Economic Assessment of Balçova – Narlıdere Geothermal District Heating System

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ABSTRACT

Development of a geothermal district heating system covers full range of activities from the determination of geothermal reservoir to the delivery of geothermal energy successfully. Economic assessments are come true in the early stages of geothermal developments. The goal of this thesis is to realize a detailed economic assessment for Balçova – Narlıdere Geothermal District Heating System (GDHS) which is one of the largest district heating systems in Turkey with its current heating capacity of 50 MW_{th}. Tasks in geothermal district heating investments are looked over at the beginning to make a correct economic evaluation and make future development in this geothermal field easy under the discipline of project management. Internal rate of return method which is commonly used financial tool to find the profitability of investments is applied to this investment. The economic analysis begin with the calculation of end of 2002 values of capital investment costs, revenues and operating costs since the existence of past cash flows. Future operating costs are determined according to the yearly expenditures realized in 2002. Future revenues are determined in accordance with the capacity of current heating system and energy utilization prices valid in 2002-2003 heating season. If the sustainability of a resource is considered in the design, the prospective geothermal district heating system could be operated in a long period. However, long-term period projects contain economic uncertainties for the future cash flows. The overall life of Balçova – Narlıdere GDHS is considered as 20 years after year 2001 and uncertainties are considered in this study. Calculations are realized according to various scenarios in which operating costs are constant throughout 20 years. To determine these scenarios, operating costs in 2002 which reflects the current expenditures are either decreased or increased by some percentages. In addition, 60 different pricing plans have been taken into consideration in these scenarios to demonstrate the effects of energy utilization prices on the profitability of investment. The continuity of current price policy for Balçova – Narlıdere GDHS is discussed and energy utilization prices per 100 m^2 are suggested for these scenarios. On the other hand, taxes paid to government in Balçova – Narlıdere GDHS investment are investigated to show the benefits of geothermal investments from the viewpoint of government. Because of the development in production of some equipment like heat exchangers, pipes and changing in marketing strategy, the costs of these equipment are

reduced. At the end, internal rate of return method is repeated for the current cost of the investment. The energy utilization prices for 13 different scenarios are found for this situation and results are compared with the prices determined to meet the real cost of the investment.

ÖZ

Bir jeotermal bölge ısıtma sisteminin gelişimi, jeotermal rezervuarın belirlenmesinden jeotermal enerjinin kullanıma sunulmasına kadar geçen tüm süreçleri kapsamaktadır. Ekonomik değerlendirmeler jeotermal yatırımların başlangıç aşamasında yapılır. Bu çalışmada, yaklaşık 50 MW_{th}'lık ısıtma kapasitesiyle Türkiye'nin en büyük bölge ısıtma sistemlerinden biri sayılan Balçova – Narlıdere Jeotermal Bölge Isıtma Sistemi (JBIS) için detaylı bir ekonomik analizin gerçekleştirilmesi amaçlanmıştır. İlk olarak, hem gelecekte bu jeotermal sahada olabilecek gelişmelerin proje yönetimi bilimi kapsamında yürütülmesini kolaylaştırma hemde doğru bir ekonomik değerlendirme yapabilme amaçlarıyla jeotermal yatırımların başlangıcından sonuna kadar yapılması gereken işler araştırılmıştır. Ardından yatırımların karlılığının hesaplanmasında en çok kullanılan finans araçlarından iç karlılık oranı yöntemi bu yatırım için uygulanmıştır. Ekonomik analize, geçmiş nakit akımlarının bulunması sebebiyle; ilk yatırım maliyetlerinin, gelirlerin ve işletme giderlerinin 2002 yılı sonu değerlerinin hesaplanmasıyla başlamıştır. Proje ömrü boyunca olabilecek işletme maliyetleri 2002 yılı baz alınarak hesaplanmıştır. Gelecekte kazanılması düşünülen gelirler ise sistemin bugünkü kapasitesi ve 2002-2003 ısıtma sezonunda geçerli olan kullanım ücretlerine göre belirlenmiştir. Eğer bir jeotermal rezervuarın sürdürülebilirliği dizayn safhasında göz önüne alınıyorsa, yapımı düşünülen jeotermal sistemin ömrü uzun tutulabilir. Bu tür uzun süreli projeler ise gelecek nakit akışlarıyla ilgili ekonomik belirsizlikler taşır. Bu çalışma, tüm sistem ömrünün 2001 yılı itibariyle 20 yıl olacağı öngörülerek yapılmıştır. İç karlılığının hesaplanmasında işletme giderlerinin değiştiği farklı senaryolar düşünülmüştür. Bu senaryoların belirlenmesinde şu anki giderleri yansıtan 2002 işletme maliyetleri belirli oranlarda arttırılmış ve azaltılmıştır. Aynı zamanda her bir senaryo için 60 farklı jeotermal enerji fiyatlandırma planı geliştirilerek, enerji kullanım fiyatlarının iç karlılık oranı üzerindeki etkileri gösterilmiştir. Balçova – Narlıdere JBIS'de halen uygulanan fiyatlandırma politikasının sürdürülebilirliği tartışılmış ve farklı harcama senaryolarında 100 m^2'lik bir alanın ısıtılması için aboneler tarafından ödenmesi gereken aylık enerji kullanım fiyatları belirlenmiştir. Diğer yandan, Balçova – Narlıdere JBIS yatırımıyla şu ana kadar devlete ödenen vergiler araştırılmış ve bu tip bir yatırımın devlet açısından yararları gösterilmiştir. Bu çalışmanın sonunda, yatırımın gelişen pazar şartları sonucunda

değişen fiyatlar ile yapıldığı kabul edilerek, iç karlılık oranı yöntemi tekrarlanmıştır. Bu durum için, farklı senaryolardaki aylık enerji kullanım ücretleri, uygulama maliyetleriyle yapılan hesaplamaların sonucunda bulunan ücretlerle karşılaştırılmıştır.

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NOMENCLATURE

A_r	: Net cash flows for the r^{th} year
BV_r	: The book value at the end of the r^{th} year after the depreciation charge for the rth year has been made
C_r	: Cost of an investment in the r^{th} year of the project
d	: The inflation rate
D_r	: Depreciation for the r^{th} year
f	: The depreciation rate
F	: Future value of an investment
GP	: Taxable (gross) profit
i_e	: Effective interest rate per interest period
i^1	: Inflation-free rate
i_m	: Market interest rate
I	: Interests
I_a	: Annual interest rate or discount rate
k	: Number of compounding periods per year
L	: Economic life of a project
m	: The accomplishment date of a project (deadline of construction)
n	: Total number of compounding periods
N	: Number of years
NP	: Net profit
NPV	: Net present value
NPV^+	: Minimum positive net present value, which is the closest one to zero
NPV^-	: Maximum negative net present value, which is the closest one to zero
O	: Operating costs which do not include
P	: Present value of an investment
r	: Rate of internal return
R	: Total revenues
r_1	: A discount rate for NPV^+
$r_{2:}$	: A discount rate for NPV^-

S : Salvage value

t : The number of the periods for the project exploitation

V : Corporation tax

CHAPTER I

INTRODUCTION

1.1 Geothermal Energy

Geothermal energy, basically, is the thermal energy within the earth's interior and recognized as an important and viable source of renewable energy. It has been used for many centuries for different purposes such as space and water heating, cooking, and medicinal bathing. In fact, usage of geothermal energy was limited by technological improvements and man's imagination [1, 2, 3].

Today usage of earth's heat involves a wide variety of applications in various fields, including agriculture, industry, heating, electricity production and tourism. It can be said that, where hot fluids or steams are required, geothermal energy can be used.

The range of potential methods for utilizing from any geothermal resource mainly depends on the temperature of resources. The most important commercial thermal applications are:

a) Heating of dwellings, hotels, offices, hospitals, campus areas and other public houses
b) Space cooling applications by using an absorption refrigeration cycle
c) Obtaining of domestic hot and cold water
d) Heat pump applications
e) Agricultural facilities like place heating, combined space and hotbed heating of greenhouses for vegetables, flowers, plants, animal farms; drying of vegetables, fishes, rice, tobacco; mushroom growing or usage in hot irrigation
f) Therapeutic (health) and recreational bathing (heating of thermal and public swimming pools)
g) Heating of aquaculture farms
h) Open field heating (heating of streets, parking areas, and sidewalks)
i) Industrial applications (in sterilization, pasteurization, evaporation, and distillation processes) [2,4].

Geothermal resources have three main components: a heat source, a reservoir, and a fluid. The heat source can be either a very high temperature (>600 ^{o}C) magmatic intrusion that has reached relatively shallow depths (5-10 km) or, as in certain low-temperature systems, the Earth's normal temperature which is increases with depth. Geothermal fluid is the carrier that transfers the heat. Circulating fluids extract heat from the reservoir, which is a volume of hot permeable rocks. Reservoirs may contain hot water and/or stream. In many, but not all cases, the reservoir is connected to a surface recharge area that replenishes all or part of the fluids emerging naturally (for example in springs) or extracted in wells [5].

High heat flow zones may be located close to the surface where convective circulation plays a significant role in bringing the heat close to the surface. Convection occurs because of the heating and consequent thermal expansion of fluids in a gravity field. Heated fluid of lower density tends to rise and to be replaced by colder fluid of high density, coming from the margins of the system. Deep circulation of groundwater along fracture zones will bring the heat to shallower levels, collecting the heat flow from a broad area and concentrating it into shallow reservoirs or discharging as hot springs. By drilling into reservoirs, the hot water and/or steam are piped to the surface [1,5].

High temperature (above 150 ^{o}C) geothermal fluid mainly found in volcanic regions and island chains is used to drive a turbine, which generates electricity. Moderate temperatures (between 90 ^{o}C and 150 ^{o}C) and low-temperatures (below 90 ^{o}C) are suitable for direct heat utilizations where heat is used directly. On the other hand, binary cycle systems using heat transfer media of lower boiling point than water (such as organic fluids), enable power to be generated from moderate temperature resources. Moderate and low temperature resources can be found on all continents.

Geothermal energy developments could be broken down into two distinct categories: electricity production and heating applications. Geothermal heating applications are called, variously, "direct use" or "low enthalpy". The term "direct use" serves to distinguish the applications from "indirect" electricity production and the term "low enthalpy" is used to indicate that fluids, which are employed for heating usually, have low heat content [2,6].

1.2 Geothermal Heating

The main purpose of a geothermal heating system is primarily to use the ground thermal heat to reduce heating costs of a building. Geothermal heating applications for households can be divided into two groups: Space heating and district heating.

Space heating usually involves one geothermal well per structure. While heat (hot water or steam) is distributed to the large number of individual houses or blocks of buildings from a central location, through a network of pipes in district heating systems. District heating is technically, economically and environmentally the most efficient method to provide space heating and sanitary hot water particularly in urban communities. [2,4,7]

Geothermal district heating systems can be designed differently according to distribution of geothermal energy. The geothermal fluid can be delivered directly to the customers if the chemical properties of fluid is excellent. Waste or cooled fluid is collected in the return piping for delivery to the disposal facility. If the geothermal fluid is delivered directly to the customers; insulation is applied only on the supply pipes. In these systems, all of the pipes expose to the geothermal fluids and as a result, corrosion considerations are critical point in design. Because of chemical composition of fluids, generally directly usage of geothermal fluids is not possible. For very small systems, usage of geothermal water directly in the heating equipment is an economical solution but the service life of these heating units are decreased. Distribution systems which have several networks are usually used in geothermal district heating system. These systems employ insulated pipes for both the supply and return. The investment cost of them is higher than the capital investment cost of a system in which geothermal fluid is delivered directly to the customers [2,8]. A heat exchanger provides an interface between the geothermal fluid and water in energy distribution network in a system which consists of several networks. Heat exchangers are used to extract heat from the geothermal fluid and isolate the system from the geothermal fluid. Whereas geothermal water passes through one side of the heat exchanger, the heating system water passes through the other side. Gasketed plate types of heat exchangers are the most preferred ones in geothermal district heating systems. Because, they can be easily cleaned and their capacity can be increased by adding new plates. Thin stainless steel plates separate the two water flows, so that there is no actual contact or mixing.

Main components of geothermal district heating schemes which have three networks are: wellheads, energy production (transmission) and distribution networks, Heat Exchanger and Pumping Stations and energy consumption networks. Two particular types of geothermal wells can be identified as production and re-injection wells. Production wells is used to bring the geothermal fluid from the reservoir to the surface. If the geothermal reservoir is not artesian or self-flowing, pumps are required. Lineshaft vertical turbine type well pumps are used in the production wells [1,2]. The lineshaft pump system consists of a multi-stage downhole centrifugal pump, electric motor located on the surface and a long drive shaft assembly extending from the motor to the pump. A variable- speed drive set just below the motor on the surface, can be used to regulate flow instead of just turning the pump on and off [9]. The source of geothermal fluid is often located some distance away from the customers. This requires an a transmission network to transport the geothermal fluid. Above ground or buried underground transmission network carries the geothermal fluid which is usually in the liquid phase in district heating applications from the wellhead to the heat exchanger and pumping station. Geothermal fluid pumps, energy distribution network pumps, heat exchangers are installed in pumping and heat exchanger stations. City water, which is heated by geothermal fluid, is sent to the buildings by energy distribution network. If the building networks are separated from the energy distribution network, secondary heat exchangers will be installed in buildings which are named as substations in this study. Surface disposal system which disposes of cooled geothermal water on the surface or an injection system in order to inject it underground [2,8].

Increasing international demand for energy and concern for the environment from burning of fossil fuels, changeable situations of fuel markets, finally fluctuations in the world economy during the recent years influenced the technologies for using geothermal energy as a possible renewable energy source for district heating systems to meet increasing energy shortages [10, 11].

Geothermal district heating systems provide significant benefits to the community besides meeting their energy demand. Firstly, they have major impacts on the environment by significantly reducing overall emissions like the emission of sulfur dioxide, nitrous oxide, and dust particles. Therefore, they have great benefits for people's health through improved air quality and major roles in providing a clean, reliable, and cost-effective supply of thermal energy. Users can benefit from using this green and simple technology, save their money since low price of energy and low operating and maintenance costs according to traditional heating systems. Especially for industrial customers, the maintenance of geothermal systems is easier than the maintenance of traditional heating systems. On the other hand, actual required land for geothermal energy production is relatively small according to fuel acquisition and energy production by the conventional methods and other renewable energy resources. Household owners do not need storing fossil fuels on their property by joining to geothermal district heating systems. Temporary and permanently jobs are created for the construction and operation of heating systems. Employment opportunities are created in local industries and geothermal field throughout the implementation and operating of district heating systems [5,12].

However, there are some limitations, which obstruct the wide usage of geothermal energy throughout the world. Firstly, geothermal energy schemes require high capital investment costs per kW of installed power. It contains high level of risk during the exploration phase. Sometimes, geothermal development can not be carried on since losses of great money during the initial years of exploitation. Geothermal energy can be accepted as a clean energy, but geothermal development involves the potential for release of small amounts of toxic materials to air and water. One of the ways to reduce the adverse impacts of these releases is to undertake development in areas where the population is low and, therefore, the risk of exposure to humans is lessened. Geothermal development in residential areas increases the risk of exposure to humans. If the decision is made to proceed with development in populated areas, extra effort must be employed to make the development safely and to reduce toxic releases. Geothermal brines can pollute the environment both chemically and thermally if geothermal energy does not used properly. Required environmental protection and proximity of geothermal resources to potential users are also limit the usage of this renewable energy. There is a large variation in the public and political attitude towards the use of geothermal energy. It could not be easy to find the reasons for the difference in public attitude. One of the reasons for the negative attitude towards the geothermal energy might be lack of knowledge about this energy source. Social acceptance of geothermal projects besides of world economy influences the widespread usage of geothermal energy. The level of unfamiliarity has an indirect effect on the cost of geothermal energy. Banks and other funding agencies are less willing to lend their money to the development of an “unknown” energy source than to the development of a “known” energy source like oil and hydro. These circumstances are expected to increase the price of money for a “risky” project and sometimes obstruct the geothermal development. [5, 13]

Geothermal energy can also be accepted as renewable energy source as long as the rate of heat extraction from the earth does not exceed the rate at which the thermal reservoir it depends upon is recharged by the earth’s heat. For electricity generation, it may take several hundred years for a geothermal reservoir to recharge after it has been fully depleted. Geothermal resources usually have projected lives of 30 to 50 years. But, district heating systems may take 100-200 years to recharge, and for geothermal heat pumps, reservoir recovery may take 30 years or so [14].

The life of a resource may be prolonged by the waste fluid re-injection back into the reservoir, which is the most common method of disposal. Injection may also help to maintain reservoir pressure. However, it brings about chemical deposition of silicates, loss of injectivity and breakthrough of coldwater from injection wells to production wells. Over ground disposal of geothermal fluid has a potential hazard of water pollution of rivers and lakes as well as air pollution [1,2].

1.3 Background on Balçova Geothermal Field

Turkey is an energy importing country with more than half of its energy requirements met by imported fuels. On the other hand, widespread volcanism, femoral hydrothermal alterations, and the existence of more than 600 hot springs, some of which have 100^{o}C and greater temperatures, indicate that Turkey possesses significant potential in geothermal energy. The estimated overall potential in Turkey is about 38,000 MW. Of this potential, around 88% is appropriate for thermal use and the remainder for electricity production. Turkey is among the first five leader countries in its geothermal direct use applications. The district heating system applications were started with large scale, city based geothermal district heating systems [15, 16].

Balçova Geothermal Field that is located in the 10 km west of the İzmir city center (Konak) and 1 km south of the İzmir- Çeşme Highway. Balçova Geothermal Field covers a total area of about 3.5 km^2 with an average thickness of the aquifer horizon of 150 m [17]. Balçova is famous with its Agamemnon Spa Complex, Olympic Indoor Swimming Pool, and thermal hotels. Dr. Serruya and K. Tezcan realized the reconnaissance and exploration studies. Dr. Serruya accomplished geologic, hydrologic study in 1962. K. Tezcan who was charged by General Directorate of Mineral Research

& Exploration which is shortly known as MTA in Turkey done resistivity surveys and applied the self-potential method in Balçova Geothermal Field. Three shallow wells (S1, S2, and S3) drilled in 1963 by General Directorate of Mineral Research & Exploration after the first evaluation of geological, geophysical, and geochemical data. Depths, temperatures, and flow rates of these three wells were respectively 39 m, 124 ^{o}C, 27 l/s; 69 m, 102 ^{o}C, 11 l/s and 140 m, 101 ^{o}C, 1.25 l/s. Because of high calcite precipitation problem, the field could not be developed until 1983. Up to 1983, approximately 50 gradient, deep, and shallow wells have been drilled by MTA. On the other hand, some of household and greenhouse owners drilled their own wells in this region since the deficiency of geothermal law in those years [18, 19, 20].

Because of the high calcite problem in Balçova Geothermal Field, Balçova Termal Turizm ve Özel Eğitim İşletmeleri Ltd. Şti." used downhole type heat exchangers in 1981. It was the first geothermal heating application in Turkey. The Faculty of Medicine buildings of Dokuz Eylül University and Balçova Princess Hotel was heated by geothermal water respectively in 1983 and 1994. At present, there is a large district heating system in Balçova – Narlıdere regions. [19, 20]

1.4 Balçova - Narlıdere Geothermal District Heating System

There are three piping networks in Balçova – Narlıdere Geothermal District Heating System (GDHS): energy production network, energy distribution network and energy consumption network.

There are eight heat exchanger and pumping stations in Balçova – Narlıdere GDHS. The stations of Swimming pools, Faculty of Medicine and Hospital of Dokuz Eylül University which have two different stations, Spa, Balçova Termal Turizm ve Özel Eğitim İşletmeleri Ltd. Şti. (Balçova Termal Hotel) and Princess Hotel are connected with energy distribution cycle. The others which are respectively in Balçova and Narlıdere regions are connected with energy production network. Therefore, Balçova – Narlıdere GDHS is divided into two subsystems: Balçova GDHS and Narlıdere GDHS.

Energy is transferred to the energy distribution network by usage of two heat exchangers in Balçova Heat Exchanger and Pumping Station. Same system was also installed to Narlıdere Heat Exchanger and Pumping Station. The outlet temperature of heat exchangers determines the power levels and economics of the scheme. Therefore, heat exchangers, which are installed in Heat Exchanger and Pumping Stations, are important equipment in Balçova – Narlıdere GDHS. Plate type heat exchangers are used in this system. In order to overcome corrosion problem, titanium is chosen as a plate material in Balçova – Narlıdere GDHS. The geothermal supply temperature is fixed by the conditions in the reservoir. The return temperature is the main parameter in the design of GDHS. The rate of heat transfer is a strong function of the return temperature and reducing temperatures improves the heat transfer. The outdoor and indoor design temperatures are respectively 0^{o}C and 22^{o}C in the feasibility reports. Design and real temperatures in the supply and return pipes of main heat exchangers are given in Table1.1. Inlet and outlet temperatures in the energy consumption network is not given in this table.

Table 1.1 Temperatures in Balçova GDHS

	$temp_i$ (^{o}C)		**$temp_o$ (^{o}C)**	
	Design	**Real**	**Design**	**Real**
Temperatures in geothermal fluid side of the heat exchangers which installed in the Balçova Heat Exchanger and Pumping Station	98	115	47	65
Temperatures in energy distribution cycle side of the heat exchangers which installed in the Balçova Heat Exchanger and Pumping Station	42	60	90	90

In the energy distribution network, water is the treated by water softening equipment before circulating. City water in energy distribution network passes through the secondary heat exchangers which are installed in each building. The water in the energy distribution network is cooled to the network outlet temperatures and returned to the heat exchangers which are installed in heat exchanger and pumping stations. Heat transferred to the water that is circulated in building networks by usage of secondary heat exchangers. In building networks, hot city water is sent to the heating systems assembled in each household. It can be, also, used to obtain hot water for daily usage purposes. Radiators, fan coils are the most common house heating systems in Balçova – Narlıdere GDHS. Size and number of radiators are selected according to 90/70 ^{o}C working temperatures. Because, the flat heating systems are generally designed according to these temperatures. But these temperatures caused problems in Balçova – Narlıdere GDHS. In addition to heating systems with radiators or fan coils, floor heating systems can be used in households. But floor heating is not preferred by customers in Balçova – Narlıdere GDHS [17].

Balçova – Narlıdere GDHS project was drawn up and constructed by a private sector company. The Balçova GDHS is designed according to 7,500 household equivalent whereas Narlıdere GDHS is designed for 1,500 household equivalent. The feasibility report for the first part of Balçova GDHS which covers heating of 2,500 and cooling of 500 households in Balçova region was prepared in October 1995. The feasibility report was accepted and the contract signed on 20.10.1995 after the competitive bidding. The construction of Balçova GDHS was started out on 25th October 1995 and over on 20th October 1996. First part of the system was taken into the operation on 29th October 1996. At this time, it was decided to increase the capacity to the heating of 5,000 and cooling of 1,000 household equivalent. However, developer called off the cooling of households contract on 26th November 1996. The heating capacity of Balçova – Narlıdere GDHS was 2,500 dwellings on 30th December 1996 but new connections were continuing after that time. It was decided to grow the Balçova – Narlıdere GDHS to the system with 7680 household equivalent on 1st July 1997. The contract was signed on 3rd July 1997 and construction of Balçova GDHS investment was got through on 31st December 1999. The construction of Narlıdere GDHS started in April 1997. Narlıdere GDHS has been operated since October 1998. The contractor company and “Balçova Termal Turizm ve Özel Eğitim İşletmeleri Ltd. Şti” had operated Balçova – Narlıdere GDHS until August 2000. In this period, Balçova Termal Turizm ve Özel Eğitim İşletmeleri Ltd. Şti” was in charge of following the new connection transactions. The contractor was responsible with the operating of the system. In the beginning of August 2000, “Balçova Jeotermal Enerji San. Tic. Ltd. Şti.” which is a local government’s company was established and took over distributing hot water and operating of the system.

1.5 Aim and Contents of the Study

Geothermal district heating schemes are interdisciplinary projects. Critical Path Method (CPM) is one of the important project management tools for scheduling of complex projects. Therefore, CPM should be correctly applied for the scheduling of GDH developments. One of the main difficulties in the CPM applications is to determine the tasks and their durations which affect time and cost. Those tasks in

Balçova – Narlıdere GDHS are determined in this study for the future developments in which they can be used for CPM application. The main goal of this thesis is an accomplishment of economic viability study for Balçova – Narlıdere GDHS investment. Time value of money and internal rate of return method are carried out to reach the goal.

Data collection is the first step in the evaluation of Balçova – Narlıdere GDHS investment. It includes classifications of capital investment and operating costs. The capital costs are determined according to the accruals. The revenue and operating cost data from 2001 to 2003 are taken from the Accountancy Department of "Balçova Jeotermal Enerji San. Tic. Ltd". Distinguishing additional investment costs from the operating costs is important in the firm accounts of Balçova – Narlıdere GDHS. They are separated from each other successfully to make prosperous economic assessment. On the other hand, operating costs are re-categorized in this study. Economic data for previous years are taken from "Balçova Termal Turizm ve Özel Eğitim İşletmeleri Ltd. Şti ".

After accomplishment of data collection, end of 2002 values of revenues, capital investment and operating costs which are collected and expended from 1996 to 2002 are calculated. In the next step, the project overall life, equipment life, future expenditures, and revenues are estimated. Finally, economic profitability of Balçova – Narlıdere GDHS investment has been expressed by the calculation of internal rate of return.

Sustainable development demands a sustainable supply of energy resources. Geothermal district heating systems, which are designed according to the sustainability of geothermal resources, operate in a long period. Long period projects include uncertainties on future economical issues. Since the uncertainties of future operating costs, 13 different scenarios are considered on the calculation of IRR in this study. In addition, 56 different pricing plans have been taken into consideration for the price tag in all scenarios. Eventually, the effects of variations on IRR are demonstrated, current energy utilization price policy for Balçova – Narlıdere GDHS is discussed and required monthly fix charges per a house which is 100 m^2 are investigated for these scenarios in accordance with the IRR method. It is found that if the current price level is kept constant in future, the investment will not be feasible within the 20 years. If the energy utilization prices are considered to be kept constant, the proper price must be US $ 55.5. But, it is observed that monthly fix charge has been increased year by year with different percentages up to now in Balçova – Narlıdere GDHS. Therefore, 4 alternative pricing plans are developed in which augmentations are considered for energy prices. Consequently, augmentations in prices are also taken into consideration in this analysis to determine profitability of Balçova – Narlıdere investment.

CHAPTER II

PROJECT MANAGEMENT: AN OVERVIEW

2.1 Characteristics of Projects

A project is a group of activities that have to be performed in a logical sequence to meet preset objectives outlined by the client [21].

Enterprises perform operations and projects by limited resources. They are planned, executed, controlled and goal oriented activities. However, operations are ongoing and repetitive while projects are essentially unique and non-repetitive.

Projects can be implemented by public or private sectors. Political parties, national or local government officials, private entrepreneurs, or multinational corporations may identify projects. Identification of projects is processes that various needs, preconditions, and policies must be taken into account [22].

Every project has definite beginning, middle period, and ending in other words they are undertaken in finite period. Therefore, they are temporary. Projects have some objectives to attain. Projects are original and different in some distinguishing way from all similar undertakings. For that reason, every project is unique.

Activities in a project are nonrecurring and realized in order. Required time to complete these facilities can be estimated. Estimations depend on various factors. Main purposes of project managers are to complete the project in an estimated time interval. If main purpose cannot be realized, there is a delay in revenues and cost of interest for initial investment increase cost of a project [23].

Any development for establishing a geothermal district heating system is goal oriented. The aim is to meet the growing energy demand in specific duration. On the other hand, because of the diversities in each GDH development, these projects are original. Properties of geothermal fields (formation, capacity, and chemical properties of resources), designing criteria for geothermal district heating projects, piping of materials, protection of mechanical systems, energy transfer systems, peak load systems, and operation conditions vary state-to-state and location-to-location. Consequently, each geothermal energy development can be accepted as a project [24].

Four main components of a project are shown in Figure 2.1. When cost is the main consideration, contracts are awarded to the lowest bidder. If time is the emphasis in projects, the completion date will be the dominant factor. In high technology projects, quality requirements often have priority over time and cost. If the project time duration is decreased, the cost of a project will be increased. In addition, scope of the projects has great affects on time. Quality is always important for projects and should not be made a concession. People are the other important component of projects and their effects should be taken into consideration in the planning stage of projects [23, 24, 25].

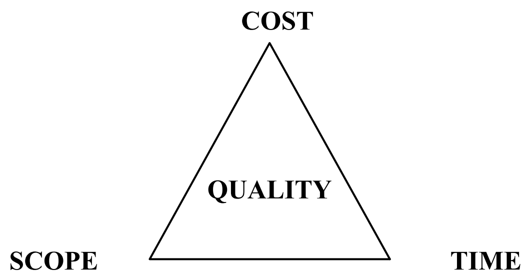

Figure 2.1 Four main components of a project

2.2 Project Management

The speed of a project, the number of departments, sub-contractors who need coordinating, high level of innovation, sophisticated communications, high volume of data, and limited availability of resources may increase the complexity of projects. If projects are complex, they include manageable components or subprojects. Coordination is needed between facilities in these types of projects. If there are some restrictions (time, scope, cost, and work force) in a project, project management will be required to meet preset objectives. Project management applies some tools (principles, concepts, and techniques) for planning, scheduling, managing, and controlling of people, equipment, and cost to realize the project efficiently, on time, within the budget and in accordance with the specifications. Eventually it improves performance of a project and organizational effectiveness of a company. A project manager is the project's single point of responsibility and company's representative to the client. When holding meetings with the client the planning and control system will provide information about every aspect of the project. If the environmental and social affects are considered in geothermal projects, the importance of planning and management processes of project is easily understood. But companies sometimes resist using project planning and control techniques because of the additional management cost. However, it should be appreciated that lack of information could be even more expensive if it leads to poor management decisions. All the processes of the project management can be organized into nine knowledge areas which is shown in Figure 2.2 [21,24,26].

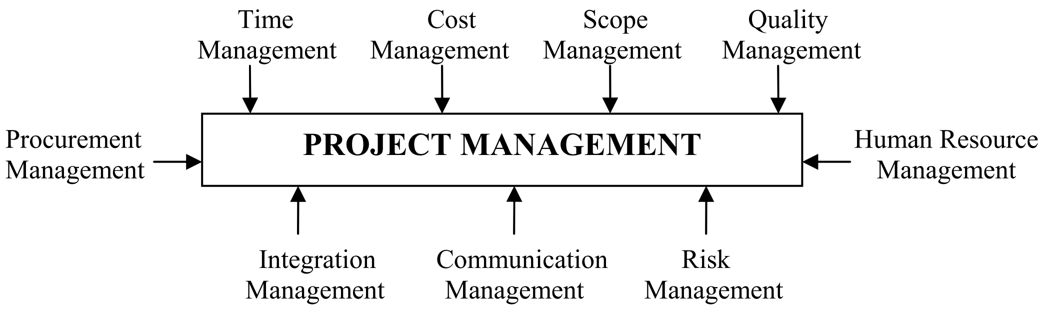

Figure 2.2 Project management knowledge areas

Geothermal district heating system projects are multidisciplinary projects as shown in Figure 2.3. High-level knowledge of different scientific disciplines is applied to enable economic and technical solutions throughout the developments. A successful geothermal development requires a well-defined and organized effort that brings together the experience of specialists (engineers, drillers, contract specialists, proven loop designers, installers, financiers and marketers) representing the disciplines needed to bring the project to a successful conclusion [2,10].

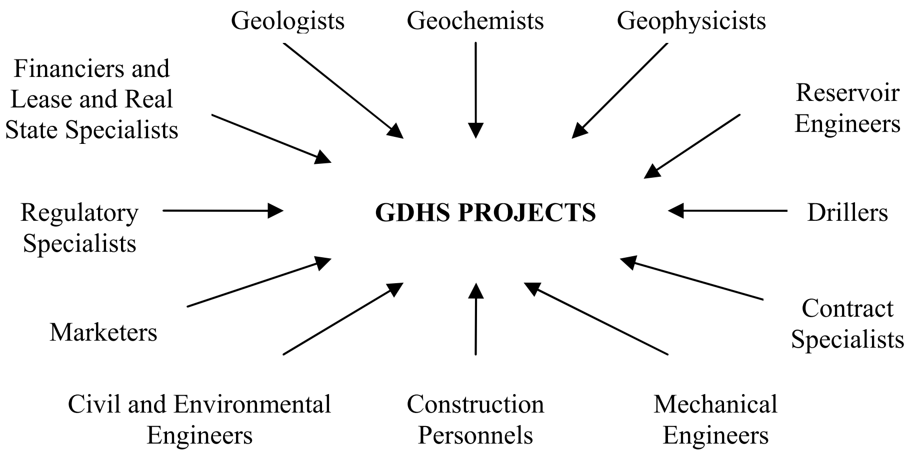

Figure 2.3 Interdisciplinary structures of geothermal district heating projects

Development of a GDHS covers full range of activities from the determination of geothermal reservoir to delivery of that energy successfully. The planning and application processes of a geothermal district heating system under the discipline of Project Management is important to improve project performance, organizational effectiveness and reach the project schedule and cost objectives.

2.3 Planning and Control Tools in Project Management Applications

Time and cost estimations, budget charts, cash flow diagrams, Gantt charts, work-breakdown structures, equipment and personnel restrictions, fishbone diagrams are some tools used for different purposes in project management.

Work-breakdown structures and some sophisticated computer programs used for scheduling of projects such as critical path method (CPM), program evaluation and review technique (PERT), graphical evaluation and review technique (GERT) are available to manage time most effectively. Project scheduling is used to identify the relations between activities, realistic time, cost estimations, and determination of critical activities for the efficient usage of all kind of resources (people, money, and materials). Gantt charts are used for project scheduling, managing human and material resources. Gantt chart allows us to see easily when tasks should begin and when they should end. Tasks are listed on the vertical axis, while time is measured along the horizontal axis in Gantt charts. Horizontal lines are drawn for each activity written in vertical axis. According to accomplishment of activities the inside of the horizontal lines are blackened. Gantt charts do not show the project wide consequences of schedule changes on a specific task.

Project management techniques break down a project into detailed activities and establish the interrelations among these tasks and subtasks. Task allows the project manager to organize the project into manageable components to coordinate all activities, and to set a time-sequence for project implementation. The work breakdown study (WBS) includes a list of all tasks. It serves as the basis of the project schedule. It usually takes one of the two possible forms: a table or a chart. Creation of WBS for the project is the first step in building a PERT/CPM network. PERT is simply a management planning and control tool. PERT/CPM is used in complex projects. Gantt charts show only the summary of the projects and complete the other network structures in complex projects like geothermal energy developments. One of the purposes of constructing the PERT chart is to determine how much time is needed to complete the project. The construction of the network requires two inputs. First, a selection must be made as to whether the events represent the start or the completion of an activity. Event completions are generally preferred. The next step is to define the sequence of events. PERT, budget charts, delayed activities, reports that show the quality of accomplished works are used to control any projects [21, 25].

Changes within the policy and political structure, difficulties with procurement and poor performance by project team members and contractors that can be occur during the life of the project must be taken into account in planning of geothermal projects.

2.4 Critical Path Method (CPM)

The critical path defines the series of activities that determine the duration of the project. Any delay in critical activities will extend the completion date of the project. Project delays invariably result in financial implications to both the client and the contractor.

If the client is responsible for delaying critical activities then the contractor should be legally entitled to an extension of time and compensation. If the contractor is late completing the project due to poor workmanship and ineffective management, then the client should be entitled to impose financial penalties as stipulated in the contract. Therefore, both the client and contractor must agree on the critical activities at the outset of the project [21].

2.4 Benefits of Project Management Applications

Benefits of project management (PM):

- PM allows developers to select the most appropriate project.
- PM allows developers to accomplish the construction of system in planned time or in less time and with less people by careful planning and scheduling.
- PM allows accomplishing the project according to the prepared specifications.
- PM allows accomplishing the project with minimum contradiction and confusion.
- PM increase the profitability of the company.

- PM provide better control of scope changes. Project management is the way for management of changing.
- PM makes the company more efficient and effective through better organizational behavior principles.
- PM enables documentation.
- PM allows people to make good company decisions.
- PM allows developer to work more closely with the current and prospective customers.
- PM increase the esteem of the project team [21].

CHAPTER III

TASKS IN GEOTHERMAL DISTRICT HEATING INVESTMENTS

3.1 Project Life Cycle

A project passes through a number of distinct phases, from project conception, through project execution to project completion. These phases are known collectively as the “Project Life Cycle”. Phases of geothermal projects vary according to their scopes.

The project life cycle of GDHS projects can be broken down into seven phases: preliminary study, appraisal study, project design, preparation of contract documents, construction, delivery of geothermal energy and project termination. The developer is responsible for preliminary studies, appraisal studies, project design and contract documents, as well as its long-term operation, regulatory permitting, financing and maintenance while a contractor is responsible for the construction of the system. Tasks in project life cycle are important for accurate cost and duration estimations and successful development. Tasks in these seven phases are summarized in this chapter [21, 25, 26].

3.1.1 Preliminary Studies

1. Selection of project manager to coordinate the project,
2. Selection of geothermal area,
3. Obtaining of the topographic map of the area,
4. Determination of desirability of geothermal heating project by the local authority,
5. Promotion of geothermal technologies at local professional meetings,
6. Determination of project management policies, procedures, and techniques,
7. Determination of tasks in a geothermal district heating project, task durations and deadlines,
8. Building of a work-breakdown structure and determination of critical milestones,

9. Establishment of standards for the authority, responsibility, and accountability of the project team,
10. Building of a project team,
11. Establishment of rewards program for project team members,
12. Reconnaissance surveys to investigate the reservoir temperature and applicability of thermal resources for a district heating development: In many of the geothermal fields as in Balçova - Narlıdere region, exploration holes or wells have already been drilled. Therefore, geologic data about the region, a sketch for existing well locations, well conditions, driller's reports, geophysical well logs, well tests can be available as well as subsurface core or drill samples [27]. They must be collected from the geothermal data banks and publications of governmental companies like MTA.
13. Reporting of resource location, apparent size, reservoir capacity, apparent quality average fluid temperature, flow rates, reservoir depths, net reservoir thickness, average porosity, transmissivity, static pressure below surface, salinity, density, pH and hydrological properties based on analysis of existing geologic, geochemical and geophysical data.
14. Decision on investigation,
15. Preparation of report on prospective drilling sites,
16. Investigation of drilling site,
17. Reporting of preliminary study results,
18. Pre-feasibility report on prospective drilling site,
19. Decision on appraisal study.

3.1.2 Appraisal Studies

1. Determination of what additional geological, geochemical and geophysical surveys are needed to site temperature gradient and exploration wells: Temperature gradient wells are often drilled to depths ranging from 2 to 200 meters (on rare occasions to 500 meters in depth) and from 50 to 150 mm in diameter. Exploration wells, can range from 200 to 3000 meters depth, with bottom-hole diameters of 100 to 220 mm. They are drilled to discover a new reservoir [28,29].
2. Preparation of geologic maps and reports,
3. Accomplishment of geophysical studies and preparation of geophysical reports: Geophysics provides important information about the nature of a geological feature

as effectively and certainly at a lower cost than a large number of boreholes. A geophysical survey consists of a set of measurements made over the surface of the earth, in the air above (and parallel to) the earth and in the boreholes within the earth. Geophysical exploration techniques have been used successfully to provide indirect evidence of resource existence, to locate the heat sources of geothermal systems that have no evident surface expression and to characterize the permeability of the potential reservoir. The survey measures variations in the physical properties of subsurface rocks. Wide variety of geophysical techniques such as Seismic Methods, Magnetic Methods, and Electrical Methods has been used in geothermal exploration [28].

4. Accomplishment of geochemical studies: Chemical components in geothermal fluids like oxygen, chlorines, calcium magnesium, CO_2 and H_2S has an important effect in selecting of materials. Geochemical studies involve sampling and analyzing water and gases from hot springs and other geothermal manifestations in the area under investigation [2,19,28].
5. Obtaining environmental, legal, regulatory (land use regulations) issues for an exploration drilling,
6. Recommendation of temperature well locations,
7. Obtaining regulatory approvals for temperature well locations,
8. Drilling and testing of temperature gradient wells,
9. Recommendation of locations for an exploration well and obtaining regulatory approvals,
10. Drilling and logging of exploration wells: There is never a guarantee that an exploration well intersects the geothermal fluids. If any desired result does not obtain from the first exploration well, opening of a new exploration well or more than one well can be discussed and decided after geothermal logging.
11. Study of fluid inclusions: It is useful in geothermal exploration. In the process of formation of minerals from hydrothermal fluids circulating in the fractures and pore spaces of geothermal system, tiny amounts of the fluids themselves become trapped when the mineral grows around them. These fluids exist as microscopic bubbles in the minerals that is known as fluid inclusions. They contain a sample of fluids that formed the mineral in which they are found, and the information derived can tell much about the formation and evolution of the geothermal system. This investigation is realized during the exploration drilling [28,29].

12. Performing a preliminary resource assessment (water level, the temperature, chemical properties of fluid, production rate, resource capacity estimations, proper locations for exploration and production wells) and formulation of preliminary conceptual model which emphasize the reservoir properties and reservoir potential,
13. Decision on making a feasibility assessment for geothermal energy district heating investment,
14. Making questionnaires for learning local people' opinions about geothermal energy,
15. Preliminary design for meeting demand:
    - Determination of distance between geothermal resources and potential heating markets,
    - Determination of size and density of population for the area where a district heating system is planned,
    - Estimation of number of residences and their locations which can easily afford the connection charges (power demand study),
    - Estimation of future population trend,
    - Determination of building density of the area and building types,
    - Enumerating the nonquantifiable effects of the project that may influence project design and the investment decision,
    - Alternative scenarios to meet the heating requirements,
    - Defining objectives of project clearly and definitely,
    - Transmission network design: Transmission network has some of the same design considerations as water distribution systems. The economic transmission radius and the maximum economical length of transmission pipelines are important.
    - Distribution network design (pipelines length and diameter),
    - Sizing and choosing of components like well pumps, geothermal and city loop pumps, heat exchangers, etc: The designer should consider the depth of wells, fluid chemistry, temperature, and pressure of geothermal fluid in choosing a geothermal well pump. Power consumption of pumps must be minimized for obtaining optimum system performance.
    - Determination of production and re-injection wells costs,
    - Making an initial market assessment,

- Defining of the project capital cost based on the sizing decisions, depth of the reservoir and layout of the surface network,
- Determination of the schemes earnings according to the physical calculations of the heat extracted from the geothermal fluid and power demand study,
- Estimation of future operating costs,
- Assessment of cost and risks,
- Internal rate of return calculations and determination of economic rationale of project (expected cost and profitability of project),
- Selecting MARR, comparing MARR with IRR,
- Completing preliminary design (physical calculations of the system) and economic assessment,
- Alternative projects to meet the heating requirements,
- Comparison of all district heating alternatives with geothermal district heating in accordance with life cycle costs and technical applicability,
- Selection of geothermal energy as a heating source of the district heating system,
- An environmental impact study which is very important document and includes reports on social structure, air and water quality effects of geothermal energy,

16. Feasibility report,
17. Decision on project design.

3.1.3 Project Design

The most cost-effective way and minimum life cycle cost for attaining the project objectives are considered in design phase.

1. Determination of heat loss and storage characteristics of typical buildings in this area: Calculating heat loss for each building is correct to determine peak heat load of the considered geothermal district heating system. However, it is not difficult to accomplish this calculation in limited time. Calculations can be made for some group of typical buildings. Average of the result reflects the characteristics of the buildings in that region [30].
2. Physical calculations of the heat extracted from the geothermal fluid,
3. Evaluation of energy demand and supply,

4. Collection of climate information (hourly temperature information for each day in a period and monthly average temperatures),
5. Analysis of collected weather records,
6. Selection of the design value of the outdoor air temperature: A design outdoor temperature value can be selected considerably higher (5-10 ^{o}C) than the lowest annual value [1].
7. Determination of the variation of required heat load: Required heat load is proportional to the difference between the design room temperature and the outdoor air temperature by times, the average heat load in a week, in a heating season, maximum heating load that is proportional to difference between the design room temperature and the minimum outdoor temperature, and total heat load for system design [1].
8. Determination of designing heat load factor: Heat load factor is the ratio between average heat load over the year and maximum demand. It shows the practicability of the geothermal systems. It influences the unit cost of energy delivery to the user. The capital investment for a district heating system is directly related to the capacity of the system. The higher the annual load factor is required to lower the unit cost for geothermal energy. On the other hand, heat load reflects working time of the system. Therefore, it should be increased [1].
9. Determination of the thermal load density which is an important criterion in district heating projects,
10. Decision on how the maximum load will be covered,
11. Standardization of well-head equipment,
12. Selection of material for considered piping system: The material of piping system will depend on the temperature at which the thermal energy is transmitted. A distribution network pipe is commonly made from pipe designed to withstand 12 bar (1.2 MPa) internal pressure. Carbon steel is the most widely used material for geothermal transmission lines and distribution networks. Other common types of piping material are fiberglass reinforced plastic (FRP) and asbestos cement (AC). Polyvinyl chloride (PVC) piping is often used for the distribution network Most district heating systems or long transmission lines carrying warm geothermal fluid will require some form of insulation. This insulation can be provided by a pre-insulated piping system. The pre-insulated system consists of a carrier pipe, through which the fluid is transported, an insulation layer, and a jacket material. The

insulation must be waterproof. Moisture can destroy the value of thermal insulation, and cause rapid external corrosion. [1,2,9].

13. Transmission network design: The pressure drop in a straight section of pipe at maximum rate of flow is on the order of 0.5-1.0 bar/km [31].
14. Determination of types and numbers of supports used in the transmission network if it is not.
15. Layout of distribution network, which includes trunk lines, branch lines and house lines with working temperatures and pressures: There may be only one trunk line or more depending on local conditions and the size of the network. The line diameter decreases from the beginning to end. Pressure drop in distribution network is more complicated and it should be calculated correctly. These lines are designed with the possibilities of growth of hot water demand in mind, to minimize the risk of insufficient pressure; minimum water pressure to any user is a not less than 1.5-2.0 bars. The maximum pumping pressure should be chosen correctly. The maximum pressure to any user should not be grater than 7.0-8.0 bars. Water velocity is accepted as 2 m/s [32].
16. Determination of exact costs of road cut and fills,
17. Designing a flow control system which collect, and control data to determine the water losses,
18. Designing a controlling system with digital programmable logic controller (PLC) based on the controls with radio telemetry between the heat exchanger and pumping station building and remote wells to control the pumps from the system manager's office,
20. Developing a detailed economic model of the geothermal project,
21. Completing any environmental studies and obtaining all pre-construction environmental approvals,
22. Desicion on drilling production wells.

3.1.4 Production Drilling

Production well design and the drilling process will be very similar to that developed during the exploration phase. Geothermal wells, whether exploration or production, are drilled using rotary drilling technologies adopted largely from the oil industry, and to a lesser extent from water and mineral exploration. A geothermal well can be vertical (straight) or deviated. Typically, geothermal wells are drilled to depths ranging from 200 to 1500 meters depth for low and medium temperature systems, and from around 700 to 3000 meters depth for high temperature systems. Wells are drilled in a series of stages, with each stage being of smaller diameter than the previous stage, and each being secured by steel casings, which are cemented in place prior to drilling the subsequent stage. The final production section/s of the well are secured by an un-cemented, perforated liner [29].

1. Recommendation of appropriate location of reservoir, the sitting of production wells, the depth of wells and drilling procedures that will allow the well to be drilled as safely and economically as possible.
2. Obtaining regulatory approvals for the locations of production wells,
3. Building the access roads to the prospective wells locations,
4. Well design,
5. Selection of blowout prevention equipment that is vital to the drilling operation and varies in different areas,
6. Selection of drilling rig: For most drilling operations, rigs in the range of 300 to 1000 hp are adequate depending upon the depth of the reservoir and the casing and pipe loads required. In some areas, where high rotary torque is encountered, an extra heavy, independently powered rotary table is used.
7. Selection of drilling bits, drilling fluid and pumps: The most common drilling fluid is made of water mixed with bentonite clay with other additives as needed to adjust the density and other properties of the fluid. This is commonly called drilling mud. It is used to clean the rock fragments from beneath the bid and carry them to the surface, exert sufficient hydrostatic pressure against subsurface formations to prevent formation fluids from flowing into the well and cool the rotating drill string and bit. The pumps are used to circulate bentonite mud. They should be sufficient size to complement the hydraulics program on the rig [28].
8. Development of a budget and schedule includes costs associated with commonly encountered drilling problems,
9. Estimation on drilling costs by drilling engineers,
10. Evaluation of the economic effects of new technologies and operational procedures on well costs,

11. Writing the bid specifications that include well description, the equipment, and procedures: Bids generally base on the cost per meter of hole drilled. If costs cannot be estimated with reasonable certainty, the bid basis is usually a contract price per day. However, in some cases, the bid is based on cost per meter down to a certain depth or formation and cost per day beyond that point [29].
12. Selection of drilling contractor and making a contract for drilling,
13. Preparation of surface location to accommodate the specific rig,
14. Mobilizing of a rotary drilling rig to the site and assembly of the rig and mud pumps,
15. Transporting of heavy thick-walled pipes, drilling pipes, bits and stabilizers to the well location,
16. Construction and isolation of mud pool and channel (bailer dump box) which enables to carry the drilling mud to isolated pool,
17. Preparation of drilling mud,
18. Drilling of the production well to the targeted depth,
19. Modifications on original drilling plan as drilling progresses because of unforeseen circumstances,
20. Dating studies for igneous rocks,
21. Stratigraphic studies during the drilling:
    - Samples are gathered in each 1-meter to analyze both surface outcrops and rock samples from drilling. Typically, 450 g -900 g of sample will be collected each 3 to 6 m of drilling [29].
    - Samples will be carefully washed to remove the drill mud.
    - Samples are placed in sample bags.
    - Samples are examined under a microscope and rock types are identified in the area by a geologist,
    - Information about the drill hole name, location, date, and the depth is recorded on sticked labels,
    - Keeping of samples.
22. Temperature logging which shows the temperature inside the well and carried out by using an equipment called Amerada: Recording of change in temperature as a function of depth is called as temperature logging. A special equipment is moved at a constant speed either up or down the well. The temperature is measured and saved

to the equipment. The information is read from the equipment and registered. This apparatus is called as Amerada [27].

23. Evaluation of temperature results by site engineers,
24. Analysis of subsurface data,
25. Formulating of conceptual model of subsurface.

3.1.5 Preparation of Contract Documents

1. Financing (domestic or international) of project,
2. Descriptions of material and work required,
3. Engineer, procurement, and construction (EPC) bid request for proposals: The implementation of a geothermal project can be achieved in a number of ways. Traditionally, geothermal projects were developed under a number of separate construction and procurement contracts, with the design and project management being undertaken by consulting engineers. Recently the trend has been away from the multi-contract implementation method to the single turnkey / EPC (Engineering-Procurement-Construction) type. The advantages of EPC contract is that it reduces cost overrun risks and most importantly, gives a single point responsibility and liability for plant performance. Often, this type of implementation method is advantageous in being able to attract project funding [6].
4. EPC proposal: The EPC proposal should be based on the preliminary engineering documents and reservoir report. Technical requirements, stipulations, pre-construction permits, other environmental and regulatory criteria, information on well pressures, temperatures, chemical properties and flow rates of geothermal fluid, location of wells, and equipment specifications are used to develop EPC contractor bid specifications. EPC contract should also include followings:
   - Project organization (availability and quality of personnel, subcontractors),
   - Developer's and contractor's responsibilities,
   - Detailed engineering plan (quality of drawings and specifications, procedures and techniques, schedules, quality of control procedures),
   - Approval for construction,
   - Procurement and purchasing of materials (knowledge of marketplace and vendors, guarantees and warrantees),
   - Penalties and incentives,

- Completion guaranties,
- Warranties [6].

5. Selection of a EPC contractor and making a contract : The developer and the EPC contractor agree on the EPC contract and all details are written to the contract: system, techniques, and procedures that the contractor and developer will follow in executing the project scope of work [6].

3.1.6 Project Construction

1. Purchase and order for pipes, valves (ball valves, butterfly valves, check valves, control valves, globe valves, spring loaded safety valves, weight loaded safety valves, zone valves installed on streets), flanges, strainers, insulation materials for pipelines, lineshaft pumps, geothermal pumps, pumps used in energy distribution network, chemical dosage pumps, heat exchangers, frequency converters and flow meters,
2. Selection of subcontractors and extra workers that will participate in the project,
3. Identifying and allocating of tasks for the construction to establish logical relationship of project activities and milestones,
4. Developing of time-based schedule for the project based on the time precedence diagram,
5. Preparation of project management charter and other delegation instruments.

3.1.6.1 Wellhead Housing

1. Installation of electric power lines,
2. Construction of wellhead buildings: The equipment use in these buildings should be easily installed or shelled out for replacement and maintenance,
3. Construction of collectors and installation of equipment (flanges, strainers butterfly valves, check valves, manometers, thermometers) in well-head buildings
4. Gas lift testing: The gas lift test involves pumping an inert gas such as nitrogen, into the well in order to force reservoir fluids to the surface. This offers a relatively simple and inexpensive method of pumping for short duration, lasting a few hours or days. Measurements obtained during gas lift testing provide preliminary

information about the reservoir, which form the basis for an initial estimate of pumping power requirements.

5. Installation of lineshaft well pump,
6. Installation of electric panel and frequency controllers.

3.1.6.2 Transmission and Distribution Networks

1. Transportation of transmission and distribution pipes: Precautions should be taken to avoid damage of pipes from the transportation to the storage of them.
2. Arrangement and preparation of pipes for laying and welding
3. Laying of pipes,
4. Saw cutting of existing pavement,
5. Removing of pavement,
6. Trenching,
7. Construction of reinforced concrete service wells which are used for easy service and repair access and located at all branch points in the streets
8. Bedding of pipes which are burying directly to a depth about 0.70 m,
9. Installation fittings and welding of pipes,
10. Constructions of house lines that connect the consumer with the distribution system: House lines differ depending on the size of the building and head demand of the building. Their nominal diameter sizes are between 20 and 32 mm nominal diameter. But larger buildings need larger pipes. Therefore, the sizes change between 20 and 100 mm nominal diameter.
11. Pressure and tightness testing of joints,
12. Backfilling and re-establishment of surfaces (paving),
13. Assembly of manholes on the top of service wells which must be located within the sidewalk area for easy service and repair access [1,33].

3.1.6.3 Heat Exchanger and Pumping Stations

1. Construction of roads (if there is not) between well-head housings and heating exchanger and pumping station,
2. Building of heat exchanger and pumping station and management offices,

3. Installation of electric power lines (if there is not), telephone lines and cable lines for computers in office building,
4. Construction of supply and return collectors for energy production and distribution networks,
5. Installation and connection (with collectors) of heat exchangers in heat exchanger and pumping station,
6. Installation of direct contact separator in which the noncondensable gases are separated and exhausted to the atmosphere while steam phase of the fluid condenses to gain more energy for the heat exchanger (now it is used as a mixing chamber in Balçova GDHS),
7. Installation of geothermal loop pumps and distribution network circulation pumps with an adjustable frequency speed control,
8. Installation of flow meters, thermometers and manometers to the energy production and distribution network sides of the heat exchanger,
9. Installation of closed expansion tanks and nitrogen tubes which are used to fix the system pressure and to prevent the corrosion caused by free oxygen in energy distribution network,
10. Building of water storage tank, installation water softening tanks and hydrofor system,
11. Installation of frequency controllers and electricity panels,
12. Installation of indicators (manometers, thermometers, pH and level sensors),
13. Purchase of computers.

3.1.7 Delivery of Geothermal Energy

1. Accomplishment of commitments,
2. Evaluation of project progress,
3. Determination of the connection fee and monthly charge,
4. Obtaining energy sale contracts for sale of the geothermal energy,
5. Training of functional personnel,
6. Setting the system into operation (operating and adjustment of equipment)
7. Recording of progress periodically,
8. Modernization and renovation of building heating systems (increasing of heating surface, changing of radiator valves with thermostatic valves),

9. Determination of a budget for research facilities,
10. Periodic measurements (fluid temperature profiles at the wellheads, entrance and exit temperatures of the heat exchanger, well-head pressure and water level in the wells, the rate of mass withdrawn from the productions wells and long-term pressure and temperature changes),
11. Periodic maintenance of the pipelines,
12. Periodic cleaning of heat exchangers used in buildings,
13. Determination and maintenance of leakage in energy distribution network,
14. Replacement of equipment (pipelines, valves, pumps),
15. Periodic cleaning of wells,
16. Remediation of other problems,
17. Assessment of potential development whether or not the scope of the project can be expended or changed: If it is feasible to expend the project, developing a long term commitments and objectives,
18. Improving of competitiveness and marketability.

3.1.8 Project Termination

1. Measurements for injection wells: Following of some parameters like in reinjection simultaneous injection rates (m^3/h) per an injection well and testing breakthrough of injected fluids into production wells using chemical tracers. Tracers are added to the injectate before it is sent to the injection well. Subsequently, production wells are monitored for the presence of the tracers. If tracer appears in the production well, one can be sure that some injected fluid is carrying it [28].
2. Performing a progress report.

CHAPTER IV

ECONOMIC VIABILITY ASSESSMENT OF A GEOTHERMAL DISTRICT HEATING INVESTMENT

4.1 Feasibility Studies

One of the initial tasks in any project is to conduct a feasibility study. Feasibility is the process of determining whether a project can be implemented. Such studies have no set format or a firm list of items to include. In general, it consists of a preliminary design to identify the project scope and all major features that would influence the cost and viability [32]. For prospective geothermal district heating development, the economic evaluation is not only factor to be taken into consideration. Numerous components such as commercial administrative and organizational aspects of the project and additional qualitative concepts which are not measured by monetary units like legal problems (water and land rights, right of ways, safety, reliability), social acceptance (public reaction to the geothermal project, either long-term or short term impacts on local economy, impact on quality of life, noise and vibration generated at heat exchanger and pumping stations, and at well-head buildings), environmental impacts (water and air pollution, visual damage to terrain, damage to vegetation which includes the pipeline routes), effects on tourism and cultural factors are crucial in making decision and can be dealt with in the feasibility reports. Technical alternatives must also be considered and evaluated to fulfill the requirements in the feasibility reports. Feasibility studies should be completed before investments begin [3].

Geothermal projects will proceed to the feasibility stage only if decision makers find them desirable. If the resource is proven and the temperatures and flow rates are compatible, the only element left for consideration is the economic viability of a geothermal district heating system project. This step comes after accomplishment of exploration studies and various technical evaluations.

Lowest bid is generally accepted as decision criterion in the investments. However, operating and maintenance costs over long life of a project can exceed the initial costs and must be factored into the decision process. It may be more economically feasible to pay a higher initial cost in order to obtain a lower total ownership cost. Life cycle costing is a method of calculating the total cost of ownership over the life span of the project. Initial cost and all subsequent expected costs are included in the calculations as well as salvage value and any other quantifiable benefits to be derived. The object of LCC in revenue-producing or non revenue-producing projects is to maximize benefits and minimize costs [21,33]

Computer programs and spreadsheets can be used in feasibility studies to make the best decision for qualitative properties like the effects of environment pollution, development of region, work opportunities, development of local industry.

4.2 Costs of Geothermal District Heating System Projects

Geothermal heating projects are characterized by high capital investment costs like other schemes with liquefied petroleum gas, coal, fuel oil and natural gas sources. However, they have relatively low operating costs because of the low marginal cost of fuel. High capital investment cost means that considerable investment has to be made before the energy production can begin. Return on a geothermal district heating investment is not achieved quickly, but longer-term economic benefits obtain from the use of this indigenous fuel source [5].

The actual capital investment cost of geothermal energy projects depend on a variety of factors ranging from differences in geology, aquifer depth, underground permeability, site accessibility, local wage levels, distance from the resource to market and population density, statutory constraints, temperature, salinity and composition of brines, location of the geothermal field, flow rate of the wells, well spacing, well drilling costs, well replacement rate, and technology. However, wellhead temperatures, well flow rates, well drilling (subsurface cost), and fluid extraction costs are the most significant variables.

Costs of geothermal district heating projects, from the viewpoint of developers, could be arranged into two categories: capital investment and operating costs. Operating costs also include depreciation expenses and taxes.

On the other hand, customers should also consider cost of improving heating efficiency of their buildings in geothermal district heating investments. It can be accepted as an important cost factor on geothermal district heating investments from the viewpoint of customers.

4.2.1 Capital Investment Costs in Geothermal District Heating Systems

Capital has a cost, regardless of whether it comes from an investor voluntarily or from taxpayer involuntarily. A business derives its capital from retained profits, borrowed funds, and sale of shares in the business. The overall cost of its financing is referred to as the "cost of capital". In other words, capital costs are the expenses occurred before beginning of business operations and depreciated over more than one year. Depreciation does not begin until business activities start. Capital costs can be also named as startup or initial costs [34,35].

Capital investment cost of geothermal development can be divided into the cost of surface equipment and the cost of subsurface investment (drilling cost) according to the risks of each phase. The risks of these two categories are quite different. Transmission and distribution pipe networks are significant cost components in surface investment. Cost associated with the pipe network is approximately 40-60 % of the overall capital cost of the project [8]. But the initial cost and the life expectancy of a pipeline vary with the type of material and requirements for linings or protective coatings [32]. For the surface investment, the risk involved is relatively small and costs can be forecasted with the same accuracy as for common civil engineering works. For the subsurface cost (drilling), the average drilling cost for one well can be predicted with slightly less accuracy than surface constructions, but the yield from each undrilled well is uncertain. Therefore, the total investment cost of geothermal development depends largely on the yield from the wells.

Capital investment costs that include purchase, transportation, and labor (installation) costs include the following items. It must be kept in mind that important variations take place due to labor costs and the duration of installation and implementation that can vary greatly from country to country. Capital investment costs are summarized below [2, 34, 35, 36] :

1. Allowances for engineering design,

2. Project management fees,
3. Cost of access, e.g. water and mining rights, right of way for pipelines, electric power lines, nationalizing of private land,
4. Exploration studies,
    a) Topographical surveys,
    b) Geological and hydro geological surveys,
    c) Geophysical and geo-chemical investigations,
    d) Drilling of temperature gradient wells.
5. Well Drilling,
    a) Hiring the drilling rig and crew,
    b) Site preparation,
    c) Rig transportation,
    d) Fuel, mud and bit costs,
    e) Casing,
    f) Cement and cementing services,
    g) Well head equipment,
    h) Miscellaneous costs (costs of special equipment, supplies, services, analyses, transport, insurance, supervision, etc.),
    i) Well measurements.
6. Civil engineering works (Construction of roads, wellhead housing, heat exchanger and pumping stations and offices),
7. Wellhead housing,
    a) Lineshaft pumps,
    b) Frequency converters,
    c) Chemical dosage equipment (pipe, pumps, storage tanks for inhibitor and nitrogen tubes) used in wellhead housing,
    d) Construction of collectors in wellhead housing.
8. Transmission and distribution networks,
    a) Construction of concrete conduit for transmission network (Transmission pipelines which are placed in concrete conduit have a high capital investment costs; however, such a system increases the life of the pipes and reduces required maintenance and replacement costs),
    b) Pipelines in transmission and distribution networks (trunk and house lines) and associated equipment (Saw cutting of existing pavement, pavement removing,

trenching, pipe bedding and hauling, traffic control which is required around open trenches or near roads, channel backfilling, paving),

   c) Building of service wells in which branch valves are installed to isolate major branches,
   d) Manhole construction.

9. Heat exchanger and pumping stations,
   a) Heat exchangers (Cost of heat exchangers depends upon the material, the method of construction, and the size of it),
   b) Geothermal pumps,
   c) Maximum and minimum load pumps of energy distribution network,
   d) Construction of collectors, pipes connections and its insulation, valves (ball valves, butterfly valves, check valves, control valves, globe valves, spring-loaded safety valves, weight-loaded safety valves), flanges, strainers, indicators (manometers, thermometers, pH and level sensors),
   e) Electrical equipment and control panels,
   f) Direct contact separator in which the noncondensable gases are separated and exhausted to the atmosphere while steam phase of the fluid condenses to gain more energy for the heat exchanger (if a separator is considered to use in the system),
   g) Closed expansion tanks and nitrogen tubes which are used to fix the system pressure and to prevent the corrosion caused by free oxygen in the primary or city circulation loop,
   h) Water storage and softening tanks,
   i) Fire protection and security systems.
10. Documentation,
11. First operating and adjustment,
12. Inspection and testing,
   a) Gas lift testing,
   b) Production pump testing,
   c) Reservoir performance tests,
   d) Leakage testing.
13. Heat exchangers used in substations,
14. Modifying existing district and / or individual heating systems.

4.2.2 Operating Costs in Geothermal District Heating Systems

Operating expenses are the cost of doing business to generate the revenues of that period. They can vary from year to year. Since, operating costs are recurred, they can be also named as recurring costs. Operating cost generally includes the following items:

1. Electricity consumption of the pumps,
2. Purchasing of inhibitor,
3. Purchasing of other chemical materials (nitrogen and oxygen gases, nitric acid, rock salt, NaOH),
4. Maintenance cost of equipment,
5. Re-drilling cost,
6. Tap water in distribution network,
7. Personnel cost (Salaries of all personnel, payments for financial and technical consultants administrative costs paid for inspection and supervisory staffs),
8. Maintenance of service buildings,
9. Marketing,
10. Research & development,
11. Management costs (Telephone, photocopy, cargo and stationery expenses, vehicle rents, maintenance cost of vehicles),
12. Cost of building rents,
13. Insurance costs,
14. Taxes (e.g. corporation taxes).

4.2.3 Depreciation Expenses

Purchase of new assets is treated by depreciating the total cost gradually over time. Because capital goods are given this unique accounting treatment, depreciation is accounted for as a separate expense in financial reports. Capital expenditures must be systematically allocated as expenses over their depreciable lives. The most widely used methods are the straight-line method, the declining balance method, and the sum-of-years-digit method [35,37].

4.3 The Time Value of Money

Large GDHS, as the system constructed in Balçova – Narlıdere regions, evolve over long periods. Cost incurred in one period generates benefits for many years to come in large GDHS. Benefits and costs that occur at quite different times should be compared for the evaluation of whether a GDHS project is worthwhile or not [38]. The most important problem in evaluation of projects over time comes from the fact that money has a time value. The existence of interest gives money a time value.

Interest can be defined as money paid for the use of borrowed money or it can be thought of as the return obtainable by the productive investment of capital [39]. A dollar at the beginning of an investment does not have the same value as a dollar at the end of the investment (even neglecting possible inflation) due to the existence of interest. In other words, a dollar now is not the same dollar a year from now. The money represents the same nominal quantity, but a dollar later does not have the same purchase power that it has today. It can be easily seen that, the worth of money has two dimensions: the amount of money and time. Since geothermal heating projects require the investment of money, it is important that the time value of money used to be properly reflected in the evaluation of prospective projects. Because of this monetary difference, total costs in dollars that are realized in different periods cannot be added to each other. To make a valid comparison, we need to translate all cash flows into comparable quantities. For purposes of definition, two amounts of money or a series of monies at different points in time are said to be equivalent if they are equal to each other at a given point in time for a given interest rate, which can be defined as the rate of capital growth or gain received from an investment.

Interest can be calculated according to two different concepts: simple interest and compound interest. Simple interest is the interest accumulated periodically on a principal sum of money. If the simple interest is used, it should be important to notice that, interest is only charged or earned on the original amount of borrowed or invested money. Compound interest earned on the interest accumulated in the account and demonstrated in Figure 4.1.

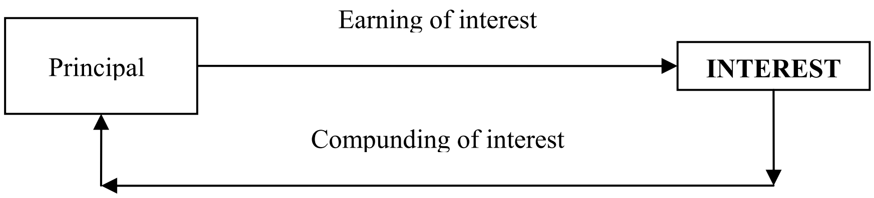

Figure 4.1 Recurring cycle in the calculations of compound interest

4.4 Present and Future Values

Present value of a future investment can be calculated by Equation (4.1).

$$P = F \cdot \left[\frac{1}{(1 + I_a)^N} \right] \tag{4.1}$$

Factor that is written in the brackets is called as single present worth (SPW) and denoted as (P/F, I_a%, N). This is the functional notation of this formulation.

Future value of an investment (according to simple interest) at the end of N years is calculated by Equation (4.2).

$$F = P \cdot (1 + N \cdot I_a) \tag{4.2}$$

The formula for the compound amount, F, at the given annual interest rate obtained in n years from the principal or present sum of money, P is calculated by Equation (4.3).

$$F = P \cdot [1 + I_a]^N \tag{4.3}$$

The Factor in Equation (4.3) is called as single compound factor (SCA) and denoted as (F/P, I_a%, N). SPW and SCA are present in tables for different interest rates and time value in many engineering economy books.

In daily applications, compounding periods, which indicate that how many times this period is repeated in a year are generally smaller than a year. Because the more frequent the compounding, the greater is the actual interest in dollars and rate. In these situations, nominal interest rates are divided by frequency of compounding (or discounting) per year to find the effective interest rates. The future value is calculated according to Equations (4.4). In the calculations, it is common to consider the year as composed of 12 months of 30 days each, or 360 days.

$$F = P \cdot \left[1 + \left(\frac{I_a}{m} \right) \right]^{(N \cdot m)} \tag{4.4}$$

4.5 Discount Rates

Discount rate is generally specified as a rate and given as some percentage per year. It is the expected minimum profit rate from the considered investment. It can be also defined as opportunity cost of capital rate or minimum attractive rate of return (MARR). Normally, this rate is assumed as constant in any particular project evaluation. It may, however, be quite different for various individuals, companies, or government, and may vary among persons or groups as circumstances change. It is determined with the effects of many factors. Interest rates, profit rates in markets, profit rates of investments, which do not have any risk, the degree of risks in the investments, are the factors that have effects on the determination of expected profit rate. The discount rate is similar with prevailing interest rate in that both can be stated as a percentage per period, and both can indicate a connection between money now and money later. The difference is that the discount rate represents real change in value to a person or group, as determined by their possibilities for productive use of money and the effects of inflation. By contrast, the interest rate narrowly defines a contractual arrangement between a borrower and a lender. The distinction implies a general rule: discount rate is generally interest rate. Investors use discount rates for comparing expected revenues with the cost of investment [26, 39, 40].

4.6 Economic Life of a Project

Life of a project is the most important input for the investment decisions in feasibility studies. Economic life of an investment is the period in which investment produce benefits and “L” represents it in this study. L is the difference with the number of the periods for the project exploitation and the accomplishment period up to the deadline of construction. An economic analysis and finance scheduling for renewable energy investments should be based on long-term consideration. If the duration extends, the degree of uncertainty of cash flows will be increased. Physical life of an investment is the duration in which all of the facilities are realized. Energy planning of district heating systems should be based on a 15-25 year planning period [34, 40, 41].

4.7 Salvage Value of an Investment

Salvage value is the market value of an asset at the end of its life. This concept includes both the value of an investment at the end of the economic and physical lives. Salvage value affects the investment decision. Therefore, to determine the accurate salvage value is important in proposed investments.[35, 41]

4.8 Project Cash Flows

Cash flows constitute the basis for evaluating projects and investment alternatives. Most economic analysis involves conversion of estimated or given cash flows to some point or points in time. The difference between cash inflows and cash outflows for the project life is defined as cash flows. Cash flow diagrams are used to visualize cash flows. Individual cash flows are represented as vertical arrows along a horizontal time scale, which covers the life of a project. Upward-pointing arrows generally used to indicate net inflows whereas downward-pointing arrows used to show net outflows. A sample cash flow diagram is drawn in Figure 4.2 [42].

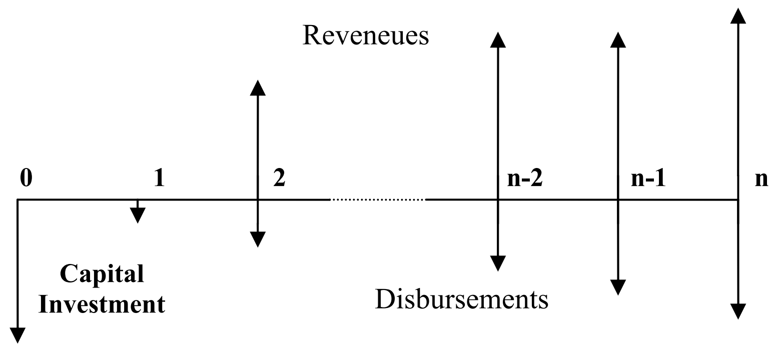

Figure 4.2 A sample cash flow diagram

Figures 4.3, 4.4, show schematically all cash flows in a GDHS. GDHS projects can be financed by ownership funds, which are furnished by the owners of an enterprise and limited by personal resources or borrowed money. A corporation may secure ownership funds in various ways from its existing stockholders or it may acquire more owners by selling stock to new stockholders. According to Figure 4.3, an organization finances the investment partially through its own capital resources and, partially, by a fixed interest loan. This financing is a combination of ownership funds and borrowed money. The loan may be raised from banks and/or by the sale of bonds. Balçova – Narlıdere GDHS investment was financed by the local government. The cash flows in Balçova – Narlıdere GDHS are given in Figures 4.5 and 4.6.

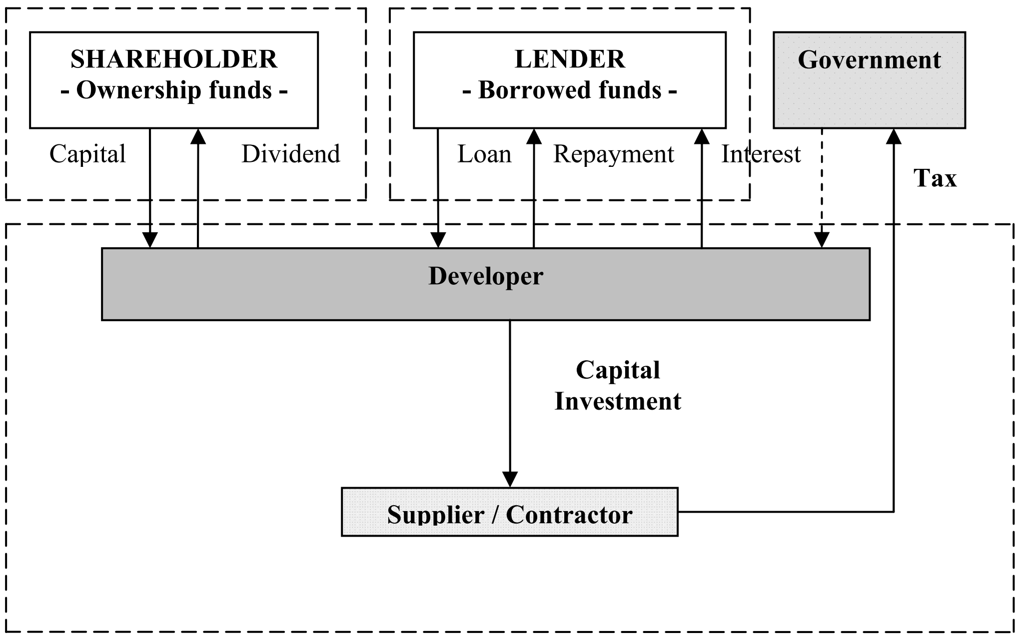

Figure 4.3 Cash flows in project planning and implementation phase of GDHS projects

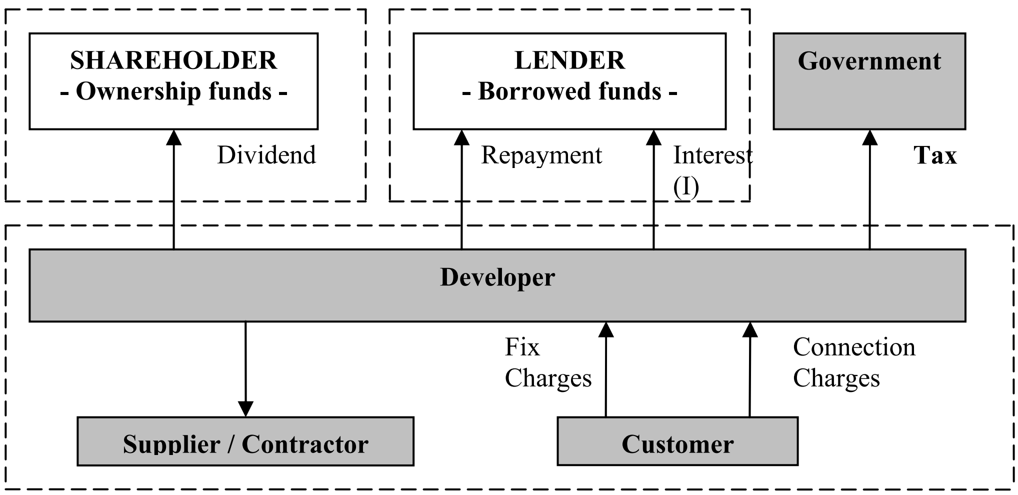

Figure 4.4 Cash flows in operating phase of GDHS projects

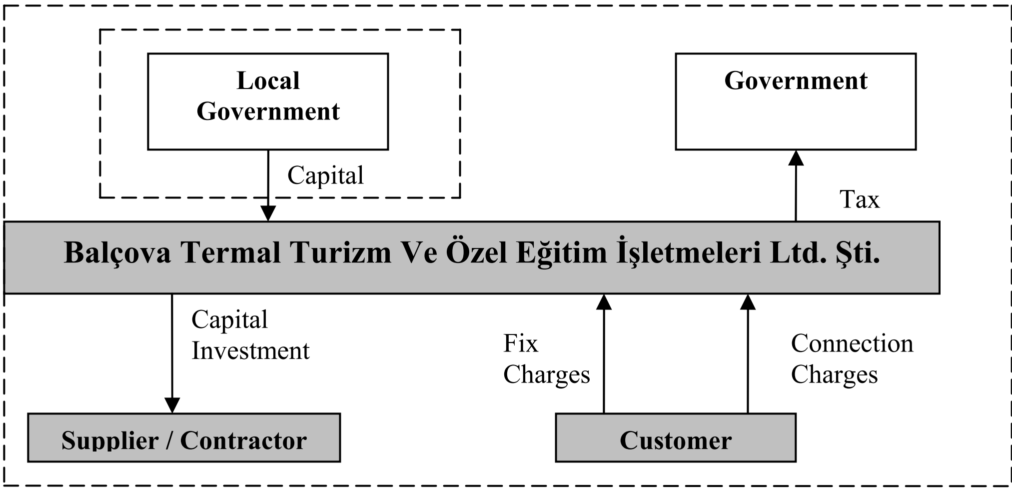

Figure 4.5 All cash flows in Balçova – Narlıdere GDHS from 1996 to 2000

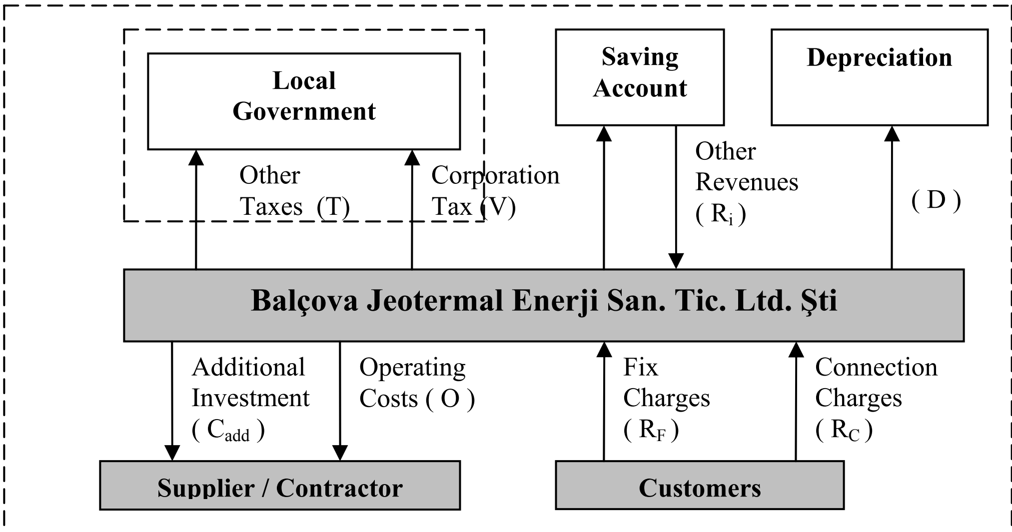

Figure 4.6 All cash flows in Balçova – Narlıdere GDHS after 2000

Basic formulas used in determination of net cash flows and profits for the r^{th} year are given in Equations (4.5), (4.6) and (4.7)

$$GP_r = (R_i + R_F + R_C)_r - O_r - D_r \tag{4.5}$$

$$NP_r = GP_r \cdot (1 - V_r) - T_r \tag{4.6}$$

$$A_r = (NP_r + D_r) - I_r \tag{4.7}$$

4.9 Economic Evaluation Methods

Investments are series of cash flow in which existing resources are invested with the expectation of receiving larger benefits in the future. Possible positive effects of a project are defined as benefits and negative effects are named as costs. Benefits and costs in a GDHS investment will be explained in detail in the following chapter. All of the positive and negative effects of alternative projects should be estimated in the evaluations. The purpose of an economic evaluation is to determine differences between outflows and inflows. In accordance with the result of an economic analysis, the project manager can compare different investments and their cash flow profiles. If the total amount of net incomes is greater than total net outcomes for a considered investment, the project will be accepted. At the end of this evaluation, a project manager decides either this project is applicable or not and selects the appropriate project among the alternatives. Projects are evaluated according to static or dynamic methods. Static methods use data gathered in only one period. The time value of money and life cycle of an investment are not taken into consideration [41]. Some static evaluation methods are:

1. "Total net cash flows / Capital investment cost" ratio method
2. "Average annual net cash flows / Capital investment cost " ratio method
3. "Average annual revenues / Average cost of investment" ratio method
4. Simple payback time period method

On the other hand, possible cash flows in the future are considered in the dynamic methods. Cash flows are determined by taking into time value of money and discounting or compounding of cash flows to a particular point in time. There are different dynamic methods for the financial viability analysis of investments, which are based on the some input values: revenues, disbursements, and capital investment costs. These methods are:

1. Net present value method
2. Net future value method
3. Internal rate of return method
4. Payback time period method
5. "Benefit/ Cost" ratio method
6. "Net Benefit/Cost" ratio method

The following assumptions can be made in order to simplify computations:

a.) All project cash flows are known with certainty or accurately forecasted,

b.) All cash flows take place at either the beginning or the end of each period,

c.) All interest is compounded (or discounted) at discrete periods; normally annually.

4.9.1 Net Present Value Method

Net Present value method take the time value of money into the consideration The net present value criterion of an investment is defined as the difference of present value of benefits and costs in the project exploitation period. Benefits of a project in a year are the difference between revenues and operating costs. Therefore, all of the benefits and costs that realized throughout the project life cycle are considered in this method. Calculations are based on a specific rate of discount that should be determined before. Mathematical expression of NPV criterion is given by Equation (4.8).

$$NPV = \sum_{N=m+1}^{t} \frac{B_N}{(1+I_a)^N} - \sum_{N=0}^{m} \frac{C_N}{(1+I_a)^N} \quad (4.8)$$

If the net present value is calculated for one project and the result is greater than zero, the project or investment is attractive and could be accepted. Otherwise, it is unattractive and it should be rejected. When the evaluation is realized among alternative projects, the project, which has the greatest net present value, should be recommended for acceptance.

Selecting of the most profitable project is not the main objective in this method. If the discount rate and benefits in the future are well estimated, these methods are easily applied on projects. Determination of a discount rate is important in the present value calculations. Different discount rates give various results. Higher discount rates enable investor to select the project that gives higher cash flows in the earliest years of the investments while smaller discount rates enable investor to select the project which has high net cash flow. On the other hand, discount rates are accepted as constant throughout the economic life of the project in the present value calculations. As a matter of fact, it is variable with regard to changing market economies. Usage of different discount rates for different years is quite difficult. Net present value method does not reflect the real output of investment project. If this method is used for more than one project, which have different size, selecting of the most appropriate project is not always correct. Therefore, internal rate of return method is more realistic than net present value method.

4.9.2 Net Future Value Method

In the net future value method, all of the cash flows are converted to an equivalent single sum at the end of overall life of an investment or at some other future time. If the future equivalent value of estimated annual benefits is greater than the future value of the capital investment cost the considered project could be accepted. Mathematical expression for net future value method is given in Equation (4.9).

$$NFV = \sum_{N=m+1}^{t} B_N \cdot (1 + I_a)^N - \sum_{N=0}^{m} C_N \cdot (1 + I_a)^N \quad (4.9)$$

4.9.3 Internal Rate of Return Method

Internal rate of return method is also called as discounted cash flow return, profitability index, or simply rate of return method. The internal rate of return (IRR) measures the performance of an investment as a rate of return unlike NPV which express it as an amount of return. It expresses the real return on any investment. Therefore IRR is related with the calculation of expected profit for the prospective investment. Profit in simple terms is what is left after all the income has been received and all the costs or expenditures have been settled.

The internal rate of return or break-even interest rate is a hypothetical discount rate that equates the sum of the present values of all cash inflows to the sum of the present values of all cash outflows. IRR use same cash flows used in NPV method. However discount rate is an unknown parameter in this method. A minimum standard of desirability which is determined by an investor, is compared against the calculated value of discount rate that sets the net present value equal to zero. If the calculated rate is higher or equal to the market interest rate, it is profitable to undertake prospective project.

For the selection of project among alternative projects, IRRs should be ranked from the highest IRR down. The one with the highest IRR is selected. On the other hand, it gives an idea to investor to choose the correct time for borrowing money for the project and payable the maximum interest rate. It gives same results with the net present value calculations for the economic evaluation of one project. However, internal rate of return methods give more clear results if it is used to compare different projects.

There is no analytical method of calculating proper discount rate. IRR involves trial and error to arrive at this rate is to choose a suitable rate to discount all the cash inflows. NPV increase as the discount rate increases or decreases as the discount rate decreases. Normally increasing the discount rate will reduce the net present value of a project.

If the rate makes the present value of the cash inflows greater than the cash outflow, a higher rate of a certain incremental value is further chosen. The reverse is the case with a lower present value of the cash inflows than the cash outflows. This goes on until there is slightly a higher and a lower net present values of the cash inflows than the cash outflows. The augmentation in discount rate must be smaller than 5 % in trial and error method. The desired rate lies between these two calculated rates. The differences between these two rates (called the discount rate interval) and the discounted value (the difference between the lower and upper values resulting from these two rates) are then used for the interpolation. If the discounting rate is greater than 14%, the project should be implemented [26, 40, 43, 44, 45].

Cash flows change during the phases of a project. Generally, the net cash flows are negative in the construction period of projects. They become positive in the following years. If the future net cash flows changes perpetually or project's net benefits switch sign more than once over time, there may be no or multiple IRRs associated with the project. The net present values of project exhibits different behaviors in these cases. In these circumstances, net present value method should be preferred. Mathematical expression for IRR is given by Equation (4.10).

$$NPV = \sum_{N=m+1}^{t} \frac{B_N}{(1+r)^N} - \sum_{N=0}^{m} \frac{C_N}{(1+r)^N} = 0 \qquad (4.10)$$

Investments are classified by counting the number of sign changes in its net cash flow sequence. A change from either "+" to "-" or "-"to "+" is counted as one sign change. Simple investment is defined as one in which the initial cash flows are negative and there is only one sign change in the net cash flow. A non-simple project is one for which there is more than one sign change in the net cash flow series. Multiple IRRs occur in non-simple projects. Sign changes in net present value for simple and non-simple project is demonstrated in Figures 4.7 and 4.8. Some methods can be used to calculate IRR values. Linear interpolation is tedious and inefficient process to find break even points [32].

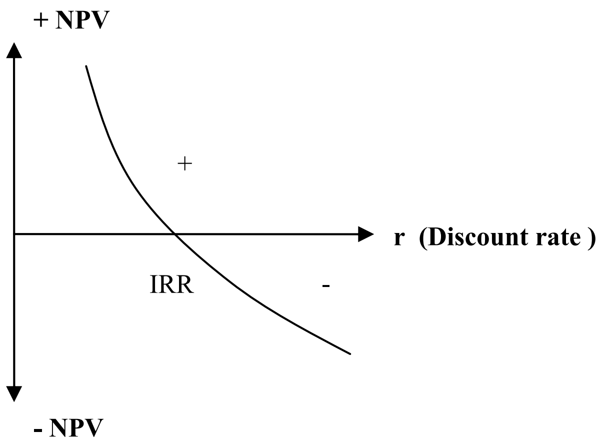

Figure 4.7 NPV profile for a simple investment

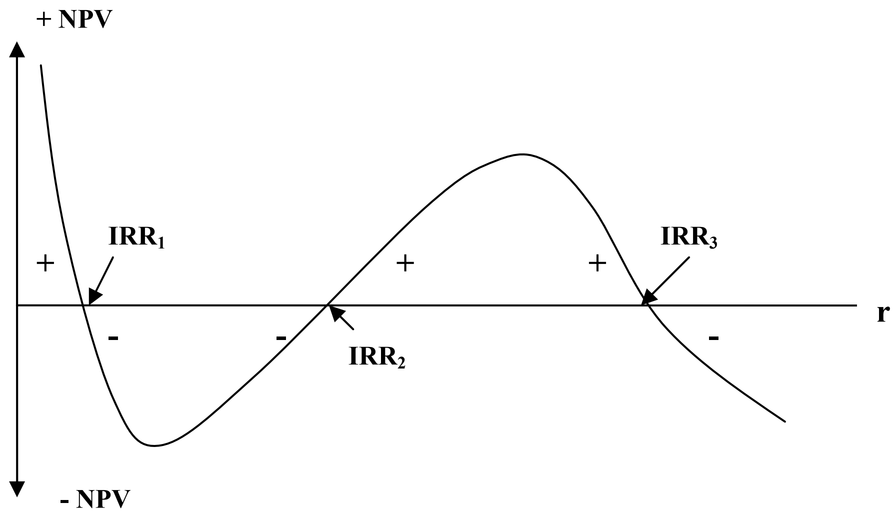

Figure 4.8 NPV profile for a typical non-simple investment

4.9.4 The Payback Time Method

The payback time is the most commonly used and simple method for assessing the economic desirability of an investment. There are two methods for the determination of a payback time: payback period with and without interest.

The payback period without interest is commonly defined as the length of time required to recover the first cost of an investment from the net cash flow produced by that investment for an interest rate of zero [37]. At the end of this period, investor has no profit and no loss. Payback time is the smallest value of “N” that satisfies Equation (4.11). Although it is the simplest method for evaluation, the size of any returns received and any expenditure after the payback point has been reached do not affect the calculation of the payback point.

$$\sum_{N=m+1}^{t} B_N - \sum_{N=0}^{m} C_N \geq 0 \qquad (4.11)$$

Time value of money is considered in discounted payback period (DPB) method which is based on the calculation of period (years) for which the total amount of discounted net income will cover the discounted total cost of investment. In the most of the applications, discounted payback period is smaller than 10 years [40]. Equation (4.12) is the mathematical expression of the payback period with interest.

$$\sum_{N=0}^{m} \frac{C_N}{(1+I_a)^N} = \sum_{N=m+1}^{t} \frac{B_N}{(1+I_a)^N} \qquad (4.12)$$

4.9.5 Benefit - Cost Ratio Method

This method depends on the ratio between the total net present value of revenues and the total net present value of expenditures. If the ratio is greater than one, the project should be accepted. The formulation is written in Equation (4.13). If the calculation is realized for many alternative projects, the project, which has the greatest ratio, must be preferred.

$$\frac{B}{C} = \frac{\sum_{N=m+1}^{t} \frac{B_N}{(1+I_a)^N}}{\sum_{N=0}^{m} \frac{C_N}{(1+I_a)^N}} \qquad (4.13)$$

4.9.6 Net Benefit-Cost Ratio Method

In this method, the difference between the net present value of net benefits and cost of the investment is calculated and result is divided by the cost of the investment. The formulation is presented in Equation (4.14). If the result is greater than zero, the project can be accepted.

$$\frac{NB}{C}=\frac{\sum_{N=m+1}^{t}\frac{B_N}{(1+I_a)^N}-\sum_{N=0}^{m}\frac{C_N}{(1+I_a)^N}}{\sum_{N=0}^{m}\frac{C_N}{(1+I_a)^N}}=\frac{B-C}{C}=\frac{B}{C}-1 \tag{4.14}$$

4.10 Impacts of Inflation on Investment Decision

Inflation is the annual percentage of increase in prices of goods and services If the effect of inflation is considered, inflation-free rate (i') must be used instead of market interest rate in the calculations. Inflation-free rate can be calculated by using the Equation (4.15) [42,46].

$$i'=\frac{(1+i)}{(1+d)}-1=i+d+i\cdot d \tag{4.15}$$

The internal rate of return method is used in this study. Balçova – Narlıdere investment are realized in the past. Therefore, its end of 2002 value is calculated before applying IRR method. Payments to the contractor were realized in TL. Because of the inflation, considerable value loss in TL is observed up to 2002. Therefore, all cash flows are converted to US $ at the end of 2002 value calculations. Bank interest rates are used to calculate future value of an investment. The effect of inflation is omitted in the future value calculations. If this analysis is made at the beginning of investment, IRR will be directly calculated without any future value calculations. The overall life of the investment is considered as 20 years. Prices are calculations according to the results of IRR method. Therefore, payback time is not calculated. The investment pays itself back in 20 years.

CHAPTER V

ECONOMIC ASSESMENT OF BALÇOVA – NARLIDERE GEOTHERMAL DISTRICT HEATING SYSTEM INVESTMENT

5.1 Processes in the Economic Assessment of Balçova – Narlıdere GDHS Investment

Before beginning the economic assessment, all data which are required in this evaluation are presented and interpreted. Future net cash flows are estimated with regard to cash flows realized in 2002. By using internal rate of return method which is explained in chapter IV, economic analysis of Balçova – Narlıdere GDHS is accomplished.

5.1.1 Data Acquisition

Data acquisition is the initial and one of the difficult phases during the economic viability study of Balçova – Narlıdere GDHS investment which includes collection of cash flow data for the system constructed in Balçova and Narlıdere regions.

Payments in Balçova – Narlıdere GDHS investment were performed according to the accruals. Accruals are the documents executed between employers and contractors according to contract signed at the beginning of a project. If there is not any controversy in the contract, accruals should be performed monthly. Contractors are responsible for the installation of the system; the developer is responsible for the supervision, inspection, and approval of the installed systems. Completed works are determined in accruals by control engineers and payments are realized according to these documents.

The classification of equipment used in the Balçova – Narlıdere GDHS investment, works, and their unit prices were fulfilled according to the handbook that is published and updated yearly by Ministry of Public Works. This handbook includes the unit prices of all equipment and works under some groups. Cost of the investment is calculated according to the unit prices given in this handbook and special prices which are determined by contract between contractor and developer.

Ministry of Public Works were responsible for the preparation of Balçova – Narlıdere GDHS accruals. “Balçova Jeotermal Enerji San. Tic. Ltd. Şti.” does not have the softcopies of accruals. Only hardcopies were put on the files and kept respectively in “Balçova Jeotermal Enerji San. Tic. Ltd. Şti.”, Ministry of Public Works and the contractor company. Data have not been transferred to the computer media. Therefore, some documents and files cannot be gathered easily.

The Ministry of Public Works prepared 36 accruals in Balçova and 10 accruals in Narlıdere for the payments of completed works. Accruals were signed in different dates which began at the end of 1995 and ended at the end of 1999. The amount determined in each accrual had been paid to contractor within two months. Because of insufficient information on accurate dates of payments, it is assumed that these amounts paid at the accrual dates in accordance with unit prices.

The construction contract of geothermal system in Balçova – Narlıdere region was signed in 1995. It is important to say that, the unit prices which are valid in the contract date are used throughout the project. However, the prices are not constant and change year by year. Therefore, differences in unit prices were paid to contractor in each accruals.

All equipment was written under a group name indicated in the unit price of handbook in these accruals. Equipment should also be classified with regard to the location where they used. For example, the cost of wellhead housing, which include construction, and installation of wellhead equipment cannot be directly obtained from the accruals. It is possible to determine the economic cost of wellheads by using their as-built draws and accruals simultaneously. As-built draws of the wells were not being delivered to “Balçova Jeotermal Enerji San. Tic. Ltd. Şti.” during the installation. “Balçova Jeotermal Enerji San. Tic. Ltd. Şti.” prepared drawings after the delivery of system. However, there are some variations on the system after the construction. Therefore, it is difficult to determine the variations from accruals.

5.1.1.1 Capital Investment Costs

Firstly, amount of payments from 1996 to 1999 are categorized according to information taken from the accruals. Details on the payments are given in Appendix B. Dollar amounts of payments were calculated in Appendix A. Total amount of payments in Balçova accruals for each item, which does not include value added tax, are given in Table 5.1. Total amount of payments in Narlıdere accruals are given in Table 5.3. Values in Tables 5.1 and 5.3 do not reflect the time value of money. Estimated well drilling costs are not included to those values. Nevertheless, approximate costs of them are integrated into capital investment costs later. If the Tables 5.1 and 5.3 are examined carefully, it will be observed that payments for thermal line are the biggest component of the capital investment costs. Thermal line includes pipelines, pipe fittings, compensators, valves used for controlling of branches, heat exchangers, flow and temperature adjustment valves used in buildings. Materials without discount contains cost of timber, cement, sand. Details on those payments are summarized in Table 5.2 for Balçova GDHS and in Table 5.4 for Narlıdere GDHS. The amounts determined by accruals are paid in TL. But, they are converted into US $ as given in Tables 5.1 and 5.3. Cost of items for Balçova and Narlıdere accruals which are obtained from Tables 5.1 and 5.3 are combined and total capital investment cost of Balçova – Narlıdere GDHS is found in Table 5.5.

Table 5.1 Cost of each item in Balçova accruals

no.	Item	Cost		%
		(in TL)	(in US $)	
B1	Construction of heat exchanger and pumping station	5,564,954,871	65,733	0.60
B2	Transport of materials used in heat exchanger and pumping station	293,634,809	5,299	0.05
B3	Electricity installation	41,474,472,017	203,360	1.86
B4	Installation of heating equipment used in heat exchanger and pumping station	8,682,585,035	48,802	0.45
B5	Shared installations (wellhead housing, building, and heat exchanger and pumping station connections)	41,075,930,123	292,102	2.67
B6	Excavation	106,804,122,262	558,181	5.11
B7	Transport of materials used in excavation	66,000,028,985	357,763	3.27
B8	Sanitary installations	285,727,503	5,004	0.05
B9	Automatic control	171,362,500	542	0.00
B10	Installation of transformer	2,840,123,611	32,007	0.29
B11	Installation in heat exchanger and pumping station)	2,986,702,755	8,822	0.08
B12	Thermal line (Piping networks, heat exchangers, compensator, pumps and other equipment)	1,725,470,200,653	9,288,700	84.99
B13	Materials without discount (Timber, cement, sand)	11,681,813,683	62,783	0.57
Total		2,013,331,658,807	10,929,098	100.00

Table 5.2 Components of thermal line in Balçova GDHS accruals

no.	Item	Cost (in US $)
1	Pipe lines and other fittings	5,854,455
2	Heat exchangers	1,456,500
3	Compensators	539,683
4	Steel separator	10,688
5	Water softening tank	7,069
6	Pumps	335,346
7	Actuator butterfly valves	55,229
8	Branch valves	9,012
9	Stainless steel materials	63,728
10	Temperature and Flow Settling Valves	587,858
11	Underground valves	162,169
12	Butterfly valves	1,869
13	Dosage equipment (Pumps, piping and other equipment)	55,479
14	Butterfly valves with gearboxes	64,926
15	Aluminum insulation for pipes	10,388
16	Flow meters	55,696
17	Other adjustment equipment	12,566
18	Strainers	6,040
Total		9,288,700

Table 5.3 Cost of each item in Narlıdere accruals

no.	Item	Cost		%
		(in TL)	(in US $)	
N1	Construction of heat exchanger and pumping station	8,510,664,179	46,390	3.47
N2	Transport of materials which are used in heat exchanger and pumping station	851,066,418	4,645	0.35
N3	Excavation	10,396,874,170	47,992	3.59
N4	Transport of materials used in excavation	7,277,811,919	33,595	2.51
N5	Electricity installations	3,322,619,419	11,011	0.82
N6	Installation of heating equipment used in heat exchanger and pumping station	2,292,053,250	7,536	0.56
N7	Sanitary installations	298,200,000	1,190	0.09
N8	Shared installations (wellhead housing, building, and heat exchanger and pumping station connections)	8,282,217,025	28,236	2.11
N9	Automatic control	22,125,000	80	0.01
N10	Thermal line (Piping networks, heat exchangers, compensator, pumps and other equipment)	184,779,640,052	851,827	63.77
N11	Materials without discount (Timber, cement, sand)	66,680,864,455	303,346	22.71
Total		292,714,135,886	1,335,848	100

Table 5.4 Components of thermal line in Narlıdere accruals

no.	Item	Cost (in US $)
1	Pipe lines and fittings	562,876
2	Compensators	22,923
3	Branch valves	4,142
4	Plate type heat exchangers	164,524
5	Flow and temperature adjustment valves	40,725
6	Water softening equipment	3,202
7	Butterfly valves with gear boxes	15,756
8	Y type strainers	475
9	Line shaft well pumps	33,780
10	Dosage equipment	3,423
Total		851,827

Table 5.5 Cost of items in Balçova and Narlıdere accruals

no.	Item	Cost	
		(in TL)	(in US $)
BN1	Construction of heat exchanger and pumping station	14,075,619,051	112.123
BN2	Transport of materials	74,422,542,130	401.302
BN3	Electrical equipment	44,797,091,436	214.370
BN4	Installation of heating equipment used in heat exchanger and pumping station	10,974,638,285	56.338
BN5	Shared installations (wellhead housing, building, and heat exchanger and pumping station connections)	52,344,849,903	329.160
BN6	Excavation	117,200,996,432	606.173
BN7	Sanitary installations	583,927,503	6.194
BN8	Automatic control	193,487,500	622
BN9	Installation of transformer	2,840,123,611	32.007
BN10	Thermal line	1,910,249,840,705	10.140.528
BN11	Materials without discount (Timber, cement, sand)	78,362,678,138	366.130
Total		2,306,045,794,693	12,264,947

5.1.1.2 Well Drilling Costs

The cost of geothermal drilling has gone down in real terms during the last decades. The wells are becoming deeper, their performance is higher, but the cost figure is almost constant in time, not following the worldwide monetary inflation [13]. Drilling costs are changeable according to the location, formation, and depth of the well. The drilling cost in countries with well-developed geothermal industry should be lower than the drilling cost in countries where drilling is an uncommon undertaking. Therefore, the real cost of drillings can not be easily estimated. But correct estimations should be taken into consideration in the economic evaluations.

The total number of the drilled wells is greater than the number of active wells in Balçova – Narlıdere region. The year 2002 value of drilling costs are calculated for only active wells in this study and the results are given in Table 5.6. These values are decided in accordance with the unit well drilling cost of "BD8" which was drilled by MTA in 2002. The unit drilling cost of "BD8" was 359,680,000 TL on 28 September 2001 (contract date). With the US $ exchange rate, which was 1,525,991 TL/m, the unit cost of drilling is found as US $235.70 per meter. It is assumed that all wells were drilled at this unit price. Well drilling cost of "BD8" is not included to this amount because it is integrated to the additional costs.

Table 5.6 Estimated costs of production and re-injection wells in Balçova – Narlıdere GDHS

no.	Well Name	Drilling Year	Depth (m)	Estimated drilling cost (in US $)
1	B1	1982	104	24,513
2	BD1	1994	560	131,993
3	BD2	1995	677	159,571
4	BD3	1996	750	176,777
5	BD4	1998	624	147,078
6	BD5	1999	1100	259,273
7	BD6	1999	605	142,600
8	BD7	1999	700	164,992
9	B4	1983	125	29,463
10	B5	1983	108.5	25,574
11	B7	1983	120	28,284
12	B9	1983	48	11,314
13	B10	1989	125	29,463
14	B11	1989	116	27,341
Total				1,358,236

5.1.1.3 Cost of Additional Investment Realized in 2001 and 2002

According to the accruals prepared for Balçova and Narlıdere, investments began at the end of 1995 and completed approximately at the end of 1999. During this period, the contractor operated the system and devolved their responsibilities to "Balçova Jeotermal Enerji San. Tic. Ltd" in August 2000. However, geothermal investment was not ended at the end of 1999. There were also new investments in years 2001 and 2002, which are named as additional investments in this study. End of 2002 values of all additional costs are integrated to the internal rate of return calculations.

Additional investment costs can be divided into three groups: auxiliary equipment, new connections and drilling costs. In year 2001, there were no new drilling costs. Monthly amounts of auxiliary equipment and cost of connections realized in 2001 are given in Tables 5.7 and 5.8. Monthly costs of additional investments realized in 2002 are given in Table 5.9. It is assumed that these investments are realized at the end of each month in accordance with the end of period convention.

Table 5.7 Costs of auxiliary equipment investments in 2001

mo	Machines		Vehicles		Other Assets		Total
	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)	(in US $)
1	40,126,551,583	59,036	0	0	1,239,970,513	1,824	60,861
2	3,502,092,514	3,786	321,152,000	347	968,590,000	1,047	5,180
3	3,727,096,338	3,634	0	0	1,397,200,000	1,362	4,997
4	0	0	8,348,305,085	7,303	0	0	7,303
5	4,704,620,000	3,882	0	0	661,065,000	545	4,427
6	7,445,467,268	5,915	0	0	0	0	5,915
7	175,000,000	132	0	0	1,520,166,666	1,143	1,275
8	33,898,305,085	24,838	0	0	59,523,810	44	24,881
9	11,286,133,546	7,396	0	0	1,222,440,000	801	8,197
10	29,044,943,474	18,209	0	0	73,968,000	46	18,256
11	14,676,865,000	9,910	0	0	0	0	9,910
12	45,296,000,000	31,161	0	0	131,408,500	90	31,251
Total	193,883,074,808	167,898	8,669,457,085	7,650	7,274,332,489	6,904	182,452

Table 5.8 Costs of connection investments in 2001

mo	New connections (in TL)			Total amount of additional investment costs	
	Faculty of Medicine and Hospital of Dokuz Eylül University	Economy University	Household	(in TL)	(in US $)
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	49,484,960,508	0	0	49,484,960,508	36,258
9	68,817,227,004	0	0	68,817,227,004	45,097
10	5,759,373,707	0	0	5,759,373,707	3,611
11		3,680,100,000	4,284,320,800	7,964,420,800	5,377
12	13,867,966,103	1,750,000,000	0	15,617,966,103	10,744
Total	137,929,527,322	5,430,100,000	4,284,320,800	147,643,948,122	101,088

Table 5.9 Costs of new investments in 2002

mo	New Connections	Auxiliary Equipment	Drilling	Total	New Connections	Auxiliary Equipme nt	Drilling
	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)	(in US $)
1	6,012,644,067	4,584	8,305,066,761	6,332	0	0	10,916
2	3,100,358,474	2,226	8,143,338,884	5,847	0	0	8,073
3	2,741,066,101	2,039	8,091,568,644	6,019	0	0	8,059
4	3,614,406,779	2,701	10,731,922,750	8,019	0	0	10,720
5	7,464,345,594	5,166	7,835,771,237	5,423	0	0	10,589
6	230,295,216,019	146,061	36,439,325,424	23,111	226,598,400,000	143,716	312,887
7	4,065,172,000	2,396	10,760,363,162	6,343	0	0	8,740
8	2,570,000,000	1,577	8,058,472,237	4,946	0	0	6,524
9	5,344,000,000	3,180	6,463,822,237	3,847	0	0	7,027
10	0	0	45,686,930,070	27,349	0	0	27,349
11	0	0	90,742,665,863	58,819	0	0	58,819
12	0	0	90,428,975,156	54,883	0	0	54,883
Total	265,207,209,034	169,930	331,688,222,425	210,939	226,598,400,000	143,716	524,585

5.1.1.4 Revenues in Balçova - Narlıdere GDHS

The geothermal project revenue is the income received by a business in exchange for providing geothermal energy. Revenues collected from Balçova – Narlıdere GDHS can be mainly divided into two groups: fix and connection charges. Fix charges are valid in flat rate pricing which is the least sophisticated and most commonly used method for customer billing throughout the world. It consists of an agreement between the customer and the system operator on the monthly sum paid for the provided energy per unit volume. Unit fix charges are determined at the end of each year according to the yearly urban indexes which is announced by Turkish Republic Prime Ministry the State Planning Organization (DPT). Customers pay charges according to household equivalents of their residence. Customers also pay maintenance fee in Balçova – Narlıdere GDHS. But it is collected with fix charges and not shown separately in this study. Connection charges are collected at the beginning of the subscription in Balçova – Narlıdere GDHS. Each customer must pay house connection fees in order to connect their individual heating system to the district heating system. Connection fees are paid once and for all. However, they can be paid in installments in Balçova. Collected fix charge revenues from year 1996 to 2002 are given in Tables 5.10 and 5.11. Connection revenues are also given in Tables 5.12 and 5.13.

Table 5.10 Fix charges collected from 1996 to 1998

mo	Year							
	1996		1997		1998		1999	
	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)
1			7,952,000	69	5,820,593,943	27,045	19,679,783,131	59,241
2			300,720,078	2,456	9,342,880,355	40,692	19,388,942,867	55,019
3			1,803,852,739	14,130	6,874,091,805	28,312	21,541,057,859	58,352
4			1,241,071,727	9,177	5,606,404,744	22,448	18,449,002,681	47,275
5			1,429,970,458	10,186	5,485,683,821	21,331	19,131,066,297	47,052
6			1,481,272,127	9,982	5,721,452,488	21,496	18,006,715,524	42,735
7			1,537,402,388	9,643	5,402,566,567	19,968	20,625,590,637	48,192
8			1,086,947,564	6,540	6,782,279,206	24,454	19,193,585,150	43,123
9			1,418,591,808	8,150	6,610,064,059	23,817	20,553,729,598	44,624
10			2,330,924,531	12,800	6,687,100,342	23,344	21,061,305,001	43,912
11			4,880,969,769	25,114	7,155,141,042	23,551	30,502,467,004	59,096
12	853,966,429	8,386	11,399,392,830	55,310	39,346,547,496	124,822	92,691,658,319	170,796
Total	853,966,429	8,386	28,919,068,019	163,557	110,834,805,868	401,279	320,824,904,068	719,417

Table 5.11 Fix charges collected from 2000 to 2002

mo	Year					
	2000		2001		2002	
	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)
1	41,894,391,546	74,735	96,671,081,708	142,228	266,776,146,897	203,392
2	36,948,000,006	64,278	75,049,521,804	81,124	183,999,541,226	132,114
3	38,635,841,250	65,385	79,440,767,549	77,467	113,979,795,312	84,791
4	38,561,062,789	62,983	80,642,125,974	70,542	113,941,122,790	85,138
5	40,602,860,479	65,732	88,859,953,429	73,319	106,438,387,882	73,663
6	34,761,573,065	55,970	76,084,722,379	60,442	93,346,102,685	59,203
7	36,220,521,439	56,721	74,512,643,977	56,046	94,887,415,265	55,937
8	35,198,004,091	53,607	141,698,546,657	103,825	91,573,820,352	56,209
9	31,759,749,619	47,467	58,881,924,925	38,586	193,616,831,350	115,220
10	43,389,599,468	63,252	114,202,287,423	71,597	97,579,951,516	58,413
11	51,214,578,703	74,723	238,360,971,845	160,937	250,935,806,977	162,656
12	180,759,432,316	267,790	345,490,273,253	237,677	434,672,389,957	263,813
Total	609,945,614,771	952,642	1,469,894,820,923	1,173,790	2,041,747,312,209	1,350,547

Table 5.12 Connection charges collected from 1996 to 1998

mo	Year					
	1996		1997		1998	
	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)
1			60,456,958	522	16,898,268,159	78,516
2			1,657,107,437	13,536	21,148,502,115	92,110
3			8,821,945,601	69,105	17,896,291,175	73,708
4			29,495,501,188	218,114	10,190,104,157	40,801
5			21,192,579,571	150,955	9,722,457,527	37,806
6			20,656,165,583	139,192	8,597,153,213	32,301
7			20,663,539,569	129,609	5,860,626,469	21,661
8			19,739,860,405	118,765	9,429,199,445	33,997
9			33,540,773,219	192,708	9,217,830,315	33,213
10			36,831,758,052	202,250	10,042,125,332	35,056
11			37,478,542,200	192,840	9,953,521,540	32,761
12	5,502,685,340	54,038	19,531,151,789	94,765	25,346,854,939	80,410
Total	5,502,685,340	54,038	249,669,381,572	1,522,362	154,302,934,386	592,340

Table 5.13 Connection charges collected from 1999 to 2002

mo	Year							
	1999		2000		2001		2002	
	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)
1	14,436,986,029	43,459	26,157,057,317	46,661	24,242,854,140	35,667	23,342,211,408	17,796
2	25,608,475,604	72,668	27,837,647,718	48,429	16,085,192,000	17,387	9,234,480,219	6,630
3	21,577,356,147	58,451	24,197,814,471	40,951	21,616,484,620	21,079	16,374,510,807	12,181
4	15,993,713,661	40,983	20,273,559,562	33,114	24,611,046,120	21,529	61,589,106,109	46,020
5	31,094,901,440	76,477	18,683,281,979	30,246	52,503,786,300	43,321	20,077,352,200	13,895
6	29,750,900,141	70,607	18,147,250,978	29,219	9,181,504,721	7,294	22,959,651,502	14,562
7	28,983,693,645	67,721	19,363,960,328	30,324	7,673,348,356	5,772	14,453,211,785	8,520
8	23,760,652,916	53,384	20,024,958,397	30,498	6,948,724,772	5,091	23,096,527,073	14,177
9	26,644,110,011	57,846	19,899,757,010	29,741	10,380,827,970	6,803	41,155,533,356	24,491
10	25,683,069,017	53,549	34,305,674,332	50,010	31,126,300,710	19,514	55,755,589,925	33,376
11	30,036,407,576	58,193	24,389,341,786	35,585	54,201,549,340	36,596	66,552,391,944	43,139
12	40,299,201,213	74,256	15,454,407,103	22,895	25,211,224,980	17,344	154,375,343,129	93,694
Total	313,869,467,400	727,593	268,734,710,981	427,673	283,782,844,029	237,397	508,965,909,457	328,482

It is determined that usually revenues can not be collected accurately each year. For instance, customers have debt which is approximately US $250,172 from the year 2002. This amount is nearly 15 % of the 2002 revenues. In addition, some of these customers paid their debts at the beginning of 2003. In addition to fix and connection revenues, company earns money from bank interest and bonds. These revenues are called as other revenues and presented in Table 5.14. It is known that, some part of other revenues are laid out to meet the cost of additional investments. Because of the higher cost of additional investments in 2002, other revenues are decreased in the last year. The small amounts of revenues in Table 5.14 are earned in daily transactions.

Table 5.14 Other revenues in Balçova – Narlıdere GDHS

mo	Year			
	2001		2002	
	(in TL)	(in US $)	(in TL)	(in US $)
1	1,078,023,384	1,586	15,900,346,252	12,123
2	12,665,081,317	13,690	18,657,192,106	13,396
3	9,735,696,507	9,494	5,380,623,431	4,003
4	26,476,450,410	23,160	5,290,900,330	3,953
5	23,204,189,517	19,146	1,246,000,015	862
6	21,919,085,266	17,412	1,408,432,985	893
7	21,597,590,532	16,245	36,601,330	22
8	25,074,921,069	18,373	0	0
9	4,211,495,538	2,760	37,764,742	22
10	20,800,388,924	13,041	38,056,837	23
11	12,227,541,998	8,256	39,239,023	25
12	6,717,876,526	4,621	88,942,722	54
Total	185,708,340,988	147,784	48,124,099,773	35,377

Changes in collected total amounts of fix, connection, and interest revenues are shown in Figure 5.1. It is obvious that since the value loss in Turkish Liras in 2001, the value of fix price in US $ decreased. Distribution of revenues is given in Figure 5.2. Time value of money is not taken into consideration in Figures 5.1 and 5.2. Connection revenues constitute the important part of the collected revenues. Consequently, they had considerable affects on total revenues in previous years. It is important to notice that after 2002, connection charges will be decreased and finally it will be zero for the existing geothermal system.

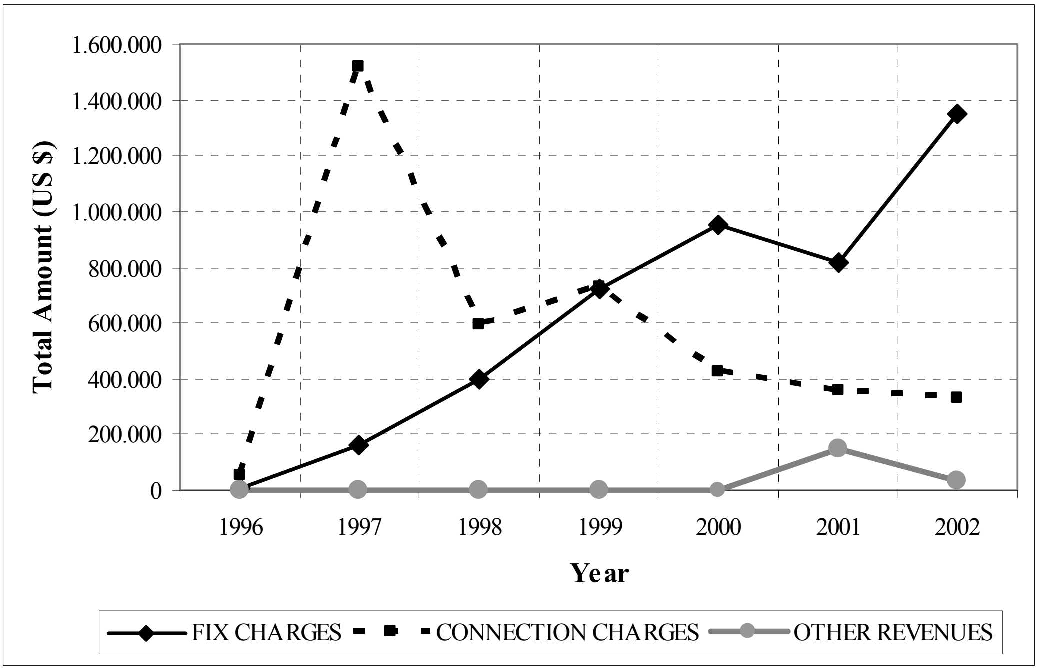

Figure 5.1 Changes in cumulative amounts of revenues from 1996 to 2002

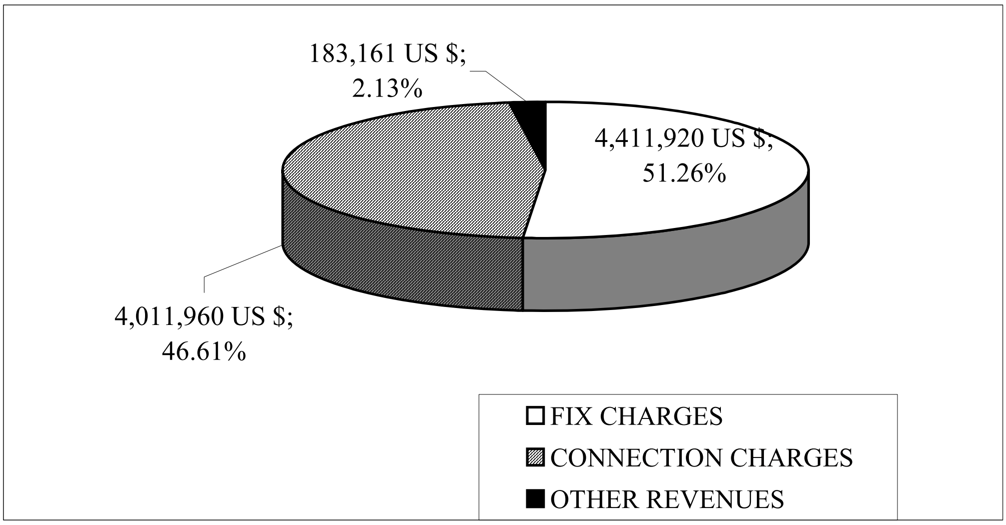

Figure 5.2 Distribution of revenues without considering the time value of money

5.1.1.5 Operating Costs

Because of changes in project scope during the construction phase and serious organizational differences in the management of Balçova – Narlıdere GDHS in the second half of year 2000, operating costs vary from 1998 to 2002. On the other hand, number of customers have been increased year by year. These augmentations caused an increase in operating costs. Operating costs in Balçova – Narlıdere GDHS is given in Table 5.15.

Operating costs in 2001 and 2002 are re-categorized in this part. Costs of some items are merged or reorganized. Cost of additional investment is separated from the operating costs. It is an important step for this economic assessment.

Cost of water and electricity consumptions are controlled and given in Tables 5.16 and 5.17 respectively.

Water consumption includes water used in Balçova GDHS and Narlıdere GDHS and tap water. In Balçova – Narlıdere GDHS, the amount of water loss rapidly raised because of increasing leakage problems in distribution network. Determination and maintenance of leakage is not easy task in such large systems. New technologies and techniques are tested to find the locations. Eventually, the tap water requirement has been increased day by day. Monthly costs of tap water which is placed to meet water loss in energy distribution network have been put on the management costs in the firm accounts. These are added to the water consumption costs in this study. The capacity of tap water softening equipment does not meet the requirement in Balçova – Narlıdere GDHS and water given to the system without softening. The quality of water in the city circulation loop is decreased. Oxygen joined to the system by tap water can increase the corrosion because of the high scaling potential of tap water in Turkey [8]. For this reason, tap water must be suitable with the water in energy distribution network. In addition, tap water is expensive and it causes an augmentation in the electricity cost for pumping fluids to heat up the system. Therefore, it has negative effects on operating costs. Electricity costs include the money paid for pumps which are installed in the heat exchanger and pumping stations of Balçova GDHS, Narlıdere GDHS, and electricity consumption in wellhead buildings. In 2001 and 2002, the cost of electricity, which was used in wellhead buildings, is paid in December to "Balçova Termal Turizm ve Özel Eğitim İşletmeleri Ltd. Şti". It is observed that energy consumption was 2,110,843 kWh_e in 2001 and 2,375,317 kWh_e in 2002. The consumed energy is nearly same but unit prices were not equal in those years. Also, the capacity has been considerably increased in 2002.

Cost of personnel wages which are shown in Table 5.18, is another important expenditure in Balçova – Narlıdere GDHS. Before the establishment of "Balçova Jeotermal Enerji San. Tic. Ltd. Şti.", "Balçova Termal Turizm ve Özel Eğitim İşletmeleri Ltd. Şti." has enough personnel to operating the system. The operating costs in these period also include personnel costs. However, extra money was not paid for the personnel worked for the geothermal system. They did not require engineers. In 2001, new company was established which has their own personnel and equipment. They have collaborated with universities, institutions, and Union of Chambers of Turkish Engineers and Architects. Therefore the personnel costs are increased after the year 2000. The personnel costs are also examined and reorganized. Wages of managers and their requirements are added to management costs in the accounts of "Balçova Jeotermal Enerji San. Tic. Ltd. Şti." This amount is subtracted from management costs and added into the cost of personnel wages. In addition, the number of technical personnel has been increased in the last two years. It increased the cost of personnel wages in 2002.

Another operating cost factor is purchase of inhibitor. Inhibitor is used in energy production network. If it is not used in production wells, the scaling will obstruct flowing of geothermal water. Geothermal fluid quality also has a great influence on maintenance costs. Fluid, which is suitable quality (low in chemical content and dissolved solids), should be pumped directly through the system. As fluid quality deteriorates, maintenance and replacement costs increase, and efficiency drops. The maintenance period of heat exchanger in heat exchanger and pumping station will be more frequent if the quality of fluid decreases. Costs of inhibitor purchasing are shown in Table 5.19. The reason of drastic increasing in 1999 is the augmentation in capacity. It is important to say that the consumed amount of inhibitor is considerably low for the last two years. Especially year 2002 expenditures are in desired level. It is also learned that the quality of inhibitor bought in 2002 is better than the quality of inhibitor purchased in the previous years.

Nitric acid, rock salt, NaOH are used in the cleaning of heat exchangers. Nitrogen is used closed expansion tanks and in the wells. These are named as other chemical materials in this study. Purchasing cost of them is presented in Table 5.20. In the previous years, some of the chemicals are used in the distribution network. This application increases the cost of them. Present only pure tap water is circulating in the system.

Cost of researches and tests on well's efficiency have been added into the cost of other chemical materials in company accounts. Nevertheless, this amount is subtracted from the other chemical's cost and added into the miscellaneous cost, which is the cost of equipment and works that needed during the operating of systems. Because of the new organization in the management of the Balçova – Narlıdere GDHS, new expenditures like marketing, miscellaneous costs, management, maintenance, facility rents are seen in 2001 and 2002. These payments are given in Table.5.21 and 5.22. Marketing costs include visual advertisements for introducing of geothermal energy and company, commissions for credit cards, newspapers, magazines, publications, and television programs on geothermal energy. “Balçova Jeotermal Enerji San. Tic. Ltd. Şti.” pays rent for using the buildings of “Balçova Termal Turizm ve Özel Eğitim İşletmeleri Ltd. Şti.”. These payments are named as facility rent and given in Tables 5.21 and 5.22. Yearly operating costs from 1998 to 2002 are summarized in Table 5.23. Yearly changes in operating costs are summarized in Figure 5.3.

Determination of total amount operating costs in 2001 and 2002 are important in this study. Because they also show the present and future operating costs if the system will be stable in accordance with the heating capacity. As it mentioned above, operating and investment costs are mixed in the accounts of company. It is quite difficult to decide which one can be accepted as operating costs. In this study, operating costs in 2002 are assumed to be realized in future. The operating costs in the last two years are compared with each other in Table 5.24. Finally, total amount of operating costs for each item in this period are given in Table 5.25. This table does not include the taxes paid by “Balçova Jeotermal Enerji San. Tic. Ltd. Şti.” and “Balçova Termal Turizm ve Özel Eğitim İşletmeleri Ltd. Şti.”. [47].

Table 5.15 Operating Costs in Balçova – Narlıdere GDHS

Operating Costs	Expression
Water	Tap Water Costs, Cost of city water used in Balçova and Narlıdere heat exchanger and pumping stations
Electricity	Electricity consumption of wellhead housings, Balçova and Narlıdere heat exchanger and pumping stations
Inhibitor	Cost of inhibitor which is used in wellhead housings
Other Chemicals	Cost of nitric acid, rock salt, NaOH and nitrogen
Miscellaneous Costs	Cost of equipment and works that needed during the operating of systems like the rents of cranes and other vehicles
Marketing	Visual advertisements, commissions for credit cards, newspapers, magazines, publications, and television programs on geothermal energy
Management	Cost of telephone, cargo, posts, rent of vehicles, cost of visitors, stationary costs

Table 5.16 Expenditures for water consumption from 1998 to 2002

mo	Year									
	1998		1999		2000		2001		2002	
	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)
1			1,773,629,600	5,339	2,205,085,000	3,934	6,191,431,391	9,109	9,720,084,745	7,411
2	474,205,955	2,065	1,659,125,000	4,708	2,759,175,000	4,800	9,682,433,037	10,466	17,601,525,424	12,638
3	2,649,095,000	10,911	1,901,645,000	5,151	4,207,000,000	7,120	4,303,361,688	4,196	22,513,050,847	16,748
4	941,990,000	3,772	1,732,445,000	4,439	3,267,810,000	5,337	6,910,383,692	6,045	17,720,169,490	13,241
5	761,895,000	2,963	1,636,565,000	4,025	4,514,020,000	7,308	12,111,352,935	9,993	11,412,033,897	7,898
6	158,975,000	597	1,971,450,000	4,679	4,047,515,000	6,517	12,030,793,528	9,557	7,475,423,728	4,741
7	99,195,000	367	3,646,020,000	8,519	2,450,390,000	3,837	5,431,544,970	4,085	3,096,779,661	1,826
8	648,245,000	2,337	1,459,465,000	3,279	5,312,175,000	8,090	17,091,507,036	12,523	7,440,472,034	4,567
9	397,255,000	1,431	2,085,410,000	4,528	5,116,530,000	7,647	2,541,474,576	1,665	31,299,401,459	18,626
10	550,955,000	1,923	1,554,875,000	3,242	5,696,690,000	8,304	17,320,423,728	10,859	8,554,457,627	5,121
11	752,305,000	2,476	1,739,594,000	3,370	5,615,050,000	8,192	14,518,016,949	9,802	10,482,707,627	6,795
12	3,105,730,000	9,853	2,340,631,000	4,313	5,693,493,690	8,435	5,670,000,000	3,901	7,715,275,424	4,683
Total	10,539,845,955	38,695	23,500,854,600	55,592	50,884,933,690	79,522	113,802,723,530	92,203	155,031,381,963	104,293

Table 5.17 Expenditure for electricity consumption from 1998 to 2002

mo	Year									
	1998		1999		2000		2001		2002	
	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)
1			4,327,942,545	13,028	12,651,927,000	22,570	27,608,607,320	40,619	2,824,889,830	2,154
2	3,209,182,000	13,977	7,257,713,343	20,595	20,252,510,000	35,233	24,736,358,974	26,739	44,350,713,400	31,844
3	3,735,866,000	15,387	6,479,328,600	17,552	21,326,020,000	36,091	22,725,103,724	22,160	42,705,203,390	31,769
4	3,002,129,000	12,021	6,651,992,472	17,046	16,665,210,000	27,220	10,864,632,827	9,504	93,177,531,051	69,623
5	1,185,720,000	4,611	1,777,581,450	4,372	5,559,013,500	8,999	12,087,221,986	9,973	32,151,644,067	22,251
6	708,306,000	2,661	899,076,313	2,134	1,952,519,000	3,144	5,739,382,380	4,559	12,959,810,424	8,220
7	599,766,000	2,217	1,219,473,366	2,849	1,403,560,000	2,198	3,077,780,938	2,315	4,996,762,712	2,946
8	498,428,500	1,797	603,445,088	1,356	2,057,880,000	3,134	433,322,034	318	7,914,474,576	4,858
9	1,028,273,000	3,705	738,289,000	1,603	3,732,030,000	5,578	5,233,763,405	3,430	4,909,025,423	2,921
10	1,184,810,500	4,136	498,840,500	1,040	2,872,220,000	4,187	6,216,008,474	3,897	5,381,576,271	3,221
11	2,004,092,000	6,596	4,156,371,518	8,053	11,300,800,000	16,488	12,563,271,187	8,483	22,550,381,356	14,617
12	2,583,429,000	8,196	9,255,319,537	17,054	12,457,030,000	18,455	80,908,087,917	55,660	150,073,366,915	91,083
Total	19,740,002,000	75,303	43,865,373,732	106,681	112,230,719,500	183,297	212,193,541,166	187,656	423,995,379,416	285,507

Table 5.18 Expenditures for wages of personnel from 1998 to 2002

mo	Year									
	1998		1999		2000		2001		2002	
	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)
1			4,589,155,351	13,814	5,056,000,000	9,019	7,266,909,835	10,691	19,578,307,797	14,927
2	469,579,495	2,045	2,001,686,094	5,680	5,056,000,000	8,796	7,735,458,235	8,362	22,647,260,284	16,261
3	813,421,505	3,350	3,952,780,997	10,708	5,056,000,000	8,556	9,418,535,466	9,184	21,790,719,504	16,210
4	553,571,251	2,217	3,315,072,398	8,495	5,056,000,000	8,258	13,977,091,120	12,227	23,319,113,771	17,424
5	3,422,818,553	13,310	4,513,238,963	11,100	5,056,000,000	8,185	15,089,395,020	12,450	22,262,466,848	15,407
6	2,632,890,038	9,892	6,782,945,269	16,098	5,056,000,000	8,141	14,019,012,413	11,137	23,543,036,269	14,932
7	1,197,130,791	4,425	5,029,290,998	11,751	5,056,000,000	7,918	18,257,012,794	13,732	25,265,479,922	14,894
8	2,230,814,590	8,043	5,092,389,668	11,441	4,593,961,396	6,997	17,574,020,320	12,877	25,207,967,654	15,473
9	3,860,592,182	13,910	4,121,792,237	8,949	5,079,050,126	7,591	15,108,748,224	9,901	22,579,263,964	13,437
10	3,739,925,537	13,056	2,954,320,738	6,160	4,862,047,760	7,088	23,852,677,839	14,954	40,112,238,693	24,012
11	3,425,539,537	11,275	2,516,092,636	4,875	5,249,642,621	7,659	20,769,669,396	14,023	28,625,848,264	18,555
12	4,831,577,662	15,328	4,494,046,207	8,281	5,532,259,591	8,196	21,291,682,634	14,647	42,348,048,304	25,702
Total	27,177,861,141	96,850	49,362,811,556	117,351	60,708,961,494	96,404	184,360,213,296	144,186	317,279,751,274	207,234

Table 5.19 Expenditure for purchase of inhibitor from 1998 to 2002

mo	Year									
	1998		1999		2000		2001		2002	
	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)
1			1,650,720,000	4,969	1,229,280,000	2,193	3,145,087,680	4,111	0	0
2	0	0	2,114,400,000	6,000	2,446,080,000	4,255	1,050,003,120	1,135	1,153,660,878	828
3	803,935,001	3,311	1,303,200,000	3,530	2,472,000,000	4,183	2,967,810,960	2,894	370,318,680	275
4	834,122,700	3,340	2,248,560,000	5,762	628,800,000	1,027	1,837,352,160	1,607	0	0
5	0	0	463,680,000	1,140	0	0	0	0	394,624,080	273
6	680,896,800	2,558	945,120,000	2,243	0	0	0	0	768,187,490	487
7	0	0	976,320,000	2,281	0	0	1,760,787,840	1,324	0	0
8	0	0	508,800,000	1,143	0	0	0	0	0	0
9	654,960,000	2,360	525,120,000	1,140	931,691,280	1,392	179,082,180	117	1,021,924,800	608
10	371,844,000	1,298	1,105,920,000	2,306	931,691,280	1,358	2,951,770,530	1,851	0	0
11	375,840,000	1,237	1,136,160,000	2,201	945,562,800	1,380	716,328,720	484	1,039,179,480	674
12	1,188,960,000	3,772	2,369,280,000	4,366	986,746,800	1,462	0	0	999,630,360	607
Total	4,910,558,501	17,876	15,347,280,000	37,082	10,571,852,160	17,251	14,608,223,190	13,523	5,747,525,768	3,753

Table 5.20 Expenditure for purchase of other chemical materials from 1998 to 2002

mo	Year									
	1998		1999		2000		2001		2002	
	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)
1			201,691,800	607	0	0	728,500,000	1,072	518,900,000	396
2	0	0	196,650,000	558	219,383,637	382	9,600,000	10	569,770,160	409
3	0	0	126,370,000	342	31,515,000	53	0	0	8,000,000	6
4	0	0	579,040,000	1,484	259,000,000	423	48,000,000	42	128,850,000	96
5	0	0	30,248,000	74	701,244	1	220,140,000	182	297,050,000	206
6	0	0	13,440,000	32	123,375,000	199	87,000,000	69	386,430,000	245
7	0	0	206,875,000	483	0	0	0	0	121,000,000	71
8	0	0	12,000,000	27	0	0	88,735,390	65	387,430,000	238
9	41,052,000	148	47,250,000	103	0	0	569,703,390	373	82,000,000	49
10	58,900,000	206	44,000,000	92	0	0	904,300,000	567	15,000,000	9
11	0	0	236,000,000	457	0	0	244,200,000	165	200,600,000	130
12	0	0	58,428,969	108	0	0	24,000,000	17	95,000,000	58
Total	99,952,000	354	1,751,993,769	4,367	633,974,881	1,058	2,924,178,780	2,562	2,810,030,160	1,912

Table 5.21 Other operating cost realized in 2001

mo	Maintenance		Miscellaneous Costs		Management		Marketing		Facility Rent		Total
	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)	(in US $)
1	65,000,000	96	5,231,013,099	7,696	3,341,747,324	4,917	3,614,279,462	5,318	50,000,000,000	73,563	91,588
2	202,000,000	218	2,768,792,417	2,993	3,336,935,036	3,607	974,467,069	1,053	50,000,000,000	54,047	61,919
3	136,600,000	133	1,131,265,390	1,103	4,651,876,352	4,536	1,310,943,506	1,278	50,000,000,000	48,758	55,809
4	380,750,000	333	12,154,357,364	10,632	8,658,609,441	7,574	1,083,630,435	948	50,000,000,000	43,738	63,225
5	110,000,000	91	1,359,575,577	1,122	8,551,779,520	7,056	7,567,845,784	6,244	50,000,000,000	41,255	55,768
6	1,107,500,000	880	1,563,760,762	1,242	8,248,214,971	6,552	2,273,607,585	1,806	50,000,000,000	39,720	50,200
7	0	0	2,789,300,979	2,098	7,929,797,199	5,965	737,480,690	555	0	0	8,617
8	1,292,600,000	947	15,667,376,808	11,480	8,628,693,329	6,322	-11,743,327	-9	0	0	18,741
9	5,345,321,142	3,503	3,143,480,920	2,060	13,379,856,119	8,768	835,793,874	548	0	0	14,878
10	4,298,750,000	2,695	17,333,368,368	10,867	12,924,058,879	8,103	3,272,742,156	2,052	0	0	23,716
11	1,326,126,977	895	35,231,057,640	23,787	18,538,477,319	12,517	2,508,998,473	1,694	0	0	38,894
12	1,860,508,475	1,280	31,711,891,459	21,816	21,447,779,762	14,755	5,385,251,424	3,705	79,878,309,877	54,951	96,507
Total	16,125,156,594	11,071	130,085,240,783	96,896	119,637,825,251	90,672	29,553,297,131	25,192	379,878,309,877	356,032	579,863

Table 5.22 Other operating costs realized in 2002

mo	Maintenance		Miscellaneous Costs		Management		Marketing		Facility Rent		Total
	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)	(in TL)	(in US $)	(in US $)
1	109,000,000	83	5,085,033,898	3,877	10,155,904,731	7,743	15,105,758,847	11,517	76,694,915,254	58,473	89,655
2	1,465,887,288	1,053	3,895,033,898	2,797	7,694,015,541	5,524	424,617,657	305	76,694,915,254	55,068	72,245
3	597,267,800	444	575,000,000	428	10,393,567,944	7,732	594,898,268	443	76,694,915,254	57,054	73,870
4	0	0	6,828,538,136	5,102	9,988,892,085	7,464	368,189,195	275	0	0	20,645
5	276,557,800	191	1,302,796,610	902	13,052,477,950	9,033	534,254,452	370	0	0	17,724
6	77,052,866,780	48,413	8,205,000,000	5,204	7,622,805,005	4,835	323,519,293	205	0	0	65,280
7	381,033,898	225	9,535,000,000	5,621	10,445,431,079	6,158	283,937,497	167	0	0	18,327
8	0	0	3,330,000,000	2,044	9,351,272,275	5,740	350,111,721	215	0	0	14,409
9	134,951,525	80	5,111,394,491	3,042	8,038,749,289	4,784	366,875,270	218	0	0	14,339
10	805,682,000	482	9,049,585,000	5,417	7,071,664,500	4,233	566,963,465	339	0	0	12,025
11	525,884,797	341	7,816,271,186	5,066	15,762,131,537	10,217	1,848,333,749	1,198	0	0	18,821
12	3,468,021,510	2,105	5,500,423,729	3,338	10,407,448,571	6,317	917,457,627	557	108,898,305,085	66,093	79,525
Total	84,817,153,398	53,417	66,234,076,948	42,838	119,984,360,507	79,779	21,684,917,041	15,809	338,983,050,847	236,688	496,864

Table 5.23 Yearly operating costs from 1998 to 2002 (US $)

no.	Item		Year				
			1998	1999	2000	2001	2002
1	Water Consumption		38,695	55,592	79,522	92,203	104,293
2	Wages of Personnel		96,850	117,351	96,404	144,142	207,234
a	Operational Personnel		96,850	117,351	96,404	117,478	181,370
b	Management Board*		-	-	-	26,664	25,864
	i	Board	-	-	-	19,098	16,206
	ii	Advisors	-	-	-	7,566	9,658
3	Electricity Cost		75,303	106,681	183,297	187,656	285,507
4	Purchase of Inhibitor		17,876	37,082	17,251	13,523	3,753
5	Purchase of Other Chemicals		354	4,367	1,058	2,056	1,912
6	Other Operating Costs					579,863	496,864
a	Maintenance Cost		0	0	0	11,071	53,417
b	Miscellaneous Costs		0	0	0	96,896	42,838
c	Management Cost		0	0	0	90,716	148,112
d	Marketing Cost		0	0	0	25,192	15,809
e	Facility Rent		0	0	0	356,032	236,688
Total			229,077	321,073	377,531	1,019,488	1,099,563

* Payments for management board from 1998 to 2000 are not available data. Therefore they are not given in this table.

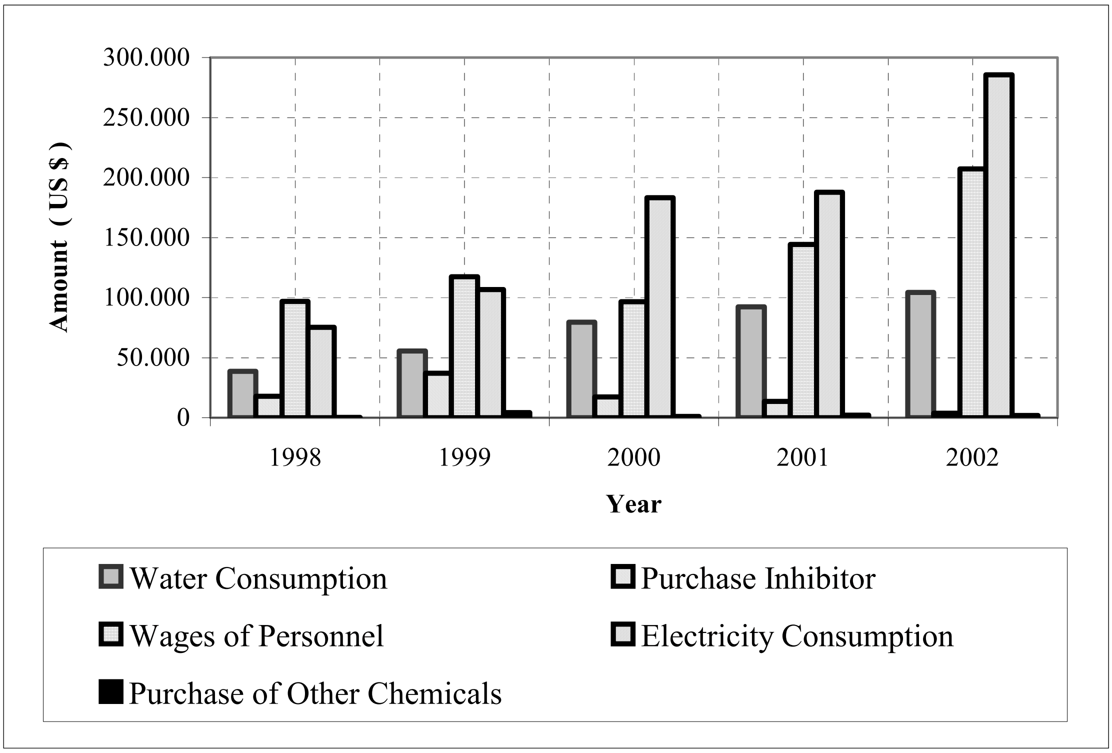

Figure 5.3 Changes in the total amounts of operating costs between 1998 and 2002

Table 5.24 Comparison of operating costs realized in 2001 and 2002

Item	2001		2002	
	(in US $)	%	(in US $)	%
Water Consumption	92,203	9.04	104,293	9.48
Purchase Inhibitor	13,523	1.33	3,753	0.34
Wages of Personnel	144,142	14.14	207,234	18.85
Electricity Consumption	187,656	18.41	285,507	25.97
Purchase of Other Chemicals	2,056	0.20	1,912	0.17
Maintenance Costs	11,071	1.09	53,417	4.86
Miscellaneous Costs	96,896	9.50	42,838	3.90
Management Costs	90,716	8.89	148,112	13.47
Marketing Costs	25,192	2.47	15,809	1.44
Facility Rent	356,032	34.92	236,688	21.53
Total	1,019,488	100	1,099,563	100

Table 5.25 Total amount of operating costs up to 2003

Item	Total Amount (in TL)	Total Amount (in US $)	Percentage (%)
Water Consumption	353,759,739,738	370,305	12.15%
Wages of Personnel	638,889,598,761	662,024	21.73%
Electricity Cost	812,025,015,814	838,444	27.52%
Purchase of Inhibitor	51,185,439,619	89,484	2.94%
Purchase of Other Chemicals	7,414,259,780	9,747	0.32%
Maintenance Cost	100,222,949,992	64,488	2.12%
Miscellaneous Costs	196,319,317,731	139,734	4.59%
Management Cost	341,129,359,491	238,784	7.84%
Marketing Cost	51,238,214,172	41,001	1.35%
Facility Rent	718,861,360,724	592,719	19.45%
Total	3,271,045,255,822	3,046,732	100%

Cash flows after the construction of project are calculated to control the accuracy of collected data. Change in cash flows from 1996 to 2002 is given in Figure 5.4. Only revenues, operating costs and taxes are taken into consideration to calculate the net cash flows. The amount of taxes paid before 2000 can not be learned and those are ignored in this Figure.

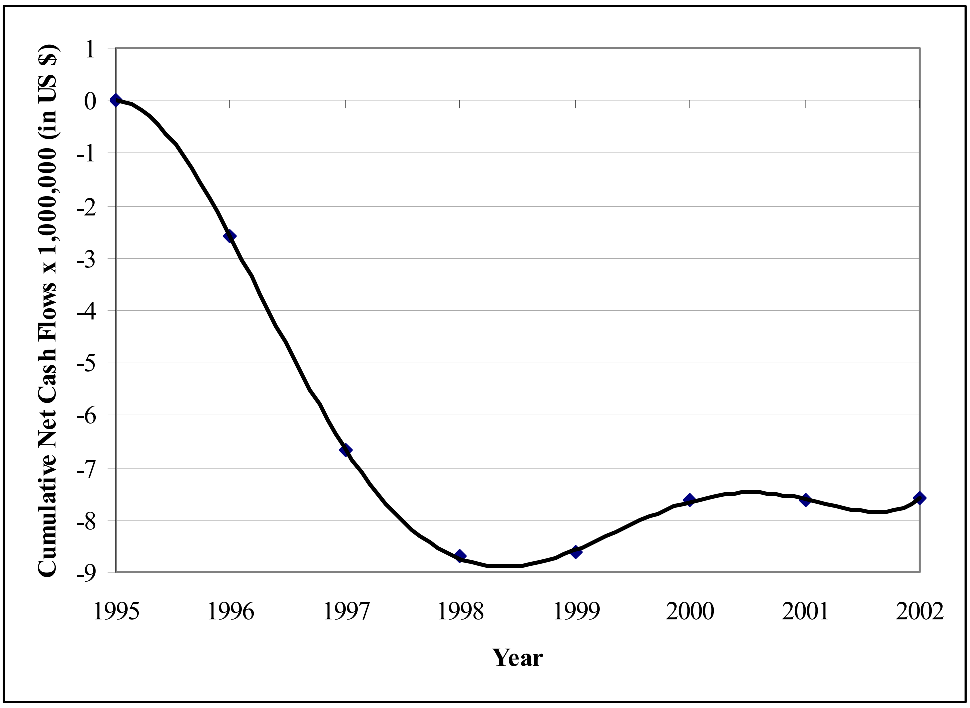

Figure 5.4 Cumulative net cash flows from 1995 to 2002

5.1.2 End of Period Calculations

The end-of-year convention has been accepted throughout the analysis. Spreadsheets are created for the calculations of end of month and year values in which bank interest rates per months are used.

5.1.2.1 End of Period Values of Capital Costs

Calculations began with the determination of end of month value of payments in each accrual. The monthly interest rate that was given by the Central Bank of Turkish Republic for the public sector was divided by 30 to calculate daily interest rates. Interest rates are given in Appendix A. By using calculated interest rate and the difference between the number of accrual date and 30, end of month value of an accrual is calculated according to Equation (4.4). End of month value calculations are given in Appendix C. After the accomplishment of this step. End of year values are calculated by using interest rates per half of a year, quarter and month. The using of interest rates with regard to months of accrual dates is presented in Figure 5.5.

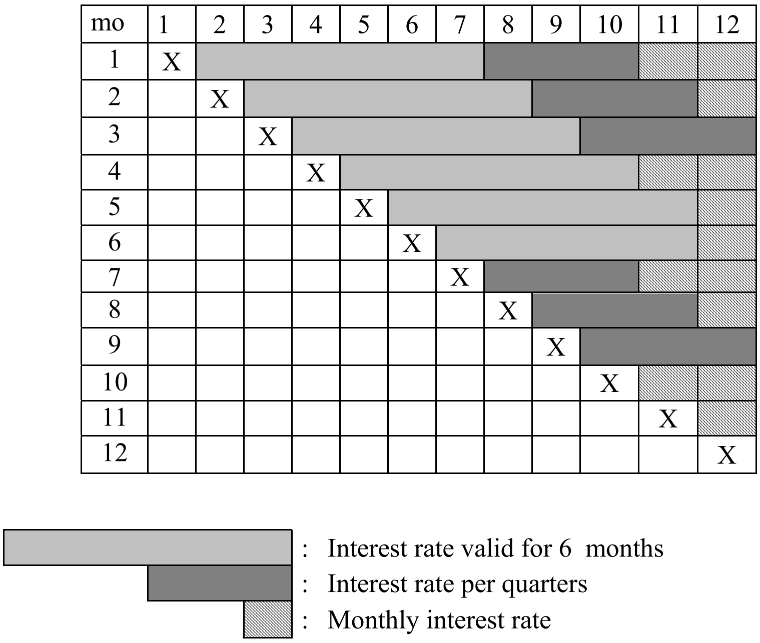

Figure 5.5 Using of interest rates for the end of year value calculations

End of period value calculation is summarized in Figure 5.6. According to this figure, there are three disbursements, which paid respectively in the first, second and eleventh months shown with solid lines. Each payment is done in different dates. Disbursements indicated by dashed lines are the calculated end of month values. These calculations are made for all the group of items in each accrual. Thus, the payments for each item in a certain year can easily be determined. In this process, rate of interests were taken from the Central Bank of Republic of Turkey and are used instead of discount rates in the formulas.

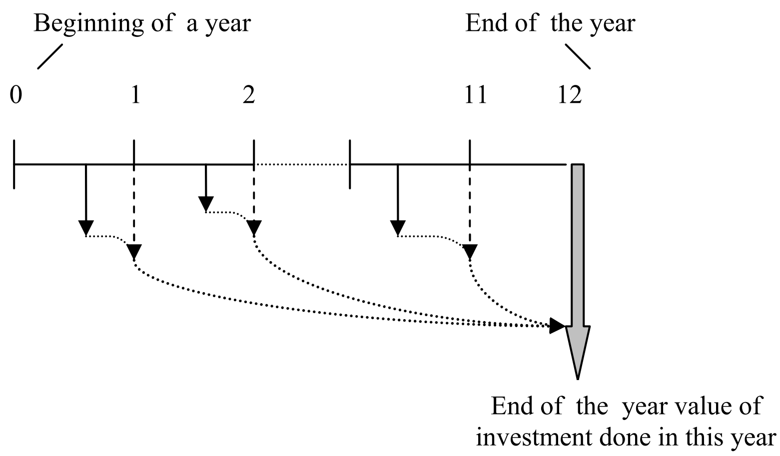

Figure 5.6 End of month and year value calculations for the payments

End of year calculations are given in Appendix D. The results of calculations for are presented in Tables 5.26 and 5.27.

Table 5.26 End of year values of each item in US $ from 1995 to 1999 in Balçova accruals

no.	Item	1995	1996	1997	1998	1999
1	Construction of heat exchanger and pumping station	4,729	113,443	5,438	0	-18,704
2	Transport of materials used in heat exchanger and pumping station	795	36,784	374	0	193
3	Electricity installation	0	118,157	370	76,373	33,159
4	Installation of heating equipment used in heat exchanger and pumping station	0	10,874	23,952	22,976	6,063
5	Shared installations (wellhead housing, building, and heat exchanger and pumping station connections)	0	50,670	231,009	34,585	16,316
6	Excavation	0	0	333,365	138,637	51,657
7	Transport of materials used in excavation	0	0	231,282	90,464	30,834
8	Sanitary installations	0	3,498	2,451	-1,083	114
9	Automatic control	0	83	0	221	847
10	Installation of transformer	0	46,203	0	0	58,164
11	Installation in heat exchanger and pumping station)	0	801	0	1,040	41,885
12	Piping networks, heat exchangers, compensator, pumps and other equipment (Thermal line)	0	2,490,430	4,339,614	2,798,624	774,459
13	Materials without discount (Timber, cement, sand)	1,601	13,786	21,099	8,630	8,960
Total		7,126	2,884,729	5,188,955	3,170,467	1,000,782

Table 5.27 End year values of each item in US $ from 1997 to 1999 in Narlıdere accruals

no.	Item	30.12.1997	30.12.1998	30.12.1999
1	Construction of heat exchanger and pumping station	43,444	4,595	508
2	Transport of materials which are used in heat exchanger and pumping station	4,351	459	51
3	Excavation	32,772	16,375	580
4	Transport of materials used in excavation	22,940	11,462	406
5	Electricity installations	197	0	0
6	Installation of heating equipment used in heat exchanger and pumping station	1,254	5,375	1,276
7	Sanitary installations	344	912	0
8	Shared installations (wellhead housing, building, and heat exchanger and pumping station connections)	9,926	11,298	9,743
9	Automatic control	0	85	0
10	Thermal line (Piping networks, heat exchangers, compensator, pumps and other equipment)	623,044	213,326	53,813
11	Materials without discount (Timber, cement, sand)	108,158	115,149	70,940
Total Amount		846,430	379,036	137,317

Up to now, yearly costs of investment have been determined. At this point, equivalent end of 2002 value of yearly costs will be calculated. End of 2002 value calculations began with finding end of 1996 value of investment realized in 1995. In accordance with the annual interest rate that is valid on 30.12.1995, end of 1996 value of investment is calculated and the cost of investment realized in 1996 is added to sum. In this process, end of the following year value of investment costs of previous years is calculated systematically up to the 2002. This process is demonstrated in Figure 5.7. The end of 2002 values of items in Balçova and Narlıdere investments are presented in Table 5.28 and 5.29, respectively. The cost percentages for each theme are given in the last columns in these tables.

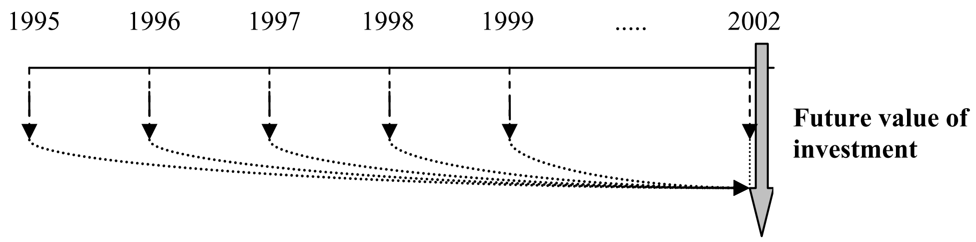

Figure 5.7 End of 2002 value calculations

Table 5.28 End of 2002 value of capital investment costs for Balçova GDHS

no.	Item	End of 2002 value (in US $)	Percentage (%)
1	Construction of heat exchanger and pumping station	173,658	0.95%
2	Transport of materials used in heat exchanger and pumping station	61,048	0.33%
3	Electricity installation	339,881	1.86%
4	Installation of heating equipment used in heat exchanger and pumping station	93,943	0.51%
5	Shared installations (wellhead housing, building, and heat exchanger and pumping station connections)	502,071	2.75%
6	Excavation	768,530	4.21%
7	Transport of materials used in excavation	518,672	2.84%
8	Sanitary installations	7,951	0.04%
9	Automatic control	1,542	0.01%
10	Installation of transformer	149,349	0.82%
11	Installation in heat exchanger and pumping station)	57,044	0.31%
12	Piping networks, heat exchangers, compensator, pumps and other equipment (Thermal line)	15,517,855	84.93%
13	Materials without discount (Timber, cement, sand)	80,617	0.44%
Total		18,272,162	100.00%

Table 5.29 End of 2002 value of capital investment costs for Narlıdere GDHS

no.	Item	End of 2002 value (in US $)	Percentage (%)
1	Construction of heat exchanger and pumping station	73,170	3.66
2	Transport of materials which are used in heat exchanger and pumping station	7,327	0.37
3	Excavation	73,575	3.68
4	Transport of materials used in excavation	51,503	2.58
5	Electricity installations	300	0.02
6	Installation of heating equipment used in heat exchanger and pumping station	11,107	0.56
7	Sanitary installations	1,803	0.09
8	Shared installations (wellhead housing, building, and heat exchanger and pumping station connections)	43,587	2.18
9	Automatic control	119	0.01
10	Thermal line (Piping networks, heat exchangers, compensator, pumps and other equipment)	1,316,671	65.92
11	Materials without discount (Timber, cement, sand)	418,106	20.93
Total		1,997,269	100

End of 2002 values of auxiliary equipment and connection investments realized in 2001 and 2002 are given in Tables 5.30 and 5.31.

Table 5.30 End of year values of additional investment realized in 2001

no.	Item	Total Amount		End of 2001 Value	End of 2002 Value
		(in TL)	(in US $)	(in US $)	(in US $)
1	Auxiliary Equipments	209,826,864,382	182,452	192,082	202,647
	Machines	193,883,074,808	167,898	176,419	186,122
	Inventory	7,274,332,489	6,904	7,425	7,834
	Vehicles	8,669,457,085	7,650	8,238	8,691
2	New Connections	147,643,948,122	101,088	103,624	109,323
	Total	357.470.812.504	283,540	295,706	311,970

Table 5.31 End of year values of additional investment realized in 2002

Item	End of 2002 Value (in US $)
New Connections	173,192
Auxiliary Equipments	212,864
Drilling Costs (BD8)	146,340
Total	532,396

Wells in Balçova – Narlıdere region were not drilled in 2002. Therefore, 2002 value of drilling costs are calculated. The results are given in Table 5.32.

Table 5.32 End of 2002 values of well drilling costs in US $

Well Name	Estimated Value of Well Drilling Cost (in US $)	End of 2002 value (in US $)
B1	24,513	131,795
BD1	131,993	236,888
BD2	159,571	272,744
BD3	176,777	282,915
BD4	147,078	206,504
BD5	259,273	336,131
BD6	142,600	184,872
BD7	164,992	213,902
B4	29,463	144,006
B5	25,574	124,998
B7	28,284	138,246
B9	11,314	55,298
B10	29,463	81,288
B11	27,341	75,435
Total		2,485,024

In accordance with the end of 2002 values of accruals and well drilling costs, the distribution of capital investment costs in Balçova – Narlıdere GDHS is given in Figure 5.8.

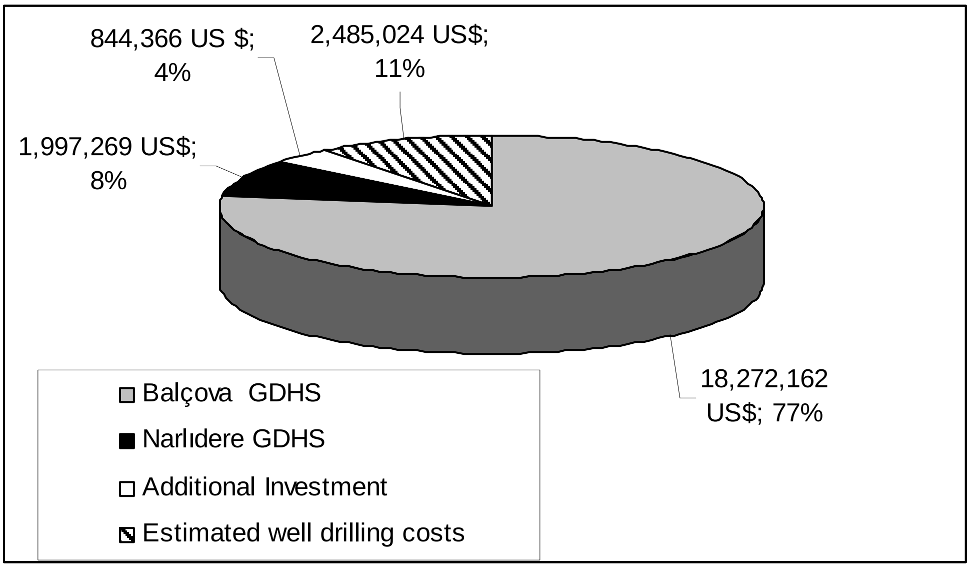

Figure 5.8 Distribution of capital investment cost of investment in accordance with the end of 2002 value in US $

5.1.2.2 End of Period Value Calculations for Revenues

It is assumed that all revenues are collected at the end of months. Calculations expressed in detailed above are applied to the revenues. End of year calculations for revenues performed according to Figures 5.5, 5.6 and 5.7. Detailed tables are presented in Appendix G. In those tables, end of year values of fix charges and connection charges are calculated by using revenues data and rate of interests. The results of these calculations are given in Table 5.33.

Beginning with the end of 1996 value of incomes, revenues carried to the end of the following year up to 2003. The results are given in Table 5.34. Distribution of end of 2002 values of revenues is given in Figure 5.9.

Table 5.33 End of year values of revenues collected in Balçova – Narlıdere GDHS from 1996 to 2002 in US $

	Year						
	1996	1997	1998	1999	2000	2001	2002
Connection	54,038	1,555,538	615,813	758.662	447,174	374,357	332,439
Fix	8,386	166,068	412,400	745,688	985,360	848,904	1,373,885
Other	0	0	0	0	0	155.690	200,803
Total	62,424	1,721,606	1,028,213	1,503,420	1,432,534	1,475,520	1,459,005

Table 5.34 End of 2002 values revenues in US $

	30.12.1997	30.12.1998	30.12.1999	30.12.2000	30.12.2001	30.12.2002
Rates of Interest	0.0525	0.0830	0.0830	0.1100	0.115	0.055
Fix Charges	174,895	601,812	1,398,155	2,537,312	3,678,007	5,254,183
Connection Charges	1,612,413	2,362,056	3,316,769	4,128,787	4,977,955	5,584,181
Other Revenues	0	0	0	0	155,690	200,803
End of 2002 value						11,039,167

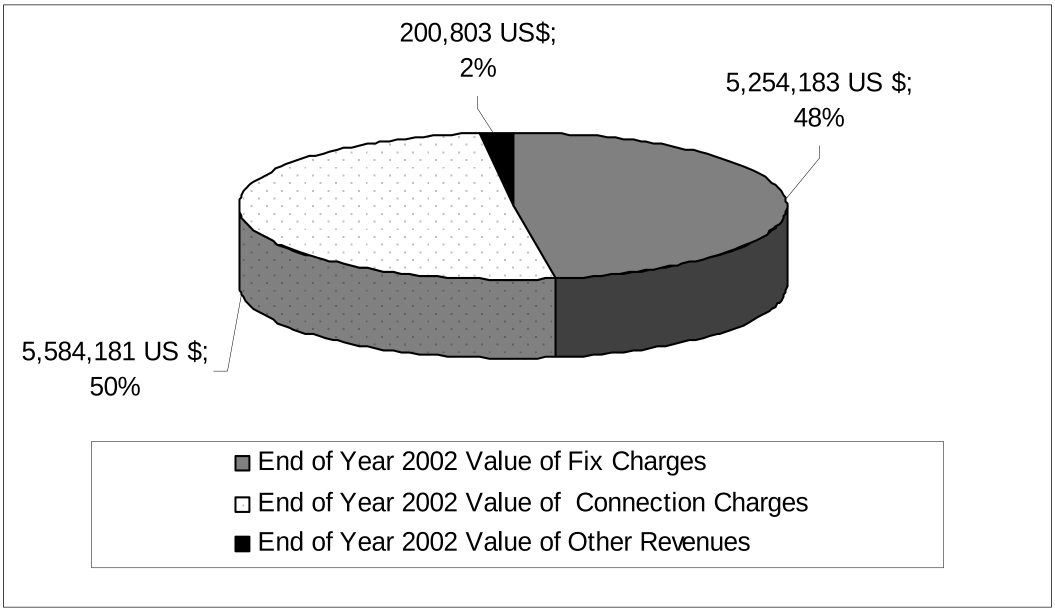

Figure 5.9 Distribution of revenues with regard to net present values

5.1.2.3 End of Period Value Calculations for Operating Costs

End of year values of operating costs are calculated and the results are given in Table 5.35. Calculations are given in Appendix F. Equivalent values at the end of 2002 are presented in Table 5.36.

Table 5.35 End of year values of operating costs in US $ from the year 1998 to 2003

no.	Item	Year				
		1998	1999	2000	2001	2002
1.	Water Consumption	39,951	58,107	82,557	96,961	106,418
2.	Wages of Personnel	99,058	122,810	100,686	150,773	210.739
3.	Electricity Cost	78,296	112,165	193,248	198,374	290,386
4.	Purchase of Inhibitor	18,407	38,916	18,170	14,520	3,810
5.	Purchase of Other Chemicals	358	4,608	1,128	2,199	1,958
6.	Other Expenditures	0	0	0	613,623	507.907
	Maintenance Costs				11,350	54.367
	General Management				94.175	151.177
	Marketing Costs				26,597	16,300
	Facility Rent				381,792	242,491
	Miscellaneous Costs				99.709	43,572
Total Costs		236,070	336,607	395,839	1,076,450	1,121,218

Table 5.36 End of 2002 values of operating costs from 1998 to 2002

Item	End of 2002 value (in US $)	(%)
Water Consumption	438,016	12.66
Wages of Personnel	788,630	22.78
Electricity Cost	984,227	28.43
Purchase of Inhibitor	117,346	3.39
Purchase of Other Chemicals	12,128	0.35
Maintenance	65,718	2.14
General Management Costs	245,396	7.09
Marketing Costs	42,896	1.24
Facility Rent	624,283	18.03
Miscellaneous Costs	143,281	4.14
Total Operating Costs	3,462,096	100

Up to this point the net present value of all cash flows are calculated and the results are given in Table 5.37.

Table 5.37 End of 2002 value of all cash flows in US $

		End of 2002 value (in US $)	Reference
CAPITAL INVESTMENT COSTS		-23,598,820	
1.	Balçova GDHS	-18,272,162	Appendix D
2.	Narlıdere GDHS	-1,997,269	Appendix D
3.	Well Drilling Costs	-2,485,024	Appendix D
4.	Additional Investments	-844,366	
a.	2001 Investments	-311,970	Appendix E
b.	2002 Investments	-532,396	Appendix E
OPERATING COSTS		-3,462,096	Appendix F
REVENUES		11,039,167	
1.	Connection	5,584,181	Appendix G
2.	Fix	5,254,183	Appendix G
3.	Other	200,803	Appendix G
TAXES		-82,547	
NET CASH FLOWS AFTER TAX		-16,104,295	

5.1.3 Future Cost of Renovations

Because of the corrosion and leakage problem in energy distribution network as explained in 5.1.1.5, a renovation will be required in pipelines. It is assumed that 75 % of pipe network installed in Balçova and Narlıdere region will be changed after 5 years while the remaining 25 % of pipes will be changed after 10 years. Because most of the piping network had been constructed for 5 years at the end of 2001. It is considered that CTP + PUR + CTP pipes will be installed instead of Steel 37 + PUR + CTP pipes. On the other hand, life of a geothermal pump changes with chemical components of geothermal fluids. It is assumed that all pumps will be changed after 10 years in Balçova – Narlıdere GDHS. System will be completely renewed and new wells will be drilled for the sustainable development of geothermal energy at the end of 2021. Cost of future renovations are summarized in Table 5.38.

Table 5.38 Cost of future renovations in US $

no.	Item	Cost of future investment (in US $)
1	Valves (after 10 years)	218,700
2	%25 of all compensators (after 5 years)	247,689
3	Pipe lines (CTP+PUR+CTP)	3,533,425
	75 % of pipe network (after 5 years)	2,650,069
	25 % of pipe network (after 10 years)	883,356
4	Pumps (after 10 years)	204,412

5.1.4 Salvage Values

The accuracy of salvage value estimations affects the result of an economic evaluation as explained in previous chapter. Wrong estimations or zero value assumptions could give error on the profitability of a project. In this study, estimated salvage values are taken into consideration. It is assumed that the existing system will be operated according to sustainability and renewability of geothermal resources. In addition, some equipment will be renewed through the project life according to their life of an asset. The physical life of Balçova – Narlıdere GDHS is accepted as 20 years after the year 2001 in this study. The system will be operated after 2021 with some renovations. Estimated lives of the equipment used in Balçova – Narlıdere GDHS investment and estimated salvage values of the components are given in Table 5.39.

Table 5.39 Estimated salvage values in US $

		Year	Balçova	Narlıdere	Total (in US $)	Salvage Value (%)	Salvage Value (in US $)
Investment realized between 1996-2000	Pipelines	10	5,768,899	562,877	6,331,775	5	316,589
	Compensators	5	461,623	22,923	484,547	5	24,227
	Pumps	10	42,129	28,236	70,365	5	3,518
	Line shaft type well pumps	10	372,807	33,779	406,587	5	20,329
	Valves	10	209,446	60,623	270,069	5	13,503
	Other Equipment	20	4,073,629	627,410	4,701,039	5	235,052
Future Renovations	Pipelines	15			3,533,425	5	176,671
	Compensators	5			247,689	5	12,384
	Valves	10			218,700	5	10,935
	Pumps	10			219,412	5	10,971

5.1.5 Depreciation Expenses for Balçova – Narlıdere GDHS

The negative affects of depreciation on the net future cash flows of Balçova – Narlıdere GDHS investment is considered in this study. Different depreciation method can be applied in the project evaluations.

Double declining balance depreciation method is preferred in this analysis. The declining balance method allocates for depreciation a fixed fraction of initial book balance each year. In other words, it involves applying a depreciation rate against the undepreciated balance, rather than to the original cost. Annual amounts of depreciation are reduced by a fixed fraction which is denoted by "f". The fraction is obtained by Equation (5.1)

$$f = \frac{1}{N} \cdot (multiplier) \tag{5.1}$$

The most commonly used multipliers are 1.5 (called 150 %DB) and 2.0 (called double declining balance, or DDB). As "N" increases "f" decreases, resulting in a situation in which depreciation is highest in the first year and decreases over the asset's depreciable life. Depreciation rates for the equipment used in Balçova – Narlıdere GDHS are given in Table 5.40. Depreciated amount should be calculated for each asset separately according to its life. In this study, double-rate declining balance method is applied. 200% is divided by given life of a equipment to compute the depreciation rate. This rate is double the straight line rate that would be allowed for an asset that has an estimated zero salvage value. It is important to note that the salvage value is not considered in the calculation of either the depreciation charge or the book value when using the double-rate declining balance method. For mathematical reasons, the net book value will never reach to zero by using this method. Therefore at the last year remaining part of the book value will be depreciated. On the other hand, annual depreciation rate can be variable. If the rate of depreciation changes by time, a depreciation rate should be chosen for the half-life of the project. It is increased toward to first periods, and decreased toward to the end of the project life [35, 37, 42].

$$BV_r = P \cdot (1 - f)^r \tag{5.2}$$

$$D_r = f \cdot BV_{r-1} = BV_{r-1} - BV_r \tag{5.3}$$

75 % of piping will be depreciated in 4 years because there will be a renovation in piping network and remaining part of the pipe network will be depreciated in 10 years. The equipment whose life is 10 years will be depreciated in 9 years. All the other equipment will be depreciated within the next 19 years. An depreciation program also is considered for future investments. But in this part, the depreciation life of pipes which will be installed in 5 years is assumed as 15 years. And calculations are accomplished according to this assumption.

Table 5.40 Depreciation rates for the equipment used in Balçova – Narlıdere GDHS investment

no.	Item	Year (n)	f=2.0/n
1	Valves	10	0.2
2	Compensator	5	0.4
3	Pipe lines		
	75 % of pipe network (St 37+ PUR+ CTP)	5	0.4
	25 % of pipe network (St 37+ PUR+ CTP)	10	0.2
	CTP + PUR+ CTP	15	0.13
4	Pumps	10	0.2
5	Other Equipment	20	0.1

The service life of a heat exchanger is claimed to be between 20 and 24 years [44]. The life of plate type heat exchanger is considered as 20 years in this study. Therefore, the cost of heat exchangers will be after 20 years. Depreciated amount in the previous years and depreciation schedule for the future is given in Tables 5.41 and 5.42.

The end of 2022 value of depreciated money with 7% of interest rate is calculated and displayed in Table 5.43.

Table 5.41 Depreciated amounts for past and future

	Depreciated Amount (in US $)
In 2000	5,448
In 2001	67,170
In 2002	160,674
For assets which depreciated in 5 years	5,375,605
For assets which depreciated in 10 year	3,388,616
For assets which depreciated in 15 year	2,650,069
For assets which depreciated in 20 year	5,960,452

Table 5.42 Planned depreciation schedule for Balçova – Narlıdere GDHS

Year	For assets which depreciated in 5 years		For assets which depreciated in 10 years		For assets which depreciated in 15 years		For assets which depreciated in 20 years		**TOTAL**
	Book Value	Depreciation Charge	Book Value	Depreciation Charge	Book Value	Depreciation Charge	Book Value	Depreciation Charge	
2002		233,293							233,293
2003	2,687,802	2,687,802	1,778,436	508,124			5,364,407	627,416	3,823,343
2004	1,343,901	1,343,901	1,383,228	395,208			4,771,664	592,743	2,331,852
2005	671,951	671,951	1,075,844	307,384			4,269,383	502,280	1,481,615
2006		671,951	836,767	239,076			3,819,975	449,409	1,360,436
2007	148,613	99,076	650,819	185,948	2,296,726	353,342	3,417,872	402,103	1,040,469
2008	89,168	59,445	506,193	144,626	1,990,496	306,230	3,058,096	359,776	870,078
2009	53,501	35,667	393,705	112,487	1,725,097	265,399	2,736,191	321,905	735,459
2010	32,101	21,400	306,215	87,490	1,495,084	230,013	2,448,171	288,020	626,923
2011		32,101		306,215	1,295,739	199,344	2,190,469	257,702	795,363
2012	148,613	99,076	881,645	457,312	1,122,974	172,765	1,959,893	230,576	959,729
2013	89,168	59,445	705,316	176,329	973,244	149,730	1,753,589	206,305	591,809
2014	53,501	35,667	564,253	141,063	843,478	129,766	1,569,000	184,588	491,085
2015	32,101	21,400	451,402	112,851	731,014	112,464	1,403,842	165,158	411,873
2016		32,101	361,122	90,280	633,546	97,469	1,256,070	147,773	367,622
2017	148,613	99,076	288,897	72,224	549,073	84,473	1,123,852	132,218	387,991
2018	89,168	59,445	231,118	57,779	475,863	73,210	1,005,552	118,300	308,735
2019	53,501	35,667	184,894	46,224	412,415	63,448	899,704	105,848	251,187
2020	32,101	21,400	147,915	36,979	357,426	54,989	804,998	94,706	208,074
2021		32,101		147,915		357,426		804,998	1,342,440

Table 5.43 Future value of depreciation charge

Year	End of year 2021 value (rate of interest : 7 %)
2002	902,770
2003	13,827,225
2004	7,881,502
2005	4,680,148
2006	4,016,229
2007	2,734,010
2008	2,192,432
2009	1,762,791
2010	1,420,877
2011	1,820,098
2012	1,790,483
2013	1,051,587
2014	836,965
2015	667,741
2016	655,782
2017	474,698
2018	378,715
2019	302,860
2020	242,761
2021	1,510,619
Total	49,150,293

5.1.6 Estimating of Future Revenues

Calculation of revenues for the remaining life of the project depends on the current heating capacity of system and the earned revenues in 2002. Total heating capacity of Balçova – Narlıdere GDHS is calculated as 92 MW_{th} according to the 60^{o}C of discharge temperature. But many of the wells are not used in the geothermal field. Temperatures and amount of energy production capacities of wells are displayed in Table 5.44. The heat load to meet the heating requirement and preparation of hot water for a household which is 100 m^2 was determined as 5,490 kcal/h. This is the average heat load for the typical 40 buildings located in Balçova GDHS [30]. 11,500,000 m^2 are heated from the geothermal energy. Therefore, the system capacity meets required amount of energy.

Table 5.44 Temperatures, flow rates of production wells, and total thermal power for Balçova – Narlıdere GDHS

no.	Well name	temp (ºC)	Flow rate (m^3/h)	Total thermal energy [Discharge temp : 60^0C]		Produced Energy
				(kcal/h)	(MW_{th})	(MW_{th})
1	BD-1	110	50	2,500,000	3	-
2	BD-2	132	180	12,960,000	15	15
3	BD-3	120	85	5,100,000	6	6
4	BD-4	135	140	10,500,000	12	12
5	BD-5	115	80	4,400,000	5	5
6	BD-6	135	100	7,500,000	9	-
7	BD-7	125	60	3,900,000	5	5
8	BD-8		2500			Re-injection
9	B-1	115	100	5,500,000	6	-
10	B-2	95	-			-
11	B-3	110	-			-
12	B-4	117	55	3,135,000	4	4
13	B-5	120	135	8,100,000	9	9
14	B-6	95	-			-
15	B-7	115	140	7,700,000	9	-
16	B-8	95	-			-
17	B-9	95	-			-
18	B-10	105	100	4,500,000	5	5
19	B-11	109	40	1,960,000	2	-
20	B-12	95	-			-
21	ND-1	115	-			-
22	N-1	95	-			-
23	BTF-2		-			-
24	BTF-3	100	30	1,200,000	1	-
25	BH-1	80	15	300,000		-
Total				76.755.000	92	61

It is assumed that the existed geothermal system has been grown up until the end of 2002 and will meet the energy requirement in the remaining life of this project. As a result, there will be no new connection revenues after 2002. Therefore, the total area of households at the beginning of 2003 is taken into consideration to determine the future revenues. The total heated area in Balçova – Narlıdere GDHS is given in Table 5.45.

Table 5.45 Temperatures, flow rates of production wells, and total thermal power for Balçova – Narlıdere GDHS

Date	Balçova GDHS		Narlıdere GDHS		Balçova - Narlıdere GDHS		Percentage
	Subscriber (m^2)	Heated Area (m^2)	Subscriber (m^2)	Heated Area (m^2)	Subscriber (m^2)	Heated Area (m^2)	
25.12.2000	556,409	508,891	74,765	64,058	631,174	572,949	0.908
24.08.2001	560,668	524,338	75,822	65,969	636,490	590,307	0.927
25.08.2001	562,648	505,843	75,932	65,929	638,580	571,772	0.895
31.12.2001	595,625	519,146	92,824	70,432	688,449	589,578	0.856
26.12.2002	611,974	599,914	99,396	89,603	711,370	689,517	0.969
28.01.2003	614,884	563,967	100,248	92,744	**715,132**	656,711	0.918

Medicine Faculty and Hospital of Dokuz Eylül University, Izmir Economy University and hotels pay their bills according to their contracts. Therefore the 2002 revenues earned from the heating of these institutions are added to yearly revenues collected from households in Narlıdere and Balçova regions. Monthly revenues earned from heating of institutions in 2002 are given in Table 5.46.

Table 5.46 Monthly revenues earned from heating of institutions in 2002

mo.	Revenues	
	(in TL)	(in US $)
1	77,364,638,796	58,983
2	36,070,782,401	25,899
3	18,922,653,360	14,077
4	20,520,499,070	15,333
5	16,035,848,919	11,098
6	5,464,906,081	3,466
7	4,750,000,000	2,800
8	4,750,000,000	2,916
9	100,991,843,220	60,099
10	4,750,000,000	2,843
11	4,750,000,000	3,079
12	69,009,286,734	41,883
Total	363,380,458,581	238,603

56 pricing plans in which monthly fix charges changes US $17 to 72 are created as shown in Table 5.48 to estimate the future revenues. It is important to notice that geothermal energy utilization price kept constant throughout the life of investment in 56 plans. Therefore, constant earning streams will constitute the project revenues in the remaining years of the project. Figure 5.10 shows the fix revenues in these plans.

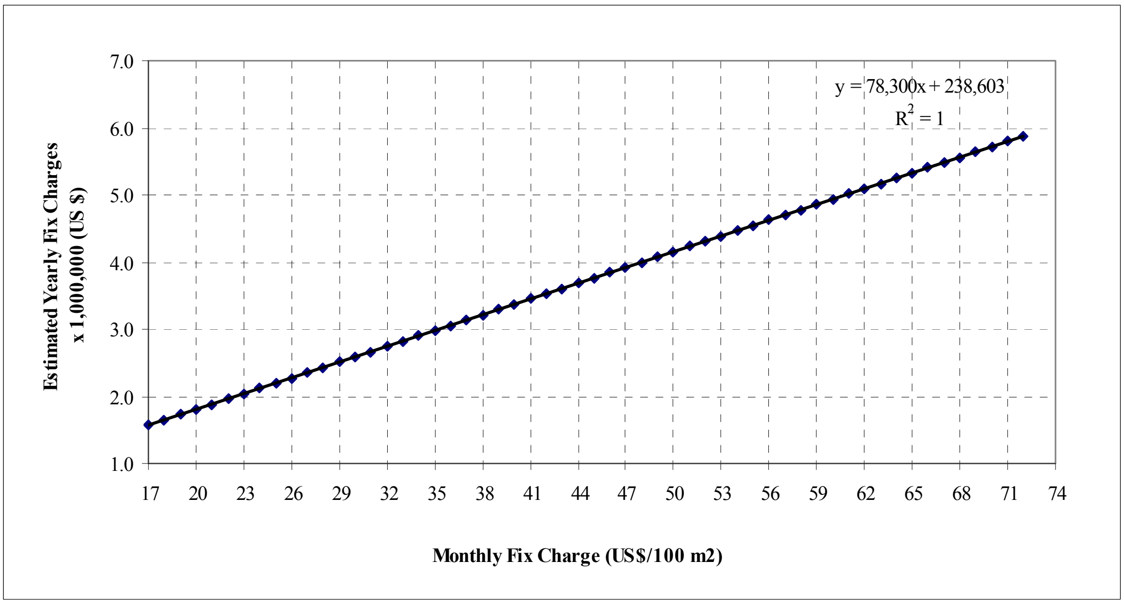

Figure 5.10 Changing in estimated yearly fix charges with monthly utilization prices per one household equivalent

If the energy utilization prices are investigated, it is seen that energy utilization price has never been constant in Balçova – Narlıdere GDHS. The price was increased in 1998, 1999, 2000 and 2002. Whereas, it degraded in 2001 because of value loss in TL. The augmentation and decrease percentage in the utilization price with regard to the prices of previous years are shown in Table 5.47.

Table 5.47 The augmentation and decrease percentages in the monthly energy utilization prices in US $

Year	Augmentation (%)	Decrease (%)
1998	14.97	
1999	35.67	
2000	1.69	
2001		-21,28
2002	28.93	
2003*	38.93	
avg	16.48	

* Energy utilization price in US $ is calculated according to the average US $ exchange rates of first six months.

On the other hand some alternative pricing plans are also considered as shown in Table 5.48. In accordance with the Plan A1, utilization price will be increased by the average augmentation percentage of previous yearly urban indexes up to year 2010 since the existence of renovation costs. After this point, it is kept constant to the end of

2021. According to the Plan A2, the prices for households will be same in Scenario S A1 but in this case the revenues collected from the institutions (universities, hospital and hotels) are increased by 50 %. In Plan A3, the augmentation percentage is increased. The price are increased up to 2010 with the augmentation percentage of 2003 and it is kept constant in US $69 up to the end. In the last scenario (Plan A4), utilization price will be increased up to year 2010 and it is kept constant in US $83 up to the end. For these alternative pricing plans, revenues are re-calculated.

Table 5.48 All plans for monthly energy utilization prices

Year	P1	P2	...	P55	P56	P A1	P A2	P A3	P A4
2003	17	18		71	72	17	17	17	17
2004	17	18		71	72	20	20	24	24
2005	17	18		71	72	23	23	33	33
2006	17	18		71	72	27	27	38	46
2007	17	18		71	72	31	31	44	53
2008	17	18		71	72	36	36	51	61
2009	17	18		71	72	41	41	59	71
2010	17	18		71	72	48	48	69	83
2011	17	18		71	72	56	56	69	83
2012	17	18		71	72	56	56	69	83
2013	17	18		71	72	56	56	69	83
2014	17	18		71	72	56	56	69	83
2015	17	18		71	72	56	56	69	83
2016	17	18		71	72	56	56	69	83
2017	17	18		71	72	56	56	69	83
2018	17	18		71	72	56	56	69	83
2019	17	18		71	72	56	56	69	83
2020	17	18		71	72	56	56	69	83
2021	17	18		71	72	56	56	69	83

If this analysis had been made at the initiation of the investment, revenues would have not been taken uniform until the system grows to the design capacity. In this case usage of uniform revenues up to this point gives wrong results. Instead of uniform revenues, arithmetic gradients should be preferred.

5.1.7 Estimating of Future Operating Costs

In these types of projects, future operating costs cannot easily be predicted in accordance with the previous cash flows. By using previous cash flow data, some mathematical methods or neural network system can be applied to determine future net cash flows. If this analysis has been made at the beginning of the investment, the incomes and expenditures should not be accepted as uniform until the system grows to the designing capacity. Usage of uniform cash flows up to this point gives errors. Arithmetic gradients should be used in these cases. In this study, uncertain future cost streams are forecasted according to constant revenues and expenditures. The operating costs realized in 2002 is considered to be realized in future.

5.1.8 Internal Rate of Return Analysis for Balçova – Narlıdere GDHS

Up to now, future cash flows which include operating costs, revenues and depreciation charges are determined. In IRR method, the results of before tax and after tax calculations are quite different. Therefore, the taxes should be taken into consideration in an analysis.

Effect of taxes was taken into consideration in this study. "Balçova Jeotermal Enerji San. Tic. Ltd" company pays different taxes like corporation taxes, value added taxes. Taxes paid to government up to 2002 is taken from company. Future taxes are estimated according taxes paid in 2002. The difference between revenues and costs are calculated for each year and it is compared with the difference in 2002. The taxes will be proportional with the difference. Value added taxes in revenues are ignored since they are directly paid to government.

IRR calculation for Balçova – Narlıdere GDHS depends on two basic assumptions: constant expenditures and constant revenues throughout the project life cycle. Calculations are realized by spreadsheets prepared in Microsoft Office Excel as expressed in Chapter IV. In IRR calculations, estimated cash flows are multiplied by the respective present value factors at various discount rates. Year 2002 value of future net cash flows are added to each other to calculate the net present value of cash flows at different discount rates.. The internal rate of return for the constant yearly operating costs is determined. The operating costs of 2002 is accepted to be realized in the remaining life of the investment. The smallest positive and the biggest negative present values which are closest to zero are selected. By the linear interpolation between the negative net present value and positive net present value, the internal rate of return is calculated. Linear interpolation formula is given by Equation (5.4).

$$irr = r_1 + \frac{NPV^+}{NPV^+ + \left|NPV^-\right|} \cdot (r_2 - r_1) \tag{5.4}$$

Since the existence of absolute value in Equation (5.4), Equation (5.5) is preferred in the calculations of internal rate of return.

$$irr = r_1 + \frac{(0 - NPV^+)}{(NPV^- - NPV^+)} \cdot (r_2 - r_1) \qquad (5.5)$$

If the net present value has not any positive values for different discount rates, the internal rate of return can be calculated according to the two values which are close to zero to determine the trend of the rate of return. If there are multiple rate of returns, IRR is not calculated [48,49].

The net cash flows are given in Table 5.49 for the conditions given below:

- The yearly operating costs realized in 2002 will be repeated in the remaining life of the investment (Operating costs will be constant)
- Monthly energy utilization price will be US $17 per 100 m^2

IRR is not calculated in this case because all of the cash flows are smaller than zero as shown in Table 5.48. The results with different discount rates are given in Figure 5.11

Table 5.49 Net cash flows in case the utilization price is US $17

r	Year	Net cash flow (A_r) (in US $)
0	2002	-16,337,588
1	2003	-4,519,775
2	2004	-3,028,285
3	2005	-2,178,048
4	2006	-4,662,139
5	2007	-1,687,364
6	2008	-1,546,696
7	2009	-1,427,928
8	2010	-1,327,319
9	2011	-2,717,197
10	2012	-1,606,623
11	2013	-1,268,426
12	2014	-1,183,554
13	2015	-1,112,268
14	2016	-1,133,408
15	2017	-1,034,885
16	2018	-985,352
17	2019	-943,656
18	2020	-908,469
19	2021	-1,878,115
Total		-51,502,098

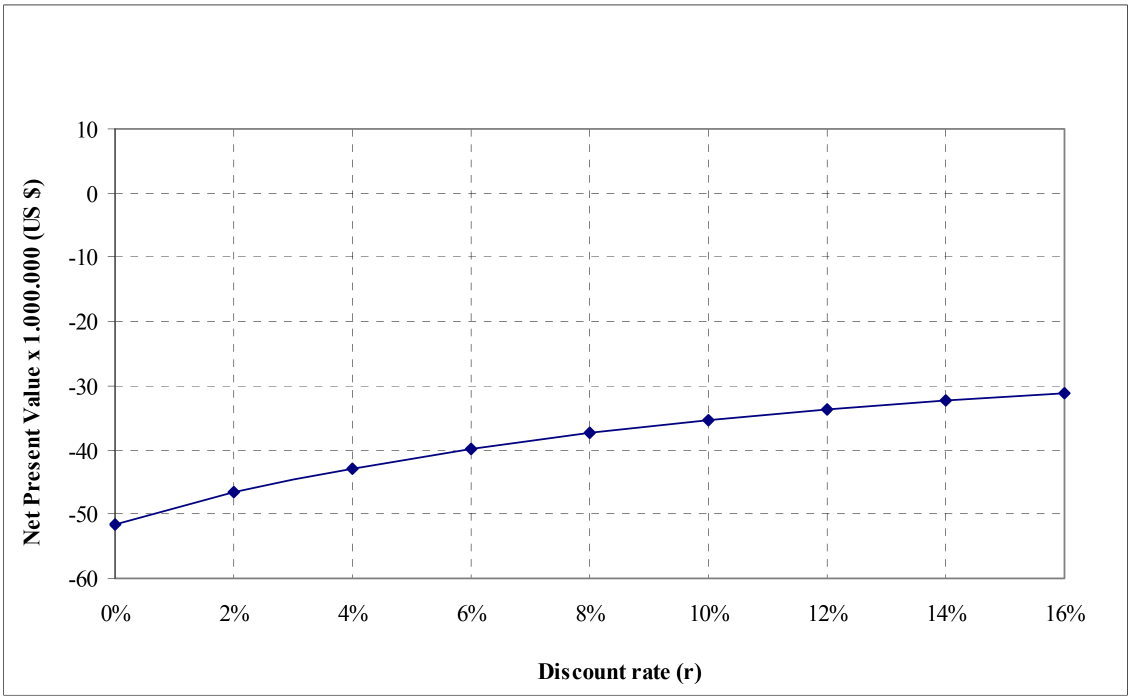

Figure 5.11 End of 2002 value of cash flows as a function of discount rate according to US $ 17 of monthly fix charges

5.1.9 Uncertainty Analysis

Projects are planned for the future developments. Especially geothermal developments cover the uncertainties for wages, prices, incomes, and technology. Social improvements, changing in law and taxes, inflation affect the uncertainties. Therefore at the beginning of the project, the boundaries for acceptable risk should be determined. There are different types of uncertainty analysis but the most applicable one is sensitivity analysis [31].

5.1.9.1 Sensitivity Analysis for Balçova – Narlıdere GDHS Investment

Sensitivity Analysis is the calculating procedure used for prediction of effect of changes of input data on output results of one model. With this analysis, optimistic and pessimistic estimations are realized for the different inputs which contain uncertainties in future. Some parameters are increased by some percentage while others are kept constant [49]. In this study, different fix prices for geothermal energy utilization are considered at the beginning of sensitivity analysis. Since the uncertainty in future operating costs, IRR calculations are realized for different outcomes. Total amount of operating costs is decreased or increased by several percentages to create 13 different operating cost scenarios as given in Table 5.50. Then internal rate of return calculations are completed for these 13 scenarios as explained before. In all scenarios, calculations are repeated with different prices to show the effects of changes in revenues as explained in 5.1.6. By this process, 60 different price scenarios are created for each operating cost scenario. As a result, revenues vary with changing prices while operating costs are kept constant in one operating cost scenario. In this analysis, the impacts of changing in IRR with different fix charges are determined.

Table 5.50 Operating costs in different scenarios

Scenario	Calculation of operating costs	Operating Costs (US $/year)
S_1	S_1S_7 x 0.70	784,853
S_2	S_2=S_7x 0.75	840,914
S_3	S_3=S_7 x 0.80	896,975
S_4	S_4=S_7 x 0.85	953,036
S_5	S_5=S_7x 0.90	1,009,096
S_6	S_6=S_7x 0.95	1,065,157
S_7	**S_7**	**1,121,218**
S_8	S_8=S_7x 1.05	1,177,279
S_9	S_9=S_7 x 1.10	1,233,340
S_{10}	S_{10}=S_7 x 1.15	1,289,401
S_{11}	S_{11}=S_7 x 1.20	1,345,462
S_{12}	S_{12}=S_7 x 1.25	1,401,523
S_{13}	S_{13}=S_7 x 1.30	1,457,584

IRR is calculated in Scenario 7 for 56 different utilization prices. It is observed that, with using US $56, positive rate of return is obtained at the end of the project life. Calculation of net present value for two different discount rates is given in Tables 5.51. In this table, Equation (4.1) is used to calculate net present values. Discount rates are used instead of i in this formula. Net present value of future cash flows are shown in Figure 5.12 with regard to different discount rates.

Table 5.51 Net present value calculations by using the discount rates (i)

n	Year	A_r	$\frac{1}{(1+i)^r}$ i=0.02	NPV at 2%	$\frac{1}{(1+i)^r}$ i=0.04	NPV at 4%
0	2002	-16,337,588	1.000	-16,337,588	1.000	-16,337,588
1	2003	-4,519,775	0.980	-4,431,152	0.962	-4,345,938
2	2004	-135,982	0.961	-130,701	0.925	-125,723
3	2005	714,256	0.942	673,059	0.889	634,971
4	2006	-1,640,372	0.924	-1,515,450	0.855	-1,402,196
5	2007	1,155,402	0.906	1,046,483	0.822	949,656
6	2008	1,325,793	0.888	1,177,266	0.790	1,047,793
7	2009	1,460,412	0.871	1,271,376	0.760	1,109,793
8	2010	1,568,947	0.853	1,339,081	0.731	1,146,414
9	2011	275,603	0.837	230,612	0.703	193,635
10	2012	1,236,142	0.820	1,014,067	0.676	835,093
11	2013	1,604,062	0.804	1,290,088	0.650	1,041,968
12	2014	1,704,786	0.788	1,344,212	0.625	1,064,804
13	2015	1,783,998	0.773	1,379,089	0.601	1,071,423
14	2016	1,828,248	0.758	1,385,584	0.577	1,055,768
15	2017	1,807,880	0.743	1,343,281	0.555	1,003,852
16	2018	1,887,136	0.728	1,374,676	0.534	1,007,557
17	2019	1,944,684	0.714	1,388,820	0.513	998,349
18	2020	1,987,797	0.700	1,391,775	0.494	981,233
19	2021	1,083,541	0.686	743,776	0.475	514,294
NPV		734,970		-4,021,646		-7,554,84

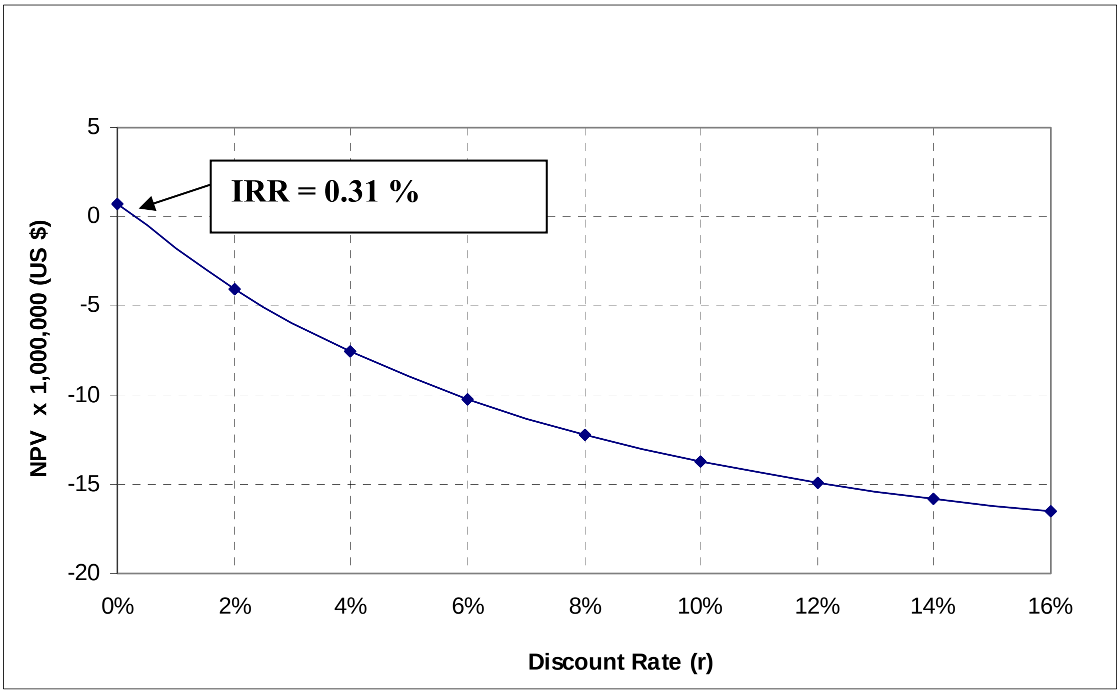

Figure 5.12 NPV as a function of discount rate according in case that the monthly price is US $56

5.1.10 Capital Investment Costs With Changing Marketing

The IRR analysis is also realized for the new prices of pipes, heat exchangers, pumps, and valves. Accrual and 2002 costs of items are compared in Tables 5.52 and 5.53. The accrual costs are given in the third column which is named as Case I. In case II, steel pipes which have same characteristics with the pipes in accruals are used. In case III, the capital investment cost of piping is given for CTP pipes. Analysis is repeated for the installation of CTP + PUR + CTP pipes instead of steel pipes.

Table 5.52 Cost of items in Balçova accruals

no.	Item	I.) Capital cost in accruals	II.*) St37 + PUR+ CTP	III. *) CTP + PUR+ CTP
1	Pipe lines and other fittings	5,854,455	1,713,242*	3,052,147*
2	Heat exchangers	1,456,500	325,333*	325,333*
3	Compensators	539,683	924,966*	0
4	Steel separator	10,688	6,453	6,453
5	Water softening tank	7,069	4,428	4,428
6	Pumps	335,346	145,715*	145,715*
7	Actuator butterfly valves	55,229	4,144*	4,144*
8	Branch valves	9,012	6,658*	6,658*
9	Stainless steel materials	63,728	39,204*	39,204*
10	Temperature and Flow Settling Valves	587,858	313,522*	313,522*
11	Underground valves	162,169	120,800	120,800
12	Butterfly valves	1,869	1,198	1,198
13	Dosage equipment (Pumps, piping and other equipment)	55,479	42,646	42,646
14	Butterfly valves with gearboxes	64,926	43,686	43,686
15	Aluminum insulation for pipes	10,388	8,224	8,224
16	Flow meters	55,696	25,393	25,393
17	Other adjustment equipment	12,566	7,194	7,194
18	Strainers	6,040	3,646	3,646
Total		9,288,700	3,736,451	4,150,390

Table 5.53 Cost of items in Narlıdere accruals

no.	Item	I.) Capital cost in accruals	II.*) St37 + PUR+ CTP	III. *) CTP + PUR+ CTP
1	Pipe lines and other fittings	562,876	176,485*	481,278*
2	Compensators	22,923	65,791*	0
3	Branch valves	4,142	9,037	9,037
4	Heat exchangers	164,524	43,525*	43,525*
5	Temperature and Flow Settling Valves	40,725	34,812*	34,812*
6	Water softening tank	3,202	6,987	6,987
7	Butterfly Valves with gearbox	15,756	34,376	34,376
8	Dosage equipment (Pumps, piping and other equipment)	475	1,037	1,037
9	Pumps	33,780	73,697*	73,697*
10	Strainers	3,423	7,468	7,468
Total		851,827	453,214	692,216

New costs of equipment are given by “ * ” in these tables. Other costs are directly taken from the accruals.

5.2 Energy Utilization Prices in Balçova – Narlıdere GDHS

Determination of energy utilization prices in GDHS involves so many variables as to make the problem difficult. The energy utilization price is the price which is paid in exchange for meeting energy demand and varies throughout the world.

Some means of energy use measurement in GDHS is necessary to accommodate customer billing. Several approaches are available for selling the geothermal energy. The three most common methods are energy metering, volume metering, and flat rate.

Energy metering involves the measurement of the water flow rate, the temperatures of the water entering the building (supply) and the water leaving the building (return). From the three values, the rate of energy use (kcal/h) can be calculated. Integrating these values over a longer period (a month) results in a value that can be used for customer billing. Energy metering requires a water flow meter, two temperature sensors, and an electronic "integrator" to make the calculations. It provides the most accurate method of energy measurement, but at a cost much higher than the other methods.

Volume metering involves the measurement of water flow. The volume of water over the period (m^3 per month for example) is read from a meter. The customer's energy use is determined by multiplying the water volume used by assumed heat content per volume (kcal per m^3 for example). The equipment to accomplish this consists only of a water meter suitable for use in hot water. Geothermal fluid metering is known as the most cost effective method.

Flat rate method, which was explained at the beginning of this chapter, is the most commonly used methods for customer billing. In most of the geothermal district heating systems that use a flat rate, there is some mechanical device installed to limit flow to the customer and/or regulate temperature. One of the primary advantages of flat rate is simpler marketing. There is no questions in the customer's mind as making savings, metering accuracy and the efficiency of his heating system [49]. In Balçova – Narlıdere GDHS, flat rate method is used in households and small shops. Institutions like universities, hospitals, shopping centers and hotels pay their bills according to volume metering method. Fix and connection charges in Balçova – Narlıdere GDHS is given in Table 5.54. Change in fix and connection charges are shown in Figures 5.13 and 5.14.

Table 5.54 Fix and connection charges in Balçova- Narlıdere GDHS from 1997 to 2003

Year	Monthly Fix Charges		Connection Charges	
	(Value Added Tax are included)	(Without Value Added Tax)	(Value Added Tax are included)	(Value Added Tax are included)
	TL/m^2	US $/ m^2	(US $/$m^2$)	(in US $)
1997	14,000	0.0897	0.0780	600
1998	27,440	0.1032	0.0897	1,000
1999	60,000	0.1400	0.1217	1,250
2000	90,000	0.1423	0.1206	1,250
2001	140,000	0.1120	0.0950	1,250
2002	220,000	0.1445	0.1224	1,250
2003	320,000	0.2050*	0.1738	1,250

* It is calculated according to the average US $ exchange rate in the first six months.

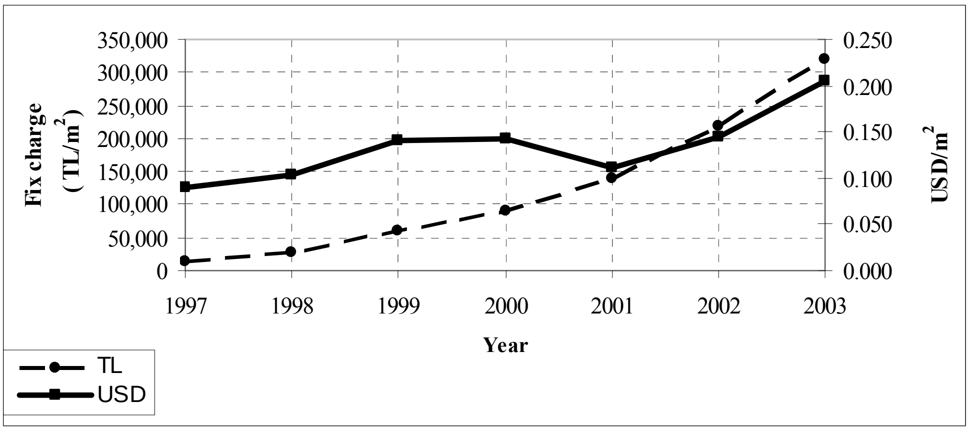

Figure 5.13 Changes in monthly fix charges from 1996 to 2003

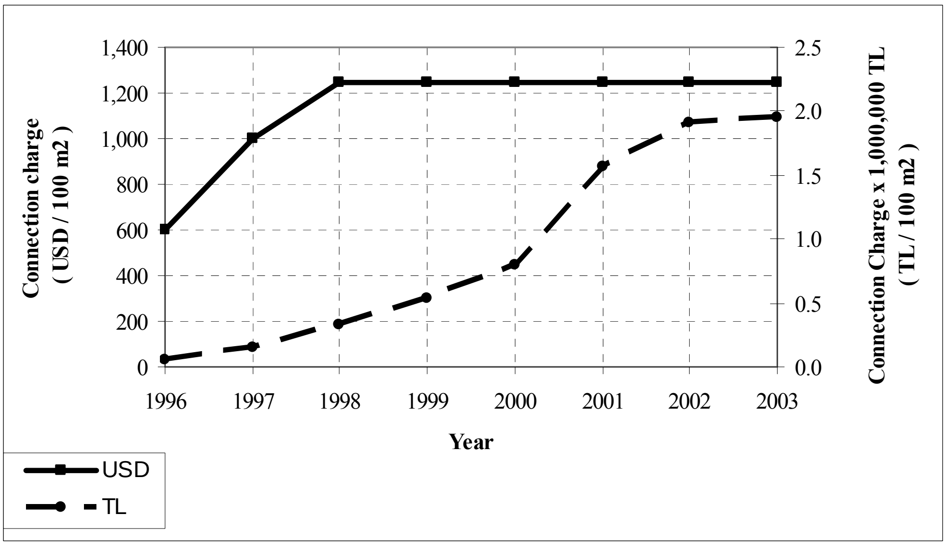

Figure 5.14 Changes in connection charges from 1996 to 2003

5.3 Economic Benefits of Balçova – Narlıdere GDHS: From the ViewPoint of Governments

From the viewpoint of governments, geothermal district heating systems obtain economic benefits in addition to their social benefits from the construction period to the end of their project life. Contractors, developers, and customers pay taxes to governments. Value added taxes paid by contractors in Balçova – Narlıdere GDHS from 1996 to 1999 are taken from accruals and given in Table 5.55 and 5.56.

Table 5.55 Value added taxes in Balçova GDHS accruals

Accrual	Date	Exchange Rate (TL / US $)	TL Amount	US $ Amount
1	29.12.1995	58,212	62,132,385	1,067
2	12.03.1996	68,100	92,513,250	1,358
3	12.04.1996	73,020	62,935,916	862
4	15.05.1996	77,020	101,043,393	1,312
5	03.07.1996	82,340	149,223,025	1,812
6	23.07.1996	83,264	3,147,676,317	37,804
7	12.08.1996	84,744	5,896,997,347	69,586
8	12.09.1996	89,036	8,404,682,722	94,396
9	31.10.1996	96,113	9,339,306,458	97,170
10	12.11.1996	98,003	6,476,766,398	66,087
11	18.12.1996	105,532	2,905,983,972	27,537
12	14.01.1997	111,770	8,692,366,051	77,770
13	14.02.1997	119,840	3,769,697,264	31,456
14	17.03.1997	125,280	7,701,608,821	61,475
15	05.05.1997	136,340	16,544,562,856	121,348
16	18.06.1997	145,490	3,689,102,111	25,356
17	07.07.1997	150,030	6,890,742,980	45,929
18	11.07.1997	151,260	25,391,038,851	167,864
19	11.08.1997	163,340	19,089,703,970	116,871
20	12.09.1997	169,760	6,540,463,939	38,528
21	31.12.1997	206,100	11,507,353,010	55,834
22	30.03.1998	241,870	1,385,785,509	5,729
23	15.04.1998	245,590	4,498,744,087	18,318
24	21.05.1998	253,550	16,295,395,683	64,269
25	29.06.1998	266,330	10,217,824,004	38,365
26	19.08.1998	276,430	4,755,278,139	17,202
27	14.09.1998	275,600	12,523,883,391	45,442
28	16.10.1998	277,670	28,139,869,337	101,343
29	20.11.1998	298,340	2,844,735,755	9,535
30	31.12.1998	315,220	19,240,897,866	61,040
31	25.02.1999	351,722	8,274,177,667	23,525
32	26.03.1999	369,155	4,337,254,986	11,749
33	31.05.1999	406,594	899,730,938	2,213
34	29.06.1999	420,206	37,197,204,802	88,521
35	31.08.1999	445,089	2,499,811,038	5,616
36	27.10.1999	479,621	2,433,249,770	5,073
Total amount of value added tax			301.999.744.008	1,639,365

In the operating period, different taxes from corporation taxes to value added taxes are paid to government. The taxes before year 2000, can not be learnt. Therefore the amounts before 2000 are not given in this study. The taxes paid by "Balçova Jeotermal Enerji San. Tic. Ltd. Şti." are given in Table 5.57. Overall payments are presented in Table 5.58.

Table 5.56 Value added taxes in Narlıdere GDHS accruals

Accrual	Date	Exchange Rate (TL / 1 US $)	TL Amount	US $ Amount
1	08.07.1997	150,580	1,842,348,372	12,235
2	12.08.1997	163,770	5,912,038,344	36,100
3	10.11.1997	184,250	12,157,654,459	65,985
4	31.12.1997	206,100	1,550,275,252	7,522
5	05.10.1998	275,910	6,281,839,446	22,768
6	30.11.1998	303,820	2,192,527,101	7,217
7	30.12.1998	314,230	9,109,095,897	28,989
8	28.04.1999	388,110	4,487,689,981	11,563
9	15.06.1999	413,714	1,759,158,932	4,252
10	30.09.1999	460,603	1,726,425,103	3,748
Total Amount of value added tax for Balçova GDHS			47,019,052,887	200,377

Table 5.57 Total amount of taxes paid by Balçova Jeotermal Enerji San. Tic. Ltd. Şti from 2000 to 2002

	2000 (in US $)	2001 (in US $)	2002 (in US $)
Value added tax paid by customers	41,982	19,549	44,511
Taxes paid by company	8,041	11,798	103,223
Total	50,023	31,347	147,735

Table 5.58 Total amount of taxes paid in Balçova – Narlıdere GDHS investment

	Amount (in US $)
Balçova investment	1,639,365
Narlıdere investment	200,377
Value Added Tax (KDV)	106,042
Other taxes paid by Balçova Jeotermal Enerji San. Tic. Ltd. Şti.	123,062
Total benefits	2,068,846

CHAPTER VI

RESULTS AND DISCUSSION

At the beginning of this study, the project management tools especially CPM and geothermal development tasks are investigated. Project management tools should be applied for the geothermal investments. It is seen that CPM and other project management tools were not applied through the implementation of Balçova – Narlıdere GDHS investment. In the feasibility studies only Gantt charts were developed but it is seen insufficient for project. It has also found that the documentation on the investment is also insufficient because of not using project management tools. On the other hand, some of the documents are not delivered to “Balçova Jeotermal Enerji San. Tic. Ltd. Şti.” Therefore, gathering information is quite difficult as a result of undelivered documents.

The next step in this study is the determination of capital investment costs in details. The capital costs are summarized in Table 6.1. Each accrual which were prepared during the construction is investigated and data on the capital investment costs have been transferred to the computer files. In this process, it is observed that some of items like actuator butterfly valves, separator are not used functionally in Balçova – Narlıdere GDHS and they increased the capital costs of this investment.

Table 6.1 Capital investment costs for Balçova – Narlıdere GDHS without time value of money

	Total (in US $)
Balçova accruals	10,929,098
Narlıdere accruals	1,335,848
Cost of additional investment in 2001	283,540
Cost of additional investment in 2002	524,585
Estimated well cost	1,358,236
Total capital investment cost	14,431,307

After determination of capital investment costs, revenues and operating costs are made out for previous years. Data on revenues and operating costs of previous years are also not delivered to “Balçova Jeotermal Enerji San. Tic. Ltd. Şti.”. Accuracy of collected data on operating costs to from 1996 to 1999 is unknown.

Some of the operating costs are increased in this period. The reasons for increase are investigated. It is known that, there is an increasing water leakage problem in distribution network. When water leakage occurs, energy loss and additional costs to meet water requirement are increased. On the other hand, as a result of establishment of new company the management cost and personnel wages are increased in Balçova – Narlıdere GDHS. Previously, they are included in to the account of "Balçova Termal Turizm ve Özel Eğitim İşletmeleri Ltd. Şti." Therefore, they are not seen as an operating cost for the geothermal system.

On the contrary, some of the operating costs are decreased and present they are in desired level. Especially purchased amount of inhibitor was considerably decreased while the quality was increased in the last two years. It can be said that, expenditures change with the increasing capacity and the age of the system. However, they can be limited and controlled by using all sources efficiently.

It is also important to say that the monthly fix charges kept in minimum level at the beginning of this development to increase the number of customers. The augmentations in utilization prices did not reflect the value loss in TL in the previous years. At the moment, it is required to increase revenues in Balçova –Narlıdere GDHS. However, it is difficult to increase revenues while the system is kept stable in terms of the system capacity. Because the connection revenues will not be collected after reaching the full production capacity. It is learnt that, some of the flats in many buildings are not taken geothermal energy while their buildings are connected geothermal systems. They should be integrated to the system. The system will be enlarged to increase the revenues. The unused wells which can be used production wells could become active after maintenance or re-drilling processes. If the system is enlarged by new investments, a capital will be required. Revenues are collected according to household equivalent. To increase the revenues, the amount of maintenance fees can be increased.

In this study, after collection of required data some of the commonly used financial tools are used to evaluate the investment. IRR method which is the most widespread one is used in the economic assessment of Balçova – Narlıdere GDHS. The most important problem in the evaluation of investments is variations on the net cash flows in a real business life. In some years, revenues can not be collected regularly as in Balçova – Narlıdere GDHS. For example in some years, some customers could not pay their debt on time or some could not want to use geothermal energy any more.

Eventually, revenues are not easily estimated and also operating costs can be change year to year. Estimations on future cash flows are quite difficult at the beginning of any geothermal district heating development. However, a sensitivity analysis is a useful to understand the impact of changes on the total evaluation of a project.

Profitability in different expenditures is calculated in accordance with the some basic assumptions explained in Chapter IV. Capital investment costs, well drilling costs, operating cots and especially future investment costs are important parameters in economic evaluation of geothermal investments. Taxes, depreciation are important components in this evaluation.

It is important to notice that this study begin with an initial assumption on the operating costs in the remaining life of the investment. According to initial scenario, which is named as Scenario 7, the operating costs in 2002 are considered to be realized in future. A scenario includes different pricing plans for one household equivalent. Future revenues are kept constant with constant utilization prices. The reference point for the energy utilization price per 100 m^2 is US $17 which was valid in 2002 - 2003 heating season. The internal rate of return for this situation is not desired one as expressed in Chapter V. Therefore, the price is increased while the expenditures kept constant for this scenario. In Figure 6.1, the change in IRR with different energy utilization prices is shown. It is seen that, the proper price for scenario 7 is approximately US $55.5. With this price, the investment does not have any profit or loss. The investment is unattractive with utilization prices below US $55.5 from an economic point of view.

However, as a result of uncertainty in the future operating costs, the operating costs in 2002 is increased or decreased by some percentages in different scenarios as explained in Chapter V. Profitability is calculated in accordance with the various prices in all scenarios.

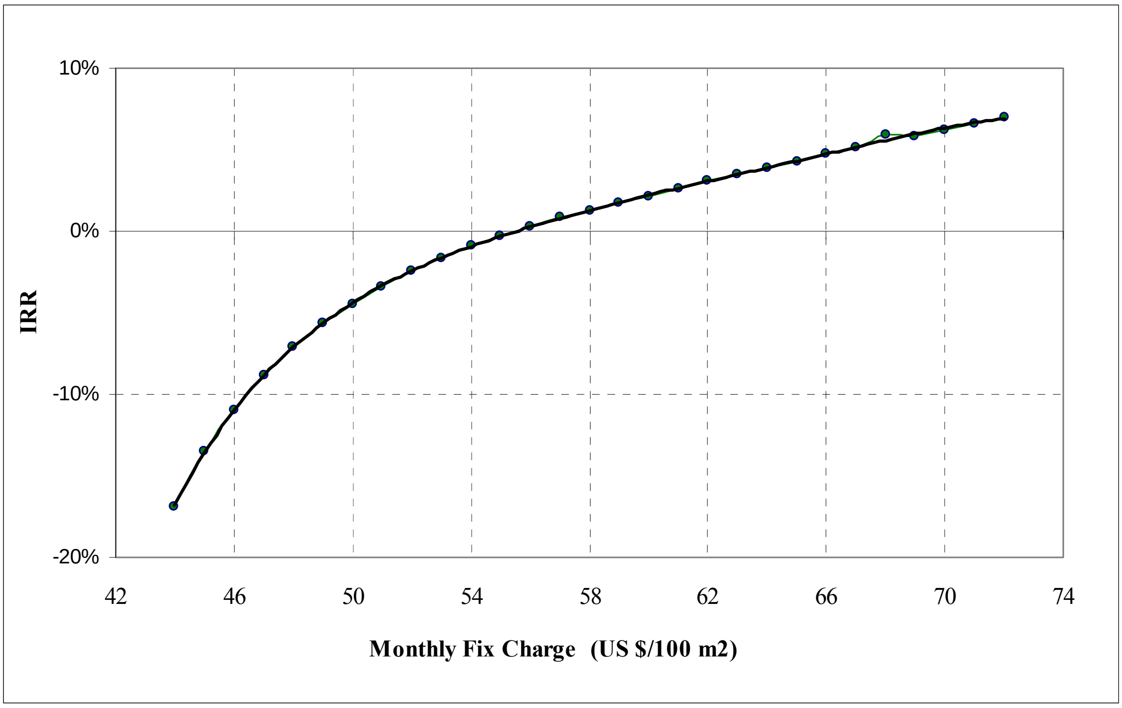

Figure 6.1 IRR as a function of fix charges for scenario7

The results of IRR calculations are given in Table 6.2. In this table, the second row shows operating costs in different scenarios. Monthly energy utilization prices per 100 m^2 are given in the first column of Table 6.2. Negative values are non-desired internal rate of returns. The bold sections refer the transition from the negative to positive internal rate of returns. IRR for the Balçova- Narlıdere investment increases significantly with a raise in utilization price. It is seen that the utilization prices up to US $55.5 for the operating costs of 2002 is not feasible for Balçova – Narlıdere GDHS investment. As a result, the augmentation in utilization prices is required to increase revenues and profitability of this investment.

Table 6.2 Internal rate of returns for 13 different scenarios and energy utilization prices (%)

Price (US $/100 m^2)	S1 784,853	S2 840,914	S3 896,975	S4 953,036	S5 1,009,096	S6 1,065,157	**S7 1,121,218**	S8 1,177,279	S9 1,233,340	S10 1,289,401	S11 1,345,462	S12 1,401,523	S13 1,457,584
45	-0.71	-1.85	-3.22	-4.91	-7.04	-9.80	**-13.54**	-18.88					
46	-0.08	-1.09	-2.30	-3.77	-5.59	-7.90	**-10.94**	-15.12	-21.22				
47	0.49	-0.42	-1.49	-2.78	-4.35	-6.32	**-8.84**	-12.20	-16.90				
48	1.01	0.18	-0.78	-1.92	-3.29	-4.98	**-7.11**	-9.88	-13.61	-18.93			
49	1.47	0.73	-0.14	-1.16	-2.37	-3.84	**-5.66**	-7.97	-11.01	-15.18	-21.26		
50	1.89	1.21	0.43	-0.48	-1.56	-2.85	**-4.43**	-6.39	-8.92	-12.27	-16.96	-23.95	
51	2.37	1.66	0.95	0.12	-0.84	-1.98	**-3.36**	-5.06	-7.19	-9.95	-13.68	-18.98	-27.12
52	2.85	2.08	1.41	0.66	-0.20	-1.22	**-2.44**	-3.91	-5.74	-8.05	-11.09	-15.25	-21.29
53	3.28	2.58	1.84	1.16	0.37	-0.55	**-1.63**	-2.92	-4.50	-6.47	-8.99	-12.35	-17.02
54	3.69	3.04	2.30	1.60	0.89	0.06	**-0.91**	-2.05	-3.43	-5.13	-7.26	-10.03	-13.75
55	4.08	3.46	2.78	2.01	1.36	0.60	**-0.27**	-1.29	-2.51	-3.98	-5.81	-8.13	-11.17
56	4.53	3.84	3.22	2.51	1.78	1.03	**0.31**	-0.61	-1.69	-2.99	-4.57	-6.55	-9.07
57	4.95	4.27	3.62	2.97	2.23	1.55	**0.83**	0.00	-0.97	-2.12	-3.51	-5.21	-7.34
58	5.35	4.71	3.99	3.39	2.71	1.95	**1.30**	0.54	-0.33	-1.35	-2.58	-4.06	-5.89
59	5.72	5.12	4.45	3.78	3.15	2.44	**1.73**	1.04	0.25	-0.67	-1.76	-3.06	-4.65
60	6.08	5.50	4.88	4.18	3.55	2.90	**2.16**	1.49	0.77	-0.06	-1.04	-2.19	-3.58
61	6.50	5.85	5.27	4.63	3.93	3.32	**2.64**	1.90	1.24	0.49	-0.39	-1.42	-2.65
62	6.89	6.24	5.64	5.04	4.37	3.71	**3.08**	2.37	1.67	0.98	0.19	-0.74	-1.83
63	7.26	6.65	5.99	5.42	4.80	4.10	**3.49**	2.83	2.09	1.43	0.71	-0.12	-1.10
64	7.61	7.03	6.41	5.78	5.19	4.55	**3.87**	3.26	2.57	1.85	1.18	0.43	-0.45
65	7.94	7.39	6.80	6.15	5.57	4.96	**4.29**	3.65	3.01	2.30	1.62	0.92	0.13
66	8.32	7.73	7.17	6.56	5.92	5.35	**4.72**	4.02	3.42	2.76	2.02	1.38	0.65

Required monthly energy utilization prices in 13 different scenarios for this public investment are given in Table 6.3. These values are calculated by a linear interpolation, which makes the IRR's zero. In Figure 6.2, the change of energy utilization prices as a function of operating costs is also shown.

In addition, the result of IRR method is given in Table 6.4 for alternative scenarios discussed in Chapter V. Changes in IRR for these scenarios are given in Figure 6.3. The acceptable operating costs are also calculated by lineer interpolation and the results are given in Table 6.5 for the first three alternative scenarios.

Table 6.3 Suggested energy utilization prices in different scenarios

Scenario	Operating Costs (US $/year)	$Price_1$ (US $/100 m^2)	IRR_1 (%)	$Price_2$ (US $/100 m^2)	IRR_2 (%)	Price (US $/100 m^2)
S1	784,853	47	0.49	46	-0.08	46.1
S2	840,914	48	0.18	47	-0.42	47.7
S3	896,975	50	0.43	49	-0.14	49.2
S4	953,036	51	0.12	50	-0.48	50.8
S5	1,009,096	53	0.37	52	-0.20	52.4
S6	1,065,157	54	0.06	53	-0.55	53.9
S7	**1,121,218**	**56**	**0.31**	**55**	**-0.27**	**55.5**
S8	1,177,279	58	0.54	57	0.00	57.0
S9	1,233,340	59	0.25	58	-0.33	58.6
S10	1,289,401	61	0.49	60	-0.06	60.1
S11	1,345,462	62	0.19	61	-0.39	61.7
S12	1,401,523	64	0.43	63	-0.12	63.2
S13	1,457,584	65	0.13	64	-0.45	64.8

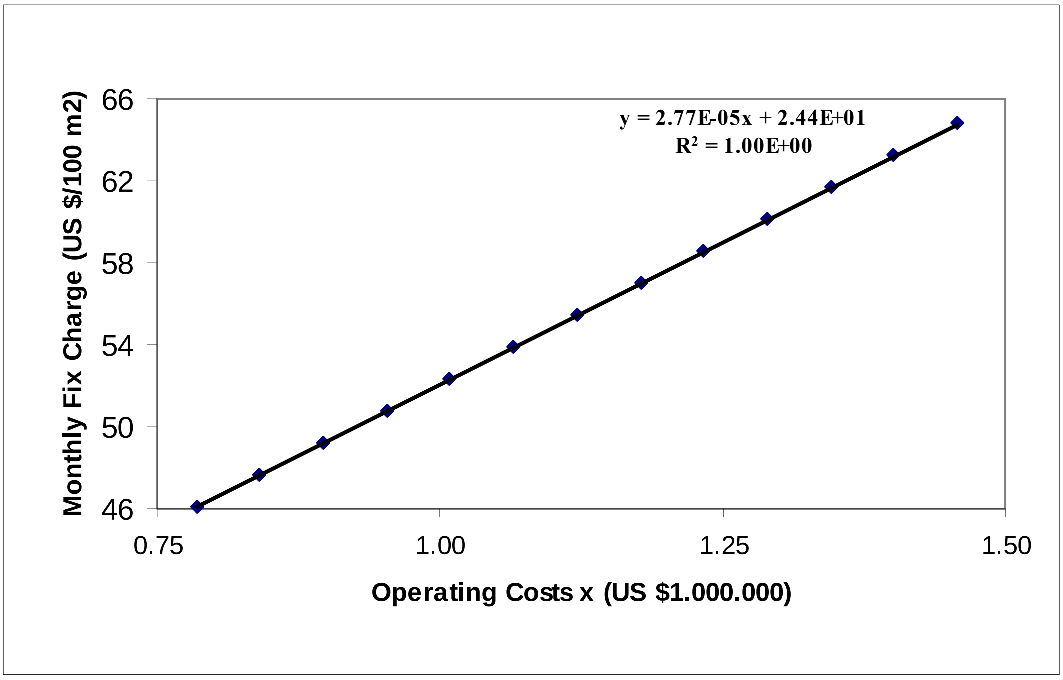

Figure 6.2 Energy utilization prices as a function of yearly operating cost

Table 6.4 IRR in alternative scenarios (%)

Scenario	Operating Costs (US $/year)	P A1	P A2	P A3	P A4
S1	784,853	0.27	0.96	5.24	7.88
S2	840,914	-0.46	0.33	4.71	7.47
S3	896,975	-1.29	-0.39	4.14	7.03
S4	953,036	-2.24	-1.21	3.63	6.55
S5	1,009,096	-3.34	-2.15	3.11	6.04
S6	1,065,157	-4.64	-3.24	2.54	5.62
S7	**1,121,218**	**-6.19**	**-4.52**	**1.93**	**5.17**
S8	1,177,279	-8.07	-6.04	1.42	4.69
S9	1,233,340	-10.39	-7.89	0.85	4.17
S10	1,289,401	-13.35	-10.17	0.21	3.71
S11	1,345,462	-17.23	-13.06	-0.52	3.26
S12	1,401,523	-22.55	-16.85	-1.34	2.76
S13	1,457,584		-22.01	-2.29	2.22

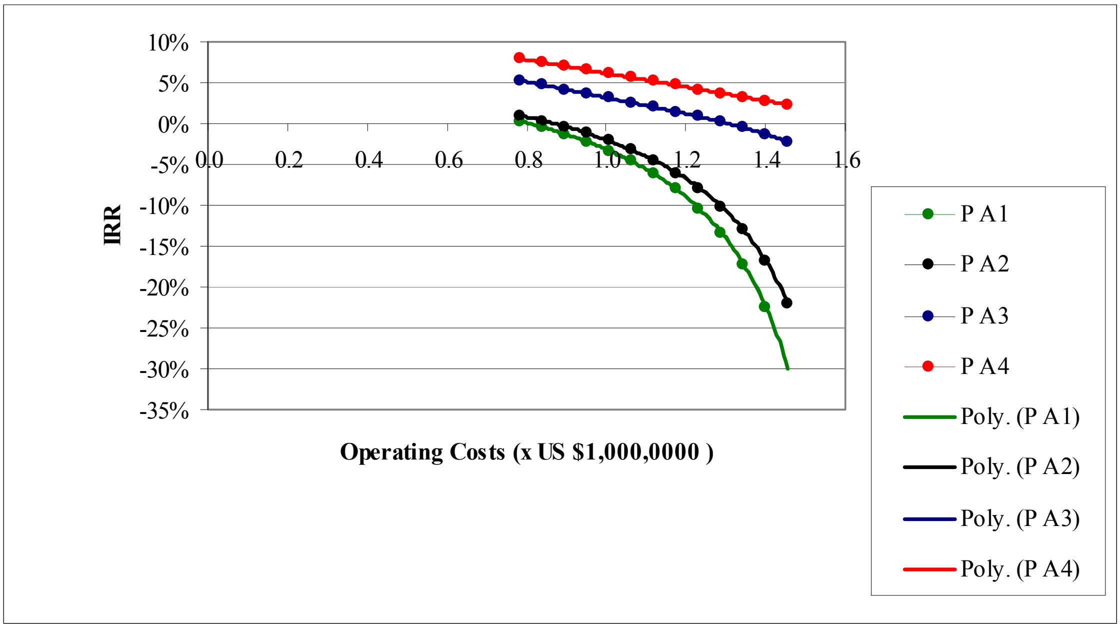

Figure 6.3 IRR as a function of yearly operating costs (constant throughout the project life) in alternative scenarios

Table 6.5 Acceptable operating costs in plans P A3 and P A4

Pricing Plan	Operating Cost (US $/year)
P A1	805,561
P A2	869,769
P A3	1,305,330

In this evaluation, the cost of possible investments in the future are taken into consideration. Nevertheless, this analysis is repeated for the case that there is no any investment in the remaining life of the project. The results are given in Tables 6.6, 6.7 and 6.8.

As explained at the end of Chapter IV, IRR analysis is also made for the new costs of equipment used in Balçova –Narlıdere GDHS. Cost of the investment is determined and the end of 2002 value of this amount is calculated. It is found thatthe price for this situation will be US $21.4 in Scenario 7. The results are given in Tables 6.9 and 6.10 for 13 different scenarios. In Figure 6.4, energy utilization prices are given as a function of yearly operating cost for the current costs of the equipment

In Figure 6.5, the current price in Balçova - Narlıdere district heating system and calculated energy utilization price according to the current costs of the equipment is compared with the prices valid in other geothermal district heating systems in Turkey. It is seen that the current price in İzmir is the lowest one in Turkey.

Table 6.6 Internal rate of returns for the case that there is no any investment in the remaining life

Price	S1	S2	S3	S4	S5	S6	**S7**	S8	S9	S10	S11	S12	13
(US $/100 m^2)	784,853	840,914	896,975	953,036	1,009,096	1,065,157	**1,121,218**	1,177,279	1,233,340	1,289,401	1,345,462	1,401,523	1,457,584
31	-0.82	-18.45	-30.01										
32	-0.01	-13.69	-21.35										
33	0.69	-10.26	-15.72	-24.85									
34	1.31	-7.67	-11.76	-18.08	-29.15								
35	1.86	-5.64	-8.83	-13.47	-20.88								
36	2.46	-4.01	-6.56	-10.12	-15.44	-24.23							
37	2.85	-3.32	-5.69	-8.96	-13.78	-21.58							
38	3.57	-1.56	-3.31	-5.60	-8.72	-13.26	**-20.43**						
39	4.06	-0.61	-2.10	-3.99	-6.50	-10.00	**-15.17**	-23.65					
40	4.62	0.20	-1.07	-2.67	-4.74	-7.51	**-11.43**	-17.39	-27.57				
41	5.13	0.90	-0.20	-1.57	-3.29	-5.55	**-8.62**	-13.06	-20.00	-32.43			
42	5.60	1.52	0.55	-0.63	-2.10	-3.97	**-6.45**	-9.87	-14.92	-23.10			
43	6.05	2.09	1.21	0.18	-1.08	-2.67	**-4.70**	-7.43	-11.27	-17.07	-26.85		
44	6.56	2.73	1.79	0.88	-0.22	-1.57	**-3.28**	-5.51	-8.53	-12.86	-19.59		
45	7.04	3.31	2.40	1.50	0.53	-0.64	**-2.10**	-3.95	-6.39	-9.75	-14.67	-22.57	
46	7.48	3.82	3.01	2.05	1.19	0.16	**-1.09**	-2.66	-4.67	-7.36	-11.12	-16.76	-26.16
47	7.89	4.38	3.55	2.69	1.76	0.86	**-0.23**	-1.58	-3.27	-5.47	-8.44	-12.67	-19.20
48	8.34	4.93	4.05	3.27	2.36	1.47	**0.51**	-0.65	-2.10	-3.93	-6.33	-9.63	-14.43
49	8.80	5.44	4.63	3.78	2.97	2.02	**1.16**	0.14	-1.10	-2.65	-4.64	-7.29	-10.97
50	9.22	5.90	5.16	4.32	3.51	2.65	**1.74**	0.84	-0.25	-1.58	-3.26	-5.42	-8.34
41	9.62	6.42	5.64	4.88	4.00	3.23	**2.32**	1.44	0.49	-0.67	-2.10	-3.91	-6.28
52	10.00	6.92	6.11	5.38	4.58	3.74	**2.93**	1.98	1.14	0.12	-1.11	-2.65	-4.61
53	10.44	7.38	6.64	5.84	5.11	4.27	**3.47**	2.61	1.71	0.81	-0.27	-1.59	-3.24
54	10.86	7.82	7.12	6.34	5.59	4.82	**3.96**	3.18	2.29	1.42	0.47	-0.68	-2.10
55	11.26	8.28	7.57	6.85	6.04	5.33	**4.52**	3.70	2.89	1.96	1.11	0.11	-1.12
56	11.63	8.75	7.99	7.31	6.57	5.79	**5.05**	4.21	3.43	2.58	1.68	0.79	-0.28
57	11.98	9.19	8.47	7.75	7.05	6.27	**5.53**	4.77	3.92	3.14	2.25	1.39	0.45
58	12.40	9.61	8.93	8.19	7.50	6.78	**5.98**	5.27	4.47	3.66	2.85	1.93	1.09

Table 6.7 Suggested prices for the case that there is no any investment in the future

Scenario	Operating Costs (US $/year)	Utilization Price (US $/month)
S1	784,853	32.02
S2	840,914	39.76
S3	896,975	41.27
S4	953,036	42.78
S5	1,009,096	44.29
S6	1,065,157	45.80
S7	**1,121,218**	**47.31**
S8	1,177,279	48.82
S9	1,233,340	50.34
S10	1,289,401	51.84
S11	1,345,462	53.36
S12	1,401,523	54.87
S13	1,457,584	56.38

Table 6.8 IRRs for alternative pricing plans in the case that there is no any investment in future

Scenario	Operating Costs (US $/year)	P A1	P A2	P A3	P A4
S1	784,853	6.13%	6.76%	10.50%	13.32%
S2	840,914	3.87%	3.87%	8.10%	11.31%
S3	896,975	2.59%	3.28%	7.57%	10.81%
S4	953,036	1.88%	2.62%	7.03%	10.28%
S5	1,009,096	1.25%	1.91%	6.44%	9.78%
S6	1,065,157	0.53%	1.28%	5.84%	9.31%
S7	**1,121,218**	**-0.30%**	**0.57%**	**5.30%**	**8.81%**
S8	1,177,279	-1.27%	-0.25%	4.71%	8.27%
S9	1,233,340	-2.40%	-1.20%	4.05%	7.76%
S10	1,289,401	-3.77%	-2.32%	3.49%	7.28%
S11	1,345,462	-5.43%	-3.66%	2.89%	6.76%
S12	1,401,523	-7.49%	-5.29%	2.21%	6.19%
S13	1,457,584	-10.14%	-7.31%	1.59%	6.76%

Table 6.9 Internal rate of returns for the current costs of equipment

Price	S1	S2	S3	S4	S5	S6	**S7**	S8	S9	S10	S11	S12	13
(US $/100 m^2)	784,853	840,914	896,975	953,036	1,009,096	1,065,157	**1,121,218**	1,177,279	1,233,340	1,289,401	1,345,462	1,401,523	1,457,584
17	0.37	-1.08	-3.03	-5.71	-9.60	-15.77							
18	1.87	0.81	-0.55	-2.32	-4.69	-8.05	**-13.35**	-22.13					
19	3.31	2.25	1.18	-0.07	-1.68	-3.80	**-6.83**	-11.14	-18.26				
20	4.60	3.62	2.60	1.52	0.36	-1.10	**-3.07**	-5.64	-9.39	-15.23			
21	5.79	4.91	3.89	2.93	1.83	0.76	**-0.63**	-2.34	-4.65	-7.90	-12.80	-21.01	
22	6.98	6.06	5.19	4.19	3.24	2.16	**1.09**	-0.13	-1.71	-3.78	-6.64	-10.80	-17.46
23	8.03	7.25	6.33	5.44	4.49	3.52	**2.48**	1.44	0.30	-1.15	-3.02	-5.54	-9.13
24	9.15	8.31	7.47	6.60	5.68	4.78	**3.77**	2.82	1.75	0.69	-0.64	-2.33	-4.58
25	10.12	9.37	8.54	7.68	6.85	5.91	**5.03**	4.04	3.13	2.05	1.05	-0.17	-1.72
26	11.15	10.36	9.57	8.76	7.89	7.08	**6.14**	5.30	4.35	3.42	2.40	1.38	0.25
27	12.06	11.36	10.57	9.75	8.98	8.11	**7.28**	6.42	5.54	4.64	3.68	2.73	1.69
28	13.04	12.28	11.53	10.76	9.93	9.18	**8.31**	7.51	6.67	5.77	4.91	3.94	3.04
29	13.91	13.23	12.46	11.70	10.95	10.13	**9.35**	8.55	7.72	6.91	5.99	5.17	4.22
30	14.83	14.09	13.39	12.64	11.86	11.13	**10.31**	9.55	8.77	7.92	7.14	6.26	5.42

Table 6.10 Suggested prices for the current costs of equipment

Scenario	Operating Costs (US $/year)	$Price_1$ (US $/100 m^2)	IRR_1 (%)	$Price_2$ (US $/100 m^2)	IRR_2 (%)	Price (US $/100 m^2)
1	784,853	16	0.37	17	-1.72	16.2
2	840,914	18	0.81	17	-1.08	17.6
3	896,975	19	1.18	18	-0.55	18.3
4	953,036	20	1.52	19	-0.07	19.0
5	1,009,096	20	0.36	19	-1.68	19.8
6	1,065,157	21	0.76	20	-1.10	20.6
7	**1,121,218**	**22**	**1.09**	**21**	**-0.63**	**21.4**
8	1,177,279	23	1.44	22	-0.13	22.1
9	1,233,340	23	0.30	22	-1.71	22.9
10	1,289,401	24	0.69	23	-1.15	23.6
11	1,345,462	25	1.05	24	-0.64	24.4
12	1,401,523	26	1.38	25	-0.17	25.1
13	1,457,584	26	0.25	25	-1.72	25.9

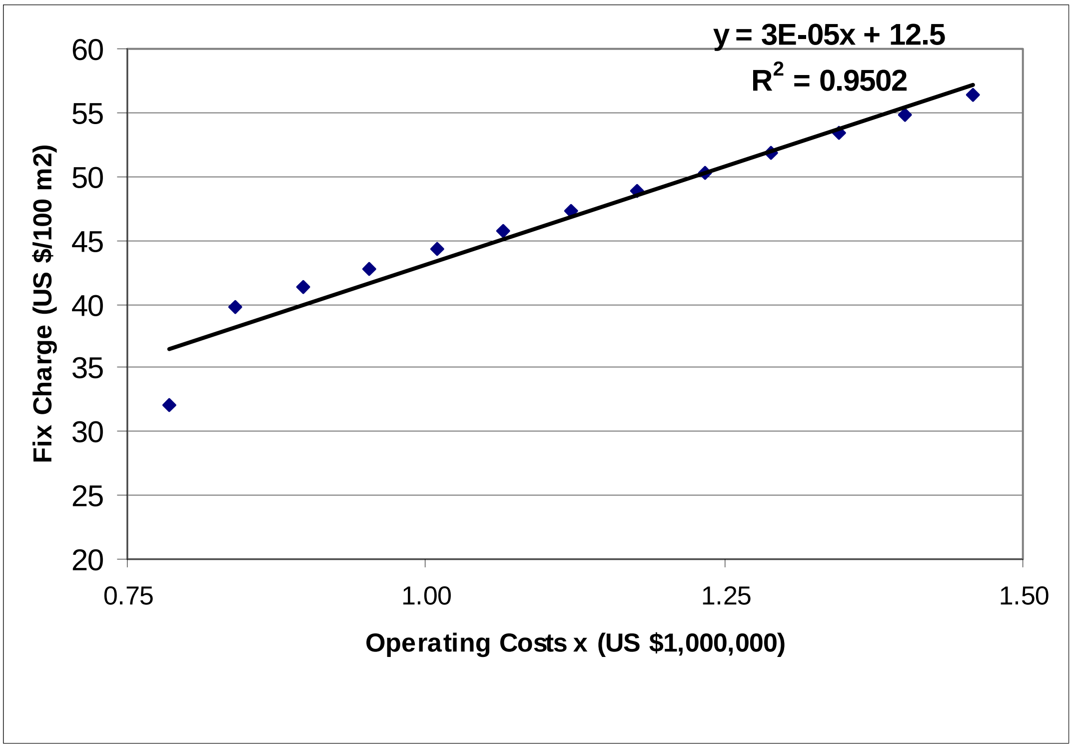

Figure 6.4 Energy utilization prices as a function of yearly operating cost for the current costs of the equipment

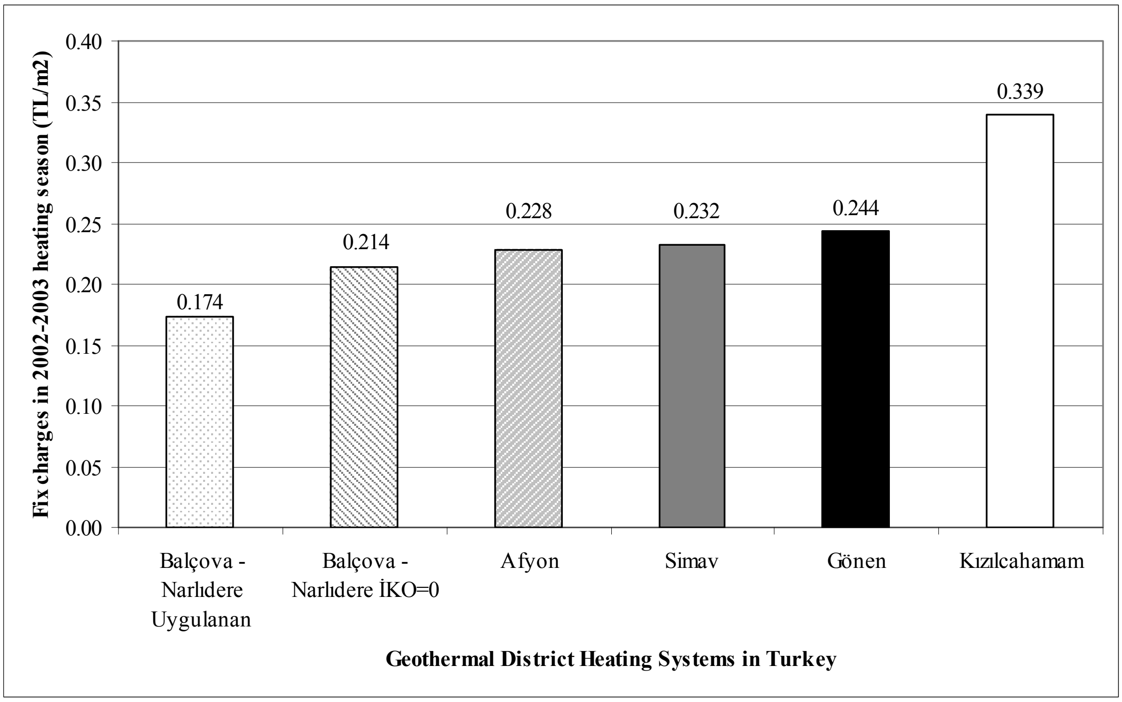

Figure 6.5 Monthly fix charges in different geothermal district heating systems for 2002-2003 heating season

If the utilization price and the number of customers remain constant, it is obvious that the revenues will be decreased after 2002. Because, the important part of revenues is connection charges up to now and it will be decreased and finally equal to zero.

In business life, this kind of economic assessment is considered as a time consumed activity. Simple analysis is preferred in the economic analysis of investment as realized in Table 6.11 instead of IRR calculations. It can be said that this is an attractive investment according to Tables 6.11 and 6.12. But, such kind of analysis does not give a correct idea for conscious investors. Because the time value of money and depreciation will not being considered in a simple approach. From Table 6.11, it is seen that after collecting approximately US $9,000,000, the investment will earn money. Without taking depreciation into consideration, the net cash flows are shown for three different monthly utilization prices in Table 6.12. According to Table 6.12 the investment will payback itself with collecting US $21 per month in 2020.

Table 6.11 Calculation of net cash flows without time value of money in US $

		1995	1996	1997	1998	1999	2000	2001	2002	Well Drilling Costs *	Total
Investment	Balçova	7,116	2,652,831	4,949,538	2,408,295	911,319	0	0	0		10,929,098
	Narlıdere	0	0	812,274	393,152	130,422	0	0	0		1,335,848
	Additional		0	0	0	0	0	283,540	524,585	1,358,236	2,166,361
Total Capital Investment Costs		7,116	2,652,831	5,761,813	2,801,447	1,041,740	0	283,540	524,585		14,431,307
Operating Costs		0	0	0	229,077	321,073	377,531	1,019,488	1,099,563		3,046,732
Taxes		-	-	-	-	-	8,041	11,798	60,641		80,480
Revenues	Connection	0	54,038	1,522,362	592,340	727,593	427,673	359,473	328,482		4,011,960
	Fix	0	8,386	163,557	401,279	719,417	952,642	816,091	1,350,547		4,411,920
	Other	0	-	-	-	-	0	147,784	35,377		183,161
Total Revenues		0	62,424	1,685,919	993,620	1,447,010	1,380,315	1,323,348	1,714,405		8,607,041
Net Cash Flows		-7,116	-2,590,407	-4,075,894	-2,036,905	84,197	994,743	8,523	29,616	-1,358,236	-8,951,478
Cumulative Totals		-7,116	-2,597,522	-6,673,416	-8,710,321	-8,626,124	-7,631,381	-7,622,858	-7,593,242	-8,951,478	

* Wells are drilled in different times. Therefore estimated well drilling costs are written in different column.

Table 6.12 Revenues in US $ for the simple analysis

Year	Net Cash Flows for Scenario 7		
	For US $20	For US $21	For US $22
2003	424,786	424,786	424,786
2004-2005	647,271	721,432	795,594
2006	-2,214,364	-2,136,064	-2,057,763
2007-2010	647,271	721,432	795,594
2011	-638,075	-559,774	-481,474
2012-2021	647,271	721,432	795,594
NCF	7,928,675	9,271,862	10,615,049

End of 2002 calculations for the capital investment costs have two meanings in this study. If this investment had not been implemented and the capital had taken into a saving account, interest would have been earned during this period and the interest accumulated in this account can be considered as the opportunity cost for this investment. The opportunity cost is shown in Table 6.13. The other meaning of these calculations is the time value of money. The investment should not be analyzed without consideration of time value of money.

Table 6.13 Opportunity cost of capital investment in US $

	Amount (in US $)
Total cost of the investment	14,431,307
End of 2002 value of capital investment cost	23,598,820
Opportunity cost	9,167,513

CHAPTER VII

CONCLUSION

Geothermal district heating systems are the investments that open to new developments with regard to the nature of the geothermal resources. The economic assessments are prepared at the beginning of an investment. But the future development must be considered in these analyses.

In this study, the capacity of Balçova – Narlıdere GDHS is kept constant after year 2002. The end of 2002 values of Balçova - Narlıdere GDHS investment is calculated and IRR method is used to show the profitability of this investment at the end of the project life. Energy utilization prices are found by IRR method. Balçova - Narlıdere investment is a public investment and the social benefits of this project is more important than making profits. Therefore, prices are calculated according to the discount rates which makes the net present value of all cash flows zero. As a matter of fact, it is not economically desired result for the private sector.

Projects are developing to establish new district heating systems in Balçova-Narlıdere geothermal region in future. In these developments, economic evaluation should be prepared before making a decision for the investment. IRR method should be applied to new projects in this field to determine the energy utilization prices.

In this study, by using 13 scenarios for operating costs and 60 plans for energy utilization prices, the effects of some parameters on internal rate of returns are demonstrated. The results of internal rate of return calculations are also compared with the results of a simple cost-revenue analysis. It is obvious that using the a simple cost analysis does not reflect the time value of money. Therefore, it should not be preferred in detailed economic assessments.

It is found that current price level is not appropriate for this investment. If the utilization prices and operating costs realized in 2002 remain constant in future, price is calculated as US \$55.5 per a house which is 100 m^2. It is impossible to increase today's price level to this amount with any marketing strategy in short time. Because the calculated price is higher than the existing price level.

It is found that this investment can be made feasible by pricing plans P A3 and P A4 for current operating costs. In these plans, the utilization prices are accepted to be increased with the average increasing rate of last four-year's prices and the amount is kept constant after some years in each alternative pricing plan. The results of these four plans are also meaningful as the results of the constant energy utilization prices. It can be applicable in Balçova – Narlıdere GDHS. Especially, plan A4 will make this public investment feasible with the current operating costs in future. Plan PA1 and PA 2 is not appropriate for operating costs realized in 2002. It is found that if the operating costs are decreased 30 %, the investment will be feasible for P A1. For P A2, yearly opearing costs must should be decreased 25 %.

As it is seen from Chapter V, because of the challenge in geothermal energy sector, the prices of materials and equipment are seriously decreased in the last years. Therefore, the project managers should pay more attention for the selection of materials and equipment in geothermal energy development.

IRR analysis is recurred according to the new prices of equipment. The cost of investment with regard to the accruals and costs of equipment in 2002 is given in Table 7.1. In this table, the heated area is accepted as 1,150,000 m^2 in Balçova and Narlıdere regions. On the other hand, required energy in 2002 is known as 176,664,816 kWh_t. The capital investment cost per unit required energy is calculated as US $ 0.134. The energy utilization price is found as US $21.4 by using new costs of equipment. If this price is applied in Balçova – Narlıdere GDHS, some part of initial costs can not be paid back.

Table 7.1 The investment cost of Balçova – Narlıdere GDHS

	Investment cost per unit area (US $/ m^2)	Investment cost per capacity (US $/kW)	Operating cost per unit area (US $/ m^2)	Energy utilization price which makes IRR zero (US $/month)
By using accrual costs of equipment	20,52	471,98	0.975	55.5
By using year 2002 costs of equipment	12.53			21.4

From the this analysis (Chapter V), it is seen that the reduction of operating costs affects the economic assessment of Balçova – Narlıdere investment. Cost of personnel and general management costs should be decreased. An automatic control system is suggested to reduce the electricity consumption in Balçova – Narlıdere GDHS which is one of the important cost component.

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APPENDIX A

DOLLAR EXCHANGE RATES AND INTEREST RATES IN CALCULATIONS

Table A-1 Selling exchange rates at the end of months from year 1996 to 2001

mo	1996	1997	1998	1999	2000	2001	2002
1		115,770	215,220	332,200	560,572	679,693	1,311,636
2		122,420	229,600	352,405	574,816	925,119	1,392,736
3		127,660	242,800	369,155	590,896	1,025,482	1,344,246
4	74,608	135,230	249,750	390,248	612,243	1,143,180	1,338,308
5	78,421	140,390	257,170	406,594	617,706	1,211,964	1,444,946
6	81,689	148,400	266,160	421,362	621,079	1,258,815	1,576,711
7	83,211	159,430	270,560	427,988	638,579	1,329,490	1,696,336
8	86,233	166,210	277,350	445,089	656,599	1,364,783	1,629,167
9	91,787	174,050	277,540	460,603	669,096	1,525,991	1,680,416
10	96,113	182,110	286,460	479,621	685,978	1,595,060	1,670,530
11	101,830	194,350	303,820	516,150	685,390	1,481,078	1,542,744
12	108,045	206,100	315,220	542,703	675,004	1,453,615	1,647,654
avg	89,104	156,010	265,971	428,677	632,330	1,249,523	1,522,953

Table A-2 Min, max, and average monthly nominal interest rates of Central Bank of the Republic of Turkey for governmental activities from year 1993 to 1995

mo	1993			1994			1995		
	min	max	avg	min	max	avg	min	max	avg
1	0.5	1.5	1.0	0.5	1.5	1.0	0.0	1.0	0.5
2	0.5	1.5	1.0	0.5	1.5	1.0	0.0	0.0	0.0
3	0.5	1.5	1.0	0.5	1.0	0.8	0.0	3.5	1.8
4	0.5	1.5	1.0	0.5	1.0	0.8	0.0	3.5	1.8
5	0.5	1.5	1.0	0.5	1.0	0.8	0.0	3.5	1.8
6	0.5	1.5	1.0	0.0	2.0	1.0	0.0	3.5	1.8
7	0.5	1.5	1.0	0.0	1.5	0.8	1.0	3.0	2.0
8	0.5	1.5	1.0	0.0	2.0	1.0	0.5	3.0	1.8
9	0.5	1.5	1.0	0.0	2.0	1.0	0.5	3.0	1.8
10	0.5	1.5	1.0	0.0	2.0	1.0	0.5	7.0	3.8
11	0.5	1.5	1.0	0.0	1.0	0.5	0.5	7.0	3.8
12	0.5	1.5	1.0	0.0	1.0	0.5	0.5	8.0	4.3

Table A-3 Min, max, and average monthly nominal interest rates of Central Bank of the Republic of Turkey for governmental activities from 1996 to 1999

mo	1996			1997			1998		
	min	max	avg	min	max	avg	min	max	avg
1	0.5	7.0	3.8	1.0	4.0	2.5	5.00	6.50	5.8
2	0.5	7.0	3.8	1.0	5.5	3.3	5.00	6.50	5.8
3	0.5	3.0	1.8	1.0	5.5	3.3	5.00	6.50	5.8
4	0.0	3.0	1.5	1.0	5.5	3.3	5.00	6.50	5.8
5	0.5	3.0	1.8	1.0	6.5	3.8	5.00	6.50	5.8
6	0.5	3.0	1.8	1.0	6.5	3.8	5.00	6.50	5.8
7	1.5	3.0	2.3	1.0	6.5	3.8	5.00	6.50	5.8
8	1.0	3.0	2.0	1.5	6.5	4.0	5.00	6.50	5.8
9	1.0	2.5	1.8	2.5	6.5	4.5	5.00	6.50	5.8
10	1.0	2.5	1.8	5.0	6.5	5.8	5.00	6.50	5.8
11	1.0	4.0	2.5	5.0	6.5	5.8	5.00	7.00	6.0
12	1.0	4.0	2.5	5.0	6.5	5.8	5.00	7.00	6.0

Table A-4 Min, max, and average monthly nominal interest rates of Central Bank of the Republic of Turkey for Governmental Activities from 1999 to 2002

mo	1999			2000			2001		
	min	max	avg	min	max	avg	min	max	avg
1	6.00	7.00	6.5	5.00	12.00	8.5	8.00	14.50	11.25
2	6.00	7.00	6.5	5.00	8.00	6.5	8.00	14.50	11.25
3	6.00	7.00	6.5	5.00	9.00	7.0	8.00	16.00	12.00
4	6.00	7.00	7.0	7.00	9.00	8.0	8.00	18.00	13.00
5	6.00	7.00	6.5	7.00	9.00	8.0	8.00	18.00	13.00
6	6.00	7.00	6.5	7.00	9.00	8.0	8.00	16.00	12.00
7	6.00	12.00	9.0	6.50	9.00	7.8	8.00	16.00	12.00
8	6.50	12.00	9.3	6.50	9.00	7.8	8.50	16.00	12.25
9	6.50	12.00	9.3	6.50	10.50	8.5	5.50	16.00	10.75
10	6.50	12.00	9.3	6.50	10.50	8.5	4.00	8.00	6.00
11	6.50	12.00	9.3	6.50	10.50	8.5	3.00	5.00	4.00
12	6.50	12.00	9.3	7.00	14.50	10.8	3.00	4.50	3.75

Table A-5 Monthly interest rates (i/100) given by Central Bank of the Republic of Turkey in year 1997

mo	1	2	3	4	5	6	7	8	9	10	11	12
1		0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0044	0.0044	0.0044	0.0048	0.0048
2			0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0049	0.0049	0.0049	0.0048
3				0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0055	0.0055	0.0055
4					0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0048	0.0048
5						0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0048
6							0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
7								0.0049	0.0049	0.0049	0.0048	0.0048
8									0.0049	0.0049	0.0049	0.0048
9										0.0055	0.0055	0.0055
10											0.0048	0.0048
11												0.0048
12												

Table A-6 Monthly interest rates (i/100) given by Central Bank of the Republic of Turkey in year 1998

mo	1	2	3	4	5	6	7	8	9	10	11	12
1		0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0062	0.0062	0.0062	0.0048	0.0050
2			0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0062	0.0062	0.0062	0.0050
3				0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0062	0.0062	0.0062
4					0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0048	0.0050
5						0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0050
6							0.0066	0.0066	0.0066	0.0066	0.0066	0.0066
7								0.0062	0.0062	0.0062	0.0048	0.0050
8									0.0062	0.0062	0.0062	0.0050
9										0.0062	0.0062	0.0062
10											0.0048	0.0050
11												0.0050
12												

Table A-7 Monthly interest rates (i/100) given by Central Bank of the Republic of Turkey in year 1999

mo	1	2	3	4	5	6	7	8	9	10	11	12
1		0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0085	0.0085	0.0085	0.0077	0.0077
2			0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0085	0.0085	0.0085	0.0077
3				0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0085	0.0085	0.0085
4					0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0077	0.0077
5						0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0077
6							0.0074	0.0074	0.0074	0.0074	0.0074	0.0074
7								0.0081	0.0081	0.0081	0.0077	0.0077
8									0.0085	0.0085	0.0085	0.0077
9										0.0085	0.0085	0.0085
10											0.0077	0.0077
11												0.0077
12												

Table A-8 Monthly interest rates (i/100) given by Central Bank of the Republic of Turkey in year 2000

mo	1	2	3	4	5	6	7	8	9	10	11	12
1		0.0078	0.0078	0.0078	0.0078	0.0078	0.0078	0.0071	0.0071	0.0071	0.0071	0.0071
2			0.0069	0.0069	0.0069	0.0069	0.0069	0.0069	0.0071	0.0071	0.0071	0.0071
3				0.0069	0.0069	0.0069	0.0069	0.0069	0.0069	0.0085	0.0085	0.0085
4					0.0084	0.0084	0.0084	0.0084	0.0084	0.0084	0.0071	0.0071
5						0.0084	0.0084	0.0084	0.0084	0.0084	0.0084	0.0071
6							0.0080	0.0080	0.0080	0.0080	0.0080	0.0080
7								0.0071	0.0071	0.0071	0.0071	0.0071
8									0.0071	0.0071	0.0071	0.0071
9										0.0085	0.0085	0.0085
10											0.0071	0.0071
11												0.0071
12												

Table A-9 Monthly interest rates (i/100) given by Central Bank of the Republic of Turkey in year 2001

mo	1	2	3	4	5	6	7	8	9	10	11	12
1		0.0097	0.0097	0.0097	0.0097	0.0097	0.0097	0.0101	0.0101	0.0101	0.0050	0.0033
2			0.0097	0.0097	0.0097	0.0097	0.0097	0.0097	0.0101	0.0101	0.0101	0.0033
3				0.0109	0.0109	0.0109	0.0109	0.0109	0.0109	0.0092	0.0092	0.0092
4					0.0109	0.0109	0.0109	0.0109	0.0109	0.0109	0.0050	0.0033
5						0.0099	0.0099	0.0099	0.0099	0.0099	0.0099	0.0033
6							0.0099	0.0099	0.0099	0.0099	0.0099	0.0099
7								0.0101	0.0101	0.0101	0.0050	0.0033
8									0.0101	0.0101	0.0101	0.0033
9										0.0092	0.0092	0.0092
10											0.0050	0.0033
11												0.0033
12												

Table A-10 Monthly interest rates (i/100) given by Central Bank of the Republic of Turkey in year 2002

mo	1	2	3	4	5	6	7	8	9	10	11	12
1		0.0039	0.0039	0.0039	0.0039	0.0039	0.0039	0.0028	0.0028	0.0028	0.0028	0.0027
2			0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0028	0.0028	0.0028	0.0027
3				0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0028	0.0028	0.0028
4					0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0028	0.0027
5						0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0027
6							0.0030	0.0030	0.0030	0.0030	0.0030	0.0030
7								0.0028	0.0062	0.0062	0.0028	0.0027
8									0.0028	0.0028	0.0028	0.0027
9										0.0026	0.0026	0.0026
10											0.0028	0.0027
11												0.0027
12												

APPENDIX B

PAYMENTS IN BALÇOVA AND NARLIDERE ACCRUALS

Table B-1 Payments for each item in Balçova accruals in years 1995 and 1996 (in TL)

no.	29.12.1995	12.03.1996	12.04.1996	15.05.1996	03.07.1996	23.07.1996	12.08.1996	12.09.1996	31.10.1996	12.11.1996	18.12.1996
B1	274,905,595	443,545,801	301,005,791	-1,036	0	104,830,000	1,386,145,419	2,997,001,556	1,477,055,556	-2,163,673,218	73,814,638
B2	46,228,000	28,433,860	24,332,762	4,164,702	-1	65,920,965	265,472,047	1,231,574,544	375,018,655	-1,795,317,649	991,291
B3	0	0	0	0	793,305,000	392,598,000	323,941,800	496,435,700	1,220,017,750	0	7,867,693,693
B4	0	0	0	161,501,785	0	0	27,625,000	365,483,000	7,263,250	-143,441,750	0
B5	0	0	0	477,576,771	0	306,076,500	373,218,000	1,583,844,100	5,458,741	269,723,659	0
B6	0	0	0	0	0	0	0	0	0	3,788,812,893	0
B7	0	0	0	0	0	0	0	0	0	2,944,103,294	0
B8	0	0	0	0	0	198,560,000	0	47,000,750	212,500	100,195,491	0
B9	0	0	0	0	0	0	0	0	7,862,500	0	0
B10	0	0	0	0	0	0	787,263,455	1,202,491,600	1,241,790,836	0	-391,422,280
B11	0	0	0	0	0	0	0	25,170,391	21,682,364	0	0
B12	0	0	0	0	0	19,906,039,082	36,004,796,175	47,917,394,519	57,768,846,665	39,064,445,121	11,797,821,082
B13	93,082,307	144,775,340	94,234,220	30,380,400	201,515,168	10,484,231	144,853,754	164,821,986	136,834,240	1,113,594,811	24,328,055
total	414,215,902	616,755,001	419,572,773	673,622,622	994,820,167	20,984,508,778	39,313,315,650	56,031,218,145	62,262,043,057	43,178,442,653	19,373,226,479

Table B-2 Payments for each item in Balçova accruals in 1997 (in TL)

no.	14.01.1997	14.02.1997	17.03.1997	05.05.1997	18.06.1997	07.07.1997	11.07.1997	11.08.1997	12.09.1997	31.12.1997
B1	0	0	297,864,280	372,460,489	0	0	0	0	0	0
B2	0	0	11,797,425	35,018,208	0	0	0	0	0	0
B3	0	0	0	0	131,325,000	0	-82,862,183	0	0	0
B4	263,831,500	0	151,470,000	306,964,750	0	0	1,932,300,000	540,450,000	0	179,625,000
B5	6,770,155,139	4,398,928,181	522,256,473	9,872,141,626	1,422,278,704	-16,150,001	3,383,904,520	1,481,844,881	0	329,992,499
B6	6,028,719,787	2,501,095,916	9,436,657,716	6,377,770,780	0	0	10,904,046,712	7,409,359,370	0	0
B7	3,918,211,714	1,231,059,627	186,980,305	11,523,953,826	0	0	7,285,455,365	6,259,573,703	0	0
B8	102,543,048	61,982,850	0	115,742,817	0	0	0	0	0	0
B9	0	0	0	0	0	0	0	0	0	0
B10	0	0	0	0	0	0	0	0	0	0
B11	0	0	0	0	0	0	0	0	0	0
B12	40,865,645,817	16,938,248,522	40,737,032,609	81,325,766,203	23,040,410,372	45,954,436,534	145,738,275,450	108,808,780,898	43,603,092,925	76,206,069,236
B13	0	0	0	367,267,011	0	0	112,472,478	2,764,684,343	0	0
total	57,949,107,005	25,131,315,096	51,344,058,808	110,297,085,709	24,594,014,075	45,938,286,533	169,273,592,342	127,264,693,195	43,603,092,925	76,715,686,736

Table B-3 Payments for each item in Balçova accruals in 1998 (in TL)

no.	30.03.1998	15.04.1998	21.05.1998	29.06.1998	19.08.1998	14.09.1998	16.10.1998	20.11.1998	31.12.1998
B1	0	0	0	0	0	0	0	0	0
B2	0	0	0	0	0	0	0	0	0
B3	0	0	0	0	10,936,330,706	0	3,786,595,370	0	2,100,130,594
B4	3,064,500,000	0	0	1,123,200,000	28,500,000	367,200,000	-7,350,000	22,499,925	1,133,400,075
B5	530,664,590	0	2,728,471,688	305,627,546	1,827,783,001	280,136,719	669,638,853	3,787,267,395	2,064,115,789
B6	0	19,386,969,663	7,048,887,084	0	7,524,833,705	1,138,198,007	-3,273,568,806	4,459,934,111	4,768,561,148
B7	0	10,604,657,582	3,409,857,076	0	-1,179,359,728	273,000,000	3,239,175,876	2,319,564,536	2,702,743,344
B8	-247,295,925	0	0	0	0	0	0	0	0
B9	0	0	0	0	58,500,000	0	0	0	0
B10	0	0	0	0	0	0	0	0	0
B11	0	0	0	0	275,100,000	0	0	0	0
B12	4,949,805,281	0	95,448,755,370	66,689,999,150	12,230,166,575	81,434,054,558	183,184,637,619	8,375,639,070	114,079,850,780
B13	940,896,115	0	0	0	0	0	0	0	1,423,850,714
total	9,238,570,060	29,991,627,245	108,635,971,217	68,118,826,696	31,701,854,259	83,492,589,284	187,599,128,912	18,964,905,037	128,272,652,443

Table B-4 Payments for each item in Balçova accruals in 1999 (in TL)

no.	25.02.1999	26.03.1999	31.05.1999	29.06.1999	31.08.1999	27.10.1999
B1	0	0	0	0	0	0
B2	0	0	0	0	0	0
B3	0	0	0	13,508,960,588	0	0
B4	151,200,000	0	432,900,000	1,172,887,500	324,675,000	-2,924,100,000
B5	241,992,188	8,004,000	1,091,528,700	4,866,477,630	192,600,000	-8,699,627,768
B6	3,766,599,993	2,695,650,572	2,939,049,127	9,812,025,746	0	90,518,740
B7	2,313,446,517	1,246,528,264	1,534,728,430	6,429,590,323	0	-243,241,067
B8	0	0	0	0	0	-93,214,028
B9	39,000,000	0	0	0	0	66,000,000
B10	0	0	0	0	0	0
B11	2,325,000,000	0	0	0	0	339,750,000
B12	46,323,944,416	23,884,647,096	0	210,422,116,875	15,550,625,392	27,218,857,265
B13	0	1,080,203,310	0	1,769,306,684	597,506,529	466,721,987
total	55,161,183,113	28,915,033,242	5,998,206,256	247,981,365,346	16,665,406,921	16,221,665,130

Table B-5 Payments in US$ for each item in Balçova accruals 1to 11 (in years 1995 and 1996)

no.	1	2	3	4	5	6	7	8	9	10	11
B1	4,722	6,513	0	0	4,122	1,259	16,357	33,661	15,368	-22,078	699
B2	794	418	0	0	333	792	3,133	13,832	3,902	-18,319	9
B3	0	0	0	0	0	4,715	3,823	5,576	12,694	0	74,553
B4	0	0	0	0	0	0	326	4,105	76	-1,464	0
B5	0	0	0	0	0	3,676	4,404	17,789	57	2,752	0
B6	0	0	0	0	0	0	0	0	0	38,660	0
B7	0	0	0	0	0	0	0	0	0	30,041	0
B8	0	0	0	0	0	2,385	0	528	2	1,022	0
B9	0	0	0	0	0	0	0	0	82	0	0
B10	0	0	0	0	0	0	9,290	13,506	12,920	0	-3,709
B11	0	0	0	0	0	0	0	283	226	0	0
B12	0	0	0	0	0	239,071	424,865	538,180	601,051	398,605	111,794
B13	1,599	2,126	0	0	1,291	126	1,709	1,851	1,424	11,363	231
total	7,116	9,057	0	0	5,746	252,024	463,907	629,310	647,800	440,583	183,577

Table B-6 Payments in US$ for each item in Balçova accruals 12 to 21 (in 1997)

no.	12	13	14	15	16	17	18	19	20	21
B1	0	0	2,378	2,732	0	0	0	0	0	0
B2	0	0	94	257	0	0	0	0	0	0
B3	0	0	0	0	903	0	-548	0	0	0
B4	2,360	0	1,209	2,251	0	0	12,775	3,309	0	872
B5	60,572	36,707	4,169	72,408	9,776	-108	22,371	9,072	0	1,601
B6	53,939	20,870	75,325	46,778	0	0	72,088	45,362	0	0
B7	35,056	10,273	1,492	84,524	0	0	48,165	38,322	0	0
B8	917	517	0	849	0	0	0	0	0	0
B9	0	0	0	0	0	0	0	0	0	0
B10	0	0	0	0	0	0	0	0	0	0
B11	0	0	0	0	0	0	0	0	0	0
B12	365,623	141,341	325,168	596,492	158,364	306,302	963,495	666,149	256,851	369,753
B13	0	0	0	2,694	0	0	744	16,926	0	0
total	518,467	209,707	409,834	808,986	169,043	306,194	1,119,090	779,140	256,851	372,226

Table B-7 Payments in US$ for each item in Balçova accruals 22 to 30 (in 1998)

no.	22	23	24	25	26	27	28	29	30
B1	0	0	0	0	0	0	0	0	0
B2	0	0	0	0	0	0	0	0	0
B3	0	0	0	0	39,563	0	13,637	0	6,662
B4	12,670	0	0	4,217	103	1,332	-26	75	3,596
B5	2,194	0	10,761	1,148	6,612	1,016	2,412	12,694	6,548
B6	0	78,940	27,801	0	27,221	4,130	-11,789	14,949	15,128
B7	0	43,180	13,448	0	-4,266	991	11,666	7,775	8,574
B8	-1,022	0	0	0	0	0	0	0	0
B9	0	0	0	0	212	0	0	0	0
B10	0	0	0	0	0	0	0	0	0
B11	0	0	0	0	995	0	0	0	0
B12	20,465	0	376,449	250,404	44,243	295,479	659,721	28,074	361,905
B13	3,890	0	0	0	0	0	0	0	4,517
total	38,196	122,121	428,460	255,769	114,683	302,948	675,619	63,568	406,931

Table B-8 Payments in US$ for each item in Balçova accruals 31 to 36 (in 1999)

no.	31	32	33	34	35	36
B1	0	0	0	0	0	0
B2	0	0	0	0	0	0
B3	0	0	0	32,148	0	0
B4	430	0	1,065	2,791	729	-6,097
B5	688	22	2,685	11,581	433	-18,139
B6	10,709	7,302	7,228	23,351	0	189
B7	6,577	3,377	3,775	15,301	0	-507
B8	0	0	0	0	0	-194
B9	111	0	0	0	0	138
B10	0	0	0	0	0	0
B11	6,610	0	0	0	0	708
B12	131,706	64,701	0	500,759	34,938	56,751
B13	0	2,926	0	4,211	1,342	973
total	156,832	78,328	14,752	590,142	37,443	33,822

Table B-9 Payments for each item in Narlıdere accruals in year 1997 (in TL)

no.	08.07.1997	12.08.1997	10.11.1997	31.12.1997
N1	873,070,481	2,806,380,950	3,432,611,337	0
N2	87,307,048	289,854,095	334,045,134	0
N3	147,981,650	3,341,241,396	1,840,677,499	0
N4	103,587,155	2,338,868,978	1,288,474,249	0
N5	0	0	34,818,750	0
N6	0	0	221,250,000	0
N7	0	0	60,637,500	0
N8	0	0	1,751,825,543	0
N9	0	0	0	0
N10	10,942,506,563	25,710,010,781	61,259,375,095	7,342,763,672
N11	127,869,586	4,927,232,759	10,827,314,621	2,992,404,674
total	12,282,322,481	39,413,588,959	81,051,029,727	10,335,168,346

Table B-10 Payments for each item in Narlıdere accruals in year 1998 (in TL)

no.	05.10.1998	30.11.1998	30.12.1998
N1	1,196,776,694	-14,190	0
N2	119,677,670	-1,419	0
N3	1,403,306,120	0	3,452,359,939
N4	982,314,284	0	2,416,651,958
N5	0	3,287,800,669	0
N6	299,978,250	0	1,265,775,000
N7	237,562,500	0	0
N8	1,787,349,564	0	930,679,961
N9	22,125,000	0	0
N10	33,958,444,506	1,202,656,754	23,917,251,329
N11	1,871,398,056	10,126,405,528	28,744,587,795
total	41,878,932,644	14,616,847,342	60,727,305,980

Table B-11 Payments for each item in Narlıdere accruals in year 1999 (in TL)

no.	28.04.1999	15.06.1999	30.09.1999
N1	0	201,838,908	0
N2	0	20,183,891	0
N3	211,307,567	0	0
N4	147,915,296	0	0
N5	0	0	0
N6	134,700,000	280,275,000	90,075,000
N7	0	0	0
N8	1,506,965,250	1,626,726,304	678,670,404
N9	0	0	0
N10	14,202,948,953	3,097,150,925	3,146,531,474
N11	13,714,096,138	6,501,551,185	7,594,223,809
total	29,917,933,204	11,727,726,213	11,509,500,687

Table B-12 Payments in US$ for each item in Narlıdere accruals 1 to 4 (in 1997)

no.	08.07.1997	12.08.1997	10.11.1997	31.12.1997
N1	5,798	17,136	18,630	0
N2	580	1,770	1,813	0
N3	983	20,402	9,990	0
N4	688	14,281	6,993	0
N5	0	0	189	0
N6	0	0	1,201	0
N7	0	0	329	0
N8	0	0	9,508	0
N9	0	0	0	0
N10	72,669	156,989	332,480	35,627
N11	849	30,086	58,764	14,519
total	81,567	240,664	439,897	50,146

Table B-13 Payments in US$ for each item in Narlıdere accruals 5 to 7 (in 1998)

no.	05.10.1998	30.11.1998	30.12.1998
N1	4,338	0	0
N2	434	0	0
N3	5,086	0	10,987
N4	3,560	0	7,691
N5	0	10,822	0
N6	1,087	0	4,028
N7	861	0	0
N8	6,478	0	2,962
N9	80	0	0
N10	123,078	3,958	76,114
N11	6,783	33,330	91,476
total	151,785	48,110	193,258

Table B-14 Payments in US$ for each item in Narlıdere accruals 8 to 10 (in 1999)

no.	28.04.1999	15.06.1999	30.09.1999
N1	0	488	0
N2	0	49	0
N3	544	0	0
N4	381	0	0
N5	0	0	0
N6	347	677	196
N7	0	0	0
N8	3,883	3,932	1,473
N9	0	0	0
N10	36,595	7,486	6,831
N11	35,336	15,715	16,488
total	77,086	28,347	24,988

APPENDIX C

END OF MONTH VALUES IN BALÇOVA AND NARLIDERE ACCRUALS

Table C -1. End of month values in dollars for each item in Balçova accruals 1 to 11

no.	1	2	3	4	5	6	7	8	9	10	11
B1	4,729	6,582	4,159	0	0	1,266	16,554	34,016	33,641	15,600	706
B2	795	422	336	55	0	796	3,170	13,978	13,824	3,961	9
B3	0	0	0	0	9,832	4,740	3,869	5,635	5,572	12,885	75,302
B4	0	0	0	2,115	0	0	330	4,148	4,102	77	0
B5	0	0	0	6,255	0	3,695	4,457	17,977	17,778	58	0
B6	0	0	0	0	0	0	0	0	0	0	0
B7	0	0	0	0	0	0	0	0	0	0	0
B8	0	0	0	0	0	2,397	0	533	528	2	0
B9	0	0	0	0	0	0	0	0	0	83	0
B10	0	0	0	0	0	0	9,402	13,648	13,498	13,115	-3,746
B11	0	0	0	0	0	0	0	286	283	229	0
B12	0	0	0	0	0	240,329	429,993	543,859	537,866	610,131	112,917
B13	1,601	2,148	1,302	398	2,497	127	1,730	1,871	1,850	1,445	233
total	7,126	9,152	5,798	8,823	12,329	253,350	469,505	635,950	628,943	657,587	185,421

Table C-2 End of month values in dollars for each item in Balçova accruals 12 to 21

no.	12	13	14	15	16	17	18	19	20	21
B1	0	0	2,411	2,819	0	0	0	0	0	0
B2	0	0	96	265	0	0	0	0	0	0
B3	0	0	0	0	916	0	-561	0	0	0
B4	2,392	0	1,226	2,323	0	0	13,082	3,394	0	870
B5	61,385	37,348	4,228	74,705	9,923	-111	22,909	9,305	0	1,598
B6	54,662	21,235	76,392	48,262	0	0	73,820	46,525	0	0
B7	35,526	10,452	1,514	87,205	0	0	49,322	39,305	0	0
B8	930	526	0	876	0	0	0	0	0	0
B9	0	0	0	0	0	0	0	0	0	0
B10	0	0	0	0	0	0	0	0	0	0
B11	0	0	0	0	0	0	0	0	0	0
B12	365,623	143,810	329,777	615,415	160,756	315,230	986,637	683,229	263,876	369,046
B13	0	0	0	2,779	0	0	761	17,360	0	0
total	520,518	213,372	415,644	834,649	171,596	315,119	1,145,970	799,117	263,876	371,513

Table C-3 End of month values in dollars for each item in Balçova accruals 22 to 30

no.	22	23	24	25	26	27	28	29	30
B1	0	0	0	0	0	0	0	0	0
B2	0	0	0	0	0	0	0	0	0
B3	0	0	0	0	40,405	0	14,008	0	6,649
B4	12,670	0	0	4,225	105	1,374	-27	77	3,588
B5	2,194	0	10,948	1,150	6,753	1,048	2,477	12,951	6,535
B6	0	81,241	28,284	0	27,801	4,258	-12,110	15,251	15,098
B7	0	44,439	13,682	0	-4,357	1,021	11,983	7,932	8,557
B8	-1,022	0	0	0	0	0	0	0	0
B9	0	0	0	0	216	0	0	0	0
B10	0	0	0	0	0	0	0	0	0
B11	0	0	0	0	1,016	0	0	0	0
B12	20,465	0	382,993	250,884	45,185	304,672	677,645	28,641	361,183
B13	3,890	0	0	0	0	0	0	0	4,508
total	38,196	125,679	435,908	256,259	117,124	312,374	693,976	64,851	406,118

Table C-4 End of month values in dollars for each item in Balçova accruals 31 to 36

no.	31	32	33	34	35	36
B1	0	0	0	0	0	-18,307
B2	0	0	0	0	0	190
B3	0	0	0	32,218	0	-512
B4	435	0	1,062	2,797	727	-196
B5	696	22	2,679	11,606	431	139
B6	10,826	7,366	7,213	23,401	0	0
B7	6,649	3,406	3,766	15,334	0	715
B8	0	0	0	0	0	0
B9	112	0	0	0	0	57,277
B10	0	0	0	0	0	982
B11	6,682	0	0	0	0	34,136
B12	133,139	65,263	0	501,844	34,831	34,136
B13	0	2,952	0	4,220	1,338	0
total	158,538	79,009	14,720	591,421	37,328	108,560

Table C-5 End of month values in dollars for each item in Narlıdere accruals 1 to 4

no.	1	2	3	4
N1	5,960	17,552	19,357	0
N2	596	1,813	1,884	0
N3	1,010	20,897	10,380	0
N4	707	14,628	7,266	0
N5	0	0	196	0
N6	0	0	1,248	0
N7	0	0	342	0
N8	0	0	9,879	0
N9	0	0	0	0
N10	74,694	160,799	345,459	35,559
N11	873	30,817	61,058	14,491
total	83,840	246,506	457,070	50,050

Table C-6 End of month values in dollars for each item in Narlıdere accruals 5 to 7

no.	5	6	7
N1	4,550	0	0
N2	455	0	0
N3	5,335	0	10,987
N4	3,735	0	7,691
N5	0	10,822	0
N6	1,141	0	4,028
N7	903	0	0
N8	6,796	0	2,962
N9	84	0	0
N10	129,113	3,958	76,114
N11	7,115	33,330	91,476
total	159,228	48,110	193,258

Table C-7 End of month values in dollars for each item in Narlıdere accruals 8 to 10

no.	8	9	10
N1	0	504	0
N2	0	50	0
N3	547	0	0
N4	383	0	0
N5	0	0	0
N6	349	700	196
N7	0	0	0
N8	3,900	4,062	1,473
N9	0	0	0
N10	36,754	7,733	6,831
N11	35,489	16,234	16,488
total	77,421	29,283	24,988

APPENDIX D

END OF YEAR VALUES FOR EACH ITEM IN BALÇOVA AND NARLIDERE ACCRUALS

Table D-1 End of year values in US $ for each item in Balçova accruals 1 to 11

	1	2	3	4	5	6	7	8	9	10	11
1	4,729	6,779	4,267	0	0	1,282	16,745	34,272	33,760	15,633	706
2	795	435	345	56	0	806	3,207	14,083	13,873	3,969	9
3	0	0	0	0	9,959	4,801	3,913	5,677	5,592	12,912	75,302
4	0	0	0	2,167	0	0	334	4,179	4,117	77	0
5	0	0	0	6,407	0	3,743	4,509	18,112	17,841	58	0
6	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	2,428	0	537	529	2	0
9	0	0	0	0	0	0	0	0	0	83	0
10	0	0	0	0	0	0	9,510	13,751	13,546	13,143	-3,746
11	0	0	0	0	0	0	0	288	284	229	0
12	0	0	0	0	0	243,449	434,941	547,948	539,773	611,402	112,917
13	1,601	2,213	1,336	408	2,530	128	1,750	1,885	1,857	1,448	233
total	7,126	9,426	5,948	9,038	12,489	256,639	474,908	640,732	631,172	658,957	185,421

Table D-2 End of year values in US $ for each item in Balçova accruals 12 to 21

	12	13	14	15	16	17	18	19	20	21
1	0	0	2,520	2,918	0	0	0	0	0	0
2	0	0	100	274	0	0	0	0	0	0
3	0	0	0	0	944	0	-574	0	0	0
4	2,554	0	1,281	2,405	0	0	13,381	3,444	0	870
5	65,539	39,143	4,418	77,343	10,225	-113	23,434	9,443	0	1,598
6	58,361	22,255	79,830	49,967	0	0	75,511	47,214	0	0
7	37,931	10,954	1,582	90,285	0	0	50,452	39,888	0	0
8	993	552	0	907	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0
12	390,365	150,721	344,617	637,148	165,639	322,454	1,009,247	693,356	263,876	369,046
13	0	0	0	2,877	0	0	779	17,617	0	0
total	555,743	223,624	434,348	864,125	176,808	322,340	1,172,230	810,962	263,876	371,513

Table D-3 End of year values in US $ for each item in Balçova accruals 22 to 30

	22	23	24	25	26	27	28	29	30
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	41,363	0	14,145	14,216	6,649
4	13,424	0	0	4,395	108	1,516	-27	-28	3,588
5	2,325	0	11,445	1,196	6,913	1,156	2,501	2,514	6,535
6	0	85,332	29,567	0	28,460	4,699	-12,229	-12,290	15,098
7	0	46,677	14,303	0	-4,461	1,127	12,100	12,161	8,557
8	-1,083	0	0	0	0	0	0	0	0
9	0	0	0	0	221	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11	0	0	0	0	1,040	0	0	0	0
12	21,683	0	400,364	260,958	46,256	336,164	684,297	687,718	361,183
13	4,122	0	0	0	0	0	0	0	4,508
total	40,470	132,009	455,679	266,549	119,901	344,662	700,788	704,291	406,118

Table D-4 End of year values in US $ for each item in Balçova accruals 31 to 36

	31	32	33	34	35	36
1	0	0	0	0	0	-18,590
2	0	0	0	0	0	193
3	0	0	0	33,679	0	-520
4	470	0	1,119	2,924	752	-199
5	752	23	2,822	12,132	446	141
6	11,698	7,899	7,598	24,462	0	0
7	7,185	3,652	3,968	16,029	0	726
8	0	0	0	0	0	0
9	121	0	0	0	0	58,164
10	0	0	0	0	0	997
11	7,221	0	0	0	0	34,664
12	143,872	69,985	0	524,595	36,006	0
13	0	3,165	0	4,411	1,383	0
total	171,319	81,560	15,506	618,232	38,588	75,576

Table D-5 End of year values in US $ for each item in Narlıdere accruals 1 to 4

no.	1	2	3	4
N1	6,096	17,898	19,450	0
N2	610	1,849	1,893	0
N3	1,033	21,309	10,430	0
N4	723	14,916	7,301	0
N5	0	0	197	0
N6	0	0	1,254	0
N7	0	0	344	0
N8	0	0	9,926	0
N9	0	0	0	0
N10	76,406	163,965	347,115	35,559
N11	893	31,423	61,351	14,491
total	85,761	251,359	459,260	50,050

Table D-6 End of year values in US $ for each item in Narlıdere accruals 5 to 7

no.	5	6	7
N1	4,595	0	0
N2	459	0	0
N3	5,388	0	10,987
N4	3,772	0	7,691
N5	0	0	0
N6	1,152	196	4,028
N7	912	0	0
N8	6,862	1,473	2,962
N9	85	0	0
N10	130,380	6,831	76,114
N11	7,185	16,488	91,476
total	160,790	24,988	193,258

Table D-7 End of year values in US $ for each item in Narlıdere accruals 8 to 10

no.	8	9	10
N1	0	508	0
N2	0	51	0
N3	580	0	0
N4	406	0	0
N5	0	0	0
N6	370	705	201
N7	0	0	0
N8	4,140	4,092	1,512
N9	0	0	0
N10	39,015	7,791	7,008
N11	37,672	16,354	16,914
total	82,183	29,500	25,634

Table D-8 Estimated well drilling costs from 1982 to 1999

Year	Total (in US $)
1982	24,513
1983	94,635
1989	56,804
1994	131,993
1995	159,571
1996	176,777
1998	147,078
1999	566,865

Table D-9 Results of end of year calculation for well drilling costs

Date	Total (in US $)
30.12.1982	24,513
30.12.1983	121,599
30.12.1984	133,759
30.12.1985	147,135
30.12.1986	161,848
30.12.1987	178,033
30.12.1988	195,836
30.12.1989	272,224
30.12.1990	299,447
30.12.1991	329,391
30.12.1992	362,331
30.12.1993	398,564
30.12.1994	550,485
30.12.1995	737,580
30.12.1996	964,512
30.12.1997	1,015,149
30.12.1998	1,246,485
30.12.1999	1,916,808
30.12.2000	2,127,657
30.12.2001	2,372,338
30.12.2002	2,485,024

APPENDIX E

END OF YEAR VALUES OF ADDITIONAL INVESTMENT IN US$

Table E-1 End of year 2001 value of machines bought in year 2001 in US$

30.01.2001	30.02.2001	30.03.2001	30.04.2001	30.05.2001	30.06.2001	30.07.2001	30.08.2001	30.09.2001	30.10.2001	30.11.2001	30.12.2001
F(1)						62,560			64,479	64,802	65,018
	F(2)						4,011			4,135	4,148
		F(3)						3,878			3,986
			F(4)						0	0	0
				F(5)						4,119	4,132
					F(6)						6,275
						F(7)			136	136	137
							F(8)			25,600	25,685
								F(9)			7,602
									F(10)		18,331
										F(11)	9,943
											31,161
Total end of year 2001 value											176,419

Table E-2 End of year 2001 value of other assets (inventory) in year 2001 in US$

30.01.2001	30.02.2001	30.03.2001	30.04.2001	30.05.2001	30.06.2001	30.07.2001	30.08.2001	30.09.2001	30.10.2001	30.11.2001	30.12.2001
F(1)						1,933			1,993	2,002	2,009
	F(2)						1,109			1,144	1,147
		F(3)						1,454			1,494
			F(4)						0	0	0
				F(5)						579	581
					F(6)						0
						F(7)			1,179	1,184	1,188
							F(8)			45	45
								F(9)			823
									F(10)		47
										F(11)	0
											90
Total end of year 2001 value											7,425

Table E-3 End of year 2001 value of vehicles bought in year 2001 in US$

30.01.2001	30.02.2001	30.03.2001	30.04.2001	30.05.2001	30.06.2001	30.07.2001	30.08.2001	30.09.2001	30.10.2001	30.11.2001	30.12.2001
F(1)						0			0	0	0
	F(2)						368			379	380
		F(3)						0			0
			F(4)						7,792	7,831	7,857
				F(5)						0	0
					F(6)						0
						F(7)			0	0	0
							F(8)			0	0
								F(9)			0
									F(10)		0
										F(11)	0
											0
										Total end of year 2001 value	8,238

Table E-4 End of year 2001 value of new connection in 2001 in US$

30.01.2001	30.02.2001	30.03.2001	30.04.2001	30.05.2001	30.06.2001	30.07.2001	30.08.2001	30.09.2001	30.10.2001	30.11.2001	30.12.2001
F(1)											
	F(2)										
		F(3)									
			F(4)								
				F(5)							
					F(6)						
						F(7)					
							F(8)			37,371	37,496
								F(9)			46,354
									F(10)		3,635
										F(11)	5,395
											10,744
										End of 2001 value of new connection investment	103,624

Table E-5 End of year 2002 value of new connection in 2002 in US$

30.01.2002	30.02.2002	30.03.2002	30.04.2002	30.05.2002	30.06.2002	30.07.2002	30.08.2002	30.09.2002	30.10.2002	30.11.2002	30.12.2002
F(1)						4,691			4,731	4,744	4,757
	F(2)						2,275			2,294	2,301
		F(3)						2,084			2,102
			F(4)						2,760	2,768	2,776
				F(5)						5,260	5,274
					F(6)						148,728
						F(7)			2,441	2,448	2,455
							F(8)			1,591	1,595
								F(9)			3,205
									F(10)		0
										F(11)	0
											0
End of 2002 value of new connection investment											173,192

Table E-6 End of year 2002 value of equipment bought in year 2002 in US$

30.01.2002	30.02.2002	30.03.2002	30.04.2002	30.05.2002	30.06.2002	30.07.2002	30.08.2002	30.09.2002	30.10.2002	30.11.2002	30.12.2002
F(1)						6,480			6,535	6,553	6,571
	F(2)						5,976			6,027	6,043
		F(3)						6,152			6,204
			F(4)						8,196	8,219	8,241
				F(5)						5,522	5,537
					F(6)						23,533
						F(7)			6,461	6,480	6,497
							F(8)			4,988	5,002
								F(9)			3,877
									F(10)		27,497
										F(11)	58,978
											54,883
End of year 2002 value of equipment bought in year 2002											212,864

Table E-7 End of year 2002 value of drilling costs realized in 2002 in US$

30.01.2002	30.02.2002	30.03.2002	30.04.2002	30.05.2002	30.06.2002	30.07.2002	30.08.2002	30.09.2002	30.10.2002	30.11.2002	30.12.2002
F(1)						0			0	0	0
	F(2)						0			0	0
		F(3)						0			0
			F(4)						0	0	0
				F(5)						0	0
					F(6)						146,340
						F(7)			0	0	0
							F(8)			0	0
								F(9)			0
									F(10)		0
										F(11)	0
End of year 2002 value of drilling costs											146,340

APPENDIX F

END OF YEAR VALUES OF OPERATING COSTS IN US$

Table F-1 End of year values of monthly expenditures for water consumption in1998

30.01.1998	30.02.1998	30.03.1998	30.04.1998	30.05.1998	30.06.1998	30.07.1998	30.08.1998	30.09.1998	30.10.1998	30.11.1998	30.12.1998
F(1)						0			0	0	0
	F(2)						2,148			2,188	2,199
		F(3)						11,349			11,560
			F(4)						3,923	3,942	3,962
				F(5)						3,082	3,097
					F(6)						621
						F(7)			373	375	377
							F(8)			2,381	2,393
								F(9)			1,458
									F(10)		1,943
										F(11)	2,489
											9,853
End of year value of expenditures for water consumption in 1998											39,951

Table F-2 End of year values of monthly expenditures for water consumption in 1999

30.01.1999	30.02.1999	30.03.1999	30.04.1999	30.05.1999	30.06.1999	30.07.1999	30.08.1999	30.09.1999	30.10.1999	30.11.1999	30.12.1999
F(1)						5,581			5,725	5,769	5,814
	F(2)						4,863			4,989	5,027
		F(3)						5,385			5,524
			F(4)						4,641	4,676	4,712
				F(5)						4,208	4,240
					F(6)						4,891
						F(7)			8,728	8,796	8,863
							F(8)			3,364	3,390
								F(9)			4,645
									F(10)		3,292
										F(11)	3,396
											4,313
End of year value of expenditures for water consumption in 1999											58,107

Table F-3 End of year values of monthly expenditures for water consumption in year 2000

30.01.2000	30.02.2000	30.03.2000	30.04.2000	30.05.2000	30.06.2000	30.07.2000	30.08.2000	30.09.2000	30.10.2000	30.11.2000	30.12.2000
F(1)						4,122			4,211	4,241	4,271
	F(2)						5,003			5,110	5,147
		F(3)						7,420			7,612
			F(4)						5,621	5,661	5,701
				F(5)						7,683	7,737
					F(6)						6,838
						F(7)			3,920	3,948	3,976
							F(8)			8,265	8,323
								F(9)			7,845
									F(10)		8,423
										F(11)	8,251
											8,435
End of year value of expenditures for water consumption in 2000											82,557

Table F-4 End of year values of monthly expenditures for water consumption in year 2001

30.01.2001	30.02.2001	30.03.2001	30.04.2001	30.05.2001	30.06.2001	30.07.2001	30.08.2001	30.09.2001	30.10.2001	30.11.2001	30.12.2001
F(1)						9,653			9,949	9,999	10,032
	F(2)						11,091			11,431	11,469
		F(3)						4,478			4,603
			F(4)						6,450	6,482	6,504
				F(5)						10,603	10,638
					F(6)						10,140
						F(7)			4,211	4,232	4,246
							F(8)			12,907	12,951
								F(9)			1,712
									F(10)		10,931
										F(11)	9,835
											3,901
End of year value of expenditures for water consumption in 2001											96,961

Table F-5 End of year values of monthly expenditures for water consumption in year 2002

30.01.2002	30.02.2002	30.03.2002	30.04.2002	30.05.2002	30.06.2002	30.07.2002	30.08.2002	30.09.2002	30.10.2002	30.11.2002	30.12.2002
F(1)						7,584			7,648	7,669	7,690
	F(2)						12,917			13,026	13,062
		F(3)						17,117			17,262
			F(4)						13,533	13,571	13,608
				F(5)						8,042	8,064
					F(6)						4,828
						F(7)			1,860	1,865	1,870
							F(8)			4,606	4,618
								F(9)			18,772
									F(10)		5,149
										F(11)	6,813
											4,683
End of year value of expenditures for water consumption in 2002											106,418

Table F-6 End of year values of monthly expenditures for electricity consumption in year 1998

30.01.1998	30.02.1998	30.03.1998	30.04.1998	30.05.1998	30.06.1998	30.07.1998	30.08.1998	30.09.1998	30.10.1998	30.11.1998	30.12.1998
F(1)						0			0	0	0
	F(2)						14,539			14,809	14,883
		F(3)						16,004			16,302
			F(4)						12,503	12,563	12,626
				F(5)						4,796	4,820
					F(6)						2,768
						F(7)			2,258	2,269	2,280
							F(8)			1,831	1,840
								F(9)			3,774
									F(10)		4,178
										F(11)	6,629
											8,196
End of year value of expenditures for electricity consumption in 1998											78,296

Table F-7 End of year values of monthly expenditures for electricity consumption in year 1999

30.01.1999	30.02.1999	30.03.1999	30.04.1999	30.05.1999	30.06.1999	30.07.1999	30.08.1999	30.09.1999	30.10.1999	30.11.1999	30.12.1999
F(1)						13,619			13,971	14,078	14,187
	F(2)						21,273			21,823	21,991
		F(3)						18,347			18,822
			F(4)						17,818	17,956	18,094
				F(5)						4,570	4,605
					F(6)						2,230
						F(7)			2,919	2,942	2,965
							F(8)			1,391	1,402
								F(9)			1,644
									F(10)		1,056
										F(11)	8,115
											17,054
End of year value of expenditures for electricity consumption in 1999											112,165

Table F-8 End of year values of monthly expenditures for electricity consumption in year 2000

30.01.2000	30.02.2000	30.03.2000	30.04.2000	30.05.2000	30.06.2000	30.07.2000	30.08.2000	30.09.2000	30.10.2000	30.11.2000	30.12.2000
F(1)						23,651			24,161	24,332	24,504
	F(2)						36,721			37,511	37,777
		F(3)						37,615			38,587
			F(4)						28,666	28,869	29,074
				F(5)						9,461	9,528
					F(6)						3,299
						F(7)			2,245	2,261	2,277
							F(8)			3,202	3,224
								F(9)			5,722
									F(10)		4,247
										F(11)	16,605
											18,455
End of year value of expenditures for electricity consumption in 2000											193,298

Table F-9 End of year values of monthly expenditures for electricity consumption in year 2001

30.01.2001	30.02.2001	30.03.2001	30.04.2001	30.05.2001	30.06.2001	30.07.2001	30.08.2001	30.09.2001	30.10.2001	30.11.2001	30.12.2001
F(1)						43,043			44,364	44,586	44,735
	F(2)						28,334			29,204	29,301
		F(3)						23,646			24,306
			F(4)						10,141	10,192	10,226
				F(5)						10,582	10,617
					F(6)						4,837
						F(7)			2,386	2,398	2,406
							F(8)			327	328
								F(9)			3,525
									F(10)		3,923
										F(11)	8,511
											55,660
End of year value of expenditures for electricity consumption in 2001											198.375

Table F-10 End of year values of monthly expenditures for electricity consumption in year 2002

30.01.2002	30.02.2002	30.03.2002	30.04.2002	30.05.2002	30.06.2002	30.07.2002	30.08.2002	30.09.2002	30.10.2002	30.11.2002	30.12.2002
F(1)						2,204			2,223	2,229	2,235
	F(2)						32,547			32,823	32,912
		F(3)						32,470			32,745
			F(4)						71,160	71,360	71,554
				F(5)						22,657	22,719
					F(6)						8,370
						F(7)			3,000	3,009	3,017
							F(8)			4,899	4,912
								F(9)			2,944
									F(10)		3,239
										F(11)	14,657
											91,083
End of year value of expenditures for electricity consumption in 2002											290,386

Table F-11 End of year values of personnel wages in year 1998

30.01.1998	30.02.1998	30.03.1998	30.04.1998	30.05.1998	30.06.1998	30.07.1998	30.08.1998	30.09.1998	30.10.1998	30.11.1998	30.12.1998
F(1)						0			0	0	0
	F(2)						2,127			2,167	2,178
		F(3)						3,485			3,550
			F(4)						2,306	2,317	2,328
				F(5)						13,844	13,913
					F(6)						10,289
						F(7)			4,507	4,529	4,551
							F(8)			8,193	8,234
								F(9)			14,169
									F(10)		13,187
										F(11)	11,331
											15,328
End of year value of personnel wages in 1998											99,058

Table F-12 End of year values of personnel wages in year 1999

30.01.1999	30.02.1999	30.03.1999	30.04.1999	30.05.1999	30.06.1999	30.07.1999	30.08.1999	30.09.1999	30.10.1999	30.11.1999	30.12.1999
F(1)						14,441			14,814	14,928	15,043
	F(2)						5,867			6,019	6,065
		F(3)						11,193			11,482
			F(4)						8,880	8,948	9,017
				F(5)						11,603	11,693
					F(6)						16,827
						F(7)			12,040	12,133	12,226
							F(8)			11,737	11,827
								F(9)			9,180
									F(10)		6,255
										F(11)	4,912
											8,281
End of year value of personnel wages in 1999											122,810

Table F-13 End of year values of personnel wages in year 2000

30.01.2000	30.02.2000	30.03.2000	30.04.2000	30.05.2000	30.06.2000	30.07.2000	30.08.2000	30.09.2000	30.10.2000	30.11.2000	30.12.2000
F(1)						9,452			9,655	9,724	9,792
	F(2)						9,167			9,365	9,431
		F(3)						8,918			9,148
			F(4)						8,697	8,759	8,821
				F(5)						8,605	8,666
					F(6)						8,541
						F(7)			8,088	8,145	8,203
							F(8)			7,147	7,198
								F(9)			7,787
									F(10)		7,189
										F(11)	7,714
											8,196
End of year value of personnel wages in 2000											100,686

Table F-14 End of year values of personnel wages in year 2001

0.01.2001	30.02.2001	30.03.2001	30.04.2001	30.05.2001	30.06.2001	30.07.2001	30.08.2001	30.09.2001	30.10.2001	30.11.2001	30.12.2001
F(1)						11,330			11,677	11,736	11,775
	F(2)						8,861			9,132	9,163
		F(3)						9,800			10,074
			F(4)						13,046	13,112	13,155
				F(5)						13,210	13,254
					F(6)						11,816
						F(7)			14,154	14,224	14,272
							F(8)			13,272	13,316
								F(9)			10,177
									F(10)		15,054
										F(11)	14,070
											14,603
End of year value of personnel wages in 2001											150,729

Table F-15 End of year values of personnel wages in year 2002

30.01.2002	30.02.2002	30.03.2002	30.04.2002	30.05.2002	30.06.2002	30.07.2002	30.08.2002	30.09.2002	30.10.2002	30.11.2002	30.12.2002
F(1)						15,275			15,404	15,448	15,490
	F(2)						16,620			16,761	16,806
		F(3)						16,568			16,708
			F(4)						17,809	17,859	17,907
				F(5)						15,688	15,731
					F(6)						15,204
						F(7)			15,171	15,214	15,255
							F(8)			15,604	15,646
								F(9)			13,542
									F(10)		24,142
										F(11)	18,605
											25,702
End of year value of personnel wages in 2002											210,739

Table F-16 End of year values of monthly expenditures for purchasing of inhibitor in year 1998

30.01.1998	30.02.1998	30.03.1998	30.04.1998	30.05.1998	30.06.1998	30.07.1998	30.08.1998	30.09.1998	30.10.1998	30.11.1998	30.12.1998
F(1)						0			0	0	0
	F(2)						0			0	0
		F(3)						3,444			3,508
			F(4)						3,474	3,491	3,508
				F(5)						0	0
					F(6)						2,661
						F(7)			0	0	0
							F(8)			0	0
								F(9)			2,404
									F(10)		1,311
										F(11)	1,243
											3,772
End of year value of expenditures for purchase of inhibitor in 1998											18,407

Table F-17 End of year values of monthly expenditures used for purchasing of inhibitor in year 1999

30.01.1999	30.02.1999	30.03.1999	30.04.1999	30.05.1999	30.06.1999	30.07.1999	30.08.1999	30.09.1999	30.10.1999	30.11.1999	30.12.1999
F(1)						5,194			5,329	5,370	5,411
	F(2)						6,198			6,358	6,407
		F(3)						3,690			3,786
			F(4)						6,023	6,070	6,116
				F(5)						1,192	1,201
					F(6)						2,345
						F(7)			2,337	2,355	2,373
							F(8)			1,173	1,182
								F(9)			1,170
									F(10)		2,342
										F(11)	2,218
											4,366
End of year value of expenditures for purchase of inhibitor in 1999											38,916

Table F-18 End of year values of monthly expenditures used for purchasing of inhibitor in year 2000

30.01.2000	30.02.2000	30.03.2000	30.04.2000	30.05.2000	30.06.2000	30.07.2000	30.08.2000	30.09.2000	30.10.2000	30.11.2000	30.12.2000
F(1)						2,298			2,347	2,364	2,381
	F(2)						4,435			4,531	4,563
		F(3)						4,360			4,473
			F(4)						1,082	1,089	1,097
				F(5)						0	0
					F(6)						0
						F(7)			0	0	0
							F(8)			0	0
								F(9)			1,428
									F(10)		1,378
										F(11)	1,389
											1,462
End of year value of expenditures for purchase of inhibitor in 2000											18,170

Table F-19 End of year values of monthly expenditures used for purchasing of inhibitor in year 2001

30.01.2001	30.02.2001	30.03.2001	30.04.2001	30.05.2001	30.06.2001	30.07.2001	30.08.2001	30.09.2001	30.10.2001	30.11.2001	30.12.2001
F(1)						4,356			4,490	4,512	4,528
	F(2)						1,203			1,240	1,244
		F(3)						3,088			3,174
			F(4)						1,715	1,724	1,729
				F(5)						0	0
					F(6)						0
						F(7)			1,365	1,372	1,376
							F(8)			0	0
								F(9)			121
									F(10)		1,863
										F(11)	485
											0
End of year value of expenditures for purchase of inhibitor in 2001											14,520

Table F-20 End of year values of monthly expenditures used for purchasing of inhibitor in year 2002

30.01.2002	30.02.2002	30.03.2002	30.04.2002	30.05.2002	30.06.2002	30.07.2002	30.08.2002	30.09.2002	30.10.2002	30.11.2002	30.12.2002
F(1)						0			0	0	0
	F(2)						847			854	856
		F(3)						282			284
			F(4)						0	0	0
				F(5)						278	279
					F(6)						496
						F(7)			0	0	0
							F(8)			0	0
								F(9)			613
									F(10)		0
										F(11)	675
											607
End of year value of expenditures for purchase of inhibitor in 2002											3,810

Table F-21 End of year values of monthly expenditures for purchasing of chemical materials in year 1998

30.01.1998	30.02.1998	30.03.1998	30.04.1998	30.05.1998	30.06.1998	30.07.1998	30.08.1998	30.09.1998	30.10.1998	30.11.1998	30.12.1998
F(1)											0
	F(2)										0
		F(3)									0
			F(4)								0
				F(5)							0
					F(6)						0
						F(7)					0
							F(8)				0
								F(9)			151
									F(10)		208
										F(11)	0
											0
End of year values of expenditures for purchasing of chemical materials in 1998											358

Table F-22 End of year values of monthly expenditures for purchasing of chemical materials in year 1999

30.01.1999	30.02.1999	30.03.1999	30.04.1999	30.05.1999	30.06.1999	30.07.1999	30.08.1999	30.09.1999	30.10.1999	30.11.1999	30.12.1999
F(1)						635			651	656	661
	F(2)						576			591	596
		F(3)						358			367
			F(4)						1,551	1,563	1,575
				F(5)						78	78
					F(6)						33
						F(7)			495	499	503
							F(8)			28	28
								F(9)			105
									F(10)		93
										F(11)	461
											108
End of year value of expenditures for purchase of other chemical materials in year 1999											4,608

Table F-23 End of year values of monthly expenditures for purchasing of chemical materials in year 2000

30.01.2000	30.02.2000	30.03.2000	30.04.2000	30.05.2000	30.06.2000	30.07.2000	30.08.2000	30.09.2000	30.10.2000	30.11.2000	30.12.2000
F(1)						0			0	0	0
	F(2)						398			406	409
		F(3)						56			57
			F(4)						445	448	452
				F(5)						1	1
					F(6)						208
						F(7)			0	0	0
							F(8)			0	0
								F(9)			0
									F(10)		0
										F(11)	0
											0
End of year value of expenditures for purchase of other chemical materials in year 2000											1,128

Table F-24 End of year values of monthly expenditures for purchasing of chemical materials in year 2001

30.01.2001	30.02.2001	30.03.2001	30.04.2001	30.05.2001	30.06.2001	30.07.2001	30.08.2001	30.09.2001	30.10.2001	30.11.2001	30.12.2001
F(1)						1,136			1,171	1,176	1,180
	F(2)						11			11	11
		F(3)						0			0
			F(4)						45	45	45
				F(5)						193	193
					F(6)						73
						F(7)			0	0	0
							F(8)			67	67
								F(9)			384
									F(10)		62
										F(11)	165
											17
End of year value of expenditures for purchase of other chemical materials in year 2001											2,199

Table F-25 End of year values of monthly expenditures for purchasing of chemical materials in year 2002

30.01.2002	30.02.2002	30.03.2002	30.04.2002	30.05.2002	30.06.2002	30.07.2002	30.08.2002	30.09.2002	30.10.2002	30.11.2002	30.12.2002
F(1)						405			408	409	411
	F(2)						418			422	423
		F(3)						6			6
			F(4)						98	99	99
				F(5)						209	210
					F(6)						250
						F(7)			73	73	73
							F(8)			240	240
								F(9)			49
									F(10)		9
										F(11)	130
											58
End of year value of expenditures for purchase of other chemical materials in year 2002											1,958

Table F-26 End of year values of monthly maintenance expenditures in year 2001

30.01.2001	30.02.2001	30.03.2001	30.04.2001	30.05.2001	30.06.2001	30.07.2001	30.08.2001	30.09.2001	30.10.2001	30.11.2001	30.12.2001
F(1)						101			104	105	105
	F(2)						231			238	239
		F(3)						142			146
			F(4)						355	357	358
				F(5)						96	97
					F(6)						933
						F(7)			0	0	0
							F(8)			976	979
								F(9)			3,601
									F(10)		2,713
										F(11)	898
											1,280
End of year value of maintenance costs of year 2001											11,350

Table F-27 End of year values of miscellaneous costs in year 2001

30.01.2001	30.02.2001	30.03.2001	30.04.2001	30.05.2001	30.06.2001	30.07.2001	30.08.2001	30.09.2001	30.10.2001	30.11.2001	30.12.2001
P(1)						8,155			8,406	8,448	8,476
	P(2)						3,172			3,269	3,280
		P(3)						1,177			1,210
			P(4)						11,345	11,402	11,440
				P(5)						1,190	1,194
					P(6)						1,318
						P(7)			2,162	2,173	2,180
							P(8)			11,832	11,871
								P(9)			2,117
									P(10)		10,939
										P(11)	23,867
											21,816
End of year value of miscellaneous costs of year 2001											99,709

Table F-28 End of year values of monthly management costs in year 2001

30.01.2001	30.02.2001	30.03.2001	30.04.2001	30.05.2001	30.06.2001	30.07.2001	30.08.2001	30.09.2001	30.10.2001	30.11.2001	30.12.2001
R(1)						5,210			5,370	5,397	5,415
	R(2)						3,822			3,940	3,953
		R(3)						4,840			4,975
			R(4)						8,082	8,122	8,149
				R(5)						7,487	7,511
					R(6)						6,952
						R(7)			6,148	6,178	6,199
							R(8)			6,516	6,538
								R(9)			9,012
									R(10)		8,157
										R(11)	12,559
											14,799
End of year value of management costs of year 2001											94,219

Table F-29 End of year values of monthly marketing costs in year 2001

30.01.2001	30.02.2001	30.03.2001	30.04.2001	30.05.2001	30.06.2001	30.07.2001	30.08.2001	30.09.2001	30.10.2001	30.11.2001	30.12.2001
X(1)						5,635			5,808	5,837	5,856
	X(2)						1,116			1,150	1,154
		X(3)						1,364			1,402
			X4)						1,011	1,017	1,020
				X(5)						6,625	6,647
					X(6)						1,916
						X(7)			572	575	577
							X(8)			-9	-9
								X(9)			563
									X(10)		2,066
										X(11)	1,700
											3,705
End of year value of marketing costs of year 2001											26,597

Table F-30 End of year values of monthly facility rents in year 2001

30.01.2001	30.02.2001	30.03.2001	30.04.2001	30.05.2001	30.06.2001	30.07.2001	30.08.2001	30.09.2001	30.10.2001	30.11.2001	30.12.2001
Y(1)						77,953			80,345	80,747	81,016
	Y(2)						57,273			59,030	59,227
		Y(3)						52,027			53,477
			Y(4)						46,670	46,904	47,060
				Y(5)						43,772	43,918
					Y(6)						42,143
						Y(7)			0	0	0
							Y(8)			0	0
								Y(9)			0
									Y(10)		0
										Y(11)	0
											54,951
End of year value of facility rents of year 2001											381,792

Table F-31 End of year values of monthly maintenance expenditures in year 2002

30.01.2002	30.02.2002	30.03.2002	30.04.2002	30.05.2002	30.06.2002	30.07.2002	30.08.2002	30.09.2002	30.10.2002	30.11.2002	30.12.2002
F(1)						85			86	86	86
	F(2)						1,076			1,085	1,088
		F(3)						454			458
			F(4)						0	0	0
				F(5)						195	195
					F(6)						49,297
						F(7)			229	229	230
							F(8)			0	0
								F(9)			81
									F(10)		485
										F(11)	342
											2,105
End of year value of maintenance costs of year 2002											54,367

Table F-32 End of year values of miscellaneous costs in year 2002

30.01.2002	30.02.2002	30.03.2002	30.04.2002	30.05.2002	30.06.2002	30.07.2002	30.08.2002	30.09.2002	30.10.2002	30.11.2002	30.12.2002
F(1)						3,967			4,001	4,012	4,023
	F(2)						2,858			2,883	2,890
		F(3)						437			441
			F(4)						5,215	5,230	5,244
				F(5)						918	921
					F(6)						5,299
						F(7)			5,726	5,742	5,757
							F(8)			2,061	2,067
								F(9)			3,066
									F(10)		5,447
										F(11)	5,080
											3,338
End of year value of miscellaneous costs of year 2001											43,572

Table F-33 End of year values of monthly management costs in year 2002

30.01.2002	30.02.2002	30.03.2002	30.04.2002	30.05.2002	30.06.2002	30.07.2002	30.08.2002	30.09.2002	30.10.2002	30.11.2002	30.12.2002
F(1)						16,072			16,208	16,253	16,297
	F(2)						13,310			13,423	13,459
		F(3)						15,843			15,977
			F(4)						15,604	15,648	15,691
				F(5)						16,558	16,603
					F(6)						11,667
						F(7)			12,543	12,579	12,613
							F(8)			12,253	12,286
								F(9)			11,085
									F(10)		5,818
										F(11)	12,249
											7,432
End of year value of management costs of year 2002											151,177

Table F-34 End of year values of monthly marketing costs in year 2002

30.01.2002	30.02.2002	30.03.2002	30.04.2002	30.05.2002	30.06.2002	30.07.2002	30.08.2002	30.09.2002	30.10.2002	30.11.2002	30.12.2002
F(1)						11,786			11,885	11,919	11,951
	F(2)						312			314	315
		F(3)						452			456
			F(4)						281	282	283
				F(5)						376	378
					F(6)						209
						F(7)			170	171	171
							F(8)			217	217
								F(9)			220
									F(10)		341
										F(11)	1,201
											557
End of year value of marketing costs of year 2002											16,300

Table F-35 End of year values of monthly facility rents in year 2002

30.01.2002	30.02.2002	30.03.2002	30.04.2002	30.05.2002	30.06.2002	30.07.2002	30.08.2002	30.09.2002	30.10.2002	30.11.2002	30.12.2002
F(1)						59,838			60,344	60,514	60,678
	F(2)						56,283			56,760	56,913
		F(3)						58,314			58,807
			F(4)						0	0	0
				F(5)						0	0
					F(6)						0
						F(7)			0	0	0
							F(8)			0	0
								F(9)			0
									F(10)		0
										F(11)	0
											66,093
										End of year value of facility rents of year 2002	242,491

APPENDIX G

END OF YEAR VALUES OF REVENUES IN US$

Table G-1 End of year values of monthly connection charges in 1997

30.01.1997	30.02.1997	30.03.1997	30.04.1997	30.05.1997	30.06.1997	30.07.1997	30.08.1997	30.09.1997	30.10.1997	30.11.1997	30.12.1997
F(1)						535			542	544	547
	F(2)						13,913			14,119	14,187
		F(3)						71,027			72,215
			F(4)						224,181	225,255	226,334
				F(5)						155,541	156,286
					F(6)						143,421
						F(7)			131,530	132,160	132,794
							F(8)			120,525	121,102
								F(9)			195,929
									F(10)		204,193
										F(11)	193,764
											94,765
TOTAL AMOUNT EARNED IN YEAR1997											1,555,538

Table G-2 End of year values of monthly connection charges in 1998

30.01.1998	30.02.1998	30.03.1998	30.04.1998	30.05.1998	30.06.1998	30.07.1998	30.08.1998	30.09.1998	30.10.1998	30.11.1998	30.12.1998
F(1)						81,669			83,189	83,588	84,006
	F(2)						95,809			97,592	98,080
		F(3)						76,668			78,095
			F(4)						42,440	42,643	42,856
				F(5)						39,324	39,520
					F(6)						33,598
						F(7)			22,064	22,170	22,281
							F(8)			34,630	34,803
								F(9)			33,831
									F(10)		35,407
										F(11)	32,925
											80,410
End of year values of monthly connection charges in 1998											615,813

Table G-3 End of year values of monthly connection charges in 1999

30.01.1999	30.02.1999	30.03.1999	30.04.1999	30.05.1999	30.06.1999	30.07.1999	30.08.1999	30.09.1999	30.10.1999	30.11.1999	30.12.1999
F(1)						45,429			46,603	46,962	47,324
	F(2)						75,962			77,925	78,526
		F(3)						61,100			62,680
			F(4)						42,841	43,172	43,504
				F(5)						79,943	80,560
					F(6)						73,807
						F(7)			69,385	69,920	70,459
							F(8)			54,764	55,186
								F(9)			59,341
									F(10)		54,377
										F(11)	58,642
											74,256
End of year values of monthly connection charges in 1998											758,662

Table G-4 End of year values of monthly connection charges in 2000

30.01.2000	30.02.2000	30.03.2000	30.04.2000	30.05.2000	30.06.2000	30.07.2000	30.08.2000	30.09.2000	30.10.2000	30.11.2000	30.12.2000
F(1)						48,898			49,951	50,304	50,661
	F(2)						50,474			51,560	51,925
		F(3)						42,680			43,783
			F(4)						34,873	35,120	35,369
				F(5)						31,798	32,024
					F(6)						30,657
						F(7)			30,976	31,196	31,417
							F(8)			31,155	31,375
								F(9)			30,510
									F(10)		50,721
										F(11)	35,837
											22,895
End of year values of monthly connection charges in 2000											447,174

Table G-5 End of year values of monthly connection charges in 2001

30.01.2001	30.02.2001	30.03.2001	30.04.2001	30.05.2001	30.06.2001	30.07.2001	30.08.2001	30.09.2001	30.10.2001	30.11.2001	30.12.2001
F(1)						37,796			38,956	39,151	39,281
	F(2)						18,425			18,990	19,054
		F(3)						22,493			23,120
			F(4)						23,496	23,614	23,693
				F(5)						45,964	46,117
					F(6)						7,739
						F(7)			5,949	5,978	5,998
							F(8)			58,103	58,296
								F(9)			6,992
									F(10)		27,759
										F(11)	38,100
											78,209
End of year values of monthly connection charges in 2001											374,357

Table G-6 End of year values of monthly connection charges in 2002

30.01.2002	30.02.2002	30.03.2002	30.04.2002	30.05.2002	30.06.2002	30.07.2002	30.08.2002	30.09.2002	30.10.2002	30.11.2002	30.12.2002
F(1)						18,212			18,366	18,418	18,467
	F(2)						6,777			6,834	6,853
		F(3)						12,450			12,555
			F(4)						47,036	47,168	47,296
				F(5)						14,149	14,187
					F(6)						14,828
						F(7)			8,679	8,703	8,727
							F(8)			14,297	14,336
								F(9)			24,683
									F(10)		33,557
										F(11)	43,256
											93,694
End of year values of monthly connection charges in 2002											332,439

Table G-7 End of year values of monthly fix charges in 1997

30.01.1997	30.02.1997	30.03.1997	30.04.1997	30.05.1997	30.06.1997	30.07.1997	30.08.1997	30.09.1997	30.10.1997	30.11.1997	30.12.1997
F(1)						70			71	72	72
	F(2)						2,525			2,562	2,574
		F(3)						14,523			14,766
			F(4)						9,433	9,478	9,523
				F(5)						10,495	10,545
					F(6)						10,285
						F(7)			9,786	9,833	9,880
							F(8)			6,637	6,668
								F(9)			8,287
									F(10)		12,922
										F(11)	25,235
											55,310
End of year values of monthly fix charges in 1997											166,068

Table G-8 End of year values of monthly fix charges in 1998

30.01.1998	30.02.1998	30.03.1998	30.04.1998	30.05.1998	30.06.1998	30.07.1998	30.08.1998	30.09.1998	30.10.1998	30.11.1998	30.12.1998
F(1)						28,131			28,655	28,792	28,936
	F(2)						42,326			43,114	43,329
		F(3)						29,449			29,997
			F(4)						23,349	23,461	23,579
				F(5)						22,188	22,298
					F(6)						22,359
						F(7)			20,340	20,437	20,539
							F(8)			24,909	25,034
								F(9)			24,260
									F(10)		23,578
										F(11)	23,668
											124,822
End of year values of monthly fix charges in 1998											412,400

Table G-9 End of year values of monthly fix charges in 1999

30.01.1999	30.02.1999	30.03.1999	30.04.1999	30.05.1999	30.06.1999	30.07.1999	30.08.1999	30.09.1999	30.10.1999	30.11.1999	30.12.1999
F(1)						61,926			63,527	64,016	64,510
	F(2)						57,513			59,000	59,454
		F(3)						60,998			62,574
			F(4)						49,418	49,799	50,183
				F(5)						49,185	49,564
					F(6)						44,672
						F(7)			49,376	49,757	50,140
							F(8)			44,238	44,579
								F(9)			45,777
									F(10)		44,592
										F(11)	59,552
											170,796
End of year values of monthly fix charges in 1999											746,393

Table G-10 End of year values of monthly fix charges in 2000

30.01.2000	30.02.2000	30.03.2000	30.04.2000	30.05.2000	30.06.2000	30.07.2000	30.08.2000	30.09.2000	30.10.2000	30.11.2000	30.12.2000
F(1)						78,317			80,003	80,570	81,141
	F(2)						66,992			68,434	68,919
		F(3)						68,146			69,907
			F(4)						66,330	66,800	67,273
				F(5)						69,105	69,594
					F(6)						58,725
						F(7)			57,942	58,352	58,765
							F(8)			54,761	55,148
								F(9)			48,693
									F(10)		64,151
										F(11)	75,253
											267,790
End of year values of monthly fix charges in 2000											985,360

Table G-11 End of year values of monthly fix charges in 2001

30.01.2001	30.02.2001	30.03.2001	30.04.2001	30.05.2001	30.06.2001	30.07.2001	30.08.2001	30.09.2001	30.10.2001	30.11.2001	30.12.2001
F(1)						97,261			100,245	100,747	101,082
	F(2)						79,844			82,294	82,568
		F(3)						22,493			23,120
			F(4)						50,034	50,284	50,452
				F(5)						57,477	57,669
					F(6)						45,654
						F(7)			41,022	41,227	41,365
							F(8)			35,219	35,336
								F(9)			36,825
									F(10)		50,834
										F(11)	151,809
											172,190
End of year values of monthly fix charges in 2001											848,904

Table G-12 End of year values of monthly fix charges in 2002

30.01.2002	30.02.2002	30.03.2002	30.04.2002	30.05.2002	30.06.2002	30.07.2002	30.08.2002	30.09.2002	30.10.2002	30.11.2002	30.12.2002
F(1)						208,141			209,902	210,492	211,062
	F(2)						135,030			136,173	136,542
		F(3)						86,663			87,396
			F(4)						87,018	87,262	87,499
				F(5)						75,008	75,211
					F(6)						60,284
						F(7)			56,978	57,138	57,293
							F(8)			56,685	56,838
								F(9)			116,122
									F(10)		58,729
										F(11)	163,096
											263,813
End of year values of monthly fix charges in 2002											1,373,885