DECARBONIZATION OF TURKISH PUBLIC ELECTRICITY SECTOR: ADOPTING SUSTAINABLE ENERGY PORTFOLIO

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ABSTRACT

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Sustainable energy settles in the core of the economic activities since climate change issues have arisen. Decarbonization strategies of the electricity sector target to reach sustainable energy by liberalization movements. To adopt the sustainable energy portfolio similar to European Union ones', Turkey took a step in decarbonization of the Turkish electricity sector by beginning with the public electricity sector. In this study, the decarbonization process of Turkish public electricity sector is projected under alternative scenarios by using the integrated model software tool, Long-range Energy Alternatives Planning (LEAP), from 2001 to 2050. Liberalization impacts on GHG emissions of Turkish public electricity sector and energy portfolio management after privatization are evaluated with the perspective of 3Es (Energy, Environment and Economy) in this study. The private electricity sector is exempt from the modeling.

There are several methodologies applied at each stage of this study. Linear regression is implemented in the baseline of models such as forecasting the future resource price

and electricity demand for various sectors. The model applied IPCC Tier-1 method placed in LEAP to calculate GHG emissions in the privatization period of the electricity generation sector. Levelized cost of electricity generation is the methodology used in social cost calculations.

For analyzing the privatization impacts of GHG emissions, Business-As-Usual (BAU) Reference scenario, stating the current strategies in the public electricity sector, and No Privatization (NP) scenario, preserving the 2012 installed electricity generation capacity, are applied. Alternative, sustainable energy portfolios are offered in the Nuclear Energy (NE) and Renewable Energy (RE) scenarios. NE portfolio involves the 3rd and 4th nuclear power plants contrary to RE scenario, which targets the diversification in potential renewable energy sources.

In conclusion, the government gets a benefit increase of 109.96 billion TL by implementing privatization in Turkish public electricity generation over the BAU scenario. In addition, cumulative GHG emission savings in BAU, NE and RE scenarios is 2.2 $GtCO_2eq$. compared to NP scenario. The cost reduction per tCO_2eq. are 47.76 TL in RE scenario and 45.57 TL in NE scenario. RE scenario distinguishes itself by its low projected costs and its diversified energy portfolio, which are complementary to 3E perspective of the sustainability.

Keyword: Decarbonization, Electricity Sector, LEAP, Greenhouse Gas Emissions

ÖZ

TÜRK KAMU ELEKTRİK SEKTÖRÜNÜN KARBONSUZLAŞTIRILMASI: SÜRDÜRÜLEBİLİR ENERJİ PORTFÖY UYGULAMALARI

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İklim değişikliği sorunlarının ortaya çıkması ile sürdürülebilir enerji, ekonomik aktivitelerin merkezinde yer almaya başlamıştır. Elektrik sektöründe, karbonsuzlaştırma stratejilerinin liberalleştirme hareketleri ile sürdürülebilir enerjiye ulaşılması amaçlanmaktadır. Türkiye, Avrupa Birliği'nin sürdürülebilir enerji portföyüne uyum sağlayabilmek için, Türk elektrik sektörünün karbonsuzlaştırımasına ilk önce kamu elektrik sektöründen başlayarak adım atmıştır. Bu çalışmada, Türk kamu elektrik sektörünün karbonsuzlaştırılma süreci LEAP (Long-range Energy Alternatives Planning) adlı entegre model yazılımı ile 2001-2050 yılları arasında öngörülmeye çalışılmıştır. Liberalleştirmenin, Türk kamu elektrik sektörünün sera gazı emisyon salımlarındaki etkisi ve özelleştirme sonrası 3E (Enerji, Çevre ve Ekonomi) açısından enerji portföy yönetimi bu çalışma içerisinde incelenmiştir. Özel elektrik sektörü, çalışma kapsamına alınmamıştır.

Bu çalışmanın her bir basamağında farklı metodolojiler uygulanmıştır. Modellemenin kurulum aşamasında lineer regresyon metodu ileriki yıllarda kaynak

fiyatlarının ve farklı sektörlerin elektrik taleplerinin tahminleri gibi yerlerde kullanılmıştır. Elektrik üretim sektörünün özelleştirilme sürecinde sera gazı emisyonlarını hesaplayabilmek için LEAP içerisinde yer alan IPCC Tier-1 metodu kullanılmıştır. İndirgenmiş elektrik üretim maliyetleri metodolojisi ise sosyal maliyetlerin hesaplanmasında kullanılmıştır.

Özelleştirmenin sera gazı emisyonları üzerindeki etkisini inceleyebilmek için elektrik kamu sektöründe uygulanan mevcut stratejileri yansıtan Referans (BAU) senaryosu ve 2012 yılı elektrik üretim kurulu güç kapasitesinin korunduğu Özelleştirmenin Uygulanmadığı (NP) senaryo kurgulanmıştır. Nükleer Enerji (NE) ve Yenilenebilir Enerji (RE) senaryolarında alternatif enerji portföy uygulamaları önerilmiştir. NE senaryosunun portföyü 3. ve 4. nükleer santralleri barındırırken, RE senaryosunda potansiyellerine göre yenilenebilir enerji kaynaklarında çeşitlendirilmeye gidilmiştir.

Sonuç olarak, NP ve BAU senaryolarının karşılaştırılmasının sonucunda devletin Türk kamu elektrik üretim sektöründeki özelleştirme uygulanmalarından 109.96 milyar TL getiri elde ettiği ortaya çıkmıştır. Buna ek olarak, BAU, NE ve RE senaryolarında, NP senaryosuna göre 2.2 $GtCO_2$eş. sera gazı emisyon salınımı önlenmiştir. 1 ton CO_2eş. salınmamasına karşılık olarak, RE senaryosunda 47.76 TL/tCO_2eş. ve NE senaryosunda 45.57 TL/tCO_2eş. maliyet azaltımı sağlanmıştır. Diğer senaryolara göre daha düşük elektrik maliyet tahmini ve enerji portföyündeki çeşitlendirme ile sürdürülebilirliğin 3E perspektifini tamamlayan RE senaryosu öne çıkmıştır.

Anahtar Kelimeler: Karbonsuzlaştırma, Elektrik Sektörü, LEAP, Sera Gazı Emisyonları

To Oktay, my beloved uncle

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ABBREVIATIONS

3E	Energy, environment, economy relationship
AIM	Asian-Pacific integrated model
ASF	Atmospheric stabilization framework
BAS or BL	Baseline
BAU	Business-as-usual
BP	Basic policy
CCS	Carbon capture and storage
CECP	Clean energy and climate plan
CH_4	Methane
CO	Carbon monoxide
Co.	Corporation
CO_2	Carbon dioxide
CO_2 eq.	Carbon dioxide equivalent
DEECO	Dynamic energy, emissions and cost optimization
DER-CAM	Distributed energy resources customer adoption model
EGC	Turkish electricity generation corporation (in Turkish, EÜAŞ)
EMRA	Energy market regulatory authority
EU	European Union
ExternE	Externalities of energy
GDP	Gross domestic product
GDP MER	Gross domestic product market exchange rate
GEMIS	Global emission model for integrated systems
GHG	Greenhouse gas
GP	Government policy
Gt	Giga tonnes
Gtoe	Giga tonnes of oil equivalent

GW	Gigawatt
GWh	Gigawatt hour
GWP	Global warming potential
HEPP	Hydroelectric power plant
HFC 134-a	Tetrafluroethane
IEA	International energy agency
IMAGE/TIMER	TARGETS-IMAGE energy regional model
Inc.	Incorporation
IPCC	International panel on climate change
kW	Kilowatt
kWh	Kilowatt hour
LC	Low carbon
LCOE	Levelized cost of energy (or electricity)
LEAP	Long-range energy alternative planning system
LEED	Leadership in energy and environmental design
LULUCF	Land-use, land-use change and forestry
MARIA	Multiregional approach for resources and industry allocation model
MARKAL	Market allocation model
MENR	Ministry of energy and natural resources
MER	Market exchange rate
MESSAGE	Model for energy supply strategy alternatives and their general environmental impact
MiniCAM	Mini climate assessment model
Mtoe	Million tonnes of oil equivalent
MW	Megawatt
MWm	Megawatt (mechanical)
N	Nitrogen
N_2O	Nitrous oxide
NE	Nuclear energy
NO_X	Nitrogen oxides

NP	No privatization
NPV	Net present value
O&M	Operation and maintenance
O_2	Oxygen
OECD	Organization for economic co-operation and development
PPM	Parts per million
RE	Renewable energy
Ret.	Retention
RETScreen	Renewable energy technology screening model
ROK	Republic of Korea
S	Sulfur
SEI	Stockholm environment institute
SGM	Second generation model
SO	Sulfur oxide
SO_2	Sulfur dioxide
SS	Sustainable society
T	Tonne
T&D	Transmission and distribution
TEA	Turkish electricity authority (in Turkish, TEK)
TECTC	Turkish electricity contracting and trading corporation (in Turkish, TETAS)
TED	Technology and environmental database
TEDC	Turkish electricity distribution corporation (in Turkish, TEDAŞ)
TETC	Turkish electricity transmission corporation (in Turkish, TEİAŞ)
TETGC	Turkish electricity generation transmission corporation (in Turkish, TEAŞ)
TJ	Terajoule
TL	Turkish lira
TOE	Tonne of oil equivalent

TSP	Total suspended particle
TURKSTAT	Turkish statistical institute
TWh	Terawatt hour
UNDP	United nations development programme
UNEP	United nations environment programme
WB	World bank
WEAP	Water evaluation and planning system
WEC	World energy council
WEM	World energy model

CHAPTER 1

INTRODUCTION

1.1. Motivation

Economy, environment and society are the three pillars of sustainable development. The balance between them is important to maintain intra- and inter-generational equity. The interactions of these three pillars form a “ring”. In other words, a change in one of their output/input can influence the others. For instance, the addiction of fossil fuel usage in economic activities creates large negative externalities by polluting the environment, on the other side, depleted resources and environmental problems constrain the economic capacity. As a reflection of this situation, human well-being is suffering from economic loss, environmental degradation and decrease in the social welfare [1].

Depletion of natural resource, especially fossil fuels, is triggered by the growth of population and economic activities. According to the 4^{th} assessment report of the International Panel on Climate Change (IPCC) [2], the greenhouse gas emissions (GHG) of the World increased from 28.7 to 49.0 Giga tonnes of carbon dioxide equivalent ($GtCO_2eq.$) between1970 and 2004. The rate of increase was estimated to be 70% compared to pre-industrial times. In 2010, this value reaches to 50.1 $GtCO_2$ eq., 20% higher than the year 2000 emissions.

The total emissions in 2010 were higher than the amount required to save global warming at 2^oC by 2020 with respect to the United Nations Environmental Programme (UNEP) model results [3]. However, the threshold specified by

UNEP model result already was exceeded. In May 2013, the measurement of CO_2 (carbon dioxide), one of the major GHG emissions, concentration has reached 400 particles per million [4].

Regardless, the energy demand of the World has increased without interrupt. According to ExxonMobil projections, from 2010 to 2040, global energy demand will increase approximately 35% greater than 2010 values. On the other hand, global economy grows at a yearly average of 2.8% [5].

Table 1 Energy, demographic, and environmental indicators for Turkey

Indicator	**2007**	**2008**	**2009**	**2010**	**2011**
GDP (current billion $)	647.16	730.34	614.55	731.14	774.98
Population (million)	70.22	71.10	72.05	73.00	73.95
Gross electricity demand (Terawatt hour (TWh))	191.56	198.42	194.81	211.21	229.39
Greenhouse gas emissions ($MtCO_2eq.$) (without LULUCF)	380.95	367.21	370.01	402.10	422.42

Source: World Bank Data [6] (Indicator: GDP and Population; TURKSTAT [7] (Indicator: Population, Greenhouse Gas Emissions); TETC [8] (Indicator: Annual Development of Electricity Generation, Consumption and Losses in Turkey (1984-2011), page 33).

Population and Gross Domestic Product (GDP) are among important issues in the calculation of electricity consumption. Electricity demand and generation have to be balanced for avoiding blackouts and preserving the growth in the economy. Positive growth of population results in the upsurge of the electricity demand, as illustrated in Table 1, although GDP fluctuates between 2007 and 2011. From an environmental perspective, 86% of the total GHG emissions without LULUCF (Land-use; Land-use Change and Forestry) in Turkey has been generated in the energy sector as stated by National GHG emission inventory report 1990-2011, [7]. Consequently, growth in the electricity demand leads to increase of fossil fuel usage in electricity generation, and results in more GHG emissions in Turkey.

Turkey targets faster urbanization and industrialization in the 2023 vision. As a developing country, reaching her development targets requires a large electricity generation capacity. Unfortunately, the electricity generation side has a dependency

on imported fossil fuel resources, mainly natural gas and coal. To get rid of this dependence and decrease GHG emissions while developing, decarbonization of the electricity sector has been given a start following the European Union. European Union (EU) clarified 20-20-20 target implementations in EU Energy Road Map 2020 [9]. Reducing greenhouse gas emissions by 20%, increasing the share of renewable energy to 20% and reducing energy consumption by 20% are focal points of decarbonization process for the EU.

Turkey does not have solid targets on energy consumption and reducing GHG emissions. Only, 30% of electricity generation is to be provided by renewable energy according to the last national energy strategic plan 2010-2014 [10]. Privatization in the electricity generation sector provided an opportunity to implement decarbonization strategies in the public electricity production. The public sector can reduce the share of high emission plants in its portfolio through privatization. This will definitely decrease the carbon emission contribution of the public sector, but same argument will not hold for total emissions in Turkey. Still the burden of emission reduction on state owned electricity generation plants would be reduced and the public sector can pave the way for further private investment in more environmentally friendly sources.

Examining the privatization impacts on GHG emissions and then constituting the best sustainable energy portfolio for Turkish public electricity sector is the main aim of this study. Integrated energy-environment software Long-range Energy Alternative Planning (LEAP) was used to foresee the decarbonization process of Turkish electricity generation company (EGC) and Turkish electricity transmission company (TETC) between 2001 and 2050 in conformity with the EU Energy Road Map 2050. The private electricity sector is out of the scope of this study, although a follow up research on private sector will be complementary.

This study constitutes one of the rare studies to analyze Turkish public electricity sector in the 3E framework using LEAP**. *It is the second study to use LEAP on electricity sector in Turkey and the first study to focus on the decarbonization***

process of the Turkish public electricity sector. There is no previous in depth study to examine the sustainability in this field. This study has a potential to be a guide for developing countries who targets or under privatization or already under liberalization movements in the electricity sector.

1.2. Research Questions

The study concentrates on ***decarbonization of the Turkish public electricity sector.*** The scope of this study covers only electricity generation and electricity transmission. The motivation for the study shelters different questions:

- Is privatization the only solution for decarbonization? What are the benefits and costs of privatization for the Turkish public electricity sector?
- How does the government reach the best sustainable energy portfolio after the privatization?

Observing the impacts on the GHG emissions of the Turkish government privatization decisions forms the first part of the study. The study begins with forecasting of electricity demand in Turkey. Privatization time schedule was arranged to take into account the Prime Ministry Privatization Administration decisions and was set to finish by 2020. After the privatization discussion the first part continues with:

- Foreseeing the changes in the total electricity generation provided by the government power plants during privatization.
- Calculating GHG emissions generated by public power plants during privatization.

In summary, the first part of the study describes the government's privatization choices and their impacts on electricity generation and GHG emissions. The second part of the study attempts to identify the best sustainable energy portfolio for the public electricity sector in the 3E (Energy, Environment and Economy) nexus.

In order to identify the best course of action for the public sector, alternative scenarios are considered. The current strategies of the government and the Ministry of Environment and Natural Resources (MENR) are covered in the business-as-usual (BAU) scenario. In contrast to the BAU, the second main scenario highlights preserving of the 2012 installed capacity of power plants, called as No Privatization (NP). Purpose for establishing the scenario is to answer what the government gains or loses with privatization.

Maintaining the sustainability in the public electricity sector means that setting up a good portfolio of electricity generation plants. With better portfolio structure and management, the dependency on imported fossil fuels can be decreased. Nuclear Energy (NE) scenario, focusing on third and fourth nuclear power plants, and Renewable Energy (RE) scenario, involving diversification of renewable energy sources, is the sub-scenarios of BAU. The main question we seek to answer in the second part is: "Can renewable energy be a better solution than a nuclear power plant?"

Although forecasting or simulation of the electricity sector gives an opportunity to see the results of current implementations and alternative ways, they have a disadvantage because of the uncertainties in the future such as technological improvement, discovery of new resources (e.g. Shale gas) and unexpected financial and energy crises. Avoiding or predicting these uncertainties is impossible; however, forming a solid baseline in the model helps to decrease the error margin of the model results. Validation in our model is done via comparison of in sample forecasts of GHG emissions with actual emissions. GHG emissions data from 2001 to 2010, taken by EGC, were compared with LEAP baseline data results. The error was found to be under ± 5%, except for 2003.

1.3. Background Information

The reasons behind the liberalization movement in the electricity sector and reshaping of the public electricity sector are explained in this section. Parallel to the liberalization process, the last national energy strategic plan is also discussed to provide a basis for scenario selection.

1.3.1. Liberalization of the Turkish electricity sector

Liberalization of the electricity sector in Europe began in the late 1980s; it was a part of the "electricity reform". Restructuring of the electricity sector, better performance in generation side, prompting to increase private investments, and creating a competitive market were the main purposes of the reform [11].

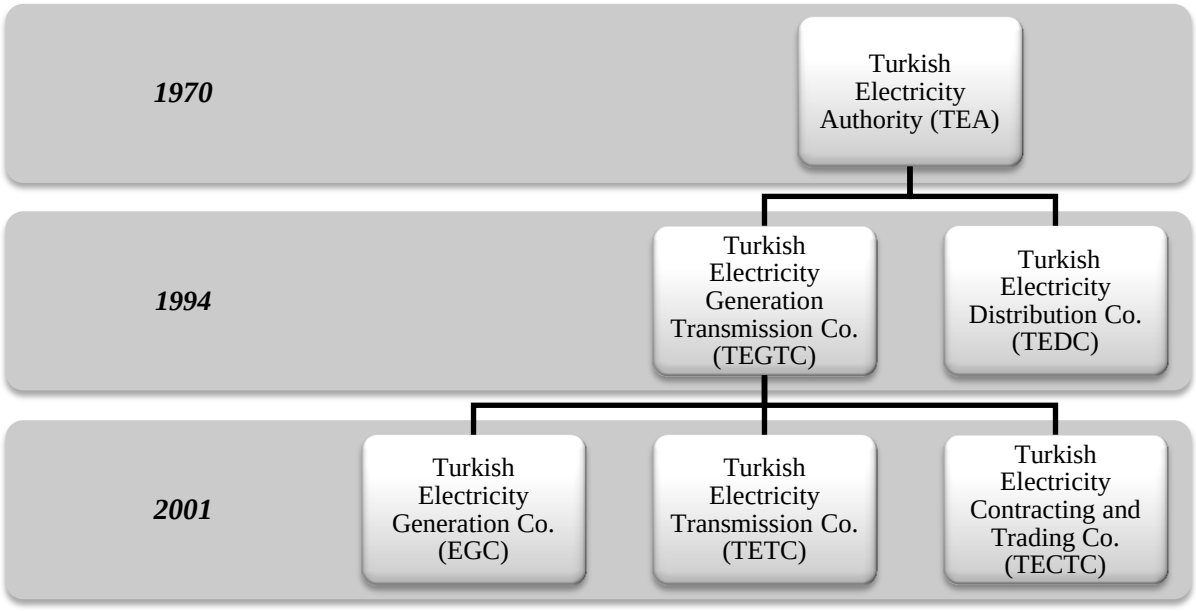
Improper management of the power plants and cumbersome structure in the decision making processes of institutions in the electricity sector created large deficits in the government budgets'. The deficit could not be eliminated. As a result of this situation, Europe incurred irreversible losses. To get rid of this situation, governments resorted to liberalization [11]. And thus, the privatization of the electricity sector began.

The Turkish electricity sector was facing similar problems. Productivity in almost every sector was restrained because of the blackouts and improper management of the electricity system. Hence, Turkey followed Europe by starting the privatization plan to solve these problems [12].

The first privatization step of Turkish Electricity Authority (TEA) was included in Fifth and Sixth Five Year Development Plans. TEA, as seen in Figure 1, was divided as the Turkish Electricity Generation Transmission (TETGC) and, Turkish Electricity Distribution Corporation (TEDC, in Turkish TEDAŞ) in 1994 due to decree in Law No: 233, which was enacted on August 13, 1993 [12].

While privatization step had been started, third separation was done in TETGC to speed up the progress. TETGC was split into three corporations with respect to Article 3 of the Law No: 233 and Electricity Market Law No: 4628. These corporations are: Turkish Electricity Generation Corporation (EGC), in Turkish EÜAŞ; Turkish Electricity Transmission Corporation (TETC), in Turkish TEİAŞ; Turkish Electricity Contracting and Trading Corporation (TECTC), in Turkish TETAŞ [12].

Privatization process on the distribution side was completed by the end of 2013. On the generation side, it has been still continuing. National strategic plans and these corporation targets have been reshaped considering privatization processes and problems faced by the electricity sector.



Source: Güney (2005) [12]. The scheme was drawn by the author

Figure 1 Liberalization of Turkish electricity sector

1.3.2. National strategic plans for energy sector

The last national energy strategic plan, covering 2010-2014 periods, focuses on five main strategic themes: *Energy supply security, using the advantage of geopolitical*

position of Turkey in the energy field, environment, natural resources and cooperation. ***"Energy Supply Security"*** targets energy mix and independency on imported fossil fuels. The second strategic theme is ***"Taking the lead by using geopolitical position in regional and global energy"***. The aim of this theme is to make Turkey an energy hub between Europe and Asia by using her geopolitical position. ***"Environment"*** is the third theme which does not have specific targets for decreasing the GHG emissions generated by the energy sector. Linked with the previous theme, ***"Natural Resources"*** focuses only on the mining sector and several resource potentials of Turkey are not taken into consideration. ***"Cooperation"*** is the last theme, and it refers to the restructuring of institutions, legal frameworks and regulations and institutional cooperation's [10].

The future energy portfolio targets increasing renewable energy share to 30% on the generation side and adding four nuclear power plants on the MENR agenda. The final decisions are made on the construction of Akkuyu and Sinop nuclear power plants. The Akkuyu nuclear power plant belongs to the private sector; independent from EGC, in opposition, Sinop nuclear power plant will be constructed and controlled by the Turkish government [10].

CHAPTER 2

LONG-RANGE ENERGY ALTERNATIVES PLANNING

2.1. Long-range Energy Alternatives Planning (LEAP)

LEAP [13] was created in 1980's during the Beijer Institute's Kenya fuel wood project. The founders of the first version of LEAP are Sweden (Sida), Germany, the Netherlands and the United States Agency for International Development. It was developed at the Stockholm Environment Institute (SEI) in the USA and Boston University.

LEAP is a software tool for energy planning. It has a broad scope mainly including demand, transformation, GHG emissions and local air pollutants, and social cost-benefit analyze. Long and short term forecasting can also be done according to the user's preferences. Hence, many users prefer LEAP because of its useful features and wide range of application areas in the energy sector [13]. The most preferred usage areas of LEAP are preparation of the national GHG emission inventories, forecasting in the energy sector and usage of domestic sources. Low emission capacity building program of the United Nations Development Programme (UNDP), Energy for a shared development agenda for Rio+20 and Europe's share of the climate change are the recent projects which use LEAP for energy planning [13].

2.2. Why LEAP, not other energy models?

To answer this question, we can start with Urban et.al. [14] study, which examines different energy models.

The study examined models with respect to two features: Characteristics and methodology. The following models are included in this study:

- AIM (Asian-Pacific Integrated Model)
- ASF (Atmospheric Stabilization Framework)
- IMAGE/TIMER (TARGETS-IMAGE Energy Regional Model)
- LEAP (Long-range Energy Alternatives Planning System)
- MARIA (Multiregional Approach for Resources and Industry Allocation model), MARKAL (MARKet ALlocation model)
- MESSAGE (Model for Energy Supply Strategy Alternatives and their General Environmental impact)
- MiniCAM (Mini Climate Assessment Model)
- PowerPlan
- RETScreen (Renewable Energy Technology Screening Model)
- SGM (Second Generation Model)
- WEM (World Energy Model).

LEAP comes to the forefront compared to other models. The performance of the power sector, electrification of the region or city, measurement of urbanization impacts, forecasting the benefits of clean development mechanisms, renewable energy implementations and rural energy planning are the few examples of LEAP usage areas. The other models such as MARKAL, MESSAGE and RETScreen have restrictions in these areas.

The second parameter for comparison of alternative models in this study is the methodology of the models. Physical accounting, simulation and optimization are the

methodologies of LEAP. The other models only contain one methodology. For instance, MARKAL and MESSAGE use the optimization. On the other hand, the economic equilibrium methodology can be applied by SGM, WEM and MiniCAM [14].

Manfren et.al. [15] analyze energy models by focusing on their usage and capabilities. Accounting, sensitivity, simulation, optimization, database and methodology are the parameters in the examination. The models examined are:

- CO2DB
- DEECO (Dynamic Energy, Emissions and Cost Optimization)
- DER-CAM (Distributed Energy Resources Customer Adoption Model)
- EnergyPLAN
- EnergyPlus
- ExternE (Externalities of Energy)
- GEMIS (Global Emission Model for Integrated Systems)
- GENOPT
- HOMER
- LEAP (Long-range Energy Alternatives Planning System)
- LEED for Neighborhood Development (Leadership in Energy and Environmental Design)
- Place^{3}S
- RETScreen (Renewable Energy Technology Screening Model)
- TRNSYS (Transient System Simulation) [15].

The wide implementation areas and various methodologies of LEAP are also emphasized in this study. The result shows that technological and environmental database of the LEAP provides an advantage for its users [15].

Therefore, the decarbonization process of Turkish public electricity sector is projected by using LEAP in our study. Liberalization impacts on GHG emissions of Turkish public electricity sector and energy portfolio management after privatization

are evaluated with the perspective of 3Es (Energy, Environment and Economy). LEAP is the most suitable and flexible model to combine with examining the GHG emission examination with management of the energy portfolio.

2.3. Case studies covering the electricity sector

UNDP Low Emission Capacity Building Programme aims to strengthen the capacities in developing countries such as China, Mexico etc. The scope of the program contains developing of GHG emission inventories, renewable energy implementations and sustainable energy planning. Turkey participated in this programme in 2012 [16].

UNDP provides LEAP free of charge to participants from these countries. Additionally, the governments of these countries use LEAP in their national strategic energy plans and GHG emission inventories. Therefore, the majority of the studies involve these countries [13].

There are various studies utilizing LEAP. Transportation, technological improvement and impacts of air pollutants on health of society are only a few among many. Because of this wide study fields', we decided to restrict the literature review by focusing on the electricity sector. The studies of China, Korea, Mexico, Taiwan and Venezuela electricity sector were analyzed briefly. The only study for Turkey focusing on the CO_2 mitigation potential of the Turkish electricity sector is examined at the end of this section.

LEAP is an integrated model. It can be integrated with many different models. One of the studies examines linkages between energy consumption and air quality in China till 2030. GHG emissions were forecasted by LEAP. The results of LEAP were inserted to other models; TRACE-P EL, CMAQ and BenMAP. Climate change and pollutant control policies were scenarios in the model. As a conclusion of the study, China has a high potential to decrease its air pollutant concentrations between 12% and 32% if the energy policies would be enforced rigorously [17].

Another study on China focused on the impacts of energy policies to energy consumption and carbon emission of Beijing. Business-As-Usual (BAU) scenario, Basic Policy (BP) and Low-Carbon (LC) are the scenarios in the model. Outcomes of the scenarios showed that LC values were lower than other scenarios. LC values were 55.82% and 32.72 % lower than BAU and BP scenarios respectively, and LC scenarios total carbon emissions were 62.22 % and 36.75 % lower than BAU and BP scenarios [18].

A base scenario, low-carbon scenario and frustrated low-carbon scenarios were applied for China by 2050. The outcome of the model revealed that, total terminal energy demand were 6.10, 5.24 and 6.24 billion tonnes of standard coal for base, low-carbon and frustrated low-carbon scenario, respectively. Additionally, fuel switching and renewable energy options were embedded in the model. There is a huge potential in the reduction of emissions in the energy sector [19].

Cai et.al. [20] investigated CO_2 emission mitigation potential in China's electricity sector. Two scenarios were applied to find the best road for low-carbon development in China's electricity sector. First scenario, namely base scenario, covered current policies and the new policy scenario targeted extent of industrial restructuring and technical advancement. According to the results, energy demand in China was to triple by 2030 compared to the 2000. Moreover, one of the best solutions to decrease CO_2 emissions was to invest in more nuclear power and hydroelectric power plants.

There are few studies focusing on cost analysis by using LEAP [21]. One of them concentrates on external costs from electricity generation of China till 2030. The study depends on different scenarios for long-term energy and environmental policies. Implementing the energy policies provides a minimum 24% reduction in the cost of electricity generation. This ratio drops to around 20% if only environmental policies could be implemented. There is a significant reduction by applying both of the scenarios which were estimated at 58.2% [21].

There is a study to forecast energy supply and demand relationships in China [22].

Baseline, maximum nuclear energy and minimum nuclear energy were scenarios used in the study. The difference between maximum and minimum nuclear energy scenario assumptions are installed capacities in the 2020 and the 2030 of the nuclear power energy. Additionally, in the minimum nuclear energy scenario, renewable, thermal and combined cycle gas turbine capacities were maximized contrary to maximum nuclear energy scenario. As a consequence of the study, nearly fourfold increase in natural gas consumption, tripling oil production usage and doubling electricity consumption until 2030 were predicted in the baseline scenario. The final end-use energy demand in 2030 had an approximately 3.8 % growth until 2030. Although nuclear power plants supplied the majority of the energy demand, GHG emission reduction was only 2-3 % of the baseline scenario [22].

Kim et.al.[23] interpreted energy demand, supply and policies combining with energy security in the Republic of Korea (ROK). The ROK electricity structure was modeled in LEAP taking multi-sector changes into consideration. Demand for and supply of the electricity, and GHG emissions were calculated. The projection time was restricted to the period between 2007 and 2030. The scenarios were specified as minimum nuclear and maximum nuclear scenarios. In conclusion, although there was a serious concern on nuclear power plants after Fukushima, establishing nuclear power plants instead of thermal power stations could be a Band-Aid to climate change with respect to model results.

A recent study on Korea focused on renewable energy in the electricity sector [24]. The paper analyzed three scenarios for the electricity sector by 2050 using LEAP. Baseline (BL), new Government Policy (GP) and Sustainable Society (SS) were the scenarios. BL and GP scenarios covered electricity generation and nuclear expansion in Korea, contrary, SS included demand management and renewable energy. Electricity demand growth rate was higher than BL electricity demand in GP scenario; however, SS electricity demand was lower than BL electricity demand. In addition to this GHG emission originated from electricity generation for BL and GP were similar to the current values. As expected, GHG emissions of SS were 80% lower than emission values in 2009. The discounted cumulative costs from 2009 to

2050 for SS scenario would be 10% higher than BL and GP scenario results [24].
The abatement cost of SO_2 control options (including flue-gas desulphurization technologies, hydraulic treatment of fuel oil, and the substitution of high-sulphur by low-sulphur content fuels) of the Mexican electricity sector was examined [25]. Under this study, ten power plants, the main SO_2 emitters in the electricity power sector, were selected to find optimum solutions for reducing SO_2 emissions taking into account the consideration to abatement, investment and total costs. The result of the model indicated that Mexican Electric Power Sector SO_2 emissions could be reduced by investing 841 million US dollars. In other words, reduction in high amount of SO_2 emissions in the Mexico electricity sector could be attained by relatively small efforts [25].

One of the studies is associated with the Taiwan's energy system [26]. The survey implemented LEAP to simulate alternative energy strategy, policies for Taiwan. Energy demand and supply, and GHG emissions were examined by applying different scenarios. The scenarios are business-as-usual, aggressive energy efficiency improvement policies and three existing nuclear power plants retirement. Each scenario was analyzed under low economic growth assumptions. At the last stage, new energy strategies were developed considering climate change. Business-as-usual (assuming current trends and government plans), GOV (enhancing energy efficiency by over 2% annually through 2025), FIN (a sensitivity case assuming the financial tsunami's far reaching negative effects on economic growth), RET (assuming that the existing three nuclear power plants are retired), and ALL (three cases combined) were the scenarios. The RET had a negative impact on the energy supply side and overall CO_2 emission originated from power plants were increased as a consequence of retirement of three nuclear power plants. Aggressive energy efficiency scenario was chosen as the best scenario, although economic growth was decreasing [26].

Another study was conducted within the Venezuelan power generation sector [27]. The aim of the study was to achieve a sustainable electricity sector by 2050. The total energy generation costs and GHG emissions of four scenarios in 2050 were estimated and examined with respect to high and low energy demand situations. The

scenarios' were business-as-usual, renewable energy and without the use of nuclear and Carbon Capture and Storage (CCS) technologies. The outcome of the survey indicated that Venezuela has sufficient resources to attain sustainability in the electricity sector, although major electricity generation resources depend on fossil fuel use. In addition to all, energy efficiency was the easiest way to reduce GHG emissions released during the electricity generation [27].

The first study [28] focused on Turkish electricity sector using LEAP was published in 2013. The aim of the study is to estimate Turkey's CO_2 reduction potential for the Turkish electricity sector, both for public and private sectors. The forecasting period was between 2006 and 2030. Two scenarios were formed: Business-as-usual and mitigation scenario. Only CO_2 emissions were considered in this study.

GDP in 1998 prices and TURKSTAT population predictions were used in the model by the 2025. The last five year estimation was done by the authors. Although the GDP and population data were included in the model, TETC 10 year electricity generation capacity projections were used in the demand estimations. Therefore, the electricity demand growth was taken approximately as 7%. The electricity demand growth of agriculture and transportation was kept stable. In addition, residential demand and services demand were predicted separately [28].

Carbon emission factors were estimated by hand calculations, although LEAP includes the IPCC carbon emission factors. Due to such computations the margin of error maybe getting larger because the calculated emission factors only represent a small data set and they were not clearly specified in the study. Different from specific carbon emission factors, mitigation scenario covers only "renewable energy except solar". Additionally, nuclear energy was not covered in the model which has a huge impact on GHG emissions and electricity generation output [28].

The outcome of the study is that electricity demand increased 6.6% per annum and parallel to this, CO_2 emissions increased by 5.8% annually. In the mitigation scenario, CO_2 emissions decreased by 18.4% in 2030 compared to the base year [28].

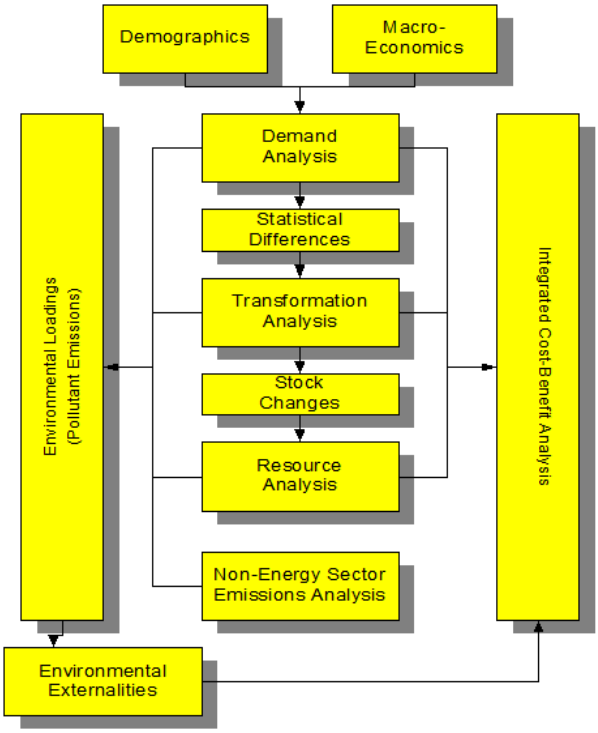
The majority of the literature is focusing on energy and GHG emissions associated with the electricity sector. Each study has only one purpose to: To find an optimum point taking sustainability into account in the electricity sector. Majority of the literature includes renewable energy and energy efficiency scenarios. Nuclear energy scenarios are mostly ignored in the LEAP applications literature, although many countries still have plans for constructing or already operating nuclear power plants.

2.4. Methodology of LEAP

A wide range of modeling technologies can be applied in LEAP. Bottom-up, end-use accounting techniques, and top-down macroeconomic modeling are commonly used ones in the energy demand analysis. On the supply side, accounting and simulation methodologies are powerful enough for modeling of the electricity sector [29].

LEAP operates on two conceptual levels. At one level, non-controversial energy, emissions and cost-benefit accounting calculations are handled by LEAP built-in calculations. In the second level, spreadsheet-like expressions can be entered by users to specify time-varying data or create multi-variable models. By this way, econometric and simulation techniques are applied in one model [29].

The calculation flowchart of the LEAP is shown in Figure 2. ***Macroeconomic*** data and demographic data are the initial points of the model. GDP and income per capita are examples for macroeconomic data. The population and urban/rural ratio are the basis of ***Demographic*** data in LEAP [29].

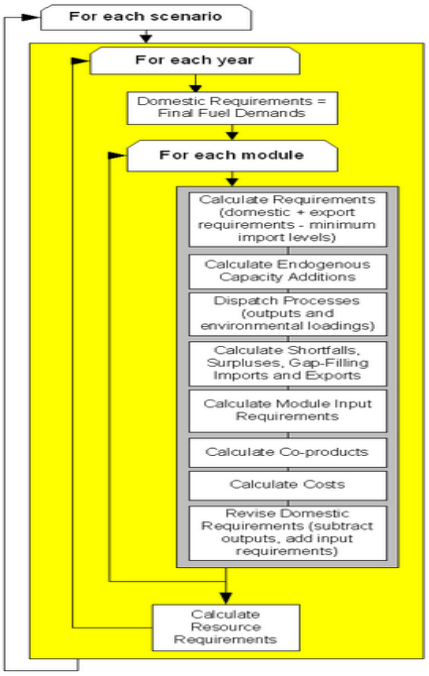


Source: LEAP User Guide for Version, 2011 [29]

Figure 2 LEAP structure and calculation flows

Demand analysis is conducted by LEAP after the macroeconomic variables are input. In the demand branch, fuel usage of each sector can be entered. Activity level and final energy intensities can be calculated by using different formulas. In addition to all, price and income elasticities can be inserted under this branch. Each sub sector energy demand is calculated in this step [29].

Electricity generation, transmission and distribution losses of the system are placed under the ***Transformation Analysis***. Technical parameters such as lifetime, efficiency and cost values of power plants are entered. As demonstrated in Figure 3, the analysis begins with calculating requirement of the electricity with respect to dispatch processes. According to the dispatch process of the model, the software calculates the net electricity generation for each year and environmental loadings of the processes. The cost calculations are done after the completion of the electricity generation and environmental loading calculations. For each module, such as natural gas, hard coal, solar, etc., these steps are repeated and for each year, this flow chart is applied [29].



Source: LEAP User Guide for Version, 2011 [29]

Figure 3 Flowchart of transformation branch

In our study, the endogenous capacity of the system, imports and exports targets of electricity and module inputs are not defined in the system because the study boundary does not cover the entire Turkish electricity system.

Returning to the general flowchart of the system, shown in Figure 2, ***Resource Analysis*** component covers the imports and exports of the resources and indigenous fuel cost (generally fuel cost). The potential resources of a country are classified as primary and secondary sources in this analysis [29].

Environmental Loadings (Pollutant Emissions) are estimated for each branch like in the transformation analysis. GHG emissions calculation in LEAP is set to *IPCC Tier 1* module [29]. The emission factors of the LEAP are taken from the 1996 IPCC Guidelines for National Greenhouse Gas Inventories [30]. The results of each scenario are demonstrated in the Result view of LEAP.

Environmental Externalities component is defined under the Effect branch of LEAP. *Only the limits of GHG emissions and their costs with respect to years can be defined in this branch.* If the costs of the emissions are defined, they are added to Net Present Value (NPV) and social cost analysis, named as environmental externalities [29]. Environmental externalities do not cover any costs of environmental damage or life cycle assessment for the defined power plants such as damage costs of nuclear waste after disposal to the environment.

The social costs of each scenario and NPV calculation results are represented in ***Integrated Cost-Benefit Analysis.*** We preferred to use to the *levelized cost of electricity methodology (LCOE)* for social cost analysis [29]. The costs of different power plants (such as capital, operating, maintenance, carbon prices) can be compared by LCOE methodology as a description of a constant unit price ($/ MWh) [31]. Social cost, calculated by LCOE, in the LEAP, refers to project costs, environmental externalities (pollutant costs) and resource costs (fuel costs).

Good forecasting performance in LEAP depends on choosing the correct functions for each module and constructing a realistic baseline. The baseline of the model will be explained in following Chapter. We next continue with functions used in this study.

LEAP includes over one hundred functions and they are categorized with respect to their applications.

- Modeling Functions: Interp, Step, Growth, Remainder etc.
- Standard Mathematical Functions: Log, Ln, Sqrt, etc.
- Logical Functions: If, Lessthan, Equal. etc
- Statistical Functions: Mean, Median, RSquared etc.
- Financial Function: PaymentPeriod, InterestRate, AnnualizedCost etc.
- Fuel Properties: It includes the properties of the fuels at the current branch such as carbon content, density, energy Content etc.
- Constants: It defines standard constant values such as molecular weight of different chemical compounds [29].

The functions in LEAP are manually written by using "Expression Builder". The functions, formulas are also defined under the module of the Expression Builder in LEAP. The expressions of each module and formulas are given in Appendix F and the functions used in LEAP are demonstrated in Table 2.

Table 2 Functions used in our model

Type of Expression	Description	Example Syntax
Growth Rate	"It calculates exponential growth over time from a base year value."	Growth (3.2%)
Interpolation	"It calculates the straight-line change between specified pairs of data years and values. Notice that the value parameters in this function can themselves be specified as mathematical functions."	Interp(2000, 40, 2010, 65, 2020, 80)
Step	"It calculates discrete changes between specified pairs of data years and values."	Step(2000, 300, 2005, 500, 2020, 700)
Remainder	"It calculates the remaining value in one branch by subtracting the values of all other neighboring branches from the function parameter."	Remainder(100)
LinForecast	"It forecasts future values based on a linear regression (y= mx+c) of historical data. Regression is not forced through base year value."	LinForecast(Year1,Value1,.., YearN,ValueN)
LinData Trend	"It uses a linear regression (y=mx+c) to fill-in gaps in historical data, but uses actual data values for those years where they are available. Future values are extrapolated using the linear regression."	LinDataTrend(Year1,Value1 ,...,YearN, ValueN)
Logistic Forecast	"Logistic forecasting is used to estimate future values based on a time series of historical data. The new values are predicted using an approximate fit of a logistic function by linear regression. Where the **Y** terms correspond to the *variable to be forecast* and the **X** term is year. ***A, B, a, b are constants*** and e is the base of the natural logarithm (2.718)"	$Y = A + \frac{B-A}{1+ e^{(a*X+b)}}$
Historical Growth	"It calculates the annual average historical growth rate for the current branch/variable or other referenced branch/variable. When no parameters are supplied, the function returns the annual average historical growth rate between the base year and the year before the first scenario year."	HistoricalGrowth

Source: LEAP User Guide for Version, 2011 [29]

CHAPTER 3

DEVELOPMENT OF LONG-TERM ENERGY SCENARIOS FOR TURKISH PUBLIC ELECTRICITY SECTOR

3.1. Development of the energy scenarios

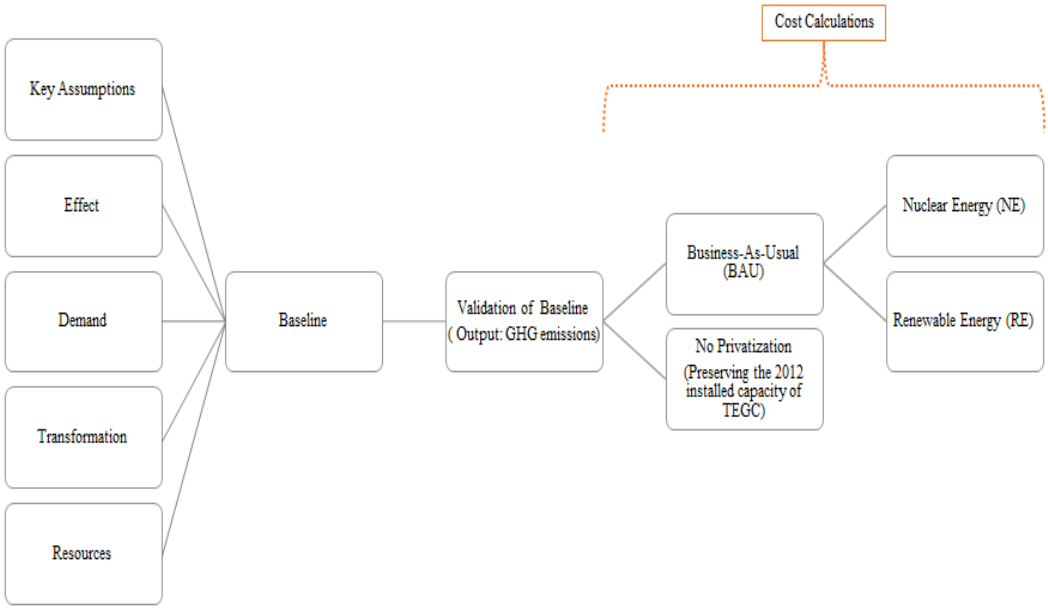
The previous studies of LEAP focus on the decreasing of GHG emissions, improving energy efficiency and increasing the share of renewable energy sources in the energy portfolios. As explained in Chapter 2, these studies have one aim that is achieving the sustainability in the electricity sector. In this study, we followed a different way in the scenario development phase compared to previous studies. The flow chart of the scenarios is demonstrated in Figure 4.

The baseline of the model was formed according to the user guide of LEAP. After this step, it was validated for error debugging and for checking the accuracy of reference data sources. In the validation step, the GHG emissions outputs of the baseline and real data taken from EGC, from 2001 to 2010, were compared to see the error range of our model.

The energy scenarios are developed considering the current situation of the Turkish public electricity sector. This sector is still under privatization process which is the reference point of the research questions in this study. The research questions are:

- Is privatization the only solution for decarbonization? What are the benefits and costs of privatization for the Turkish public electricity sector?
- How does the Turkish government reach the best sustainable energy portfolio after the privatization?

To answer these questions, at first, it is necessary to examine the impacts of privatization on the Turkish public electricity sector. Thus, two main scenarios are created: ***No Privatization (NP) and Business-As-Usual (BAU).***



Source: The figure was drawn by the author

Figure 4 Flow chart of the scenario development

NP scenario is established to foresee what happens *if the privatization is stopped.* The last data in the baseline of the model is the 2012. Therefore, the Turkish electricity system is preserved according to the 2012 installed capacity in electricity generation, i.e., there are no additional or retired power plants in this scenario.

BAU scenario is based on the privatization of the Turkish electricity system. *The*

privatization of the generation sector is taken to be completed by 2020. In this scenario, only Sinop nuclear power plant is added to the installed capacity by 2020. *There are no additional power plants except Sinop nuclear power plant under this scenario.*

The first part of the study, from 2013 to 2020, covers the privatization process of the public electricity generation sector. After the completion of privatization process we extend our projections for the Turkish public electricity sector to 2050. Under this first part, electricity generation, GHG emissions and costs and benefits of privatization are analyzed.

The second part of this study is related to the sustainability of the electricity system. The main purpose is to analyze and compare two alternative scenarios. In this part, Nuclear Energy (NE) and Renewable Energy (RE) scenarios are considered for the decarbonization of the public electricity system. The time period covered is between 2020 and 2050.

NE scenario is based on *two additional nuclear power plants planned to be constructed in Turkey other than Akkuyu and Sinop nuclear power plants.* The third and fourth nuclear power plants installed capacities are assumed to be same as Sinop nuclear power plants 4480 MW.

RE scenario is created as an alternative scenario. *13050 MW installed capacity of renewable energy power plants (geothermal, solar and wind) is added to the system step by step from 2030 to 2050.*

The other alternative scenarios such as rehabilitation of the power plants scenario were not covered in this study because rehabilitation of specified power plants vary with respect to plant types and features in their rehabilitation processes. Besides, LEAP does not allow separate examination of a specified power plant separately, such as Atatürk hydroelectric power plant rehabilitation or improving the efficiency in its process.

To sum up, this study is composed of two parts. In the first part, we analyze the privatization impacts on the system. The second part of the study focuses on adopting sustainable energy portfolio for the Turkish public electricity sector. Next, the model setup and detailed scenario descriptions will be explained.

3.2. Building the baseline of the model

Forming the baseline data requires the identification of the parameters, classification of each branch and raw data and developing expressions of the functions. The establishment of the baseline begins with identification of the branches of the model. In this study, Key Assumptions, Effect, Demand, Transformation and Resources are the main branches of the model.

a. Key assumptions

Energy intensity, GDP Market Exchange Rate (MER), value added of sectors (agriculture, industry, services and manufacturing), population and transportation are the basic indicators included in the model [29]. Data of these parameters are explained in Appendix A.

b. Effect

The annual emission constraints and their environmental externality cost are described in this branch. In this study, within the Effect branch, the 100 Year Global Warming Potential (GWP) values were updated with regard to the IPCC Fourth Assessment Report [2], as demonstrated in Table 3. All GHG emissions were defined and calculated as CO_2 equivalent.

Table 3 Direct global warming potential values

Effect	Abbreviation	GWP (100 yr)
Carbon Dioxide Non Biogenic	CO_2	1
Methane	CH_4	25
Nitrous Oxide	N_2O	298

Source: IPCC 4th Assessment Report: Climate Change 2007[2] (Working Group I: The Physical Science Basis, Chapter 2, Direct Global Warming Potentials)

c. Demand

Demand is the centerpiece of the energy model because the generation amount of electricity has to meet the demand. *The residential and services, agriculture and industrial energy usage, transportation, non-energy usage and bunker fuel* were components of the demand branch. The classification of the data and fuel share of the mentioned components were specified by using the General Energy Balances 2001-2012 taken from the World Energy Council (WEC) Turkish National Committee [32] and MENR [33], given in Appendix B.

d. Transformation

Electricity generation and transmission and distribution (T&D) are the sub branches under the transformation branch where the core of our study lies. The important notes for the transformation branch are given below:

- Planning reserve margin was set to the default value in the LEAP, which is 30%.
- Maximum availability, process efficiencies and cost variables were calculated by using a sample data set.
- A 10 % discount rate and a 5% interest rate were taken in the cost calculations.
- The last five years' data were used in the cost calculations. In other words,

before the 2008 values were assumed to be same because there were no accurate past data for the capital and operation and maintenance (O&M) costs.

- The fuel cost was not included in the O&M costs for avoiding double counting in the Net Present Value (NPV) calculation.
- Fixed O&M cost were taken from sample data that included labor costs and personnel expenditure costs.
- The variable cost included material cost, services cost, other cost, taxes and depreciation cost.
- Salvage values and decommissioning costs were not included.

Electricity generation

EGC and affiliated partnerships of EGC are covered in this study because the power plants of EGC affiliated partnerships have been operated independently from EGC although they are included in total installed capacity of EGC represented in Blue Book 2013 (Mavi Kitap 2013) [35].

Process efficiency, maximum availability, merit orders of the power plants, system peak load shape and installed capacity are commonly known examples of technical parameters. We selected power plants due to existing raw data and grouped them according to their fuel types. 14 thermal and 22 hydroelectric power plants were included in the sample data set, listed in Table 4. The majority of raw data were taken from the Eltem-Tek Database [34]. The detailed technical parameters of the selected power plant types are given in Appendix C.

Table 4 Selected power plants and their physical features

Power Plant Name	Fuel Type	Capacity (MW)
Çatalağzı	Hard Coal	300
Afşin-Elbistan B	Lignite	1440
Afşin-Elbistan A	Lignite	1355
Çan	Lignite	320
Tunçbilek	Lignite	365
Orhaneli	Lignite	210
Kemerköy	Lignite	630
Yatağan	Lignite	630
Yeniköy	Lignite	420
Soma A-B	Lignite	990
Ambarlı Doğal Gaz	Natural Gas	1350.9
Aliağa Doğal Gaz	Natural Gas	180
Bursa Doğal Gaz	Natural Gas	1432
Ambarlı Fuel Oil	Fuel Oil	1130
Adıgüzel	Hydraulic	62
Almus	Hydraulic	27
Altınkaya	Hydraulic	702.55
Aslantaş	Hydraulic	138
Çatalan	Hydraulic	168.9
Demirköprü	Hydraulic	69
Derbent	Hydraulic	56.4
Doğankent	Hydraulic	74.5
Gezende	Hydraulic	159.38
Gökçekaya	Hydraulic	278.4
Hasan Uğurlu	Hydraulic	500
Hirfanlı	Hydraulic	128
Kapulukaya	Hydraulic	54
Karacaören-1	Hydraulic	32
Kemer	Hydraulic	48
Kesikköprü	Hydraulic	76
Kılıçkaya	Hydraulic	120
Köklüce	Hydraulic	90
Menzelet	Hydraulic	124
Sarıyar	Hydraulic	160
Suat Uğurlu	Hydraulic	69
Tortum	Hydraulic	26.2

Source: Eltem-Tek Database [34]. The table was drawn by the author.

Transmission and distribution losses

LEAP cannot separate transmission and distribution losses branch. Thus, historical data of the total network electricity losses were inserted and are shown in Table 5. Labour costs, material costs, various expenditures, taxes and amortization costs were taken into account during the cost calculations.

Table 5 Transmission and distribution losses in the Turkish electricity system

Losses	Transmission (%)	Distribution (%)	Total Network (%)
2001	2.8	16.5	19.3
2002	2.7	16.1	18.8
2003	2.4	15.2	17.6
2004	2.4	13.6	16.0
2005	2.4	13.0	15.4
2006	2.7	11.3	14.0
2007	2.5	12.0	14.5
2008	2.3	12.1	14.4
2009	2.1	13.3	15.5
2010	2.8	12.0	14.8
2011	1.9	12.7	14.6
2012	2.6	12.7	15.3

Source: TETC [8] (Indicator: Annual Development of Electricity Generation, Consumption and Losses in Turkey (1984-2012), page 34)

e. Resources

Fuel types defined in the process of each module are automatically arranged and replaced under primary and secondary resources. The import and export of resources, base year reserves, additions to reserves, and annual yield for renewable resources are placed under the Resource branch. The base year reserves and annual yields were taken from MENR Blue Book between 2008 and 2012 [36].

The fuel prices defined in the electricity generation branch were entered from 2008 to 2012. The average prices of fuels, except hard coal, were taken from the IEA report [37]. All prices, entered as indigenous costs, include the taxes.

The hard coal price was calculated externally by the author. The sample data set was used to determine the hard coal price because Çatalağzı is the only hard coal power plant in EGC portfolio. The hard coal price estimations are given in Appendix D and the monthly raw data was sourced from Eltem-Tek database.

3.3. Validation of the baseline: Comparison of GHG emissions

The long-term forecasting or simulation draws a picture to help during the decision making stages. During forecasting or simulation, we have to make various assumptions at certain levels to proceed. This creates some errors at the forecasting phase. In this study, we need to check the baseline for error debugging and for checking the accuracy of reference data sources.

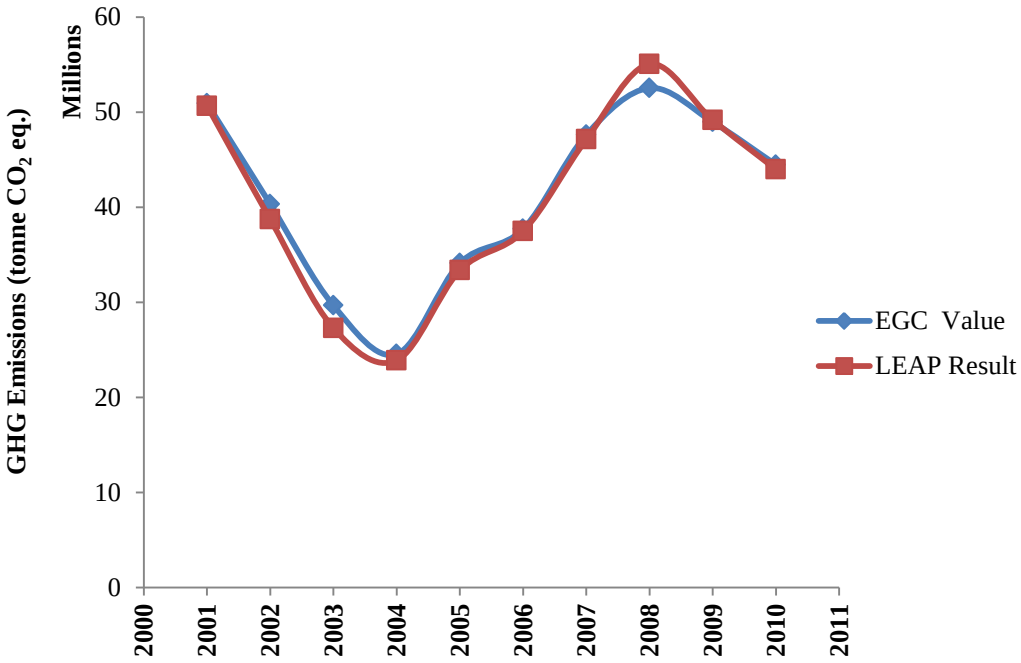
The validation of the baseline is done via comparison of LEAP GHG emissions outputs and the actual GHG emissions ***in the electricity generation***. GHG emissions data from 2001 to 2010, compiled by EGC, were compared with LEAP baseline data results. The conversion of their units to CO_2 eq. was done by multiplying the emission values with GWP values of the emissions. Fuel oil and diesel usage are covered in natural gas values. Conversion of the EGC values to CO_2 equivalent of hard coal, lignite and natural gas are given in Appendix E.

The examination of the comparison results is given in Table 6. The trends of real values and LEAP results of our model are demonstrated in Figure 5. According to the examination results, the error was found to be under ± 5%, except for 2003. This proves that the data inserted in LEAP proximate the reality. Figure 5 shows how closely the model output follows actual emissions. With a solid baseline in the model, the error margin for the future projections will be minimized.

Table 6 Comparison GHG emission of EGC and LEAP

	EGC Value (tCO_2 eq.)	LEAP Result (tCO_2 eq.)	Difference (tCO_2 eq.)	Difference over EGC GHG Value (%)
2001	50,928,606.00	50,661,048.54	267,557.46	0.53
2002	40,321,160.00	38,720,213.34	1,600,946.66	3.97
2003	29,658,411.00	27,276,966.05	2,381,444.95	**8.03**
2004	24,545,669.00	23,883,502.70	662,166.30	2.70
2005	34,115,384.00	33,363,022.49	752,361.51	2.21
2006	37,705,545.00	37,470,311.45	235,233.55	0.62
2007	47,618,920.00	47,135,312.08	483,607.92	1.02
2008	52,528,041.00	55,053,772.29	-2,525,731.29	-4.81
2009	48,959,321.00	49,165,106.42	-205,785.42	-0.42
2010	44,461,546.00	43,970,317.46	491,228.54	1.10

Source: All calculations are done by the author.



Source: The figure was drawn by the author

Figure 5 GHG emissions comparison

3.4. Descriptions of the scenarios

Before describing the scenarios, few issues within the forecasting phase have to be clarified. Firstly, our model scope does not cover the future projections of population and GDP MER. Thus, the projections of well-known institutions were used. The projections of population and GDP MER are given in Table 7 and 8.

Table 7 Population estimations in BAU scenario

	Unit	2015	2020	2025	2030	2035	2040	2045	2050
Population	**Million People**	76.69	80.31	83.71	86.83	89.54	91.78	93.47	94.61

Source: UN Secretariat, World Populations Prospects: The 2012 Revision [39].

Table 8 Real GDP growth rates in BAU scenario

	Unit	2012-2017	2018-2030	2031-2050
Growth Rate (Annual Averages)	**%**	5.2	4.1	2.3

Source: OECD Economic Outlook, Volume 2012/1, Chapter 4, page 200 [40].

Another issue that has to be clarified is the methodologies used in this study. Forecasting methodologies change in every phase of the model. For the GHG emission calculations, IPCC Tier 1 method was applied. On the other hand, LCOE methodology was used in the social cost calculations.

Apart from these, simple formulas, such as for the calculation of the final energy intensity, were inserted during the development phase of the baseline. For instance, linear regression was preferred in demand estimation and fuel price forecasting. The related expressions and functions are clarified in Appendix F for distinguishing the methodologies for each phase.

After clarifying these issues, the scenarios will be explained in an order shown in the flow chart in Figure 4. The description of scenarios starts with the NP scenario is the baseline for two other scenarios.

a. No Privatization (NP) scenario

Overview

This scenario reflects the 2012 situation of the Turkish public electricity sector. The installed capacity of the power generation sector is fixed to the 2012 values, i.e., there is no addition/retired power plants till 2050. NP scenario is a baseline for the other two scenarios. The privatization cost or benefits can be seen clearly and compared to other scenarios by NP scenario.

Assumptions

- The 2012 total installed capacity of public electricity generation was kept as is.
- Total T&D losses were decreased to 8 % in 2023 [41].
- The annual CO_2 emission constraint was taken to be 10% lower in the 2010 CO_2 emissions of the electricity generation sector. The limit of emitting CO_2 for the power plants was 40 million metric tonnes in the 2020, which is fixed till 2050.
- The carbon market was assumed to be operational by 2020 and carbon prices [42] were fixed to 20 US dollar/tCO_2 .

b. Business-As-Usual (BAU) scenario

Overview

BAU scenario reflects the current trends in the Turkish public electricity sector. Previously, we emphasized that this sector still has been under privatization. Therefore, the privatization schedule was arranged according to Republic of Turkey Prime Ministry Privatization Administration special portfolio groups [43], which have been specified in Appendix G.

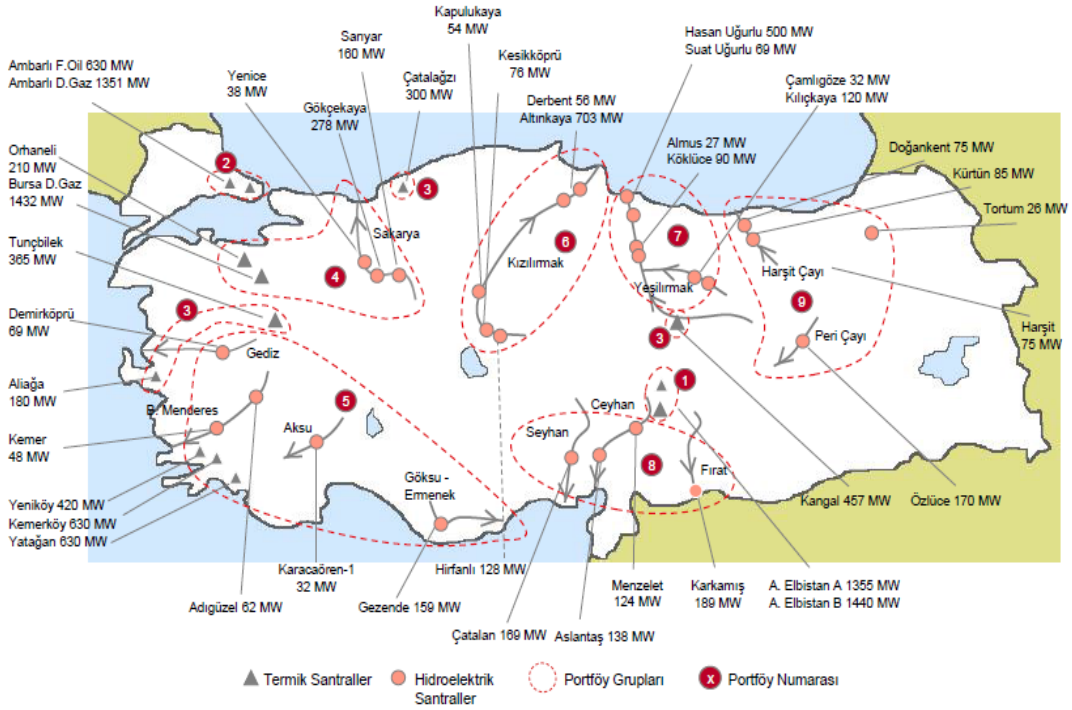
Assumptions

- The privatization was assumed to be finished by 2020 which constituted the first part of this study.
- Total T&D losses were decreased to 8 % in 2023 [41].
- Sinop nuclear power plant has four units and each of them is 1120 MW. The first unit is assumed to be operational in 2020, and then the power plant will work at full capacity after 2023 [44]. The change in the total installed capacity of EGC is given in Table 9.
- Akkuyu nuclear power plant was not covered in our model because construction and operations rights are given to Russian companies, i.e., it will be operated by the private sector.
- Nuclear waste disposal cost was taken as 0.22 TL/kWh [45]. The currency ratio Turkish Lira over US dollar was decided to be 0.46.

Table 9 Changes in total installed capacity of EGC, 2012-2023

Year	Unit	Cumulative Installed Capacity
2012	**MW**	24,775
2013	**MW**	22,499
2014	**MW**	22,499
2015	**MW**	20,283
2016	**MW**	15,134
2017	**MW**	12,135
2018	**MW**	10,830
2019	**MW**	8,315
2020	**MW**	8,958
2021	**MW**	10,078
2022	**MW**	11,198
2023	**MW**	12,318

Source: LEAP EGC. The table was prepared by the author.



Source: ICCI International Energy & Environment Fair and Conference, 2012, Republic of Turkey Prime Ministry Privatization Administration Presentation [43].

Figure 6 Privatization portfolio groups

c. Nuclear Energy (NE) scenario

Overview

The government is planning to use nuclear power plants as a base instead of natural gas combined power plants. Therefore, establishment of Akkuyu and Sinop nuclear power plant works are accelerated by the government. In addition, constructions of the third and fourth nuclear power plant were added to the agenda of the MENR [46]. The aim of this scenario is to foresee what the government gains or losses if they proceed with the third and fourth nuclear power plants in Turkey.

Assumptions

- Total T&D losses were decreased to 8 % in 2023 [41].
- Construction of the third nuclear power plant is expected to start in 2030 [46].

The usual construction time for a nuclear power plant is 7 years [47]. This period covers surveys, expropriation, license, construction and many other procedure time schedules that have to be taken before starting to operate. Hence, the first unit of nuclear power plant will be started to operate in 2037. In 2040, the third nuclear power plant will start operating at full capacity.

- Fourth nuclear power plant construction period was assumed to start in 2038 before the third nuclear power plants' last two units are connected to the national grid system. By this way, the first unit of fourth nuclear power plant will be operational in 2045 and fourth nuclear power plant will be operational at full capacity in 2048.
- The installed capacities of the third and fourth nuclear power plants were assumed to be the same as Sinop nuclear power plant capacity, which is 4480 MW. The capacity additions of the nuclear power plants are detailed in Table 10.
- The operation rights of the three nuclear power plants are given to EGC.
- Nuclear waste disposal cost was taken as 0.22 TL/kWh [45]. The currency ratio Turkish Lira over US dollar was decided to be 0.46.

Table 10 Installed capacity addition in NE scenario

Year	**Unit**	**Cumulative Installed Capacity**
Sinop Nuclear Power Plant		
2020	**MW**	1120
2021	**MW**	2240
2022	**MW**	3360
2023	**MW**	4480
Third Nuclear Power Plant		
2037	**MW**	5600
2038	**MW**	6720
2039	**MW**	7840
2040	**MW**	8960
Fourth Nuclear Power Plant		
2045	**MW**	10080
2046	**MW**	11200
2047	**MW**	12320
2048	**MW**	13440

Source: The table was prepared by the author.

d. Renewable Energy (RE) scenario

Overview

RE scenario was developed as an alternative scenario to the NE scenario. The purpose of this scenario is to see what will happen if renewable energy power plants (except hydroelectric power plants) are constructed instead of third and fourth nuclear power plants. The expansion of renewable energy usage into diversified sources will have positive impact on energy security. Therefore, we designed this scenario by using geothermal, wind and solar energy for improving the energy portfolio of EGC. The capacity of renewable energy rose to 13050 MW, as listed in Table 11. Solar and wind power plants brought to the fore because their construction period is shorter than geothermal and O&M cost is approximately 2% lower.

Assumptions

- Total T&D losses were decreased to 8 % in 2023 [41].
- Nuclear waste disposal cost was taken as 0.22 TL/kWh [45]. The exchange rate of US dollar over Turkish Lira was taken to be 0.46.
- Geothermal power plants installed capacity was raised to 450 MW, which is close to total potential capacity of 600 MW in Turkey.
- The solar power plants' installed capacity was taken to be 3000 MW in 2050.
- Wind power plants' installed capacity was enlarged to 9600 MW by 2050, i.e., 20% of the total potential capacity.
- The renewable power plants are assumed to be operated in 2030. The reasons are:
    - Carbon market, which is planned to start in 2020, will push the energy market to invest in renewable energy.
    - The investment required for the renewable energy might be decreased by manufacturing their mechanical and electrical equipment's in domestic markets.
    - Akkuyu and Sinop nuclear power plants will be planned to operate in

full capacity after 2023. The transitions from natural gas to nuclear energy needs a long time period. It is expected that this transition will overload the national grid system. Therefore, the government may not want to invest in renewable energy sources until the 2030 as a precaution.

- The most important thing is that the electricity transmission system of Turkey needs to be improved with new technologies to prevent overloading of the system.

Table 11 Installed capacity addition in RE scenario

Year	Unit	Cumulative Installed Capacity
Geothermal		
2030	**MW**	150
2035	**MW**	300
2040	**MW**	450
Solar		
2030	**MW**	1000
2035	**MW**	2000
2040	**MW**	3000
Wind		
2030	**MW**	3000
2035	**MW**	6000
2040	**MW**	9000
2045	**MW**	9600

Source: The table was prepared by the author

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1. Electricity consumption

The electricity consumption is associated with population and GDP dynamics. The increase or decrease in these variables impacts the consumption. In this study, the population values between 2015 and 2050 were taken from UNDP projections [39] and growth rates of GDP MER for specific time periods were taken from OECD [40]. The annual average growth rate between 2013 and 2050 for population and GDP MER are estimated to be 0.60% and 3.20 % respectively.

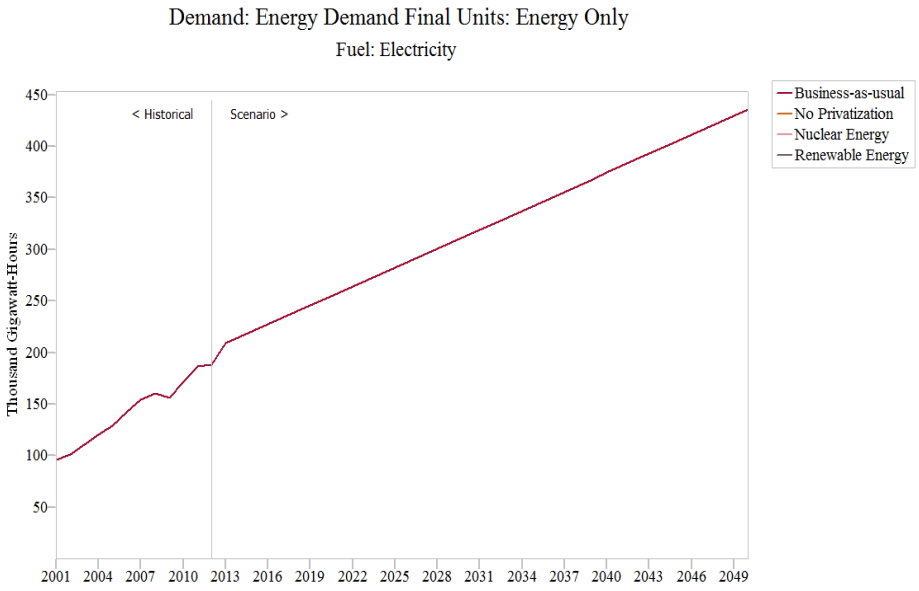
Our model demonstrates that the annual growth rate of total electricity consumption in Turkey between 2013 and 2050 will be 2.01%, which is really low compared to TETC estimations [48], around 7% till 2021. Total electricity consumption reaches 435.63 TWh in 2050 as seen in Figure 7.

Analysis of the sectorial electricity consumption is demonstrated in Figure 8. The detailed examination shows that the share of residential and services sectors' electricity consumption share will be larger than the share of industry sector in 2050.

Table 12 Changes in percentages of sectorial electricity consumptions

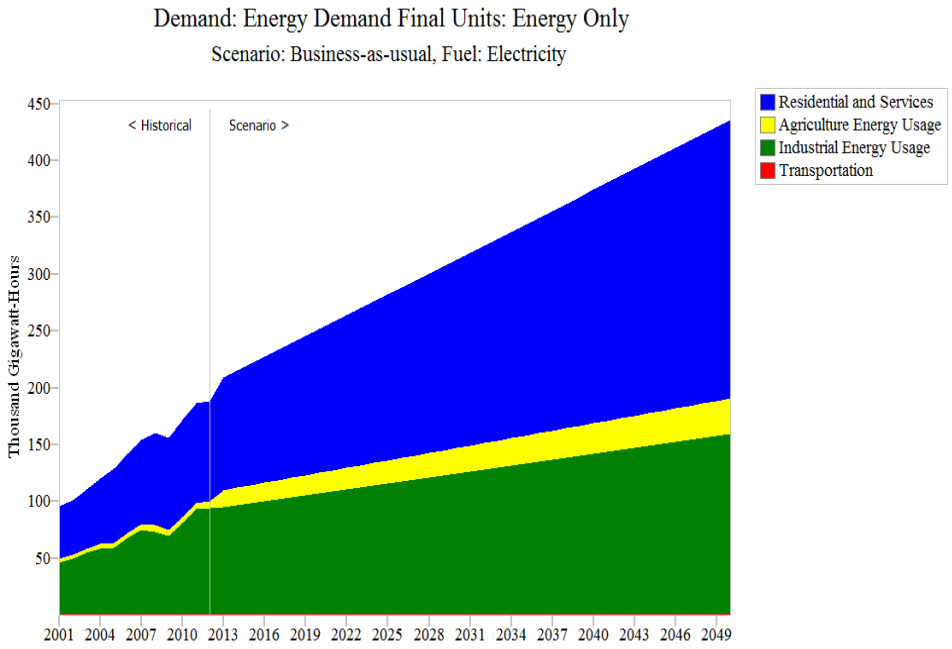
Shares as percentages (%)	**2012**	**2050**
Residential and Services	47.04	56.23
Agriculture Energy Usage	3.15	7.16
Industrial Energy Usage	49.54	36.37
Transportation	0.28	0.24

Source: Our model



Source: Our model

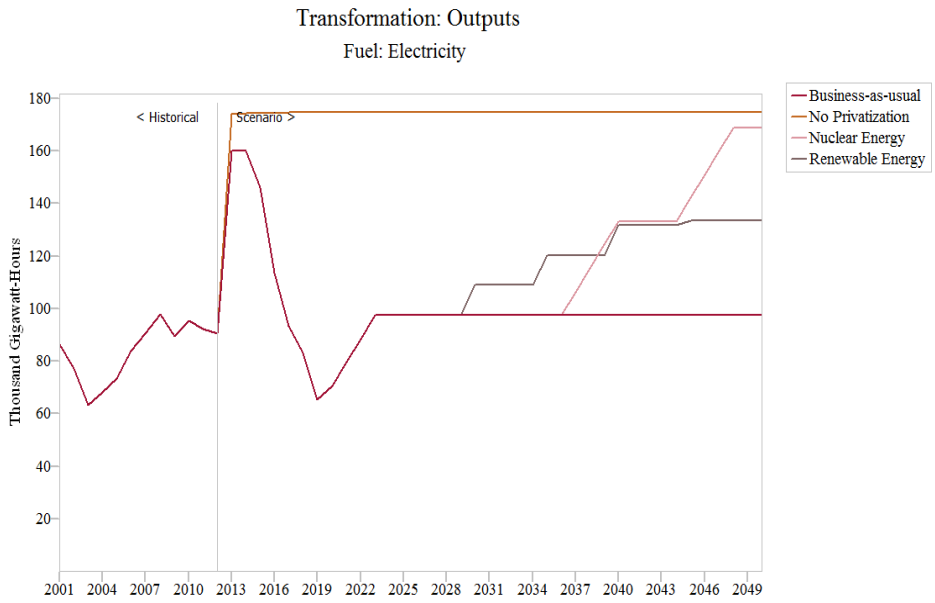
Figure 7 Future total electricity consumptions



Source: Our model

Figure 8 Sectorial electricity consumptions

4.2. Energy generation



Source: Our model

Figure 9 Electricity generation of defined scenarios

No Privatization (NP) scenario reflects the 2012 profile of EGC. The electricity generation in 2012 is estimated as 90.58 TWh. Parallel to increase in the electricity demand, the system forced power plants to work full capacity without interruptions. Therefore, electricity generation rises to 173.86 TWh in 2013 and to 174.63 TWh in 2050.

The 2012 electricity generation is 90.58 TWh in ***Business-as-usual (BAU) scenario***. This value increases to 159.99 TWh according to electricity consumption increase. By implementation of the privatization plan, thermal power plants and some hydroelectric power plants are removed from the EGC portfolio and as a result of this, the electricity generation drops to 65.43 TWh at the end of the 2019. In 2020, the first unit of Sinop nuclear power plant is added to the system. In 2023, where full units of the Sinop nuclear power plant will be operational, the electricity generation rises to 97.44 TWh and it is stable till 2050.

Nuclear Energy (NE) scenario and ***Renewable Energy (RE) scenario*** *are designed over the baseline Business-As-Usual (BAU) scenario. Therefore, up to 2030, the electricity generation amount is the same as BAU scenario*. Then, we focus on the electricity generation after 2030 for NE and RE scenarios because of changes in their portfolios' structure.

Starting 2030, the third and fourth nuclear power plants are added to the portfolio in the ***Nuclear Energy (NE) scenario.*** The first unit of third nuclear power plant will be operational in 2037. The other three units are added to the system year after year, i.e., each year 1120 MW is added to the system. Thus, there is a sharp increase between 2037 and 2040. The electricity generation of NE scenario, where only the third nuclear power plant is added to the system, reaches 133.15 TWh. Five years later, the fourth nuclear power plant is entered into the system applying a similar procedure to the third one. After all units of fourth nuclear power plants become operational, the electricity generation is increased to 168.87 TWh. In conclusion, *we found that a nuclear power plant which has the same characteristic features similar to Sinop nuclear power plant can increase the electricity generation by around 35 TWh. This is a really considerable amount for the Turkish public electricity sector.* In addition, the NE scenario can catch the total electricity generation of NP. *The electricity generation difference of NP and NE scenario is approximately 5 TWh in 2050.*

Renewable Energy (RE) scenario is created as an alternative to the NE scenario. The electricity generation of the RE scenario in 2050 reaches 133.40 TWh and it is lower than the NE scenario. However, between 2030 and 2040, the electricity generation of RE scenario approximates the third nuclear power plant generation amount. The difference between these years is nearly 2 TWh.

The electricity generation trends of four scenarios are explained and their shares in meeting the electricity consumption in 2050 are listed in Table 13. *The share of EGC electricity generation in 2012 is 48.06%*. In none of the scenarios EGC reaches the same electricity generations share in 2012 even if all power plants are overworked.

Table 13 Percentages of the scenarios to meet the electricity consumptions in 2050

Shares as percentages (%)	**2050**
No Privatization	40.09
Business-As-Usual	22.37
Nuclear Energy	38.76
Renewable Energy	30.62

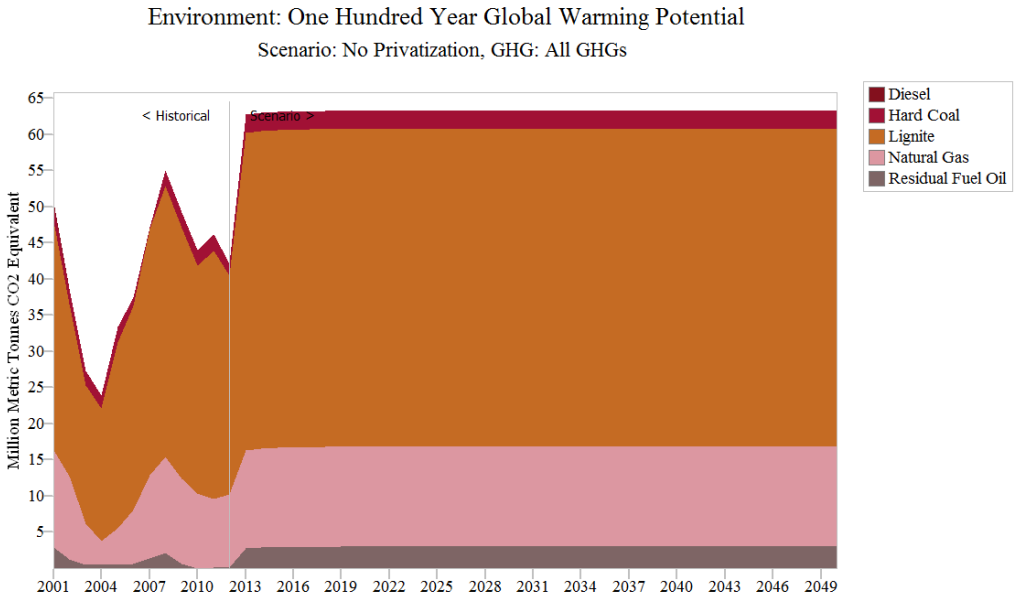
Source: Our model

The sharp increase in the first simulation year, the 2013, is grabbing the attention while analyzing the trends. This sudden increase in this year does happen because of two reasons. The first one is that the power plants in each scenario portfolio are overworked to meet the electricity demand. The second is that power plants, whose electricity generation are highly sensitive to weather conditions, are assumed to work at a maximum capacity, i.e., the weather impacts on hydroelectric, solar and wind power plants are not considered during the forecasting. To analyze the weather impacts, equations, showing the relationship between electricity generation and weather, have to be defined in LEAP during the establishment of the baseline.

4.3. GHG emissions

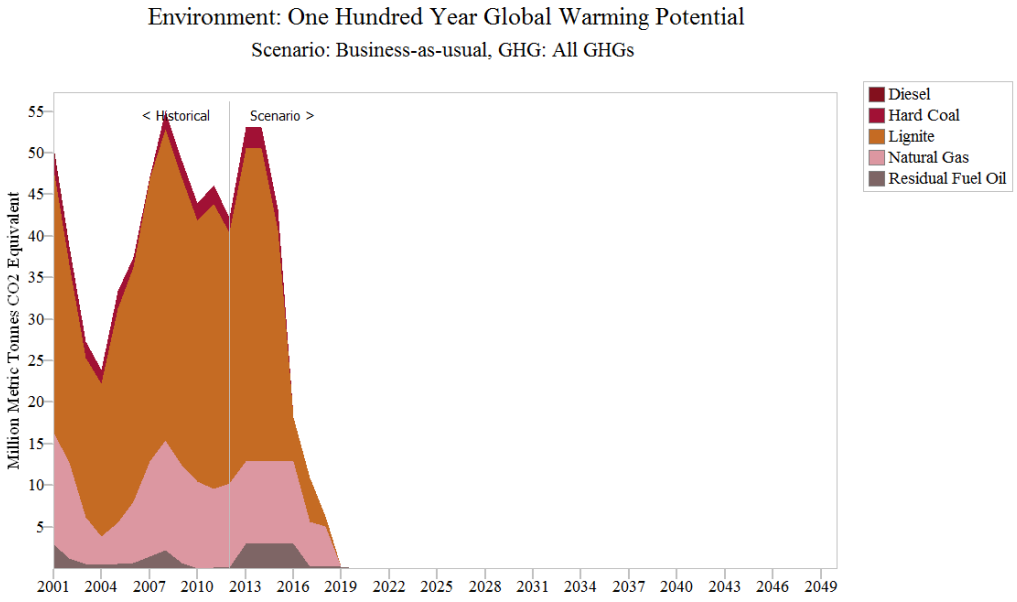
The GHG emissions of the scenarios depend on the energy portfolio. In 2012, the GHG emissions reached 42.15 $MtCO_2$ eq. for all the scenarios. After the 2012, the GHG emissions are increased parallel to electricity generation mix of the scenarios. If the scenario energy portfolio of a scenario includes more thermal power plants, of course, the total GHG emissions will be higher than others. The highest amount of GHG emissions, 63.23 $MtCO_2$ eq., is observed in the ***NP scenario*** whose portfolio includes thermal power plants. On the other hand, ***BAU, NE and RE*** scenarios GHG emissions approximates to zero within the privatization process. The reason is that thermal power plants will be sold out by privatization and the portfolio of BAU, NE and RE includes only carbon free zero power plants such as hydroelectric, nuclear, solar, geothermal and wind. The GHG emission trends of the scenarios are given in Figure 10 and 11. *By privatization in EGC portfolio, 2216.96 $MtCO_2$ eq or 2.22 $GtCO_2$ eq. GHG emissions are saved in BAU, NE and RE scenarios compared to NP*

scenario.



Source: Our model, 100 Year GWP, Transformation Branch

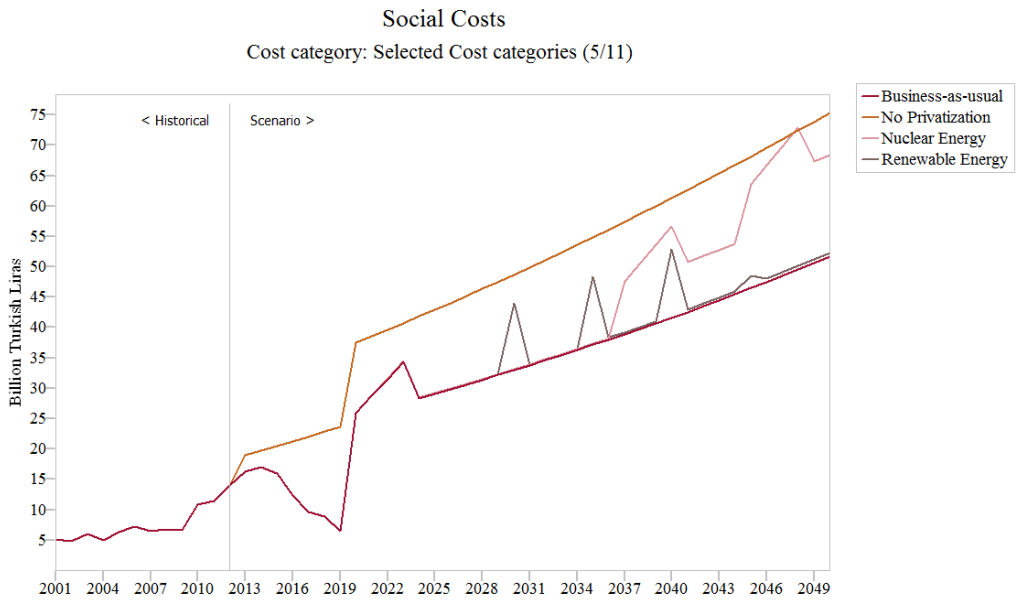
Figure 10 GHG emissions of NP scenario



Source: Our model, 100 Year GWP, Transformation Branch

Figure 11 GHG emissions of BAU, NE and RE scenarios

4.4. Social costs (Projected costs)



Source: Our model

Figure 12 Projected costs of scenarios for public electricity sector

Before examining the scenarios, it is essential to understand that what the exact meaning of the social costs in LEAP is. The social costs in LEAP refer to the projected costs of the scenarios, and LCOE methodology is used in calculations as explained in Chapter 2. The social cost in LEAP covers:

- Investment costs of new power plants
- Operation and maintenance costs (including disposal price of nuclear waste)
- Carbon prices
- Fuel prices (Only resource extraction costs)
- All taxes for each parameter (such as VAT in natural gas price)

Therefore, LEAP examines the project costs and benefits within a specified time period.

Projected nominal costs of the scenarios are shown in Figure 12. The projected costs for all scenarios in 2012 are 13.98 billion Turkish Lira (TL). ***NP scenario*** has the highest projected costs compared to other scenarios. In 2013, in this scenario, costs increase from 13.98 to 19.01 billion TL associated with an increase in the electricity generation. It suddenly moves up to 37.50 billion TL in 2020 with the impact of the carbon prices. The steady increase in the projected costs is due to the increase in the fuel prices, which are estimated by the linear regression method.

On the other hand, we see that the projected costs of other three scenarios are the same till 2030. The reason is that NE and RE scenarios are based on the BAU scenario and their portfolios are rearranged only after 2030.

In ***BAU scenario***, the growth in the projected costs after 2019 increase because the Sinop nuclear power plant is added to its profile. Between 2020 and 2023, it still continues to increase because 1120 MW units of Sinop nuclear power plant are added each year. The installed capacity of Sinop nuclear power plant is 4480 MW. In 2023, BAU scenario projected costs reach 34.38 billion TL and suddenly drops to 28.38 billion TL in 2024.

The pink line in Figure 12 demonstrates ***NE scenario*** projected costs over the years. The same behavior in the BAU scenario where Sinop nuclear power plant is added to system can be seen in the NE scenario. As mentioned in Chapter 3, the third and fourth nuclear power plants are added to the portfolio after 2037. Before the addition of the third nuclear power plant to the system, projected cost of NE scenario is estimated as 38.14 billion TL. The projected costs rise to 56.60 billion TL as the last unit of nuclear power plant is connected to the national electricity grid system and drops thereafter. The same behavior is observed in the fourth nuclear power plant between 2045 and 2049. At the end of the addition of third and fourth nuclear power plants, the projected cost in 2050 of NE scenario as amounts to 68.35 billion TL. One of the highest shares in the projected costs of NE scenario belongs to disposal prices of nuclear waste, which is equal to 36.30% of the total projected costs in 2050.

RE scenario projected costs are represented by the gray line in Figure 12. The gray peaks show where the renewable energy power plants are added to the portfolio. Three new renewable energy power plants are added to the system between 2030 and 2045. The 2050 projected cost of RE scenario reaches 52.24 billion TL, which is smaller than NP and NE scenarios. All the scenarios' projected costs in 2050 are shown in Table 14 and the detailed values are given in Appendix H.

Table 14 Projected costs of the scenarios in 2050

Projected costs (billion TL)	**2050**
No Privatization	75.29
Business-As-Usual	51.72
Nuclear Energy	68.35
Renewable Energy	52.24

Source: Our model

4.5. Selecting the best sustainable scenario

Until now, we examined all the scenarios according to their electricity generation, GHG emissions, and projected costs. To select the best sustainable scenario for the Turkish public electricity sector, the summaries view of the LEAP, where all results are summarized and compared in a table, is used.

Firstly, BAU, NE and RE scenarios are compared to the NP scenario to see what the privatization costs or benefits to the government are. Secondly, we compare the NE and RE scenarios to determine which scenario is more sustainable. Before beginning the examination, we want to clarify some important points in the cumulative costs and benefits: 2001-2050. These are:

- The minus values (-) represent the profits and positive values (+) are the costs.
- Resource represents the fuel costs for the power plants.
- Environmental externalities only cover carbon costs.

- Cost of avoided CO_2 is calculated by NPV over GHG emission savings. It shows how much money it costs the government to decrease 1 tonne CO_2 eq. in that scenario.

Table 15 demonstrates the BAU, NE and RE scenarios profits compared to the NP scenario which gives the answers to the questions for the first part of this study:

"Is privatization the only solution for decarbonization? What are the benefits and costs of privatization for the Turkish public electricity sector?"

Table 15 Cumulative costs and benefits: 2001-2050 compared to NP scenario

Costs (Billion Turkish Lira)	**Business-as-usual (BAU)**	**Nuclear Energy (NE)**	**Renewable Energy (RE)**
Transformation			
Electric Generation	-26.47	-17.82	-22.40
Resources *(Fuel Cost)*			
Production	-58.63	-58.34	-58.63
Imports	-12.75	-12.75	-12.75
Environmental Externalities *(Carbon Cost)*	-12.11	-12.11	-12.11
Net Present Value	-109.96	-101.02	-105.89
GHG Savings *(Mill. Tonnes CO_2 Eq.)*	2216.96	2216.96	2216.96
Cost of Avoided CO_2 *(Turkish Lira/Tonne CO_2 Eq.)*	-49.60	-45.57	-47.76

Source: Our model

To answer the first part question, *we have to look at the BAU scenario* in the Table 15. According to results:

- EGC gets 109.96 billion TL profit by implementing privatization.
- If the privatization does not occur, the EGC should pay 12.11 billion TL for the carbon costs.
- By implementing the privatization, 2216.96 $MtCO_2eq$. GHG emission is saved.

- If the EGC wants to decrease 1 tonne CO_2 eq. GHG emissions in NP scenario, she has to pay 49.60 TL according to BAU scenarios, i.e., the government has a 49.60 TL/tonne CO_2 eq. profit in BAU scenario.

To come back to the first question, privatization is a method to decarbonize the Turkish electricity sector. It supports the changes in the current portfolio structure of EGC. *In this study, we analyze the privatization impacts in Turkish public electricity sector, i.e., looking at the EGC perspective.* To complement this study, the privatization impacts on the end-users or consumers have to be examined; however, LEAP does not allow the calculation of its impact on the end-users. This can be the topic of future studies in the electricity sector.

The second part of this study is designed to find the best sustainable portfolio for Turkish public electricity sector. Our question is:

"How does the government reach the best sustainable energy portfolio after the privatization?"

NE and RE scenarios are compared to find an answer. According to results given in Table 15:

- Their GHG emission savings and environmental externalities are the same because their portfolios include zero carbon energy resources, nuclear and renewable energy.
- RE scenario is 4.87 billion TL more profitable than NE scenario.
- In NE scenario, the government has to pay 0.29 billion TL for fuel costs, i.e., cumulative cost of uranium.

From 3E perspective, analyses of economic and environmental effects of the scenarios are not sufficient to choose the best sustainable scenario. Electricity generation amount of each scenario and their shares in the total electricity generation have to be compared as well. In Table 14, the shares in the total electricity generation

of each scenario are given. If we look at Table 14, RE scenario electricity generation share in 2050 is 30.62% while NE scenario share is 38.76 %. Although NE scenario generates more electricity than RE scenario in 2050, its projected costs are 16.11 billion TL, more than RE scenario. Therefore, ***RE scenario appears as the best sustainable scenario for Turkish public electricity sector.***

It is a fact that renewable energy sources are highly sensitive to weather conditions and they cannot be base power plants in the system such as nuclear energy power plants. However, it helps to diversify the EGC portfolio which helps to decrease EGC portfolio risks. In addition, renewable energy resources are independent from imported fossil fuels opposite to nuclear energy. Alternative diversification strategies could be the topic of future research.

4.6. Comparison to previous study results

The only study implemented LEAP for Turkish electricity sector focused on CO_2 mitigation of the electricity sector for the period 2006-2030. The authors took electricity consumption growth as 7.3%, as represented in the TETC capacity reports [48]. The future GHG emissions were estimated by hand calculations and mitigation scenario did not include solar and nuclear energy. In addition, the cost calculations were not in the scope of the study. Therefore, we only compare the electricity consumption growth and sectoral shares in it [28].

In our study, the annual average growth of electricity consumption is estimated to be 2.01%. The increase in the electricity consumption for the residential and services sector reaches to 53.01% in 2030 associated with the growth in population. The industry electricity consumption decreases to 39.64% in 2030. There is only slightly change in electricity consumption of the transportation sector in 2030. On the contrary, agriculture sector electricity consumption is increased to 7.11 % in 2030.

In the previous study, the electricity consumption was taken from TETC capacity projection report [48] and according to their model, residential and services

electricity consumption reached 43.2% in 2030. The industry share was 38.1% in 2030 and there were small electricity consumption changes for transportation, agriculture, and commercial sectors [28].

The previous study includes two scenarios: Business-as-usual and mitigation scenarios. The mitigation scenario was created to observe the renewable energy impacts on the CO_2 emission of the Turkish electricity sector. *The emission reduction was calculated as 104 million metric tonnes of CO_2 in mitigation scenario for* ***Turkish electricity sector*** *although nuclear energy and solar energy were not taken into account in the mitigation scenario [28]. On the other hand, in our study we focused on* ***Turkish public electricity sector*** *and the government gets rid of 2216.96 million metric tonnes of GHG emissions by privatization*, i.e., 2216.96 million metric tonnes of GHG emissions will start to be produced by private sector after 2020.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary and Conclusion

Long-range Alternatives Planning (LEAP), integrated model software, is used to analyze the liberalization of the Turkish public electricity sector. Liberalization impacts on GHG emissions of Turkish public electricity sector and energy portfolio management after privatization are evaluated with the perspective of 3Es (Energy, Environment and Economy) within the period of 2001 to 2050. The private electricity sector is exempt from the modeling. The objective of this study is to examine the decarbonization process of Turkish electricity sector, and then via alternative scenarios to make sustainability assessments.

To the extent of our knowledge this study is the only work analyzing Turkish public electricity sector in the 3E framework using LEAP***. It is the second study to use LEAP on electricity sector in Turkey and the first study to focus on the decarbonization process of the Turkish public electricity sector.*** There is no previous in depth study to examine the sustainability in this field. This study has a potential to be a guide for developing countries who targets or under privatization or already under liberalization movements in the electricity sector.

Different methodologies are used during establishment of the model. Linear regression is implemented in the baseline of the model such as forecasting the future resource price and electricity consumption for various sectors. IPCC Tier-1 method placed in LEAP is implemented for the calculation of GHG emissions during the privatization period of the electricity generation sector. In addition, social costs are accounted by using the levelized cost of electricity generation (LCOE) methodology.

Although forecasting or simulation of the electricity sector gives an opportunity to see the results of current implementations and alternative strategies, they have a disadvantage because of the uncertainties in the future such as technological improvement, discovery of new resources (e.g. Shale gas) and unexpected financial and energy sector developments. Avoiding or predicting these uncertainties is impossible; however, forming a solid baseline in the model helps to decrease the error margin of the model results. Validation in our model is done via comparison of in sample forecasts of GHG emissions with actual emissions. GHG emissions data from 2001 to 2010, taken by EGC, were compared with LEAP baseline data results. *The error was found to be under ± 5%, except for 2003*.

After establishment of the model, Business-As-Usual (BAU) scenario and No Privatization (NP) scenario are formed. BAU scenario states the current strategies on public electricity sector, and NP scenario preserves the 2012 electricity generation capacity. Alternative, sustainable energy portfolios are offered in the Nuclear Energy (NE) and Renewable Energy (RE) scenarios. NE portfolio involves the 3rd and 4th nuclear power plants, whereas the RE scenario targets the diversification into potential renewable energy sources.

The electricity consumption is associated with population and GDP dynamisms. The annual average growth rate between 2013 and 2050 for population and GDP MER are estimated to be 0.60% and 3.20 % respectively. Although there is a slight decrease in the growth of population and GDP MER, electricity consumption growth is estimated to be 2.01% between 2013 and 2050, and total electricity consumption

reaches 435.63 TWh in 2050. Examination of the sectoral electricity consumption over the modeling period demonstrates that residential and services sectors' electricity consumption share will be larger dominated compared to that of the industry sector in 2050.

The results of the model are evaluated with respect to research questions mentioned in Chapter 1. The first research question is: *"Is privatization the only solution for decarbonization? What are the benefits and costs of privatization for the Turkish public electricity sector?"*

According to the comparison between NP and BAU scenarios, the government gets 109.96 billion TL profit and 2216.96 $MtCO_2eq$. GHG emission reduction is reached by implementing privatization in the Turkish public electricity sector. If the privatization is not implemented and carbon markets are operated in 2020, EGC would pay 12.11 billion TL for the carbon costs. In addition, if the government wants to decrease 1 tonne of CO_2 eq. GHG emissions in NP scenario, she has to pay 49.60 TL according to BAU scenario. Thus, privatization can be a solution for changing the portfolio structure and to support mechanism for the decarbonization of EGC.

The second part of the study concentrates on reaching the more sustainable portfolio for Turkish public electricity generation among NE and RE scenarios. The second part research question is: *"How does the government reach the best sustainable energy portfolio after the privatization?"*

To answer this question, NE and RE scenarios are compared with respect to 3E perspective. According to the comparisons, their GHG emission savings and environmental externalities are the same because their portfolio includes zero carbon energy resources which are nuclear and renewable energy. Therefore, we have to analyze them by comparing their electricity generation and projected costs. NE scenario meets the 38.76 % of the electricity consumptions in 2050. On the other hand, this value for RE scenario is 30.62%. Regardless, RE scenario is 4.87 billion TL more profitable than NE scenario and the government has to pay 0.29 billion TL

for fuel costs, i.e., cumulative cost of uranium in NE scenario.

In conclusion, the decarbonization of the Turkish public electricity sector can be achieved under the NE or the RE scenario because their portfolio includes carbon free technologies. However, from the point of sustainability, RE scenario distinguishes itself by its low projected costs and its diversified energy portfolio which are complementary to 3E perspective of the sustainability.

5.2. Limitations of this study and recommendations for further research

LEAP is an integrated and flexible software tool analyzing the energy sector. In the previous Chapters, we emphasize that this study analyzes decarbonization of the Turkish public electricity sector and takes only the government perspective into account. Therefore, privatization impacts on end-users are out of the scope of our study and LEAP does not allow the analyzing privatization impacts by looking at consumer and producer sides. This is one of the limitations of the LEAP. One of the other limitations is weather impacts on the electricity generation. In this study, we could not analyze weather impacts on renewable energy power plants such as hydroelectric, solar and wind by LEAP. If the equations between weather impacts and load shapes of the power plants are entered in the baseline of model, LEAP can calculate the electricity generation considering these equations. Thus, we suggest topics for future works for the electricity sector which can be implemented by LEAP.

- Private electricity sector can be analyzed by LEAP. The structural changes and projected costs of the various scenarios can be examined.
- Different energy portfolios similar to EU Energy Road Map 2050 can be developed and implemented on Turkish electricity system by LEAP.
- The effects of precipitation regime of water on hydroelectric power plants can be a different study of the LEAP literature. The examination can be done by using linkage between LEAP and WEAP.
- The new technological developments in the electricity sector such as biogas power plants or using shale gas in the electricity generation can be analyzed

by LEAP.

- Demand side management is one of the untouched research fields in Turkey. Energy efficiency implementations can be applied in LEAP. For instance, micro grid systems in the electricity structure in METU or energy efficiency in buildings' and dormitories can be modeled with 3E perspective by LEAP.
- Air quality of the specified research areas (similar to METU campus) can be examined by using LEAP.

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APPENDIX - A

KEY ASSUMPTIONS

Table A- 1 Key assumptions

Indicator Name	2001	2002	2003	2004	2005	2006
GDP (constant 2005 US$) *(10^11)	3.65	3.87	4.07	4.45	4.83	5.16
Agriculture, value added (% of GDP)	9.95	11.71	11.39	10.92	10.80	9.52
Industry, value added (% of GDP)	30.24	28.67	28.62	28.52	28.51	28.67
Manufacturing, value added (% of GDP)	21.47	20.25	20.35	20.02	19.93	19.82
Services, etc., value added (% of GDP)	59.82	59.62	59.99	60.56	60.69	61.80
Roads, passengers carried (billion passenger-km)	168.21	163.33	164.31	174.31	182.15	187.59
Railways, passengers carried (billion passenger-km)	5.57	5.20	5.88	5.16	5.04	5.28
Air transport, passengers carried (million passenger-km)	10.60	10.69	10.75	14.27	16.94	19.36
Railways, goods transported (billion tonne-km)	7.49	7.17	8.62	9.33	8.94	9.54
Roads, goods transported (billion tonne-km)	151.42	150.91	152.16	156.85	166.83	177.40
Air transport, freight (million tonne-km)	349.98	380.79	376.66	370.18	382.95	463.90
Passenger cars (per 1,000 people)	No data	No data	66.00	77.00	81.00	85.00

Source: World Bank Database [6]. The table was drawn by the author

Table A- 1 Key assumptions (Continued)

Indicator Name	2007	2008	2009	2010	2011	2012
GDP (constant 2005 US$)*(10^11)	5.40	5.44	5.18	5.65	6.15	6.28
Agriculture, value added (% of GDP)	8.68	8.61	9.35	9.65	9.14	No data
Industry, value added (% of GDP)	28.26	27.69	25.94	26.95	27.88	No data
Manufacturing, value added (% of GDP)	19.13	18.31	17.20	17.91	18.59	No data
Services, etc., value added (% of GDP)	63.07	63.71	64.71	63.40	62.98	No data
Roads, passengers carried (billion passenger-km)	209.11	206.10	212.46	226.91	No data	No data
Railways, passengers carried (billion passenger-km)	5.55	5.10	5.37	5.50	No data	No data
Air transport, passengers carried (million passenger-km)	22.89	25.51	31.34	45.67	53.50	63.35
Railways, goods transported (billion tonne-km)	9.68	10.10	9.68	11.03	No data	No data
Roads, goods transported (billion tonne-km)	181.33	181.94	176.46	190.36	No data	No data
Air transport, freight (million tonne-km)	466.10	480.67	856.03	1149.28	1544.79	1933.23
Passenger cars (per 1,000 people)	89.00	92.00	94.82	103.71	No data	No data

Source: World Bank Database [6]. The table was drawn by the author

Table A- 1 Key assumptions (Continued)

Population (million people)

Year	Medium
2001	64.10
2002	65.02
2003	65.94
2004	66.85
2005	67.74
2006	68.63
2007	69.50
2008	70.36
2009	71.24
2010	72.14
2011	73.06
2012	74.00

Source: World Bank Database [6]. The table was prepared by the author.

APPENDIX - B

GENERAL ENERGY BALANCE

Table B- 1 General energy balance, 2001 (Thousand TOE)

Parameter	Hard Coal	Lignite	Asphaltite	Coke	Petroleum Coke	Wood
Production (+)	1144.57	11123.69	13.19	0.00	0.00	4878.90
Imports (+)	5452.34	3.22	0.00	366.10	988.86	0.00
Exports (-)	0.00	0.00	0.00	0.00	0.00	0.00
Bunker fuel (-)	0.00	0.00	0.00	0.00	0.00	0.00
Stock Changes (+/-)	413.79	301.99	0.00	69.19	33.09	0.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00	0.00	0.00
Primary Energy Supply	7010.69	11428.90	13.19	435.29	1021.96	4878.90
Production Except Refinery	0.00	0.00	0.00	0.00	0.00	0.00
Total Primary Energy Supply	7010.69	11428.90	13.19	435.29	1021.96	4878.90
Energy Sector	-3547.66	-9196.27	-0.43	1812.11	0.00	0.00
Electricity Plants	-916.71	-9160.10	0.00	0.00	0.00	0.00
Coking Plant	-2627.98	0.00	0.00	1811.11	0.00	0.00
Briquette	0.00	-0.60	0.00	1.00	0.00	0.00
Petroleum Refineries	0.00	0.00	0.00	0.00	0.00	0.00
Internal Consumption and Losses	-2.97	-35.58	-0.43	0.00	0.00	0.00
Total Final Energy Consumption	3463.03	2232.63	12.76	2247.41	1021.96	4878.90
Sectorial Detail	3463.03	2232.63	12.76	2247.40	1021.96	4878.90
Industrial Consumption	2950.63	1458.32	0.00	2231.00	1021.96	0.00
Iron and Steel	0.00	0.00	0.00	2038.77	0.00	0.00
Chemistry and Petrochemical	39.00	14.10	0.00	0.00	0.00	0.00
Petrochemical Feedstock	0.00	0.00	0.00	0.00	0.00	0.00
Manure	0.00	8.10	0.00	0.00	0.00	0.00
Cement	613.55	480.01	0.00	0.00	914.89	0.00
Sugar	58.52	337.81	0.00	49.00	0.00	0.00
Nonferrous Metals	50.00	14.40	0.00	73.50	0.00	0.00
Others	2189.56	603.89	0.00	69.73	107.06	0.00

Source: WEC Turkish National Committee web archive [32].

Table B- 1 General energy balance, 2001 (Thousand TOE) (Continued)

Parameter	Hard Coal	Lignite	Asphaltite	Coke	Petroleum Coke	Wood
Transportation	0.00	0.00	0.00	0.00	0.00	0.00
Railways	0.00	0.00	0.00	0.00	0.00	0.00
Sea	0.00	0.00	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00	0.00	0.00
Road	0.00	0.00	0.00	0.00	0.00	0.00
Other Sectors	512.40	774.31	12.76	16.40	0.00	4878.90
Residential and Services	512.40	774.31	12.76	16.40	0.00	4878.90
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00
Non-Energy	0.00	0.00	0.00	0.00	0.00	0.00

Source: WEC Turkish National Committee web archive [32].

Table B- 1 General energy balance, 2001 (Thousand TOE) (Continued)

Parameter	Animal and Plant Residual	Total Solid Fuels	Petroleum/Oil	Natural Gas
Production (+)	1331.70	18492.05	2679.04	283.52
Imports (+)	0.00	6810.52	30680.31	14894.88
Exports (-)	0.00	0.00	2582.69	0.00
Bunker fuel (-)	0.00	0.00	624.03	0.00
Stock Changes (+/-)	0.00	818.07	523.29	-310.31
Statistical Differences(+/-)	0.00	0.00	154.52	0.00
Primary Energy Supply	1331.70	26120.63	30830.44	14868.09
Production Except Refinery	0.00	0.00	105.20	0.00
Total Primary Energy Supply	1331.70	26120.63	30935.64	14868.09
Energy Sector	0.00	-10932.25	-6562.92	-9586.44
Electricity Plants	0.00	-10076.80	-3466.16	-9578.70
Coking Plant	0.00	-816.87	0.00	0.00
Briquette	0.00	0.40	0.00	0.00
Petroleum Refineries	0.00	0.00	-1713.08	0.00
Internal Consumption and Losses	0.00	-38.98	-1383.69	-7.74
Total Final Energy Consumption	1331.70	15188.38	24372.65	5281.65
Sectorial Detail	1331.70	15188.38	24372.65	5281.65
Industrial Consumption	0.00	7661.90	5159.28	2460.80
Iron and Steel	0.00	2038.77	479.71	5.36
Chemistry and Petrochemical	0.00	53.10	758.40	330.95
Petrochemical Feedstock	0.00	0.00	1537.79	0.00
Manure	0.00	8.10	457.56	119.18
Cement	0.00	2008.45	61.07	54.04
Sugar	0.00	445.33	531.73	101.45
Nonferrous Metals	0.00	137.90	265.44	262.99
Others	0.00	2970.25	1067.59	1586.83
Transportation	0.00	0.00	11925.23	3.91
Railways	0.00	0.00	170.78	0.00
Sea	0.00	0.00	251.63	0.00
Air	0.00	0.00	1123.62	0.00
Road	0.00	0.00	10379.21	3.91
Other Sectors	1331.70	7526.47	5650.36	2816.94
Residential and Services	1331.70	7526.47	2962.08	2816.94
Agriculture	0.00	0.00	2688.27	0.00
Non-Energy	0.00	0.00	1637.77	0.00

Source: WEC Turkish National Committee web archive [32].

Table B- 1 General energy balance, 2001 (Thousand TOE) (Continued)

Parameter	Hydraulic	Geothermal	Wind	Electricity
Production (+)	2064.85	77.06	5.37	0.00
Imports (+)	0.00	0.00	0.00	393.83
Exports (-)	0.00	0.00	0.00	37.22
Bunker fuel (-)	0.00	0.00	0.00	0.00
Stock Changes (+/-)	0.00	0.00	0.00	0.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00
Primary Energy Supply	2064.85	77.06	5.37	356.61
Production Except Refinery	0.00	0.00	0.00	0.00
Total Primary Energy Supply	2064.85	77.06	5.37	356.61
Energy Sector	-2064.85	-77.06	-5.37	7851.66
Electricity Plants	-2064.85	-77.06	-5.37	10554.32
Coking Plant	0.00	0.00	0.00	0.00
Briquette	0.00	0.00	0.00	0.00
Petroleum Refineries	0.00	0.00	0.00	-139.75
Internal Consumption and Losses	0.00	0.00	0.00	-2562.91
Total Final Energy Consumption	0.00	0.00	0.00	8208.27
Sectorial Detail	0.00	0.00	0.00	8208.27
Industrial Consumption	0.00	0.00	0.00	3901.30
Iron and Steel	0.00	0.00	0.00	0.00
Chemistry and Petrochemical	0.00	0.00	0.00	0.00
Petrochemical Feedstock	0.00	0.00	0.00	0.00
Manure	0.00	0.00	0.00	41.84
Cement	0.00	0.00	0.00	277.14
Sugar	0.00	0.00	0.00	0.00
Nonferrous Metals	0.00	0.00	0.00	0.00
Others	0.00	0.00	0.00	3582.33
Transportation	0.00	0.00	0.00	70.52
Railways	0.00	0.00	0.00	70.52
Sea	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00
Road	0.00	0.00	0.00	0.00
Other Sectors	0.00	0.00	0.00	4236.45
Residential and Services	0.00	0.00	0.00	3960.98
Agriculture	0.00	0.00	0.00	275.46
Non-Energy	0.00	0.00	0.00	0.00

Source: WEC Turkish National Committee web archive [32].

Table B- 1 General energy balance, 2001 (Thousand TOE) (Continued)

Parameter	Heat	Solar	Total
Production (+)	687.00	287.00	24575.88
Imports (+)	0.00	0.00	52779.53
Exports (-)	0.00	0.00	2619.91
Bunker fuel (-)	0.00	0.00	624.03
Stock Changes (+/-)	0.00	0.00	1031.05
Statistical Differences (+/-)	0.00	0.00	154.52
Primary Energy Supply	687.00	287.00	75297.04
Production Except Refinery	0.00	0.00	105.20
Total Primary Energy Supply	687.00	287.00	75402.25
Energy Sector	2023.00	0.00	-19354.23
Electricity Plants	2023.00	0.00	-12691.62
Coking Plant	0.00	0.00	-816.87
Briquette	0.00	0.00	0.00
Petroleum Refineries	0.00	0.00	-1852.83
Internal Consumption and Losses	0.00	0.00	-3993.32
Total Final Energy Consumption	2710.00	287.00	56048.01
Sectorial Detail	2710.00	287.00	56047.94
Industrial Consumption	2023.00	118.00	21324.29
Iron and Steel	0.00	0.00	2523.83
Chemistry and Petrochemical	0.00	0.00	1142.45
Petrochemical Feedstock	0.00	0.00	1537.79
Manure	0.00	0.00	626.69
Cement	0.00	0.00	2400.69
Sugar	0.00	0.00	1078.52
Nonferrous Metals	0.00	0.00	666.33
Others	2023.00	118.00	11347.99
Transportation	0.00	0.00	11999.67
Railways	0.00	0.00	241.30
Sea	0.00	0.00	251.63
Air	0.00	0.00	1123.62
Road	0.00	0.00	10383.12
Other Sectors	687.00	169.00	21086.21
Residential and Services	687.00	169.00	18122.47
Agriculture	0.00	0.00	2963.74
Non-Energy	0.00	0.00	1637.77

Source: WEC Turkish National Committee web archive [32].

Table B- 2 General energy balance, 2002 (Thousand TOE)

Parameter	Hard Coal	Lignite	Asphaltite	Coke	Petroleum Coke	Wood
Production (+)	1047.13	10310.89	2.28	0.00	0.00	4684.20
Imports (+)	7856.53	0.00	0.00	485.80	1344.57	0.00
Exports (-)	0.00	0.00	0.00	0.00	0.00	0.00
Bunker fuel (-)	0.00	0.00	0.00	0.00	0.00	0.00
Stock Changes (+/-)	-67.92	124.26	0.00	-89.71	-1.31	0.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00	0.00	0.00
Primary Energy Supply	8835.73	10435.15	2.28	396.09	1343.26	4684.20
Production Except Refinery	0.00	0.00	0.00	0.00	0.00	0.00
Total Primary Energy Supply	8835.73	10435.15	2.28	396.09	1343.26	4684.20
Energy Sector	-3496.54	-7645.68	-0.02	1819.70	0.00	0.00
Electricity Plants	-863.40	-7607.78	0.00	0.00	0.00	0.00
Coking Plant	-2594.44	0.00	0.00	1818.70	0.00	0.00
Briquette	0.00	-0.60	0.00	1.00	0.00	0.00
Petroleum Refineries	0.00	0.00	0.00	0.00	0.00	0.00
Internal Consumption and Losses	-38.70	-37.30	-0.02	0.00	0.00	0.00
Total Final Energy Consumption	5339.20	2789.48	2.25	2215.79	1343.26	4684.20
Sectorial Detail	5339.20	2789.48	2.25	2215.65	1343.26	4684.20
Industrial Consumption	4782.15	1722.92	2.25	2184.68	1343.26	0.00
Iron and Steel	0.00	0.00	0.00	1939.30	0.00	0.00
Chemistry and Petrochemical	48.45	14.10	0.00	0.00	0.00	0.00
Petrochemical Feedstock	0.00	0.00	0.00	0.00	0.00	0.00
Manure	0.00	6.24	0.00	0.00	0.00	0.00
Cement	670.54	376.78	0.00	0.00	1018.86	0.00
Sugar	50.15	286.69	0.00	52.50	0.00	0.00
Nonferrous Metals	54.91	14.40	0.00	75.60	0.00	0.00
Others	3958.10	1024.71	2.25	117.29	324.40	0.00
Transportation	0.00	0.00	0.00	0.00	0.00	0.00
Railways	0.00	0.00	0.00	0.00	0.00	0.00
Sea	0.00	0.00	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00	0.00	0.00
Road	0.00	0.00	0.00	0.00	0.00	0.00
Other Sectors	557.05	1066.56	0.00	30.97	0.00	4684.20
Residential and Services	557.05	1066.56	0.00	30.97	0.00	4684.20
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00
Non-Energy	0.00	0.00	0.00	0.00	0.00	0.00

Source: WEC Turkish National Committee web archive [32].

Table B- 2 General energy balance, 2002 (Thousand TOE) (Continued)

Parameter	Animal and Plant Residual	Total Solid Fuels	Petroleum/Oil	Natural Gas
Production (+)	1290.07	17334.57	2563.61	344.35
Imports (+)	0.00	9686.90	32867.05	15766.66
Exports (-)	0.00	0.00	3124.94	0.00
Bunker fuel (-)	0.00	0.00	1233.24	0.00
Stock Changes (+/-)	0.00	-34.68	-23.30	-9.10
Statistical Differences (+/-)	0.00	0.00	-159.13	0.00
Primary Energy Supply	1290.07	26986.79	30890.05	16101.91
Production Except Refinery	0.00	0.00	42.18	0.00
Total Primary Energy Supply	1290.07	26986.79	30932.23	16101.91
Energy Sector	0.00	-9322.54	-6711.94	-10324.72
Electricity Plants	0.00	-8471.17	-3401.60	-10070.00
Coking Plant	0.00	-775.74	0.00	0.00
Briquette	0.00	0.40	0.00	0.00
Petroleum Refineries	0.00	0.00	-1724.25	0.00
Internal Consumption and Losses	0.00	-76.02	-1586.09	-254.72
Total Final Energy Consumption	1290.07	17664.25	24220.22	5777.19
Sectorial Detail	1290.07	17664.12	24220.22	5777.19
Industrial Consumption	0.00	10035.27	5477.73	2902.11
Iron and Steel	0.00	1939.30	448.77	6.32
Chemistry and Petrochemical	0.00	62.55	758.40	301.67
Petrochemical Feedstock	0.00	0.00	1568.69	0.00
Manure	0.00	6.24	91.61	481.10
Cement	0.00	2066.18	55.57	40.63
Sugar	0.00	389.34	612.28	64.08
Nonferrous Metals	0.00	144.91	265.44	329.28
Others	0.00	5426.75	1676.96	1679.02
Transportation	0.00	0.00	11329.34	3.96
Railways	0.00	0.00	178.02	0.00
Sea	0.00	0.00	258.45	0.00
Air	0.00	0.00	362.84	0.00
Road	0.00	0.00	10530.02	3.96
Other Sectors	1290.07	7628.85	5606.71	2871.12
Residential and Services	1290.07	7628.85	2877.04	2871.12
Agriculture	0.00	0.00	2729.67	0.00
Non-Energy	0.00	0.00	1806.44	0.00

Source: WEC Turkish National Committee web archive [32].

Table B- 2 General energy balance, 2002 (Thousand TOE) (Continued)

Parameter	Hydraulic	Geothermal	Wind	Electricity
Production (+)	2896.81	89.96	4.13	0.00
Imports (+)	0.00	0.00	0.00	308.59
Exports (-)	0.00	0.00	0.00	37.42
Bunker fuel (-)	0.00	0.00	0.00	0.00
Stock Changes (+/-)	0.00	0.00	0.00	0.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00
Primary Energy Supply	2896.81	89.96	4.13	271.17
Production Except Refinery	0.00	0.00	0.00	0.00
Total Primary Energy Supply	2896.81	89.96	4.13	271.17
Energy Sector	-2896.81	-89.96	-4.13	8440.45
Electricity Plants	-2896.81	-89.96	-4.13	11128.36
Coking Plant	0.00	0.00	0.00	0.00
Briquette	0.00	0.00	0.00	0.00
Petroleum Refineries	0.00	0.00	0.00	-141.90
Internal Consumption and Losses	0.00	0.00	0.00	-2546.00
Total Final Energy Consumption	0.00	0.00	0.00	8711.62
Sectorial Detail	0.00	0.00	0.00	8711.62
Industrial Consumption	0.00	0.00	0.00	4183.21
Iron and Steel	0.00	0.00	0.00	694.36
Chemistry and Petrochemical	0.00	0.00	0.00	468.70
Petrochemical Feedstock	0.00	0.00	0.00	0.00
Manure	0.00	0.00	0.00	43.93
Cement	0.00	0.00	0.00	282.54
Sugar	0.00	0.00	0.00	0.00
Nonferrous Metals	0.00	0.00	0.00	218.82
Others	0.00	0.00	0.00	2474.85
Transportation	0.00	0.00	0.00	71.38
Railways	0.00	0.00	0.00	71.38
Sea	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00
Road	0.00	0.00	0.00	0.00
Other Sectors	0.00	0.00	0.00	4457.03
Residential and Services	0.00	0.00	0.00	4156.88
Agriculture	0.00	0.00	0.00	300.15
Non-Energy	0.00	0.00	0.00	0.00

Source: WEC Turkish National Committee web archive [32].

Table B- 2 General energy balance, 2002 (Thousand TOE) (Continued)

Parameter	Heat	Solar	Total
Production (+)	730.00	318.00	24281.42
Imports (+)	0.00	0.00	58629.19
Exports (-)	0.00	0.00	3162.36
Bunker fuel (-)	0.00	0.00	1233.24
Stock Changes (+/-)	0.00	0.00	-67.08
Statistical Differences (+/-)	0.00	0.00	-159.13
Primary Energy Supply	730.00	318.00	78288.80
Production Except Refinery	0.00	0.00	42.18
Total Primary Energy Supply	730.00	318.00	78330.98
Energy Sector	2065.00	0.00	-18844.64
Electricity Plants	2065.00		-11740.31
Coking Plant	0.00	0.00	-775.74
Briquette	0.00	0.00	0.00
Petroleum Refineries	0.00	0.00	-1866.15
Internal Consumption and Losses	0.00	0.00	-4462.83
Total Final Energy Consumption	2795.00	318.00	59486.35
Sectorial Detail	2795.00	318.00	59486.14
Industrial Consumption	2065.00	119.00	24782.32
Iron and Steel	0.00	0.00	3088.75
Chemistry and Petrochemical	0.00	0.00	1591.32
Petrochemical Feedstock	0.00	0.00	1568.69
Manure	0.00	0.00	622.88
Cement	0.00	0.00	2444.93
Sugar	0.00	0.00	1065.70
Nonferrous Metals	0.00	0.00	958.45
Others	2065.00	119.00	13441.59
Transportation	0.00	0.00	11404.67
Railways	0.00	0.00	249.40
Sea	0.00	0.00	258.45
Air	0.00	0.00	362.84
Road	0.00	0.00	10533.98
Other Sectors	730.00	199.00	21492.71
Residential and Services	730.00	199.00	18462.88
Agriculture	0.00	0.00	3029.83
Non-Energy	0.00	0.00	1806.44

Source: WEC Turkish National Committee web archive [32].

Table B- 3 General energy balance, 2003 (Thousand TOE)

Parameter	Hard Coal	Lignite	Asphaltite	Coke	Petroleum Coke	Wood
Production (+)	1131.77	9500.71	144.48	0.00	0.00	4497.30
Imports (+)	10546.35	0.00	0.00	356.35	1284.97	0.00
Exports (-)	0.00	4.50	0.00	0.00	0.00	0.00
Bunker fuel (-)	0.00	0.00	0.00	0.00	0.00	0.00
Stock Changes (+/-)	-476.72	-25.23	0.00	24.73	35.54	0.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00	0.00	0.00
Primary Energy Supply	11201.40	9470.98	144.48	381.08	1320.51	4497.30
Production Except Refinery	0.00	0.00	0.00	0.00	0.00	0.00
Total Primary Energy Supply	11201.40	9470.98	144.48	381.08	1320.51	4497.30
Energy Sector	-4888.06	-6370.06	0.00	2037.98	0.00	0.00
Electricity Plants	-1873.28	-6323.13	0.00	0.00	0.00	0.00
Coking Plant	-2983.68	0.00	0.00	2014.48	0.00	0.00
Briquette	0.00	-12.90	0.00	23.50	0.00	0.00
Petroleum Refineries	0.00	0.00	0.00	0.00	0.00	0.00
Internal Consumption and Losses	-31.10	-34.04	0.00	0.00	0.00	0.00
Total Final Energy Consumption	6313.34	3100.91	144.48	2419.07	1320.51	4497.30
Sectorial Detail	6313.34	3100.91	144.48	2419.07	1320.51	4497.30
Industrial Consumption	5679.53	1862.37	144.48	2284.46	1320.51	0.00
Iron and Steel	0.00	0.00	0.00	2125.56	0.00	0.00
Chemistry and Petrochemical	0.00	9.59	0.00	0.00	0.00	0.00
Petrochemical Feedstock	0.00	0.00	0.00	0.00	0.00	0.00
Manure	0.00	5.68	0.00	0.00	0.00	0.00
Cement	867.99	474.62	0.00	0.00	964.54	0.00
Sugar	38.01	280.95	0.00	46.20	0.00	0.00
Nonferrous Metals	51.86	16.50	0.00	9.10	0.00	0.00
Others	4721.67	1075.02	144.48	103.60	355.97	0.00
Transportation	0.00	0.00	0.00	0.00	0.00	0.00
Railways	0.00	0.00	0.00	0.00	0.00	0.00
Sea	0.00	0.00	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00	0.00	0.00
Road	0.00	0.00	0.00	0.00	0.00	0.00
Other Sectors	633.81	1238.55	0.00	134.61	0.00	4497.30
Residential and Services	633.81	1238.55	0.00	134.61	0.00	4497.30
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00
Non-Energy	0.00	0.00	0.00	0.00	0.00	0.00

Source: WEC Turkish National Committee web archive [32].

Table B- 3 General energy balance, 2003 (Thousand TOE) (Continued)

Parameter	Animal and Plant Residual	Total Solid Fuels	Petroleum/Oil	Natural Gas
Production (+)	1250.97	16525.23	2493.80	510.18
Imports (+)	0.00	12187.68	34003.26	18948.93
Exports (-)	0.00	4.50	4034.92	0.00
Bunker fuel (-)	0.00	0.00	644.27	0.00
Stock Changes (+/-)	0.00	-441.68	-98.62	-9.10
Statistical Differences (+/-)	0.00	0.00	86.85	0.00
Primary Energy Supply	1250.97	28266.73	31806.10	19450.01
Production Except Refinery	0.00	0.00	0.00	0.00
Total Primary Energy Supply	1250.97	28266.73	31806.10	19450.01
Energy Sector	0.00	-9220.14	-6292.29	-11424.66
Electricity Plants	0.00	-8196.41	-3049.49	-11201.00
Coking Plant	0.00	-969.20	0.00	0.00
Briquette	0.00	10.60	-13.41	0.00
Petroleum Refineries	0.00	0.00	-1718.08	0.00
Internal Consumption and Losses	0.00	-65.14	-1511.30	-223.66
Total Final Energy Consumption	1250.97	19046.58	25513.81	8025.34
Sectorial Detail	1250.97	19046.58	5601.13	4368.87
Industrial Consumption	0.00	11291.35	439.98	0.00
Iron and Steel	0.00	2125.56	758.40	335.64
Chemistry and Petrochemical	0.00	9.59	1384.06	0.00
Petrochemical Feedstock	0.00	0.00	91.31	432.21
Manure	0.00	5.68	52.83	53.97
Cement	0.00	2307.15	253.73	85.32
Sugar	0.00	365.17	265.44	360.96
Nonferrous Metals	0.00	77.46	2355.38	3100.77
Others	0.00	6400.74	12314.51	3.96
Transportation	0.00	0.00	183.20	0.00
Railways	0.00	0.00	280.22	0.00
Sea	0.00	0.00	905.76	0.00
Air	0.00	0.00	10945.34	3.96
Road	0.00	0.00	5500.49	3652.52
Other Sectors	1250.97	7755.23	2728.95	3652.52
Residential and Services	1250.97	7755.23	2771.53	0.00
Agriculture	0.00	0.00	2097.68	0.00
Non-Energy	0.00	0.00		

Source: WEC Turkish National Committee web archive [32].

Table B- 3 General energy balance, 2003 (Thousand TOE) (Continued)

Parameter	Hydraulic	Geothermal	Wind	Electricity
Production (+)	3038.34	76.20	5.28	0.00
Imports (+)	0.00	0.00	0.00	99.59
Exports (-)	0.00	0.00	0.00	50.53
Bunker fuel (-)	0.00	0.00	0.00	0.00
Stock Changes (+/-)	0.00	0.00	0.00	0.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00
Primary Energy Supply	3038.34	76.20	5.28	49.05
Production Except Refinery	0.00	0.00	0.00	0.00
Total Primary Energy Supply	3038.34	76.20	5.28	49.05
Energy Sector	-3038.34	-76.20	-5.28	9475.27
Electricity Plants	-3038.34	-76.20	-5.28	12089.92
Coking Plant	0.00	0.00	0.00	0.00
Briquette	0.00	0.00	0.00	0.00
Petroleum Refineries	0.00	0.00	0.00	-87.55
Internal Consumption and Losses	0.00	0.00	0.00	-2527.10
Total Final Energy Consumption	0.00	0.00	0.00	9524.33
Sectorial Detail	0.00	0.00	0.00	9524.33
Industrial Consumption	0.00	0.00	0.00	4650.97
Iron and Steel	0.00	0.00	0.00	824.05
Chemistry and Petrochemical	0.00	0.00	0.00	493.39
Petrochemical Feedstock	0.00	0.00	0.00	0.00
Manure	0.00	0.00	0.00	42.87
Cement	0.00	0.00	0.00	295.73
Sugar	0.00	0.00	0.00	0.00
Nonferrous Metals	0.00	0.00	0.00	264.97
Others	0.00	0.00	0.00	2729.95
Transportation	0.00	0.00	0.00	76.54
Railways	0.00	0.00	0.00	76.54
Sea	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00
Road	0.00	0.00	0.00	0.00
Other Sectors	0.00	0.00	0.00	4796.82
Residential and Services	0.00	0.00	0.00	4482.31
Agriculture	0.00	0.00	0.00	314.51
Non-Energy	0.00	0.00	0.00	0.00

Source: WEC Turkish National Committee web archive [32].

Table B- 3 General energy balance, 2003 (Thousand TOE) (Continued)

Parameter	Heat	Solar	Total
Production (+)	784.00	350.00	23783.02
Imports (+)	0.00	0.00	65239.46
Exports (-)	0.00	0.00	4089.96
Bunker fuel (-)	0.00	0.00	644.27
Stock Changes (+/-)	0.00	0.00	-549.40
Statistical Differences (+/-)	0.00	0.00	86.85
Primary Energy Supply	784.00	350.00	83825.70
Production Except Refinery	0.00	0.00	0.00
Total Primary Energy Supply	784.00	350.00	83825.70
Energy Sector	1746.00	0.00	-18835.63
Electricity Plants	1746.00	0.00	-11730.79
Coking Plant	0.00	0.00	-969.20
Briquette	0.00	0.00	-2.81
Petroleum Refineries	0.00	0.00	-1805.63
Internal Consumption and Losses	0.00	0.00	-4327.20
Total Final Energy Consumption	2530.00	350.00	64990.07
Sectorial Detail	2530.00	350.00	64990.07
Industrial Consumption	1746.00	119.00	27777.32
Iron and Steel	0.00	0.00	3389.59
Chemistry and Petrochemical	0.00	0.00	1597.03
Petrochemical Feedstock	0.00	0.00	1384.06
Manure	0.00	0.00	572.07
Cement	0.00	0.00	2709.69
Sugar	0.00	0.00	704.22
Nonferrous Metals	0.00	0.00	968.82
Others	1746.00	119.00	16451.85
Transportation	0.00	0.00	12395.01
Railways	0.00	0.00	259.74
Sea	0.00	0.00	280.22
Air	0.00	0.00	905.76
Road	0.00	0.00	10949.30
Other Sectors	784.00	231.00	22720.06
Residential and Services	784.00	231.00	19634.01
Agriculture	0.00	0.00	3086.05
Non-Energy	0.00	0.00	2097.68

Source: WEC Turkish National Committee web archive [32].

Table B- 4 General energy balance, 2004 (Thousand TOE)

Parameter	Hard Coal	Lignite	Asphaltite	Coke	Petroleum Coke	Wood
Production (+)	1080.68	9141.12	310.41	0.00	0.00	4317.90
Imports (+)	10928.90	0.00	0.00	272.77	1474.16	0.00
Exports (-)	0.00	0.00	0.00	0.00	0.00	0.00
Bunker fuel (-)	0.00	0.00	0.00	0.00	0.00	0.00
Stock Changes (+/-)	316.27	308.43	0.00	-32.86	-37.28	0.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00	0.00	0.00
Primary Energy Supply	12325.85	9449.55	310.41	239.91	1436.88	4317.90
Production Except Refinery	0.00	0.00	0.00	0.00	0.00	0.00
Total Primary Energy Supply	12325.85	9449.55	310.41	239.91	1436.88	4317.90
Energy Sector	-5744.45	-6207.71	0.00	2172.28	0.00	0.00
Electricity Plants	-2509.01	-6136.22	0.00	0.00	0.00	0.00
Coking Plant	-3205.64	0.00	0.00	2092.78	0.00	0.00
Briquette	0.00	-42.00	0.00	79.50	0.00	0.00
Petroleum Refineries	0.00	0.00	0.00	0.00	0.00	0.00
Internal Consumption and Losses	-29.80	-29.49	0.00	0.00	0.00	0.00
Total Final Energy Consumption	6581.40	3241.84	310.41	2412.19	1436.88	4317.90
Sectorial Detail	6581.46	3241.90	310.41	2412.19	1436.88	4317.90
Industrial Consumption	5985.75	1622.82	310.41	2280.11	1436.88	0.00
Iron and Steel	0.00	0.00	0.00	2180.50	0.00	0.00
Chemistry and Petrochemical	0.00	9.59	0.00	0.00	0.00	0.00
Petrochemical Feedstock	0.00	0.00	0.00	0.00	0.00	0.00
Manure	0.00	3.34	0.00	0.00	0.00	0.00
Cement	1218.91	542.01	0.00	0.00	1395.20	0.00
Sugar	37.57	226.86	0.00	29.53	0.00	0.00
Nonferrous Metals	57.73	18.00	0.00	10.50	0.00	0.00
Others	4671.55	823.02	310.41	59.58	41.68	0.00
Transportation	0.00	0.00	0.00	0.00	0.00	0.00
Railways	0.00	0.00	0.00	0.00	0.00	0.00
Sea	0.00	0.00	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00	0.00	0.00
Road	0.00	0.00	0.00	0.00	0.00	0.00
Other Sectors	595.71	1619.08	0.00	132.07	0.00	4317.90
Residential and Services	595.71	1619.08	0.00	132.07	0.00	4317.90
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00
Non-Energy	0.00	0.00	0.00	0.00	0.00	0.00

Source: WEC Turkish National Committee web archive [32].

Table B- 4 General energy balance, 2004 (Thousand TOE) (Continued)

Parameter	Animal and Plant Residual	Total Solid Fuels	Petroleum/Oil	Natural Gas
Production (+)	1213.94	16064.05	2389.31	644.13
Imports (+)	0.00	12675.83	35334.47	19835.27
Exports (-)	0.00	0.00	3923.26	0.00
Bunker fuel (-)	0.00	0.00	630.62	0.00
Stock Changes (+/-)	0.00	554.56	-391.42	-53.69
Statistical Differences (+/-)	0.00	0.00	143.40	0.00
Primary Energy Supply	1213.94	29294.45	32921.88	20425.71
Production Except Refinery	0.00	0.00	0.00	0.00
Total Primary Energy Supply	1213.94	29294.45	32921.88	20425.71
Energy Sector	0.00	-9779.88	-5788.19	-11753.05
Electricity Plants	0.00	-8645.23	-2576.09	-11746.00
Coking Plant	0.00	-1112.86	0.00	0.00
Briquette	0.00	37.50	-43.28	0.00
Petroleum Refineries	0.00	0.00	-1870.43	0.00
Internal Consumption and Losses	0.00	-59.29	-1298.39	-7.05
Total Final Energy Consumption	1213.94	19514.57	27133.69	8672.67
Sectorial Detail	1213.94	19514.69	27133.69	8672.67
Industrial Consumption	0.00	11635.98	5399.89	4490.24
Iron and Steel	0.00	2180.50	343.85	5.19
Chemistry and Petrochemical	0.00	9.59	758.40	340.19
Petrochemical Feedstock	0.00	0.00	1384.38	0.00
Manure	0.00	3.34	835.48	493.18
Cement	0.00	3156.12	49.61	67.62
Sugar	0.00	293.96	228.62	119.73
Nonferrous Metals	0.00	86.23	265.44	482.73
Others	0.00	5906.24	1534.10	2981.60
Transportation	0.00	0.00	13707.84	3.96
Railways	0.00	0.00	183.20	0.00
Sea	0.00	0.00	388.52	0.00
Air	0.00	0.00	1626.10	0.00
Road	0.00	0.00	11510.03	3.96
Other Sectors	1213.94	7878.71	5851.83	4178.46
Residential and Services	1213.94	7878.71	2873.29	4178.46
Agriculture	0.00	0.00	2978.53	0.00
Non-Energy	0.00	0.00	2174.13	0.00

Source: WEC Turkish National Committee web archive [32].

Table B- 4 General energy balance, 2004 (Thousand TOE) (Continued)

Parameter	Hydraulic	Geothermal	Wind	Electricity
Production (+)	3963.20	79.98	4.96	0.00
Imports (+)	0.00	0.00	0.00	39.86
Exports (-)	0.00	0.00	0.00	98.41
Bunker fuel (-)	0.00	0.00	0.00	
Stock Changes (+/-)	0.00	0.00	0.00	0.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00
Primary Energy Supply	3963.20	79.98	4.96	-58.55
Production Except Refinery	0.00	0.00	0.00	0.00
Total Primary Energy Supply	3963.20	79.98	4.96	-58.55
Energy Sector	-3963.20	-79.98	-4.96	10404.77
Electricity Plants	-3963.20	-79.98	-4.96	12960.05
Coking Plant	0.00	0.00	0.00	0.00
Briquette	0.00	0.00	0.00	0.00
Petroleum Refineries	0.00	0.00	0.00	-71.98
Internal Consumption and Losses	0.00	0.00	0.00	-2483.30
Total Final Energy Consumption	0.00	0.00	0.00	10346.22
Sectorial Detail	0.00	0.00	0.00	10346.22
Industrial Consumption	0.00	0.00	0.00	4991.61
Iron and Steel	0.00	0.00	0.00	940.84
Chemistry and Petrochemical	0.00	0.00	0.00	320.78
Petrochemical Feedstock	0.00	0.00	0.00	0.00
Manure	0.00	0.00	0.00	43.55
Cement	0.00	0.00	0.00	333.52
Sugar	0.00	0.00	0.00	0.00
Nonferrous Metals	0.00	0.00	0.00	231.94
Others	0.00	0.00	0.00	3120.98
Transportation	0.00	0.00	0.00	62.87
Railways	0.00	0.00	0.00	62.87
Sea	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00
Road	0.00	0.00	0.00	0.00
Other Sectors	0.00	0.00	0.00	5291.74
Residential and Services	0.00	0.00	0.00	4956.77
Agriculture	0.00	0.00	0.00	334.97
Non-Energy	0.00	0.00	0.00	0.00

Source: WEC Turkish National Committee web archive [32].

Table B- 4 General energy balance, 2004 (Thousand TOE) (Continued)

Parameter	Heat	Solar	Total
Production (+)	811.00	375.00	24331.63
Imports (+)	0.00	0.00	67885.43
Exports (-)	0.00	0.00	4021.67
Bunker fuel (-)	0.00	0.00	630.62
Stock Changes (+/-)	0.00	0.00	109.46
Statistical Differences (+/-)	0.00	0.00	143.40
Primary Energy Supply	811.00	375.00	87817.63
Production Except Refinery	0.00	0.00	0.00
Total Primary Energy Supply	811.00	375.00	87817.63
Energy Sector	2150.70	0.00	-18813.78
Electricity Plants	2150.70	0.00 0.00	-11904.70
Coking Plant	0.00	0.00	-1112.86
Briquette	0.00	0.00	-5.78
Petroleum Refineries	0.00	0.00	-1942.41
Internal Consumption and Losses	0.00	0.00	-3848.03
Total Final Energy Consumption	2961.70	375.00	69003.85
Sectorial Detail	2961.70	375.00	69003.97
Industrial Consumption	2150.70	121.00	28789.43
Iron and Steel	193.61	0.00	3664.00
Chemistry and Petrochemical	0.00	0.00	1428.96
Petrochemical Feedstock	0.00	0.00	1384.38
Manure	0.00	0.00	1375.55
Cement	0.00	0.00	3606.87
Sugar	0.00	0.00	642.30
Nonferrous Metals	0.00	0.00	1066.34
Others	1957.09	121.00	15621.02
Transportation	0.00	0.00	13774.67
Railways	0.00	0.00	246.06
Sea	0.00	0.00	388.52
Air	0.00	0.00	1626.10
Road	0.00	0.00	11513.99
Other Sectors	811.00	254.00	24265.74
Residential and Services	811.00	254.00	20952.24
Agriculture	0.00	0.00	3313.50
Non-Energy	0.00	0.00	2174.13

Source: WEC Turkish National Committee web archive [32].

Table B- 5 General energy balance, 2005 (Thousand TOE)

Parameter	Hard Coal	Lignite	Asphaltite	Coke	Petroleum Coke	Wood
Production (+)	1183.52	9648.17	381.71	0.00	0.00	4145.70
Imports (+)	11432.15	0.00		289.85	1662.32	0.00
Exports (-)	0.00	0.00	0.00	0.00	0.00	0.00
Bunker fuel (-)	0.00	0.00	0.00	0.00	0.00	0.00
Stock Changes (+/-)	-101.65	-322.43	-64.50	15.30	7.21	0.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00	0.00	0.00
Primary Energy Supply	12514.02	9325.74	317.21	305.15	1669.53	4145.70
Production Except Refinery	0.00	0.00	0.00	0.00	0.00	0.00
Total Primary Energy Supply	12514.02	9325.74	317.21	305.15	1669.53	4145.70
Energy Sector	-5849.42	-6923.56	0.00	2154.19	0.00	0.00
Electricity Plants	-2653.39	-6850.73	0.00		0.00	0.00
Coking Plant	-3170.25	0.00	0.00	2094.19	0.00	0.00
Briquette	0.00	-48.00	0.00	60.00	0.00	0.00
Petroleum Refineries	0.00		0.00		0.00	0.00
Internal Consumption and Losses	-25.78	-24.83	0.00	0.00	0.00	0.00
Total Final Energy Consumption	6664.61	2402.18	317.21	2459.34	1669.53	4145.70
Sectorial Detail	6664.58	2402.18	317.21	2459.34	1669.53	4145.70
Industrial Consumption	6049.87	960.65	59.21	2351.46	1669.53	0.00
Iron and Steel	60.03	0.00	0.00	2212.62	0.00	0.00
Chemistry and Petrochemical	0.00	48.99	0.00	0.00	0.00	0.00
Petrochemical Feedstock	0.00	0.00	0.00	0.00	0.00	0.00
Manure	0.00	0.00	0.00	0.00	0.00	0.00
Cement	1290.26	524.02	0.00	15.40	1620.31	0.00
Sugar	45.37	261.46	0.00	32.38	0.00	0.00
Nonferrous Metals	61.19	0.00	0.00	14.00	0.00	0.00
Others	4593.02	126.18	59.21	77.05	49.22	0.00
Transportation	0.00	0.23	0.00	0.00	0.00	0.00
Railways	0.00	0.23	0.00	0.00	0.00	0.00
Sea	0.00	0.00	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00	0.00	0.00
Road	0.00	0.00	0.00	0.00	0.00	0.00
Other Sectors	614.71	1441.29	258.00	107.88	0.00	4145.70
Residential and Services	614.71	1441.29	258.00	107.88	0.00	4145.70
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00
Non-Energy	0.00	0.00	0.00	0.00	0.00	0.00

Source: WEC Turkish National Committee web archive [32].

Table B- 5 General energy balance, 2005 (Thousand TOE) (Continued)

Parameter	Animal and Plant Residual	Total Solid Fuels	Petroleum/Oil	Natural Gas
Production (+)	1179.21	16538.32	2395.19	816.27
Imports (+)	0.00	13384.32	35519.32	24521.77
Exports (-)	0.00	0.00	5016.33	0.00
Bunker fuel (-)	0.00	0.00	627.62	0.00
Stock Changes (+/-)	0.00	-466.08	-72.00	-323.96
Statistical Differences (+/-)	0.00	0.00	-6.75	0.00
Primary Energy Supply	1179.21	29456.57	32191.80	25014.08
Production Except Refinery	0.00	0.00	0.00	0.00
Total Primary Energy Supply	1179.21	29456.57	32191.80	25014.08
Energy Sector	0.00	-10618.78	-4872.40	-14040.60
Electricity Plants	0.00	-9504.12	-2060.50	-14035.00
Coking Plant	0.00	-1076.05	0.00	0.00
Briquette	0.00	12.00	-13.84	0.00
Petroleum Refineries	0.00	0.00	-1558.03	0.00
Internal Consumption and Losses	0.00	-50.61	-1240.03	-5.60
Total Final Energy Consumption	1179.21	18837.78	27319.40	10973.48
Sectorial Detail	1179.21	18837.75	27319.40	10973.48
Industrial Consumption	0.00	11090.73	4288.38	5504.50
Iron and Steel	0.00	2272.65	253.02	5.69
Chemistry and Petrochemical	0.00	48.99	758.40	734.61
Petrochemical Feedstock	0.00	0.00	793.19	0.00
Manure	0.00	0.00	74.90	555.87
Cement	0.00	3449.99	130.60	77.57
Sugar	0.00	339.22	90.91	120.72
Nonferrous Metals	0.00	75.19	268.61	520.31
Others	0.00	4904.69	1918.75	3489.71
Transportation	0.00	0.23	13780.43	4.32
Railways	0.00	0.23	220.46	0.00
Sea	0.00	0.00	411.41	0.00
Air	0.00	0.00	1368.02	0.00
Road	0.00	0.00	11780.55	4.32
Other Sectors	1179.21	7746.80	5954.86	5464.67
Residential and Services	1179.21	7746.80	2949.42	5464.67
Agriculture	0.00	0.00	3005.44	0.00
Non-Energy	0.00	0.00	3295.72	0.00

Source: WEC Turkish National Committee web archive [32].

Table B- 5 General energy balance, 2005 (Thousand TOE) (Continued)

Parameter	Hydraulic	Geothermal	Wind	Electricity	
Production (+)	3402.20	81.18	5.07	0.00	0.00
Imports (+)	0.00	0.00	0.00	54.69	
Exports (-)	0.00	0.00	0.00	154.64	
Bunker fuel (-)	0.00	0.00	0.00	0.00	
Stock Changes (+/-)	0.00	0.00	0.00	0.00	
Statistical Differences (+/-)	0.00	0.00	0.00	0.00	
Primary Energy Supply	3402.20	81.18	5.07	-99.95	
Production Except Refinery	0.00	0.00	0.00	0.00	
Total Primary Energy Supply	3402.20	81.18	5.07	-99.95	
Energy Sector	-3402.20	-81.18	-5.07	11229.73	
Electricity Plants	-3402.20	-81.18	-5.07	13928.23	
Coking Plant	0.00	0.00	0.00	0.00	
Briquette	0.00	0.00	0.00	0.00	
Petroleum Refineries	0.00	0.00	0.00	-72.84	
Internal Consumption and Losses	0.00	0.00	0.00	-2625.67	
Total Final Energy Consumption	0.00	0.00	0.00	11129.78	
Sectorial Detail	0.00	0.00	0.00	11129.78	
Industrial Consumption	0.00	0.00	0.00	5050.01	
Iron and Steel	0.00	0.00	0.00	1002.85	
Chemistry and Petrochemical	0.00	0.00	0.00	422.52	
Petrochemical Feedstock	0.00	0.00	0.00	0.00	
Manure	0.00	0.00	0.00	43.70	
Cement	0.00	0.00	0.00	371.81	
Sugar	0.00	0.00	0.00	0.00	
Nonferrous Metals	0.00	0.00	0.00	213.71	
Others	0.00	0.00	0.00	2995.42	
Transportation	0.00	0.00	0.00	64.41	
Railways	0.00	0.00	0.00	64.41	
Sea	0.00	0.00	0.00	0.00	
Air	0.00	0.00	0.00	0.00	
Road	0.00	0.00	0.00	0.00	
Other Sectors	0.00	0.00	0.00	6015.36	
Residential and Services	0.00	0.00	0.00	5661.64	
Agriculture	0.00	0.00	0.00	353.72	
Non-Energy	0.00	0.00	0.00	0.00	

Source: WEC Turkish National Committee web archive [32].

Table B- 5 General energy balance, 2005 (Thousand TOE) (Continued)

Parameter	Heat	Solar	Total
Production (+)	926.00	385.00	24549.24
Imports (+)	0.00	0.00	73480.10
Exports (-)	0.00	0.00	5170.96
Bunker fuel (-)	0.00	0.00	627.62
Stock Changes (+/-)	0.00	0.00	-862.04
Statistical Differences (+/-)	0.00	0.00	-6.75
Primary Energy Supply	926.00	385.00	91361.96
Production Except Refinery	0.00	0.00	0.00
Total Primary Energy Supply	926.00	385.00	91361.96
Energy Sector	2227.00	0.00	-19563.52
Electricity Plants	2227.00		-12932.85
Coking Plant	0.00	0.00	-1076.05
Briquette	0.00	0.00	-1.84
Petroleum Refineries	0.00	0.00	-1630.87
Internal Consumption and Losses	0.00	0.00	-3921.91
Total Final Energy Consumption	3153.00	385.00	71798.44
Sectorial Detail	3153.00	385.00	71798.41
Industrial Consumption	2227.00	121.00	28281.61
Iron and Steel	166.55	0.00	3700.76
Chemistry and Petrochemical	0.00	0.00	1964.52
Petrochemical Feedstock	0.00	0.00	793.19
Manure	0.00	0.00	674.47
Cement	0.00	0.00	4029.97
Sugar	0.00	0.00	550.84
Nonferrous Metals	0.00	0.00	1077.82
Others	2060.45	121.00	15490.03
Transportation	0.00	0.00	13849.40
Railways	0.00	0.00	285.10
Sea	0.00	0.00	411.41
Air	0.00	0.00	1368.02
Road	0.00	0.00	11784.87
Other Sectors	926.00	264.00	26371.68
Residential and Services	926.00	264.00	23012.52
Agriculture	0.00	0.00	3359.16
Non-Energy	0.00	0.00	3295.72

Source: WEC Turkish National Committee web archive [32].

Table B- 6 General energy balance, 2006 (Thousand TOE)

Parameter	Hard Coal	Lignite	Asphaltite	Coke	Petroleum Coke	Wood
Production (+)	1364.55	11600.02	194.53	0.00	0.00	3988.04
Imports (+)	13351.70	8.81	0.00	317.99	1454.77	0.00
Exports (-)	0.00	0.00	0.00	0.00	0.00	0.00
Bunker fuel (-)	0.00	0.00	0.00	0.00	0.00	0.00
Stock Changes (+/-)	107.56	-367.52	64.50	-13.40	70.95	0.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00	0.00	0.00
Primary Energy Supply	14823.81	11241.32	259.03	304.59	1525.72	3988.04
Production Except Refinery	0.00	0.00	0.00	0.00	0.00	0.00
Total Primary Energy Supply	14823.81	11241.32	259.03	304.59	1525.72	3988.04
Energy Sector	-6645.80	-8473.58	0.00	2326.49	0.00	-7.64
Electricity Plants	-3060.77	-8392.51	0.00	0.00	0.00	-7.64
Coking Plant	-3558.75	0.00	0.00	2248.99	0.00	0.00
Briquette	0.00	-57.00	0.00	77.50	0.00	0.00
Petroleum Refineries	0.00		0.00	0.00	0.00	0.00
Internal Consumption and Losses	-26.28	-24.07	0.00	0.00	0.00	0.00
Total Final Energy Consumption	8178.01	2767.73	259.03	2631.09	1525.72	3980.40
Sectorial Detail	8178.07	2767.73	259.03	2631.09	1525.72	3980.40
Industrial Consumption	7609.36	1206.34	51.60	2528.35	1525.72	0.00
Iron and Steel	58.74	0.00	0.00	2225.64	0.00	0.00
Chemistry and Petrochemical	0.00	50.73	0.00	0.00	0.00	0.00
Petrochemical Feedstock	0.00	0.00	0.00	0.00	0.00	0.00
Manure	0.00	0.00	0.00	0.00	0.00	0.00
Cement	1419.03	562.79	0.00	14.00	1498.19	0.00
Sugar	46.20	216.58	0.00	33.33	0.00	0.00
Nonferrous Metals	60.21	0.00	0.00	14.00	0.00	0.00
Others	6025.17	376.24	51.60	241.38	27.53	0.00
Transportation	0.00	0.00	0.00	0.00	0.00	0.00
Railways	0.00	0.00	0.00	0.00	0.00	0.00
Sea	0.00	0.00	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00	0.00	0.00
Road	0.00	0.00	0.00	0.00	0.00	0.00
Other Sectors	568.71	1561.39	207.43	102.73	0.00	3980.40
Residential and Services	568.71	1561.39	207.43	102.73	0.00	3980.40
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00
Non-Energy	0.00	0.00	0.00	0.00	0.00	0.00

Source: WEC Turkish National Committee web archive [32].

Table B- 6 General energy balance, 2006 (Thousand TOE) (Continued)

Parameter	Animal and Plant Residual	Total Solid Fuels	Petroleum/Oil	Natural Gas
Production (+)	1146.32	18293.45	2284.45	825.00
Imports (+)	0.00	15133.28	37355.62	27975.58
Exports (-)	0.00	0.00	6379.39	0.00
Bunker fuel (-)	0.00	0.00	588.25	0.00
Stock Changes (+/-)	0.00	-137.91	-368.15	-306.00
Statistical Differences (+/-)	0.00	0.00	246.99	0.00
Primary Energy Supply	1146.32	33288.82	32551.26	28494.58
Production Except Refinery	0.00	0.00	0.00	0.00
Total Primary Energy Supply	1146.32	33288.82	32551.26	28494.58
Energy Sector	0.00	-12800.52	-5034.75	-15063.60
Electricity Plants	0.00	-11460.91	-1754.67	-15058.00
Coking Plant	0.00	-1309.76	0.00	0.00
Briquette	0.00	20.50	-23.83	0.00
Petroleum Refineries	0.00	0.00	-1561.38	0.00
Internal Consumption and Losses	0.00	-50.35	-1694.87	-5.60
Total Final Energy Consumption	1146.32	20488.30	27516.51	13430.98
Sectorial Detail	1146.32	20488.36	27516.51	13430.98
Industrial Consumption	0.00	12921.37	3333.72	6631.53
Iron and Steel	0.00	2284.38	164.67	4.70
Chemistry and Petrochemical	0.00	50.73	633.60	920.88
Petrochemical Feedstock	0.00	0.00	1071.15	0.00
Manure	0.00	0.00	74.17	147.56
Cement	0.00	3494.01	124.46	75.06
Sugar	0.00	296.12	92.46	168.25
Nonferrous Metals	0.00	74.21	268.61	660.52
Others	0.00	6721.93	904.60	4654.56
Transportation	0.00	0.00	14793.77	4.69
Railways	0.00	0.00	221.49	0.00
Sea	0.00	0.00	464.21	0.00
Air	0.00	0.00	1509.36	0.00
Road	0.00	0.00	12598.71	4.69
Other Sectors	1146.32	7566.98	5225.88	6794.76
Residential and Services	1146.32	7566.98	1997.91	6794.76
Agriculture	0.00	0.00	3227.97	0.00
Non-Energy	0.00	0.00	4163.14	0.00

Source: WEC Turkish National Committee web archive [32].

Table B- 6 General energy balance, 2006 (Thousand TOE) (Continued)

Parameter	Hydraulic +Geothermal	Biofuel	Wind	Electricity
Production (+)	3885.84	18.59	10.88	0.00
Imports (+)	0.00	0.00	0.00	49.30
Exports (-)	0.00	0.00	0.00	192.27
Bunker fuel (-)	0.00	0.00	0.00	0.00
Stock Changes (+/-)	0.00	-0.97	0.00	0.00
Statistical Differences(+/-)	0.00	0.00	0.00	0.00
Primary Energy Supply	3885.84	17.61	10.88	-142.98
Production Except Refinery	0.00	0.00	0.00	0.00
Total Primary Energy Supply	3885.84	17.61	10.88	-142.98
Energy Sector	-3885.84	0.00	-10.88	12373.51
Electricity Plants	-3885.84	0.00	-10.88	15161.78
Coking Plant	0.00	0.00	0.00	0.00
Briquette	0.00	0.00	0.00	0.00
Petroleum Refineries	0.00	0.00	0.00	-73.53
Internal Consumption and Losses	0.00	0.00	0.00	-2714.74
Total Final Energy Consumption	0.00	17.61	0.00	12230.53
Sectorial Detail	0.00	17.70	0.00	12230.53
Industrial Consumption	0.00	0.00	0.00	5776.79
Iron and Steel	0.00	0.00	0.00	1152.23
Chemistry and Petrochemical	0.00	0.00	0.00	353.29
Petrochemical Feedstock	0.00	0.00	0.00	0.00
Manure	0.00	0.00	0.00	43.95
Cement	0.00	0.00	0.00	395.14
Sugar	0.00	0.00	0.00	0.00
Nonferrous Metals	0.00	0.00	0.00	239.51
Others	0.00	0.00	0.00	3592.68
Transportation	0.00	17.70	0.00	67.94
Railways	0.00	0.00	0.00	67.94
Sea	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00
Road	0.00	17.70	0.00	0.00
Other Sectors	0.00	0.00	0.00	6385.80
Residential and Services	0.00	0.00	0.00	6003.88
Agriculture	0.00	0.00	0.00	381.93
Non-Energy	0.00	0.00	0.00	0.00

Source: WEC Turkish National Committee web archive [32].

Table B- 6 General energy balance, 2006 (Thousand TOE) (Continued)

Parameter	Heat	Solar	Total
Production (+)	1081.00	402.50	26801.70
Imports (+)	0.00	0.00	80513.77
Exports (-)	0.00	0.00	6571.66
Bunker fuel (-)	0.00	0.00	588.25
Stock Changes (+/-)	0.00	0.00	-813.03
Statistical Differences (+/-)	0.00	0.00	246.99
Primary Energy Supply	1081.00	402.50	99589.52
Production Except Refinery	0.00	0.00	0.00
Total Primary Energy Supply	1081.00	402.50	99589.52
Energy Sector	2198.89	0.00	-22223.19
Electricity Plants	2198.89	0.00	-14809.63
Coking Plant	0.00	0.00	-1309.76
Briquette	0.00	0.00	-3.33
Petroleum Refineries	0.00	0.00	-1634.91
Internal Consumption and Losses	0.00	0.00	-4465.57
Total Final Energy Consumption	3279.89	402.50	77366.33
Sectorial Detail	3279.89	402.50	77366.47
Industrial Consumption	2198.89	121.50	30983.81
Iron and Steel	183.23	0.00	3789.21
Chemistry and Petrochemical	0.00	0.00	1958.49
Petrochemical Feedstock	0.00	0.00	1071.15
Manure	0.00	0.00	265.68
Cement	0.00	0.00	4088.67
Sugar	0.00	0.00	556.83
Nonferrous Metals	0.00	0.00	1242.85
Others	2015.66	121.50	18010.92
Transportation	0.00	0.00	14884.10
Railways	0.00	0.00	289.43
Sea	0.00	0.00	464.21
Air	0.00	0.00	1509.36
Road	0.00	0.00	12621.10
Other Sectors	1081.00	281.00	27335.42
Residential and Services	1081.00	281.00	23725.52
Agriculture	0.00	0.00	3609.90
Non-Energy	0.00	0.00	4163.14

Source: WEC Turkish National Committee web archive [32].

Table B- 7 General energy balance, 2007 (Thousand TOE)

Parameter	Hard Coal	Lignite	Asphaltite	Coke	Petroleum Coke	Wood
Production (+)	1089.46	13371.84	336.11	0.00	0.00	3879.72
Imports (+)	14333.64	0.00	0.00	309.17	1496.88	0.00
Exports (-)	0.00	0.00	0.00	0.00	0.00	0.00
Bunker fuel (-)	0.00	0.00	0.00	0.00	0.00	0.00
Stock Changes (+/-)	-11.83	72.27	-64.50	27.48	-51.63	0.00
Statistical Differences(+/-)	0.00	0.00	0.00	0.00	0.00	0.00
Primary Energy Supply	15411.26	13444.10	271.61	336.65	1445.25	3879.72
Energy Sector	-6486.33	-9819.98	0.00	2362.52	0.00	-58.02
Electricity Plants	-3136.97	-9771.08	0.00	0.00	0.00	-58.02
Coking Plant	-3237.31	0.00	0.00	2334.77	0.00	0.00
Briquette	0.00	-23.96	0.00	27.75	0.00	0.00
Petroleum Refineries	0.00	0.00	0.00	0.00	0.00	0.00
Internal Consumption and Losses	-112.06	-24.94	0.00	0.00	0.00	0.00
Total Final Energy Consumption	8924.94	3624.13	271.61	2699.16	1445.25	3821.70
Sectorial Detail	8924.94	3624.13	271.61	2699.16	1445.25	3821.70
Industrial Consumption	8406.69	1741.54	54.31	2653.15	1445.25	0.00
Iron and Steel	176.23	0.00	0.00	2379.73	0.00	0.00
Chemistry and Petrochemical	0.00	10.84	0.00	0.00	0.00	0.00
Petrochemical Feedstock	0.00	0.00	0.00	0.00	0.00	0.00
Manure	0.00	0.00	0.00	0.00	0.00	0.00
Cement	1603.22	573.81	0.00	0.00	1132.96	0.00
Sugar	7.84	194.84	0.00	25.00	0.00	0.00
Nonferrous Metals	98.20	0.00	0.00	54.56	0.00	0.00
Others	6521.19	962.04	54.31	193.86	280.05	0.00
Transportation	0.00	0.00	0.00	0.00	0.00	0.00
Railways	0.00	0.00	0.00	0.00	0.00	0.00
Sea	0.00	0.00	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00	0.00	0.00
Pipeline	0.00	0.00	0.00	0.00	0.00	0.00
Road	0.00	0.00	0.00	0.00	0.00	0.00
Other Sectors	518.25	1882.59	217.30	46.02	0.00	3821.70
Residential and Services	518.25	1882.59	217.30	46.02	0.00	3821.70
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00
Non-Energy	0.00	0.00	0.00	0.00	0.00	0.00

Source: MENR website [33].

Table B- 7 General energy balance, 2007 (Thousand TOE) (Continued)

Parameter	Animal and Plant Residual	Total Solid Fuels	Petroleum/Oil	Natural Gas
Production (+)	1115.50	19792.62	2240.88	826.61
Imports (+)	0.00	16139.68	38232.54	33167.07
Exports (-)	0.00	0.00	6688.64	28.58
Bunker fuel (-)	0.00	0.00	91.71	0.00
Stock Changes (+/-)	0.00	-28.22	-366.90	-12.40
Statistical Differences(+/-)	0.00	0.00	-16.18	0.00
Primary Energy Supply	1115.50	35904.08	33309.99	33952.70
Energy Sector	0.00	-14001.80	-3879.91	-18168.37
Electricity Plants	0.00	-12966.07	-1034.59	-17567.48
Coking Plant	0.00	-902.53	0.00	0.00
Briquette	0.00	3.79	-9.52	
Petroleum Refineries	0.00	0.00	-1484.91	-552.46
Internal Consumption and Losses	0.00	-136.99	-1350.89	-48.43
Total Final Energy Consumption	1115.50	21902.28	29430.08	15784.33
Sectorial Detail	1115.50	21902.28	29430.08	15784.33
Industrial Consumption	0.00	14300.93	2718.06	7921.00
Iron and Steel	0.00	2555.96	135.85	0.72
Chemistry and Petrochemical	0.00	10.84	24.44	981.94
Petrochemical Feedstock	0.00	0.00	810.03	0.00
Manure	0.00	0.00	4.78	0.00
Cement	0.00	3310.00	21.47	90.87
Sugar	0.00	227.68	62.22	70.88
Nonferrous Metals	0.00	152.76	21.02	3990.59
Others	0.00	8011.46	1638.24	2785.99
Transportation	0.00	0.00	17005.17	185.64
Railways	0.00	0.00	136.72	0.00
Sea	0.00	0.00	507.33	0.00
Air	0.00	0.00	2014.28	0.00
Pipeline	0.00	0.00	0.00	175.58
Road	0.00	0.00	14346.84	10.05
Other Sectors	1115.50	7601.35	5276.56	7677.69
Residential and Services	1115.50	7601.35	1760.17	7677.69
Agriculture	0.00	0.00	3516.39	0.00
Non-Energy	0.00	0.00	4430.29	0.00

Source: MENR website [33].

Table B- 7 General energy balance, 2007 (Thousand TOE) (Continued)

Parameter	Hydraulic +Geothermal	Biofuel	Wind	Electricity
Production (+)	3217.24	10.62	30.54	0.00
Imports (+)	0.00	0.00	0.00	74.33
Exports (-)	0.00	0.00	0.00	208.31
Bunker fuel (-)	0.00	0.00	0.00	0.00
Stock Changes (+/-)	0.00	0.00	0.00	0.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00
Primary Energy Supply	3217.24	10.62	30.54	-133.98
Energy Sector	-3217.24	0.00	-30.54	13386.76
Electricity Plants	-3217.24		-30.54	16474.00
Coking Plant	0.00	0.00	0.00	0.00
Briquette				
Petroleum Refineries	0.00	0.00	0.00	-88.85
Internal Consumption and Losses	0.00	0.00	0.00	-2998.39
Total Final Energy Consumption	0.00	10.62	0.00	13252.79
Sectorial Detail	0.00	10.62	0.00	13252.79
Industrial Consumption	0.00	0.00	0.00	6346.33
Iron and Steel	0.00	0.00	0.00	1331.02
Chemistry and Petrochemical	0.00	0.00	0.00	395.14
Petrochemical Feedstock	0.00	0.00	0.00	0.00
Manure	0.00	0.00	0.00	16.79
Cement	0.00	0.00	0.00	470.88
Sugar	0.00	0.00	0.00	0.00
Nonferrous Metals	0.00	0.00	0.00	261.10
Others	0.00	0.00	0.00	3863.48
Transportation	0.00	10.62	0.00	80.50
Railways	0.00	0.00	0.00	80.50
Sea	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00
Pipeline	0.00	0.00	0.00	0.00
Road	0.00	10.62	0.00	0.00
Other Sectors	0.00	0.00	0.00	6825.96
Residential and Services	0.00	0.00	0.00	6397.59
Agriculture	0.00	0.00	0.00	428.37
Non-Energy	0.00	0.00	0.00	0.00

Source: MENR website [33].

Table B- 7 General energy balance, 2007 (Thousand TOE) (Continued)

Parameter	Electricity	Heat	Solar	Total
Production (+)	0.00	914.00	420.00	27452.52
Imports (+)	74.33	0.00	0.00	87613.62
Exports (-)	208.31	0.00	0.00	6925.53
Bunker fuel (-)	0.00	0.00	0.00	91.71
Stock Changes (+/-)	0.00	0.00	0.00	-407.53
Statistical Differences (+/-)	0.00	0.00	0.00	-16.18
Primary Energy Supply	-133.98	914.00	420.00	107625.19
Energy Sector	13386.76	958.49	0.00	-24952.60
Electricity Plants	16474.00	958.49	0.00	-17383.43
Coking Plant	0.00	0.00	0.00	-902.53
Briquette				-5.74
Petroleum Refineries	-88.85	0.00	0.00	-2126.21
Internal Consumption and Losses	-2998.39	0.00	0.00	-4534.70
Total Final Energy Consumption	13252.79	1872.49	420.00	82672.59
Sectorial Detail	13252.79	1872.49	420.00	82672.59
Industrial Consumption	6346.33	958.49	126.00	32370.81
Iron and Steel	1331.02	183.23	0.00	4206.79
Chemistry and Petrochemical	395.14	0.00	0.00	1412.36
Petrochemical Feedstock	0.00	0.00	0.00	810.03
Manure	16.79	0.00	0.00	21.57
Cement	470.88	0.00	0.00	3893.22
Sugar	0.00	0.00	0.00	360.79
Nonferrous Metals	261.10	0.00	0.00	4425.47
Others	3863.48	775.26	126.00	17200.43
Transportation	80.50	0.00	0.00	17281.92
Railways	80.50	0.00	0.00	217.21
Sea	0.00	0.00	0.00	507.33
Air	0.00	0.00	0.00	2014.28
Pipeline	0.00	0.00	0.00	175.58
Road	0.00	0.00	0.00	14367.52
Other Sectors	6825.96	914.00	294.00	28589.56
Residential and Services	6397.59	914.00	294.00	24644.81
Agriculture	428.37	0.00	0.00	3944.75
Non-Energy	0.00	0.00	0.00	4430.29

Source: MENR website [33].

Table B- 8 General energy balance, 2008 (Thousand TOE)

Parameter	Hard Coal	Lignite	Asphaltite	Coke	Petroleum Coke
Production (+)	1204.31	15204.98	264.60	0.00	0.00
Imports (+)	12708.02		0.00	146.83	1739.84
Exports (-)	0.00	0.00	0.00	0.00	0.00
Bunker fuel (-)	0.00	0.00	0.00	0.00	0.00
Stock Changes (+/-)	266.96	-201.93	0.00	1.82	55.60
Statistical Differences (+/-)	0.00	0.00	0.00	0.00	0.00
Primary Energy Supply	14179.28	15003.05	264.60	148.65	1795.45
Energy Sector	-7169.74	-10865.39	0.00	2466.30	0.00
Electricity Plants	-3288.36	-10821.53	0.00	0.00	0.00
Air Gas Plant (-)	0.00	0.00	0.00	0.00	0.00
Coking Plant	-3853.44	0.00	0.00	2532.14	0.00
Briquette	0.00	-21.10	0.00		0.00
Petroleum Refineries	0.00	0.00	0.00	0.00	0.00
Internal Consumption and Losses	-27.94	-22.76	0.00	-65.84	0.00
Total Final Energy Consumption	7009.54	4137.67	264.60	2614.95	1795.45
Sectorial Detail	7009.54	4137.67	264.60	2614.95	1795.45
Industrial Consumption	2815.96	1921.75	96.60	2614.95	1795.45
Iron and Steel	437.24	0.00	0.00	2342.65	0.14
Chemistry and Petrochemical	0.70	5.37	0.00	0.00	0.00
Petrochemical Feedstock	0.00	0.00	0.00	0.00	0.00
Manure	0.00	0.00	0.00	0.00	0.00
Cement	1570.11	1104.57	42.00	0.00	1438.00
Sugar	5.22	24.46	0.00	29.14	0.00
Nonferrous Metals	0.00	0.00	0.00	0.00	0.00
Others	802.68	787.35	54.60	243.15	357.31
Transportation	0.00	0.00	0.00	0.00	0.00
Railways	0.00	0.00	0.00	0.00	0.00
Sea	0.00	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00	0.00
Pipeline	0.00	0.00	0.00	0.00	0.00
Road	0.00	0.00	0.00	0.00	0.00
Other Sectors	4193.59	2215.92	168.00	0.00	0.00
Residential and Services	4193.59	2215.92	168.00	0.00	0.00
Agriculture	0.00	0.00	0.00	0.00	0.00
Non-Energy	0.00	0.00	0.00	0.00	0.00

Source: MENR website [33].

Table B- 8 General energy balance, 2008 (Thousand TOE) (Continued)

Parameter	Briquette	Wood	Animal and Plant Residual	Total Solid Fuels
Production (+)	0.00	3679.12	1134.42	21487.42
Imports (+)	0.00	0.00	0.00	14594.69
Exports (-)	0.00	0.00	0.00	0.00
Bunker fuel (-)	0.00	0.00	0.00	0.00
Stock Changes (+/-)	0.00	0.00	0.00	122.45
Statistical Differences (+/-)	0.00	0.00	0.00	0.00
Primary Energy Supply	0.00	3679.12	1134.42	36204.56
Energy Sector	20.83	-9.82	-48.13	-15605.94
Electricity Plants	0.00	-9.82	-48.13	-14167.83
Air Gas Plant (-)	0.00	0.00	0.00	0.00
Coking Plant	0.00	0.00	0.00	-1321.30
Briquette	20.83	0.00	0.00	-0.27
Petroleum Refineries	0.00	0.00	0.00	0.00
Internal Consumption and Losses	0.00	0.00	0.00	-116.54
Total Final Energy Consumption	20.83	3669.30	1086.29	20598.62
Sectorial Detail	20.83	3669.30	1086.29	20598.62
Industrial Consumption	0.00	0.00	0.00	9244.70
Iron and Steel	0.00	0.00	0.00	2780.03
Chemistry and Petrochemical	0.00	0.00	0.00	6.07
Petrochemical Feedstock	0.00	0.00	0.00	0.00
Manure	0.00	0.00	0.00	0.00
Cement	0.00	0.00	0.00	4154.68
Sugar	0.00	0.00	0.00	58.83
Nonferrous Metals	0.00	0.00	0.00	0.00
Others	0.00	0.00	0.00	2245.09
Transportation	0.00	0.00	0.00	0.00
Railways	0.00	0.00	0.00	0.00
Sea	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00
Pipeline	0.00	0.00	0.00	0.00
Road	0.00	0.00	0.00	0.00
Other Sectors	20.83	3669.30	1086.29	11353.92
Residential and Services	20.83	3669.30	1086.29	11353.92
Agriculture	0.00	0.00	0.00	0.00
Non-Energy	0.00	0.00	0.00	0.00

Source: MENR website [33].

Table B- 8 General energy balance, 2008 (Thousand TOE) (Continued)

Parameter	Petroleum/Oil	Natural Gas	Hydraulic	Geothermal	Biofuel
Production (+)	2268.07	930.65	2861.20	139.69	1.42
Imports (+)	36680.93	34013.38	0.00	0.00	0.00
Exports (-)	6687.93	399.02	0.00	0.00	0.00
Bunker fuel (-)	760.62	0.00	0.00	0.00	0.00
Stock Changes (+/-)	371.00	-737.73	0.00	0.00	0.00
Statistical Differences (+/-)	-87.58	0.00	0.00	0.00	0.00
Primary Energy Supply	31783.88	33807.28	2861.20	139.69	1.42
Energy Sector	-3051.56	-19850.38	-2861.20	-139.69	0.00
Electricity Plants	-1700.23	-19143.44	-2861.20	-139.69	0.00
Air Gas Plant (-)	0.00	0.00	0.00	0.00	0.00
Coking Plant	0.00	0.00	0.00	0.00	0.00
Briquette	-8.15	0.00	0.00	0.00	0.00
Petroleum Refineries	-1096.07	-448.48	0.00	0.00	0.00
Internal Consumption and Losses	-247.11	-258.46	0.00	0.00	0.00
Total Final Energy Consumption	28732.32	13956.90	0.00	0.00	1.42
Sectorial Detail	28732.32	13956.90	0.00	0.00	1.42
Industrial Consumption	2520.57	6502.44	0.00	0.00	0.00
Iron and Steel	96.63	721.49	0.00	0.00	0.00
Chemistry and Petrochemical	0.49	199.36	0.00	0.00	0.00
Petrochemical Feedstock	559.93	0.00	0.00	0.00	0.00
Manure	6.77	213.55	0.00	0.00	0.00
Cement	595.52	13.87	0.00	0.00	0.00
Sugar	337.10	26.70	0.00	0.00	0.00
Nonferrous Metals	3.86	108.51	0.00	0.00	0.00
Others	920.26	5218.95	0.00	0.00	0.00
Transportation	15732.83	203.45	0.00	0.00	1.42
Railways	145.22	0.00	0.00	0.00	0.00
Sea	491.09	0.00	0.00	0.00	0.00
Air	1748.38	0.00	0.00	0.00	0.00
Pipeline	0.00	174.78	0.00	0.00	0.00
Road	13348.14	28.67	0.00	0.00	1.42
Other Sectors	6138.08	7251.01	0.00	0.00	0.00
Residential and Services	1683.34	7251.01	0.00	0.00	0.00
Agriculture	4454.74	0.00	0.00	0.00	0.00
Non-Energy	4340.85	0.00	0.00	0.00	0.00

Source: MENR website [33].

Table B- 8 General energy balance, 2008 (Thousand TOE) (Continued)

Parameter	Wind	Electricity	Heat	Solar	Total
Production (+)	72.80	0.00	1011.01	420.00	29192.27
Imports (+)	0.00	67.89	0.00	0.00	85356.89
Exports (-)	0.00	96.51	0.00	0.00	7183.45
Bunker fuel (-)	0.00	0.00	0.00	0.00	760.62
Stock Changes (+/-)	0.00	0.00	0.00	0.00	-244.28
Statistical Differences (+/-)	0.00	0.00	0.00	0.00	-87.58
Primary Energy Supply	72.80	-28.62	1011.01	420.00	106273.23
Energy Sector	-72.80	13786.77	1015.82	0.00	-26778.98
Electricity Plants	-72.80	17063.94	1015.82	0.00	-20005.43
Air Gas Plant (-)	0.00	0.00	0.00	0.00	0.00
Coking Plant	0.00	0.00	0.00	0.00	-1321.30
Briquette	0.00	0.00	0.00	0.00	-8.42
Petroleum Refineries	0.00	-169.33	0.00	0.00	-1713.88
Internal Consumption and Losses	0.00	-3107.84	0.00	0.00	-3729.94
Total Final Energy Consumption	0.00	13758.15	2026.83	420.00	79494.24
Sectorial Detail	0.00	13758.15	2026.83	420.00	79494.24
Industrial Consumption	0.00	6267.79	1015.82	126.00	25677.32
Iron and Steel	0.00	1377.28	0.00	0.00	4975.44
Chemistry and Petrochemical	0.00	317.25	0.00	0.00	523.18
Petrochemical Feedstock	0.00	0.00	0.00	0.00	559.93
Manure	0.00	21.62	0.00	0.00	241.94
Cement	0.00	485.58	0.00	0.00	5249.66
Sugar	0.00	40.35	0.00	0.00	462.99
Nonferrous Metals	0.00	212.58	0.00	0.00	324.95
Others	0.00	3813.12	1015.82	126.00	13339.24
Transportation	0.00	41.76	0.00	0.00	15979.45
Railways	0.00	19.01	0.00	0.00	164.23
Sea	0.00	0.00	0.00	0.00	491.09
Air	0.00	0.00	0.00	0.00	1748.38
Pipeline	0.00	12.90	0.00	0.00	187.68
Road	0.00	9.85	0.00	0.00	13388.08
Other Sectors	0.00	7448.61	1011.01	294.00	33496.63
Residential and Services	0.00	6949.25	791.03	294.00	28322.55
Agriculture	0.00	499.36	219.98	0.00	5174.07
Non-Energy	0.00	0.00	0.00	0.00	4340.85

Source: MENR website [33].

Table B- 9 General energy balance, 2009 (Thousand TOE)

Parameter	Hard Coal	Lignite	Asphaltite	Coke	Petroleum Coke
Production (+)	1294.00	15632.00	476.00	0.00	0.00
Imports (+)	13119.00	0.00	0.00	183.00	2039.00
Exports (-)	0.00	0.00	0.00	0.00	0.00
Bunker fuel (-)	0.00	0.00	0.00	0.00	0.00
Stock Changes (+/-)	355.00	40.00	-26.00	-174.00	-24.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00	0.00
Primary Energy Supply	14768.00	15672.00	450.00	8.00	2015.00
Energy Sector	-6917.00	-10355.00	-104.00	2292.00	0.00
Electricity Plants	-3409.00	-10336.00	-104.00	0.00	0.00
Air Gas Plant (-)	0.00	0.00	0.00	0.00	0.00
Coking Plant	-3383.00	0.00	0.00	2292.00	0.00
Briquette	0.00	0.00	0.00	0.00	0.00
Petroleum Refineries	0.00	0.00	0.00	0.00	0.00
Internal Consumption and Losses	-126.00	-19.00	0.00	0.00	0.00
Total Final Energy Consumption	7851.00	5317.00	345.00	2300.00	2015.00
Sectorial Detail	7851.00	5317.00	345.00	2300.00	2015.00
Industrial Consumption	2816.00	2506.00	137.00	2300.00	2015.00
Iron and Steel	597.00	0.00	0.00	2231.00	0.00
Chemistry and Petrochemical	48.00	84.00	0.00	0.00	0.00
Petrochemical Feedstock	0.00	0.00	0.00	0.00	0.00
Manure	0.00	0.00	0.00	0.00	0.00
Cement	1474.00	674.00	0.00	0.00	1748.00
Sugar	4.00	40.00	0.00	32.00	0.00
Nonferrous Metals	0.00	19.00	0.00	0.00	14.00
Others	693.00	1688.00	137.00	37.00	253.00
Transportation	0.00	0.00	0.00	0.00	0.00
Railways	0.00	0.00	0.00	0.00	0.00
Sea	0.00	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00	0.00
Pipeline	0.00	0.00	0.00	0.00	0.00
Road	0.00	0.00	0.00	0.00	0.00
Other Sectors	5036.00	2811.00	208.00	0.60	0.00
Residential and Services	5035.00	2811.00	208.00	0.60	0.00
Agriculture	1.00	0.00	0.00	0.00	0.00
Non-Energy	0.00	0.00	0.00	0.00	0.00

Source: MENR website [33].

Table B- 9 General energy balance, 2009 (Thousand TOE) (Continued)

Parameter	Briquette	Wood	Animal and Plant Residual	Total Solid Fuels
Production (+)	0.00	3530.00	1136.00	22068.00
Imports (+)	0.00	0.00	0.00	15341.00
Exports (-)	0.00	0.00	0.00	0.00
Bunker fuel (-)	0.00	0.00	0.00	0.00
Stock Changes (+/-)	0.00	0.00	0.00	170.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00
Primary Energy Supply	0.00	3530.00	1136.00	37579.00
Energy Sector	0.00	-7.00	-77.00	-15169.00
Electricity Plants	0.00	-7.00	-77.00	-13933.00
Air Gas Plant (-)	0.00	0.00	0.00	0.00
Coking Plant	0.00	0.00	0.00	-1091.00
Briquette	0.00	0.00	0.00	0.00
Petroleum Refineries	0.00	0.00	0.00	0.00
Internal Consumption and Losses	0.00	0.00	0.00	-145.00
Total Final Energy Consumption	0.00	3523.00	1059.00	22410.00
Sectorial Detail	0.00	3523.00	1059.00	22410.00
Industrial Consumption	0.00	0.00	0.00	9773.00
Iron and Steel	0.00	0.00	0.00	2828.00
Chemistry and Petrochemical	0.00	0.00	0.00	132.00
Petrochemical Feedstock	0.00	0.00	0.00	0.00
Manure	0.00	0.00	0.00	0.00
Cement	0.00	0.00	0.00	3896.00
Sugar	0.00	0.00	0.00	76.00
Nonferrous Metals	0.00	0.00	0.00	33.00
Others	0.00	0.00	0.00	2808.00
Transportation	0.00	0.00	0.00	0.00
Railways	0.00	0.00	0.00	0.00
Sea	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00
Pipeline	0.00	0.00	0.00	0.00
Road	0.00	0.00	0.00	0.00
Other Sectors	0.00	3523.00	1059.00	12638.00
Residential and Services	0.00	3523.00	1059.00	12637.00
Agriculture	0.00	0.00	0.00	1.00
Non-Energy	0.00	0.00	0.00	0.00

Source: MENR website [33].

Table B- 9 General energy balance, 2009 (Thousand TOE) (Continued)

Parameter	Petroleum/Oil	Natural Gas	Hydraulic	Geothermal	Biofuel
Production (+)	2349.00	627.00	3092.00	375.00	9.00
Imports (+)	33887.00	32827.00	0.00	0.00	0.00
Exports (-)	6048.00	649.00	0.00	0.00	0.00
Bunker fuel (-)	657.00	0.00	0.00	0.00	0.00
Stock Changes (+/-)	-441.00	-30.00	0.00	0.00	0.00
Statistical Differences (+/-)	1473.00	0.00	0.00	0.00	0.00
Primary Energy Supply	30565.00	32775.00	3092.00	375.00	9.00
Energy Sector	-1225.00	-20089.00	-3092.00	-375.00	0.00
Electricity Plants	-1169.00	-18752.00	-3092.00	-375.00	0.00
Air Gas Plant (-)	0.00	0.00	0.00	0.00	0.00
Coking Plant	0.00	0.00	0.00	0.00	0.00
Briquette	0.00	0.00	0.00	0.00	0.00
Petroleum Refineries	-1344.00	-917.00	0.00	0.00	0.00
Internal Consumption and Losses	1288.00	-420.00	0.00	0.00	0.00
Total Final Energy Consumption	29340.00	12685.00	0.00	0.00	9.00
Sectorial Detail	29340.00	12685.00	0.00	0.00	9.00
Industrial Consumption	3539.00	5507.00	0.00	0.00	0.00
Iron and Steel	9.00	710.00	0.00	0.00	0.00
Chemistry and Petrochemical	58.00	296.00	0.00	0.00	0.00
Petrochemical Feedstock	1796.00	0.00	0.00	0.00	0.00
Manure	5.00	26.00	0.00	0.00	0.00
Cement	31.00	20.00	0.00	0.00	0.00
Sugar	15.00	16.00	0.00	0.00	0.00
Nonferrous Metals	3.00	429.00	0.00	0.00	0.00
Others	1623.00	4009.00	0.00	0.00	0.00
Transportation	15642.00	208.00	0.00	0.00	9.00
Railways	141.00	0.00	0.00	0.00	0.00
Sea	525.00	0.00	0.00	0.00	0.00
Air	1721.00	0.00	0.00	0.00	0.00
Pipeline	0.00	172.00	0.00	0.00	0.00
Road	13254.00	37.00	0.00	0.00	9.00
Other Sectors	6006.00	6970.00	0.00	0.00	0.00
Residential and Services	1640.00	6970.00	0.00	0.00	0.00
Agriculture	4366.00	0.70	0.00	0.00	0.00
Non-Energy	4153.00	0.00	0.00	0.00	0.00

Source: MENR website [33].

Table B- 9 General energy balance, 2009 (Thousand TOE) (Continued)

Parameter	Wind	Electricity	Heat	Solar	Total
Production (+)	129.00	0.00	1250.00	429.00	30328.00
Imports (+)	0.00	70.00	0.00	0.00	82124.00
Exports (-)	0.00	133.00	0.00	0.00	6829.00
Bunker fuel (-)	0.00	0.00	0.00	0.00	657.00
Stock Changes (+/-)	0.00	0.00	0.00	0.00	-301.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00	1473.00
Primary Energy Supply	129.00	-63.00	1250.00	429.00	106138.00
Energy Sector	-129.00	13458.00	1056.00	0.00	-25565.00
Electricity Plants	-129.00	16754.00	1056.00	0.00	-19640.00
Air Gas Plant (-)	0.00	0.00	0.00	0.00	0.00
Coking Plant	0.00	0.00	0.00	0.00	-1091.00
Briquette	0.00	0.00	0.00	0.00	0.00
Petroleum Refineries	0.00	-98.00	0.00	0.00	-2360.00
Internal Consumption and Losses	0.00	-3198.00	0.00	0.00	-2474.00
Total Final Energy Consumption	0.00	13395.00	2306.00	429.00	80574.00
Sectorial Detail	0.00	13395.00	2306.00	429.00	80574.00
Industrial Consumption	0.00	5962.00	1056.00	129.00	25966.00
Iron and Steel	0.00	1376.00	232.00	0.00	5155.00
Chemistry and Petrochemical	0.00	385.00	0.00	0.00	872.00
Petrochemical Feedstock	0.00	0.00	0.00	0.00	1796.00
Manure	0.00	20.00	0.00	0.00	50.00
Cement	0.00	478.00	0.00	0.00	4426.00
Sugar	0.00	42.00	0.00	0.00	149.00
Nonferrous Metals	0.00	165.00	0.00	0.00	630.00
Others	0.00	3495.00	824.00	129.00	12888.00
Transportation	0.00	57.00	0.00	0.00	15916.00
Railways	0.00	21.00	0.00	0.00	162.00
Sea	0.00	0.00	0.00	0.00	525.00
Air	0.00	0.00	0.00	0.00	1721.00
Pipeline	0.00	27.00	0.00	0.00	199.00
Road	0.00	9.00	0.00	0.00	13309.00
Other Sectors	0.00	7376.00	1250.00	300.00	34540.00
Residential and Services	0.00	6956.00	964.00	300.00	29466.00
Agriculture	0.00	420.00	286.00	0.00	5073.00
Non-Energy	0.00	0.00	0.00	0.00	4153.00

Source: MENR website [33].

Table B- 10 General energy balance, 2010 (Thousand TOE)

Parameter	Hard Coal	Lignite	Asphaltite	Coke	Petroleum Coke
Production (+)	1511.00	15505.00	508.00	0.00	0.00
Imports (+)	13734.00	0.00	0.00	115.00	2072.00
Exports (-)	0.00	0.00	0.00	0.00	0.00
Bunker fuel (-)	0.00	0.00	0.00	0.00	0.00
Stock Changes (+/-)	234.00	-119.00	-48.00	-1.00	21.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00	0.00
Primary Energy Supply	15479.00	15385.00	460.00	114.00	2093.00
Energy Sector	-7393.00	-9306.00	-257.00	2823.00	0.00
Electricity Plants	-3574.00	-9288.00	-257.00	0.00	0.00
Coking Plant	-3793.00	0.00	0.00	2823.00	0.00
Briquette	0.00	0.00	0.00	0.00	0.00
Petroleum Refineries	0.00	0.00	0.00	0.00	0.00
Internal Consumption and Losses	-26.00	-18.00	0.00	0.00	0.00
Total Final Energy Consumption	8086.00	6079.00	203.00	2937.00	2093.00
Sectorial Detail	8086.00	6079.00	203.00	2937.00	2093.00
Industrial Consumption	3043.00	3233.00	34.00	2937.00	2093.00
Iron and Steel	1016.00	58.00	0.00	2904.00	0.00
Chemistry and Petrochemical	55.00	151.00	0.00	0.00	0.00
Petrochemical Feedstock	0.00	0.00	0.00	0.00	0.00
Manure	0.00	0.00	0.00	0.00	0.00
Cement	1728.00	778.00	0.00	0.00	1625.00
Sugar	18.00	20.00	0.00	21.00	0.00
Nonferrous Metals	0.00	44.00	0.00	0.00	8.00
Others	227.00	2182.00	34.00	12.00	461.00
Transportation	0.00	0.00	0.00	0.00	0.00
Railways	0.00	0.00	0.00	0.00	0.00
Sea	0.00	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00	0.00
Pipeline	0.00	0.00	0.00	0.00	0.00
Road	0.00	0.00	0.00	0.00	0.00
Other Sectors	5042.00	2846.00	168.00	0.00	0.00
Residential and Services	5042.00	2846.00	168.00	0.00	0.00
Agriculture	1.00	0.00	0.00	0.00	0.00
Non-Energy	0.00	0.00	0.00	0.00	0.00

Source: MENR website [33].

Table B- 10 General energy balance, 2010 (Thousand TOE) (Continued)

Parameter	Briquette	Wood	Animal and Plant Residual	Total Solid Fuels
Production (+)	0.00	3392.00	1166.00	22081.00
Imports (+)	0.00	0.00	0.00	15921.00
Exports (-)	0.00	0.00	0.00	0.00
Bunker fuel (-)	0.00	0.00	0.00	0.00
Stock Changes (+/-)	0.00	0.00	0.00	86.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00
Primary Energy Supply	0.00	3392.00	1166.00	38089.00
Energy Sector	0.00	-9.00	-109.00	-14252.00
Electricity Plants	0.00	-9.00	-109.00	-13238.00
Coking Plant	0.00	0.00	0.00	-970.00
Briquette	0.00	0.00	0.00	0.00
Petroleum Refineries	0.00	0.00	0.00	0.00
Internal Consumption and Losses	0.00	0.00	0.00	-44.00
Total Final Energy Consumption	0.00	3383.00	1057.00	23837.00
Sectorial Detail	0.00	3383.00	1057.00	23837.00
Industrial Consumption	0.00	0.00	0.00	11341.00
Iron and Steel	0.00	0.00	0.00	3977.00
Chemistry and Petrochemical	0.00	0.00	0.00	206.00
Petrochemical Feedstock	0.00	0.00	0.00	0.00
Manure	0.00	0.00	0.00	0.00
Cement	0.00	0.00	0.00	4130.00
Sugar	0.00	0.00	0.00	59.00
Nonferrous Metals	0.00	0.00	0.00	52.00
Others	0.00	0.00	0.00	2916.00
Transportation	0.00	0.00	0.00	0.00
Railways	0.00	0.00	0.00	0.00
Sea	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00
Pipeline	0.00	0.00	0.00	0.00
Road	0.00	0.00	0.00	0.00
Other Sectors	0.00	3383.00	1057.00	12497.00
Residential and Services	0.00	3383.00	1057.00	12496.00
Agriculture	0.00	0.00	0.00	1.00
Non-Energy	0.00	0.00	0.00	0.00

Source: MENR website [33].

Table B- 10 General energy balance, 2010 (Thousand TOE) (Continued)

Parameter	Petroleum/Oil	Natural Gas	Hydraulic	Geothermal	Biofuel
Production (+)	2671.00	625.00	4454.00	575.00	12.00
Imports (+)	36566.00	34823.00	0.00	0.00	0.00
Exports (-)	7250.00	594.00	0.00	0.00	0.00
Bunker fuel (-)	387.00	0.00	0.00	0.00	0.00
Stock Changes (+/-)	-472.00	53.00	0.00	0.00	0.00
Statistical Differences (+/-)	-1908.00	0.00	0.00	0.00	0.00
Primary Energy Supply	29221.00	34907.00	4454.00	575.00	12.00
Energy Sector	-1554.00	-20887.00	-4454.00	-575.00	0.00
Electricity Plants	-888.00	-19657.00	-4454.00	-575.00	0.00
Coking Plant	0.00	0.00	0.00	0.00	0.00
Briquette	0.00	0.00	0.00	0.00	0.00
Petroleum Refineries	-1060.00	-1010.00	0.00	0.00	0.00
Internal Consumption and Losses	395.00	-220.00	0.00	0.00	0.00
Total Final Energy Consumption	27667.00	14020.00	0.00	0.00	12.00
Sectorial Detail	27667.00	14020.00	0.00	0.00	12.00
Industrial Consumption	3860.00	7170.00	0.00	0.00	0.00
Iron and Steel	356.00	678.00	0.00	0.00	0.00
Chemistry and Petrochemical	633.00	152.00	0.00	0.00	0.00
Petrochemical Feedstock	1855.00	0.00	0.00	0.00	0.00
Manure	4.00	64.00	0.00	0.00	0.00
Cement	26.00	15.00	0.00	0.00	0.00
Sugar	9.00	51.00	0.00	0.00	0.00
Nonferrous Metals	3.00	510.00	0.00	0.00	0.00
Others	975.00	5700.00	0.00	0.00	0.00
Transportation	14817.00	452.00	0.00	0.00	12.00
Railways	150.00	0.00	0.00	0.00	0.00
Sea	541.00	0.00	0.00	0.00	0.00
Air	956.00	0.00	0.00	0.00	0.00
Pipeline	0.00	223.00	0.00	0.00	0.00
Road	13169.00	230.00	0.00	0.00	12.00
Other Sectors	5530.00	6397.00	0.00	0.00	0.00
Residential and Services	1252.00	6396.00	0.00	0.00	0.00
Agriculture	4278.00	2.00	0.00	0.00	0.00
Non-Energy	3459.00	0.00	0.00	0.00	0.00

Source: MENR website [33].

Table B- 10 General energy balance, 2010 (Thousand TOE) (Continued)

Parameter	Wind	Electricity	Heat	Solar	Total
Production (+)	251.00	0.00	1391.00	432.00	32493.00
Imports (+)	0.00	98.00	0.00	0.00	87409.00
Exports (-)	0.00	165.00	0.00	0.00	8009.00
Bunker fuel (-)	0.00	0.00	0.00	0.00	387.00
Stock Changes (+/-)	0.00	0.00	0.00	0.00	-332.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00	-1908.00
Primary Energy Supply	251.00	-67.00	1391.00	432.00	109266.00
Energy Sector	-251.00	14858.00	1221.00	0.00	-25894.00
Electricity Plants	-251.00	18164.00	1221.00	0.00	-19678.00
Coking Plant	0.00	0.00	0.00	0.00	-970.00
Briquette	0.00	0.00	0.00	0.00	0.00
Petroleum Refineries	0.00	-92.00	0.00	0.00	-2162.00
Internal Consumption and Losses	0.00	-3214.00	0.00	0.00	-3083.00
Total Final Energy Consumption	0.00	14791.00	2612.00	432.00	83372.00
Sectorial Detail	0.00	14791.00	2612.00	432.00	83372.00
Industrial Consumption	0.00	6906.00	1221.00	130.00	30628.00
Iron and Steel	0.00	1562.00	166.00	0.00	6740.00
Chemistry and Petrochemical	0.00	480.00	0.00	0.00	1471.00
Petrochemical Feedstock	0.00	0.00	0.00	0.00	1855.00
Manure	0.00	12.00	0.00	0.00	81.00
Cement	0.00	458.00	0.00	0.00	4629.00
Sugar	0.00	28.00	0.00	0.00	147.00
Nonferrous Metals	0.00	198.00	0.00	0.00	763.00
Others	0.00	4168.00	1055.00	130.00	14943.00
Transportation	0.00	47.00	0.00	0.00	15328.00
Railways	0.00	19.00	0.00	0.00	170.00
Sea	0.00	0.00	0.00	0.00	541.00
Air	0.00	0.00	0.00	0.00	956.00
Pipeline	0.00	17.00	0.00	0.00	240.00
Road	0.00	10.00	0.00	0.00	13421.00
Other Sectors	0.00	7838.00	1391.00	302.00	33956.00
Residential and Services	0.00	7364.00	1057.00	302.00	28868.00
Agriculture	0.00	474.00	334.00	0.00	5089.00
Non-Energy	0.00	0.00	0.00	0.00	3459.00

Source: MENR website [33].

Table B- 11 General energy balance, 2011 (Thousand TOE)

Parameter	Hard Coal	Lignite	Asphaltite	Coke	Petroleum Coke
Production (+)	1307.80	16138.40	422.80	0.00	0.00
Imports (+)	15351.40	0.00	0.00	214.80	2015.50
Exports (-)	3.00	0.00	0.00	0.80	0.00
Bunker fuel (-)	0.00	0.00	0.00	0.00	0.00
Stock Changes (+/-)	9.70	281.70	-19.30	175.40	-47.30
Statistical Differences (+/-)	0.00	0.00	0.00	0.00	-5.50
Primary Energy Supply	16665.90	16420.00	403.50	389.40	1962.60
Energy Sector	-10056.70	-10780.50	-217.20	2621.50	0.00
Electricity Plants	-6243.80	-10765.30	-217.20	0.00	0.00
Coking Plant	-3791.10	0.00	0.00	2621.50	0.00
Petroleum Refineries	0.00	0.00	0.00	0.00	0.00
Internal Consumption and Losses	-21.80	-15.20	0.00	0.00	0.00
Total Final Energy Consumption	6609.20	5639.50	186.30	3010.90	1962.60
Sectorial Detail	6609.20	5639.50	186.30	3010.90	1962.60
Industrial Consumption	2490.00	3044.00	40.00	3010.90	1962.60
Food	48.50	26.50	0.00	2.20	0.00
Sugar	13.70	290.90	0.00	28.80	0.00
Textile	0.00	93.00	0.00	2.70	0.00
Paper	1.30	67.00	0.00	0.00	0.00
Ceramic	43.70	115.20	0.00	0.00	24.70
Glass and Glass Products	0.00	0.00	0.00	0.00	0.00
Chemical-Petrochemical	86.30	95.90	0.00	57.10	0.00
Manure	0.00	0.00	0.00	0.00	0.00
Cement	1330.70	1622.80	0.00	0.00	1689.40
Iron and Steel	932.40	30.90	0.00	2920.20	2.00
Non-ferrous metals	12.50	130.60	0.00	0.00	0.00
Rail Industry	0.00	10.00	0.00	0.00	0.00
Others	20.90	561.30	40.00	0.00	246.50
Transportation	0.00	0.00	0.00	0.00	0.00
Railways	0.00	0.00	0.00	0.00	0.00
Sea	0.00	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00	0.00
Pipeline Transport	0.00	0.00	0.00	0.00	0.00
Road	0.00	0.00	0.00	0.00	0.00
Others	4119.20	2595.50	146.30	0.00	0.00
Residential and Services	4119.20	2595.50	146.30	0.00	0.00
Agriculture	0.00	0.00	0.00	0.00	0.00
Non-energy	0.00	0.00	0.00	0.00	0.00

Source: MENR website [33].

Table B- 11 General energy balance, 2011 (Thousand TOE) (Continued)

Parameter	Wood	Animal and Plant Residual	Total Solid Fuels
Production (+)	2446.20	1091.40	21406.50
Imports (+)	0.00	0.00	17581.70
Exports (-)	0.00	0.00	3.80
Bunker fuel (-)	0.00	0.00	0.00
Stock Changes (+/-)	0.00	0.00	400.10
Statistical Differences (+/-)	0.00	0.00	-5.50
Primary Energy Supply	2446.20	1091.40	39379.00
Energy Sector	-3.90	-35.20	-18472.00
Electricity Plants	-3.90	-35.20	-17265.30
Coking Plant	0.00	0.00	-1169.60
Petroleum Refineries	0.00	0.00	0.00
Internal Consumption and Losses	0.00	0.00	-37.10
Total Final Energy Consumption	2442.30	1056.20	20907.10
Sectorial Detail	2442.30	1056.20	20907.00
Industrial Consumption	0.60	30.10	10578.20
Food	0.00	0.00	77.10
Sugar	0.00	0.10	333.50
Textile	0.00	0.00	95.60
Paper	0.00	30.00	98.30
Ceramic	0.10	0.00	183.60
Glass and Glass Products	0.00	0.00	0.00
Chemical-Petrochemical	0.00	0.00	239.30
Manure	0.00	0.00	0.00
Cement	0.00	0.00	4643.00
Iron and Steel	0.00	0.00	3885.50
Non-ferrous metals	0.50	0.00	143.60
Rail Industry	0.00	0.00	10.00
Others	0.00	0.00	868.80
Transportation	0.00	0.00	0.00
Railways	0.00	0.00	0.00
Sea	0.00	0.00	0.00
Air	0.00	0.00	0.00
Pipeline Transport	0.00	0.00	0.00
Road	0.00	0.00	0.00
Others	2441.70	1026.10	10328.80
Residential and Services	2441.70	1026.10	10328.80
Agriculture	0.00	0.00	0.00
Non-energy	0.00	0.00	0.00

Source: MENR website [33].

Table B- 11 General energy balance, 2011 (Thousand TOE) (Continued)

Parameter	Petroleum/Oil	Natural Gas	Hydraulic	Geothermal	Biofuel
Production (+)	2555.10	652.40	4501.20	596.80	17.70
Imports (+)	36099.40	36219.20	0.00	0.00	0.00
Exports (-)	5298.40	589.50	0.00	0.00	0.00
Bunker fuel (-)	2945.60	0.00	0.00	0.00	0.00
Stock Changes (+/-)	88.30	627.00	0.00	0.00	0.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00	0.00
Primary Energy Supply	30498.80	36909.10	4501.20	596.80	17.70
Energy Sector	-2143.50	-18550.50	-4501.20	-596.80	0.00
Electricity Plants	-264.50	-18381.30	-4501.20	-596.80	0.00
Coking Plant	0.00	0.00	0.00	0.00	0.00
Petroleum Refineries	-1690.90	0.00	0.00	0.00	0.00
Internal Consumption and Losses	-188.10	-169.20	0.00	0.00	0.00
Total Final Energy Consumption	28355.40	18358.50	0.00	0.00	17.70
Sectorial Detail	28355.40	18358.50	0.00	0.00	17.70
Industrial Consumption	2149.30	8686.70	0.00	0.00	0.00
Food	50.60	37.20	0.00	0.00	0.00
Sugar	47.50	191.10	0.00	0.00	0.00
Textile	29.20	511.90	0.00	0.00	0.00
Paper	26.20	308.20	0.00	0.00	0.00
Ceramic	78.10	620.70	0.00	0.00	0.00
Glass and Glass Products	16.60	565.90	0.00	0.00	0.00
Chemical-Petrochemical	660.40	1430.70	0.00	0.00	0.00
Manure	5.50	618.30	0.00	0.00	0.00
Cement	34.90	83.30	0.00	0.00	0.00
Iron and Steel	27.00	1854.70	0.00	0.00	0.00
Non-ferrous metals	18.90	171.30	0.00	0.00	0.00
Rail Industry	43.80	143.50	0.00	0.00	0.00
Others	1110.60	2150.00	0.00	0.00	0.00
Transportation	15484.50	402.30	0.00	0.00	17.70
Railways	154.90	0.00	0.00	0.00	0.00
Sea	718.00	0.00	0.00	0.00	0.00
Air	1127.30	0.00	0.00	0.00	0.00
Pipeline Transport	0.00	157.10	0.00	0.00	0.00
Road	13484.30	245.20	0.00	0.00	17.70
Others	6279.20	9269.50	0.00	0.00	0.00
Residential and Services	1300.90	9249.30	0.00	0.00	0.00
Agriculture	4978.30	20.20	0.00	0.00	0.00
Non-energy	4442.30	0.00	0.00	0.00	0.00

Source: MENR website [33].

Table B- 11 General energy balance, 2011 (Thousand TOE) (Continued)

Parameter	Wind	Electricity	Heat	Solar	Total
Production (+)	406.30	0.00	1463.00	630.00	32228.90
Imports (+)	0.00	391.80	0.00	0.00	90292.00
Exports (-)	0.00	313.40	0.00	0.00	6205.10
Bunker fuel (-)	0.00	0.00	0.00	0.00	294.60
Stock Changes (+/-)	0.00	0.00	0.00	0.00	1115.40
Statistical Differences (+/-)	0.00	0.00	0.00	0.00	-5.50
Primary Energy Supply	406.30	78.40	1463.00	630.00	114480.20
Energy Sector	-406.30	15926.20	1216.00	0.00	-27528.00
Electricity Plants	-406.30	19728.00	1216.00	0.00	-20471.40
Coking Plant	0.00	0.00	0.00	0.00	-1169.60
Petroleum Refineries	0.00	0.00	0.00	0.00	-1690.90
Internal Consumption and Losses	0.00	-3801.80	0.00	0.00	-4196.10
Total Final Energy Consumption	0.00	16004.60	2679.00	630.00	86952.20
Sectorial Detail	0.00	16004.60	2679.00	630.00	86952.10
Industrial Consumption	0.00	8011.00	1216.00	189.00	30830.20
Food	0.00	438.60	143.00	0.00	746.50
Sugar	0.00	46.80	0.00	0.00	618.80
Textile	0.00	1292.10	0.00	0.00	1928.80
Paper	0.00	168.60	0.00	0.00	601.20
Ceramic	0.00	85.90	0.00	0.00	968.30
Glass and Glass Products	0.00	83.00	0.00	0.00	665.50
Chemical-Petrochemical	0.00	522.90	0.00	0.00	2853.30
Manure	0.00	26.60	0.00	0.00	650.50
Cement	0.00	624.10	0.00	0.00	5385.40
Iron and Steel	0.00	1734.30	0.00	0.00	7501.40
Non-ferrous metals	0.00	214.60	0.00	0.00	548.40
Rail Industry	0.00	110.00	0.00	0.00	307.30
Others	0.00	2663.40	1073.00	189.00	8054.80
Transportation	0.00	45.70	0.00	0.00	15950.20
Railways	0.00	18.40	0.00	0.00	173.30
Sea	0.00	0.00	0.00	0.00	718.00
Air	0.00	0.00	0.00	0.00	1127.30
Pipeline Transport	0.00	17.20	0.00	0.00	174.30
Road	0.00	10.10	0.00	0.00	13757.20
Others	0.00	7947.80	1463.00	441.00	35729.40
Residential and Services	0.00	7572.80	1081.00	441.00	29973.90
Agriculture	0.00	375.00	382.00	0.00	5755.50
Non-energy	0.00	0.00	0.00	0.00	4442.30

Source: MENR website [33].

Table B- 12 General energy balance, 2012 (Thousand TOE)

Parameter	Hard Coal	Lignite	Asphaltite	Coke
Production (+)	1095.00	17860.00	567.00	0.00
Imports (+)	19237.00	0.00	0.00	253.00
Exports (-)	5.00	0.00	0.00	0.00
Bunker fuel (-)	0.00	0.00	0.00	0.00
Stock Changes (+/-)	-12.00	-945.00	-96.00	22.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00
Primary Energy Supply	20316.00	16915.00	471.00	275.00
Energy Sector	-11018.00	-10078.00	-219.00	2743.00
Electricity Plants	-6922.00	-10023.00	-219.00	0.00
Coking Plant	-4085.00	0.00	0.00	2743.00
Petrochemical Feedstock	0.00	0.00	0.00	0.00
Petroleum Refineries	0.00	0.00	0.00	0.00
Internal Consumption and Losses	-11.00	-55.00	0.00	0.00
Total Final Energy Consumption	9297.00	6837.00	252.00	3018.00
Sectorial Detail	9297.00	6837.00	252.00	3018.00
Industrial Consumption	2574.00	3521.00	144.00	3018.00
Food	56.00	37.00	0.00	2.00
Sugar	8.00	244.00	0.00	33.00
Textile	46.00	96.00	0.00	0.00
Paper	3.00	74.00	0.00	0.00
Ceramic	58.00	185.00	0.00	0.00
Glass and Glass Products	0.00	0.00	0.00	0.00
Chemical-Petrochemical	83.00	83.00	0.00	41.00
Manure	0.00	0.00	0.00	0.00
Cement	1452.00	1447.00	0.00	1.50
Iron and Steel	833.00	28.00	0.00	2940.00
Non-ferrous metals	11.00	55.00	0.00	0.00
Rail Industry	0.00	11.00	0.00	0.00
Others	24.00	1261.00	144.00	0.00
Transportation	0.00	0.00	0.00	0.00
Railways	0.00	0.00	0.00	0.00
Sea	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00
Pipeline Transport	0.00	0.00	0.00	0.00
Road	0.00	0.00	0.00	0.00
Others	6724.00	3317.00	108.00	0.00
Residential and Services	6724.00	3317.00	108.00	0.00
Agriculture	6662.00	3317.00	108.00	0.00
Non-energy	62.00	0.00	0.00	0.00

Source: MENR website [33].

Table B- 12 General energy balance, 2012 (Thousand TOE) (Continued)

Parameter	Petroleum Coke	Wood	Animal and Plant Residual	Total Solid Fuels
Production (+)	0.00	2350.00	1115.00	22987.00
Imports (+)	2936.00	0.00	0.00	22426.00
Exports (-)	0.00	0.00	0.00	5.00
Bunker fuel (-)	0.00	0.00	0.00	0.00
Stock Changes (+/-)	-136.00	0.00	0.00	-1167.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00
Primary Energy Supply	2800.00	2350.00	1115.00	44242.00
Energy Sector	0.00	-5.00	-60.00	-18638.00
Electricity Plants	0.00	-5.00	-60.00	-17230.00
Coking Plant	0.00	0.00	0.00	-1342.00
Petrochemical Feedstock	0.00	0.00	0.00	0.00
Petroleum Refineries	0.00	0.00	0.00	0.00
Internal Consumption and Losses	0.00	0.00	0.00	-66.00
Total Final Energy Consumption	2800.00	2345.00	1055.00	25604.00
Sectorial Detail	2800.00	2345.00	1055.00	25605.00
Industrial Consumption	2800.00	0.00	0.00	12057.00
Food	0.00	0.00	0.00	95.00
Sugar	0.00	0.00	0.00	285.00
Textile	0.00	0.00	0.00	142.00
Paper	0.00	0.00	0.00	77.00
Ceramic	24.00	0.00	0.00	267.00
Glass and Glass Products	0.00	0.00	0.00	0.00
Chemical-Petrochemical	0.00	0.00	0.00	207.00
Manure	0.00	0.00	0.00	0.00
Cement	2170.00	0.00	0.00	5070.00
Iron and Steel	136.00	0.00	0.00	3938.00
Non-ferrous metals	0.00	0.00	0.00	66.00
Rail Industry	0.00	0.00	0.00	11.00
Others	470.00	0.00	0.00	1899.00
Transportation	0.00	0.00	0.00	0.00
Railways	0.00	0.00	0.00	0.00
Sea	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00
Pipeline Transport	0.00	0.00	0.00	0.00
Road	0.00	0.00	0.00	0.00
Others	0.00	2195.00	211.00	12554.00
Residential and Services	0.00	2195.00	211.00	12492.00
Agriculture	0.00	0.00	0.00	62.00
Non-energy	0.00	150.00	844.00	994.00

Source: MENR website [33].

Table B- 12 General energy balance, 2012 (Thousand TOE) (Continued)

Parameter	Petroleum/Oil	Natural Gas	Hydraulic	Geothermal	Biofuel
Production (+)	2440.00	533.00	4976.00	733.00	23.00
Imports (+)	37856.00	37910.00	0.00	0.00	0.00
Exports (-)	6103.00	504.00	0.00	0.00	0.00
Bunker fuel (-)	3453.00	0.00	0.00	0.00	0.00
Stock Changes (+/-)	-126.00	-565.00	0.00	0.00	0.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00	0.00
Primary Energy Supply	30614.00	37373.00	4976.00	773.00	23.00
Energy Sector	-3744.00	-20105.00	-4976.00	-773.00	0.00
Electricity Plants	-753.00	-19049.00	-4976.00	-773.00	0.00
Coking Plant	0.00	0.00	0.00	0.00	0.00
Petrochemical Feedstock	-1771.00	0.00	0.00	0.00	0.00
Petroleum Refineries	-1018.00	-1042.00	0.00	0.00	0.00
Internal Consumption and Losses	-202.00	-14.00	0.00	0.00	0.00
Total Final Energy Consumption	26870.00	17268.00	0.00	0.00	23.00
Sectorial Detail	26870.00	17268.00	0.00	0.00	23.00
Industrial Consumption	1811.00	8079.00	0.00	0.00	0.00
Food	440.00	0.00	0.00	0.00	0.00
Sugar	202.00	0.00	0.00	0.00	0.00
Textile	513.00	0.00	0.00	0.00	0.00
Paper	123.00	0.00	0.00	0.00	0.00
Ceramic	610.00	0.00	0.00	0.00	0.00
Glass and Glass Products	253.00	0.00	0.00	0.00	0.00
Chemical-Petrochemical	709.00	0.00	0.00	0.00	0.00
Manure	655.00	0.00	0.00	0.00	0.00
Cement	139.00	0.00	0.00	0.00	0.00
Iron and Steel	832.00	0.00	0.00	0.00	0.00
Non-ferrous metals	462.00	0.00	0.00	0.00	0.00
Rail Industry	129.00	0.00	0.00	0.00	0.00
Others	3012.00	0.00	0.00	0.00	0.00
Transportation	341.00	0.00	0.00	0.00	0.00
Railways	0.00	0.00	0.00	0.00	0.00
Sea	0.00	0.00	0.00	0.00	0.00
Air	0.00	0.00	0.00	0.00	0.00
Pipeline Transport	279.00	0.00	0.00	0.00	0.00
Road	62.00	0.00	0.00	23.00	0.00
Others	8848.00	0.00	0.00	0.00	0.00
Residential and Services	8833.00	0.00	0.00	0.00	0.00
Agriculture	14.00	0.00	0.00	0.00	0.00
Non-energy	0.00	0.00	0.00	0.00	0.00

Source: MENR website [33].

Table B- 12 General energy balance, 2012 (Thousand TOE) (Continued)

Parameter	Wind	Electricity	Heat	Solar	Total
Production (+)	504.00	0.00	1463.00	768.00	34468.00
Imports (+)	0.00	501.00	0.00	0.00	98693.00
Exports (-)	0.00	254.00	0.00	0.00	6866.00
Bunker fuel (-)	0.00	0.00	0.00	0.00	3453.00
Stock Changes (+/-)	0.00	0.00	0.00	0.00	-1858.00
Statistical Differences (+/-)	0.00	0.00	0.00	0.00	0.00
Primary Energy Supply	504.00	247.00	1463.00	768.00	120984.00
Energy Sector	-504.00	16418.00	1225.00	0.00	-31097.00
Electricity Plants	-504.00	20597.00	1225.00	0.00	-21463.00
Coking Plant	0.00	0.00	0.00	0.00	-1342.00
Petrochemical Feedstock	0.00	0.00	0.00	0.00	-1771.00
Petroleum Refineries	0.00	-99.00	0.00	0.00	-2158.00
Internal Consumption and Losses	0.00	-4080.00	0.00	0.00	-4362.00
Total Final Energy Consumption	0.00	16665.00	2688.00	768.00	89887.00
Sectorial Detail	0.00	16665.00	2688.00	768.00	89887.00
Industrial Consumption	0.00	8027.00	1225.00	268.00	31467.00
Food	0.00	511.00	0.00	0.00	1061.00
Sugar	0.00	42.00	0.00	0.00	592.00
Textile	0.00	1244.00	0.00	0.00	1937.00
Paper	0.00	151.00	0.00	0.00	393.00
Ceramic	0.00	94.00	0.00	0.00	1146.00
Glass and Glass Products	0.00	83.00	0.00	0.00	370.00
Chemical-Petrochemical	0.00	600.00	0.00	0.00	1949.00
Manure	0.00	27.00	0.00	0.00	688.00
Cement	0.00	600.00	0.00	0.00	5856.00
Iron and Steel	0.00	1716.00	126.00	0.00	6704.00
Non-ferrous metals	0.00	219.00	0.00	0.00	762.00
Rail Industry	0.00	70.00	0.00	0.00	220.00
Others	0.00	2624.00	1100.00	268.00	9789.00
Transportation	0.00	44.00	0.00	0.00	20284.00
Railways	0.00	17.00	0.00	0.00	160.00
Sea	0.00	0.00	0.00	0.00	10.00
Air	0.00	0.00	0.00	0.00	1258.00
Pipeline Transport	0.00	17.00	0.00	0.00	296.00
Road	0.00	10.00	0.00	0.00	18561.00
Others	0.00	8594.00	1463.00	500.00	33746.00
Residential and Services	0.00	8084.00	1081.00	500.00	31794.00
Agriculture	0.00	511.00	382.00	0.00	1952.00
Non-energy	0.00	0.00	0.00	0.00	4390.00

Source: MENR website [33].

APPENDIX - C

TECHNICAL PARAMETERS

Table C- 1 System peak load shape

Time Slice	Hours	Cum. Hours	Avg. Value
January Weekday Day	252	252	88.29
January Weekday Night	252	504	66.48
January Weekend Day	120	624	76.48
January Weekend Night	120	744	61.26
February Weekday Day	240	984	86.90
February Weekday Night	240	1224	64.85
February Weekend Day	96	1320	76.79
February Weekend Night	96	1416	62.02
March Weekday Day	276	1692	84.42
March Weekday Night	276	1968	64.20
March Weekend Day	96	2064	74.80
March Weekend Night	96	2160	61.42
April Weekday Day	252	2412	80.84
April Weekday Night	252	2664	60.44
April Weekend Day	108	2772	71.60
April Weekend Night	108	2880	62.39
May Weekday Day	264	3144	77.68
May Weekday Night	264	3408	60.22
May Weekend Day	108	3516	67.59
May Weekend Night	108	3624	53.23
June Weekday Day	264	3888	82.15
June Weekday Night	264	4152	61.25
June Weekend Day	96	4248	71.96
June Weekend Night	96	4344	57.88
July Weekday Day	252	4596	93.79
July Weekday Night	252	4848	69.66
July Weekend Day	120	4968	82.19
July Weekend Night	120	5088	65.93

Source: MENR, Turkey LEAP [49]. The table was drawn by the author

Table C- 1 System peak load shape (Continued)

Time Slice	Hours	Cum. Hours	Avg. Value
August Weekday Day	276	5364	88.36
August Weekday Night	276	5640	69.00
August Weekend Day	96	5736	81.42
August Weekend Night	96	5832	68.07
September Weekday Day	264	6096	85.70
September Weekday Night	264	6360	63.38
September Weekend Day	96	6456	77.74
September Weekend Night	96	6552	67.07
October Weekday Day	252	6804	82.86
October Weekday Night	252	7056	64.04
October Weekday Night	252	7056	64.04
October Weekend Day	120	7176	73.51
October Weekend Night	120	7296	56.84
November Weekday Day	264	7560	86.64
November Weekday Night	264	7824	64.93
November Weekend Day	96	7920	76.93
November Weekend Night	96	8016	61.96
December Weekday Day	264	8280	93.06
December Weekday Night	264	8544	67.01
December Weekend Day	108	8652	84.12
December Weekend Night	108	8760	66.04

Source: MENR, Turkey LEAP [49]. The table was drawn by the author.

Table C- 2 Process efficiencies of the selected PP

Power Plant Name	Main Fuel	2008	2009	2010	2011	2012	Average
Çatalağzı	**Hard Coal**	28.00	28.00	31.00	30.00	30.00	**29.40**
Afşin-Elbistan B	**Lignite**	37.00	35.00	35.00	34.00	33.00	**34.80**
Afşin-Elbistan A	**Lignite**	31.00	30.00	30.00	28.00	29.00	**29.6**
Çan	**Lignite**	39.00	39.00	36.00	37.00	38.00	**37.8**
Tunçbilek	**Lignite**	33.00	32.00	32.00	32.00	29.00	**31.6**
Orhaneli	**Lignite**	35.10	32.90	34.40	34.30	32.00	**33.74**
Kemerköy	**Lignite**	33.00	34.00	34.00	33.00	33.00	**33.4**
Yatağan	**Lignite**	33.00	33.00	32.00	32.00	34.00	**32.80**
Yeniköy	**Lignite**	36.00	32.00	35.00	37.00	36.00	**35.20**
Soma A-B	**Lignite**	30.00	31.00	30.00	31.00	30.00	**30.40**
Ambarlı Doğal Gaz	**Natural gas**	48.00	47.00	48.00	47.00	48.00	**47.60**
Aliaağa Doğal Gaz	**Natural gas**	25.00	29.00	30.00	26.00	22.00	**26.40**
Bursa Doğal Gaz	**Natural gas**	53.00	52.80	53.40	41.32	40.71	**48.25**
Ambarlı Fuel Oil	**Fuel oil**	36.00	36.00	33.00	34.00	33.00	**34.40**
Adıgüzel	**Hydraulic**	78.00	85.00	86.00	85.00	84.00	**83.60**
Almus	**Hydraulic**	70.00	76.00	80.00	80.00	81.00	**77.40**
Altınkaya	**Hydraulic**	88.00	86.00	88.00	88.00	89.00	**87.80**
Aslantaş	**Hydraulic**	87.00	88.00	87.00	88.00	88.00	**87.60**
Çatalan	**Hydraulic**	87.00	87.00	88.00	91.00	91.00	**88.80**
Demirköprü	**Hydraulic**	78.00	77.00	77.00	77.00	78.00	**77.40**
Derbent	**Hydraulic**	88.00	88.00	89.00	89.00	89.00	**89.00**
Doğankent	**Hydraulic**	86.00	87.00	87.00	87.00	87.00	**86.80**
Gezende	**Hydraulic**	83.00	83.00	85.00	-	80.00	**82.00**
Gökçekaya	**Hydraulic**	88.00	88.00	88.00	88.00	88.00	**88.00**
Hasan Uğurlu	**Hydraulic**	87.00	87.00	87.00	88.00	88.00	**87.40**
Hirfanlı	**Hydraulic**	88.00	88.00	86.00	86.00	87.00	**87.00**
Kapulukaya	**Hydraulic**	87.00	86.00	86.00	87.00	87.00	**86.60**
Karacaören-1	**Hydraulic**	87.00	88.00	89.00	88.00	89.00	**88.20**
Kemer	**Hydraulic**	80.00	84.00	84.00	83.00	85.00	**83.20**
Kesikköprü	**Hydraulic**	87.00	87.00	87.00	87.00	87.00	**87.00**
Kılıçkaya	**Hydraulic**	82.00	82.00	82.00	82.00	82.00	**82.00**
Köklüce	**Hydraulic**	85.00	85.00	85.00	84.00	85.00	**84.80**
Menzelet	**Hydraulic**	84.00	86.00	86.00	86.00	86.00	**85.60**
Sarıyar	**Hydraulic**	86.00	86.00	86.00	86.00	86.00	**86.00**
Suat Uğurlu	**Hydraulic**	87.00	87.00	87.00	87.00	87.00	**87.00**
Tortum	**Hydraulic**	83.00	83.00	83.00	84.00	84.00	**83.40**

Source: Eltem-Tek database [34]. The table was drawn by the author.

Table C- 3 Maximum availabilities of the selected PP

Power Plant Name	Main Fuel	2008	2009	2010	2011	2012	Average
Çatalağzı	**Hard Coal**	85.00	82.00	84.00	91.00	77.00	**83.80**
Afşin-Elbistan B	**Lignite**	78.00	71.00	73.00	66.00	77.00	**73.00**
Afşin-Elbistan A	**Lignite**	54.00	63.00	37.00	30.00	29.00	**42.60**
Çan	**Lignite**	84.80	79.70	83.20	81.00	88.22	**83.38**
Tunçbilek	**Lignite**	47.70	52.50	58.50	61.00	48.00	**53.54**
Orhaneli	**Lignite**	80.90	74.40	74.30	77.00	55.50	**72.42**
Kemerköy	**Lignite**	74.00	68.00	69.00	58.00	65.00	**66.80**
Yatağan	**Lignite**	79.00	69.00	73.00	73.00	75.00	**73.80**
Yeniköy	**Lignite**	63.00	39.00	44.00	73.00	79.00	**59.60**
Soma A-B	**Lignite**	76.00	76.00	76.00	82.00	66.00	**75.20**
Ambarlı Doğal Gaz	**Natural gas**	92.80	91.30	89.90	83.08	90.00	**89.42**
Aliaağa Doğal Gaz	**Natural gas**	43.00	31.00	42.00	70.00	82.00	**53.60**
Bursa Doğal Gaz	**Natural gas**	88.80	90.90	88.00	86.00	96.00	**89.94**
Ambarlı Fuel Oil	**Fuel oil**	79.00	53.00	52.30	29.00	42.00	**51.06**
Adıgüzel	**Hydraulic**	100.00	90.00	90.00	91.00	93.00	**92.80**
Almus	**Hydraulic**	93.00	96.00	87.00	85.00	83.00	**88.80**
Altınkaya	**Hydraulic**	83.00	83.00	97.00	95.00	94.00	**89.80**
Aslantaş	**Hydraulic**	97.00	97.00	96.00	95.00	97.00	**96.40**
Çatalan	**Hydraulic**	95.00	96.00	91.00	94.00	97.00	**94.60**
Demirköprü	**Hydraulic**	72.00	78.00	83.00	83.00	80.00	**79.20**
Derbent	**Hydraulic**	93.00	90.00	96.00	96.00	97.00	**94.40**
Doğankent	**Hydraulic**	100.00	97.00	95.00	96.00	97.00	**97.00**
Gezende	**Hydraulic**	66.00	87.00	63.00	-	87.00	**75.75**
Gökçekaya	**Hydraulic**	60.00	79.00	84.00	95.00	86.00	**80.80**
Hasan Uğurlu	**Hydraulic**	91.00	89.00	93.00	91.00	86.00	**90.00**
Hirfanlı	**Hydraulic**	92.00	92.00	93.00	94.00	86.00	**91.40**
Kapulukaya	**Hydraulic**	99.00	95.00	98.00	96.00	97.00	**97.00**
Karacaören-1	**Hydraulic**	96.00	98.00	98.00	98.00	96.00	**97.20**
Kemer	**Hydraulic**	90.00	97.00	93.00	95.00	92.00	**93.40**
Kesikköprü	**Hydraulic**	92.00	76.00	65.00	73.00	63.00	**73.80**
Kılıçkaya	**Hydraulic**	90.00	87.00	88.00	89.00	90.00	**88.80**
Köklüce	**Hydraulic**	94.00	93.00	94.00	93.00	91.00	**93.00**
Menzelet	**Hydraulic**	95.00	95.00	99.00	95.00	94.00	**95.60**
Sarıyar	**Hydraulic**	85.00	67.00	92.00	92.00	91.00	**85.40**
Suat Uğurlu	**Hydraulic**	100.00	97.00	90.00	94.00	98.00	**95.80**
Tortum	**Hydraulic**	85.00	94.00	94.00	94.00	85.00	**90.40**

Source: Eltem-Tek database [34]. The table was drawn by the author.

Table C- 4 Process efficiencies and maximum availability values

Power Plant Type	Process Efficiency	Maximum Availability
Fuel Oil	40.75	77.65
Diesel	40.75	77.65
Natural Gas	40.75	77.65
Hydraulic	85.30	89.90
Coal	29.40	83.80
Lignite	33.26	66.70
Geothermal	10.24	96.20
Solar	100.00	26.40
Wind	100.00	30.00
Nuclear	34.00	91.00

Source: LEAP Default Values [50]. (Indicator: Geothermal and nuclear process efficiencies and wind, solar, geothermal and nuclear maximum availability values were taken from the LEAP TED database.) Eltem-Tek [34].(The other values are calculated by author. Fuel oil, diesel and natural gas values are assumed to be same.)

Table C- 5 Lifetime and merit order values

Power Plant Type	Lifetime (year)	Merit Order
Fuel Oil	30	4
Diesel	30	4
Natural Gas	30	3
Hydraulic	80	2
Coal	40	2
Lignite	40	2
Geothermal	40	1
Solar	25	1
Wind	25	1
Nuclear	60	1

Source: IEA, NEA and OECD [47] (Indicator: Lifetime, Projected Costs of Generating Electricity,2010, page 43)

Table C- 6 Reserves and additional reserve data for primary resources

Reserves		2008	2009	2010	2011	2012
Base Year Reserves						
Uranium	**Metric tonne**	9129.00	9129.00	9129.0	9129.0	9129.00
Lignite	**Million metric tonne**	7339.00	9837.00	9837.9	10782.3	10782.30
Natural Gas	**Billion metric tonne**	7.00	7.00	6.20	6.20	6.20
Hard Coal	**Million metric tonne**	541.21	534.62	534.6	526	526
Additions to Reserves						
Uranium	**Metric tonne**	0.00	0.00	0.00	0.00	0.00
Lignite	**Million metric tonne**	1036.00	1608.00	1607.00	969.91	969.91
Natural Gas	**Billion metric tonne**	0.00	0.00	0.00	0.00	0.00
Hard Coal	**Million metric tonne**	793.40	799.99	799.90	793.40	793.40
Yield						
Wind	**MW/year**	48000.00	48000.00	48000.00	48000.00	48000.00
Solar	**Million MWh**	380.00	380.00	380.00	380.00	380.00
Hydraulic	**GWh**	129388.00	129388.00	129388.00	129388.00	129388.00
Geothermal	**MW/year**	510.00	510.00	600.00	600.00	600.00

Source: MENR, Blue Book [35]

Table C- 7 Gross electricity generation of EGC (GWh)

Power Plant Type	2001	2002	2003	2004	2005	2006
Hard Coal	1888.90	1777.00	1727.60	1475.70	1856.70	1909.40
Lignite	31411.50	23612.0	18985.10	18237.90	25533.60	28029.50
Fuel Oil	4502.80	1872.60	851.30	701.90	854.80	1035.90
Diesel	811.50	188.30	0.20	2.90	0.20	21.70
Natural Gas	27249.30	23473.70	11417.00	6837.10	10076.40	14946.20
Hydraulic	20408.80	26303.90	30027.10	40668.50	35045.80	38679.40
Geothermal	89.60	104.60	88.60	93.20	94.40	94.00
Wind	0.00	0.00	0.00	0.00	0.00	0.00
Total	86362.00	77332.00	63097.00	68017.00	73462.00	84716.00

Source: TETC [8]. (Indicator: Turkey's Gross Electricity Generation by Primary Energy Resources and Electric Utilities, page 41 and 42) The table was drawn by the author.

Table C- 8 Gross electricity generation of EGC (GWh) (Continued)

Power Plant Type	2007	2008	2009	2010	2011	2012
Hard Coal	2072.50	1882.40	1851.10	1882.70	2004.20	1479.10
Lignite	33738.00	37236.00	34369.80	31170.90	33996.30	29940.80
Fuel Oil	2224.40	3365.10	974.40	62.20	103.00	105.20
Diesel	12.20	0.40	0.20	0.00	0.00	0.0
Natural Gas	23247.90	26813.60	23919.90	21039.30	19358.90	20738.90
Hydraulic	30980.60	28419.40	28338.20	41377.40	36888.20	38311.10
Geothermal	51.80	0.00	0.00	0.00	0.00	0.00
Wind	0.00	0.00	0.00	0.00	0.00	0.00
Total	**92327**	**97717**	**89454**	**95532**	**92351**	**90575**

Source: TETC [8]. (Indicator: Turkey's Gross Electricity Generation by Primary Energy Resources and Electric Utilities, page 41 and 42) The table was drawn by the author.

Table C- 9 Installed capacity of EGC (MW)

Year	Hard Coal*	Lignite	Fuel Oil	Diesel	Natural Gas	Hydraulic	Geothermal	Wind	Total
2001	300	5770	680	204	3983	10109	18	0	**21063**
2002	300	5765	680	204	3983	10109	18	0	**21058**
2003	300	5701	680	204	3903	10990	15	0	**21793**
2004	300	5701	680	196	3903	10995	15	0	**21790**
2005	300	6381	680	196	3903	11110	15	0	**22585**
2006	300	7461	680	196	3903	11161	15	0	**23716**
2007	300	7461	680	181	3903	11350	0	0	**23875**
2008	300	7461	680	1	4083	11456	0	0	**23981**
2009	300	7461	680	1	4083	11678	0	0	**24203**
2010	300	7461	680	1	4083	11678	0	0	**24203**
2011	300	7461	680	1	4119	11590	0	0	**24150**
2012	300	7461	680	1	4119	12214	0	0	**24775**

Source: TETC [8]. (Indicator: Installed Capacity of EGC and affiliated partnerships of EGC). *Hard Coal values include imported coal values. Because of insufficient data available in TETC, the imported coal values are assumed to be hard coal.

Table C- 10 Fuel type physical characteristic features in our model

Fuel Type	Net Energy Content	Energy Units	Per Physical Unit	LHV/HHV Ratio	Density (kg/liter)
Electricity	1	Gigajoule	Gigajoule	1.00	0.00
Natural Gas	8250	Kilocalorie	Cubic Meter	0.90	0.00
Diesel	10350	Kilocalorie	Kilogramme	0.95	0.85
Residual Fuel Oil	9600	Kilocalorie	Kilogramme	0.95	0.97
Oil	40.19	Gigajoule	Metric Tonne	0.95	0.87
Hard Coal	29.31	Gigajoule	Metric Tonne	0.95	1.33
Wind	1	Gigajoule	Gigajoule	1.00	0.00
Solar	1	Gigajoule	Gigajoule	1.00	0.00
Hydro	1	Gigajoule	Gigajoule	1.00	0.00
Geothermal	1	Gigajoule	Gigajoule	1.00	0.00
Heat	1	Gigajoule	Gigajoule	1.00	0.00
Petroleum Coke	31	Gigajoule	Metric Tonne	0.95	1.14
Lignite	2000	Kilocalorie	Kilogramme	0.95	1.29
Coke	6100	Kilocalorie	Kilogramme	0.95	1.35
Asphaltit	40.19	Gigajoule	Metric Tonne	0.95	1.04
Wood	15.5	Gigajoule	Metric Tonne	0.90	0.71
Briquettes	15.5	Gigajoule	Metric Tonne	0.90	0.71
Waste	15.5	Gigajoule	Metric Tonne	0.90	0.71
Air Gas	34.2	Megajoule	Cubic Meter	0.90	0.00
Biofuel	15.5	Gigajoule	Metric Tonne	0.90	0.71
Uranium	630000	Gigajoule	Metric Tonne	0.95	1.00

Source: IEA [37] (Indicator: Density and net energy content of fuel oil, diesel, lignite and natural gas were taken from IEA, Energy Prices and Taxes, 1st quarter 2013, page 270-271). TAEA [56] (Indicator: Uranium: The net energy content was taken from Turkish Atomic Energy Authority Website, Nükleer Güvenlik, Table 2.2)

Table C- 11 Fuel type chemical characteristic features in our model

Chemical Features with respect to Fuel Types	C %	S %	N %	Ash %	Moisture %	CH_4 %	Oxidized %	Sulfur Ret. %
Electricity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas	73.40	0.01	0.03	0.00	0.00	96.20	99.50	0.00
Diesel	86.50	0.40	0.59	0.00	0.00	0.00	99.00	0.00
Residual Fuel Oil	84.40	2.00	1.00	0.08	0.00	0.00	99.00	0.00
Oil	86.50	0.40	0.59	0.00	0.00	0.00	99.00	0.00
Hard Coal	74.60	2.00	1.50	8.00	5.00	0.00	98.00	30.00
Wind	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
Solar	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
Hydro	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Geothermal	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
Heat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum Coke	83.00	1.00	1.00	0.00	0.00	0.00	99.00	0.00
Lignite	31.00	0.50	0.60	6.00	35.00	0.00	98.00	0.00
Coke	85.00	0.75	1.00	2.75	5.00	0.00	98.00	0.00
Asphaltit	86.50	0.40	0.59	0.00	0.00	0.00	99.00	0.00
Wood	43.80	0.00	0.09	0.00	15.00	0.00	100.00	0.00
Briquettes	43.80	0.00	0.09	0.00	15.00	0.00	100.00	0.00
Waste	43.80	0.00	0.09	0.00	15.00	0.00	100.00	0.00
Air Gas	73.40	0.01	0.03	0.00	0.00	0.00	99.50	0.00
Biofuel	43.80	0.00	0.09	0.00	15.00	0.00	100.00	0.00
Uranium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: LEAP Default Values [50].

APPENDIX - D

COST DATA

Table D- 1 Cost data for the selected PP, 2008

Power Plant Name	Installed Capacity (MW)	Fuel Type	Fixed O&M Cost (TL/MW)	Variable O&M Cost (TL/kWh)
Çatalağzı	**300**	***Hard Coal***	79967.56	0.03
Afşin-Elbistan A	**1355**	***Lignite***	29003.58	0.02
Afşin-Elbistan B	**1440**	***Lignite***	17728.71	0.04
Çan	**320**	***Lignite***	31383.77	0.04
Kemerköy	**630**	***Lignite***	31203.09	0.03
Orhaneli	**210**	***Lignite***	81141.62	0.03
Soma A-B	**990**	***Lignite***	57426.28	0.03
Tunçbilek	**365**	***Lignite***	52598.69	0.02
Yatağan	**630**	***Lignite***	55667.52	0.02
Yeniköy	**420**	***Lignite***	62817.06	0.01
Ambarlı Doğal Gaz	**1350.9**	***Natural Gas***	8681.86	0.01
Aliağa Doğal Gaz	**180**	***Natural Gas***	24520.30	0.01
Bursa Doğal Gaz	**1432**	***Natural Gas***	6607.97	0.01
Ambarlı Fuel Oil	**1130**	***Fuel Oil***	10604.49	0.00
Adıgüzel	**62**	***Hydraulic***	19553.63	0.19
Almus	**27**	***Hydraulic***	77616.96	0.02
Altınkaya	**702.55**	***Hydraulic***	5208.19	0.02
Aslantaş	**138**	***Hydraulic***	28693.88	0.00
Çatalan	**168.9**	***Hydraulic***	15898.55	0.00
Demirköprü	**69**	***Hydraulic***	22580.65	0.50
Derbent	**56.4**	***Hydraulic***	10206.23	0.02
Doğankent	**74.50**	***Hydraulic***	35978.01	0.01
Gezende	**159.38**	***Hydraulic***	16701.29	0.01
Gökçekaya	**278.4**	***Hydraulic***	8193.43	0.05
Hasan Uğurlu	**500**	***Hydraulic***	5494.55	0.01
Hirfanlı	**128**	***Hydraulic***	24981.53	0.02

Source: Eltem-Tek database [34]. The table was drawn by the author. Fixed and variable O&M costs do not include fuel costs.

Table D- 1 Cost data for the selected PP, 2008 (Continued)

Power Plant Name	Installed Capacity (MW)	Fuel Type	Fixed O&M Cost (TL/MW)	Variable O&M Cost (TL/kWh)
Kapulukaya	**54**	***Hydraulic***	26453.30	0.01
Karacaören-1	**32**	***Hydraulic***	61712.39	0.01
Kemer	**48**	***Hydraulic***	32448.07	0.04
Kesikköprü	**76**	***Hydraulic***	11922.70	0.02
Kılıçkaya	**120**	***Hydraulic***	18304.03	0.02
Köklüce	**90**	***Hydraulic***	18410.55	0.00
Menzelet	**124.00**	***Hydraulic***	25154.96	0.01
Sarıyar	**160**	***Hydraulic***	20044.11	0.02
Suat Uğurlu	**69**	***Hydraulic***	20867.12	0.01
Tortum	**26.20**	***Hydraulic***	71296.75	0.01

Source: Eltem-Tek database [34]. The table was drawn by the author. Fixed and variable O&M costs do not include fuel costs.

Table D- 2 Cost data for the selected PP, 2009

Power Plant Name	Installed Capacity (MW)	Fuel Type	Fixed O&M Cost (TL/MW)	Variable O&M Cost (TL/kWh)
Çatalağzı	**300**	***Hard Coal***	84554.94	0.03
Afşin-Elbistan A	**1355**	***Lignite***	30356.50	0.02
Afşin-Elbistan B	**1440**	***Lignite***	19254.78	0.04
Çan	**320**	***Lignite***	35580.62	0.04
Kemerköy	**630**	***Lignite***	34021.29	0.03
Orhaneli	**210**	***Lignite***	84229.28	0.04
Soma A-B	**990**	***Lignite***	57193.20	0.03
Tunçbilek	**365**	***Lignite***	51736.47	0.02
Yatağan	**630**	***Lignite***	52495.78	0.02
Yeniköy	**420**	***Lignite***	61736.46	0.03
Ambarlı Doğal Gaz	**1350.9**	***Natural Gas***	9621.24	0.01
Aliağa Doğal Gaz	**180**	***Natural Gas***	26823.86	0.02
Bursa Doğal Gaz	**1432**	***Natural Gas***	4910.63	0.01
Ambarlı Fuel Oil	**1130**	***Fuel Oil***	9755.71	0.01
Adıgüzel	**62**	***Hydraulic***	19751.34	0.03
Almus	**27**	***Hydraulic***	89334.96	0.02
Altınkaya	**702.55**	***Hydraulic***	5838.25	0.02
Aslantaş	**138**	***Hydraulic***	29884.24	0.00
Çatalan	**168.9**	***Hydraulic***	17508.76	0.00
Demirköprü	**69**	***Hydraulic***	23032.25	0.02
Derbent	**56.4**	***Hydraulic***	10589.87	0.02
Doğankent	**74.50**	***Hydraulic***	38599.01	0.01
Gezende	**159.38**	***Hydraulic***	17139.44	0.00
Gökçekaya	**278.4**	***Hydraulic***	8734.29	0.03
Hasan Uğurlu	**500**	***Hydraulic***	5977.15	0.00
Hirfanlı	**128**	***Hydraulic***	27608.04	0.04
Kapulukaya	**54**	***Hydraulic***	29895.08	0.01
Karacaören-1	**32**	***Hydraulic***	64533.17	0.02
Kemer	**48**	***Hydraulic***	32633.20	0.02
Kesikköprü	**76**	***Hydraulic***	11637.61	0.02
Kılıçkaya	**120**	***Hydraulic***	20936.19	0.02
Köklüce	**90**	***Hydraulic***	21867.79	0.00
Menzelet	**124.00**	***Hydraulic***	29292.01	0.00
Sarıyar	**160**	***Hydraulic***	20488.37	0.01
Suat Uğurlu	**69**	***Hydraulic***	19992.75	0.01
Tortum	**26.20**	***Hydraulic***	75475.21	0.01

Source: Eltem-Tek database [34]. The table was drawn by the author. Fixed and variable O&M costs do not include fuel costs.

Table D- 3 Cost data for the selected PP, 2010

Power Plant Name	Installed Capacity (MW)	Fuel Type	Fixed O&M Cost (TL/MW)	Variable O&M Cost (TL/kWh)
Çatalağzı	**300**	***Hard Coal***	79248.78	0.03
Afşin-Elbistan A	**1355**	***Lignite***	27034.45	0.04
Afşin-Elbistan B	**1440**	***Lignite***	19239.36	0.04
Çan	**320**	***Lignite***	35900.37	0.04
Kemerköy	**630**	***Lignite***	34589.60	0.03
Orhaneli	**210**	***Lignite***	78528.95	0.04
Soma A-B	**990**	***Lignite***	58178.60	0.04
Tunçbilek	**365**	***Lignite***	47638.00	0.02
Yatağan	**630**	***Lignite***	54800.11	0.03
Yeniköy	**420**	***Lignite***	62535.20	0.02
Ambarlı Doğal Gaz	**1350.9**	***Natural Gas***	9515.56	0.01
Aliağa Doğal Gaz	**180**	***Natural Gas***	25532.39	0.05
Bursa Doğal Gaz	**1432**	***Natural Gas***	4846.32	0.01
Ambarlı Fuel Oil	**1130**	***Fuel Oil***	8957.14	0.23
Adıgüzel	**62**	***Hydraulic***	19745.13	0.02
Almus	**27**	***Hydraulic***	90145.51	0.02
Altınkaya	**702.55**	***Hydraulic***	5971.30	0.01
Aslantaş	**138**	***Hydraulic***	30670.73	0.00
Çatalan	**168.9**	***Hydraulic***	17120.91	0.00
Demirköprü	**69**	***Hydraulic***	24885.52	0.02
Derbent	**56.4**	***Hydraulic***	10442.05	0.01
Doğankent	**74.50**	***Hydraulic***	39322.96	0.02
Gezende	**159.38**	***Hydraulic***	16980.50	0.05
Gökçekaya	**278.4**	***Hydraulic***	8334.99	0.03
Hasan Uğurlu	**500**	***Hydraulic***	6866.87	0.01
Hirfanlı	**128**	***Hydraulic***	27725.93	0.01
Kapulukaya	**54**	***Hydraulic***	28366.08	0.01
Karacaören-1	**32**	***Hydraulic***	60673.72	0.01
Kemer	**48**	***Hydraulic***	28004.67	0.02
Kesikköprü	**76**	***Hydraulic***	11934.84	0.01
Kılıçkaya	**120**	***Hydraulic***	21765.83	0.02
Köklüce	**90**	***Hydraulic***	22997.67	0.00
Menzelet	**124.00**	***Hydraulic***	29017.51	0.00
Sarıyar	**160**	***Hydraulic***	22076.80	0.01
Suat Uğurlu	**69**	***Hydraulic***	15109.48	0.01
Tortum	**26.20**	***Hydraulic***	93321.12	0.01

Source: Eltem-Tek database [34]. The table was drawn by the author. Fixed and variable O&M costs do not include fuel costs.

Table D- 4 Cost data for the selected PP, 2011

Power Plant Name	Installed Capacity (MW)	Fuel Type	Fixed O&M Cost (TL/MW)	Variable O&M Cost (TL/kWh)
Çatalağzı	**300**	***Hard Coal***	84393.02	0.03
Afşin-Elbistan A	**1355**	***Lignite***	29779.24	0.03
Afşin-Elbistan B	**1440**	***Lignite***	21910.32	0.05
Çan	**320**	***Lignite***	45199.63	0.04
Kemerköy	**630**	***Lignite***	30956.92	0.04
Orhaneli	**210**	***Lignite***	88023.71	0.04
Soma A-B	**990**	***Lignite***	54725.25	0.03
Tunçbilek	**365**	***Lignite***	58904.05	0.02
Yatağan	**630**	***Lignite***	58207.54	0.03
Yeniköy	**420**	***Lignite***	63078.45	0.01
Ambarlı Doğal Gaz	**1350.9**	***Natural Gas***	13048.24	0.01
Aliağa Doğal Gaz	**180**	***Natural Gas***	34587.96	0.08
Bursa Doğal Gaz	**1432**	***Natural Gas***	5671.00	0.01
Ambarlı Fuel Oil	**1130**	***Fuel Oil***	9163.95	0.22
Adıgüzel	**62**	***Hydraulic***	22041.20	0.02
Almus	**27**	***Hydraulic***	105412.95	0.02
Altınkaya	**702.55**	***Hydraulic***	7167.75	0.01
Aslantaş	**138**	***Hydraulic***	37239.06	0.00
Çatalan	**168.9**	***Hydraulic***	19967.77	0.00
Demirköprü	**69**	***Hydraulic***	35966.33	0.03
Derbent	**56.4**	***Hydraulic***	13149.91	0.01
Doğankent	**74.50**	***Hydraulic***	45782.16	0.02
Gezende	**159.38**	***Hydraulic***	23457.14	0.00
Gökçekaya	**278.4**	***Hydraulic***	9533.52	0.03
Hasan Uğurlu	**500**	***Hydraulic***	8087.76	0.01
Hirfanlı	**128**	***Hydraulic***	31861.73	0.01
Kapulukaya	**54**	***Hydraulic***	30185.05	0.01
Karacaören-1	**32**	***Hydraulic***	68887.10	0.03
Kemer	**48**	***Hydraulic***	26044.24	0.03
Kesikköprü	**76**	***Hydraulic***	14046.36	0.01
Kılıçkaya	**120**	***Hydraulic***	24212.00	0.03
Köklüce	**90**	***Hydraulic***	28300.44	0.01
Menzelet	**124.00**	***Hydraulic***	34050.31	0.01
Sarıyar	**160**	***Hydraulic***	30702.74	0.02
Suat Uğurlu	**69**	***Hydraulic***	15624.30	0.01
Tortum	**26.20**	***Hydraulic***	94222.44	0.02

Source: Eltem-Tek database [34]. The table was drawn by the author. Fixed and variable O&M costs do not include fuel costs.

Table D- 5 Cost data for the selected PP, 2012

Power Plant Name	Installed Capacity (MW)	Fuel Type	Fixed O&M Cost (TL/MW)	Variable O&M Cost (TL/kWh)
Çatalağzı	**300**	***Hard Coal***	84434.06	0.05
Afşin-Elbistan A	**1355**	***Lignite***	34392.37	0.04
Afşin-Elbistan B	**1440**	***Lignite***	25106.80	0.07
Çan	**320**	***Lignite***	48138.80	0.06
Kemerköy	**630**	***Lignite***	39498.17	0.03
Orhaneli	**210**	***Lignite***	89495.00	0.05
Soma A-B	**990**	***Lignite***	59977.29	0.02
Tunçbilek	**365**	***Lignite***	63208.41	0.03
Yatağan	**630**	***Lignite***	63140.89	0.03
Yeniköy	**420**	***Lignite***	61205.30	0.01
Ambarlı Doğal Gaz	**1350.9**	***Natural Gas***	13402.08	0.01
Aliağa Doğal Gaz	**180**	***Natural Gas***	37673.42	0.71
Bursa Doğal Gaz	**1432**	***Natural Gas***	6461.64	0.01
Ambarlı Fuel Oil	**1130**	***Fuel Oil***	10705.03	0.16
Adıgüzel	**62**	***Hydraulic***	23349.85	0.01
Almus	**27**	***Hydraulic***	119721.54	0.02
Altınkaya	**702.55**	***Hydraulic***	7862.80	0.03
Aslantaş	**138**	***Hydraulic***	39692.74	0.01
Çatalan	**168.9**	***Hydraulic***	22451.44	0.01
Demirköprü	**69**	***Hydraulic***	42015.64	0.02
Derbent	**56.4**	***Hydraulic***	14442.78	0.01
Doğankent	**74.50**	***Hydraulic***	50826.69	0.01
Gezende	**159.38**	***Hydraulic***	25047.45	0.03
Gökçekaya	**278.4**	***Hydraulic***	9864.62	0.03
Hasan Uğurlu	**500**	***Hydraulic***	8578.42	0.01
Hirfanlı	**128**	***Hydraulic***	32630.91	0.01
Kapulukaya	**54**	***Hydraulic***	33137.54	0.01
Karacaören-1	**32**	***Hydraulic***	60369.43	0.02
Kemer	**48**	***Hydraulic***	32532.39	0.01
Kesikköprü	**76**	***Hydraulic***	16770.32	0.01
Kılıçkaya	**120**	***Hydraulic***	26710.04	0.02
Köklüce	**90**	***Hydraulic***	29283.35	0.01
Menzelet	**124.00**	***Hydraulic***	36046.18	0.01
Sarıyar	**160**	***Hydraulic***	31763.10	0.01
Suat Uğurlu	**69**	***Hydraulic***	18567.75	0.01
Tortum	**26.20**	***Hydraulic***	98623.83	0.03

Source: Eltem-Tek database [34]. The table was drawn by the author. Fixed and variable O&M costs do not include fuel costs.

Table D- 6 Calculated ratio of renewable and nuclear power plants

Power Plant Type	Capital Cost ($/kW)	Fixed O & M Cost ($/kW-year)	Calculated Ratio (%)
Geothermal	4362	100.00	2.29
Solar	4183	27.75	0.66
Wind	2213	39.55	1.79
Nuclear	5530	93.28	1.69

Source: EIA [51] (Indicator: Capital and Fixed O&M cost in 2012, Updated Capital Cost Estimates for Utility Scale Electricity Generating Plants, page 6).

Table D- 7 Capital costs of power plants

Fuel Type	Unit of the Cost	2008	2009	2010	2011	2012
Fuel Oil	TL/MW	1600000.00	1600000.00	1600000.00	1600000.00	1000000.00
Diesel	TL/MW	1600000.00	1600000.00	1600000.00	1600000.00	1000000.00
Natural Gas	TL/MW	1000000.00	1000000.00	1000000.00	1000000.00	1000000.00
Hydraulic	TL/MW	1600000.00	1600000.00	1600000.00	1600000.00	1600000.00
Coal	TL/MW	125000.00	125000.00	125000.00	125000.00	125000.00
Lignite	TL/MW	125000.00	125000.00	125000.00	125000.00	125000.00
Geothermal	TL/MW	2100000.00	2100000.00	2100000.00	2100000.00	2100000.00
Solar	TL/MW	4200000.00	4200000.00	4200000.00	4200000.00	3000000.00
Wind	TL/MW	2000000.00	2000000.00	2000000.00	2000000.00	2500000.00
Nuclear	TL/MW	6000000.00	6000000.00	6000000.00	6000000.00	6000000.00

Source: EMRA [52] (Indicator: Capital Cost, 2008 value was taken from Ocak, A., 2008, "Türkiye Elektrik Piyasası", 3. Türkiye Altyapı Finansmanı Konferansı [53]; 2012 values were taken from EMRA, "Elektrik Piyasasında Kaynak Bazındaki Toplam Birim Yatırım Tutarları")

Table D- 8 Fixed O&M costs of power plants

Fuel Type	Unit of the Cost	2008	2009	2010	2011	2012
Fuel Oil	TL/MW	10604.49	9755.71	8957.14	9163.95	10705.03
Diesel	TL/MW	10604.49	9755.71	8957.14	9163.95	10705.03
Natural Gas	TL/MW	13270.04	13785.24	13298.09	17769.07	19179.05
Hydraulic	TL/MW	26260.04	28215.86	28703.64	32997.37	35467.67
Coal	TL/MW	79967.56	84554.94	79248.78	84393.02	84434.06
Lignite	TL/MW	46552.26	47400.49	46493.85	50087.23	53795.89
Geothermal	TL/MW	48090.00	48090.00	48090.00	48090.00	48090.00
Solar	TL/MW	27720.00	27720.00	27720.00	27720.00	27720.00
Wind	TL/MW	35800.00	35800.00	35800.00	35800.00	35800.00
Nuclear	TL/MW	101400.00	101400.00	101400.00	101400.00	101400.00

Source: Eltem-Tek database [34]. (Indicator: The selected power plants last five year data) and EIA [51] (Indicator: Renewable resources except hydroelectric power plants and nuclear cost data ratio were taken from EIA "Updated Capital Cost Estimates for Utility Scale Electricity Generating Plants, 2013, and then calculated by author)

Table D- 9 Variable O&M costs of power plants

Fuel Type	Unit of the Cost	2008	2009	2010	2011	2012
Fuel Oil	TL/kWh	0.004	0.01	0.23	0.22	0.16
Diesel	TL/kWh	0.004	0.01	0.23	0.22	0.16
Natural Gas	TL/kWh	0.01	0.01	0.23	0.22	0.24
Hydraulic	TL/kWh	0.05	0.02	0.01	0.02	0.02
Coal	TL/kWh	0.03	0.03	0.03	0.03	0.05
Lignite	TL/kWh	0.03	0.03	0.03	0.03	0.04
Geothermal	TL/kWh	0.00	0.00	0.00	0.00	0.00
Solar	TL/kWh	0.00	0.00	0.00	0.00	0.00
Wind	TL/kWh	0.00	0.00	0.00	0.00	0.00
Nuclear	TL/kWh	0.00	0.00	0.00	0.00	0.00

Source: Eltem-Tek database [34]. (Indicator: The selected power plants last five year data) and EIA [51] (Indicator: Renewable resources except hydroelectric power plants and nuclear cost data ratio were taken from EIA "Updated Capital Cost Estimates for Utility Scale Electricity Generating Plants, 2013, and then calculated by author)

Table D- 10 Transmission and distribution variable O&M cost

Variable O&M Cost		2008	2009	2010	2011	2012
Transmission	**TL/MWh**	5.1	5.5	5.5	5.4	5.4
Distribution	**TL/MWh**	8.02	9.80	11.89	12.11	13.85

Source: TETC [8] (Indicator: Transmission Variable O&M Cost, Breakdown of Transmission Cost to the Cost Items between 2008-2012, for 2011, page 67 and 2012, page 71) and TEDC [54] (Indicator: Distribution Variable O&M Cost from 2008 to 2012, TEDC website, Electricity Tariffs)

Table D- 11 Monthly fuel cost for Çatalağzı thermal PP, 2008-2012

Fuel Cost (TL/ Tonne)	2008	2009	2010	2011	2012
January	91.24	105.77	96.38	104.89	122.53
February	96.67	105.11	94.41	109.15	124.78
March	98.54	103.86	96.55	109.72	125.35
April	101.17	102.54	97.12	112.40	127.11
May	102.21	113.87	99.33	115.36	127.90
June	102.21	111.76	100.84	120.00	128.95
July	104.36	108.09	95.00	118.00	128.99
August	104.06	104.58	101.15	117.60	128.57
September	103.99	103.94	104.48	119.87	129.13
October	103.62	102.58	103.52	121.77	130.07
November	106.59	102.58	109.35	123.49	130.63
December	105.22	101.44	112.72	124.68	132.51
Average	**101.66**	**105.51**	**100.90**	**116.41**	**128.04**

Source: Eltem-Tek database [34].

Table D- 12 Resource costs of primary and secondary resources

Price of Resources	Unit	2008	2009	2010	2011	2012
Primary Resources						
Lignite	**TL/tonne**	42.0	49.7	54.5	62.5	69.6
Natural Gas	**TL/ MW**	63.88	62.02	51.15	55.70	73.40
Hard Coal	**TL/ tonne**	101.66	105.51	100.90	116.41	128.04
Secondary Resources						
Diesel	**TL/litter**	2.873	2.594	3.059	3.679	4.018
Fuel Oil	**TL/tonne**	1298	1242	1395	1873	2183

Source: IEA, Energy Prices and Taxes,1st Quarter 2013 [37].Uranium cost [55] is taken as 130 $/tonne .

APPENDIX - E

GHG EMISSION DATA

Table E- 1 IPCC Tier-1 GHG emission factors for electricity generation sector

Sector	Gas	Unit	Emission Factor
Energy			
Hard Coal	CO_2	tC/TJ	25.8
Lignite	CO_2	tC/TJ	27.6
Asphalt	CO_2	tC/TJ	25.8
Secondary Fuel Coal	CO_2	tC/TJ	25.8
Petroleum Coke	CO_2	tC/TJ	25.8
Petroleum	CO_2	tC/TJ	20.0
Natural Gases	CO_2	tC/TJ	15.3
Energy-Electricity Production			
Hard Coal	CH_4	KG/TJ	1.0
Lignite	CH_4	KG/TJ	1.0
Asphalt	CH_4	KG/TJ	1.0
Secondary Fuel Coal	CH_4	KG/TJ	1.0
Petroleum Coke	CH_4	KG/TJ	1.0
Petroleum	CH_4	KG/TJ	3.0
Natural Gas	CH_4	KG/TJ	1.0
Energy -Electricity Production			
Hard Coal	N_2O	KG/TJ	1.4
Lignite	N_2O	KG/TJ	1.4
Asphalt	N_2O	KG/TJ	1.4
Secondary Fuel Coal	N_2O	KG/TJ	1.4
Petroleum Coke	N_2O	KG/TJ	1.4
Petroleum	N_2O	KG/TJ	0.6
Natural Gas	N_2O	KG/TJ	0.1

Source: Turkish Statistical Institute [30].

Table E- 2 Conversion of EGC GHG emissions

Year	GHG Emissions (tonne of CO_2 equivalent)			
	CO_2	CH_4	N_2O	Total
		Hard Coal		
2001	2,075,658.00	550.00	8,940.00	2,085,148.00
2002	1,841,298.00	475.00	8,046.00	1,849,819.00
2003	1,869,048.00	475.00	7,748.00	1,877,271.00
2004	1,637,171.00	450.00	7,450.00	1,645,071.00
2005	2,063,173.00	550.00	9,238.00	2,072,961.00
2006	2,161,531.00	575.00	9,834.00	2,171,940.00
2007	2,354,281.00	625.00	10,728.00	2,365,634.00
2008	2,140,099.00	575.00	9,536.00	2,150,210.00
2009	2,116,352.00	575.00	9,536.00	2,126,463.00
2010	1,936,892.00	525.00	8,642.00	1,946,059.00
Lignite				
2001	37,772,939.00	8,600.00	143,338.00	37,924,877.00
2002	28,850,572.00	6,575.00	109,962.00	28,967,109.00
2003	22,974,436.00	5,225.00	87,016.00	23,066,677.00
2004	19,955,273.00	5,025.00	84,036.00	20,044,334.00
2005	27,755,978.00	7,000.00	116,816.00	27,879,794.00
2006	29,239,954.00	7,375.00	123,074.00	29,370,403.00
2007	35,584,076.00	8,975.00	149,596.00	35,742,647.00
2008	39,034,844.00	9,850.00	164,198.00	39,208,892.00
2009	36,762,030.00	9,275.00	154,662.00	36,925,967.00
2010	33,626,988.00	8,475.00	141,550.00	33,777,013.00
Natural Gas				
2001	10,907,746.00	4,875.00	5,960.00	10,918,581.00
2002	9,494,916.00	4,250.00	5,066.00	9,504,232.00
2003	4,709,979.00	2,100.00	2,384.00	4,714,463.00
2004	2,853,499.00	1,275.00	1,490.00	2,856,264.00
2005	4,158,668.00	1,875.00	2,086.00	4,162,629.00
2006	6,157,174.00	2,750.00	3,278.00	6,163,202.00
2007	9,501,323.00	4,250.00	5,066.00	9,510,639.00
2008	11,157,979.00	5,000.00	5,960.00	11,168,939.00
2009	9,897,102.00	4,425.00	5,364.00	9,906,891.00
2010	8,729,806.00	3,900.00	4,768.00	8,738,474.00

Source: EGC [38]. (The values were taken from EGC by Right to Information Act, 2012)

APPENDIX - F

EXPRESSIONS AND FORMULAS USED IN OUR MODEL

Formula used in GHG emission calculations are given in Eq.1.

$$\textbf{Emissions}_{GHG,fuel} = \textbf{Fuel Consumption}_{fuel} * \textbf{Emission Factor}_{GHG,fuel} \qquad \textbf{(Eq.1)} \qquad \textbf{[30]}$$

Emissions $_{GHG,fuel}$: *Emissions of a given GHG by type of fuel (kg GHG)*

Fuel Consumption $_{fuel}$: *Amount of fuel combusted (TJ)*

Emission Factor $_{GHG,fuel}$: *Default emission factor of a given GHG by type of fuel (kg/TJ). For CO_2, it includes the carbon oxidation factor, assumed to be 1.*

Formula used in LCOE calculations are given in Eq.2.

$$\textbf{LCOE} = \frac{\sum_t [(\textbf{Investment}_t + \textbf{O\&M}_t + \textbf{Fuel}_t + \textbf{Carbon}_t + \textbf{Decommisioning}_t)*(1+r)^{-t}]}{\sum_t [\textbf{Electricity}_t *(1+r)^{-t}]} \qquad \textbf{(Eq.2)} \qquad \textbf{[47]}$$

Investment$_t$: *Investment costs in year "t"*

O&M$_t$: *Operation and maintenance costs in year "t"*

Carbon$_t$: *Carbon costs in year "t"*

Decommisioning$_t$: *Decommissioning costs in year "t", taken as a zero.*

Electricity$_t$: *The amount of electricity produced in year "t"*

$\textbf{(1+r)}^{-t}$: *The discount factor for year "t"*

Table F- 1 Activity level expressions in demand branch

Sub-branch Name	Activity Level
Residential and Services	Key\Population\Medium[Million people]
Agriculture Energy Usage	Key\GDP\GDP MER[Billion us$] * Key\ValueAdded\Agriculture[%]
Industrial Energy Usage	Key\GDP\GDP MER[Billion us$] *Key\ValueAdded\Industry[%]
Transportation	Key\GDP\GDP MER[Billion us$]
Non-Energy Usage	Key\GDP\GDP MER[Billion us$]
Bunker Fuel	No data

Source: Our model. The expressions were determined by the author.

Table F- 2 Final energy intensity expressions in demand branch

Sub-branch Name	Final Energy Intensity
Residential and Services	HistTotalEnergy[TOE] / Total Activity[Person]
Agriculture Energy Usage	HistTotalEnergy[TOE]/ Total Activity[USD]
Industrial Energy Usage	HistTotalEnergy[TOE]/ Total Activity[USD]
Transportation	HistTotalEnergy[TOE]/Transportation:Total Activity[USD]
Non-Energy Usage	HistTotalEnergy[Thousand TOE]/Total Activity[USD]
Bunker Fuel	No data

Source: Our model. The expressions were determined by the author.

Table F- 3 Expressions used in BAU scenario

Main Branch	Sub-branch Name	Expressions
Key Assumptions		
GDP	**GDP MER**	Growth (4.92%, 2013, 5.2%, 2018, 4.1%, 2030, 2.3%)
Value Added	**Agriculture**	Growth (Key\Intensity\MaxDecline[rate])
	Industry	LogisticForecast
	Services	LinDataTrend
	Manufacturing	LogisticForecast
	Manufacturing2	100 * Manufacturing[%] / Industry[%]
Population	**Medium**	Interp
Income	**Income MER**	Key\GDP\GDP MER[us$] / Key\Population\Medium[people]
Demand		
Residential and Services	**Baseline/ HistTotalEnergy Tab**	LinForecast
Agriculture Energy Usage	**Baseline/ HistTotalEnergy Tab**	LinForecast
Industrial Energy Usage	**Baseline/ HistTotalEnergy Tab**	LinForecast
Transportation	**Baseline/ HistTotalEnergy Tab**	LinForecast
Non Energy Usage	**Baseline/ HistTotalEnergy Tab**	LinForecast
Bunker Fuel	**Baseline/ Total Energy**	LinDataTrend
Transformation		
Electric Generation	**Output Fuels/ Output Price Tab**	Growth(HistoricalGrowth)
Electric Generation	**Processes / Exogenous Tab**	Step
Transmission and Distribution Losses	**Processes/ Losses Tab**	Interp
Transmission and Distribution Losses	**Process / Variable Cost Tab**	Growth(HistoricalGrowth)
Resources		
Primary	**Lignite/ Indigenous Tab**	LinForecast
Primary	**Natural Gas/ Indigenous Tab**	LinForecast
Primary	**Hard Coal/ Indigenous Tab**	LinForecast
Secondary	**Diesel/Indigenous Tab**	LogisticForecast
Secondary	**Fuel Oil/Indigenous Tab**	LogisticForecast

Source: The expressions were determined by the author.

APPENDIX - G

PRIVATIZATION TIME SCHEDULE

Table G- 1 The privatized power plants in 2013

Power Plant Name	Fuel Type	Installed Capacity(MW)
Kangal	Lignite	457
Seyitömer	Lignite	600
Hamitabat	Natural Gas	1156
Berdan	Hydraulic	10.20
Hasanlar	Hydraulic	9.35
Hoşap (Zeynek)	Hydraulic	3.45
Koçköprü	Hydraulic	8.80
Arpaçay-Telek	Hydraulic	0.06
Bozkır	Hydraulic	0.08
Bozüyük	Hydraulic	0.36
Durucasu	Hydraulic	0.80
Engil	Hydraulic	4.59
Erciş	Hydraulic	0.80
Ermenek	Hydraulic	1.12
Göksu	Hydraulic	10.80
Haraklı- Hendek	Hydraulic	0.26
Kısık	Hydraulic	9.26
Kiti	Hydraulic	2.76
Ladik-Büyükkızoğlu	Hydraulic	0.40
Pazarköy-Akyazı	Hydraulic	0.18

Source: Republic of Turkey Prime Ministry Privatization Administration [43].

Table G- 2 Privatization time schedule

Power Plant Name	Fuel Type	Installed Capacity (MW)	Assumed Privatization Year
Kangal	Lignite	457	
Seyitömer	Lignite	600	
Hamitabat	Natural Gas	1156	
Arpaçay- Telek	Hydraulic	0.06	
Berdan	Hydraulic	10.2	
Bozkır	Hydraulic	0.07	
Bozüyük	Hydraulic	0.36	
Durucasu	Hydraulic	0.80	
Engil	Hydraulic	4.59	
Erciş	Hydraulic	0.80	**2013**
Ermenek	Hydraulic	1.12	
Göksu	Hydraulic	10.80	
Haraklı-Hendek	Hydraulic	0.26	
Hasanlar	Hydraulic	9.35	
Hoşap	Hydraulic	3.45	
Kısık	Hydraulic	9.26	
Kiti	Hydraulic	2.76	
Koçköprü	Hydraulic	8.80	
Ladik-Büyükkızıloğlu	Hydraulic	0.40	
Pazarköy-Akyazı	Hydraulic	0.18	
Kemerköy	Lignite	630	
Yatağan	Lignite	630	
Yeniköy	Lignite	420	
Adıgüzel	Hydraulic	62	
Alpaslan-1	Hydraulic	160	**2014**
Demirköprü	Hydraulic	69	
Gezende	Hydraulic	159	
Karacaören-1	Hydraulic	32	
Kemer	Hydraulic	48	

Source: Privatization years are determined by considering Republic of Turkey Prime Ministry Privatization Administration privatization portfolio [43] and Turkish government strategies. The part of power plants (generally hydroelectric power plants) privatization years are assumed by the author.

Table G- 3 Privatization time schedule (Continued)

Power Plant Name	Fuel Type	Installed Capacity (MW)	Assumed Privatization Year
Çatalağzı	Hard Coal	300	
Afşin-Elbistan A	Lignite	1440	
Afşin-Elbistan B	Lignite	1355	
Soma A-B	Lignite	1034	
Altınkaya	Hydraulic	702.55	
Anamur	Hydraulic	0.84	
Bozyazı	Hydraulic	0.42	
Derbent	Hydraulic	56.40	
Dere	Hydraulic	0.60	
Esendal	Hydraulic	0.30	**2015**
Hirfanlı	Hydraulic	128.00	
Işıklar (Visera)	Hydraulic	1.04	
İvriz	Hydraulic	1.04	
Kapulukaya	Hydraulic	54.00	
Kayaköy	Hydraulic	2.56	
Kesikköprü	Hydraulic	76.00	
Mut-Derinçay	Hydraulic	0.88	
Silifke	Hydraulic	0.40	
Zeyne	Hydraulic	0.33	
Ambarlı	Natural Gas	1351	
Ambarlı	Fuel Oil	1170	
Almur	Hydraulic	27.00	
Çamlıgöze	Hydraulic	32.00	**2016**
Hasan Uğurlu	Hydraulic	500.00	
Kılıçkaya	Hydraulic	120.00	
Köklüce	Hydraulic	90.00	
Suat Uğurlu	Hydraulic	69.00	
Aliağa	Natural Gas	180	
Çan	Lignite	320	
Tunçbilek A	Lignite	65	
Tunçbilek B	Lignite	300	**2017**
Aslantaş	Hydraulic	138.00	
Çatalan	Hydraulic	168.90	
Karkamış	Hydraulic	189.00	
Menzelet	Hydraulic	124.00	

Source: Privatization years are determined by considering Republic of Turkey Prime Ministry Privatization Administration privatization portfolio [43] and Turkish government strategies. The part of power plants (generally hydroelectric power plants) privatization years are assumed by the author.

Table G- 4 Privatization time schedule (Continued)

Power Plant Name	Fuel Type	Installed Capacity (MW)	Assumed Privatization Year
Bursa	Natural Gas	1432	
Orhaneli	Lignite	210	
Doğankent	Hydraulic	74.50	
Gökçekaya	Hydraulic	278.40	
Kılavuzlu	Hydraulic	40.50	**2018**
Kürtün	Hydraulic	85.00	
Özlüce	Hydraulic	170.00	
Sarıyar	Hydraulic	160	
Tortum	Hydraulic	26.20	
Yenice	Hydraulic	38	
Hopa	Fuel Oil	50	
Çukurca	Diesel	1.04	
Akköprü	Hydraulic	115.00	
Botar	Hydraulic	1.58	**2019**
Dereiçi	Hydraulic	0.40	
Erik	Hydraulic	6.48	
Ermenek	Hydraulic	302.40	
Koyulhisar	Hydraulic	0.20	

Source: Privatization years are determined by considering Republic of Turkey Prime Ministry Privatization Administration privatization portfolio [43] and Turkish government strategies. The part of power plants (generally hydroelectric power plants) privatization years are assumed by the author.

APPENDIX - H

RESULTS OF OUR MODEL

Table H- 1 Numerical results of GDP MER and population, 2013-2050

Year	GDP MER (Billion US Dollar)	Population (Million People)
2012		
2013	661.10	74.9
2014	695.50	75.8
2015	731.70	76.7
2016	769.70	77.4
2017	809.70	78.1
2018	842.90	78.9
2019	877.50	79.6
2020	913.50	80.3
2021	950.90	81
2022	989.90	81.7
2023	1030.50	82.3
2024	1072.70	83
2025	1116.70	83.7
2026	1162.50	84.3
2027	1210.20	85
2028	1259.80	85.6
2029	1311.40	86.2
2030	1341.60	86.8
2031	1372.40	87.4
2032	1404.00	87.9
2033	1436.30	88.5
2034	1469.30	89
2035	1503.10	89.5
2036	1537.70	90
2037	1573.10	90.4
2038	1609.30	90.9
2039	1646.30	91.3
2040	1684.10	91.8

Source: Our model. The table was drawn by the author.

Table H- 1 Numerical results of GDP MER and population, 2013-2050 (Continued)

Year	GDP MER (Billion US Dollar)	Population (Million People)
2041	1722.90	92.1
2042	1762.50	92.5
2043	1803.00	92.8
2044	1844.50	93.1
2045	1886.90	93.5
2046	1930.30	93.7
2047	1974.70	93.9
2048	2020.10	94.2
2049	2066.60	94.4
2050	2114.10	94.6

Source: Our model. The table was drawn by the author.

Table H- 2 Electricity consumption for each sub-branches (TWh)

	Residential and Services	Agriculture Energy Usage	Industrial Energy Usage	Transportation	Total
2012	88.65	5.94	93.36	0.52	188.47
2013	98.89	14.67	94.94	0.48	208.97
2014	102.83	15.11	96.65	0.50	215.10
2015	106.78	15.56	98.37	0.51	221.22
2016	110.73	16.01	100.08	0.53	227.35
2017	114.68	16.46	101.80	0.54	233.47
2018	118.62	16.90	103.52	0.56	239.60
2019	122.57	17.35	105.23	0.57	245.73
2020	126.52	17.80	106.95	0.59	251.85
2021	130.47	18.24	108.66	0.60	257.98
2022	134.41	18.69	110.38	0.62	264.10
2023	138.36	19.14	112.09	0.64	270.23
2024	142.31	19.59	113.81	0.65	276.36
2025	146.26	20.03	115.53	0.67	282.48
2026	150.20	20.48	117.24	0.68	288.61
2027	154.15	20.93	118.96	0.70	294.73
2028	158.10	21.37	120.67	0.71	300.86
2029	162.04	21.82	122.39	0.73	306.98
2030	165.99	22.27	124.11	0.74	313.11
2031	169.94	22.71	125.82	0.76	319.24
2032	173.89	23.16	127.54	0.77	325.36
2033	177.83	23.61	129.25	0.79	331.49
2034	181.78	24.06	130.97	0.81	337.61
2035	185.73	24.50	132.69	0.82	343.74
2036	189.68	24.95	134.40	0.84	349.86
2037	193.62	25.40	136.12	0.85	355.99
2038	197.57	25.84	137.83	0.87	362.12
2039	201.52	26.29	139.55	0.88	368.24
2040	205.47	26.74	141.27	0.90	374.37
2041	209.41	27.19	142.98	0.91	380.49
2042	213.36	27.63	144.70	0.93	386.62
2043	217.31	28.08	146.41	0.94	392.74
2044	221.26	28.53	148.13	0.96	398.87
2045	225.20	28.97	149.84	0.97	405.00
2046	229.15	29.42	151.56	0.99	411.12
2047	233.10	29.87	153.28	1.01	417.25
2048	237.04	30.32	154.99	1.02	423.37
2049	240.99	30.76	156.71	1.04	429.50
2050	244.94	31.21	158.42	1.05	435.63

Source: Our model. The table was prepared by the author.

Table H- 3 Total electricity generation of the scenarios (TWh)

	Business-as-usual	No Privatization	Nuclear Energy	Renewable Energy
2012	90.58	90.58	90.58	90.58
2013	159.99	173.86	159.99	159.99
2014	160.04	174.23	160.04	160.04
2015	146.10	174.41	146.1	146.10
2016	113.45	174.51	113.45	113.45
2017	93.38	174.57	93.38	93.38
2018	83.27	174.62	83.27	83.27
2019	65.43	174.63	65.43	65.43
2020	70.66	174.63	70.66	70.66
2021	79.59	174.63	79.59	79.59
2022	88.51	174.63	88.51	88.51
2023	97.44	174.63	97.44	97.44
2024	97.44	174.63	97.44	97.44
2025	97.44	174.63	97.44	97.44
2026	97.44	174.63	97.44	97.44
2027	97.44	174.63	97.44	97.44
2028	97.44	174.63	97.44	97.44
2029	97.44	174.63	97.44	97.44
2030	97.44	174.63	97.44	108.90
2031	97.44	174.63	97.44	108.90
2032	97.44	174.63	97.44	108.90
2033	97.44	174.63	97.44	108.90
2034	97.44	174.63	97.44	108.90
2035	97.44	174.63	97.44	120.36
2036	97.44	174.63	97.44	120.36
2037	97.44	174.63	106.37	120.36
2038	97.44	174.63	115.3	120.36
2039	97.44	174.63	124.23	120.36
2040	97.44	174.63	133.15	131.82
2041	97.44	174.63	133.15	131.82
2042	97.44	174.63	133.15	131.82
2043	97.44	174.63	133.15	131.82
2044	97.44	174.63	133.15	131.82
2045	97.44	174.63	142.08	133.40
2046	97.44	174.63	151.01	133.40
2047	97.44	174.63	159.94	133.40
2048	97.44	174.63	168.87	133.40
2049	97.44	174.63	168.87	133.40
2050	97.44	174.63	168.87	133.40

Source: Our model. The table was drawn by the author.

Table H- 4 Total GHG emissions of the scenarios ($MtCO_2$ eq.)

	BAU	**NP**	**NE**	**RE**
2012	42.15	42.15	42.15	42.15
2013	53.07	62.80	53.07	53.07
2014	53.10	63.01	53.10	53.10
2015	43.24	63.10	43.24	43.24
2016	18.19	63.16	18.19	18.19
2017	10.90	63.19	10.90	10.90
2018	6.26	63.22	6.26	6.26
2019	0.22	63.23	0.22	0.22
2020	0.00	63.23	0.00	0.00

Source: Our model. The table was prepared by the author.

Table H- 5 Social cost results for the scenarios (Billion Turkish Lira)

	BAU	NP	NE	RE
2012	13.98	13.98	13.98	13.98
2013	16.31	19.01	16.31	16.31
2014	16.98	19.79	16.98	16.98
2015	15.93	20.55	15.93	15.93
2016	12.30	21.30	12.30	12.30
2017	9.63	22.07	9.63	9.63
2018	8.87	22.84	8.87	8.87
2019	6.50	23.62	6.50	6.50
2020	25.95	37.50	25.96	25.95
2021	28.75	38.55	28.77	28.75
2022	31.56	39.63	31.60	31.56
2023	34.38	40.71	34.45	34.38
2024	28.38	41.81	28.45	28.38
2025	29.11	42.93	29.19	29.11
2026	29.85	44.06	29.94	29.85
2027	30.61	45.20	30.71	30.61
2028	31.39	46.35	31.49	31.39
2029	32.17	47.52	32.28	32.17
2030	32.97	48.71	33.09	43.95
2031	33.79	49.91	33.92	33.95
2032	34.62	51.12	34.75	34.78
2033	35.46	52.34	35.60	35.62
2034	36.31	53.58	36.47	36.48
2035	37.18	54.83	37.35	48.32
2036	38.02	56.10	38.14	38.34
2037	38.80	57.38	47.59	39.12
2038	39.71	58.68	50.58	40.03
2039	40.63	59.98	53.59	40.95
2040	41.57	61.31	56.60	52.87
2041	42.52	62.64	50.84	43.01
2042	43.49	63.99	51.80	43.97
2043	44.47	65.36	52.78	44.96
2044	45.47	66.73	53.78	45.95
2045	46.47	68.13	63.58	48.49
2046	47.50	69.53	66.68	48.01
2047	48.53	70.95	69.80	49.04
2048	49.58	72.38	72.93	50.09
2049	50.65	73.83	67.27	51.16
2050	51.72	75.29	68.35	52.24

Source: Our model. The table was prepared by the author.