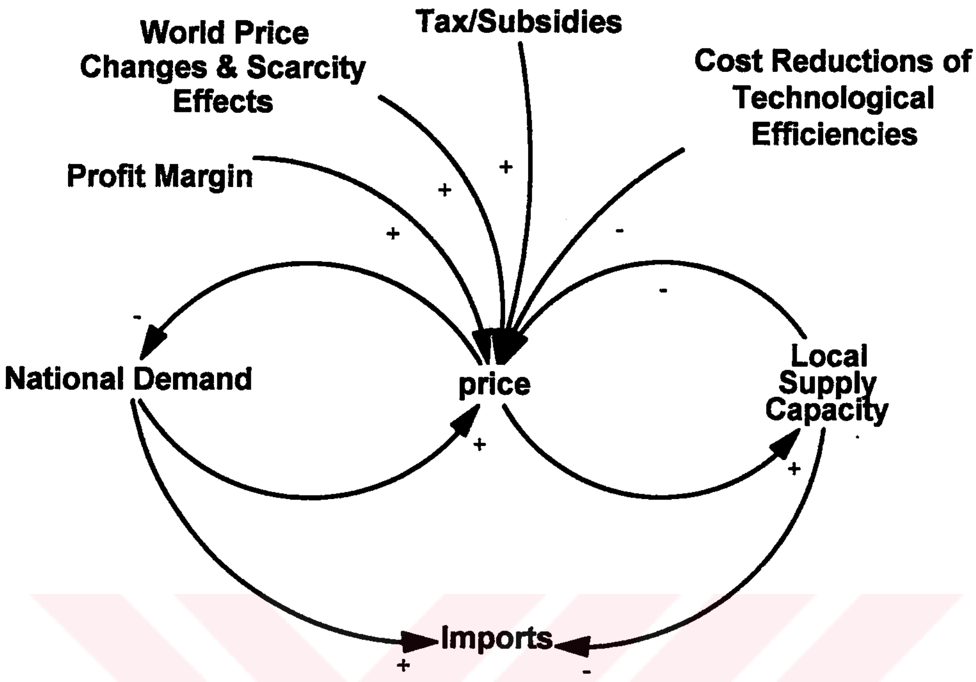

Figure 3.10 Price change casual loop diagram

3.4.8 Price changes and energy consumption fractions

Price change is calculated from the difference between demand and capacity. The main idea of the price change equation is as follows:

$$priceChange = 1 + ((demand - capacity) / capacity) * priceElasticity) \qquad (3.31)$$

The equation above has been applied to each energy resource regarding the structure in the Figure 3.3. There are effects of profit margins, cost reduction of technological improvements, tax and subsidies over the price change of each sector. Since petroleum price and availability is a significant factor in global markets, world petroleum prices are considered as an effect over local price changes. These relations are demonstrated in Figure 3.10.

The generic price and demand of energy structure can be inspected in the figure below:

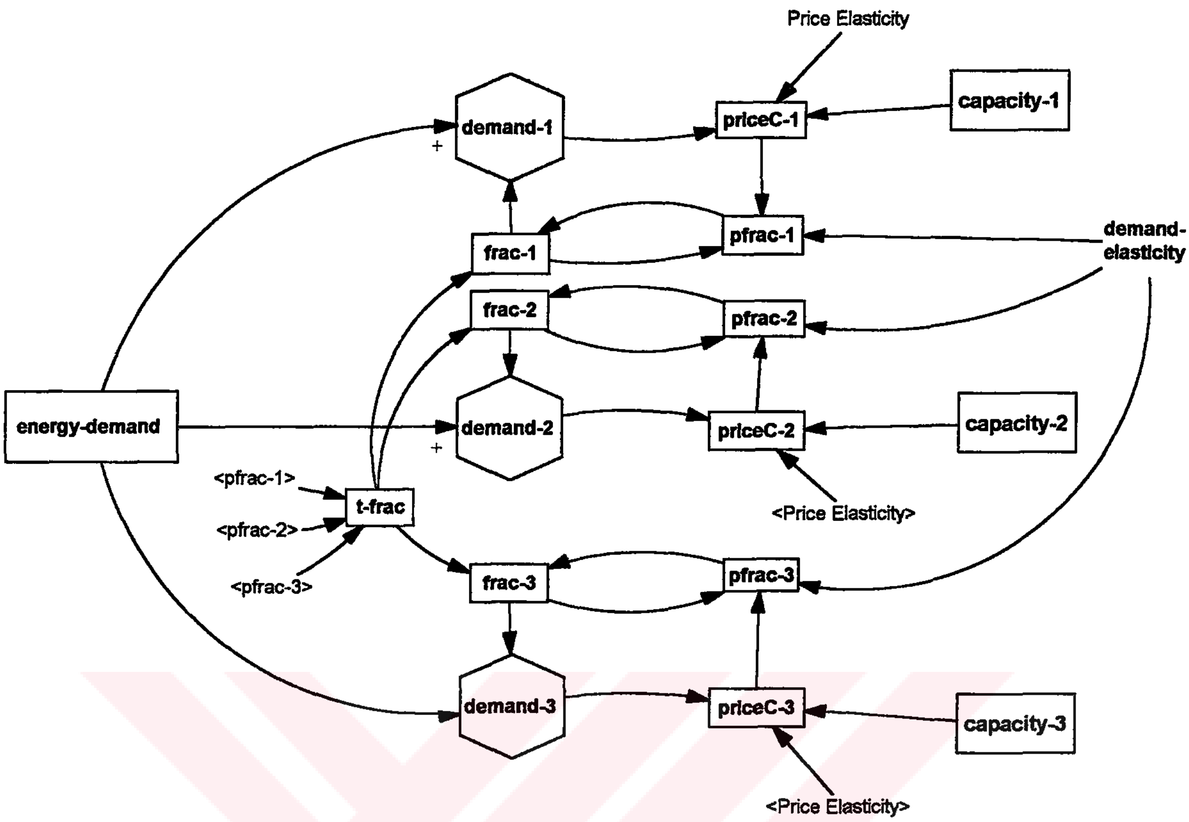

Figure 3.11 Price change structure

Continuing the examining of price change structure, price change in equation 3.31 is used in the calculation of the fraction variable for the determination of the energy share in the next period:

$$pfrac_t = frac_{t-1} * (1 - demandElasticity * priceChange_{t-1}) \qquad (3.32)$$

$$tfrac = \sum pfrac_t \qquad (3.33)$$

$$frac = pfrac \,/\, tfrac \qquad (3.34)$$

Equations 3.28, 3.29 and 3.30 are developed for the sake of normalization in the model. Here, price elasticity and demand elasticity variables are constants and can be manipulated for applications of different scenarios. *Energy-demand* variable is one of the energy consuming sectors such as industry and the *demand-n* variables are different energy resources for the energy demand. The difference between the demand for one type of energy resource at time t and the capacity available at time develops a fraction called pfrac in the model. This variable effects the calculation of the next year's consumption fraction as demonstrated in equations 3.32, 33 and 34.

3.4.9 Simulation game variables

The model is designed to have the chance to simulate as a game. This will allow the user to observe various decisions about energy investments, tax or subsidy policies or world price change scenarios. Gaming variables are listed below:

a. Tax / subsidy rates over each fuel price
b. Technological effects to fuel costs
c. World fuel prices
d. Profit margins of each fuel
e. Import availability of each fuel
f. GNP growth rate
g. Population growth rate
h. Sectoral energy demand growth rates
i. Energy efficiencies of appliances in each sector
j. Intelligence capabilities of energy investors
k. Project management capabilities of energy investors.

3.5 Delphi Survey Structure

Delphi survey topics are technological improvements on energy sector. These topics are applied to English participants during national foresight studies of England in 1995. In order to have the chance to compare the results, topics are only translated into Turkish and no changes applied.

Delphi questionnaire consists of four major sectors, which are

a. Discovery, extraction and supply 26 events
b. Transmission, transportation and distribution 12 events

c. Conversion 15 events

d. End use 27 events.

Each sector contains a number of topics related to its field. Topic numbers ranges are explained above also. The participant is asked to evaluate the topic in some fields related to the impact of the future of national energy sector. The evaluation fields are listed below:

a. Respondents degree of expertise

b. Respondents assessment of degree of impact on quality of life

c. Period within which the event/development will have first occurred

d. Necessity of collaboration

e. Current national position versus other countries

f. Constraints on occurrence in Turkey

g. Budget range to develop the event

h. Economic benefits of the development

With according to the structure explained above, a Delphi survey questionnaire has been designed to apply the participants. Full text of events in the questionnaire form is available in Appendix-D.

3.5.1 Delphi application media

It is important to capture a wide number of participants' visions about energy sector. In order to satisfy that need, Delphi survey is designed in different media. Time is a strict constraint because of the sponsoring organization's expectations. Delphi survey questionnaire is designed in different formats to handle that problem. Formats are listed below:

a. Spreadsheet format, as demonstrated in Appendix-D

b. MS Access database and questionnaire format

c. Web survey format

It will be helpful to discuss each of these formats.

3.5.1.1 Spreadsheet form

This is the basic and initial format of the questionnaire. It is transferred from its English version with little differences. It is a must to have a hard format of the survey. Details of the spreadsheet can be observed in Appendix-D.

3.5.1.2 MS Access database form

Spreadsheet format is a basic format and that is all. It is not useful when evaluating *n* times 80 topics with 20 answers in each topic. A common computer application for database management is used to get the results in a less time consuming manner. A form interface is designed to get the responses of the attendant to store in the database. A screenshot of the interface can be observed in Figure 3.12.

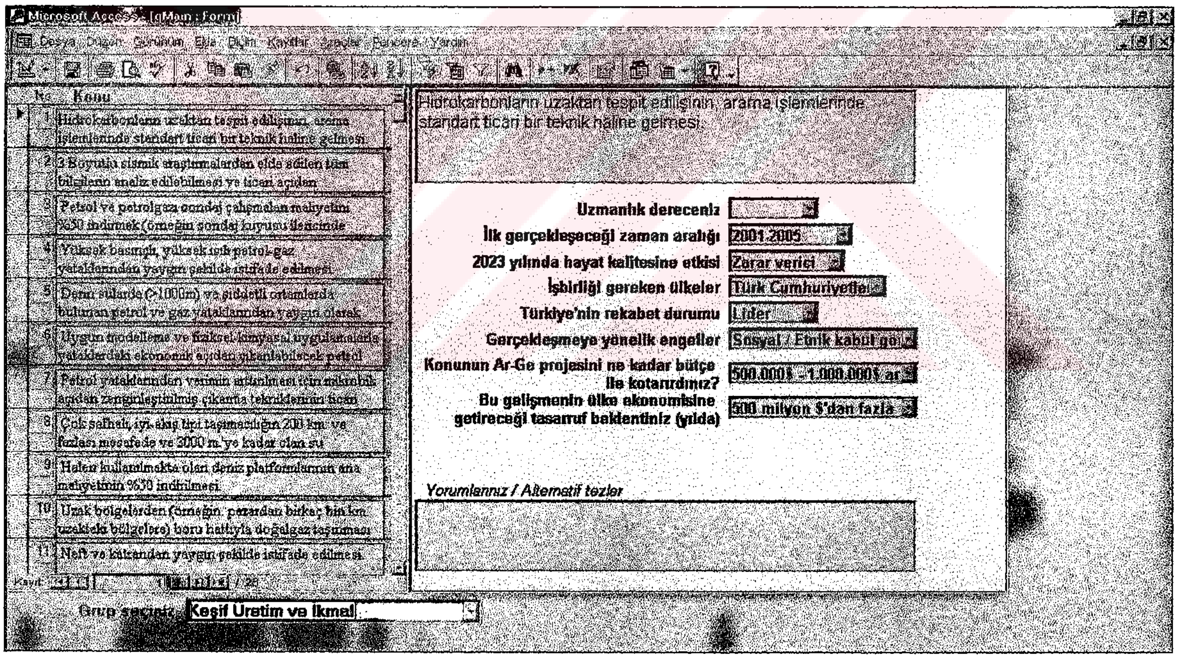

Figure 3.12 MS Access database form of Delphi

3.5.1.3 Internet form of Delphi

Internet is a widely used information media in Turkey. It will be helpful to use the benefits of internet during the Delphi sessions. As a result of that, the existing database file has been put on a web server, and published via using active server page technologies. In order to promote the web survey and share the results with the participants, a web site and an e-mail discussion groups has been created. Foresight networking web site is located at http://www.enerji2023.net. The e-mail address of the discussion group is tr2023_enerji@egroups.com.

The main entry page of the web based Delphi survey can be seen in Figure 3.13.

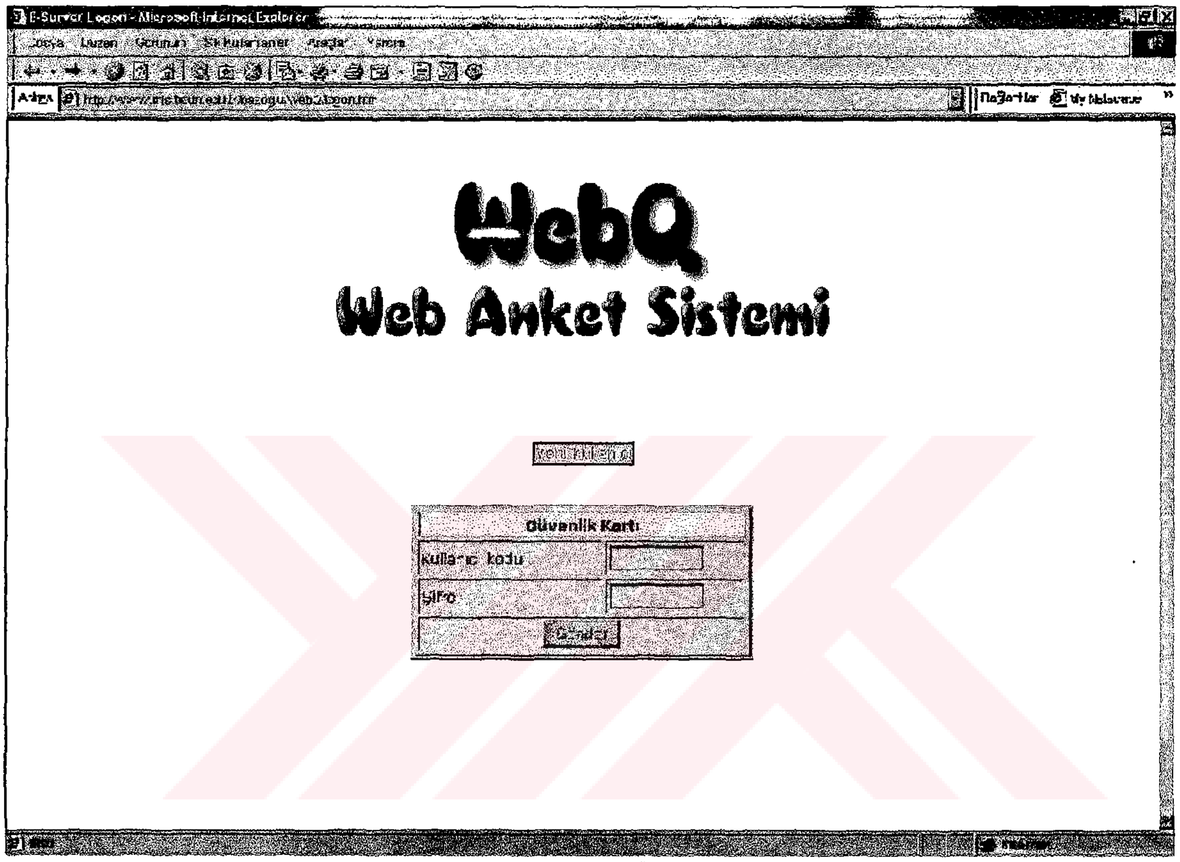

Figure 3.13 Log on page of web survey server

There are four main sectors in the survey as described above. After logging on the survey server, the questionnaire page seems like Figure 3.14.

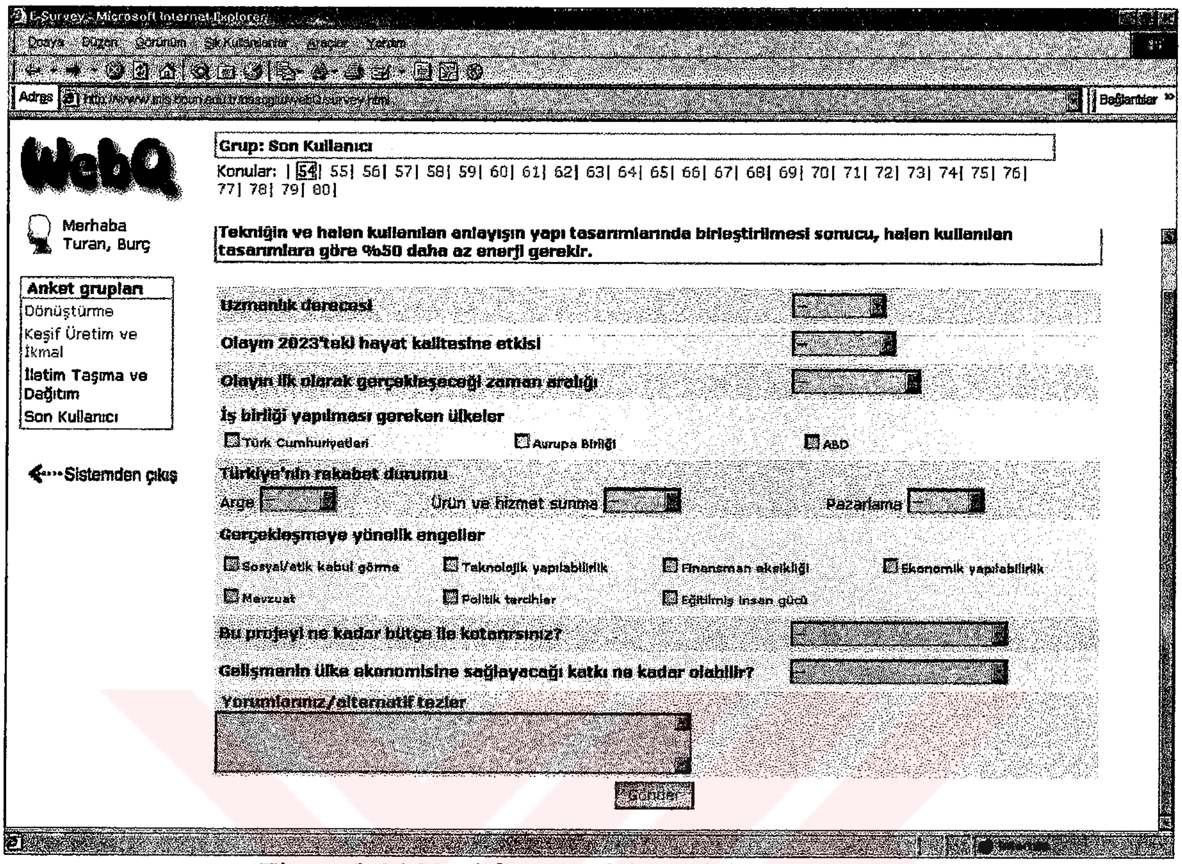

Figure 3.14 Html format of the Delphi survey form

4 . SIMULATION RESULTS

4.1 Chapter Summary

It is needed to state the assumptions and data collection problems as a start for this chapter. Later, the behavior of the model between 1975 and 1999 is compared to the actual data of the national energy sector. The model captures major trends such as population, GNP, total and sectoral energy consumption behavior with an error tolerance of 10%. The simulation of the energy sector is extended to 2023. Results show that the effects of policy planning without sufficient information about the system cause excess investments and resource losses. Finally, sensitivity tests will take place in the chapter.

4.2 Assumptions and Simulation Inputs

There are different kinds of energy resources in the model. Each of them is held into accounts in different units. In order to avoid the confusion of energy units during the internal calculations of 308 variables or constants of the model, all units of energy have been converted into kilotons equivalent of petroleum (KTEP) units. The conversion table has been attached as Appendix-E.

Unfortunately, the author experienced that it was not possible to gather the sufficient data in order to develop a behavior within the components of the national energy system. It is interesting that, the data about energy sector is collected, every time when a significant project like World Energy Congress activity in Turkey or a research sponsored by Turkish Industrialists' and Businessmen's Association (TUSIAD) occurs. It is not common to hold a periodically updated database in energy sector for researchers in this field. Available data in the literature seems to be gathered in mass process methods, independent from the preceding one. It has been realized that there are significant differences because of the discontinuity of the data gathering processes. In order to recover from the missing data problems, extrapolations have been applied over the existing data to create time series for modeling.

4.2.1 Elasticity variables

Sectoral demand elasticity variables are used in order to model the structure of reaction to price changes in the energy market. This structure was explained with equations 3.31 - 3.34 in the previous chapter. Reference value for demand elasticity refers to Kavrakoğlu's elasticity statement, as 0.24 for petroleum. (Kavrakoğlu, 1988) The stated value was proposed in 1988, however it is assumed that the consumer demand elasticity has decreased to 0.2 because of the regulated energy market with that of other liberal sectors. Different values both for industry and residence/office demand elasticitys have been tested separately.

It is obvious that, regulation of the energy sector causes a smoothing factor over price changes. While petroleum prices rise and fall up to far levels within quite short periods, Turkish government keeps the fuel prices' oscillation as smooth as possible in order to obey the economic programs. This behavior of the system led the author to insert a price elasticity variable in order to smooth the fluctuations. It is found that the best value for price elasticity would be between 0.2 and 0.4.

4.2.2 Investment intelligence index variables

There are eight different resource supply sectors in the model. Each one is affected by the demand of that resource in the market. According to the capacity gap between the actual capacity and the total demand for that resource, an investment decision is made in the sector. This decision is under some delay coefficients, as in real life. The delay differs depending on the forecasting ability, new project planning and assessing ability and new plant construction speed of the sector. Each one of the above has been put as a variable set in the model to give the real behavior.

Within the network of decision variables in each sector, there is an intelligence variable that reflects each sector's intelligence about the capacities under construction. This is an important variable because, if an investment for a capacity demand were decided without considering the other units in the sector, there would be an excess capacity soon. In order to reflect this knowledge in each sector, an index variable has been put within the limits from 0 to 1. 0 implies that there is insufficient knowledge about the under construction capacity and 1 implies a full range of knowledge.

4.2.3 Efficiency index variables

Technological improvements in the energy sector are indexed to the major consumption variables by means of simple data series. Energy efficiency index is assumed as 1 up to 1999. Later, it decreases slowly down to 0.8 as a multiplier to the consumption variable. This effect reflects the energy efficiency of the appliances and goods. There are three unique efficiency index variables for industrial, residential/official electricity and residential/official heating sectors.

4.2.4 Input values for exogenous variables

Historical values of exogenous variables are analyzed and their behavior is modeled in the simulation. These input equations and results of analyses will be described with the historical comparison in the following part.

4.3 Comparison to Historical Behavior

The model is started in 1975, providing up to 24 years of simulated historical comparison data. Unfortunately, not all the results have the chance to be compared as time series because of the unavailability of some data series as described in the previous section. In fact, since the modeling method is system dynamics; there have to be a clear picture of the system that is being modeled. System dynamics does provide with results letting the modeler or the decision maker to analyze the behavior of the system rather than to forecast what will happen in the near future. Let us investigate the historical behavior of the model, taking into consideration of the constraints mentioned above.

4.3.1 GNP

GNP data refers to State Institute of Statistics' (SIS) time series. Since GNP is an exogenous variable, simulation data matches the historical values. The behavior of simulation slope can be inspected in Figure 4.1. The general behavior of the system is kept constant, but altering the GNP growth rate by variable *gSlope* in the model, according to different scenarios is possible.

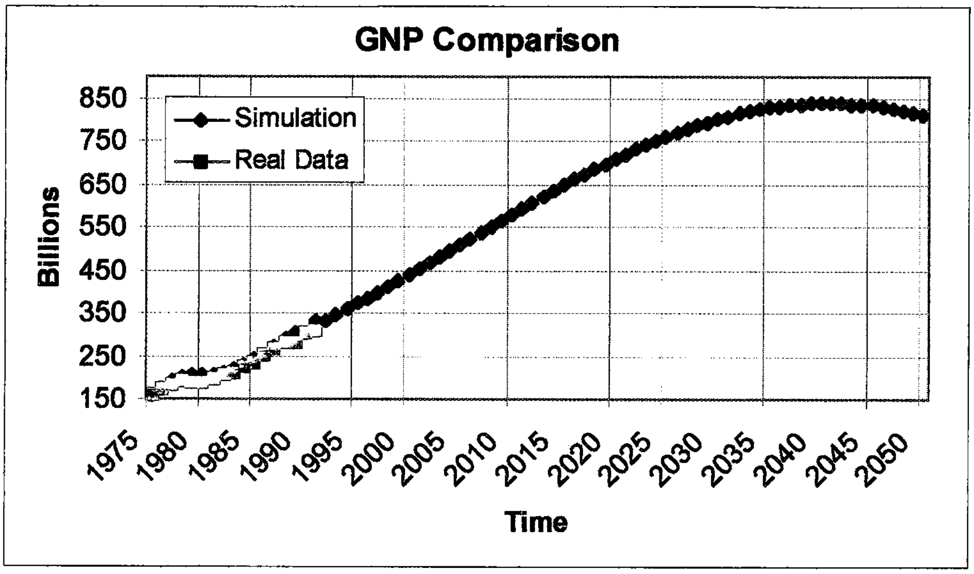

Figure 4.1 GNP comparison

4.3.2 Population

Population data also refers to SIS time series. Historical data comparison is demonstrated in Figure 4.2 below. Population growth rate displays a gradual decreasing behavior as seen in Figure 4.2. Final value of population is under 100 millions in year 2050.

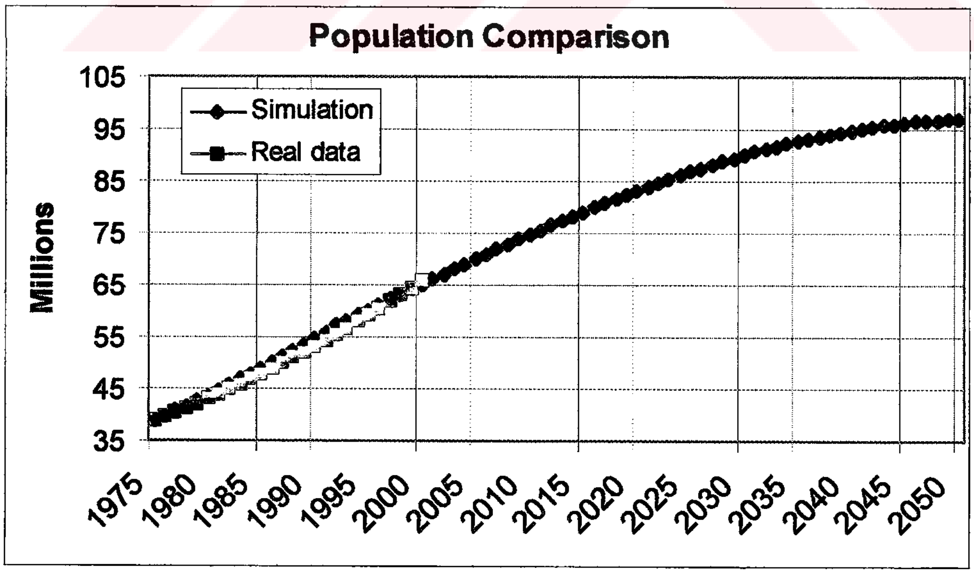

Figure 4.2 Population comparison

4.3.3 Urban population

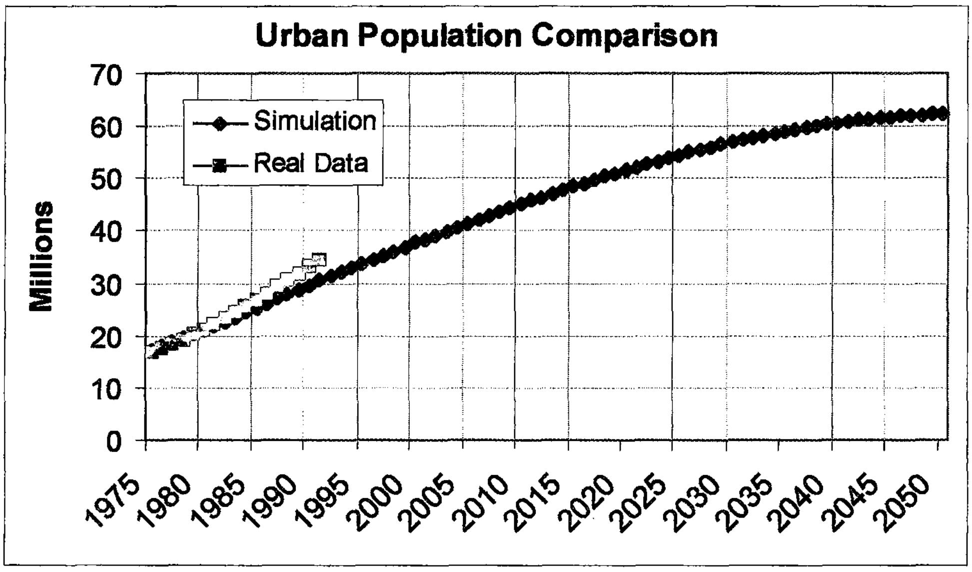

Figure 4.3 Urban population comparison

Urban population is a function of national population. There is a significant relationship between population and urban population. Urban population is an input of street lighting electricity consumption. Since it is a function of population, growth rate of urban population decreases gradually. Urban population growth can be manipulated by variable *cSlope* as a gaming variable.

4.3.4 Household

Household quantity growth shows a strong relationship between growth of GNP. Household quantity comparison graph will not be displayed here because there are only two year's values for household quantity in literature. These values are 9730 for year 1985 and 1189 for year 1990. Simulation values match to these real values.

4.3.5 Electricity requirements of household

In order to simulate a meaningful behavior of the energy demand of residential sector, residence energy consumption is considered in two groups. One of the groups is only electricity consuming appliances group such as television or VCR sets, refrigerators, and lighting equipments. The other one is the heating group, which consists space heaters, water heaters, cooking devices, etc. This group consumes a resource among a group of choices such as natural gas, electricity, fuel oil, coal, etc. Let's describe the electricity group first:

GNP is an effective factor for the development of electrical appliances of household. It is found that there is a strong relationship between GNP and electricity consumption per household. The comparison can be observed in Figure 4.4.

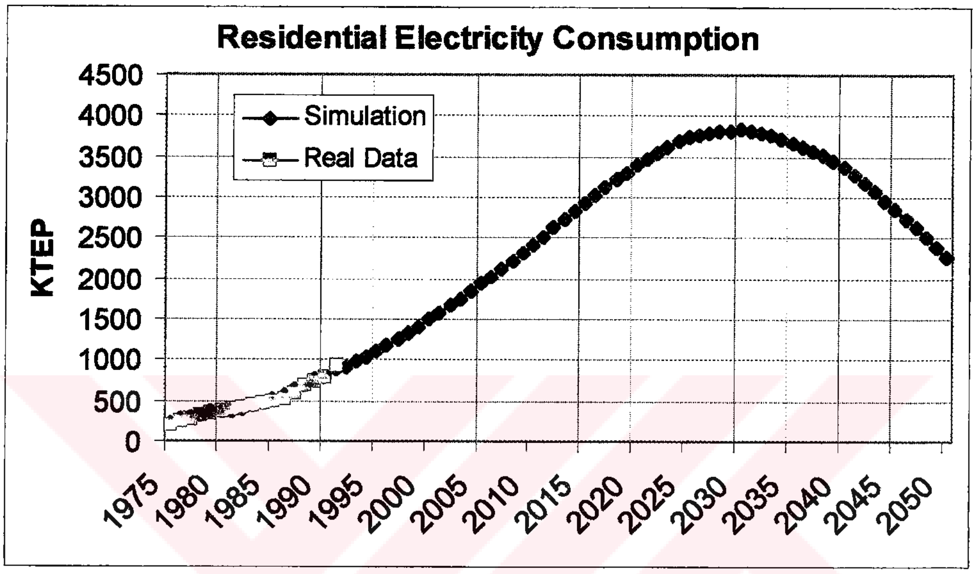

Figure 4.4 Residential electricity consumption

4.3.6 Heating energy requirements of household

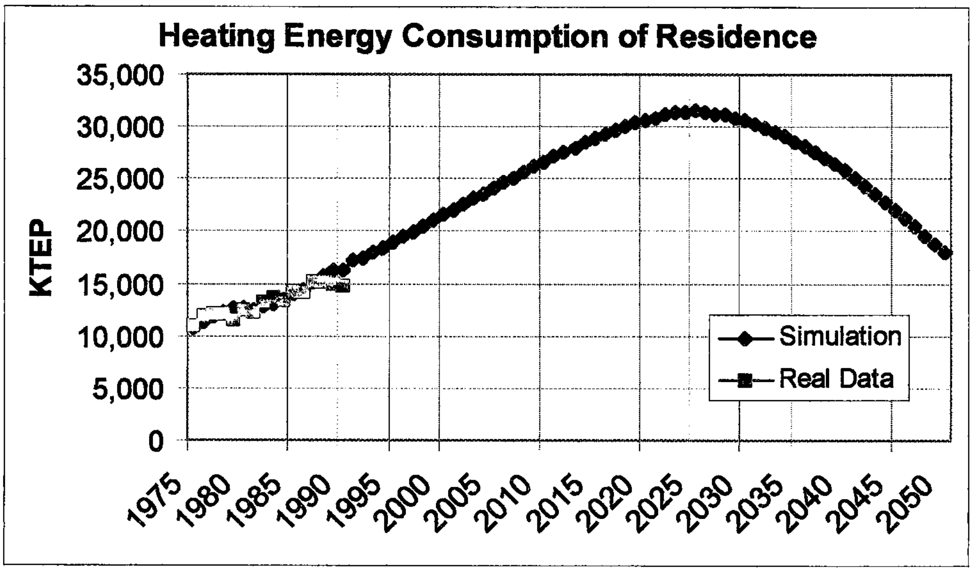

Figure 4.5 Heating energy consumption of residence

The latter group in the residential sector is heating devices group. This group has the chance to make a choice between most available resources to use. There are electricity, natural gas, hard coal, lignite, wood, biomass and renewable energy resources to use. Total consumption of these resources gives us a value of energy demand for heating equipments. Heating energy demand for residence has a significant relation between GNP. The comparison graph can be inspected in Figure 4.5.

4.3.7 Electricity requirements of business sector

Business sector includes private and governmental administration offices and their energy consumption. Energy consumption of operational units of business sector is modeled in the industry sector. The best factor effecting the change of average energy consumption of a single office is found GNP.

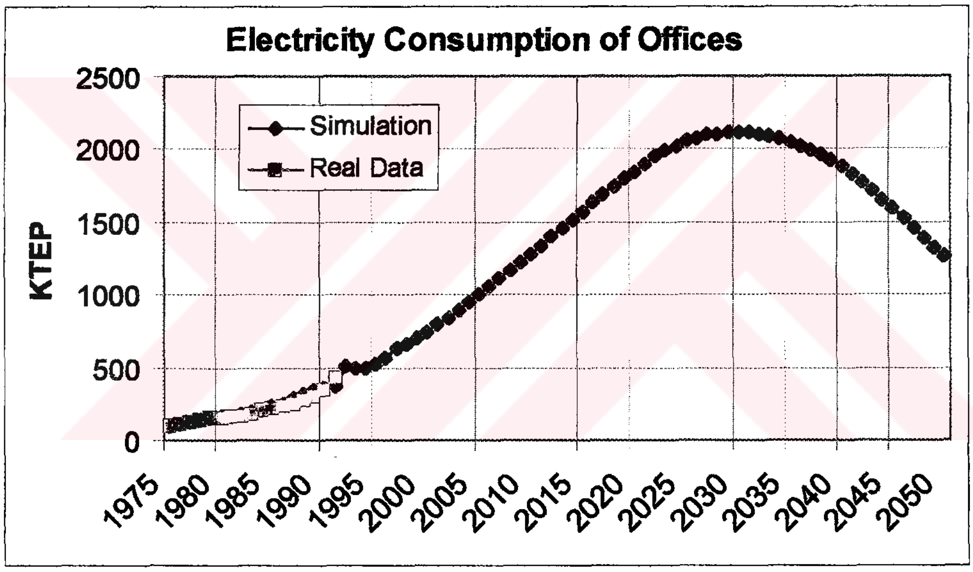

Figure 4.6 Electricity consumption of offices

4.3.8 Number of offices

It will be helpful to remember that the office concept contains both governmental and private business sectors. Number of offices variable grows in relation with GNP.

Office data is not available for the whole historical time period. Available data is sketched in Figure 4.7. Growth rate of number of offices show a decreasing behavior. Number of offices decrease by the year 2045.

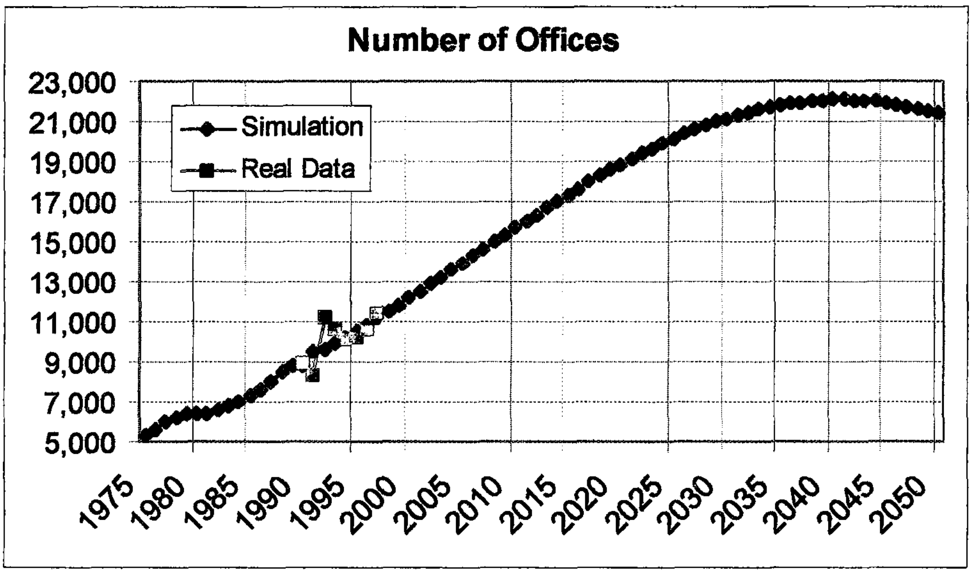

Figure 4.7 Number of offices

4.3.9 National petroleum demand

National petroleum demand is an endogenous variable. It is calculated from the sum of all sectors' petroleum demands and petroleum demand of electricity production sector. Let us see the simulation and real data comparison in Figure 4.8 and discuss the results. There is a slight difference between the real and simulated data between 1980 and 1995. But the rest of the consumption data does not show a similarity to the real one. It seems that the price pressure variables of the petroleum sector is different from the actual values. It is possible to calibrate the results.

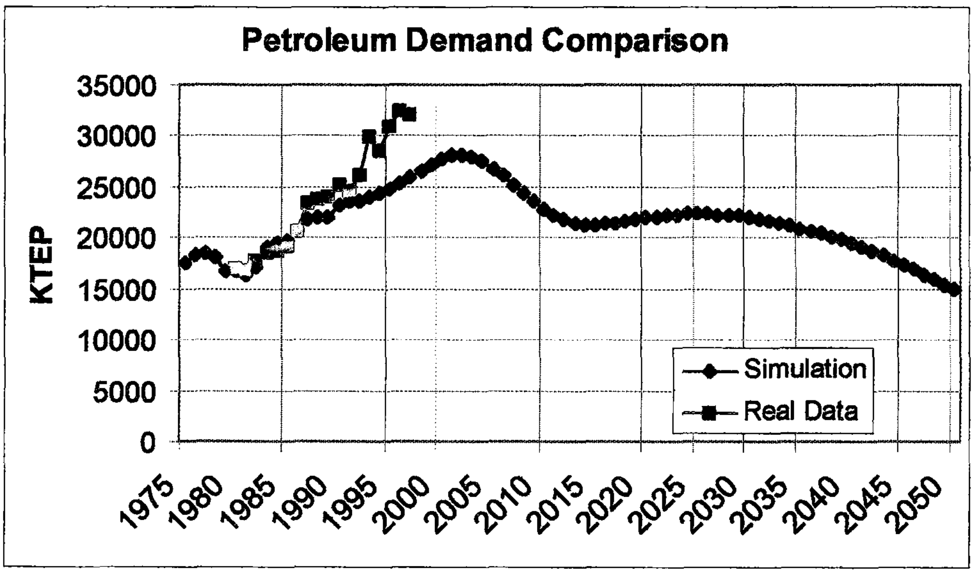

Figure 4.8 National petroleum demand

4.3.10 Industrial petroleum demand

Industrial petroleum demand is a function of industrial energy demand. The consumers decide fraction of the energy resources among the most available resources. Since there is limited data for petroleum demand of industry, it is not possible to make a judgment about the behavior of the displayed data in Figure 4.9.

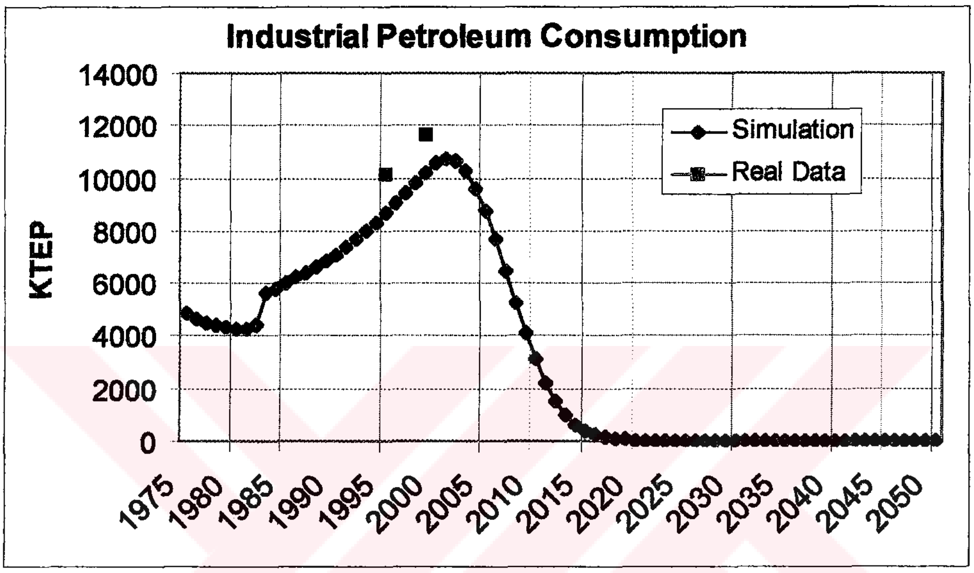

Figure 4.9 Industrial petroleum consumption

4.3.11 Agricultural petroleum demand

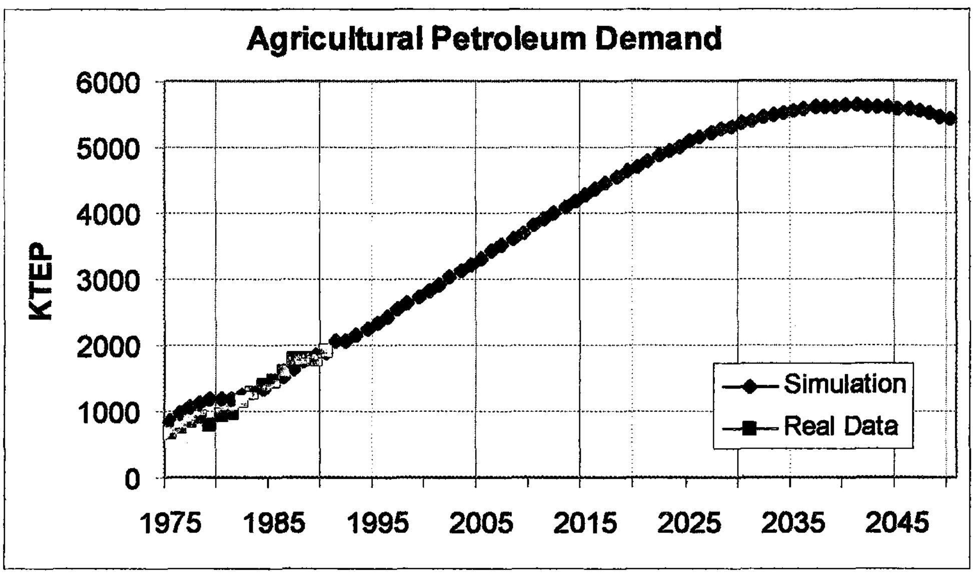

Figure 4.10 Agricultural petroleum demand

Agricultural petroleum demand is a function of GNP. The change of agricultural petroleum demand has a relation with GNP. Petroleum demand of agriculture is used with KTEP units in the simulation. Real data and the simulation data seem to match in Figure 4.10.

4.3.12 Agricultural electricity demand

Electricity consumed by agriculture seems to have a relationship between GNP also. The simulation results are compared to the actual data in the following graph.

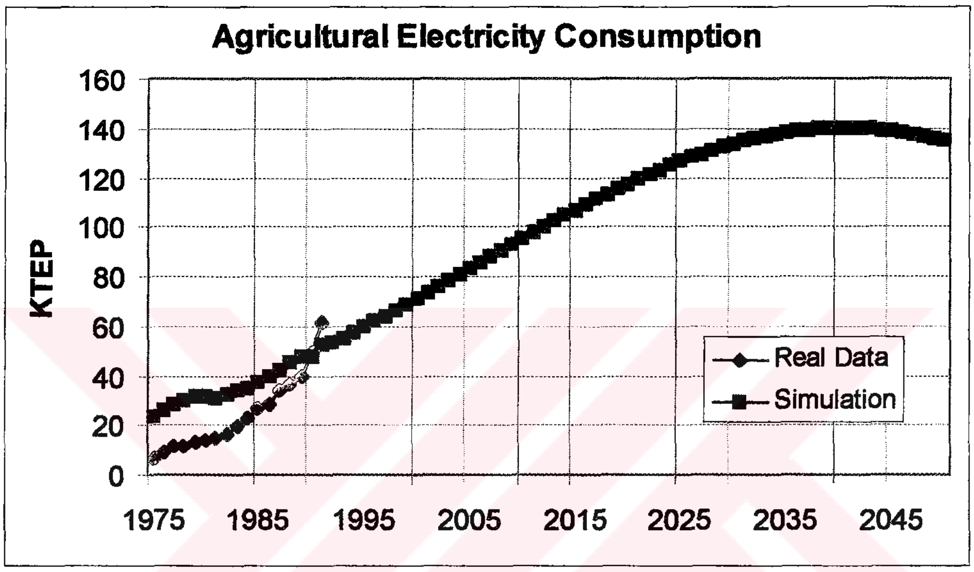

Figure 4.11 Agricultural electricity consumption

The equation curve shows a slight difference between the actual data. This occurs because of the unavailability of the sufficient data about this sector. Analysis results demonstrate that a meaningful relationship between GNP and agricultural electricity demand, however, the application of the equation differs from the actual data. Electricity demand of agriculture is calculated in KTEP units in the simulation.

4.3.13 Petroleum Imports

Petroleum imports variable is calculated from the difference between national petroleum extraction and petroleum demand. Because of the demand is under effect of price changes, whenever the demand is over the local capacity, prices rise and fraction of demand decreases in the next period. The structure of the relationship used in the model is demonstrated in the Figure 4.12 below.

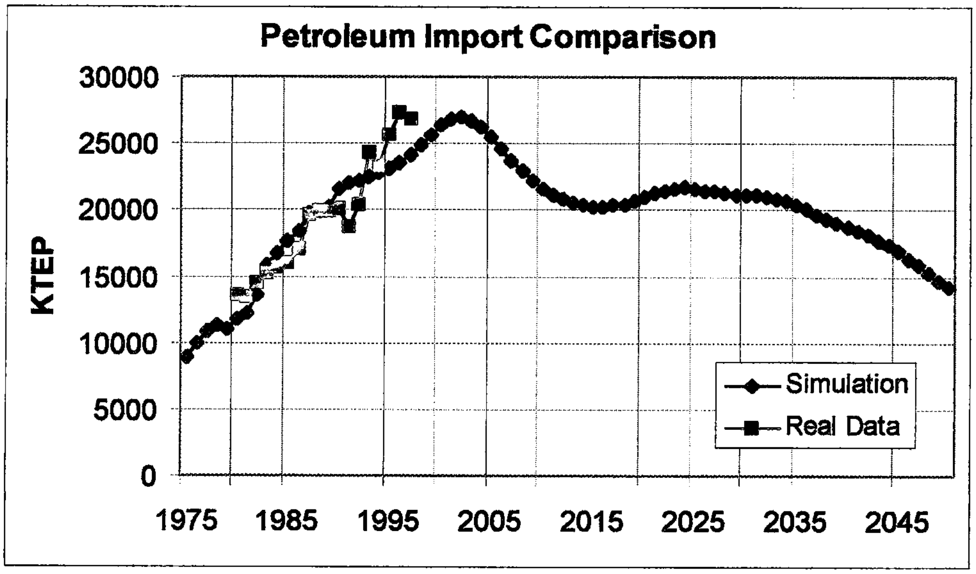

Figure 4.12 Petroleum imports

As it is observed in the Figure 4.12, there is a slight difference between the real and simulated data, although the behavior of the model is stable and similar to the real one. It should be interpreted as the missing data in some important demand sectors, result the model to create these differences. In order to use system dynamics tools as an aid for policy or strategic planning, entire system must be able to be viewed and analyzed. Because of the missing data, it was impossible to identify some of the critical behaviors of model variables. Sterman has modeled entire U.S. energy system with its economical interactions, and proposed a policy strategy covering a span of 70 years' future. (Sterman, 1981)

4.3.14 National hard coal demand

National hard coal demand is a sum of demands of each sub sector. Industrial and residential sectors' energy demands require an amount of hard coal via the price and demand elasticity functions described in the previous chapter. Unfortunately there is not sufficient reliable data to test the behavior of the total hard coal demand curve. Simulated and real consumption data is demonstrated in the following graph.

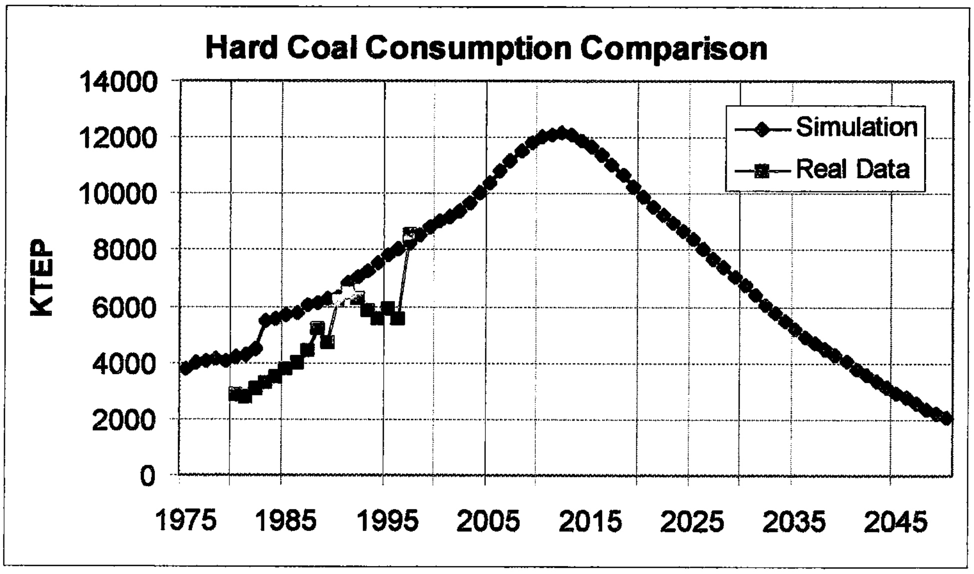

Figure 4.13 Hard coal consumption

4.4 Behavior and Causes

In this part, behavior demonstrations of the base case simulation and discussions about the results will take place.

4.4.1 Electricity demand

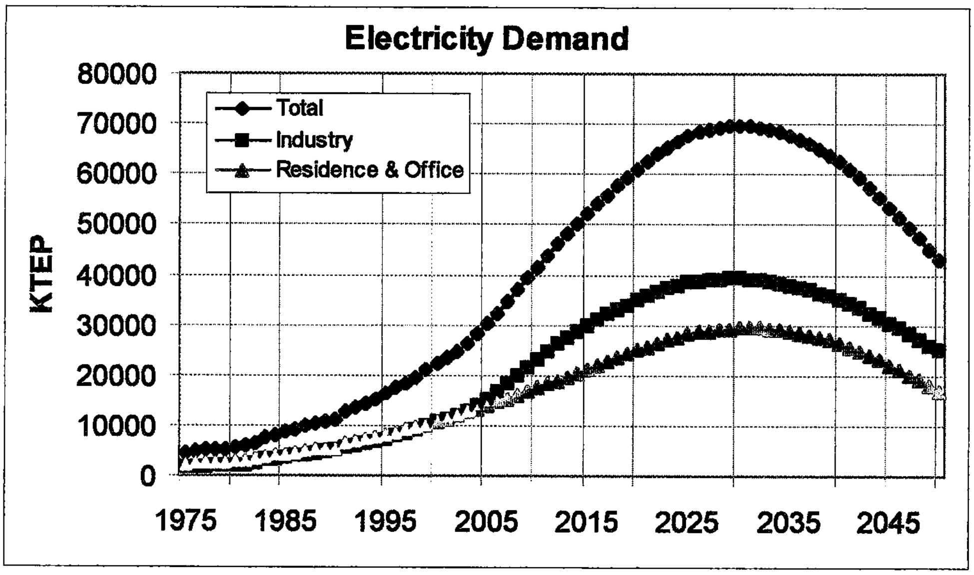

Figure 4.14 Electricity demand

Electricity demand indicates a gradual increase to the year 2030, but later a gradual decrease appears. That behavior is mainly because of the increase in the efficiency of electrical appliances. Efficiency indexes of residence, office, industry and agriculture sector are set to the values of 7% efficiency improvement in the year 2025 and 30% in year 2040. All the efficiency improvements have been kept similar, but it is possible to input different rates of efficiency for each economic sector. The electricity demand behavior is depicted in Figure 4.14.

4.4.2 Electricity supply and imports

Total electricity supply and imports are shown in the Figure 4.17. Electricity supply capacity starts a continuous decrease by the year 2033. With the decrease of the supply capacity, a limited amount of electricity energy seems to be exported by the year 2033. There are certain causes for that behavior. The major cause of that is the consumption of alternative resources, like wind and solar energy, become more available. Another cause seems that energy efficient appliances are more widely used than the earlier times in the simulation.

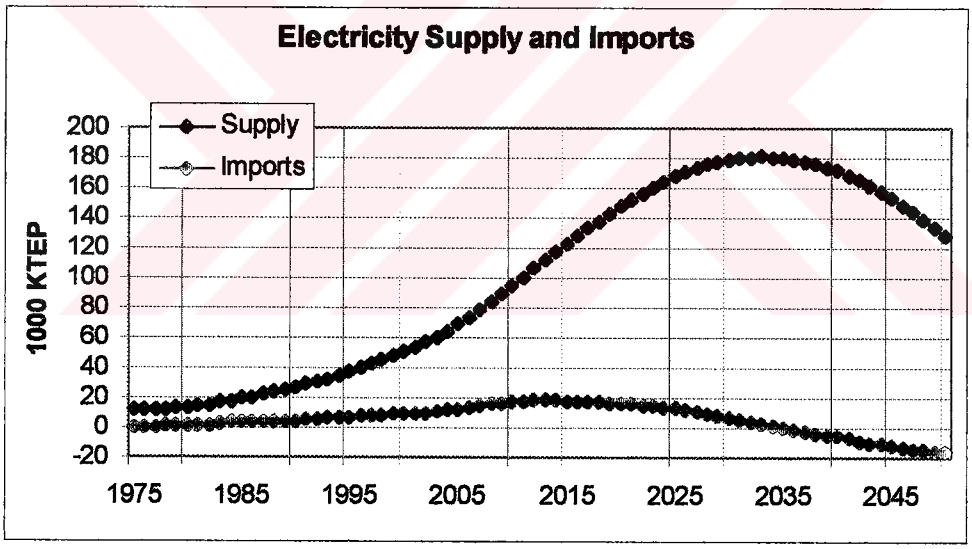

Figure 4.15 Electricity supply and imports

4.4.3 Petroleum demand

Petroleum demand of each sector is demonstrated in the Figure 4.16. The consumption of petroleum in residence and industry decrease because of the availability of the resource. Industrial petroleum demand display a sharp decline after year 2003. Base case parameters of the petroleum sector are set parallel to the historical policies. Industrial availability of petroleum may need to be altered after 2003 if suitable conditions exist. Transportation and agriculture sectors display a different behavior from industry, because transportation and agricultural energy demands have been kept constant in terms of energy types. Alternative energy resources can be plugged in these sectors, to examine the resulting shifts in fuel types. Residential petroleum consumption is in terms of fuel oil.

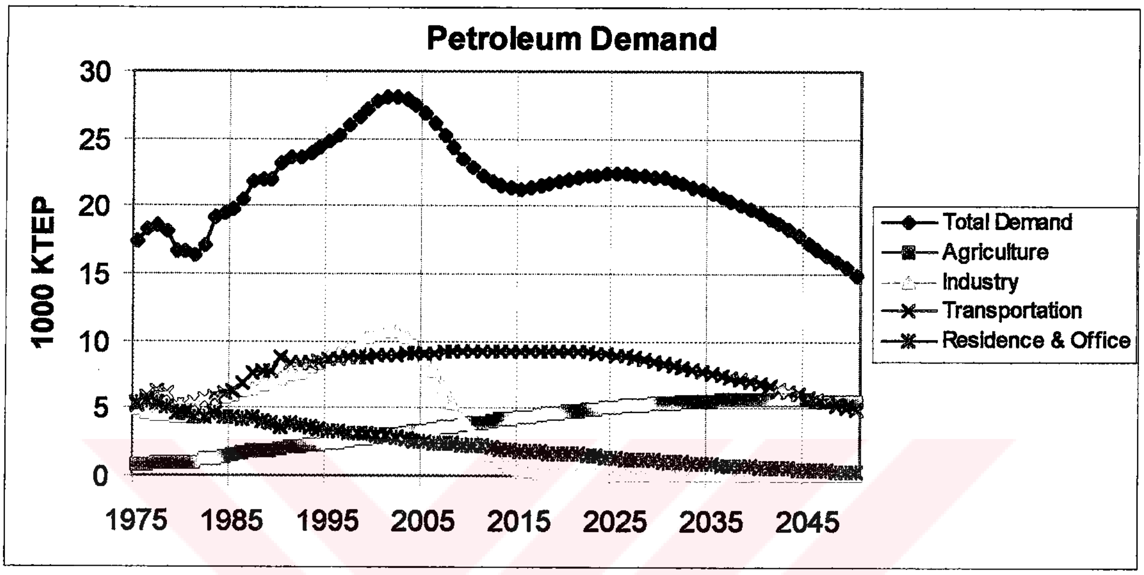

Figure 4.16 Petroleum demand

4.4.4 Petroleum supply and imports

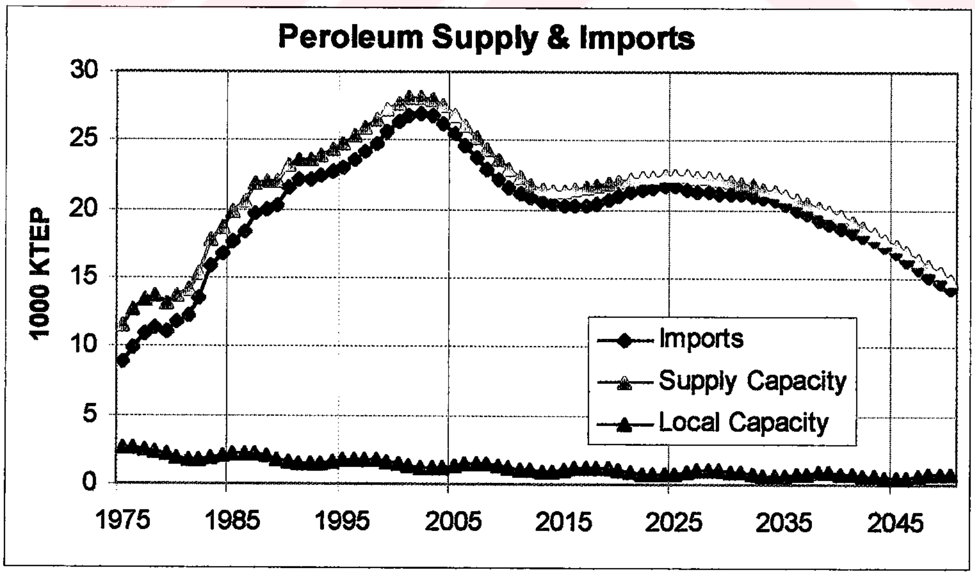

Figure 4.17 Petroleum supply and imports

As seen in Figure 4.17, local reserves are quite limited within current projections of the Ministry of Energy and Natural Resources. Most of the petroleum supply is imported. Because of the global price and scarcity effects over it, consumption of petroleum is declining after the year 2020.

4.4.5 Natural gas

Natural gas is an emerging resource for Turkey. It can be observed from Figure 4.18. The demand is increasing till year 2030. Because of the growing availability of renewable resources, natural gas consumption decreases after 2030. Natural gas consumption for electricity decreases after an increase up to 4541 KTEP per year in 2020.

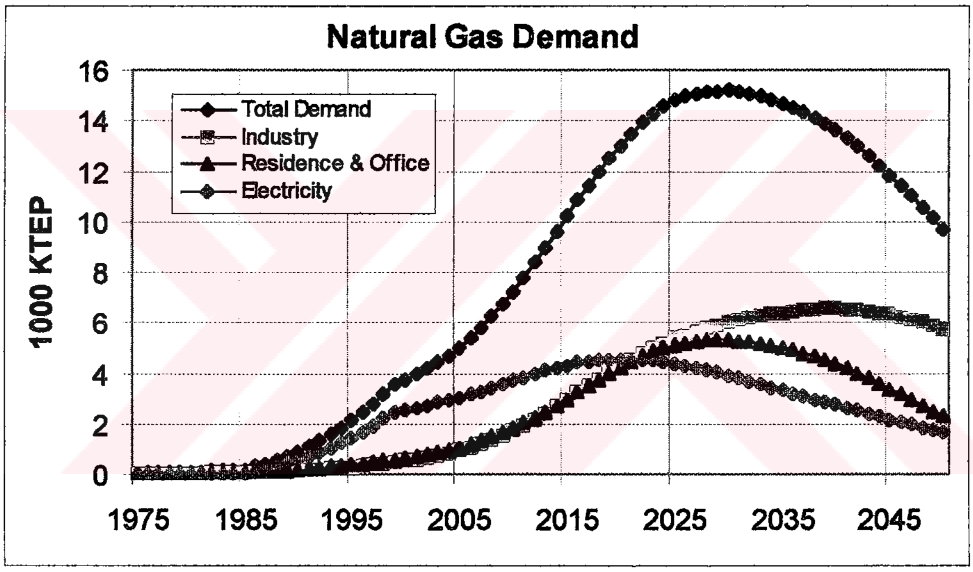

Figure 4.18 Natural gas demand

Since local natural gas reserves are considerably low, most of the demand is supplied with import. The behavior of natural gas import is the same as the demand.

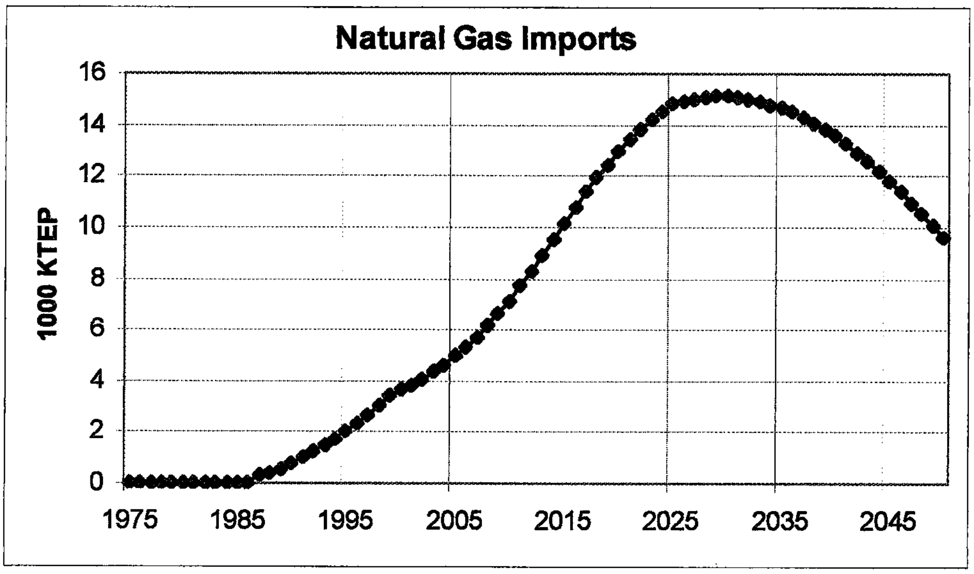

Figure 4.19 Natural gas imports

4.4.6 Renewable energy resources

Renewable energy resources, which are wind, solar and geothermal energy, are transformed in two forms of energy. These are heat and electricity. Electricity production from renewable resources is increasing up to the feasible limit in 2028 and stays constant. Heat production from renewable resources is increasing gradually reaching to 8791 KTEP in 2050.

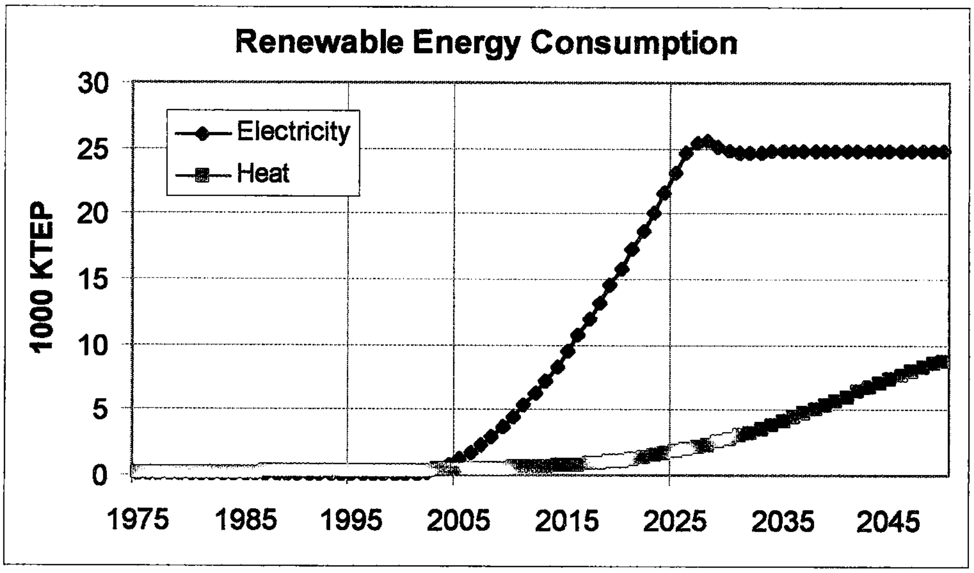

Figure 4.20 Renewable energy consumption

4.4.7 Coal

Coal demand is depicted in Figure 4.21. Depleting conventional fuels cause a demand shift from fossil fuels to renewable resources after 2025. The change in the behavior of coal demand can be explained by the effects of new energy resources.

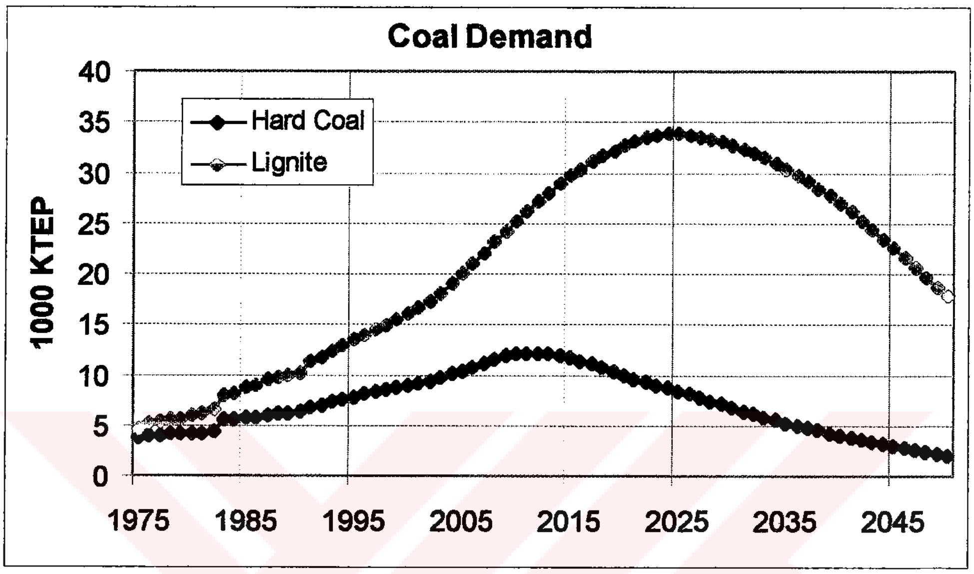

Figure 4.21 Coal demand

Lignite and hard coal is extracted locally and imported where needed. Model behavior on local coal extraction and coal imports can be observed in Figure 4.22.

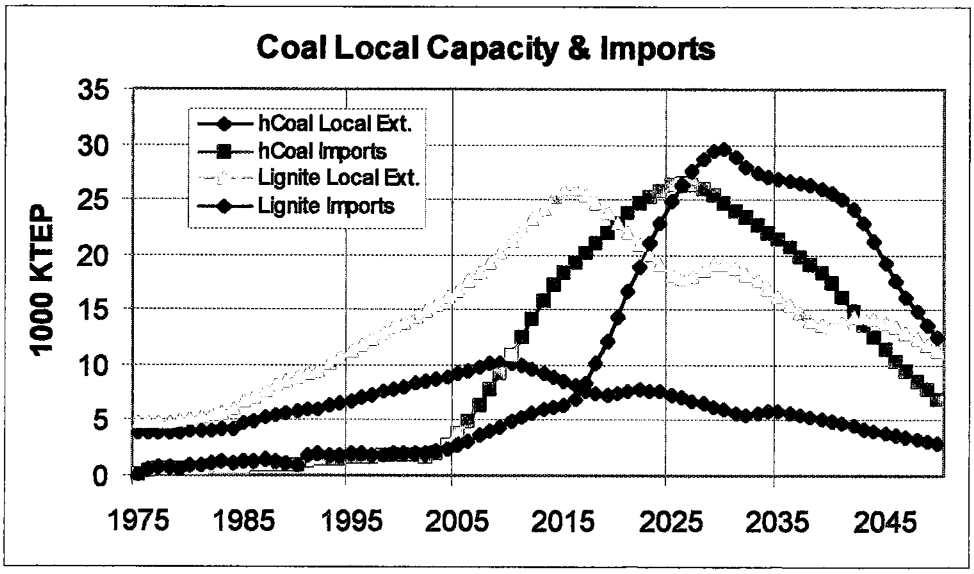

Figure 4.22 Local coal capacity and imports

4.4.8 Wood

Economical wood consumption is depicted in Figure 4.23. Scarcity effects and government tax pressure because of the environmental constraints cause a decrease in wood consumption after year 2020. It is assumed that the noncommercial wood consumption has a negligible rate to that of commercial one.

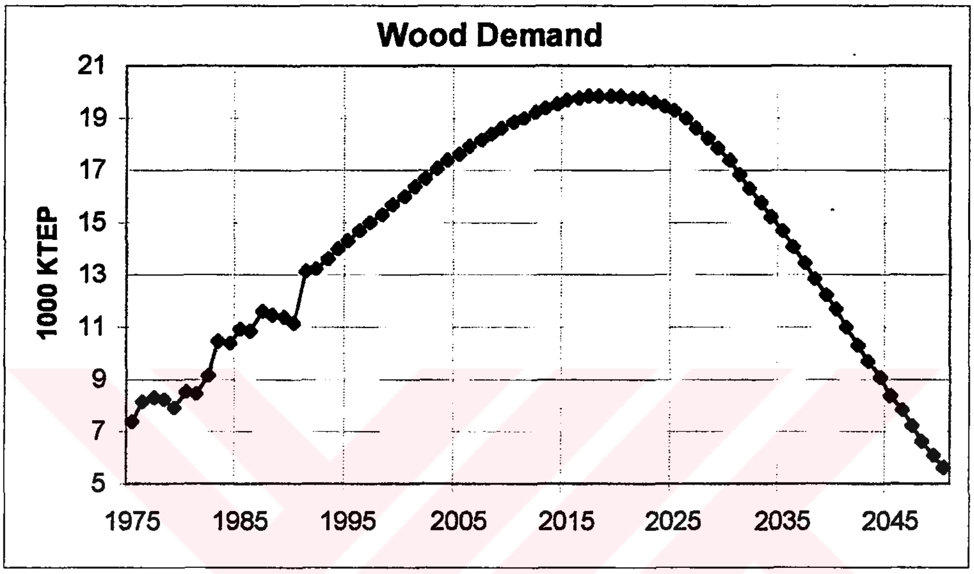

Figure 4.23 Wood demand

4.4.9 Biomass

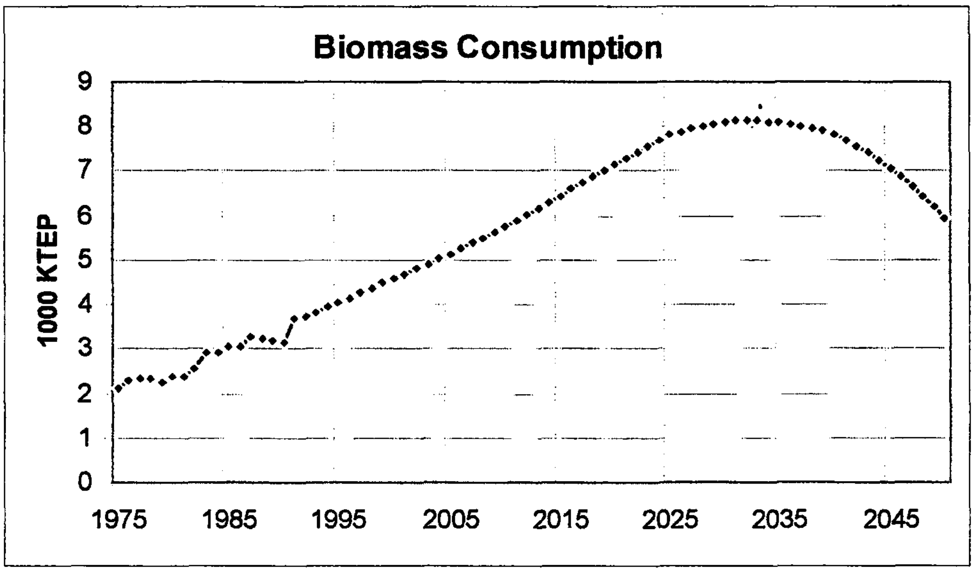

Figure 4.24 Biomass consumption

Biomass fuel is the residue of plant and animals. This resource is traditionally used by rural residences. In addition to that behavior, new technologies are perceived to diffuse in urban areas to use methane gas as a fuel for heating or generating electricity.

4.5 Scenario Parameters

In this section, examples of altering the scenario parameters are given. The entire set of parameters, which are listed in Chapter 3, can be used to differ the scenario structure.

4.5.1 Increasing efficiency of electrical appliances

It is implied that the energy consumption efficiency of electrical appliances is increased during the base case simulation. The increase rate can be observed in Figure 4.25. This input can be altered according to different scenarios.

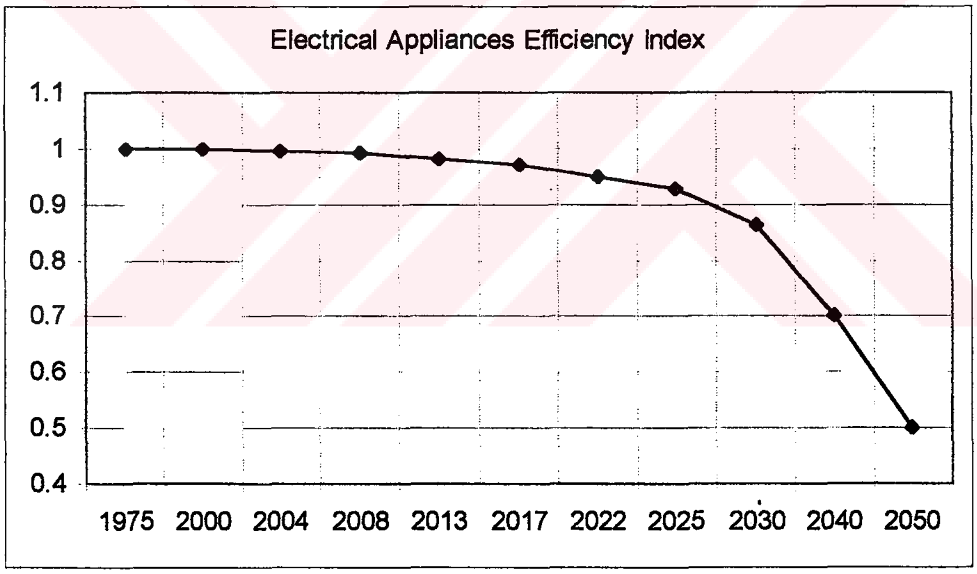

Figure 4.25 Efficiency index of electrical appliances

Let us investigate the difference between the base case scenario and no increase in efficiency scenario simulations in Figure 4.26. There is a 22% of difference in electricity consumption between the two scenarios at the peak level in year 2023. We can interpret this situation that the mere development on efficient technologies for electricity consumption causes energy save of 22 % in year 2023.

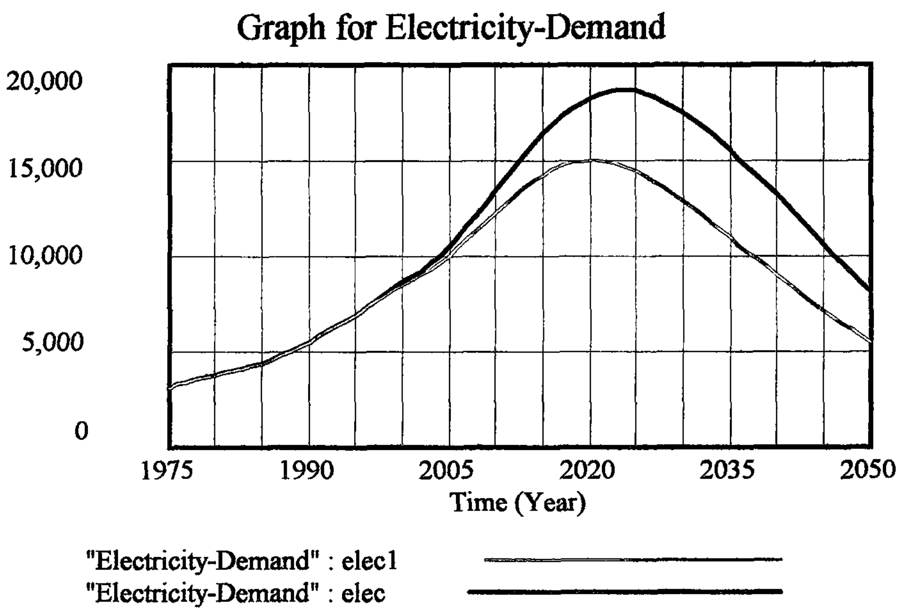

Figure 4.26 Effect of efficiency on electricity consumption

4.5.2 Increasing cost effectiveness of renewable resources

Base case scenario inputs anticipate an improvement in cost effectiveness of renewable resources 20%, 30% and 50% in years 2015, 2025 and 2050 respectively. The alternative scenario is no improvement in this field. Let us compare these two results in Figure 4.27.

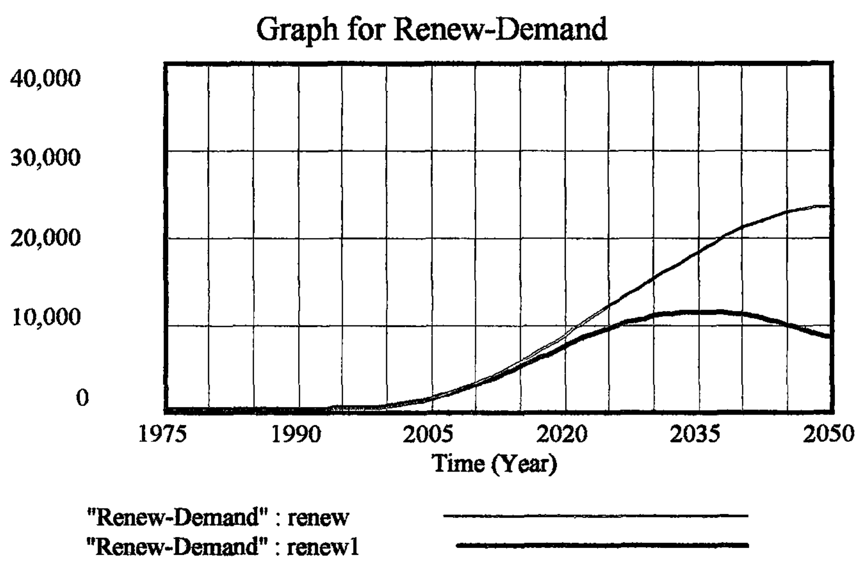

Figure 4.27 Effect of efficiency on renewable resources

The increase in the cost effectiveness of renewable resources causes a demand increase by 180% in year 2050.

4.5.3 Scenario development from Delphi results

Scenario development for this model can be made through different approaches. Even the model developer's vision and anticipation can be sources for scenario building. In order to analyze the expected future on simulation models, it will be more helpful to use foresight techniques for scenario development.

Delphi methodology has been used to gather scenario inputs for the base case simulation. Unfortunately, time constraints of the thesis project prevented the author to reach a sufficient number of experts about energy policies. However, the structure that was constructed for Delphi sessions has been used and 23 participants have attended to the survey. Here are the brief results of the survey as the first session. Events are listed in Appendix-D.

4.5.3.1 Degree of impact on quality of life in 2023

Each event is evaluated as the impact on quality of life in year 2023. Degree of impact on quality of life is indexed with relative coefficients and the events are listed in the order from the most beneficial to the least. The most beneficial event is perceived to be the 10th event, which is about natural gas transmitting technologies. The most beneficial and the least beneficial events can be observed in Figure 4.28.

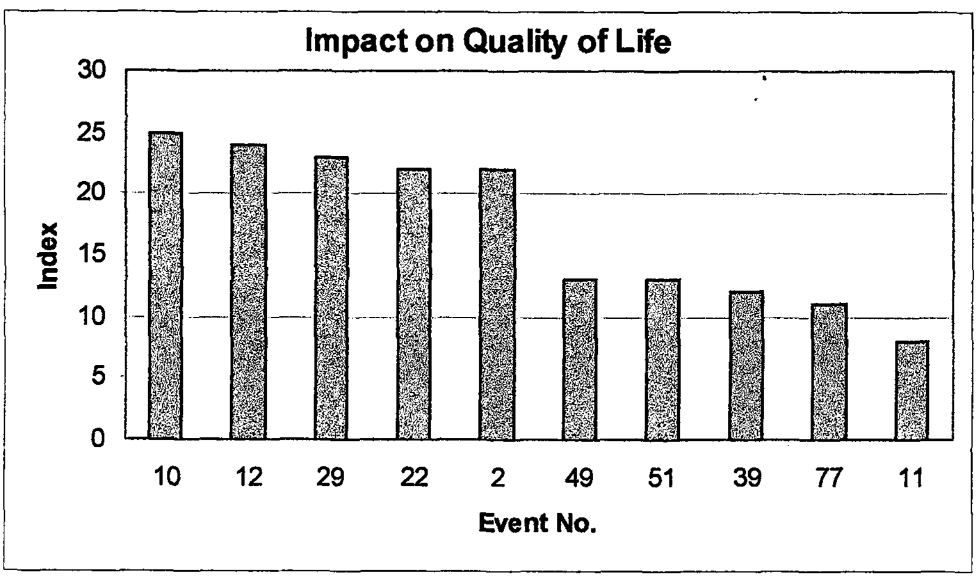

Figure 4.28 Impact on quality of life

4.5.3.2 Expectation of occurrence

Each event is evaluated as the first occurrence in the time scale. The distribution of expectation of occurrence is depicted in Figure 4.29. It can be interpreted as the most event occurrence expectation on the time scale among the participants is in 2013. There is no expectation of occurrence before 2009 and after 2021.

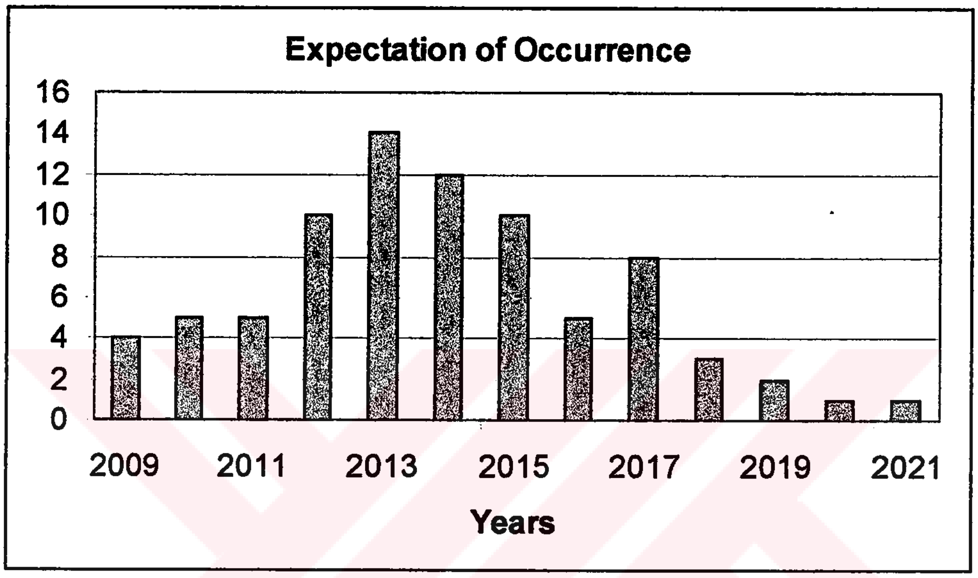

Figure 4.29 Expectation of occurrence

4.5.3.3 Constraints on occurrence

There are seven types of constraints that set resistance on the occurrence of related event. Each of them can be anticipated as a constraint for each event. The constraints are listed in order of importance most to least;

1. Lack of funding
2. Technological feasibility
3. Economic viability
4. Lack of skill
5. Political issues
6. Regulatory issues
7. Social / ethical acceptability

It can be interpreted that the most important factor limiting the occurrence of the events is lack of funding. Lack of funding has an average of 7.83 hits per event. Social issues do not have an important effect over events with an average of 0.89 hit per event.

5 . CONCLUSION AND FUTURE WORK

Energy sector is one of the important sectors of national economy. In order to reach the chances in front of this country, sensitive and effective planning must be a principle. Projects that find limited chance to be realized do no good for the future of Turkey. State Planning Organization has been developing policy for national development for years. Unfortunately, it is usually not a chance to execute all of these items, because of the way they are created.

National energy sector consists of some components, which must be taken into consideration when deciding on a strategic problem. From a global point of view, these components can be listed as demand, supply and price sectors, briefly. There will be a number of unexpected responses from the system, with each attempt to solve a problem on one of these components. This is the nature of a system. It is critical to consider the whole energy system and develop a solution for the whole system. There are a number of projections and academic research in this field; unfortunately they are not capable of analyzing the whole energy system.

System dynamics has been used for similar problems in different western countries. System dynamics is capable of analyzing and modeling the structure of complex systems. It has been tried to develop a simulation game model for decision makers of the Turkish energy sector, using system dynamics methodology. Since this methodology has not been used in this field in Turkey, but also is a common tool in more developed countries, it can and may help solving decision problems in energy investments.

National energy system has been analyzed and modeled using system dynamics methodology. Model boundaries has been kept narrow because of the sponsoring organization's limitations however, national energy system has been covered with all major components. Scenario parameters have been designed so as to enable the user to differ and inspect the scenario of the base case simulation.

It is anticipated that renewable energy resources will gain more consumption share, since fossil fuel is depleting around the world. The consumption share of renewable resources will change according to the scenario parameters. Base case inputs reflect an expectation on technological developments causing price decrease of 20% in year 2015 and 50% in year 2050. The expectation on improvement of technological developments will increase the renewable energy consumption by 180% in year 2050. In the same manner, technological effectiveness improvements on electrical appliances affects the electricity consumption with an energy save of 22%, if the effectiveness is increased by 6% in year 2023.

The construction of Delphi as a foresight tool has been completed successfully. The test run has also been run and results have been derived from the responses of attendants. According to the limited amount of responses, namely it is 23 attendants, most beneficial technological improvement about energy sector, seems to be about natural gas transporting technologies. Most technological improvement is expected to first occur in year 2017. No new improvement is expected to occur before year 2009. Most challenging constraint, which seems to limit the events, is lack of funding.

System dynamics uses and needs a detailed database about the system that is being modeled. Unfortunately, authors could not be able to reach every kind of data about Turkish energy sector, and therefore could not set a precise calibration on the model, described above.

It will be proper to broaden the boundaries of the model to national economic sector in order to see the complete behavior or reaction of the economy to the alterations of the scenario parameters. Authors plan to expand the boundaries of the model to cover the energy economy interactions. It is also aimed to improve the model with adding a user friend interface, presenting the user to differ the scenario parameters easily and see the result graphs quickly. To keep the dynamic behavior of the model alive, integration of the model with a well-designed and up to date database of energy sector can be plugged in to the model.

Appendix-A

Energy and National Development Plans

National development plans are organized by State Planning Organization (SPO), which is a subordinate unit of Prime Ministry, in five-year periods. SPO generates macro plans about national development. Government units fund their projects from national budget according to current development plan. Following pages demonstrate the brief content about the then current status about energy sector and projections about the planned period.

Expected values of energy sector for each plan period have errors. These errors cause defective plans and destabilize the sector. Since the reliability of the plans decrease, addiction to plan principles decreases and destabilization increases. This is a negative reinforcing loop itself.

Some tables, demonstrating the forecasted numbers about the energy sector of the five-year development plans, are listed in the following pages.

Enerji Talep Tahminleri (Plan 1)

	Kuzey Batı sistemi		Batı sistemi		Çukurova sistemi		Antalya sistemi		Sistem		Toplam	
Yıllar	Güç (MW)	En.	Güç (MW)	En.	Güç (MW)	En.	Güç (MW)	En.	Güç (MW)	En.	Güç (MW)	En.
1962	445	2360	76	353	40	182	22	109	178	546	766	3550
1963	510	2663	90	423	45	207	23	157	187	561	855	4011
1967	800	4200	157	768	100	456	32	192	292	923	1381	6539

Enerji Sektörü Uzun Dönem Gelişme Perspektifleri (Plan 3)

	1972	1977	1982	1987	1992	1995
ANA MALLAR						
I — GENEL ENERJİ						
Toplam enerji tüketimi (BTEP)	23250	36555	53600	78000	105000	125000
Fert başına enerji tüketimi (KGEP/Kişi)	620	858	1100	1405	1688	1896
II — ELEKTRİK ENERJİSİ						
Puvant güç (Mw)	1982	3650	6384	10720	17000	22400
Enerji (Gwh)	11000	20330	35430	59500	95000	125000
Enerji / Kişi (Kwh)	294	447	728	1090	1527	1896
Ortalama yıllık enerji artışı (Yüzde)	13.1	11.8	10.9	9.7	9.6	

Birincil Enerji Tüketimi ve Hedefleri (Orijinal Birimler) (Plan 4)

(Bin Ton, GWh)

Anamallar	1962	1967	1972	1977	1978	1983
Taşkömürü	3553	4550	4650	4910	5200	8800
Linyit	3337	4634	7271	13000	15000	51555
Petrol ürünleri	2699	5446	10311	16827	17429	27074
Hidrolik	1124	2382	3204	8592	9240	13739
Odun (l)	13052	12831	13503	14350	14240	9500
Hayvan ve bitki artıkları	8818	10258	10769	10380	10348	10000

(1) Yakacak odun ve ikincil ürünlere ilişkin veriler 1978 yılında Türkiye başında yapılan dolaylı talep çalışmaları sonuçlarına göre kesinleşecektir.

BİRİNCİL ENERJİ TÜKETİMİ VE KAYNAKLARIN ORANLARI
IV. PLAN GERÇEKLEŞME VE V. PLAN HEDEFLERİ (Plan 5)

(BTEP)

	1978	1983	1984	1989
Taşkömürü	2827	3208	3294	5063
Linyit	4056	5597	5870	10680
Petrol Ürünleri	17115	16814	17210	24069
Doğal Gaz	20	7	7	632
Hidrolik Enerji	2341	2839	3046	5600
Jeotermal Enerji	0	0	14	23
Elektrik Ener. İth.	156	556	548	0
Güneş Enerjisi	0	0	1	2
TOP. TİC. ENERJİ	26515	29021	29990	46069
Odun	4574	5126	5177	5344
Hayvan ve Bitki. Atık.	2903	3574	3396	3158
TOPLAM GAYRİTİCARİ ENERJİ	7477	8700	8573	8502
GENEL TOPLAM	33992	37721	38563	54571

Birincil Enerji Tüketiminde Gelişmeler (Plan 6)

(Orijinal Birimler)

	1984	1988	1989	1994	V. PLAN (84-89) ARTIŞ HIZI (%)	VI. PLAN (89-94) ARTIŞ HIZI (%)
Taşkömürü (1)	5678	7551	7980	14500	7	12.7
Linyit (1) (5)	25821	34067	41990	66300	10.2	9.6
Ham Petrol (1)	16890	20620	21650	31560	5.1	7.8
Doğal Gaz (2)	40	1214	3060	7250	138.1	18.8
Hidrolik Enerji (3)	13426	28928	24200	34500	12.5	7.3
Jeotermal Enerji (3)	22	68	40	60	12.7	8.4
Elektrik ithalatı	2653	360	350	500	-33.3	7.4
TİCARİ ENERJİ (4)	30276	41173	44250	69100	7.9	9.3
Odun (1) (6) (D	17256	17711	17167	16000	-0.1	-1.4
Hayvan ve Bitki Artık.(1)(T)	14766	11365	11300	10870	-5.2	-0.8
GAYRİ-TİCARİ ENERJİ (4)	8572	7927	7750	7300	-2	-1.2
GENEL TOPLAM (4)	38848	49100	52000	76400	6	8

(T) Tahmini

(1) Bin Ton; (2) Milyon m^3; (3) Gwh; (4) Bin TEP;
(5) Asfaltit ve özel sektör üretimi dahil; (6) Kaçak kesim dahil.

Elektrik Enerjisi Tüketiminin Kullanıcı Gruplarına Göre Dağılımı (Plan 7)

(GWh)

	1995 Gerçekleşme		1999		2000		2005		Yıllık Ortalama Artış (%)	
	GWh	Pay (%)	GWh	Pay (%)	GWh	Pay (%)	GWh	Pay (%)	VII.Plan	VIII.Plan
Konutlar	14493	16,9	21800	18,4	24000	18,9	40600	20,8	10,6	11,1
Ticarethaneler	4195	4,9	8700	7,3	9400	7,4	16000	8,2	17,5	11,2
Resmi Daire	3012	3,5	4700	4,0	5100	4,0	6400	3,3	11,1	4,6
Genel Aydınlatma	3106	3,6	4100	3,5	4400	3,5	7400	3,8	7,2	11,0
Sanayi	38007	44,4	46000	38,8	50000	39,4	77000	39,5	5,6	9,0
Diğer	4581	5,4	6100	5,1	6500	5,1	11500	5,9	7,2	12,1
NET TOPLAM	67394	78,8	91400	77,1	99400	78,4	158900	81,4	8,1	9,8
İç Tüketim ve Kayıp	18157	21,2	27085	22,9	27400	21,6	36200	18,6	8,6	5,7
BRÜT TOPLAM	85551	100,0	118485	100,0	126800	100,0	195100	100,0	8,2	9,0
Kişi Başına Net Tüketim (kWh)	1115		1420		1522		2258		6,4	8,2
Kişi Başına Brüt Tüketim (kWh)	1416		1840		1941		2773		6,5	7,4

Birincil Enerji Tüketiminin Kaynaklar İtibariyle Sektörel Dağılımı (Plan 8)

	1995						1999					
	Konut ve Hizmetler	Ulaştırma	Tarım	Elektrik	Sanayi ve Diğer	Toplam	Konut ve Hizmetler	Ulaştırma	Tarım	Elektrik	Sanayi ve Diğer	Toplam
TİCARİ ENERJİ	7.747	11.024	2.425	15.494	19.39	56.08	8.143	11.083	2.863	22.331	23.683	68.103
Taşkömürü	876	2		568	5.244	6.69	471	4		756	7.955	9.186
Linyit	1.918			6.841	1.875	10.634	2.085			9.158	1.711	12.954
Petrol Ürünleri	3.933	11.021	2.425	1.803	10.141	29.323	3.282	11.075	2.863	2.44	11.632	31.292
Doğal Gaz	904	1		3.278	2.13	6.313	2.155	4		6.81	2.385	11.354
Hidrolik Enerji				3.057		3.057				2.982		2.982
Yenilenebilir Enerji	116			7		123	150			9		159
Elektrik İthalatı				-60		-60				176		176
GAYRİ-TİCARİ ENERJİ	7.068					7.068	6.387			70		6.457
Odun (T)	5.512					5.512	5.082					5.082
Hayvan ve Bitki Artıkları (T)	1.556					1.556	1.305			70		1.375
T O P L A M	14.815	11.024	2.425	15.494	19.39	63.148	14.53	11.083	2.863	22.401	23.683	74.56
YÜZDE DAĞILIM	23,5	17,5	3,8	24,5	30,7	100,0	19,5	14,9	3,8	30,0	31,8	100,0

(T) Tahmini

Birincil Enerji Tüketiminin Kaynaklar İtibariyle Sektörel Dağılımı (Devamı)

	2000						2005					
	Konut ve Hizmetler	Ulaştırma	Tarım	Elektrik	Sanayi ve Diğer	Toplam	Konut ve Hizmetler	Ulaştırma	Tarım	Elektrik	Sanayi ve Diğer	Toplam
TİCARİ ENERJİ	8.366	11.66	3	24.5	24.85	72.376	10.8	15.02	3.6	37.065	34.1	245.337
Taşkömürü	300	5		750	7.8	8.855	200	5		2.54	6.5	9.245
Linyit	1.9			9.885	1.7	13.485	1.2			11.775	800	13.775
Petrol Ürünleri	3.65	11.65	3	2.676	12.9	33.876	3.3	15	3.6	3.775	18.2	43.875
Doğal Gaz	2.35	5		8.271	2.45	13.076	5.8	15		14.69	8.6	29.105
Hidrolik Enerji				2.675		2.675				4.007		4.007
Yenilenebilir Enerji	166			19		185	300			175		475
Elektrik İthalatı				224		224				103		103
GAYRİ-TİCARİ ENERJİ	6.334			70		6.404	5.315			70		5.385
Odun (T)	5.07					5.07	4.35					4.35
Hayvan ve Bitki Artıkları (T)	1.264			70		1.334	965			70		1.035
T O P L A M	14.7	11.66	3	24.57	24.85	78.78	16.115	15.02	3.6	37.135	34.1	248.83
YÜZDE DAĞILIM	18,7	14,8	3,8	31,2	31,5	100,0	15,2	14,2	3,4	35,0	32,2	100,0

Appendix-B COLLECTED DATA

Gayri Safi Yurtiçi Hasıla (1950-1991)
(Milyon 1968 - TL)

Yıllar	Tarım	Sanayi	Hizmetler	GSYtH
1950	15620	4149	15020	34789
1951	18710	4263	16210	39183
1952	20500	4769	18070	43339
1953	22300	5623	20470	48393
1954	19200	6133	21580	46913
1955	21285	6900	22845	51030
1956	22339	7606	23299	53244
1957	23763	8781	25477	58021
1958	25948	9021	25697	60666
1959	26020	9194	27397	62611
1960	26570	9375	28716	64661
1961	25284	10498	29790	65572
1962	26449	10818	31697	68964
1963	29033	12074	34614	75721
1964	28905	13377	36614	78896
1965	27768	14641	38372	80781
1966	30757	16873	42721	90351
1967	30810	18262	44755	93827
1968	31291	20707	48904	100902
1969	31665	22918	52042	106625
1970	32419	23474	56359	112252
1971	36675	25544	60094	122313
1972	36543	28079	65061	129683
1973	32932	31240	70877	135049
1974	36330	33827	76712	146869
1975	39675	35615	84648	159938
1976	42732	39165	92233	174130
1977	42180	43145	97391	182716
1978	43302	45991	101346	190639
1979	44518	43429	101562	189509
1980	45268	40833	102421	188522
1981	45298	43859	106180	195337
1982	48202	46015	109934	204151
1983	48146	49686	114258	212090
1984	49840	54687	120327	224854
1985	51030	58106	125138	234274
1986	55059	63171	133156	251386
1987	56234	69218	142240	267692
1988	60750	71389	148026	280165
1989	54188	73601	154071	281160
1990	60472	80231	164227	304930
1991	59990	82800	165510	308300

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Nufus Gelişimi (1950-1991)
(Bin Kişi)

Yıllar	Şehirler	Köyler	Toplam
1950	5250	15700	20950
1951	5550	15980	21530
1952	5860	16260	22120
1953	6200	16550	22750
1954	6550	16840	23390
1955	6930	17140	24070
1956	7190	17250	24440
1957	7580	17670	25250
1958	7950	18030	25980
1959	8370	18370	26740
1960	8780	18730	27510
1961	9150	19080	28230
1962	9520	19410	28930
1963	9910	19750	29660
1964	10300	20090	30390
1965	10720	20430	31150
1966	11240	20700	31940
1967	11790	20960	32750
1968	12360	21230	33590
1969	12950	21490	34440
1970	13600	21700	35300
1971	14160	22100	36260
1972	14780	22400	37180
1973	15380	22700	38080
1974	16040	23000	39040
1975	16750	23300	40050
1976	17560	23440	41000
1977	18410	23570	41980
1978	19300	23680	42980
1979	20240	23760	44000
1980	21210	23840	45050
1981	22240	23880	46120
1982	23320	23890	47210
1983	24430	23910	48340
1984	25630	23860	49490
1985	26870	23800	50670
1986	28050	23720	51770
1987	29280	23620	52900
1988	30570	23500	54070
1989	31920	23340	55260
1990	33330	23140	56470
1991	34340	23350	57690

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Appendix-B (Continued) COLLECTED DATA

Elektrik Tüketiminin Sektörel Gelişimi (1950-1991)

(GWh)

								Sokak	TOPLAM	
	Tarım	Sanayi	Konutlar	Tic. hane	Hizmetler	R. Daireler	Ulaştırma	Aydınlatma	Net	Brüt
1950	8.0	466.2	75.1	33.5	34.7	21.4	17.9	22.0	678.8	789.5
1951	9.0	523.3	86.0	41.0	39.0	22.0	17.7	26.0	764.0	887.9
1952	10.0	601.8	102.8	46.0	44.8	24.9	17.0	31.2	878.5	1020.2
1953	12.0	688.5	129.0	48.9	51.3	30.1	16.7	36.1	1012.6	1200.8
1954	14.0	809.6	156.7	57.6	60.3	33.5	17.2	42.7	1191.6	1402.5
1955	16.0	908.7	182.6	66.9	67.7	37.1	20.0	48.4	1347.4	1579.8
1956	18.0	1046.3	201.5	77.0	77.9	37.1	33.8	53.2	1544.8	1819.1
1957	20.0	1187.5	227.4	91.1	8.4	49.6	36.2	56.8	1757.0	2056.7
1958	23.0	1325.2	252.9	105.8	98.7	35.7	38.6	62.8	1942.7	2303.4
1959	26.0	1458.2	299.9	107.0	108.7	59.7	41.4	69.6	2170.5	2587.3
1960	15.0	1617.1	344.2	116.2	119.1	68.5	38.5	76.8	2395.4	2815.1
1961	21.0	1711.7	370.8	129.7	126.9	103.1	41.3	80.9	2585.4	3011.1
1962	25.0	2068.2	412.8	147.4	153.3	122.4	43.7	86.5	3059.3	3559.8
1963	10.0	2316.8	451.5	165.6	170.4	144.7	52.2	96.3	3407.5	3983.4
1964	20.4	2588.1	506.4	182.3	190.2	152.2	54.4	103.8	3797.8	4450.9
1965	21.7	2847.7	640.9	203.2	210.1	163.0	53.9	116.5	4257.0	4952.7
1966	22.2	3210.8	695.3	233.7	236.7	174.5	55.2	130.6	4759.0	5550.9
1967	13.2	3559.6	817.0	253.1	258.3	206.2	57.7	146.6	5311.7	6216.8
1968	16.9	3964.4	926.6	275.4	284.7	229.5	60.7	162.7	5920.9	6935.8
1969	21.3	4512.0	1087.3	298.9	312.1	260.8	75.0	185.0	6752.4	7838.0
1970	26.9	4689.7	1161.9	348.9	505.6	301.8	80.0	193.0	7307.8	8623.0
1971	34.0	5344.8	1348.1	378.6	558.2	342.4	83.2	200.0	8289.3	9781.1
1972	43.0	6192.7	1532.7	445.5	633.9	363.5	108.0	208.0	9527.3	11241.9
1973	54.3	7061.3	1557.8	452.7	701.2	370.4	116.5	216.9	10531.1	12425.2
1974	57.4	7559.1	1721.7	576.5	663.9	434.9	122.8	222.4	11358.7	13477.0
1975	74.6	8732.2	2359.1	659.4	766.5	495.9	153.4	250.6	13491.7	15719.0
1976	104.9	10489.9	2821.8	748.2	948.7	555.6	153.9	255.9	16078.9	18615.0
1977	128.9	11961.6	3180.8	896.3	840.8	554.6	151.0	254.8	17968.8	21056.8
1978	130.5	12384.8	3578.8	923.7	879.6	600.6	159.2	276.6	18933.8	22347.1
1979	149.0	12507.7	3954.2	1124.1	832.6	622.0	153.0	290.5	19633.1	23566.2
1980	160.3	12821.2	4387.1	1146.7	834.8	609.2	149.4	289.5	20398.2	24616.6
1981	169.0	14016.9	4614.0	1256.9	882.0	638.1	154.7	298.4	22030.0	26288.9
1982	187.7	14962.2	4926.4	1375.8	1043.4	596.1	186.2	309.0	23586.8	28324.9
1983	224.1	15364.6	5144.9	1399.5	1160.3	687.0	188.4	296.3	24465.1	29567.6
1984	260.0	17774.0	5472.4	1569.9	1252.8	766.7	208.6	330.8	27635.2	33266.5
1985	311.4	19299.3	5634.3	1620.5	1325.8	891.5	218.5	407.3	29708.6	36361.3
1986	325.7	20603.2	6104.1	1680.0	1579.4	1036.3	215.0	666.0	32209.7	40471.4
1987	397.5	23518.1	6943.2	1747.8	1904.4	1168.7	231.3	786.3	36697.3	44925.0
1988	424.9	24802.8	7954.3	1981.4	2223.3	1269.4	250.0	815.4	39721.5	48430.0
1989	464.1	27150.5	8436.5	2300.2	2277.7	1278.3	297.0	915.7	43120.0	52601.7
1990	575.1	28813.8	9162.3	2557.8	2686.3	1463.3	330.0	1231.4	46820.0	56811.7
1991	711.8	28008.8	11001.5	3054.1	2864.5	1864.3	360.0	1417.9	49282.9	60499.3

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Appendix-B (Continued) **COLLECTED DATA**

Yakıt Tüketiminin Sektörel Gelişimi (1955-1990)

(BTEP)

	Tarım	Sanayi	Konutlar	Ulaştırma	Çevrim	Santrallar	Toplam
1955	139.9	685.0	5984.3	1424.5	97.2	395.0	8725.9
1956	150.3	891.7	6195.0	1418.3	108.8	454.8	9218.9
1957	171.0	890.6	6520.2	1654.1	121.3	514.2	9871.4
1958	191.7	983.4	6740.0	1640.5	129.3	575.9	10260.8
1959	182.4	1026.1	6982.6	1582.9	140.3	646.8	10561.1
1960	183.4	1130.1	7161.8	1698.7	137.1	703.8	11014.9
1961	194.9	1113.8	7297.1	1666.2	159.4	752.8	11184.2
1962	236.3	1146.7	7388.2	1768.9	275.2	890.0	11705.3
1963	267.3	1622.8	7598.0	1853.2	353.2	995.9	12690.4
1964	298.4	2031.2	7704.2	2046.6	390.2	1112.7	13583.3
1965	329.4	2174.1	7709.1	2135.2	484.8	1238.2	14070.8
1966	371.9	2536.2	8019.1	2325.6	521.5	1387.7	15162.0
1967	438.1	2555.9	8183.2	2416.0	549.9	1554.2	15697.3
1968	545.8	3183.4	8384.0	2662.5	605.6	1734.0	17115.3
1969	627.5	3314.4	8619.5	2968.2	624.1	1959.5	18113.2
1970	500.4	3548.7	8547.5	3196.8	662.1	2155.8	18611.3
1971	642.2	3712.3	8642.5	3444.9	720.7	2445.3	19607.9
1972	703.3	4075.4	9640.5	3866.1	885.7	2810.5	21981.5
1973	707.4	4335.2	10042.0	4280.8	1072.3	3106.3	23544.0
1974	694.0	4578.7	10492.8	4532.7	1126.1	3369.3	24793.6
1975	679.5	5194.5	10806.2	5134.1	1113.7	3929.8	26857.8
1976	760.2	5410.9	11824.9	5751.2	1190.9	4653.8	29591.9
1977	858.5	6474.0	12042.9	6230.0	1239.3	5264.2	32108.9
1978	909.2	6345.6	12007.7	6150.3	1271.2	5586.8	32270.8
1979	773.5	6155.1	11565.2	5236.0	1272.8	5891.6	30894.2
1980	935.9	6328.2	12418.0	5223.0	1302.8	6154.2	32362.1
1981	964.6	6251.6	12291.6	5295.6	1272.2	6572.2	32647.8
1982	1165.4	6629.5	13183.1	5644.7	1405.4	7081.2	35109.3
1983	1259.6	6430.7	13578.8	5856.1	1496.4	7391.9	36013.5
1984	1408.6	7422.9	13467.3	6104.6	1530.9	8316.6	38250.9
1985	1458.3	7113.1	14184.3	6176.9	1727.8	9090.3	39750.7
1986	1620.8	7280.9	14174.2	6809.4	1790.3	10117.9	41793.5
1987	1778.1	8503.6	15202.7	7569.0	2307.5	11231.3	46592.2
1988	1791.6	8842.7	15096.6	7663.8	2272.1	12107.5	47774.3
1989	1800.9	9345.4	14977.0	7713.2	2266.5	13150.4	49253.4
1990	1906.5	10697.6	14663.8	8813.5	2455.6	14376.0	52913.0

Elektrik Fiyatlarında ve Elektrikli Köy Sayısında Gelişmeler (1950-1991)

	ELEKTRİK FİYAT ENDEKSİ (*)			Elektrikli
	Sanayi	Ticarethane	Konutlar	Köy Sayısı
1950	38.7	38.7	81.7	12
1951	32.1	32.1	78.6	12
1952	32.9	32.9	75.2	12
1953	39.6	39.6	73.7	14
1954	31.1	31.1	60.7	60
1955	28.6	28.6	52.3	99
1956	25.7	25.7	49.1	102
1957	22.7	22.7	42.8	116
1958	20.0	20.0	34.7	129
1959	25.5	25.5	36.7	161
1960	26.7	26.7	37.6	173
1961	25.5	25.5	40.4	185
1962	24.1	24.1	40.5	197
1963	24.4	24.4	40.6	210
1964	24.9	24.9	40.2	250
1965	24.1	24.1	38.3	375
1966	23.4	23.4	35.0	577
1967	24.9	24.9	36.5	734
1968	27.0	27.0	36.7	1097
1969	29.0	29.0	34.7	1609
1970	28.1	28.1	31.4	2371
1971	26.7	26.7	27.5	2972
1972	25.4	25.4	25.1	3906
1973	24.6	24.6	23.9	4883
1974	22.5	22.5	27.5	5986
1975	22.5	22.5	27.8	7462
1976	20.1	20.1	24.3	9157
1977	20.3	20.3	23.5	11206
1978	19.2	19.2	22.4	12994
1979	15.3	15.3	15.6	15460
1980	19.0	19.0	23.0	18345
1981	18.5	18.5	20.2	19811
1982	21.3	21.3	18.2	22032
1983	21.1	21.1	27.1	24436
1984	24.8	24.8	33.8	26515
1985	34.5	34.5	45.7	30591
1986	36.8	36.8	41.5	33885
1987	35.6	35.6	46.0	34557
1988	29.7	29.7	35.6	34834
1989	29.1	29.1	35.7	35000
1990	28.0	29.0	34.5	35100
1991	28.0	29.0	34.5	35100

(*) 1968 yılı fiyatlarına getirilmiştir. TUSIAD

Yakıt Fiyatlarının Gelişimi (1955-1990)*

(1968=100)

	KONUTLAR		SANAYİ				
	Toplam	Fuel-Oil	Komur	Toplam	Fuel-Oil	Linyit	Benzin
1955	102.5	103.2	104.3	85.9	106.5	94.8	116.5
1956	96.4	93.8	99.8	80.2	91.5	84.9	116.1
1957	94.4	88.5	95.3	72.1	81.8	79.3	108.2
1958	100.7	97.4	115.9	86.1	89.1	95.3	113.3
1959	111.6	105.8	122.7	96.1	99.1	103.5	110.8
1960	116.2	98.8	124.0	93.7	94.1	108.5	105.8
1961	118.1	97.4	122.9	92.6	92.6	109.3	104.2
1962	116.6	94.2	122.1	90.7	88.8	115.2	100.3
1963	111.3	87.7	118.2	92.0	86.0	114.6	112.0
1964	110.9	99.8	110.7	87.6	99.0	110.3	114.2
1965	106.4	102.5	99.3	88.2	100.7	97.9	107.8
1966	106.1	97.0	95.9	84.5	95.0	90.5	102.1
1967	103.0	100.0	97.5	89.8	99.2	90.9	101.0
1968	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1969	102.1	93.1	107.9	98.3	100.8	101.5	92.9
1970	100.5	99.8	94.1	95.5	100.0	86.6	97.2
1971	118.1	108.1	107.9	103.8	108.1	92.6	101.2
1972	138.4	100.0	114.9	104.8	97.4	98.7	91.8
1973	136.9	86.2	91.7	90.3	80.7	81.3	79.1
1974	130.0	122.8	80.5	86.4	106.3	65.1	105.0
1975	114.2	108.8	58.5	85.1	102.4	63.7	98.3
1976	103.3	93.7	48.2	75.4	87.9	48.7	84.5
1977	104.7	83.1	45.8	68.1	81.6	64.2	80.7
1978	119.4	84.7	64.7	70.9	83.5	84.9	106.1
1979	130.0	113.9	68.1	79.1	99.2	69.3	188.0
1980	160.5	171.6	72.1	112.2	167.1	89.6	193.1
1981	168.3	207.1	102.6	129.0	201.0	99.6	215.8
1982	172.6	226.5	114.0	132.2	211.6	107.1	239.4
1983	188.3	217.1	106.5	130.4	211.2	107.0	235.3
1984	162.8	212.4	90.5	124.4	204.8	89.8	233.9
1985	163.0	226.3	104.7	134.1	223.1	107.8	243.7
1986	192.4	203.4	108.0	135.1	210.8	108.8	213.0
1987	184.9	150.1	98.2	119.5	158.0	90.5	156.8
1988	200.6	138.8	115.5	129.4	155.2	104.6	162.7
1989	217.8	144.8	154.3	136.7	154.3	120.2	174.4
1990	205.7	161.2	157.0	138.6	178.8	135.3	186.1

(*) Sabit fiyat endeksi haline getirilmiştir. TUSIAD

 COLLECTED DATA

TÜRKİYE BİRİNCİL ENERJİ ÜRETİMİ (BİN TON PETROL EŞDEĞERİ)

Yıllar	Petrol	Doğal Gaz	Linyit	Taşkömürü	Diğerleri	Toplam
1980	2447	21	3780	2195	8855	17298
1981	2481	15	4271	2422	9050	18239
1982	2450	41	4652	2445	9516	19104
1983	2313	7	5378	2159	9356	19213
1984	2191	36	6498	2216	9203	20144
1985	2216	62	8212	2199	9014	21703
1986	2514	416	8949	2151	9204	23234
1987	2762	270	9827	2111	9783	24753
1988	2692	90	8603	2212	10670	24267
1989	3020	158	10564	2027	9645	25414
1990	3903	193	9524	2080	9423	25123
1991	4674	185	9117	1827	9335	25138
1992	4495	180	10299	1727	9707	26408
1993	4087	182	9790	1722	10240	26021
1994	3871	182	10471	1636	9899	26059
1995	3692	166	10735	1319	10343	26255
1996	3675	187	10876	1382	10767	26887
1997	3630	230	11759	1347	10721	27687

TPAO

TÜRKİYE BİRİNCİL ENERJİ TÜKETİMİ (BİN TON PETROL EŞDEĞERİ)

Yıllar	Petrol	Doğal Gaz	Linyit	Taşkömürü	Diğerleri	Toplam
1980	16074	21	3970	2824	9024	31913
1981	15845	15	4181	2758	9190	31989
1982	16933	41	4616	3077	9639	34306
1983	17540	7	5294	3255	9501	35597
1984	17840	36	6408	3464	9499	37247
1985	18134	62	7933	3775	9263	39167
1986	19622	416	8879	3992	9259	42168
1987	22301	669	9189	4404	9996	46559
1988	22590	1115	7932	5204	10729	47570
1989	22865	2878	10207	4722	9693	50365
1990	23901	3110	9765	6150	9706	52632
1991	23315	3827	10572	6501	9700	53915
1992	24865	4197	10743	6243	10250	56298
1993	28412	4630	9918	5834	11051	59845
1994	27142	4921	10331	5512	10769	58675
1995	29324	6313	10570	5905	11068	63180
1996	30939	7186	12351	5560	11999	68035
1997	30515	9165	12280	8495	10912	71367

TPAO

Sektörel Enerji Tüketimi

(BTEP)

	1995						1999						2000 (Tahmin)					
	Konut ve Hizmetler	Ulaştırma	Tarım	Elektrik	Sanayi ve	Toplam	Konut ve Hizmetler	Ulaştırma	Tarım	Elektrik	Sanayi ve	Toplam	Konut ve Hizmetler	Ulaştırma	Tarım	Elektrik	Sanayi ve	Toplam
TİCARİ ENERJİ	7,747	11,024	2,425	15,494	19,390	56,080	8,143	11,083	2,863	22,331	23,683	68,103	8,366	11,660	3,000	24,500	24,850	72,376
Taşkömürü	876	2		568	5,244	6,690	471	4		756	7,955	9,186	300	5		750	7,800	8,855
Linyit	1,918			6,841	1,875	10,634	2,085			9,158	1,711	12,954	1,900			9,885	1,700	13,485
Petrol Ürünleri	3,933	11,021	2,425	1,803	10,141	29,323	3,282	11,075	2,863	2,440	11,632	31,292	3,650	11,650	3,000	2,676	12,900	33,876
Doğal Gaz	904	1		3,278	2,130	6,313	2,155	4		6,810	2,385	11,354	2,350	5		8,271	2,450	13,076
Hidrolik Enerji				3,057		3,057				2,982		2,982				2,675		2,675
Yenilenebilir Enerji	116			7		123	150			9		159	166			19		185
Elektrik İthalatı				-60		-60				176		176				224		224
GAYRİ-TİCARİ ENERJİ	7,068					7,068	6,387			70		6,457	6,334			70		6,404
Odun (T)	5,512					5,512	5,082					5,082	5,070					5,070
Hayvan ve Bitki Artıkları (T)	1,556					1,556	1,305			70		1,375	1,264			70		1,334
T O P L A M	14,815	11,024	2,425	15,494	19,390	63,148	14,530	11,083	2,863	22,401	23,683	74,560	14,700	11,660	3,000	24,570	24,850	78,780
YÜZDE DAĞILIM	23.5	17.5	3.8	24.5	30.7	100	19.5	14.9	3.8	30	31.8	100	18.7	14.8	3.8	31.2	31.5	100

DPT

Elektrik Enerjisi Tüketiminin Kullanıcı Gruplarına Göre Dağılımı

GWh	1989	1994	1995	1999	2000
Konutlar	8436	14000	14493	21800	24000
Ticarethaneler	2300	4100	4195	8700	9400
Resmi Daire	1278	2550	3012	4700	5100
Genel Aydınlatma	916	2750	3106	4100	4400
Sanayi	27603	34700	38007	46000	50000
Diğer	2587	4700	4581	6100	6500
NET TOPLAM	43120	62800	67394	91400	99400
İç Tüketim ve	9482	14917	18157	27085	27400
BRÜT TOPLAM	52602	77717	85551	118485	126800
Kişi Başına Net Tüketim (kWh)	784	1038	1115	1420	1522
Kişi Başına Brüt Tüketim (kWh)	956	1284	1416	1840	1941

DPT

Türkiye Elektrik Enerjisi Tüketiminin Yıllar İtibariyle Gelişimi (1980-1998)

(GW)

Yıllar	Brüt Üretim	İç İhtiyaç	Net Üretim	Dışardan Alınan	Brüt Tüketim	Şebeke Kaybı	Dışarıya Satılan	Net Tüketim	Ev ve Ticaret haneler	Resmi Daireler	Sokak Aydınlatması	Sanayi	Diğer	Kişi Başına Tüketim (kWh)
1980	23275	1394	21881	1341	23222	2825	-	20398	4646	609	290	13008	1846	459
1981	24673	1328	23345	1616	24961	2931	-	22030	4922	638	298	14206	1965	484
1982	26552	1421	25131	1773	26904	3318	-	23587	5222	596	309	15198	2262	505
1983	27347	1680	25667	2221	27888	3422	-	24465	5424	687	296	15576	2482	511
1984	30614	1891	28723	2653	31376	3741	-	27635	5875	767	331	18027	2636	564
1985	34219	2307	31912	2142	34054	4346	-	29709	6599	892	407	19608	2203	591
1986	39695	2815	36880	777	37657	5447	-	32210	7342	1036	666	20886	2280	626
1987	44353	2608	41745	572	42317	5620	-	36697	8255	1169	786	23873	2615	698
1988	48049	2400	45649	381	46030	6309	-	39722	9594	1269	815	25258	2786	739
1989	52043	3235	48808	559	49367	6247	-	43120	10565	1278	916	27603	2759	786
1990	57543	3311	54232	176	54408	6680	907	46820	11618	1463	1231	29212	3296	835
1991	60246	3655	56591	759	57350	7562	507	49283	13887	1864	1418	28512	3602	860
1992	67342	4237	63105	189	63294	8995	314	53985	14752	2009	1860	31536	3829	921
1993	73808	3943	69865	213	70078	10252	589	59237	16164	2266	2270	34247	4289	984
1994	78322	4539	73783	31	73814	11843	570	61401	17154	3315	2502	34138	4291	999
1995	86248	4389	81859	-	81859	13769	696	67394	18688	3012	3106	38007	4581	1093
1996	94862	4777	90084	270	90355	15855	343	74157	22135	3002	3085	40638	5297	1183
1997	103296	5050	98246	2492	100738	18582	271	81885	25367	3803	3310	43491	5914	1303
1998	111022	5523	105499	3299	108798	20569	298	87931	27240	4084	3545	46703	6359	1386

ETKB

Türkiye Brüt Elektrik Enerjisi Üretiminin Üretici Kuruluşlarla Dağılımı İthalat-İhracat Arzının Yıllar İtibariyle Gelişimi (1990-1998)

(GWh)

KURULUŞLAR		1990	1991	1992	1993	1994	1995	1996	1997	1998
TEAŞ	Termik	30698	34068	36936	35372	42998	38439	31684	35145	38980
	Hidrolik	22156	21393	24597	31728	28945	33105	37440	37342	39601
	Toplam	52854	55461	61533	67100	71943	71544	69124	72487	78581
AYRICALIKLI ŞİRKETLER	Termik	346	130	123	329	123	0	0	0	0
	Hidrolik	959	1239	1892	2138	1563	2301	2908	2214	2299
	Toplam	1305	1369	2015	2467	1686	2301	2908	2214	2999
OTOPRODÜK TÖRLER	Termik	3351	3365	3715	4156	4615	5617	6061	7745	10097
	Hidrolik	10	4	12	16	4	8	10	9	31
	Rüzgar	-	-	-	-	-	-	-	-	4
	Toplam	3361	3369	3727	4172	4619	5625	6071	7754	10132
ÜRETİM ŞİRKETLERİ	Termik	-	-	-	-	-	-	351	2157	2217
	Hidrolik	23	47	67	69	74	126	118	252	298
	Rüzgar	-	-	-	-	-	-	-	-	2
	Toplam	23	47	67	69	74	126	469	2409	2517
TEAŞ BAĞLI ORTAKLIKLARI	Termik	-	-	-	-	-	6651	16291	18432	17494
TÜRKİYE ÜRETİMİ	Termik	34395	37563	40774	39857	47736	50707	54387	63480	68788
	Hidrolik	23148	22683	26568	33951	30586	35541	40475	39816	42229
	Rüzgar	-	-	-	-	-	-	-	-	6
	Toplam	57543	60246	67342	73808	78322	86248	94862	103296	111023
İTHALAT	Bulgaristan	0	568	-	-	-	-	26	1863	2317
	SSCB/Gürc.	176	191	189	13	31	-	16	459	779
	İran	-	-	-	-	-	-	55	170	202
	Azerbaycan	-	-	-	200	-	-	174	-	-
	Toplam	176	759	189	213	31	-	270	2492	3298
İHRACAT	Toplam	907	506	314	589	570	696	343	271	298
ARZ	84987	56812	60499	67217	73432	77783	85552	94789	105517	114023

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Development Indicators of Turkey

Turkey	Commercial energy production (kt of oil equivalent)	Electricity production (kwh)	Electricity production from coal sources (% of total)	Electricity production from hydroelectric sources (% of total)	Electricity production from natural gas sources (% of total)	Electricity production from nuclear sources (% of total)	Electricity production from oil sources (% of total)	Energy imports, net (% of commercial energy use)	Vehicles (per 1,000 people)	GDP per unit of energy use (1995 US$ per kg of oil equivalent)	GDP per unit of energy use (PPP $ per kg of oil equivalent)	Fax machines (per 1,000 people)	Internet hosts (per 10,000 people)	Television sets (per 1,000 people)
1960	9,371	2,815,000,064	54.67	35.6	..	..	8.28	12.49	..	..	..	..	..	..
1961	9,484	3,011,000,064	48.72	42.01	..	..	7.8	12.73	..	..	..	..	..	..
1962	9,727	3,560,000,000	59.55	31.57	..	..	7.61	17.75	..	..	..	..	..	..
1963	10,202	3,983,000,064	38.26	52.82	..	..	7.33	18.01	..	..	..	..	..	..
1964	10,594	4,450,999,808	53.65	37.03	..	..	7.14	19.19	..	..	..	..	..	..
1965	11,204	4,952,999,936	44.82	43.99	..	..	9.17	18.8	..	..	..	..	..	0.08
1966	12,226	5,551,000,064	47.13	42.12	..	..	8.56	19.47	..	..	..	..	..	..
1967	13,155	6,210,999,808	34.17	38.35	..	..	24.7	16.5	..	..	..	..	..	..
1968	13,527	6,936,000,000	32.19	45.78	..	..	19.45	18.26	..	3.24	..	..	..	..
1969	14,026	7,838,000,128	30.61	43.95	..	..	23.17	19.51	..	3.2	..	..	..	..
1970	13,966	8,622,999,552	32.75	35.17	..	..	30.15	23.27	..	3.17	..	..	..	11.23
1971	13,770	9,781,000,192	30.48	26.68	..	..	41.18	29.26	..	3.13	..	..	..	..
1972	15,080	11,242,999,808	25.98	28.51	..	..	43.96	31.47	..	2.98	..	..	..	..
1973	15,475	12,424,999,936	26.11	20.95	..	..	51.36	36.37	..	2.77	..	..	..	..
1974	15,836	13,477,000,192	28.72	24.9	..	..	44.84	37.11	..	2.8	..	..	..	..
1975	16,206	15,623,000,064	26.33	37.79	..	..	34.47	39.39	..	2.84	2.41	..	..	26.02
1976	16,552	18,282,999,808	23.67	45.81	..	..	29.65	43.16	..	2.89	2.48	..	..	44.47
1977	16,886	20,565,000,192	23.79	41.68	..	..	33.47	47.16	..	2.73	2.41	..	..	55.93
1978	17,553	21,725,999,104	25.63	42.97	..	..	30.77	44.89	..	2.78	2.66	..	..	63.59
1979	17,355	22,521,999,360	28.59	45.68	..	..	25.09	42.69	..	2.9	3.12	..	..	71.79
1980	17,190	23,274,999,808	25.61	48.76	..	..	25.05	45.1	23	2.78	3.3	..	..	78.24
1981	18,119	24,672,999,424	24.87	51.13	..	..	23.55	42.5	..	2.89	3.64	..	..	109.02
1982	18,951	26,552,000,512	24.26	53.36	..	..	22.39	43.81	..	2.8	3.56	..	..	116.97
1983	19,207	27,346,999,296	31.37	41.48	..	..	27.15	45.82	..	2.8	3.59	..	..	124.47
1984	20,109	30,613,000,192	33.05	43.86	..	..	23.02	45.1	..	2.88	3.85	..	..	155.81
1985	21,672	34,218,999,808	43.92	35.2	0.17	..	20.7	44.25	..	2.84	4.02	..	..	157.9
1986	23,281	39,694,999,552	48.96	29.91	3.38	..	17.64	44.43	..	2.83	4.35	0.03	..	160.76
1987	24,790	44,352,999,424	39.8	41.98	5.7	..	12.39	46.45	..	2.81	4.71	0.08	..	171.23
1988	24,525	48,048,001,024	25.99	60.25	6.74	..	6.88	47.53	..	2.84	5.04	0.28	..	171.27
1989	25,420	52,044,001,280	38.95	34.47	18.3	..	8.16	47.89	44.2	2.73	4.84	0.33	..	173.06
1990	25,682	57,543,000,064	35.07	40.23	17.71	..	6.85	51.08	49.3	2.77	4.98	0.58	..	229.99
1991	25,724	60,245,999,616	35.79	37.65	20.9	..	5.47	51.91	54	2.74	5.07	0.84	..	253.44
1992	26,261	67,342,000,128	36.49	39.45	16.06	..	7.83	52.23	60.9	2.82	5.45	1.07	..	256.04
1993	26,024	73,808,003,072	32.19	46	14.62	..	7.01	55.21	69.9	2.89	5.73	1.29	..	267.25
1994	25,976	78,321,000,448	36.05	39.05	17.65	..	7.08	54.25	62.2	2.79	5.61	1.44	0.32	227.19
1995	26,139	86,246,998,016	32.52	41.21	19.22	..	6.69	57.98	64.6	2.73	5.65	1.59	0.92	239.9
1996	26,767	94,862,000,128	32.06	42.67	18.1	..	6.89	60.43	68.1	2.68	5.59	1.6	2.85	308.6
1997	27,556	103,296,000,000	32.78	38.55	21.38	..	6.93	61.34	71.2	2.74	5.67	1.72	3.67	286.32
1998	..	..	..	..	..	..	..	..	81.3	..	..	..	4.39	..

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COLLECTED DATA

Yenilenebilir Enerji Rezervleri

Hidrolik Enerji	MW	34862
	milyar kWh/yıl	124.5
Jeotermal	Isı(MW)	2843
	Mtep/yıl	1.8
	Elektrik (MW)	350
	milyar kWh/yıl	1.4
Güneş	Isı+Elektr.(MW)	116000
	milyar kWh/yıl	305
	Mtep/yıl	25
Rüzgar karasal	Elektrik (MW)	20000
	milyar kWh/yıl	50
Rüzgar denizsel	Elektrik (MW)	-
	milyar kWh/yıl	-
Klasik biomas enerji	Yakıt	
	Mtep/yıl	7
Modern biomas	Yakıt	
	Mtep/yıl	25
Toplam (Btep)		58841.36

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Birincil Enerji Kaynakları (1998 Yılı Sonu İtibariyle)

Kaynaklar	Görünür	Muhtemel	Mümkün	Toplam
Taşkömürü	(*)428	449	249	1.126
Linyit				
Elbistan	3,357	-	-	3,357
Diğer	3,982	626	110	4,718
Toplam	7,339	626	110	(**)8,075
Asfaltit	45	29	8	82
Bitümlar	555	1,086	0	1,641
Hidrolik	123,799	-	-	123,799
Gwh/Yıl	35,045	-	-	35,045
MW/Yıl				
Ham Petrol (Milyon Ton)	43.7	-	-	43.7
Doğ.Gaz (Milyar m^3)	8.9	-	-	8.9
Nükleer Kaynaklar(Ton)	9,129	-	-	9,129
Tabii Uranyum	380,000	-	-	380,000
Toryum				
Jeotermal(MW/Yıl)	200		4,300	
Elektrik	2,250		28,850	
Termal		-		4,500
		-		31,100
Güneş(Milyon TEP/Yıl)				
Elektrik				
Isı				8.8
				26.4

(*) Hazır rezerv dahil.
(**) 300 milyon ton belirlenmiş ve potansiyel kaynakla 8.375 milyon ton olmaktadır.
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Appendix-C

REGRESSION ANALYSIS RESULTS

Population vs. Time Regression

Regresyon İstatistikleri	
Çoklu R	0.9999
R Kare	0.9999
Ayarlı R Kare	0.9999
Standart Hata	2.05698E-15
Gözlem	50

ANOVA

	df	*SS*	*MS*	*F*	*Anlamlılık F*
Regresyon	1	0.000851701	0.000851701	2.01292E+26	0.99999
Fark	48	2.03097E-28	4.23118E-30		
Toplam	49	0.000851701			

	Katsayılar	*Standart Hata*	*t Stat*	*P-değeri*	*Düşük %95*	*Yüksek %95*
Kesişim	**0.587**	4.08316E-14	1.43761E+13	0.999989	0.587	0.587
Yıllar	**-0.000286**	2.01583E-17	-1.41877E+13	0.999998	-0.000286	-0.000286

GNP vs. Time Regression

Regresyon İstatistikleri	
Çoklu R	0.264225938
R Kare	0.069815346
Ayarlı R Kare	0.045964458
Standart Hata	0.034826831
Gözlem	41

ANOVA

	df	*SS*	*MS*	*F*	*Anlamlılık F*
Regresyon	1	0.003550375	0.003550375	2.927159131	0.095044962
Fark	39	0.047303419	0.001212908		
Toplam	40	0.050853794			

	Katsayılar	*Standart Hata*	*t Stat*	*P-değeri*	*Düşük %95*	*Yüksek %95*
Kesişim	**1.604587159**	0.905590953	1.771867479	0.0842298116	-0.227141639	3.436315956
Yıllar	**-0.000786468**	0.000459683	-1.710894249	0.0950449615	-0.001716263	0.000143327

Urban population vs. national population regression

Regresyon İstatistikleri	
Çoklu R	0.990863309
R Kare	0.981810096
Ayarlı R Kare	0.981355349
Standart Hata	1.176241152
Gözlem	42

ANOVA

	df	*SS*	*MS*	*F*	*Anlamlılık F*
Regresyon	1	2987.100461	2987.100461	2159.022111	1.988835E-36
Fark	40	55.34172986	1.383543247		
Toplam	41	3042.44219			

	Katsayılar	*Standart Hata*	*t Stat*	*P-değeri*	*Düşük %95*	*Yüksek %95*
Kesişim	**-12.68135411**	0.64317831	-19.7167005	3.277609E-22	-13.98126545	-11.38144278
Toplam Nüfus	**0.773534658**	0.016647585	46.46527855	1.988835E-36	0.739888648	0.807180668

Office population vs. GNP regression

Regresyon İstatistikleri	
Çoklu R	0.972325153
R Kare	0.945416204
Ayarlı R Kare	0.941777284
Standart Hata	290.9788585
Gözlem	17

ANOVA

	df	*SS*	*MS*	*F*	*Anlamlılık F*
Regresyon	1	21997505.54	21997505.54	259.8068301	7.004286E-11
Fark	15	1270030.442	84668.69611		
Toplam	16	23267535.98			

	Katsayılar	*Standart Hata*	*t Stat*	*P-değeri*	*Düşük %95*	*Yüksek %95*
Kesişim	**1311.358677**	354.6085113	3.698046254	2.147666E-03	555.528062	2067.189292
GNP	**24.73491357**	1.534564387	16.11852444	7.004286E-11	21.46406499	28.00576214

Industry vs. GNP regression

Regresyon İstatistikleri	
Çoklu R	0.991656876
R Kare	0.983383359
Ayarlı R Kare	0.982275583
Standart Hata	326.4285869
Gözlem	17

ANOVA

	df	*SS*	*MS*	*F*	*Anlamlılık F*
Regresyon	1	94590439.42	94590439.42	887.709511	9.203302E-15
Fark	15	1598334.335	106555.6224		
Toplam	16	96188773.75			

	Katsayılar	*Standart Hata*	*t Stat*	*P-değeri*	*Düşük %95*	*Yüksek %95*
Kesişim	**2416.767658**	397.8101909	6.075177845	2.124584E-05	1568.854787	3264.68053
GSYİH	**51.29172448**	1.721519174	29.79445437	9.203302E-15	47.62239096	54.96105799

Vehicle population vs. GNP

Regresyon İstatistikleri	
Çoklu R	0.976827717
R Kare	0.954192388
Ayarlı R Kare	0.952612815
Standart Hata	246350.4158
Gözlem	31

ANOVA

	df	*SS*	*MS*	*F*	*Anlamlılık F*
Regresyon	1	3.66609E+13	3.66609E+13	604.0825511	5.755801E-21
Fark	29	1.75997E+12	60688527383		
Toplam	30	3.84208E+13			

	Katsayılar	*Standart Hata*	*t Stat*	*P-değeri*	*Düşük %95*	*Yüksek %95*
Kesişim	**-1156952.39**	110102.1159	-10.50799413	2.119230E-11	-1382136.622	-931768.1539
GNP	**15320.68153**	623.3470941	24.57809087	5.755801E-21	14045.79288	16595.57018

Agricultural petroleum demand vs. GNP

Regresyon İstatistikleri	
Çoklu R	0.982021339
R Kare	0.96436591
Ayarlı R Kare	0.963317849
Standart Hata	104.4394196
Gözlem	36

ANOVA

	df	*SS*	*MS*	*F*	*Anlamlılık F*
Regresyon	1	10036539.44	10036539.44	920.1425113	3.327810E-26
Fark	34	370858.1407	10907.59237		
Toplam	35	10407397.58			

	Katsayılar	*Standart Hata*	*t Stat*	*P-değeri*	*Düşük %95*	*Yüksek %95*
Kesişim	**-266.0696026**	38.27553122	-6.951428081	5.151131E-08	-343.8547896	-188.2844155
GNP	**7.024264164**	0.231565197	30.33385091	3.327810E-26	6.553667373	7.494860955

Agricultural electrcicity demand vs. GNP

Regresyon İstatistikleri	
Çoklu R	0.909228566
R Kare	0.826696585
Ayarlı R Kare	0.822364
Standart Hata	72.31657485
Gözlem	42

ANOVA

	df	*SS*	*MS*	*F*	*Anlamlılık F*
Regresyon	1	997871.7134	997871.7134	190.8090702	8.194504E-17
Fark	40	209187.4799	5229.686998		
Toplam	41	1207059.193			

	Katsayılar	*Standart Hata*	*t Stat*	*P-değeri*	*Düşük %95*	*Yüksek %95*
Kesişim	**-133.5098106**	21.94850652	-6.082865386	3.614223E-07	-177.8693791	-89.15024201
GNP	**1.883912036**	0.136383274	13.81336564	8.194504E-17	1.608271267	2.159552805

REGRESSION ANALYSIS RESULTS

Electricity consumption of household vs. GNP

Regresyon İstatistikleri	
Çoklu R	0.991395144
R Kare	0.982864331
Ayarlı R Kare	0.982424955
Standart Hata	2.82718E-06
Gözlem	41

ANOVA

	df	*SS*	*MS*	*F*	*Anlamlılık F*
Regresyon	1	1.78799E-08	1.78799E-08	2236.954382	4.658686E-36
Fark	39	3.11725E-10	7.99295E-12		
Toplam	40	1.81916E-08			

	Katsayılar	*Standart Hata*	*t Stat*	*P-değeri*	*Düşük %95*	*Yüksek %95*
Kesişim	**-1.14587E-05**	8.76948E-07	-13.06653887	7.927015E-16	-1.32325E-05	-9.68489E-06
GSYIH	**2.66551E-07**	5.63576E-09	47.29645211	4.658686E-36	2.55152E-07	2.77951E-07

Heating energy consumption of household vs. GNP

Regresyon İstatistikleri	
Çoklu R	0.988467807
R Kare	0.977068606
Ayarlı R Kare	0.976394153
Standart Hata	457.0726769
Gözlem	36

ANOVA

	df	*SS*	*MS*	*F*	*Anlamlılık F*
Regresyon	1	302652345.2	302652345.2	1448.683529	1.841112E-29
Fark	34	7103124.686	208915.4319		
Toplam	35	309755469.9			

	Katsayılar	*Standart Hata*	*t Stat*	*P-değeri*	*Düşük %95*	*Yüksek %95*
Kesişim	**4581.063735**	167.5105011	27.34791972	9.853791E-25	4240.641663	4921.485807
X Değişkeni 1	**38.57277286**	1.013430799	38.06157549	1.841112E-29	36.51323504	40.63231069

GNP & Consumption / Office

Regresyon İstatistikleri	
Çoklu R	0.9246643
R Kare	0.855004067
Ayarlı R Kare	0.845337671
Standart Hata	35570.57264
Gözlem	17

ANOVA

	df	*SS*	*MS*	*F*	*Anlamlılık F*
Regresyon	1	1.11914E+11	1.11914E+11	88.45117749	1.113281E-07
Fark	15	18978984567	1265265638		
Toplam	16	1.30893E+11			

	Katsayılar	*Standart Hata*	*t Stat*	*P-değeri*	*Düşük %95*	*Yüksek %95*
Kesişim	**-62056.40477**	43348.94938	-1.431554989	1.727773E-01	-154452.56	30339.75049
X Değişkeni 1	**1764.275265**	187.5920961	9.404848616	1.113281E-07	1364.431931	2164.118599

GNP & Office Pop.

Regresyon İstatistikleri	
Çoklu R	0.972325153
R Kare	0.945416204
Ayarlı R Kare	0.941777284
Standart Hata	290.9788585
Gözlem	17

ANOVA

	df	*SS*	*MS*	*F*	*Anlamlılık F*
Regresyon	1	21997505.54	21997505.54	259.8068301	7.004286E-11
Fark	15	1270030.442	84668.69611		
Toplam	16	23267535.98			

	Katsayılar	*Standart Hata*	*t Stat*	*P-değeri*	*Düşük %95*	*Yüksek %95*
Kesişim	**1311.358677**	354.6085113	3.698046254	2.147666E-03	555.528062	2067.189292
X Değişkeni 1	**24.73491357**	1.534564387	16.11852444	7.004286E-11	21.46406499	28.00576214

m:		Tek seçim				Tek seçim				Tek seçim							Çoklu seçim					Tek seçim						Çoklu seçim							Metin	Metin	Metin
Alt KONU	Enerji	Uzmanlık Derecesi				Olayın 2023'teki hayat kalitesine etkisi				Olayın ilk olarak gerçekleşeceği zaman aralığı							İşbirliği yapılması gereken ülkeler					Türkiye'nin rekabet durumu						Gerçekleşmeye yönelik engeller							Konunun Ar-Ge projesini ne kadar bütçe ile kotarırdınız?	Sizce bu gelişmenin ülke ekonomisine getireceği kazanç/tasarruf ne kadar olabilir?	Yorumlarınız/ Alternatif Tezler
																						ArGe kabiliyeti		Ürün ve Hizmet sunumu kabiliyeti		Pazarlama kabiliyeti											
Sıra No.	OLAY	Yüksek	Orta	Düşük	yok	zarar verici	etkisiz	yararlı	çok yararlı	2001 - 2005	2006 - 2010	2011 - 2015	2016 - 2020	2020 - 2023	2023'den sonra	asla	Gerek yok	Komşular	Avrupa Birliği	Diğer Türk Cumhuriyetleri	ABD	Lider	Takipçi	Lider	Takipçi	Lider	Takipçi	Sosyal/Etik Kabul Görme	Teknolojik Yapılabilirlik	Finansman eksikliği	Ekonomik Yapılabilirlik	Mevzuat	Politik Tercihler	Eğitilmiş İnsan Gücü			
1	Hidrokarbonların uzaktan tespit edilişinin, arama işlemlerinde standart ticari bir teknik haline gelmesi.																																				
2	3 Boyutlu sismik araştırmalardan elde edilen tüm bilgilerin analiz edilebilmesi ve ticari açıdan yorumlanmasında kullanılan ileri teknolojilerin geliştirilmesi.																																				
3	Petrol ve petrolgazı sondaj çalışmaları maliyetini %50 indirmek (örneğin sondaj kuyusu ilerisinde bulunan kaya oluşumlarının on-line olarak sürekli ölçülmesi, sarmal sondaj boruları ve diğer techizat).																																				
4	Yüksek basınçlı, yüksek ısılı petrol-gaz yataklarından yaygın şekilde istifade edilmesi.																																				
5	Derin sularda (>1000m) ve şiddetli ortamlarda bulunan petrol ve gaz yataklarından yaygın olarak istifade edilmesi.																																				
6	Uygun modelleme ve fiziksel-kimyasal uygulamalarla yataklardaki ekonomik açıdan çıkarılabilecek petrol miktarının %50 artırılması.																																				
7	Petrol yataklarından verimin arttırılması için mikrobik açıdan zenginleştirilmiş çıkarma tekniklerinin ticari açıdan kullanılması.																																				
8	Çok safhalı, iyi-akış tipi taşımacılığın 200 km. ve fazlası mesafede ve 3000 m.'ye kadar olan su derinliğinde ticari açıdan kullanılması.																																				
9	Halen kullanılmakta olan deniz platformlarının ana maliyetinin %50 indirilmesi.																																				
10	Uzak bölgelerden (örneğin. pazardan birkaç bin km. uzaktaki bölgelere) boru hattıyla doğalgaz taşınması veya LDG gibi sistemlere alternatif olan sistemlerin kullanımı.																																				
11	Neft ve katrandan yaygın şekilde istifade edilmesi.																																				
12	İleri otomasyon ve robot kullanımının; ekonomi, emniyet ve ince maden duvarlarında ve tehlikeli bölgelerde kullanım kabiliyeti açısından, yüksek duvarlı kömür çıkarma faaliyetlerinde standart birer teçhizat olması.																																				

		Tek seçim				Tek seçim				Tek seçim							Çoklu seçim					Tek seçim						Çoklu seçim							Metin	Metin	Metin
		Uzmanlık Derecesi				Olayın 2023'teki hayat kalitesine etkisi				Olayın ilk olarak gerçekleşeceği zaman aralığı							İşbirliği yapılması gereken ülkeler					Türkiye'nin rekabet durumu: ArGe kabiliyeti		Ürün ve Hizmet sunumu kabiliyeti		Pazarlama kabiliyeti		Gerçekleşmeye yönelik engeller							Konunun Ar-Ge projesini ne kadar bütçe ile kotarırdınız?	Sizce bu gelişmenin ülke ekonomisine getireceği kazanç/tasarruf ne kadar olabilir?	Yorumlarınız/ Alternatif Tezler
Sıra No.	OLAY	Yüksek	Orta	Düşük	yok	zarar verici	etkisiz	yararlı	çok yararlı	2001 - 2005	2006 - 2010	2011 - 2015	2016 - 2020	2020 - 2023	2023'den sonra	asla	Gerek yok	Komşular	Avrupa Birliği	Diğer Türk Cumhuriyetleri	ABD	Lider	Takipçi	Lider	Takipçi	Lider	Takipçi	Sosyal/Etik Kabul Görme	Teknolojik Yapılabilirlik	Finansman eksikliği	Ekonomik Yapılabilirlik	Mevzuat	Politik Tercihler	Eğitimiş İnsan Gücü			
13	Madenden çıkarılan kömürden, sülfürün ayrıştırılması maliyetinin %25 düşürülmesi.																																				
14	Kömür yataklarında bulunan metan gazının yaygın bir şekilde çıkarılması ve kullanılması.																																				
15	Hafif-su nükleer reaktörlerinin, diğer elektrik üretim şekillerinin maliyeti ile rekabet edebilecek şekilde elektrik üretebilmesi.																																				
16	Şartların uzaktan kontrolu, denetlenmesi, bakımı ve onarımı için kullanılan ileri tekniklerin yaygınlaştırılması, nükleer enerji üretim merkezlerinin kullanım ömrünü ve buna bağlı olan yakıt döngülerini önemli ölçüde arttıracaktır.																																				
17	Yeraltı derinliklerinde gömülerek depolama yöntemi, tüm orta ve yüksek seviye nükleer atıkların bertaraf edilmesinde evrensel bir yöntem olmuştur.																																				
18	Kullanılan nükleer yakıtın ve atığının direkt bertaraf edilmesi ile karşılaştırıldığında, nükleer atıkların ticari açıdan tekrar bir sürece tabi tutulması, maliyet açısından rekabet edebilecek durumdadır ve tüm güvenlik gereksinimlerini karşılar.																																				
19	Hızlı Reaktörün ilk ticari kullanımı.																																				
20	Küçük (<3000 Mwe) ve modüler yapıda olan ve pasif güvenlik tasarımlarıyla birleştirilmiş nükleer reaktörün ticari açıdan ilk kullanımı.																																				
21	Nükleer görev hizmetlerine ait dünya pazarının 10 kat arttırılması.																																				
22	Elektrik üretiminde ticari açıdan rekabet vasfına sahip ürünlerin ilk kullanımı.																																				
23	"Photovoltaic" modüllerin daha önceki işçilik maliyetleri, watt başına 2$'ın altına indirilmiştir.																																				
24	Ticari açıdan rekabet edebilecek olan rüzgar türbinlerinin grid-bağlantılı uygulamalarda yaygın olarak kullanılması.																																				
25	Türkiye'de atık maddelerden enerji sağlanmasının yaygınlaştırılması.																																				
26	Bölgesel jeneratör kullanım oranının %30 seviyesinin üzerine çıkması.																																				

İsim:			Tek seçim				Tek seçim				Tek seçim							Çoklu seçim					Tek seçim						Çoklu seçim							Metin	Metin	Metin
		Enerji	Uzmanlık Derecesi				Olayın 2023'teki hayat kalitesine etkisi				Olayın ilk olarak gerçekleşeceği zaman aralığı							İşbirliği yapılması gereken ülkeler					Türkiye'nin rekabet durumu: Ar-Ge kabiliyeti		Ürün ve Hizmet sunumu kabiliyeti		Pazarlama kabiliyeti		Gerçekleşmeye yönelik engeller							Konunun Ar-Ge projesini ne kadar bütçe ile kotarırdınız?	Sizce bu gelişmenin ülke ekonomisine getireceği kazanç/tasarruf ne kadar olabilir?	Yorumlarınız/ Alternatif Tezler
Alt KONU	Sıra No.	OLAY	Yüksek	Orta	Düşük	Yok	zarar verici	etkisiz	yararlı	çok yararlı	2001 - 2005	2006 - 2010	2011 - 2015	2016 - 2020	2020 - 2023	2023'den sonra	asla	Gerek yok	Komşular	Avrupa Birliği	Diğer Türk Cumhuriyetleri	ABD	Lider	Takipçi	Lider	Takipçi	Lider	Takipçi	Sosyal/Etik Kabul Görme	Teknolojik Yapılabilirlik	Finansman eksikliği	Ekonomik Yapılabilirlik	Mevzuat	Politik Tercihler	Eğitilmiş İnsan Gücü			
İletim, Taşıma ve Dağıtım	27	Daha önce belirlenen yakıt fiyatı, tipi, uygunluğu ve emisyon özelliklerine bağlı olarak, yakıt ve tedarikçisi arasında otomatik olarak karar verebilmemizi sağlayan teknolojinin yaygın olarak kullanımı.																																				
	28	30 yıl süreli kullanım ömrüne rağmen paslanma nedeniyle değiştirilme ihtiyacı gerektirmeyen hidrokarbon boru hatları ve teçhizatınının imalatında düşük maliyetli malzemelerin kullanımının yaygınlaştırılması.																																				
	29	Boru hatlarında arıza oluşturan hataları ve sızmaları tespit edebilecek akıllı ve on-line denetleme sistemlerinin kullanımı.																																				
	30	Başlangıç noktasından yüzlerce metre uzaklığa 600 mm. çaplı elastik boruların yerleştirilmesini sağlayan çukursuz boru hattı döşeme teknolojisinin kullanımı.																																				
İletim, Taşıma ve Dağıtım	31	Şartların uzaktan kontrolü ve dağıtım gridlerinin kontrolunün yaygın kullanımı.																																				
	32	Aşırma tip taşımaya rakip olan yer altı güç kabloları kullanımının yaygınlaşması.																																				
	33	Halen kullanımda olan sisteme göre, kayıplarda en az %25 indirim yapacak olan yüksek verimli dönüştürücülerin yaygın olarak kullanımı.																																				
	34	Düzenlenmemiş bölgelerde dinamik elektrik ve gaz sistem kontrolünü etkin kılan ağ yönetim sistemleri, modelleri ve veri tabanlarının yaygın olarak kullanımı.																																				
İletim, Taşıma ve Dağıtım	35	Doğalgazın sıvılaştırılması için kullanılan ileri teknolojinin geliştirilmesi, sıvılaştırma maliyetini %25 indirir.																																				
	36	Halen kullanılan sistemden 4 kat daha fazla depolama yapabilen gelişmiş gaz depolama sistemlerinin ilk pratik kullanımı.																																				
	37	Kurşun-asit teknolojisine rakip olan yüksek yoğunluklu (Kurşun-asite göre 4 kat daha yoğun) akünün yaygın kullanımı.																																				
	38	Sıkıştırılmış depolama teknolojisine rakip geniş kullanım alanlı diğer enerji depolama sistemlerinin ilk kullanımı.																																				

İsim:			Tek seçim				Tek seçim				Tek seçim							Çoklu seçim					Tek seçim						Çoklu seçim							Metin	Metin	Metin
Enerji			Uzmanlık Derecesi				Olayın 2023'teki hayat kalitesine etkisi				Olayın ilk olarak gerçekleşeceği zaman aralığı							İşbirliği yapılması gereken ülkeler					Türkiye'nin rekabet durumu						Gerçekleşmeye yönelik engeller							Konunun Ar-Ge projesini ne kadar bütçe ile kotarırdınız?	Sizce bu gelişmenin ülke ekonomisine getireceği kazanç/tasarruf ne kadar olabilir?	Yorumlarınız/ Alternatif Tezler
																							ArGe kabiliyeti		Ürün ve Hizmet sunumu kabiliyeti		Pazarlama kabiliyeti											
Alt KONU	Sıra No.	OLAY	Yüksek	Orta	Düşük	Yok	zarar verici	etkisiz	yararlı	çok yararlı	2001 - 2005	2006 - 2010	2011 - 2016	2016 - 2020	2020 - 2023	2023'den sonra	asla	Gerek yok	Komşular	Avrupa Birliği	Diğer Türk Cumhuriyetleri	ABD	Lider	Takipçi	Lider	Takipçi	Lider	Takipçi	Sosyal/Etik Kabul Görme	Teknolojik Yapılabilirlik	Finansman eksikliği	Ekonomik Yapılabilirlik	Mevzuat	Politik Tercihler	Eğitimli İnsan Gücü			
Dönüştürme	39	Küçük (<100 Mwe), dağıtık tip üretim merkezlerinin yapımı, Türkiye'de enerji kapasitesinin büyük kısmını oluşturmaktadır. (Halen inşası planlanan merkezler geniş merkezi istasyonlar şeklindedir)																																				
	40	Enerji uygulamalarında yüksek ısılı süper-iletkenlerin ilk ticari kullanımı.																																				
	41	Ultra-süper-kritik buhar türbinlerinin, elektrikli aletler tarafından pratik kullanımı (örneğin, 300 bar'dan büyük iç basınç ve 625 C'den büyük bir ısı)																																				
	42	Geniş, etkin (>60% net), gazla ateşlenen birleşik devre elektrik jeneratörünün ilk ticari kullanımı..																																				
	43	Geniş kapsamlı operasyonlarla Humid Air Turbine (Nemli Hava Türbini) veya diğer gelişmiş ürünlerin ilk pratik kullanımı.																																				
	44	Halen kullanılan sistemlerle karşılaştırıldığında, verimlilikte %10 artırım sağlayan ileri açık-devre gaz türbinlerinin geliştirilmesi.																																				
Dönüştürme	45	OECD ülkelerinde yeni kömür ile üretim yapan santral siparişlerinin %50'si gazlaştırma veya diğer temiz kömür teknolojilerini gerektirmektedir.																																				
	46	NOx yakıcıları ve tüm yakıtlar için yanma sistemlerinin yaygın kullanımı (hem işlem hem de üretim santrallarında).																																				
	47	Yakıtın temiz bir şekilde taşınabilmesi ihtiyaçlarını karşılayan ve etkin maliyetli rafine işlemlerinin geliştirilmesi.																																				
	48	Atıkların sıvı ürünlere dönüştürülmesine rakip olan petrol rafinerisi atıklarının enerji üretimi için gazlaştırılması işleminin ilk pratik kullanımı.																																				
Dönüştürme	49	Türkiye'de endüstriyel ve ticari işletmelerde ortak üretim kapasitesinin 5 GW'a ulaşması.																																				
	50	Ortak üretim/birleştirilmiş-ısı ve güç yöntemleriyle imal edilen dünyaca yaygın elektrik jeneratörünün kullanımını 2 katına çıkarmak.																																				
	51	Konut tipi birleştirilmiş ısı ve güç paketinin (circa 2kWe) yaygın kullanımı.																																				
	52	Metan gazının direkt (non-syngas) ağır hidrokarbonlara dönüştürülme işleminin geliştirilmesi.																																				
	53	Kontrol tekniklerinde (ve uygun yenileme usullerinde) gelişmelerin yaygın kullanımı, nükleer olmayan enerji merkezlerinin ömrünü 10 yıl arttırır.																																				

			Tek seçim				Tek seçim				Tek seçim							Çoklu seçim					Tek seçim						Çoklu seçim							Metin	Metin	Metin
Enerji			Uzmanlık Derecesi				Olayın 2023'teki hayat kalitesine etkisi				Olayın ilk olarak gerçekleşeceği zaman aralığı							İşbirliği yapılması gereken ülkeler					Türkiye'nin rekabet durumu: ArGe kabiliyeti		Ürün ve Hizmet sunumu kabiliyeti		Pazarlama kabiliyeti		Gerçekleşmeye yönelik engeller							Konunun Ar-Ge projesini ne kadar bütçe ile kotarırdınız?	Sizce bu gelişmenin ülke ekonomisine getireceği kazanç/tasarruf ne kadar olabilir?	Yorumlarınız/ Alternatif Tezler
Alt KONU	Sıra No.	OLAY	Yüksek	Orta	Düşük	Yok	zarar verici	etkisiz	yararlı	çok yararlı	2001 - 2005	2006 - 2010	2011 - 2015	2016 - 2020	2020 - 2023	2023'den sonra	asla	Gerek yok	Komşular	Avrupa Birliği	[illegible]	ABD	Lider	Takipçi	Lider	Takipçi	Lider	Takipçi	Sosyal/Etik Kabul Görme	Teknolojik Yapılabilirlik	Finansman eksikliği	Ekonomik Yapılabilirlik	Mevzuat	Politik Tercihler	Eğitimli İnsan Gücü			
Son Kullanıcı	54	Tekniğin ve halen kullanılan anlayışın yapı tasarımlarında birleştirilmesi sonucu, halen kullanılan tasarımlara göre %50 daha az enerji gerekir.																																				
	55	Yeni yapıların (binaların) çoğunluğunda ve varolan binaların yenilenmesinde uygulanan düşük enerjili pasif ısıtma ve/veya soğutma tekniklerinin kullanımı.																																				
	56	Yapı tasarımında pasif güneş enerji sistemlerinin birleştirilmesi yeni evlerde enerji verimliliğine %20 katkı sağlar. (Yürürlükteki yapı düzenleme gerekliliği.)																																				
	57	Yürürlükteki teknik anlayışı kullanarak enerji performansını yenilenmiş binalarda %50 geliştiren bütünleme yaklaşımının eski binalarda geliştirilmesi.																																				
	58	"Akıllı" tekniklerin (hizmet, kontrol ve dinamik bina karakteristikleri vs.) yaygın kullanımı, halen kullanılmakta olan binalarda enerji performansını önemli ölçüde geliştirir.																																				
	59	Gelişmiş hava sızdırmazlığı, enerji tasarrufu ve hava hareketi teçhizatının kullanımı, mekanik havalandırmayı her çeşit bina tipi için en verimli ve tercih edilen seçenek yapar.																																				
	60	Enerji talebini %30 düşüren birleştirilmiş HVAC (ve DHW) sistemlerinden enerji tasarrufu yapılmasının yaygınlaştırılması.																																				
	61	Yüksek verimli sıkıştırma kazanlarının Türkiye'de ev kullanımı ve endüstriyel kullanımlarda tercih edilen seçenek olması.																																				
	62	Günümüzde kullanılan sistemle karşılaştırıldığında binaların soğutma sistemlerinde %30 a varan gelişme sağlanması.																																				
	63	Türkiye'de yeni konut sistemlerinde birleştirilmiş ısıtma/soğutma sistemlerinin yaygın kullanımı.																																				
	64	Ticari binalarda soğutma sistemleri kullanmayan rutubeti yok etme sistemlerinin (dehumidification systems) yaygın kullanımı.																																				
	65	Yeni binalarda off-peak gücünü kullanabilmek için düşük seviye ısı ve soğuğun depolanmasının yaygın kullanımı.																																				
	66	Günümüzde kullanılanlara oranla %50 daha enerji verimliliği olan konut tipi cihazların (buzdolabı, çamaşır makinası, fırın, tv-radyo vs.) satın alınmasının yaygınlaştırılması.																																				

Son Kullanıcı

Sıra No.	OLAY	Uzmanlık Derecesi (Tek seçim): Yüksek	Orta	Düşük	yok	Olayın 2023'teki hayat kalitesine etkisi (Tek seçim): zarar verici	etkisiz	yararlı	çok yararlı	Olayın ilk olarak gerçekleşeceği zaman aralığı (Tek seçim): 2001 - 2005	2006 - 2010	2011 - 2015	2016 - 2020	2020 - 2023	2023'den sonra	asla	İşbirliği yapılması gereken ülkeler (Çoklu seçim): Gerek yok	Komşular	Avrupa Birliği	Diğer Türk Cumhuriyetleri	ABD	Türkiye'nin rekabet durumu (Tek seçim) – Ar-Ge kabiliyeti: Lider	Takipçi	Ürün ve Hizmet sunumu kabiliyeti: Lider	Takipçi	Pazarlama kabiliyeti: Lider	Takipçi	Gerçekleşmeye yönelik engeller (Çoklu seçim): Sosyal/Kültürel Kabul Görme	Teknolojik Yapılabilirlik	Finansman eksikliği	Ekonomik Yapılabilirlik	Mevzuat	Politik Tercihler	Eğitimli İnsan Gücü	Metin: Konunun Ar-Ge projesini ne kadar bütçe ile kaldırırdınız?	Metin: Sizce bu gelişmenin ülke ekonomisine getireceği kazanç/tasarruf ne kadar olabilir?	Metin: Yorumlarınız/ Alternatif Tezler
67	Düşük enerjili aydınlanma; konut, ticari ve endüstriyel uygulamalarda tercih edilen seçenek olmuştur.																																				
68	Müşterilere istedikleri zaman ve istedikleri miktarda elektrik kullanabilme seçenekleri sağlayan 2 çıkışlı haberleşme ve cihazların kontrolüyle bütünleşmiş "akıllı" tip ölçme cihazlarının ilk pratik kullanımı.																																				
69	Konutlarda ve endüstriyel işletmelerde değişken hızlı ve yüksek verimli elektrik kullanabilen komutatörlü motorların kullanımının yaygınlaştırılması.																																				
70	Düşük kaliteli endüstriyel atık durumundaki ısının (200 C'nin altındaki) kullanımı, Türkiye'de ticari bir uygulama olmuştur.																																				
71	Katalizör teknolojilerindeki gelişmeler, kullanılan yüksek ısı/yüksek basınç kimyasal işlemlerin %30'unun düşük ısı/düşük basınç alternatifiyle değiştirilmesine imkan verir.																																				
72	Gelişmiş dizayn metodları (süreç birleştirme, süreç yoğunlaştırma vs.) vasıtasıyla endüstriyel işlem fabrikalarında enerji atığının düşürülmesi ve verimliliğin arttırılmasında %20 gelişme sağlanmasının yaygınlaştırılması.																																				
73	Taşımacılıkta düşük emisyonlu, yüksek verimli (yürürlükteki duruma göre %20 daha fazla) motorların yaygın kullanımı.																																				
74	Dizel motorların, benzinli motor atıklarıyla ilgili AB yönetmeliği gereklerini karşılayabilen pratik kullanımı.																																				
75	Yollardaki dizel araçların %50'sinin egzozundan çıkan parçacıklı atıkların engellenmesi.																																				
76	Türkiye'de araçlar için alternatif yakıtların kullanımının yaygınlaştırılması (otomobiller için metanol, hafif ticari araçlar için doğalgaz kullanımı gibi).																																				
77	Alkol ve hidrokarbon yakıtların kullanılmasıyla etkin maliyetli yakıt hücrelerinin ilk ticari kullanımı.																																				
78	Etkin maliyetli, sıfır atıklı araçlar Türkiye'nin araç piyasasının %10'unu ele geçirmiştir. (California kriterlerine uyan akü ve hidrojen enerjisi vs.)																																				
79	Karbondioksit atma/depolama ile ilgili tekniklerin ticari kullanımı. (Bitki yetiştirilmesi dışındaki).																																				
80	%20 oranına varan(+,-) küresel ısınma ile insan yapımı karbondioksit arasındaki ilişkinin açıklanması.																																				

ENERGY CONVERSION TABLE

Enerji kaynaklannin isil degerleri ve petrol esdegerlerine cevirim katsayilan
Heating values and tons of oil equivalent conversion factors of energy sources

ÇevrimTablosu / Energy Conversion Table

Enerji Kaynağı	Energy Source	Yoğunluk Density	Isıl Değer Heating Value	Birim Unit	Miktar Quantity	(TEP) Conversion Fac (TOE) '
Taş kömürü	- Hard coal		6,100	kcal/kg	1 ton	0.61
Kok komürü	- Coke coal		7,200	kcal/kg	1 ton	0.72
Biriket	- Brick		5,000	kcal/kg	1 ton	0.5
Sanayi linyiti	- Lignite used in industry		3,000	kcal/kg	1 ton	0.3
Linyit santral	- Lignite used power plan		2,000	kcal/kg	1 ton	0.2
Elbistan linyiti	- Elbistan lignites		1,100	kcal/kg	1 ton	0.11
Petrokok	- Petrocoke		7,600	kcal/kg	1 ton	0.76
Prina	- Prina		4,300	kcal/kg	1 ton	0.43
Talas	- Wood powder		3,000	kcal/kg	1 ton	0.3
Grafit	- Graphite		8,000	kcal/kg	1 ton	0.8
Kok tozu	- Coke powder		6,000	kcal/kg	1 ton	0.6
Maden Komuru	- Hard coal		5,500	kcal/kg	1 ton	0.55
Asfaltit	- Asphaltite		4,300	kcal/kg	1 ton	0.43
Odun	- Wood		3,000	kcal/kg	1 ton	0.3
Hayvan ve bitki artigi	- Animal & vegetal waste		2,300	kcal/kg	1 ton	0.23
Ham petrol	- Crude petroleum		10,500	kcal/kg	1 ton	1.05
Kalorifer Yakiti	- Furnace fuel		10,000	kcal/kg	1 ton	1
Fuel oil No:5	- Fuel oil No:5	0,92 kg/lt	10,025	kcal/kg	1 ton	1.003
Fuel oil N0:6	- Fuel Oil N0:6	0,94 kg/lt	9,860	kcal/kg	1 ton	0.986
Motorin	- Diessel oil	0,83 kg/lt	10,200	kcal/kg	1 ton	1.02
Benzin	- Gasoline	0,735 kg/lt	10,400	kcal/kg	1 ton	1.04
Gaz yagi	- Kerosene	0,78 kg/lt	8,290	kcal/kg	1 ton	0.829
Siyah likor	- Black liqueur		3,000	kcal/kg	1 ton	0.3
Nafta	- Naphta		10,400	kcal/kg	1 ton	1.04
Dogal gaz	- Natural gas	0,67 kg/m3	8,250	kcal/m3	1000 m3	0.825
Kok gazi	- Coke gas	0,49 kg/m3	4,026	kcal/m3	1000 m3	0.403
Yliksek firm gazi	- Owen gas	1,29 kg/m3	791	kcal/m3	1000 m3	0.08
Fuel-gaz (Rafineri gazi)	- Fuel-gas		10,500	kcal/kg	1000 m3	1.05
Asetilen	- Acetylene		14,230	kcal/m3	1000 m3	1.423
Propan	- Propane		10,200	kcal/m3	1000 m3	1.02
LPG	- LPG		10,900	kcal/kg	1 ton	1.09
LPG	-LPG	2,477 kg/m3	27,000	kcal/m3	1000 m3	2.7
Elektrik	- Electricity		860	kcal/kWh	1000 kWh	0.086
Hidrolik	- Hydroulic		860	kcal/kWh	1000 kWh	0.086
Jeotermal	- Geothermal		8,600	kcal/kWh	1000 kWh	0.86

Kaynak: DIE

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