A DECISION SUPPORT TOOL FOR FEASIBILITY ASSESSMENT OF HYDRO ELECTRICAL POWER PLANT PROJECTS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

NOYAN ERCAN

IN PARTIAL FULLFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
CIVIL ENGINEERING

DECEMBER 2011

Approval of the thesis:

A DECISION SUPPORT TOOL FOR FEASIBILITY ASSESSMENT OF HYDRO ELECTRICAL POWER PLANT PROJECTS

Submitted by **NOYAN ERCAN** in partial fulfillment of the requirements for the degree of **Master of Science in Civil Engineering Department, Middle East Technical University** by,

Examining Committee Members:

Prof. Dr. Canan Özgen ____________________
Dean, Graduate School of **Natural and Applied Sciences**

Prof. Dr. Güney Özcebe ____________________
Head of Department, **Civil Engineering**

Prof. Dr. M. Talat Birgönül ____________________
Supervisor, **Civil Engineering Dept., METU**

Prof. Dr. Irem Dikmen Toker ____________________
Co-Supervisor, **Civil Engineering Dept., METU**

Examining Committee Members:

Assoc. Prof. Dr. Rıfat Sönmez ____________________
Civil Engineering Dept., METU

Prof. Dr. M. Talat Birgönül ____________________
Civil Engineering Dept., METU

Prof. Dr. İrem Dikmen Toker ____________________
Civil Engineering Dept., METU

Assoc. Prof. Dr. Murat Gündüz ____________________
Civil Engineering Dept., METU

Gülşah Fidan, M.Sc. ____________________
METAG A.Ş.

Date: ____________________

I hereby declare that the information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all the material and results that are not original to this work

Name, Last name: NOYAN ERCAN

Signature:

ABSTRACT

A DECISION SUPPORT TOOL FOR FEASIBILITY ASSESSMENT OF HYDRO ELECTRICAL POWER PLANT PROJECTS

Ercan, Noyan
M.Sc Department of Civil Engineering
Supervisor: Prof. Dr. M. Talat Birgönül
Co-Supervisor: Prof. Dr. İrem Dikmen Toker

December 2011, 104 pages

The objective of this thesis is to develop a decision support tool to assess the feasibility of a hydro electrical power plant (HEPP) investment option by estimating its profitability under various scenarios. The decision support tool may help the decision makers to understand critical parameters that affect the internal rate of return (IRR) of a HEPP investment, create realistic scenarios by assigning different values to these parameters and monitor profitability under various scenarios. The information and the assumptions to construct the proposed decision support tool have been collected by conducting interviews with experts and its reliability has been tested by a real case study.

Keywords: Internal Rate of Return (IRR), HEPP, Feasibility, Risk Analysis

ÖZ

HİDRO ELEKTRİK SANTRAL PROJELERİNİN FİZİBİLİTE DEĞERLENDİRMESİNE YÖNELİK BİR KARAR DESTEK ARACI

Ercan, Noyan

Yüksek Lisans, İnşaat Mühendisliği Bölümü

Tez Yöneticisi: Prof. Dr. M. Talat Birgönül

Ortak Tez Yöneticisi: Prof. Dr. İrem Dikmen Toker

Aralık 2011, 104 sayfa

Bu tezin amacı, değişken koşullar altında yatırımın karlılığını hesaplayarak hidro elektrik santrali fizibilitesini değerlendiren bir karar destek aracı geliştirmektir. Bu karar destek aracının, karar verecek yatırımcıya, hidro elektrik santrali yatırımlarının iç verimlilik oranını etkileyen kritik parametrelerin anlaşılmasında, bu parametrelere çeşitli değerler atayarak gerçekçi senaryolar oluşturulmasında ve çeşitli senaryolarla karlılığın takibinde yardımcı olması amaçlanmıştır. Karar destek aracını oluşturmada kullanılan bilgiler ve kabuller, çeşitli uzmanlarla yapılan görüşmeler sonucunda toparlanmış ve aracın gerçekçiliği gerçek vakalarla denenerek doğrulanmıştır.

Anahtar Kelimeler: İç Verimlilik Oranı, HES, Fizibilite, Risk Analizi

ACKNOWLEDGMENTS

I would like to express my sincere thanks to my supervisors Prof. Dr. İrem Dikmen Toker and Prof. Dr. M. Talat Birgönül for their continuous support throughout my graduate studies. This thesis would not have been possible without their creative ideas and experience.

I would like to thank to my family; Neşe Ercan, Subutay Ercan and Batur Ercan for their endless support.

I wish to thank Murat Meral for his priceless ideas. His feedback was certainly fundamental to my success.

I would like to thank to my friends Berk Baltacı and Erdem Çuhadar for their irreplaceable friendship.

Finally, I would like to thank all the contractors and experts for sparing their invaluable time during the interview process.

Dedicated to Nercan, Sercan and Bercan…

TABLE OF CONTENT

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES

LIST OF ABBREVIATIONS

GDP	Gross Domestic Product
BOT	Build Operate Transfer
HEPP	Hydro Electrical Power Plant
IRR	Internal Rate of Return
NPV	Net Present Value
MARR	Minimum Attractive Rate of Return
PV	Present Value
FV	Future Value
EUAV	Equivalent Uniform Annual Value
B/C	Benefit/Cost
BCA	Benefit Cost Analysis
PP	Payback Period
PI	Profitability Index
ANP	Analytic Network Process
ICPRR	International Construction Project Risk Rating
CBR	Case Base Reasoning
GMR	Geometric Mean Revision
LIBOR	London Interbank Offered Rate
PC	Project Cost

FC	Facility Cost
EM	Electro Mechanical
CPM	Critical Path Method
MBA	Master of Business Administration

CHAPTER 1

INTRODUCTION

1.1 The Importance of Energy

The energy of the world is running out. The crisis of energy is not only the problem of one or two countries; it is the problem of the whole world. Population is increasing steadily, industrialization is becoming widespread and technology is becoming a part of the daily life. As a consequence, we are facing a serious energy crisis in the 21st century.

In fact, one of the biggest issues in the upcoming decade is the energy deficiency and the poor use of potential energy resources. Energy consumption, a fundamental component of the economic and social development, is growing parallel with increasing population, urbanization, industrialization, developing technology and increasing welfare. Energy is indispensible and it is one of the most important requirement for industry. However, insufficiency and infeasible use of the substantial energy resources elevate energy prices. Any fluctuations or a deficit in the energy can cause an increase in the industrial costs and decrease the chance of competition of national industrial products on the world scale.

1.2 Determinants of Electricity Demand

For better understanding of the topic, some of the determinants for electricity demand will be explained in more detail in this section.

1.2.1 Gross Domestic Product

The definition of gross domestic product **(**GDP) is the monetary, market value of all final goods and services produced in a country over one year period by both its citizens and foreigners. (Van den Bergh, 2008). GDP is one of the main parameters to measure and compare the welfare, living conditions, quality of life, richness of country, health rate, happiness rate, economic growth, income ratio and financial development of the countries (Van den Bergh, 2008; Demirhan *et al.*, 2011).

There are various studies which correlate economic growth and its impact on living standards with electricity consumption. In fact, it is also stated in Asian Development Bank (2003) that, “Empirical studies show that there should be a significant and stable correlation between GDP and electricity consumption.” (Table 1.1.) shows the top 20 countries in the world with the highest Gross Domestic Product and their annual electricity consumption.

Table 1.1: GDP vs. Electricity Consumption Projection by CIA’s The World Factbook

GDP Rank	**Country**	**GDP (Billion $)**	**E.C. Rank**	**Electricity Cons. (billion kWh)**
1	United States	$ 14,720	1	3.873,00
2	China	$ 9,872	2	3.438,00
3	Japan	$ 4,338	3	925,50
4	India	$ 4,046	5	568,00
5	Germany	$ 2,951	6	547,30
6	Russia	$ 2,229	4	857,60
7	Brazil	$ 2,194	9	404,30
8	United Kingdom	$ 2,189	11	345,80
9	France	$ 2,160	8	447,20
10	Italy	$ 1,782	12	315,00
11	Mexico	$ 1,560	19	181,50
12	Korea, South	$ 1,467	10	402,00

Table 1.1 Continued

13	Spain	$ 1,374	13	276,10
14	Canada	$ 1,335	7	536,10
15	Indonesia	$ 1,033	27	119,30
16	Turkey	$ 958,3	18	198,10
17	Australia	$ 889,6	15	222,00
18	Iran	$ 863,5	17	206,70
19	Taiwan	$ 807,2	14	229,80
20	Poland	$ 721,7	24	129,30

As stated above, GDP is an indicator of economic growth potential and the consequence of economic growth on living standards is an increase in the electricity consumption. The trend in Table 1.1indicates that 18 of the top 20 GDP Countries (except Indonesia and Poland) are also in the top 20 Electricity Consumption Projection rating list.

1.2.2 Population Growth

Population growth is the variability in the population of a country on an annual basis. "Population growth has substantial impact on electricity consumption." (Asian Development Bank, 2003). The high rate of population growth alone is the sign of danger for a country but if this data is supported with high GDP values, this shows a great potential for development. In order to meet the increasing infrastructure and resource needs of the population, government and private sector together should create and execute solutions, which end up with the developing national installed energy capacity.

1.3 The Place of Turkey In the Energy World

Table 1.1 represents that Turkey is at the 16th place with $958.3 billion GDP and has the largest national economy in Central and Eastern Europe. The rapid GDP growth of Turkey is shown in Figure 1.1. Though there is a sharp decrease in the growth rate in 2009 (mostly due to the 2009 world economic crisis), a steady and positive growth rate is apparent in the last decade.

Figure 1.1: Growth Rate of Turkey by TradingEconomics.com.

Turkey's rapidly growing GDP, as well as the developments of industrial sector lead to socio-economic development, which in turn improves the living standards. Improvement in life standards makes the technology and its requirements more available to people. Therefore, the improvement in living standards, in parallel with a growing population, causes an increase in electricity consumption. Turkey is at 17th place in the world ranking with a population of 77.804.122. The population growth rate is 1.27 %, which is 97th place in the world ranking but 2nd place in the top 20 GDP Country. This means that in the following years, the increasing population of Turkey will potentially create more serious economical problems compared to the other top 20 GDP countries in terms of infrastructure (schools, hospitals, houses, roads etc.) and resources (food, water, electricity etc.) (www.cia.gov)

Table 1.2: Population Growth Rate according to the CIA's The World Factbook.

Rank	**Country**	**Growth Rate**
89	India	1.38%
97	Turkey	1.27%
99	Iran	1.25%
107	Australia	1.17%
108	Brazil	1.17%
112	Mexico	1.12%
115	Indonesia	1.10%

Table 1.2 Continued

121	United States	0.97%
138	Canada	0.80%
151	United Kingdom	0.56%
152	France	0.53%
153	China	0.49%
154	Spain	0.49%
176	Korea, South	0.26%
183	Taiwan	0.21%
203	Poland	-0.05%
205	Germany	-0.06%
208	Italy	-0.08%
215	Japan	-0.24%
222	Russia	-0.47%

The trend in electric consumption data, when analyzed together with gross domestic product and population growth data is a clear indicator of Turkey's demand for energy. However, this data, itself, does not give reference to Turkey's status in energy demand. In order to understand the overall picture, it must be compared with other countries.

Table 1.3: Electricity Consumption Per Capita by CIA's The World Factbook

Country	**GDP Rank**	**E.C. Rank**	**Electricity Cons. (kWh per capita)**	**GDP (Billion $)**
United States	1	2	12.484,17	$ 14,720
China	2	15	2.584,68	$ 9,872
Japan	3	6	7.298,64	$ 4,338
India	4	20	484,18	$ 4,046
Germany	5	8	6.651,43	$ 2,951
Russia	6	9	6.152,51	$ 2,229
Brazil	7	17	2.010,41	$ 2,194
United Kingdom	8	11	5.546,25	$ 2,189

Table 1.3 Continued

France	9	7	6.904,60	$ 2,160
Italy	10	12	5.422,56	$ 1,782
Mexico	11	18	1.613,78	$ 1,560
Korea, South	12	5	8.265,47	$ 1,467
Spain	13	10	5.936,87	$ 1,374
Canada	14	1	15.879,86	$ 1,335
Indonesia	15	19	491,01	$ 1,033
Turkey	16	16	2.546,14	$ 958,3
Australia	17	3	10.318,02	$ 889,6
Iran	18	14	2.687,09	$ 863,5
Taiwan	19	4	9.980,47	$ 807,2
Poland	20	13	3.361,61	$ 721,7

Table 1.3 clearly shows that Turkey's electricity consumption per capita falls behind that of top 20 GDP countries' average, which is 5.830,99 kWh per capita. To solve this issue, several government ministries are working for a solution that will increase the electricity power production. The aim is to improve, Turkey's national energy policy by reevaluating energy resources in a more efficient, effective, safe, punctual and environment friendly manner. The aim is to reduce the dependency on foreign sources and make a significant contribution to the public welfare by supporting economical and social development of the country.

1.4 Developments in Turkey

Since 2004, there has been a serious improvement in the installed electricity capacity of Turkey, mostly driven by the private sector. The government introduced new incentives, worked steadily on privatization, removed various obstacles on the biding process and new policies were developed to encourage private capital.

Table 1.4: Annual Development of Turkey's Installed Electricity Capacity in MW as reported by TEİAŞ

YEAR	THERMAL	HYDRO	GEO. WIND	TOTAL	ANNUAL INC. %
1980	2.987,9	2.130,8		5.118,7	0,0
1981	3.181,3	2.356,3		5.537,6	8,18%
1982	3.556,3	3.082,3		6.638,6	19,88%
1983	3.695,8	3.239,3		6.935,1	4,47%
1984	4.569,3	3.874,8	17,5	8.461,6	22,01%
1985	5.229,3	3.874,8	17,5	9.121,6	7,80%
1986	6.220,2	3.877,5	17,5	10.115,2	10,89%
1987	7.474,3	5.003,3	17,5	12.495,1	23,53%
1988	8.284,8	6.218,3	17,5	14.520,6	16,21%
1989	9.193,4	6.597,3	17,5	15.808,2	8,87%
1990	9.535,8	6.764,3	17,5	16.317,6	3,22%
1991	10.077,8	7.113,8	17,5	17.209,1	5,46%
1992	10.319,9	8.378,7	17,5	18.716,1	8,76%
1993	10.638,4	9.681,7	17,5	20.337,6	8,66%
1994	10.977,7	9.864,6	17,5	20.859,8	2,57%
1995	11.074,0	9.862,8	17,5	20.954,3	0,45%
1996	11.297,1	9.934,8	17,5	21.249,4	1,41%
1997	11.771,8	10.102,6	17,5	21.891,9	3,02%
1998	13.021,3	10.306,5	26,2	23.354,0	6,68%
1999	15.555,9	10.537,2	26,2	26.119,3	11,84%
2000	16.052,5	11.175,2	36,4	27.264,1	4,38%
2001	16.623,1	11.672,9	36,4	28.332,4	3,92%
2002	19.568,5	12.240,9	36,4	31.845,8	12,40%
2003	22.974,4	12.578,7	33,9	35.587,0	11,75%
2004	24.144,7	12.645,4	33,9	36.824,0	3,48%
2005	25.902,3	12.906,1	35,1	38.843,5	5,48%
2006	27.420,2	13.062,7	81,9	40.564,8	4,43%

Table 1.4 Continued

2007	27.271,6	13.394,9	169,2	40.835,7	0,67%
2008	27.595,0	13.828,7	393,5	41.817,2	2,40%
2009	29.339,1	14.553,3	868,8	44.761,2	7,04%

Table 1.4 shows the development of Turkey's installed electricity capacity throughout the years. As can be observed, between the years 1990 to 2009, Turkey had a 237% increase, having the 9th place in the world. The enhancement in the installed electricity capacity of the renewable energy resources (which are basically: hydro energy, geothermal energy and wind energy) is can be seen after the 2004 national energy policy changes of the government. One of the biggest changes in the government policy towards energy production is in hydroelectric power generation. Governmental agencies have investigated all the rivers all around the country regardless of their sizes to enhance the hydroelectric power potential of Turkey. Gayer *et al.* (2009) stated that "In view of all the concerns associated with fossil fuels and energy demand, it is appropriate to investigate the large number of abandoned small hydropower plants". As a result of the investigation made through the last decade, a lot of small rivers have been found feasible to establish hydroelectric power plants.

Hydro-power plants play an important role for the economic and social development of a developing country (Forouzbakhsh *et al.* 2006). However, governments of many developing countries are not able to support these projects, mostly due to economical reasons. According to Xing and Wu (2002), the solution is encouraging the private sector to play a critical part in electricity generation through build-operate-transfer (BOT) method. This method is widely used in developing countries, such as China, Pakistan and Turkey. It not only creates a costless onset to the projects, but also divides the financial risks among different parties.

In Turkey, after 2007, with the help of governmental incentives, the power sector has become more attractive to the private investors. As Huang and Wu (2007) stated, throughout the history, the necessity of stable energy supply created a pressure over the energy prices and rising energy prices shifted the focus of authorities from the quantity to the risk management of fluctuating energy prices. This reality created the core of incentives and the governments tried to protect the investors from the risks associated with energy price fluctuations. “Turkish Government has made a strong step towards increasing electricity generation from renewable energy sources by publishing Turkish Renewable Energy Law. Hence, Turkey is aiming to connect to the grid 10.000 MW of wind capacity alone by 2020 and exploit its total hydropower potential by building more small hydropower plants” (Kucukali and Baris, 2009).

According to Turkish Water Report (2009), published by General Directorate of State Hydraulic Works, the overall installed hydroelectric power capacity of Turkey is nearly 45.000 MW. Currently, Turkey has 172 hydroelectric power plants in operation with total capacity of 13.700 MW, which is only 30% of the installed capacity. 148 hydroelectric power plants are under construction with an installed capacity of 8.600 MW and an additional 1.418 hydroelectric power plants will be built according to the future plans of governmental institutions.

1.5 Application Procedure for HEPP investments in Turkey

The procedures and principles of Water Use Right Agreements arranged between General Directorate of State Hydraulic Works (DSİ) and legal entities regarding the establishment of hydro-electric energy production facilities are based on the regulation which is entitled as “Elektrik Piyasasında Üretim Faaliyetinde Bulunmak Üzere Su Kullanım Hakkı Anlaşması İmzalanmasına İlişkin Usul ve Esaslar Hakkında Yönetmelik” (in Turkish). When an investor decides to make an investment for HEPP, the application procedure is explained in detail in the aforementioned regulation. To summarize, there are seven tables published on the web page of DSİ:

TABLE-1: HEPP projects of Turkey

TABLE-2: HEPP projects open to application.

TABLE-3: Projects developed by legal entities

TABLE-4: HEPP projects under construction

TABLE-5: HEPP projects on the scope of bilateral agreement

TABLE-6: HEPP projects on the scope of BOT

TABLE-7: Group HEPP projects

These seven tables are regularly examined by the investors. When an investor comes up with a potential project, an application is made to the DSİ in order to conclude a contract of Water Use Right Agreement. The steps are:

1. If the project is on TABLE-1, it is appealed with a petition to transfer the project into TABLE-2
2. If the project is on TABLE-2-3-4-5-6-7, it is appealed with the documents mentioned in the related regulation.

Those documents are:

a. Commercial registry gazette showing the establishment of the corporation
b. List of authorized signatures
c. Feasibility report
d. Feasibility control fee
e. Receipt of remuneration fee
f. Bid bond
g. Company address and contact details
h. Company tax identification number

After the appeal with above documents, DSİ opens the project to the application for 30 days. At the end of 30 days, the evaluation of the applications begins. The applicatans who provided all the required document are invited to a bid, where the highest bidder is entitled to sign Water Use Right Agreements. On the following steps, the investor organizes a final folder, which includes finalized feasibility report and environmental impact assessment. If the final folder is accepted, the investor has a right to sign Water Use Right Agreement and starts the construction.

1.6 Aim of the Thesis

The comprehensive studies and incentives of the governmental agencies to enhance hydropower capacity of Turkey is achieving its purpose. Many private investors, especially contractors who are intensely interested in hydro power, are waiting to invest on new hydro electric power plant. However, since profitability of every investment depends on feasibility studies and financial management, the poorly studied projects may lead to great economic losses.

During the construction period, the investors secure funding for the construction of the hydro electric power plant. Once the construction is over, the investors sell the generated electricity to the governmental agencies and cash inflow begins. However, it is important to state that operational, maintenance and renewal costs create a cash outflow for this investment. Munoz *et al.* (2009) mentioned that renewable energy investments have risks, such as electricity market price, investments cost and operational costs, and etc. In order to mitigate the effects of those risks, investors should pick projects which have the greatest possible rate of return.

The objective of this thesis is to develop a novel MS Excel based decision support system tool to monitor the profitability of an investment under various scenarios. With this study, the decision quality of a potential investor is aimed to be enhanced with a new methodology and a tool. The tool is intended to guide the investors throughout the “Invest or Don’t Invest” decision process and ensure them to make the most reliable decisions.

When a company comes up with an investment opportunity, they need to make an investment appraisal and gives an “invest or not decision” using various techniques as reported in the literature. Literature survey on the investment appraisal methods, tools and steps of the development process of the tool will be discussed in Chapter 2.

The fundamentals of the decision support tool and its sub-components are discussed in Chapter 3.

For the proper execution of the tool, a reliable database has to be created. In order to create a comprehensive and reliable database, face-to-face interviews have been conducted with experts. Detailed information related with the surveys is provided in Chapter 4.

Finding the components and creating a database lead to the modeling step. The modeling studies were conducted in the MS Excel. The general overview of the tool is introduced and explained in detail in Chapter 5.

In Chapter 6, a hypothetical project is studied to demonstrate how the tool can be used and the results can be analyzed.

Chapter 7 presents the findings of a real case study, results of which are used to make necessary revisions on the developed tool. The final version of the decision support tool and related revisions are depicted in Chapter 8.

Finally, the conclusions of this research; benefits, shortcomings and recommendations for further researchers are given in Chapter 9.

CHAPTER 2

LITERATURE SURVEY FINDINGS AND DEVELOPMENT OF THE DECISION SUPPORT TOOL FOR FEASIBILITY ASSESSMENT

Existing literature about the feasibility of the projects and investment appraisal tools can be grouped under mainly three categories, which are;

1. Investment appraisal methods and their utilization in different applications/areas,
2. Tools that can be used in the investment appraisal process
3. Case studies that demonstrate the utilization of the methodologies or the tools.

In this chapter, first, the process of investment appraisal will be discussed, then, literature survey findings will be presented and finally, the steps of the proposed decision support tool will be introduced.

2.1 What is investment appraisal?

Investment appraisal is basically the assessment of the project whether it is beneficial for the company or not. The investment decision is usually associated to strategic and tactical business decision; thus, it needs to be in accord with the desired long-term goal, which is usually the maximization of company profit. It can be extremely expensive and difficult to reverse an investment decision, so a comprehensive study and careful cost/profit assessment needs to be completed before reaching a final investment decision.

Tough, there are different appraisal techniques which help the investor assess the profitability of the investment. The key considerations in making investment decision are:

- How much will the investment cost? Are there funds available?
- How long will it be before the investment starts to yield returns?
- How long will it take to pay back the investment?
- What is the expected profit from the investment?
- Could the money spent for the investment yield higher returns elsewhere?

(http://www.thetimes100.co.uk/theory/theory--investment-appraisal--380.php)

2.2 Investment appraisal methods

Bas and Kahraman (2009) stated that *"Internal Rate of Return (IRR) method was one of the investment appraisal techniques to evaluate the acceptability of a single project which was characterized by the comparison of IRR with Minimum Attractive Rate of Return (MARR) of the company. Some other methods were Present Value (PV), Future Value (FV), Equivalent Uniform Annual Value (EUAV), Benefit/Cost Ratio (B/C Ratio) and Payback Period."*

Also according to Ruta *et al.* (2010) there are four main indicators which show the economical feasibility of the investment and they can be calculated either using cash flow method or cost-benefit method. These indicators are: Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period (PP), and Profitability Index (PI). Currently, net present value (NPV) and internal rate of return (IRR) are the most commonly used methods in almost all branches of investments as an investment appraisal tool.

2.3 Use of investment appraisal methods in different areas

Shinoda (2010) conducted a survey to find out which methods the investors use on the capital budgeting practices. The results of this study stated that *"Firms in Japan remained heavily dependent on payback period methods. This situation in Japan was similar to that in the U.S.A. Many firms in both Japan and U.S.A. combined discounted cash flow methods with non-discounted cash flow methods."*

Liang and Dijk (2010) used the ratio of benefits to costs (benefit-cost analysis, BCA) as an indicator of economical and financial feasibility of the decentralized wastewater reuse systems in Bejing.

Fong *et al.* (2005) conducted a research for the economic feasibility of an aquaculture operation, black pearl oyster farm. In the feasibility study, the initial capital of the investment and annual costs were formulated and an annual cash flow area was developed. The suggested profitability of the investment was found by using NPV method and as a result, the sensitivity analysis of the profit due to variable conditions was presented.

Paepe and Mertens (2007) claimed that the decision of installing cogeneration units to a power plant strictly depends on the economic feasibility of the investment. In this study, three types of cogeneration power plants were compared using the IRR of the investments.

As a methodology of economic feasibility of waste minimization of construction materials, Begum *et al.* (2006) used BCA analysis. In the study, all the benefits and costs were quantified in terms of monetary value. It was stated that "*The related data was collected through the interviews (using questionnaire) with project quantity surveyors, site supervisors and team of researchers that conduct site visits to survey the waste piles and obtain accurate information.*"

Kim (2008) tried to evaluate the economic feasibility of a new power generation technology known as integrated gasification combined cycle (IGCC), considering various potential business conditions. Traditional capital budgeting method, which was the calculation of NPV, was performed in this study to conduct a feasibility test. After finding the NPV, researchers evaluated the IRR of the project. The biggest problem was the fact that the results of the feasibility study were directly related with the current market system conditions. Since the research did not give a solution to such variable market conditions, it was advised to carry out the feasibility analysis with careful assessment of variable conditions.

According to Rebiasz (2005), "*Computer simulation seemed to be one of the most effective tools for risk appraisal. Simulation was based on repeated calculation of project effectiveness for randomly selected input parameters, and the probability* *distribution of the effectiveness measured thus calculated. Consequently, the probability of occurrence of unfavorable values of the effectiveness indicator and also measures of its variability such as a variance could be determined*." In this study, net present value (NPV) was selected as the investments appraisal method. A program was written in C++ programming language and optimization problems were solved by standard linear optimization package Lp-solve 5.1. The uncertain parameters and predictions related to future were obtained from the experts. The output of the computer simulation becomes the probability distribution of NPV. The major problem in this simulation was the determination of the uncertainty distributions of the forecasts.

Rebiasz (2005) tried to estimate the risk of investment projects. However the determination of uncertainty distributions was the fundamental practical problem in the simulation methods. To solve this problem, the NPV of the project, presented in the form of fuzzy numbers and fuzzy sets, was created.

Pantaleo et al. (2005) calculated the profitability of an investment with NPV and IRR. They conducted profitability analysis between the selected four off-shore wind farms and the one with IRR of 27% becomes the most profitable. At the end of the study, they observed that "*The high uncertainties in the investment and operational costs and in the expected wind farm availability made it difficult to accurately forecast the cost of energy for this kind of applications*"

After a comprehensive literature survey, it was realized that IRR was the method of choice in various studies as an investment appraisal method. IRR could be obtained by finding the inflow of the project, finding the outflow of the project, finding the NPV of the investment and evaluating the related rate of return, which made the NPV equal to zero. In this study, the greatest return was calculated by using IRR logic, which formed the foundation of the investment appraisal tool presented in this thesis.

Sarper *et al.* (2010) stated that "*The Internal Rate of Return (IRR) has long been used as one of the several major indices in determining the desirability of a given investment such as a new project or an incremental investment between two projects. It is defined as the interest paid or earned on the unrecovered balance such that the* *initial principal and interest are completely recovered with the final payment. This method solves the interest rate that equates the equivalent worth of cash inflows to the equivalent worth of the cash outflows*." However, there was still the risk of "change of the IRR components", which significantly altered the IRR of investment.

IRR is basically a mathematical formula that has lots of components, prone to change without the control of the investor. At the beginning of the investment during the decision making phase, investors create a most probable case and obtain an IRR for that case. The final decision on investment is given based on the IRR value. However, in the forthcoming months, the variable IRR components change the IRR value. The uncertainty of IRR is beyond debate. The computed IRR value at the beginning of the investment can turn out to be completely different at the end of the project. In order to increase reliability of the investment decisions, the uncertainties should be assessed.

2.4 Investment appraisal tools

Khan *et al.* (2010) created a decision support tool to help irrigators with making irrigation infrastructure investment decision. The tools has been analyzed, authorized and accepted by the irrigation community and researchers in Australia. It was claimed that the interface was flexible and allowed irrigators to iteratively define and analyze various water allocations, water pricing and water trading scenarios. Existing and new crop level information, modern irrigation technology level information, water trading prices and financial information was the input for the model. The output of the model was NPV, IRR, benefit-cost ratio (BCR) and payback period. In addition, the module also performed sensitivity analysis under different parameters.

Kilanc and Or (2008) said that *"investment decisions mainly depend on cash flow expectations of the investor and the dynamics of demand supply while policies, constraints and availabilities (regarding incentives, surcharges, taxes, primary energy reserves, real time pricing issues, seasonal effects, current plant portfolios of the producers, interest rates on debt) greatly influence these primary factors."* In that study, a SD-based simulation model was developed through Stella 7.01 R. Weighted cost of capital and NPV of the investment were found by a formula that has been defined to the program. The program also provided the user the opportunity to change the input variables and study the effect of a variety of problems on the electricity market. The simulation outputs of each scenario set were checked against the reference scenario set, and then impacts of the factors to the market were detected. Moreover, the simulation outputs were compared with different indicators, representing the behavior of the electricity market.

Researchers also investigated risk assessment for construction projects. Bu-Qammaz *et al*. (2009) used analytic network process (ANP) for the risk assessment of an international construction project as a part of a decision support tool for the bidding decision. Developing a risk assessment model that investigated different risk factors and their interrelations was aimed within the context of the research. In that study, modeling process was divided into four steps: i) risk identification, ii) risk categorization, iii) risk prioritization and iv) risk assessment. ANP technique was used during the prioritization, as well as assessment steps and software called international construction project risk rating (ICPRR) developed. The advantages of the tool was explained as "*The subjectivity associated with decision making could be reduced*." and "*ICPRR made it easy for decision makers to carry out risk-rating calculations and guided them through all steps of the risk assessment process*.".However, assumptions were made during the model and the subjectivity of input data was seen as a shortcoming of the study.

Ozorhon *et al.* (2006) emphasized the importance of organizational memory to make better a decision. In their study, a case-based reasoning (CBR) decision support tool was created to use the experiences of competitors to support international market selection decisions. It was said that *"Although many methods had been proposed to facilitate decision making during international project selection such as multiattribute decision-making tools, neural networks, etc., CBR was successfully used for the first time as a decision support tool that can predict potential profitability in overseas projects."* and added that *"it demonstrated how experiences of other companies and expert opinions might be incorporated into organizational memory and how CBR could be used to facilitate organizational learning in construction companies."*. As a shortcoming, the model required new input parameters for increased accuracy.

Munoz *et al.* (2011) created a decision making tool to evaluate the investment of a wind energy power plant. By using Weibull distribution, the uncertainty caused by wind regimes was simulated. Also by using Geometric Mean Reversion (GMR), the fluctuation on the market prices was estimated. By using these values, as well as other project specific values, such as maintenance and investment costs, NPV of the investment was calculated. The final decision of the investment was made by inserting volatility, strength of reversion and long-term trend of the NPV curve reflecting different periods to the trinomial investment option valuation tree. The tool allowed the investors of wind energy to decide whether to invest or not for variety of scenarios. The author finally stated that *"This model permitted an estimation of the best time to execute the investment within the projects lifetime, seeking the maximum profit and also an estimation of the probability that a specific future scenario took place."*

Alam and Doucette (2010) observed that the expected return of the investment often carried a high degree of uncertainty. Therefore, they formulated an investment decision problem in a stochastic dynamic programming framework and used policy iteration technique to get the optimum investment decision. They also tested the proposed method by making case studies with a reasonable test scenario. It was concluded that the algorithm was able to help users in taking an optimum investment decision by eliminating the uncertainty in the return of the investment.

Dikmen *et al.* (2008) developed a tool to demonstrate how learning from risks could be facilitated into practice. For this purpose, a database was developed and sources, events, consequences and vulnerability of the projects were defined. The created database was aimed to use in more effective risk management in the future projects.

In order to estimate bid mark up values more systematically, Dikmen *et al.* (2007) presented a decision support tool. With the contribution of 95 cases of Turkish contractors working in the international markets, a CBR model has been created and the factors that affect the bid mark-up decision was gathered under three groups: risk, opportunity and competition. These factors and any other factor relevant with these groups were defined as input of the model. In this research, ESTEEM Software version 1.4 was used to develop the CBR models due to its availability and user friendly interface.

There are many methods and tools that assess uncertainty, such as sensitivity analysis, Monte Carlo analysis, scenario analysis, NUSAP, PRIMA etc. (Van der Sluijs *et al.* 2004). However, in this study, a different tool will be utilized.

2.5 Steps of the Proposed Decision Support Tool

1. Since the tool would be based on the logic of IRR, identifying the components of IRR was the first step. By definition, the main components were inflow and outflow; and they would be explained in more detail in the 3rd Chapter.

2. After identifying the components of IRR, it was concluded that the fundamental components of IRR originate from “Quantity”, “Efficiency”, “Price” and “Time”. Therefore, as the second step, the change of the aforementioned values during the lifetime of the investment was studied.

3. In this study, the database of the variables that affect IRR components was developed with the contribution of the risk breakdown structure for international construction companies, as proposed by Dikmen and Birgonul (2006), and with the help of the contractors who had worked on similar projects. A survey was conducted among contractors and they were expected to answer questions related to the percentage changes of the quantity, efficiency, price and time values during the life of investment. The answers were used to build up the database of the tool. The results of the interviews would be presented in Chapter 4.

4. As the forth step, a MS Excel base software was prepared. After the definition of IRR components and their change values for the best and worst case, four “Changing Probability” values, which were “High, Medium, Low and Very Low”, were entered into the program.

5. The tool was tested on a hypothetical project to demonstrate how it worked and how the results could be interpreted.

6. The final version of the tool was tested on a real case study and interviews were made with experts to enhance this tool.

7. Finally, under the light of all the feedback and the test results, the tool was revised and finalized.

CHAPTER 3

FORMULIZATION OF IRR

3.1 Definition of IRR

Yumurtaci and Erdem (2006) indicated that "In build-operate-transfer model, the private sector undertakes all the liabilities regarding operation of the plant starting from the construction until transfer. All the economic risks that may arise during construction and operation are undertaken by the enterprise. Return of the investment in a predetermined period and, in order to achieve this return, determining the investment cost accurately is very critical for the enterprise in this model, in which it is assumed that all the monetary expenditures like escalation and interest burden and direct and indirect expenditures belong to the builder."

It is crucial that investors conduct detailed studies for the investment model. Since the investment model proposed in this thesis is based on IRR, the formulization of IRR is essential.

The concept of IRR is vague and not much understood in industry. It is typically accepted as a mathematical concept, which is prone to personal interpretation. However, the best explanation can be made by the simple definition of IRR itself (Johnstone, 2008).

Brealey and Myers (2003) defined IRR as: "IRR is a derived figure without any simple economic interpretation. If we wish to define it, we can do no more than say that it is the discount rate which applied to all cash flows makes NPV=0".

To better understand the IRR concept, one can think of a person who deposits 2000TL to his account with a 25% interest. He annually withdraws 1500TL, 850TL and 500TL during a three year period. At the end of the 3rd year, the balance is 0 TL. (See Table 3.1) It is easy to adapt this scenario to an IRR case. It can be said that this is an investment of 2000TL at the beginning. By earning annually 1500TL, 850TL, and 500TL, an investment having IRR of 25% is obtained (See Table 2.2).

Table 3.1: The tabular representation of above example

Account at the beginning of the year :	2000 TL	1000 TL	400 TL
Year :	**Year 2010**	**Year 2011**	**Year 2012**
Account at the end of the year (i=25%):	2500 TL	1250 TL	500 TL
Withdraw at the end of the year :	-1500 TL	-850 TL	-500 TL
Balance :	1000 TL	400 TL	0 TL

Table 3.2: The tabular representation of the above example's IRR cash-flow

Year	Inflow	Outflow	Cash-flow	IRR
0	-	2000	- 2000	**25%**
1	1500	-	1500	
2	850	-	850	
3	500	-	500	

For an investment, which has a multi-period cash flow, the IRR is simply the discount rate at which the net present value (NPV) of an investment's cash flow equals to zero. Since IRR is the discount rate to be calculated, the variable component of this computation is the cash flow, which is simply the difference between inflow and outflow.

3.2 Inflow Analysis: Revenues

Inflow can be determined as taxes subtracted from the money coming from the production. The production is equal to the annual production multiplied by the selling price. There are three main components of inflow. These are:

1. Annual production
2. Selling price and
3. Taxes

The following sections will assess these components in detail.

3.2.1 First Main Component of Inflow: Annual Production

Annual production is related with the discharge, net fall, and the efficiencies. The potential energy of water at the head of river creates an electrical energy at the tail. As stated by Küçükbeycan (2008), the energy of water, which is converted to power inside the turbine, can be calculated by the potential energy formula as:

- **P.E.(joule) = m(kg) * g(m/s^2) * H(m)**; The components of the potential energy can be written as:

  - **m(kg) = discharge(m^3/s) * 1 (s) * density(kg/m^3)** if two formulas concatenate and discharge taken not for 1 second but for 1 year and density of water taken as 1000kg/m^3,

    - **1 year = 60*60*24*356 second**; Formula should be taken not for one second, but for one year in order to calculate annual data.

    - **Density = 1000 kg/m3**

    - **Gravity (g) = 9.81 m/s^2**

- **P.E.(joule) = D(m^3/s) * (60*60*24*365 (s)) * 1000 kg/m^3 * 9.81(m/s^2) * H(m)**; In order to express energy(joule) in terms of power(watt), the below formulas are needed:
  - **Power (watt) * time (s) = Energy (joule)**
  - **1000(watt) * 60*60(s) =3,600,000(joule)**
  - **1kWh = 3,600,000(joule);** joule in this formula can be written in the above formula to change the unit from joule to kWh.

1kWh = D(m^3/s) * (60*60*24*365 (s)) * 1000 kg/m^3 * 9.81(m/s^2) * H(m) / 3.600.000 Further simplification yields**:**,

- **1kWh = D(~~m~~^{3}/s) * (60*60*24*365 (s)) * 1000 kg/~~m~~^{3} * 9.81(m/s^2) * H(m) / 3.600.000**

- **1 kWh = D * H * 85,935.60 (kg*m^2/s^2 or joule)**

It can be concluded that the energy produced in the river type hydro electrical power plants depends on the discharge and the height. Furthermore, it is necessary to add an efficiency coefficient to take into account the energy loss caused by the turbine, transformer, generator, regulation and etc. The final formula can be expressed as:

- **Energy Produced (kWh) = D * H * $Loss_{-coeff.}$ * 85,935.60 (kg*m^2/s^2 or joule)**

3.2.2 Second Main Component of Inflow: Selling Price

The income money is the money earned by selling the produced energy to the government or to the market. Therefore, a new parameter, ‘the selling price in $/kWh’ needs to be considered.

The information regarding the selling price of electricity is regulated in the Utilization of Renewable Energy Sources for the Purpose of Generating Electrical

Energy, Article 6, Section C (*Yenilenebilir Enerji Kaynaklarının Elektrik Enerjisi Üretimi Amaçlı Kullanımına İlişkin Kanun, 6.Madde, C Şıkkı*):

- "The price to be applicable to the electrical energy to be purchased within the scope of this law, for each year shall be the electricity average wholesale price in Turkey for the previously year as determined by Energy Market Regulation Authority-EMRA *(Enerji Piyasası Denetleme Kurulu-EPDK)*. However, such applicable price may not be less than the Turkish Lira equivalent of 5.00 Euro Cent per kWh and may not exceed the Turkish Lira equivalent of 5.50 Euro Cent per kWh. However, legal entities that hold licenses based on renewable energy resources and which have the opportunity to sell above the limit of 5.50 Euro Cent per kWh in the market shall benefit from this opportunity."

This is an incentive and a guarantee by the government to protect the investors from the energy market fluctuations and to encourage the investments. With this law, that it is guaranteed that the government will buy the electricity for at least 5.00 Euro Cent and it is possible to sell the electricity in the market even for a higher price.

3.2.3 Third Main Component of Inflow: Taxes

Though there are various kinds of tax which can directly or indirectly affect inflow, the scope of this study only covers the, income tax, which is 20% of the net profit.

3.2.4 Summary of Income Analysis

To summarize the formula for produced energy, all the components influencing the income can be listed as follows:

1. Discharge or Volume of water used
2. Water density
3. Gravitational acceleration
4. River head
5. KWh/joule ratio
6. Turbine efficiency
7. Transformer efficiency
8. Generator acceleration
9. Regulation coefficient
10. Loss coefficient
11. Sale price
12. Income taxes

It is noted that water density, gravitational acceleration, kWh/joule ratio are scientifically constants,

River head, turbine efficiency, transformer efficiency, generator efficiency regulation coefficient, lost coefficient are project specific values and they are decided during the design stage. They can also be regarded as constants which do not depend on external effects.

Sale price is announced by the government and the fluctuation risk is eliminated by defining a lower price. In this study, the selling price will be taken as 5.50 Euro Cent.

Water usage potential is also defined in the design stage by taking into account the hydrological and geological data of the basin. However, the real water volume depends strictly on the external effects. Weather conditions such as precipitation, evaporation, social conditions and etc., are some of the reasons for the volume of water to be unstable.

Finally, on the operation phase of a HEPP, the most important component influencing the income is the “volume of water used”. The other components are either a scientific constant or a constant defined on the design stage.

3.3 Outflow Analysis: Expenses

Expenses are all of the spending made during the lifetime of a structure. It includes construction costs, which are covered by the credit funding, operational costs, maintenance costs and any other overhead expenses.

There are three main components of expenses:

1. Equity capital

2. Credit payments

3. Operational-maintenance-renewal costs.

Before giving detailed information on expenses, the basic cost component, Investment Cost, is explained in the following section.

3.3.1 Subdivisions of Investment Cost

In a hydro electrical power plant feasibility study, the cost of the investment is divided into three categories: facility cost, project cost and investment cost. The components of investment cost are important because the main components of expenses, which are equity capital, credit payments and operational-maintenance-renewal cost, is composed by the subdivisions of investment cost. Before giving further details, the blow figure help to visualize the concepts.

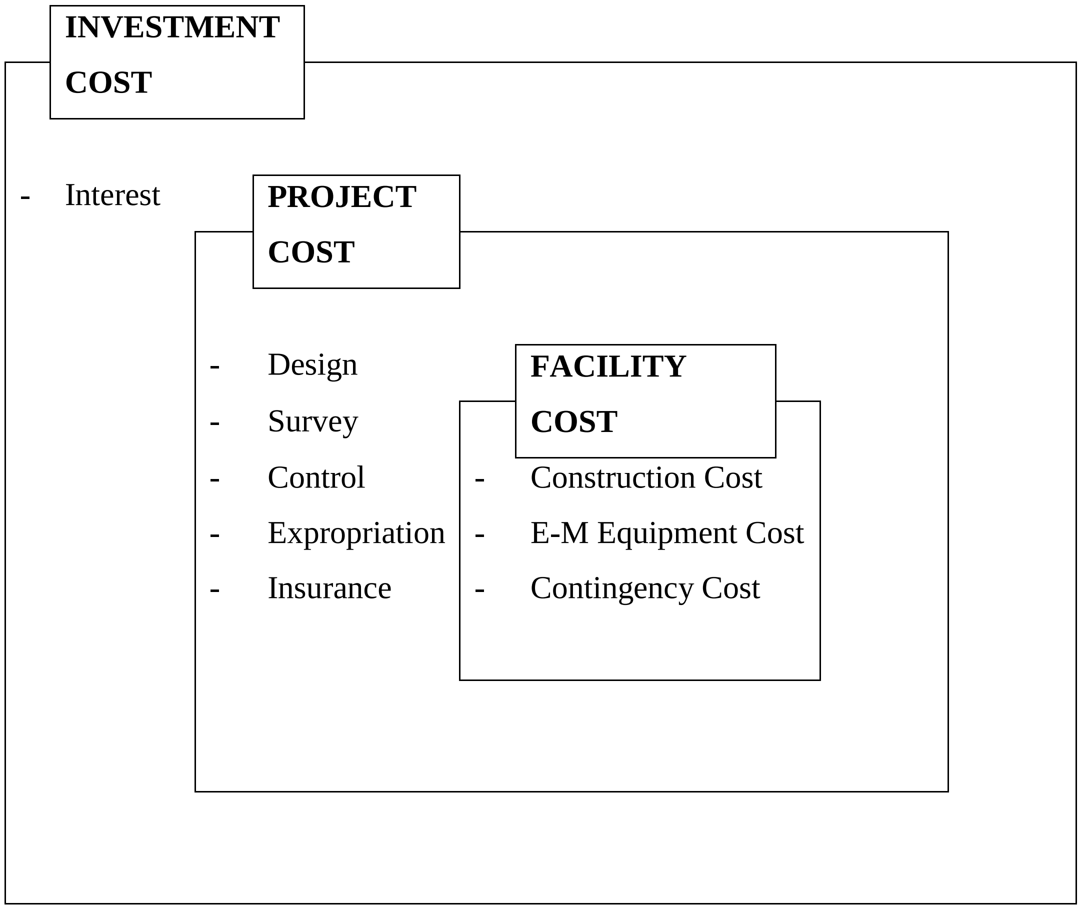


Figure 3.1: Subdivisions of investment cost

3.3.1.1 Facility Cost

Facility cost is composed of three subcomponents: Construction cost, electromechanical equipment cost and contingency cost.

3.3.1.1.1 Construction Cost

The construction cost consists of the earth works done by construction machines and the building practices conducted by construction workers, typically with concrete and steel. In general, the "Construction Cost" for a hydro electrical power plant consists of:

- Roads
- Permanent site
- Temporary site
- Regulator
- Derivation structure
- Sediment pool
- Water intake structure
- Gravel pass
- Spillway
- Transmission structure
- Forebay pool
- Penstock
- Power house
- Tail water canal

3.3.1.1.2 Electromechanical Equipment Cost

The facility contains power plant buildings and hydraulic structures, as well as the equipments, which produce and transmit electricity to the nearest power distribution unit. These equipments are:

- Electro-Mechanical equipment
- Energy transmission line

3.3.1.1.3 Contingency Cost

The amount of contingency is determined by the contractor. It increases the facility cost; yet it secures the contractor from an unexpected increase in the construction cost. Since every construction has its own unique features, the real cost and the anticipated cost rarely match at the end of the project. Therefore, the contingency cost is essential not to aggrieve the contractors economically. In this study, the contingency cost is taken as 20%, 15% of which is for the construction works and the rest is for the electromechanical works.

3.3.1.2 Project Cost

Aside from the production part, there are other parts of a project important to determine the project cost of a hydro electrical power plant; namely costs related to design, surveying, control and insurance.

3.3.1.2.1 Design

It is of the investors' responsibility to determine the preliminary and final design of a hydro electrical power plant. In this study, the cost of design is accepted to be 9% of the facility cost.

3.3.1.2.2 Surveying

The core data of design is gathered through field surveys. Therefore, surveying and design complement each other and have to be executed in parallel with the production process. In this study, the cost of surveying is coupled with the cost of control and is taken as 1% of the facility cost.

3.3.1.2.3 Control

As mentioned in the above subsection, the cost of surveying is couped with the cost of control and the total cost is accepted as 1% of the facility cost. It is noted that in cases where the investor is the controlled party, the investor does not spend any funding for the control service.

3.3.1.2.4 Insurance

Insurance is a fixed cost and set at the beginning of every construction project. In this study, it is assumed to be 0.7% of the construction cost.

3.3.1.2.5 Construction Overhead Expenses

Overhead expenses are the money spent on running the construction site. They include the payments of the workers, office expenses, dining hall expenses, site visiting expenses and etc. The general practice is paying it on monthly basis during the construction period.

3.3.1.2.6 Expropriation

This part of the project requires the investor to interact with local people. Basically, the investors try to persuade local people to sell their lands. While doing this, it is most critical that the social peace is maintained.

3.3.1.3 Investment Cost

3.3.1.3.1 Interest

Interest is the money paid to the credit company.

3.3.1.4 Summary of Investment Cost

To summarize, the aforementioned concepts (facility cost, project cost and investment cost) are subsets of each other, where the facility cost is a subset of the project cost and the project cost is a subset of investment cost. This explanation plays a critical role understanding of the components of "*Expenses".*

As mentioned in part 3.3, there are three main components of outflow: Equity capital, credit payments and operational-maintenance-renewal costs.

3.3.2 First Main Component of Outflow: Equity Capital

In order to be eligible for a bank loan, an investor has to pay an equity capital. The equity capital is composed of:

1. Project Cost

2. Credit Company's Equity Ratio (or Banks Equity Ratio).

As explained before, "*Project Cost"* is the detailed anticipated cost of the project at the final design stage. "Project Cost" does not include *"Interest"* because the companies provide loans from the "Project Cost". "Interest" is the cost need to be paid during the payback period due to the time value of the money.

3.3.2.1 Project Cost

The cost of the project and its components are explained in section 3.3.1.2.

3.3.2.2 Banks Equity Ratio

When an investor requests credit, the bank (or Credit Company) asks the investors to pay equity in order to support the project. This is a common risk assessment process for the banks not to carry the whole financial risk of the project. They do not provide credit for the whole project cost; instead, they share the financial risk of the project with the investor.

The "Equity Ratio" of the bank is decided by the banks' specialists. The banks usually ask investors to provide 25-30% of the project cost; however this percent depends highly on variables related with the reliability of the project, the company and the country. Before supporting a project, the bank or the credit company examines the profitability of the project by looking through the feasibility studies, the financial history of the company and the political/economical status of the country. Once the risk is assessed, the bank decides the *"Equity Ratio"*.

The components of an "*Equity Capital"* are *"Project Cost"* and *"Banks Equity Ratio"*. The detailed components can be listed as:

- Roads
- Permanent site
- Temporary site
- Regulator
- Derivation structure
- Sediment pool
- Water intake structure
- Gravel pass
- Spillway
- Transmission structure
- Forebay pool
- Penstock
- Power house

- Tail water canal
- Electro-Mechanical equipment

  - Energy transmission line
  - Contingency Cost
  - Design
  - Survey
  - Control
  - Expropriation
  - Insurances

- Project Risk (Profitability)
- Company Risk
- Country Risk

3.3.3 Second Main Component of Outflow: Credit Payments

This is the annual payments of the investors. The conditions of the credit contract directly affect the credit payments. As mentioned previously, the investors are responsible to assure some percentage of the Project Cost as per banks' equity ratio, and the rest is provided by the bank as a credit. Once the construction is completed or the investment starts to make money, the investor pays the credit back to the bank with annual payments specified in the credit contract.

The basic components of credit payments are:

1. Project Cost

2. Banks Equity Ratio

3. Banks Interest Rate

4. Payback Period

5. Duration of Construction

3.3.3.1 Project Cost

The cost of the project and its component are explained in the above chapters.

3.3.3.2 Banks Equity Ratio

The ratio of the bank or the credit company and its components are explained in part 3.3.2.2 Banks Equity Ratio

3.3.3.3 Banks Interest Rate

Banks decide the rate of interest after conducting studies about the project, the company and the country of the investment. As the risk for project increases, so does the interest rate.

Another parameter representing and indirectly affecting the interest rates is "LIBOR-London Interbank Offered Rate". In most of the financial transactions around the world, LIBOR is used as a reference interest rate. (http://www.bbalibor.com/bbalibor-explained/the-basics;Jordan, 2009). If an investor takes a loan with LIBOR+5% interest rate, it will be affected by the LIBOR on a yearly basis.

3.3.3.4 Payback Period

There can be variety of payback periods. The payback periods are determined during the negotiations between the investor and the bank. Investors usually do not want to start paybacks before the construction is over and the energy is produced. Banks, on the other hand, can be open to these kinds of payment schedules depending on the associated risks of a given project.

3.3.3.5 Duration of Construction

The project cost is sensible to the duration of the construction.

An example is given below to better understand the formulization of the credit payments. Variables are defined as:

- Credit Payments = x
- Number of Installments = n,

- ➢ Duration of construction = c,
- ➢ Interest Rate = i
- ➢ Project Cost = P.C.

In Figure 2.2, the credit payments are displayed with the letter x. The number of installments (n) is four and they are at the end of the 3rd, 4th, 5th and 6th years. The duration of construction is 2 years, the interest rate is i, and the project cost is P.C. Firstly, the summation, ∑ is found using the present value formula as given below:

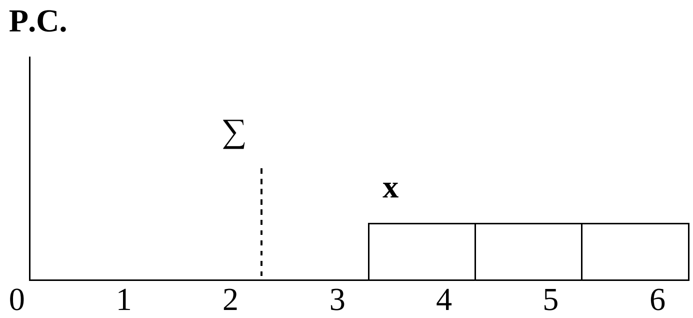


Figure 3.2: Scheme of an example investment

- $\sum = \frac{x}{(1+i)} + \frac{x}{(1+i)^2} + \frac{x}{(1+i)^3} + \frac{x}{(1+i)^4}$; take $\frac{x}{(1+i)}$ parenthesis
- $\sum = \frac{x}{(1+i)} + \left(1 + \frac{1}{(1+i)} + \frac{1}{(1+i)^2} + \frac{1}{(1+i)^3} \right)$; let $\frac{1}{(1+i)} = a$
- $\sum = (ax) \times (1 + a + a^2 + a^3)$; let $(1 + a + a^2 + a^3) = Q$
  - $Q = 1 + a + a^2 + a^3$
  - $a \times Q = a + a^2 + a^3 + a^4$; subtract those side by side
  - $Q - (a \times Q) = (1 + \cancel{a} + \cancel{a^2} + \cancel{a^3}) - (\cancel{a} + \cancel{a^2} + \cancel{a^3} + a^4)$
  - $Q(1-a) = (1 - a^4)$
  - $Q = \frac{(1-a^4)}{(1-a)}$; put “Q” in the above equation
- $\sum = (ax) \times \frac{(1-a^4)}{(1-a)}$; “a” can be written in the previous order which was $\frac{1}{(1+i)} = a$
- $\sum = \frac{x}{(1+i)} \times \frac{\left(1 - \frac{1}{(1+i)^4}\right)}{\left(1 - \frac{1}{(1+i)}\right)}$

- $\sum = \frac{x}{\cancel{(1+i)}}$ x $\frac{(1+i)^4-1}{(1+i)^4}$ x $\frac{\cancel{(1+i)}}{(\cancel{1}+i-\cancel{1})}$
- $\boldsymbol{\sum = (x) \text{ x } \frac{(1+i)^4-1}{(1+i)^4 \text{ x } (i)}}$

The summation of credit payments are shown in the second year. With the subsequent equations, this summation is shown in the year zero by using present value formula:

- $\sum = (x)$ x $\frac{(1+i)^4-1}{(1+i)^4 \text{ x } (i)}$
- P.C. = $\sum$ x $\frac{1}{(1+i)^2}$
- P.C. = (x) x $\frac{(1+i)^4-1}{(1+i)^4 \text{ x } (i)}$ x $\frac{1}{(1+i)^2}$; Credit Payment "x" is
- X = P.C. x $(1+i)^2$ x $\frac{(1+i)^4 \text{ x } (i)}{(1+i)^4-1}$; Number of Installments (n) = 4, Duration of Construction (c) = 2

$$\mathbf{X = P.C. \text{ x } (1+i)^c \text{ x } \frac{(1+i)^n \text{ x } (i)}{(1+i)^n - 1}}$$

To conclude, the components of the credit payments are:

- *Project Cost* (P.C.)
- *Interest Rate* (i)
- *Duration of Construction* (c)
- Number of Installments (n) or "*Payback Period*"

3.3.4 Third Main Component of Outflow: Operational - Maintenance - Renewal Cost

It is noted that the calculations for operational cost, maintenance cost and renewal cost show some variability between companies due to company policies.

3.3.4.1 Operational Cost

There are two components of operational cost: Personal expenses and overhead expenses.

3.3.4.1.1 Personal Expenses

To operate this type of organizations, there must be work force on the site to do the necessary interferences when the need arises. For security and operation purposes, three staffed workers are found to be appropriate with 2.000 TL/month salaries. The annual personal expenses are calculated as:

- **3 (workers) x 12(month) x 2.000 TL = 72.000 TL/year**

3.3.4.1.2 Overhead Expenses

For continued functioning of the business there are some necessary expenses such as travel expenses, gas/electricity expenses, telephone bills etc. In this study, 5.000 TL per month overhead expenses is found to be appropriate. The annual overhead expenses are calculated as:

- **12(month) x 5.000 TL = 60.000 TL/year**

3.3.4.2 Maintenance Cost

The facility of hydro electrical power plants, which is composed of all the buildings, hydraulic structures, mechanical and electronic components, needs maintenance and repairing. In this study, for maintenance expenses, 1% of facility cost per year is found to be appropriate. The annual maintenance cost is calculated as:

- **Maintenance Cost = Facility Cost (TL) x Maint. Coefficient (1%)**

3.3.4.3 Renewal Cost

In this study, it is assumed that there will be the renewal cost which will be spent annually and will be equal to the facility cost at the end of 50th year. In other words at the end of the operational life, the facility has to be renewed before transferring to the government. Thus in the cash flow, at the 50th year there will be a renewal cost for the facilities. The formulization of that financial movement in yearly basis during the life of investment is displayed in Figure 2.3.

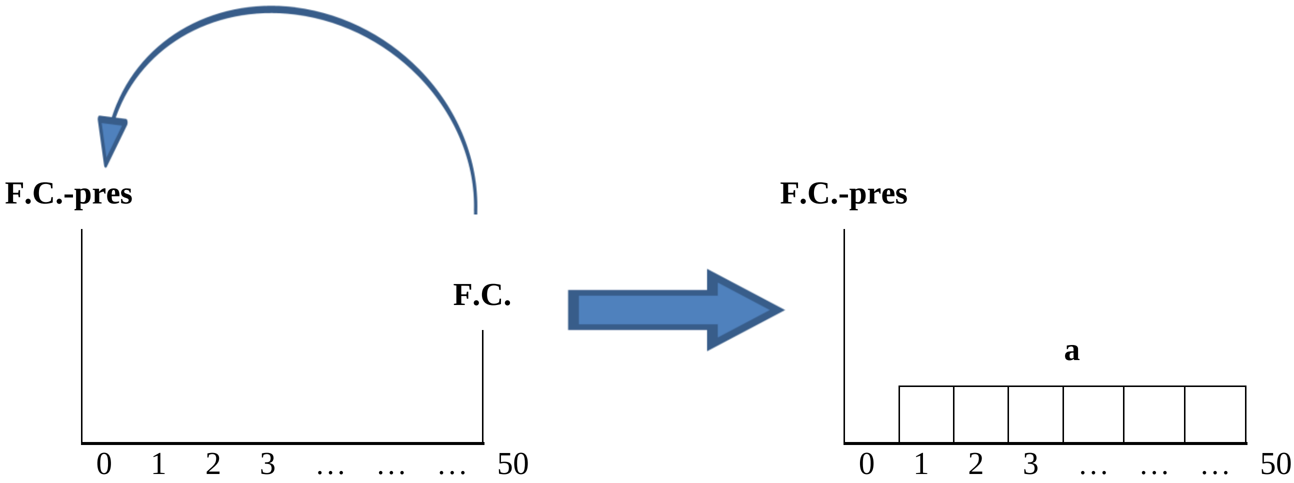


Figure 3.3: Scheme of renewal cost

- F.C.-pres = $\frac{F.C.}{(1+i)^{50}}$; Renewal cost at the end of the 50th year carried to the year 0.
- F.C.-pres = (a) x $\frac{(1+i)^{50}-1}{(1+i)^{50} \text{ x (i)}}$; Rnw-pres can also be shown with annual payments
- $\frac{F.C.}{(1+i)^{50}}$ = (a) x $\frac{(1+i)^{50}-1}{(1+i)^{50} \text{ x (i)}}$
- a = F.C. x $\frac{1}{\cancel{(1+i)^{50}}}$ x $\frac{\cancel{(1+i)^{50}} \text{ x (i)}}{(1+i)^{50}-1}$; this makes the annual payments of renewal cost:

a = Facility Cost x $\frac{\boldsymbol{i}}{\boldsymbol{(1+i)^{50}-1}}$

The formula shows that the renewal cost depends on the facility cost, the discount rate and life of the investment. In this study the discount rate is taken as 9.5% and the life of the investment is taken as 50 years. When those data is put to the related place in the formula, the renewal coefficient becomes 0.001027. This makes the annual renewal cost:

- **Renewal Cost = Facility Cost (TL) x Renew. Coefficient (0.001027)**

3.3.5 Summary of IRR Components List

The list of IRR components are summarized as:

Income Related

1. Volume of water used
2. Water Density
3. Gravitational acceleration
4. River head of Fall
5. kWh/joule ratio
6. Turbine efficiency
7. Transformer efficiency
8. Generator efficiency
9. Regulation coefficient
10. Loss coefficient
11. Sale price
12. Income tax

Construction Related

13. Excavation & Fill (Unit cost-Quantity-Delay)
14. Explosion (Unit cost-Quantity-Delay)
15. Concrete (Unit cost-Quantity-Delay)
16. Formwork (Unit cost-Quantity-Delay)
17. Reinforcing Steel (Unit cost-Quantity-Delay)
18. Steel equipment (Unit cost-Quantity-Delay)
19. Concrete transportation (Unit cost-Quantity-Delay)
20. Steel transportation (Unit cost-Quantity-Delay)
21. Excavation transportation (Unit cost-Quantity-Delay)
22. EM Equipment (Cost-Delay)
23. Energy transition lines (Unit cost-Quantity-Delay)

24. Contingency cost
25. Expropriation (Unit cost-Quantity-Delay)
26. Mobilization (Cost-Delay)
27. Design (Cost-Delay)
28. Survey (Cost-Delay)
29. Control (Delay)
30. Equity ratio
31. Interest rate
32. Number of installments
33. Insurances
34. Duration of Construction
35. Maintenance coefficient
36. Renewal coefficient
37. Overhead expenses
38. Personnel expenses

However, since every project is unique, it is likely to have changes in the components, which can in turn affect the IRR. These effects can range from being significant amounts to negligible quantities. Generally, as a project progresses, the investors face many unpredicted problems. The important questions are if the actual IRR would be the same with the reference case IRR and if the computations and the predictions made in the reference case stage were accurately? Despite the fact that the answer to those questions plays a crucial role in "Make the Investment or Don't Make the Investment" decision, it cannot be given unless the investment life comes to an end. Therefore, the aim of the model proposed in this study is to predict the answers to these questions.

After the establishment of the IRR components, it is required to address the following question: Which variables change the values of IRR components and in what rate do they affect? In that sense, two factors should be considered:

1. The variability of the conditions.
2. The effect of variable conditions on the IRR components (sensitivity).

CHAPTER 4

DATA COLLECTION BY CONDUCTING INTERVIEWS

Generally, the investors can not foresee the future values of all the factors (or variable conditions) that can possibly change the IRR. Furthermore, even if they can anticipate some of the factors; they cannot know how much the variable conditions may affect the IRR. To find a solution to this problem and to create a decision support tool, large amount of data had to be collected.

In this study, face-to-face interviews are preferred for data gathering procedure since the questionnaire sent via e-mails usually are not responded or the questions that are not fully understood are neglected. The instant receipt of the answers and the brainstorming atmosphere of face-to-face interviews remarkably increased the credibility of the survey.

Interview process consists of two stages. They both include face-to-face interviews with the contractors, however, the content of the interviews are different from each other. In the first stage, the primary aim is to identify the variable conditions that can potentially affect the IRR component. In the second stage, the amounts of the effect of variables are aimed to be evaluated.

In the selection of the interviewees, the experts who built or currently building hydro-electrical power plants are preferred. The experts chose for the interviews are either the owners or the general managers of their companies. Majority of the experts have at least 20 years of experience in the construction field.

At the beginning of the interviews, the aim of the study is briefly to capture the attention of the interviewees to the related subject. It took around one hour to finish an interview with satisfactory results. In the first stage, the IRR components are introduced to the experts and asked their opinion about the potential variables which can change those IRR components. In addition, at the beginning of this stage, since there are 38 components, a guideline, which has 11 topics to be developed, has been prepared with the help of the table that is published by Dikmen *et al.* (2007) in order to help the experts estimate the variables more accurately and quickly. In that study the factors that affect bidding decision of the contractors are studied comprehensively. For each of the 38 IRR components, the related topics are discussed individually and the subtopics are found and noted. After interviewing with 20 experts, all the answers are gathered. The profiles of the experts are shown in Table 4.1

Table 4.1: Profiles of the experts that participated in this study

	Title	Profession	Age Range
Profile # 1	Owner	Civil Eng.	+ 50
Profile # 2	Owner	Civil Eng.	+ 50
Profile # 3	Owner	Civil Eng.	+ 50
Profile # 4	Owner	Mech. Eng.	+ 50
Profile # 5	Owner	Mech. Eng.	+ 50
Profile # 6	Owner	Mech. Eng.	+ 50
Profile # 7	Owner	Elect. Eng.	+ 50
Profile # 8	General Man.	Civil Eng.	+ 50
Profile # 9	General Man.	Civil Eng.	30 - 40
Profile # 10	General Man.	Civil Eng.	30 - 40
Profile # 11	General Man.	Civil Eng.	40 - 50
Profile # 12	General Man.	Mech. Eng.	40 - 50
Profile # 13	Manager	Civil Eng.	30 - 40
Profile # 14	Manager	Civil Eng.	30 - 40
Profile # 15	Manager	Civil Eng.	40 - 50
Profile # 16	Manager	Civil Eng.	40 - 50
Profile # 17	Manager	Civil Eng.	40 - 50
Profile # 18	Engineer	Civil Eng.	40 - 50
Profile # 19	Engineer	Civil Eng.	+ 50
Profile # 20	Engineer	Civil Eng.	+ 50

Some of the subtopics that are not mentioned or accepted by majority of the experts during face-to-face interviews are excluded from the list and the final version of the "IRR Variables Table" with 44 subtopics is built.

In the second stage, it is aimed to identify the lower and upper change percentage boundaries of the related IRR components' cost, quantity, duration and other related values. For every variable, it is requested from the experts to assume that 0% change of the value of IRR component would be accepted for the most probable case where there is no unpredicted positive or negative change of the IRR variables (expected values). Then, experts are asked to consider the worst and best change values of the IRR components. It gets very difficult since there are 44 variables affecting 38 components, which give a total of 1672 combinations However, at the end of the survey, since every variable does not affect each component, 202 relations were found that had to be determined.

The final "Change Percentage" results are found to be biased depending on the personal experience of the experts and subjective judgments. The average values are found to minimize the effect of outliers.

The questions and the finalized average answers to the survey are presented in Figure 4.1 to Figure 4.44. The best and the worst case scenario results are presented in the upper and lower sides of the boxes, respectively. Moreover, there are boxes that display the delay values for the associated IRR components.

What is the probability of experiencing a change in steel price?			
If there is a change in steel prices, in what rate would it effect the IRR components' given feature?			
Q1	**Change in Steel Price**		
17	* Reinforcing steel (%48 workmanship)	Unit Cost	40% -25%
18	* Steel equipments (Penstock, gates..)	Unit Cost	30% -15%
22	EM Equipment	Cost	5% -5%
23	Eng Trans. Line	Unit Cost	30% -30%

Figure 4.1 Result of the survey showing "Change in Steel Price".

What is the probability of experiencing a change in concrete price?			
If there is a change in concrete prices, in what rate would it effect the IRR components' given feature?			
Q2	**Change in Concrete Price**		
15	* Concrete (%21 workmanship)	Unit Cost	10% -10%

Figure 4.2 Result of the survey showing "Change in Concrete Price"

What is the probability of experiencing a remarkable change in diesel oil price?			
If there is a remarkable change in diesel oil prices, in what rate would it effect the IRR components' given feature?			
Q3	**Change in Diesel Oil Price**		
13	* Excavation & Fill	Unit Cost	30% -30%
19	* Concrete transp.	Unit Cost	30% -30%
20	* Steel transp.	Unit Cost	30% -30%
21	* Excavation transp.	Unit Cost	30% -30%

Figure 4.3 Result of the survey showing “Change in Diesel Oil Price”

What is the probability of experiencing a change in labour costs?			
If there is a change in labour costs, in what rate would it effect the IRR components' given feature?			
Q4	**Change in Labour Cost**		
15	* Concrete (%21 workmanship)	Unit Cost	2% 0%
17	* Reinforcing steel (%48 workmanship)	Unit Cost	5% 0%
38	Personel Expenses	Cost	10% 0%

Figure 4.4 Result of the survey showing “Change in Labour Cost”

What is the probability of experiencing a change in service costs?			
If there is a change in service costs, in what rate would it effect the IRR components' given feature?			
Q5	**Change in Service Cost**		
14	* Explosion	Unit Cost	15% -5%
16	* Formwork	Unit Cost	15% -5%
23	Eng Trans. Line	Unit Cost	10% -5%

Figure 4.5 Result of the survey showing “Change in Service Cost”

What is the probability of experiencing a change in selling prices?			
If there is a change in selling prices, in what rate would it effect the IRR components' given feature?			
Q6	**Change in Selling Price**		
15	* Concrete (%21 workmanship)	Unit Cost	10% -5%
18	* Steel equipments (Penstock, gates..)	Unit Cost	10% -5%
22	EM Equipment	Cost	10% -5%

Figure 4.6 Result of the survey showing “Change in Selling Price”

What is the probability of experiencing a remarkable change in the exchange rate of $/TL ?			
If there is a remarkable change in $/TL rate, in what rate would it effect the IRR components' given feature?			
Q7	**Change in $/TL**		
13	* Excavation & Fill	Unit Cost	30% -30%
14	* Explosion	Unit Cost	30% -30%
15	* Concrete (%21 workmanship)	Unit Cost	30% -30%
16	* Formwork	Unit Cost	30% -30%
17	* Reinforcing steel (%48 workmanship)	Unit Cost	15% -15%
18	* Steel equipments (Penstock, gates...)	Unit Cost	15% -15%
19	* Concrete transp.	Unit Cost	5% -5%
20	* Steel transp.	Unit Cost	5% -5%
21	* Excavation transp.	Unit Cost	5% -5%
23	Eng Trans. Line	Unit Cost	10% -10%
25	Expropriation	Unit Cost	30% -30%
26	Mobilization	Cost	30% -30%
27	Design	Cost	30% -30%
28	Survey	Cost	30% -30%
33	Insurances	Cost	30% -30%
35	Maintenance Expenses		
36	Renewal Expenses		
37	Overhead Expenses	Cost	30% -30%
38	Personel Expenses	Cost	30% -30%

Figure 4.7 Result of the survey showing “Change in $/TL”

What is the probability of experiencing a remarkable change in the exchange rate of $/€ ?			
If there is a remarkable change in $/€ rate, in what rate would it effect the IRR components' given feature?			
Q8	**Change in $/€**		
22	EM Equipment	Cost	15% -15%

Figure 4.8 Result of the survey showing “Change in $/€”

What is the probability of experiencing a remarkable change in the exchange rate of €/TL ?			
If there is a remarkable change in €/TL rate, in what rate would it effect the IRR components' given feature?			
Q9	**Change in €/TL**		
11	Sale Price	Sale price	25% -25%

Figure 4.9 Result of the survey showing “Change in €/TL”

What is the probability of experiencing a change in LIBOR?			
If there is a change in LIBOR, in what rate would it effect the IRR components' given feature?			
Q10	**Change in LIBOR**		
31	Interest Rate	Point	3% -3%

Figure 4.10 Result of the survey showing "Change in LIBOR"

What is the probability of experiencing a remarkable change in inflation rate?			
If there is a remarkable change in inflation rate, in what rate would it effect the IRR components' given feature?			
Q11	**Change in Inflation Rates**		
13	* Excavation & Fill	Unit Cost	5% -5%
14	* Explosion	Unit Cost	5% -5%
15	* Concrete (%21 workmanship)	Unit Cost	5% -5%
16	* Formwork	Unit Cost	5% -5%
17	* Reinforcing steel (%48 workmanship)	Unit Cost	5% -5%
18	* Steel equipments (Penstock, gates...)	Unit Cost	5% -5%
19	* Concrete transp.	Unit Cost	5% -5%
20	* Steel transp.	Unit Cost	5% -5%
21	* Excavation transp.	Unit Cost	5% -5%
22	EM Equipment	Cost	5% -5%
23	Eng Trans. Line	Unit Cost	5% -5%
25	Expropriation	Unit Cost	5% -5%
26	Mobilization	Cost	5% -5%
27	Design	Cost	5% -5%
28	Survey	Cost	5% -5%
33	Insurances	Cost	5% -5%
35	Maintenance Expenses		
36	Renewal Expenses		
37	Overhead Expenses	Cost	5% -5%
38	Personel Expenses	Cost	5% -5%

Figure 4.11 Result of the survey showing "Change in Inflation Rate"

What is the probability of experiencing a change in tax rates?			
If there is a change in tax rates, in what rate would it effect the IRR components' given feature and duration?			
Q12	**Change in Income Tax Rates**		
12	Income Taxes	Ratio	5% -5%

Figure 4.12 Result of the survey showing "Change in Tax Rates"

What is the probability of experiencing a change in workforce productivity in your project?			
If there is a change in workforce productivity, in what rate would it effect the IRR components' given feature and duration?			
Q13	**Change in Productivity of Workforce**		**Delay %**
15	* Concrete (%21 workmanship)	Delay %	10% -5%
16	* Formwork	Delay %	10% -5%
17	* Reinforcing steel (%48 workmanship)	Delay %	10% -5%
18	* Steel equipments (Penstock, gates...)	Delay %	10% -5%

Figure 4.13 Result of the survey showing "Change in Productivity of Workforce"

What is the probability of experiencing a change in equipment productivity in your project?				
If there is a change in equipment productivity, in what rate would it effect the IRR components' given feature and duration?				
Q14	**Change in Productivity of Equipment**			**Delay %**
6	Turbine Eff.	Efficiency	-5% 0%	-
7	Transfor. Eff.	Efficiency	-5% 0%	-
8	Generator Eff.	Efficiency	-5% 0%	-
9	Regulation Coeff.	Coefficient	-5% 0%	-
10	Loss Coeff.	Coefficient	-5% 0%	-
13	* Excavation & Fill	Unit Cost	10% -5%	10% -5%

Figure 4.14 Result of the survey showing “Change in Productivity of Equipment”

What is the probability of experiencing a change in design in your project?				
If there is a change in design, in what rate would it effect the IRR components' given feature and duration?				
Q15	**Change in Design**			**Delay**
13	* Excavation & Fill	Quantity	30% -30%	30% -30%
14	* Explosion	Quantity	30% -30%	30% -30%
15	* Concrete (%21 workmanship)	Quantity	10% -10%	10% -10%
16	* Formwork	Quantity	10% -5%	10% -5%
17	* Reinforcing steel (%48 workmanship)	Quantity	10% -5%	10% -5%
18	* Steel equipments (Penstock, gates...)	Unit Cost	25% 0%	4 w
		Quantity	5% -5%	
19	* Concrete transp.	Quantity	10% -10%	-
20	* Steel transp.	Quantity	10% -5%	-
21	* Excavation transp.	Quantity	30% -30%	-
23	Eng Trans. Line	Unit Cost	10% 0%	100% -50%
		Quantity	100% -50%	
25	Expropriation	Quantity	25% -25%	12 w
27	Design	Cost	10% 0%	4 w
28	Survey	Cost	30% 0%	3 w

Figure 4.15 Result of the survey showing “Change in Design”

What is the probability of experiencing a change in soil conditions in your project?				
If there is a change in soil conditions, in what rate would it effect the IRR components' given feature and duration?				
Q16	**Change in Soil Conditions**			**Delay %**
13	* Excavation & Fill	Unit Cost	100% -50%	20% -10%
		Quantity	20% -10%	
14	* Explosion	Unit Cost	100% -50%	10% -10%
		Quantity	10% -10%	
23	Eng Trans. Line	Unit Cost	10% 0%	25% -25%
28	Survey	Cost	50% -10%	-

Figure 4.16 Result of the survey showing "Change in Soil Conditions"

What is the probability of experiencing a change in weather conditions in your project?				
If there is a change in weather conditions, in what rate would it effect the IRR components' given feature and duration?				
Q17	**Change in Weather Conditions**			**Delay**
13	* Excavation & Fill	Unit Cost	25% -5%	8 w
		Quantity	25% -5%	
14	* Explosion	Delay	-	4 w
15	* Concrete (%21 workmanship)	Unit Cost	10% 0%	4 w
16	* Formwork	Delay	-	4 w
23	Eng Trans. Line	Delay	-	4 w
26	Mobilization	Delay	-	2 w
28	Survey	Delay	-	4 w
29	Control	Delay	-	3 w
38	Personel Expenses	Cost	10% 0%	-

Figure 4.17 Result of the survey showing "Change in Weather Conditions"

What is the probability of experiencing workforce unavailability in your project?			
If there is workforce unavailability, in what rate would it effect the IRR components' given feature and duration?			
Q18	**Unavailability of Workforce**		
15	* Concrete (%21 workmanship)	Delay	2 w
16	* Formwork	Delay	2 w
17	* Reinforcing steel (%48 workmanship)	Delay	2 w
23	Eng Trans. Line	Delay	2 w
38	Personel Expenses	Cost	10% 0%

Figure 4.18 Result of the survey showing “Unavailability of Workforce”

What is the probability of experiencing material unavailability in your project?			
If there is material unavailability, in what rate would it effect the IRR components' given feature and duration?			
Q19	**Unavailability of Material**		
15	* Concrete (%21 workmanship)	Unit Cost	15% 0%
17	* Reinforcing steel (%48 workmanship)	Unit Cost	10% 0%
19	* Concrete transp.	Quantity	30% 0%
23	Eng Trans. Line	Unit Cost	15% 0%

Figure 4.19 Result of the survey showing “Unavailability of Material”

What is the probability of experiencing machines and equipment unavailability in your project?				
If there is an unavailability of machines and equipents, in what rate would it effect the IRR components' given feature and duration?				
Q20	**Unavailability of Machines & Equipment**			**Delay**
13	* Excavation & Fill	Unit Cost	30% 0%	2 w

Figure 4.20 Result of the survey showing "Unavailability of Machines & Equipment"

What is the probability of experiencing services unavailability in your project?				
If there is an unavailability of services, in what rate would it effect the IRR components' given feature and duration?				
Q21	**Unavailability of Services**			**Delay**
14	* Explosion	Delay	-	4 w
18	* Steel equipments (Penstock, gates...)	Unit Cost	10% 0%	4 w
22	EM Equipment	Cost	15% 0%	8 w
27	Design	Delay	-	2 w
28	Survey	Cost	10% 0%	2 w
29	Control	Delay	-	2 w

Figure 4.21 Result of the survey showing "Unavailability of Services"

What is the probability of experiencing delay of design in your project?			
If there is a design delay, how many weeks would it effect the duration of construction for the worst case?			
Q22	**Design Delays**		**Delay**
27	Design	Week	12 w

Figure 4.22 Result of the survey showing “Design Delay”

What is the probability of experiencing delay of EM equipment in your project?			
If there is a EM Equipment delay, how many weeks would it effect the duration of construction for the worst case?			
Q23	**EM Equipment Delay**		**Delay**
34	EM Equipment	Week	24 w

Figure 4.23 Result of the survey showing “EM Equipment Delay”

What is the probability of experiencing custom delay in your project?			
If there is a custom delay, how many weeks would it effect the duration of construction for the worst case?			
Q24	**Custom Delay**		**Delay**
34	EM Equipment	Week	12 w

Figure 4.24 Result of the survey showing “Custom Delay”

What is the probability of experiencing bureaucratic delay in your project?			
If there is a bureaucratic delay, how many weeks would it effect the duration of construction for the worst case?			
Q25	**Bureaucratic Delay**		**Delay**
14	* Explosion	Week	4 w
22	EM Equipment	Week	4 w
23	Eng Trans. Line	Week	4 w
25	Expropriation	Week	2 w

Figure 4.25 Result of the survey showing "Bureaucratic Delay"

What is the probability of experiencing expropriation delay in your project?			
If there is a expropriation delay, how many weeks would it effect the duration of construction for the worst case?			
Q26	**Expropriation Delay**		**Delay**
34	Expropriation	Week	8 w

Figure 4.26 Result of the survey showing "Expropriation Delay"

What is the probability of experiencing mobilization delay in your project?			
If there is a mobilization delay, how many weeks would it effect the duration of construction for the worst case?			
Q27	**Mobilization Delay**		**Delay**
34	Mobilization	Week	2 w

Figure 4.27 Result of the survey showing "Mobilization Delay"

What is the probability of experiencing transportation delay in your project?			
If there is a transportation delay, how many weeks would it effect the duration of construction for the worst case?			
Q28	**Transportation Delay**		**Delay**
	* Excavation transp. (Delay due to Change In Weather Conditions)	Week	4 w
	* Concrete transp. (Delay due to Change In Weather Conditions)	Week	2 w
	* Reinforcing Steel transp. (Delay due to Cahnge in Weather Cond.)	Week	2 w
	* Steel transp. (Delay due to Cahnge in Weather Conditions)	Week	2 w
	EM Equipment (Delay due to Cahnge in Weather Conditions)	Week	8 w
	* Excavation transp. Delay due to Unavailability of Mach. and Equip.	Week	2 w
34	Duration of Construction	Week	20 w

Figure 4.28 Result of the survey showing "Transportation Delay"

What is the probability of experiencing a strike in your project?			
If there had been a strike, in what rate would it effect the IRR components' given feature and the construction duration?			
Q29	**Strikes**		
24	Contingencies	Cost	5%
34	Duration of Construction	Delay (Week)	4 w

Figure 4.29 Result of the survey showing "Strikes"

What is the probability of experiencing a terrorist attack in your project?			
If there had been a terrorist attack, in what rate would it effect the IRR components' given feature and the construction duration?			
Q30	**Terrorism**		
24	Contingencies	Cost	25%
34	Duration of Construction	Delay (Week)	4 w

Figure 4.30 Result of the survey showing “Terrorism”

What is the probability of experiencing a war in your project?			
If there had been a war, in what rate would it effect the IRR components' given feature and the construction duration?			
Q31	**War**		
11	Sale Price	Cost	-50%
24	Contingencies	Cost	100%
34	Duration of Construction	Delay (Week)	52 w

Figure 4.31 Result of the survey showing “War”

What is the probability of experiencing a theft in your project?			
If there had been a theft, in what rate would it effect the IRR components' given feature and the construction duration?			
Q32	**Theft**		
24	Contingencies	Cost	5%
34	Duration of Construction	Delay (Week)	2 w

Figure 4.32 Result of the survey showing "Theft"

What is the probability of experiencing an accident in your project?			
If there had been an accident, in what rate would it effect the IRR components' given feature and the construction duration?			
Q33	**Accident**		
24	Contingencies	Cost	25%
34	Duration of Construction	Delay (Week)	6 w

Figure 4.33 Result of the survey showing "Accident"

What is the probability of experiencing a natural disaster in your project?			
If there had been a natural disaster, in what rate would it effect the IRR components' given feature and the construction duration?			
Q34	**Natural disasters**		
24	Contingencies	Cost	50%
34	Duration of Construction	Delay (Week)	8 w

Figure 4.34 Result of the survey showing "Natural Disasters"

What is the probability of experiencing a force majeure affecting EM equipment in your project?			
If there had been a force majeure affecting EM equipment, in what rate would it effect the IRR components' given feature and the construction duration?			
Q35	**Force Majeure Affecting EM Equipment**		
24	Contingencies	Cost	100%
34	Duration of Construction	Delay (Week)	36 w

Figure 4.35 Result of the survey showing "Force Majeure Affecting EM Equipment"

What is the probability of experiencing manufacturing defects in your project?				
If there had been manufacturing defects, in what rate would it effect the IRR components' given feature and the construction duration?				
Q36	**Manufacturing Defects**			**Delay %**
6	Turbine Eff.	Efficiency	-5% 1%	-
7	Transfor. Eff.	Efficiency	-5% 1%	-
8	Generator Eff.	Efficiency	-5% 1%	-
9	Regulation Coeff.	Efficiency	-5% 1%	-
10	Loss Coeff.	Efficiency	-5% 1%	-
13	* Excavation & Fill	Unit Cost	15% 0%	15% 0%
14	* Explosion	Delay %	-	10% 0%
15	* Concrete (%21 workmanship)	Unit Cost	10% 0%	10% 0%
17	* Reinforcing steel (%48 workmanship)	Delay %	-	15% 0%
18	* Steel equipments (Penstock, gates...)	Delay %	-	100% 0%
22	EM Equipment	Delay %	-	100% 0%
24	Contingencies	Cost	100%	-

Figure 4.36 Result of the survey showing "Manufacturing Defects"

What is the probability of experiencing negative environmental effects in your project?			
If there had been negative environmental effects, in what rate would it effect the IRR components' given feature?			
Q37	**Negative Environmental Effects**		
1	Volume of water used	Mass	-15% 0%
13	* Excavation & Fill	Unit Cost	5% 0%
24	Contingencies	Cost	5% 0%
27	Design	Cost	5% 0%

Figure 4.37 Result of the survey showing "Negative Environmental Effects"

What is the probability of experiencing negative attitude of public in your project?				
If there had been negative attitude of public, in what rate would it effect the IRR components' given feature and the construction duration?				
Q38	**Negative Attitude of Public**			**Delay**
25	Expropriation	Unit Cost	100% 0%	50% 0%
26	Mobilization	Delay		2 w

Figure 4.38 Result of the survey showing "Negative Attitude of Public"

What is the probability of experiencing water irregularities due to upstream project in your project?			
If there had been water irregularities due to upstream project, in what rate would it effect the IRR components' given feature?			
Q39	**Water Irregularities Due To Upstream Projects**		
1	Volume of water used	Mass	-50% 0%

Figure 4.39 Result of the survey showing “Water Irregularities Due To Upstream Projects”

What is the probability of Project's being considered as, "Having risk of low profitability" by the authorities?			
If the Project Risk is identified by the authorities, in what rate would it effect the IRR components' given feature?			
Q40	**Project Risk**		
30	Equity Ratio	Point	20% -5%
31	Interest Rate	Point	1,5% 0%
32	Number of Instalment	Number	-30% 0%
33	Insurances	Cost	15% 0%

Figure 4.40 Result of the survey showing “Project Risk”

What is the probability of Project's being considered as "Having Company Risk to end", by the authorities?			
If the Company Risk is identified by the authorities, in what rate would it effect the IRR components' given feature?			
Q41	**Company Risk**		
30	Equity Ratio	Point	30% -5%
31	Interest Rate	Point	3% 0%
32	Number of Instalment	Number	-40% 0%
33	Insurances	Cost	15% 0%

Figure 4.41 Result of the survey showing "Company Risk"

What is the probability of Project's being considered as "Having Country Risk to end", by the authorities?			
If the Country Risk is identified by the authorities, in what rate would it effect the IRR components' given feature?			
Q42	**Country Risk**		
30	Equity Ratio	Point	70% 0%
31	Interest Rate	Point	5,5% 0%
32	Number of Instalment	Number	-50% 0%
33	Insurances	Cost	100% 0%

Figure 4.42 Result of the survey showing "Country Risk"

What is the probability of experiencing a change in design that will effect "Volume of Water Used"?			
If there is a change in design related with "Volume of Water Used", in what rate would it effect the IRR components' given feature?			
Q43	**Change in Design Related With "Volume of Water Used"**		
1	Volume of water used	Mass	-25% 25%

Figure 4.43 Result of the survey showing "Change in Design Related with 'Volume of Water Used' "

What is the probability of experiencing a change in climate that will effect "Volume of Water Used"?			
If there is a change in climate that effect "Volume of Water Used", in what rate would it effect the IRR components' given feature?			
Q44	**Change in Climate that Effect Volume of Water Used**		
1	Volume of water used	Mass	-75% 25%

Figure 4.44 Result of the survey showing "Change in Climate that Effect Volume of Water Used"

In the next chapter, the model used in the decision support tool will be discussed.

CHAPTER 5

THE MODEL USED IN THE DEVELOPMENT OF THE DECISION SUPPORT TOOL

The parameters, values and assumptions used in the model development are explained in this Chapter.

5.1 Change Values

In reality, it is most likely to have cases between the best and the worst case scenarios. Therefore, in this study the difference between the best and the worst case scenarios are divided into 5 intervals. The value at the midpoint of the interval is taken as the reference case value and it is assumed to represent "0%" change. In other words, if everything occurs as anticipated during the life of investment and there is no change in the price data or in the quantity data, the "Reference Case" value will be the output. To represent the amount of perturbations around the reference case due to variability in the input parameters, a term called "Change Value" is defined. One additional change value is taken between the best case and the reference case, and another one is taken between the worst case and the reference case. To illustrate, for a unit price of an IRR component, if the best case change value is "10% decrease" and the worst case change value is "40% increase", then the change values are as follows:

1. Worst case: 40%
2. Middle-1: 20%
3. Reference Case: 0%
4. Middle-2: -5%
5. Best Case: -10%

The best case and the worst case values are calculated from the surveys. Model calls 0% change as the base line and the worst case and the best case as the extreme lines. The model creates two extra “Change Values”, one in between the best case and reference case (-5% decrease in the unit price); and one in between worst case and the reference case (20% increase in the unit price). The “Change Value” can randomly (without the control of the investor) be one of the above values.

5.2 Probability of Experiencing a Change

Every IRR component has a specific “Change Value” under the influence of related “Variable”. But at the same time, every “Variable” has a user specified probability of experiencing a change from the assumed value. Therefore, the next step is to combine the effect of “Variables’ Change Probability” with the “IRR Components’ Change Value”. For example, while a user creates a reference case, the assumed weather condition (Variable) for that specific project location is to be above 0 Celsius degrees for 11 months. But the user also knows that there is always an inherent variability in the assumed weather conditions; it can be lower or higher. Thus, four probability data, which are “High – Medium – Low - Very Low”, are defined to the model, changing the probability of the variables.

At the beginning, this model is designed to execute only three “Change Probability” input data. But after some tests, it is observed that three input data creates some expressional anomalies. For instance, users usually enter the “Change Probability” as “Low” to the “Change in concrete prices” option. However, they also specify “Low” to the “Experiencing a War during the project life” option. After running some tests, it is observed that in 15-20% of the projects (in other words one in every six or seven projects) user experiences a war, which is to be impossible. This leads to the conclusion that an alternative expression is required for the extreme cases. Furthermore, the feedback of the model users followed the same line. They indicated the need for a “Change Probability” in order to realistically simulate the cases having probabilities of occurrence lower than low. It is also discussed whether there is a need for a change probability to account for the cases having probability of occurrence more that high. The model users commented that a variable having a very high change probability can be easily expressed with "High" and the difference can be assumed to be negligible. Furthermore, it is emphasized that "Very High" change probability does not point to a realistic case in the construction business and it definitely decreases the reliability of the model.

In a construction project, the anticipated costs and quantities are likely to be different than what is obtained at the end of a project. In other words, the variability is inevitable. The proposed model analyses both the variability and its effects together. It can be inferred that if the probability of experiencing a change is "Very Low", it means that in the related variable, variability is not expected and the change percentages are modeled to be around reference case percentage, which is 0%. In a similar sense, if the probability of experiencing a change is "High", the aforementioned five cases have nearly the same probability of occurrence and the output modeled to be one of the five cases randomly. The background logic of the proposed model is based on this probabilistic approach.

To illustrate, if the probability of experiencing a change in the steel price (Variable) is defined to be "High" by the user, then the change in the unit price of "Steel Equipments" (IRR Component) can be defined to be floating. It can be either -15% (the best case value) or with the same probability (which is 1/5); it can be 30% (the worst case value). There is also a possibility for a no change scenario and this corresponds to 0% (reference case value). On the other hand, if "Negative Attitude of Public" (Variable) is entered as "Low" by the user, the change in the unit price of "Expropriation" (IRR Component) usually becomes 0%. It can also take middle case values and rarely, it is equal to the best case or the worst case value depending on the modeling code assignment.

5.3 Effects of Duration

Another point to be investigated is the effects of duration (or delays) on IRR. Some variables may create a delay in the project duration. From contractors' and investors' point of view, a delay in the construction should be strongly avoided since it directly affects the financial plans of the investors by increasing the cost of construction, the terms of credit payment and electricity production (income) schedule.

An ideal working schedule is implemented in this model. The working schedule is prepared using the CPM method. The activities of the work schedule can be grouped into five work categories:

1. Preparation works: Design, Survey, Mobilization
2. Earth works: Excavation, Excavation transportation, Explosion.
3. Construction works: Reinforcement, Steel transportation, Formwork, Concrete, Concrete transportation.
4. Installation works: Steel Equipment, Electro-mechanical Equipment, Energy Transmission Line
5. Other Factors affecting the duration: Control, Force majeure.

The user is asked to enter the duration of the above activities. Since the interrelations between the activities are implemented in the model, firstly the model creates a working schedule and specifies the duration of construction for the reference case. For the second step, a delay is found by assessing the effects of variables and a new duration is obtained. It is noted that the new working schedule is important because it defines the duration of construction, which critically affects the credit payments, credit payment schedule and cost of construction.

The coupled effect of the new IRR component values and the new duration is used as a new input to the model. With these refined parameters, the model creates the new IRR as the output.

5.4 How to Use the Tool?

For every financial model, the investor creates a most-likely case by using anticipated data for the project. In this thesis, the most-likely case is called the "Reference Case". By looking at the IRR of the reference case, the investor can make a final decision about the investment. In order to create a reference case, users have to input 3 kinds of data.

1. IRR Components
2. Work Schedule Components
3. Change probabilities of the "Variables"

IRR COMPONENTS							
	Quantity	**Unit**	**Unit Pr.**	**Unit**	**CONS.**	**FAC. Co.**	**PRJ. Co.**
Mobilization	1,00	L.Sum	(1)	TL			
* Excavation & Fill	(2)	m3	(3)	TL			
* Explosion	(4)	m3	(5)	TL			
* Concrete	(6)	m3	(7)	TL			
* Formwork	(8)	m2	(9)	TL			
* Reinforcing steel	(10)	ton	(11)	TL			
* Steel equipments	(12)	kg	(13)	TL			
* Concrete transp.	(14)	km	(15)	TL			
* Steel transp.	(16)	km	(17)	TL			
* Excavation transp.	(18)	km	(19)	TL			
Eng Trans. Line	(20)	km	(21)	$/km			
EM Equipment	(22)	kW	(23)	€/kW			
					-		
Contingencies			-	TL		-	
Design			-	TL			
Survey - Control			-	TL			
Insurances			-	TL			
Cons. Overhead Exp.	(WS)	mon.	(24)	TL/mon			
Expropriation	(25)	m2	(26)	TL			-

1 $:	(27)	TL			
1 € :	(28)	TL			
Duration of Cons. :	(WS)	year	(WS)	months	**Coming from Work Schedule**

Equity Ratio	E% :	(29)	%	
Interest Rate	i :	(30)	%	
Number of Instalment	n :	(31)	num.	
Duration of Construction	c :	3,00	year	**In financial norms**
Maintenance Coeff.	C-main :	0,010	coeff.	
Renewal Coeff.	C-renew :	0,001027	coeff.	
Personnel Expenses	EXP-p :	(32)	TL/year	
Overhead Expenses	EXP-o :	(33)	TL/year	

Volume of water used	Q :	(34)	m3	
Water Density	d :	1.000,00	kg/m3	
Gravit. Acc.	g :	9,81	m/s2	
Fall	H :	210,42	m	
kWh/Joule	1/3.600.00 :	2,77778E-07	coeff.	
Turbine Eff.	EFF-1 :	(35)	coeff.	**Recommended Value : 0,92**
Transfor. Eff.	EFF-2 :	(36)	coeff.	**Recommended Value : 0,98**
Generator Eff.	EFF-3 :	(37)	coeff.	**Recommended Value : 0,99**
Regulation Coeff.	C-reg :	(38)	coeff.	**Recommended Value : 0,95**
Loss Coeff.	C-loss :	(39)	coeff.	**Recommended Value : 0,90**
Sale Price	S.P. :	(40)	€/kWh	
Income Tax	TAX :	(41)	%	

Figure 5.1: IRR components as an input by the users

Figure 5.1 shows a snapshot of the window to be filled initially by the users. It requires information about the unit prices, quantities, project expenses, exchange rates, project efficiencies, project coefficients, financial data and any other engineering and financial components that will form the investment cost.

In the second window, displayed in Figure 5.2, the users are required to input the duration data to construct the working schedule of the construction. The structure of the working schedule and the effects of duration are explained in part 5.3 Effects of Duration

WORK SCHEDULE COMPONENTS		
Activity Name	**Duration**	
Mobilization	(42)	week
Excavation	(43)	week
Explosion	(44)	week
Expropriation	(45)	week
Reinforcement	(46)	week
Formwork	(47)	week
Concrete	(48)	week
Steel Equipment	(49)	week
EM Equipment	(50)	week
Energy Transmission Line	(51)	week

Figure 5.2: Working schedule components as an input by the users

After filling these two tables, the program creates the reference case and outputs the results of the reference case, as shown in Figure 5.3, The outputs are IRR (%), Annual Production (in GWh), Sale Price (in TL/kWh), Cost of Construction (in TL), Loan Installments (in TL), and Annual Expense (in TL).. Users are going to use this reference case data as a control group for the oncoming steps.

OUTPUT - REFERENCE CASE			
1	IRR (%)	-	
2	Annual Production (GWh) :	-	**INCOME**
3	Sale Price (TL/kWh) :	-	
4	Annual Income (TL) :	-	
5	Cost of Construction (TL) :	-	**OUTFLOW**
6	Loan Installments (TL) :	-	
7	Annual Expense (TL) :	-	

Figure 5.3: First output of the program.

For the third and final step, the users are required to input the change probabilities of the variables. Although there are 42 variables in the proposed model, as mentioned previously in Chapter 3, Figure 5.4 is the third and the last window users need to interact, greatly simplifying the decision making process. In this window, the users are expected to answer questions regarding the probability of experiencing certain situations by inputting a probability rate. The probability rates can either be High (H), Medium (M), Low (L) or Very Low (VL).

CHANGE PROBABILITIES OF "VARIABLES"		
1	What is the probability of experiencing a change in steel price?	(52)
2	What is the probability of experiencing a change in concrete price?	(53)
3	What is the probability of experiencing a remarkable change in diesel oil price?	(54)
4	What is the probability of experiencing a change in labour costs?	(55)
5	What is the probability of experiencing a change in service costs?	(56)
6	What is the probability of experiencing a change in selling prices?	(57)
7	What is the probability of experiencing a remarkable change in the exchange rate of $/TL?	(58)
8	What is the probability of experiencing a remarkable change in the exchange rate of $/€?	(59)
9	What is the probability of experiencing a remarkable change in the exchange rate of €/TL?	(60)
10	What is the probability of experiencing a change in LIBOR?	(61)
11	What is the probability of experiencing a remarkable change in inflation rate?	(62)
12	What is the probability of experiencing a change in tax rates?	(63)
13	What is the probability of experiencing a change in workforce productivity in your project?	(64)
14	What is the probability of experiencing a change in equipment productivity in your project?	(65)
15	What is the probability of experiencing a change in design in your project?	(66)
16	What is the probability of experiencing a change in soil conditions in your project?	(67)
17	What is the probability of experiencing a change in weather conditions in your project?	(68)
18	What is the probability of experiencing workforce unavailability in your project?	(69)
19	What is the probability of experiencing material unavailability in your project?	(70)
20	What is the probability of experiencing machines and equipment unavailability in your project?	(71)
21	What is the probability of experiencing services unavailability in your project?	(72)

Figure 5.4 The change probability of the “Variables” as a user input

22	What is the probability of experiencing delay of design in your project?	(73)
23	What is the probability of experiencing delay of EM equipment in your project?	(74)
24	What is the probability of experiencing custom delay in your project?	(75)
25	What is the probability of experiencing bureaucratic delay in your project?	(76)
26	What is the probability of experiencing expropriation delay in your project?	(77)
27	What is the probability of experiencing mobilization delay in your project?	(78)
28	What is the probability of experiencing transportation delay in your project?	(79)
29	What is the probability of experiencing a strike in your project?	(80)
30	What is the probability of experiencing a terrorist attack in your project?	(81)
31	What is the probability of experiencing a war in your project?	(82)
32	What is the probability of experiencing a theft in your project?	(83)
33	What is the probability of experiencing an accident in your project?	(84)
34	What is the probability of experiencing a natural disaster in your project?	(85)
35	What is the probability of experiencing a force majeure affecting EM equipment in your project?	(86)
36	What is the probability of experiencing manufacturing defects in your project?	(87)
37	What is the probability of experiencing negative environmental effects in your project?	(88)
38	What is the probability of experiencing negative attitude of public in your project?	(89)
39	What is the probability of experiencing water irregularities due to upstream project in your project?	(90)
40	What is the prob. of prj.'s being consid. as, "Having risk of low profitability" by the authorities?	(91)
41	What is the prob. of prj.'s being consid. as "Having Company Risk to end", by the authorities?	(92)
42	What is the prob. of prj.'s being consid. as "Having Country Risk to end", by the authorities?	(93)

Figure 5.4: The change probability of the "Variables" as a user input (Continued)

After this procedure, the model processes,

- Reference Case (defined by the user)
- The "Change Values" on the database highlighted in green, red and blue. (defined by the experienced contractors)
- The "Change Probability" of variables (defined by the user)

and finally outputs the new IRR value.

The user can repeat this procedure by just pressing one button on the computer (F9) at any time. In every repetition, the model outputs a new IRR so that the user can assess the effect of that individual parameter, as well as the probability distribution of his/her IRR.

Figure 6.5 displays the output of the program. It compares the reference case with any probable scenario. To make better comparisons, it is reasonable to show the value of IRR and the values of IRR's basic components, which are Annual Production, Sale Price, Cost of Construction, Loan Installments and Annual Expense. Furthermore, to increase the efficiency and understandability of these comparisons, the percentage change is also indicated at the last column.

				UNIT	REFERENCE CASE	PROBAB. CASE	CHANGE %
OUTPUT							
	1	IRR :		%			
INCOME	2	Annual Production :		GWh			
	3	Sale Price :		TL/kWh			
	4	Annual Income :		TL			
OUTFLOW	5	Cost of Construction :		TL			
	6	Loan Installments :		TL			
	7	Annual Expense :		TL			

Figure 5.5: Output of the program showing the comparison of reference case with a probabilistic case.

Finally, to make detailed comparisons of probabilistic and reference cases, program outputs a sensitivity report. It presents the detailed version of the previous output. As mentioned previously, the first output of the program contains the main components of the IRR; in other words, the main components of Input and Outflow. However, in the sensitivity analysis, the subcomponents of Annual Production, Sale Price, Cost of Construction, Loan Installments and Annual Expense are displayed. Using this method, it is much simpler for the users to analyze the cost components, as shown in Figure 5.6

SENSITIVITY REPORT

ANNUAL PRODUCTION		UNIT	REFERENCE CASE	PROBAB. CASE	CHANGE %
*	**Annual Production :**	**GWh**			
1	Volume of Water Used :	m3			
2	Turbine Eff.	coeff.			
3	Transfor. Eff.	coeff.			
4	Generator Eff.	coeff.			
5	Regulation Coeff.	coeff.			
6	Loss Coeff.	coeff.			

Figure 5.6: Sensitivity Analysis

	COST OF CONSTRUCTION	UNIT	REFERENCE CASE	PROBAB. CASE	CHANGE %
*	**Cost of Construction :**	**TL**			
1	Mobilization cost	TL			
2	Excavation & Fill - Unit cost :	TL			
3	Excavation & Fill - Quantity :	m3			
4	Explosion - Unit Cost :	TL			
5	Explosion - Quantity :	m3			
6	Concrete - Unit Cost :	TL			
7	Concrete - Quantity :	m3			
8	Formwork - Unit Cost :	TL			
9	Formwork - Quantity :	m3			
10	Reinforcing Steel - Unit Cost :	TL			
11	Reinforcing Steel - Quantity :	m3			
12	Steel equipment - Unit Cost :	TL			
13	Steel equipment - Quantity :	m3			
14	Concrete transp. - Unit Cost :	TL			
15	Concrete transp. - Quantity :	km			
16	Steel transp. - Unit Cost :	TL			
17	Steel transp. - Quantity :	km			
18	Excavation transp - Unit Cost :	TL			
19	Excavation transp - Quantity :	km			
20	Energy trans. lines - Unit Cost :	$/km			
21	Energy trans. lines - Quantity :	km			
22	EM Equipment - Cost	€/kW			
23	EM Equipment - Delay	kW			
24	Contingency cost :	TL			
25	Design - Cost :	TL			
26	Survey - Cost :	TL			
27	Insurances :	TL			
28	Construction Overhead Ex. :	TL/mon			
29	Expropriation - Unit Cost :	TL			
30	Expropriation - Quantity :	m2			

	LOAN INSTALLMENTS	UNIT	REFERENCE CASE	PROBAB. CASE	CHANGE %
*	**Loan Installments :**	**TL**			
1	Project Cost :	TL			
2	Equity Ratio :	Point			
3	Interest Rate :	Point			
4	Number of Installments :	num.			
5	Duration of Construction :	year			

Figure 5.6: Sensitivity Analysis (Continued)

ANNUAL EXPENSE		UNIT	REFERENCE CASE	PROBAB. CASE	CHANGE %
*	**Annual Expense :**	**TL**			
1	Renewal cost :	TL			
2	Maintenance cost :	TL			
3	Personnel expenses :	TL			
4	Overhead expenses :	TL			

Figure 5.6: Sensitivity Analysis (Continued)

After developing the model, a hypothetical case study is conducted to test the developed model. The primary aim in this case study is to assess the usability and reliability of the proposed model.

CHAPTER 6

UTILIZATION OF THE DECISION SUPPORT TOOL: A HYPOTHETICAL CASE STUDY

6.1 Hypothetical Case Study

In this research, a hypothetical case study is conducted to test and demonstrate the usability of the decision support tool. The data required to create a reference case is displayed on the actual user interface in Figure 6.7, Figure 6.8 and Figure 6.9. To summarize the project, it is assumed that the hydro electrical power plant has a 3,5 GWh capacity, the annual water volume used in energy production is roughly 29 million meter cube. Under the light of studied sample cases, the cost of the project is calculated to be nearly 9.250.000,00 TL, 1 dollar ($) is 1,50 TL, 1 euro (€) is 2,00 TL, the equity ratio of the bank is assumed to be 25%, the interest rate is assumed to be 8%, the number of installments are 6, the duration of the construction is planned to be 20 months with 50.000,00 TL monthly construction overhead expenses and also in the operation phase 72.000, 00 TL annual personnel expenses and 60.000,00 TL annual overhead expenses are estimated to be spent.

STEP 1							
IRR COMPONENTS							
	Quantitiy	**Unit**	**Unit Price**	**Unit**	**CONSTR. COST**	**FACILITY COST**	**PROJECT COST**
Mobilization	1,00	L.Sum	100.000,00	TL	100.000,00		
* Excavation & Fill	55.970,00	m3	3,50	TL	195.895,00		
* Explosion	700,00	m3	10,00	TL	7.000,00		
* Concrete	8.140,00	m3	65,00	TL	529.100,00		
* Formwork	7.440,00	m2	15,00	TL	111.600,00		
* Reinforcing steel	244,00	ton	1.100,00	TL	268.400,00		
* Steel equipments	304.938,00	kg	7,00	TL	2.134.566,00		
* Concrete transp.	27.200,00	km	1,50	TL	40.800,00		
* Steel transp.	15.516,66	km	1,50	TL	23.274,99		
* Excavation transp.	53.764,00	km	1,50	TL	80.646,00		
Eng Trans. Line	10,00	km	50.000,00	$/km	750.000,00		
EM Equipment	3.500,00	kW	350,00	€/kW	2.450.000,00		
					6.691.281,99		
Contingencies			683.692,30	TL		**7.374.974,29**	
Design			663.747,69	TL			
Survey - Control			73.749,74	TL			
Insurances			46.838,97	TL			
Construction Overhead Exp.	20	mon.	50.000,00	TL/mon	1.000.000,00		
Expropriation	1.000,00	m2	100,00	TL	100.000,00		**9.259.310,69**

Figure 6.1: Data to define the cost of the project

1 $:	1,50	TL			
1 € :	2,00	TL			
Duration of Construction :	1,50	year	20	months	Coming from Work Schedule

Equity Ratio	E% :	25%	%	
Interest Rate	i :	8%	%	
Number of Instalment	n :	6,00	num.	
Duration of Construction	c :	2,00	year	In financial norms
Maintenance Coeff.	C-main :	0,010	coeff.	Recomended Value : 0,01
Renewal Coeff.	C-renew :	0,001027	coeff.	Recomended Value : 0,001027
Personnel Expenses	EXP-p :	72.000,00	TL/year	
Overhead Expenses	EXP-o :	60.000,00	TL/year	

Volume of water used	Q :	28.930.000,00	m3	
Water Density	d :	1.000,00	kg/m3	Recomended Value : 1000
Gravit. Acc.	g :	9,81	m/s2	Recomended Value : 9,81
Fall	H :	210,42	m	
kWh/Joule	1/3.600.00 :	2,77778E-07	coeff.	Recomended Value : 1/3600000
Turbine Eff.	EFF-1 :	0,92	coeff.	Recomended Value : 0,92
Transfor. Eff.	EFF-2 :	0,98	coeff.	Recomended Value : 0,98
Generator Eff.	EFF-3 :	0,99	coeff.	Recomended Value : 0,99
Regulation Coeff.	C-reg :	0,95	coeff.	Recomended Value : 0,95
Loss Coeff.	C-loss :	0,90	coeff.	Recomended Value : 0,90
Sale Price	S.P. :	0,08	€/kWh	
Income Tax	TAX :	20%	%	

Figure 6.2: Data to find the IRR of Reference Case

STEP 2		
WORK SCHEDULE COMPONENTS		
Activity Name	**Duration**	
Mobilization	2	week
Excavation	52	week
Explosion	8	week
Expropriation	4	week
Reinforcement	24	week
Formwork	50	week
Concrete	50	week
Steel Equip.	32	week
EM Equip.	52	week
Eng trans. Line.	52	week

Figure 6.3: Data to create a working schedule

After creating a reference case, the tool outputs an analysis of the reference case. As mentioned in the previous chapter, IRR of the reference case and its main components are shown in the output window in Figure 6.4.

OUTPUT - REFERENCE CASE			
1	IRR (%)	14,47%	
2	Annual Production (GWh) :	12,66	INCOME
3	Sale Price (TL/kWh) :	0,16	
4	Annual Income (TL) :	2.025.522,87	
5	Cost of Construction (TL) :	9.259.310,69	OUTFLOW
6	Loan Installments (TL) :	1.752.164,36	
7	Annual Expense (TL) :	205.784,77	

Figure 6.4: First output of the tool, reference case analysis

The IRR of the investment is found to be 14,47% by the decision support tool. In this scenario the investor loans a credit from the bank and with that capital the construction of the power plant is finished at the end of 2 years with a cost of 9.259.310,69 TL. At the end of third year, the annually expenses of the power plant is 205.784,77 TL and it produces electricity about 12,66 GWh. The produced electricity is sold to the government for 0,16 TL/kWh and it earns annually 2.025.522,87 TL. Investor also annually pays 1.752.164,36 TL to the credit provider company for 6 years as a credit payment.

Those values are taken same for 50 years but it is certain that this situation is far from the reality; changes will occur. In order to contribute the effect of variability, table shown in Figure 6.5 is inputted. As mentioned in Chapter 5, there are 4 change probability rates: Low (L), Medium (M), High (H) and Very Low (VL)

STEP 3		
ASSIGNMENT OF CHANGE PROBABILITIES OF VARIABLES		
1	What is the probability of experiencing a change in steel price?	H
2	What is the probability of experiencing a change in concrete price?	L
3	What is the probability of experiencing a remarkable change in diesel oil price?	M
4	What is the probability of experiencing a change in labour costs?	VL
5	What is the probability of experiencing a change in service costs?	M
6	What is the probability of experiencing a change in selling prices?	L
7	What is the probability of experiencing a remarkable change in the exchange rate of $/TL ?	M
8	What is the probability of experiencing a remarkable change in the exchange rate of $/€ ?	VL
9	What is the probability of experiencing a remarkable change in the exchange rate of €/TL ?	M
10	What is the probability of experiencing a change in LIBOR?	VL
11	What is the probability of experiencing a remarkable change in inflation rate?	L
12	What is the probability of experiencing a change in tax rates?	VL
13	What is the probability of experiencing a change in workforce productivity in your project?	VL
14	What is the probability of experiencing a change in equipment productivity in your project?	L
15	What is the probability of experiencing a change in design in your project?	M
16	What is the probability of experiencing a change in soil conditions in your project?	M
17	What is the probability of experiencing a change in weather conditions in your project?	M
18	What is the probability of experiencing workforce unavailability in your project?	VL
19	What is the probability of experiencing material unavailability in your project?	L
20	What is the probability of experiencing machines and equipment unavailability in your project?	L

Figure 6.5: Input data for the probability of variables

21	What is the probability of experiencing services unavailability in your project?	L
22	What is the probability of experiencing delay of design in your project?	L
23	What is the probability of experiencing delay of EM equipment in your project?	L
24	What is the probability of experiencing custom delay in your project?	L
25	What is the probability of experiencing bureaucratic delay in your project?	M
26	What is the probability of experiencing expropriation delay in your project?	M
27	What is the probability of experiencing mobilization delay in your project?	VL
28	What is the probability of experiencing transportation delay in your project?	L
29	What is the probability of experiencing a strike in your project?	VL
30	What is the probability of experiencing a terrorist attack in your project?	VL
31	What is the probability of experiencing a war in your project?	VL
32	What is the probability of experiencing a theft in your project?	L
33	What is the probability of experiencing an accident in your project?	L
34	What is the probability of experiencing a natural disaster in your project?	VL
35	What is the probability of experiencing a force majeure affecting EM equipment in your project?	VL
36	What is the probability of experiencing manufacturing defects in your project?	L
37	What is the probability of experiencing negative environmental effects in your project?	L
38	What is the probability of experiencing negative attitude of public in your project?	L
39	What is the probability of experiencing water irregularities due to upstream project in your project?	L
40	What is the prob. of project's being consid. as, "Having risk of low profitability" by the authorities?	L
41	What is the prob. of project's being consid. as "Having Company Risk to end", by the authorities?	L
42	What is the prob. of project's being consid. as "Having Country Risk to end", by the authorities?	VL
42	What is the probability of having a design change that effect "Volume of Water Used"?	VL
42	What is the probability of having aclimate change that effect "Volume of Water Used"?	VL

Figure 6.5: Input data for the probability of variables (Continue)

After inputting all the data required from the user, the decision support tool creates a new scenario and outputs an Income/Outflow analysis and Sensitivity Report of the new scenario, as show in Figure 6.6 and Figure 6.7.

OUTPUT - NEW SCENARIO

			UNIT	REFERENCE CASE	PROBAB. CASE	CHANGE %
	1	IRR :	%	14,47%	11,08%	-23%
INCOME	2	Annual Production :	GWh	12,66	12,66	0%
	3	Sale Price :	TL/kWh	0,16	0,18	13%
	4	Annual Income :	TL	2.025.522,87	2.278.713,23	13%
OUTFLOW	5	Cost of Construction :	TL	9.259.310,69	12.653.246,14	37%
	6	Loan Installments :	TL	1.752.164,36	2.394.407,93	37%
	7	Annual Expense :	TL	205.784,77	260.440,85	27%

Figure 6.6: The Income/Outflow analysis of new scenario

The IRR of the new scenario is calculated to be 11,08%, which is 23% less than the reference case, as shown in Figure 6.6. The reason for that decrease is also summarized in Figure 6.6. In Figure 6.6, it can also be observed that for this scenario, there is a 13% increase in annual income arising from a 13% increase in the selling price however, a 37% increase in the cost of construction, a 37% increase in loan installments and a 27% increase in annual expenses lead to a total of 23% decrease in IRR of the investment. In Figure 6.7, the reason for that change is given in Sensitivity Report in detail.

SENSITIVITY REPORT

ANNUAL PRODUCTION		UNIT	REFERENCE CASE	PROBAB. CASE	CHANGE %
*	**Annual Production :**	**GWh**	**12,66**	**12,66**	**0%**
1	Volume of Water Used :	m3	28.930.000,00	28.930.000,00	0%
2	Turbine Eff.	coeff.	0,92	0,92	0%
3	Transfor. Eff.	coeff.	0,98	0,98	0%
4	Generator Eff.	coeff.	0,99	0,99	0%
5	Regulation Coeff.	coeff.	0,95	0,95	0%
6	Loss Coeff.	coeff.	0,90	0,90	0%

COST OF CONSTRUCTION		UNIT	REFERENCE CASE	PROBAB. CASE	CHANGE %
*	**Cost of Construction :**	**TL**	**9.259.310,69**	**12.653.246,14**	**37%**
1	Mobilization cost	TL	100.000,00	117.500,00	18%
2	Excavation & Fill - Unit cost :	TL	3,50	4,64	33%
3	Excavation & Fill - Quantity :	m3	55.970,00	64.365,50	15%
4	Explosion - Unit Cost :	TL	10,00	11,25	13%
5	Explosion - Quantity :	m3	700,00	805,00	15%
6	Concrete - Unit Cost :	TL	65,00	75,40	16%
7	Concrete - Quantity :	m3	8.140,00	8.547,00	5%
8	Formwork - Unit Cost :	TL	15,00	17,25	15%
9	Formwork - Quantity :	m3	7.440,00	7.812,00	5%
10	Reinforcing Steel - Unit Cost :	TL	1.100,00	1.457,50	33%
11	Reinforcing Steel - Quantity :	m3	244,00	256,20	5%
12	Steel equipment - Unit Cost :	TL	7,00	9,45	35%
13	Steel equipment - Quantity :	m3	304.938,00	312.561,45	2%
14	Concrete transp. - Unit Cost :	TL	1,50	1,80	20%
15	Concrete transp. - Quantity :	km	27.200,00	28.560,00	5%

Figure 6.7: Sensitivity report of new scenario

16	Steel transp. - Unit Cost :	TL	1,50	1,80	20%
17	Steel transp. - Quantity :	km	15.516,66	16.292,49	5%
18	Excavation transp - Unit Cost	TL	1,50	1,80	20%
19	Excavation transp - Quantity :	km	53.764,00	61.828,60	15%
20	Energy trans. lines - Unit Cost	$/km	50.000,00	93.750,00	88%
21	Energy trans. lines - Quantity	km	10,00	15,00	50%
22	EM Equipment - Cost	€/kW	350,00	358,75	2%
23	EM Equipment - Delay	kW	3.500,00	3.500,00	0%
24	Contingency cost :	TL	683.692,30	683.692,30	0%
25	Design - Cost :	TL	663.747,69	813.090,92	23%
26	Survey - Cost :	TL	73.749,74	97.718,41	33%
27	Insurances :	TL	46.838,97	55.035,79	18%
28	Construction Overhead Ex. :	TL/mon	50.000,00	58.750,00	18%
29	Expropriation - Unit Cost :	TL	100,00	117,50	18%
30	Expropriation - Quantity :	m2	1.000,00	1.125,00	13%

LOAN INSTALLMENTS		UNIT	REFERENCE CASE	PROBAB. CASE	CHANGE %
*	**Loan Installments :**	**TL**	**1.752.164,36**	**2.394.407,93**	**37%**
1	Project Cost :	TL	9.259.310,69	12.653.246,14	37%
2	Equity Ratio :	Point	25%	25%	0%
3	Interest Rate :	Point	8%	8%	0%
4	Number of Instalment :	num.	6,00	6,00	0%
5	Duration of Construction :	year	2,00	2,00	0%

ANNUAL EXPENSE		UNIT	REFERENCE CASE	PROBAB. CASE	CHANGE %
*	**Annual Expense :**	**TL**	**205.784,77**	**260.440,85**	**27%**
1	Renewal cost :	TL	6.871,95	9.475,64	38%
2	Maintenance cost :	TL	66.912,82	92.265,21	38%
3	Personel expenses :	TL	72.000,00	88.200,00	23%
4	Overhead expenses :	TL	60.000,00	70.500,00	18%

Figure 6.7: Sensitivity report of new scenario (continue)

The designed decision support tool is very simple and convenient to use that to create an entirely different and independent scenario by slightly altering the input data, pressing the F9 button is merely enough. In addition, the support tool also produces a new sensitivity report and a new IRR for every repetition of the simulation.

For this specific hypothetical project, after creating a reference case and a new probabilistic case, the simulation process continued. In order to analyze the general overview of the tool, 50 more repetitions have been made and the IRR outputs are recorded and shown in Table 6.1.

Table 6.1: The results of the 50 simulations for the hypothetical case

1	12,15%	**11**	9,49%	**21**	18,55%	**31**	15,77%	**41**	6,11%
2	13,65%	**12**	8,20%	**22**	7,29%	**32**	0,00%	**42**	7,98%
3	14,34%	**13**	5,82%	**23**	0,00%	**33**	10,64%	**43**	24,33%
4	6,89%	**14**	6,53%	**24**	26,41%	**34**	13,87%	**44**	12,47%
5	9,15%	**15**	16,59%	**25**	7,46%	**35**	15,90%	**45**	17,44%
6	11,14%	**16**	12,06%	**26**	8,60%	**36**	18,34%	**46**	0,00%
7	10,70%	**17**	11,82%	**27**	0,00%	**37**	13,92%	**47**	6,87%
8	7,22%	**18**	16,13%	**28**	10,54%	**38**	16,39%	**48**	14,65%
9	6,48%	**19**	8,92%	**29**	8,49%	**39**	10,69%	**49**	19,13%
10	10,91%	**20**	10,44%	**30**	12,00%	**40**	7,98%	**50**	8,50%

AVERAGE:	**10,26%**

On the reference case stage, the IRR of the investment is calculated to be 14.47 %. However, this decision support tool showed the variety of IRR's under the influence of changing variables.

When Table 6.1 is analyzed, it is realized that the smallest IRR is 0,00 % and it is repeated four times in the 23rd, 27th, 32nd and 46th repetitions. When those cases are analyzed, it is observed that the annual income, which is the main component of income, is decreased 56%, 51%, 53%, and 78% respectively. On the other hand, the main components of outflow, which are cost of construction, loan installments and annual expenses, have a considerable amount of increase, as shown in Figure 6.8, Figure 6,9, Figure 6.10 and Figure 6.11.

OUTPUT - NEW SCENARIO

			UNIT	REFERENCE CASE	PROBAB. CASE	CHANGE %
	1	IRR :	%	14,47%	#SAYI!	#SAYI!
INCOME	2	Annual Production :	GWh	12,66	6,33	-50%
	3	Sale Price :	TL/kWh	0,16	0,14	-13%
	4	Annual Income :	TL	2.025.522,87	886.166,26	-56%
OUTFLOW	5	Cost of Construction :	TL	9.259.310,69	12.019.566,92	30%
	6	Loan Installments :	TL	1.752.164,36	2.274.495,10	30%
	7	Annual Expense :	TL	205.784,77	220.725,03	7%

Figure 6.8: 23rd repetition of the simulation of hypothetical case

OUTPUT - NEW SCENARIO

			UNIT	REFERENCE CASE	PROBAB. CASE	CHANGE %
	1	IRR :	%	14,47%	#SAYI!	#SAYI!
INCOME	2	Annual Production :	GWh	12,66	8,21	-35%
	3	Sale Price :	TL/kWh	0,16	0,12	-25%
	4	Annual Income :	TL	2.025.522,87	984.928,39	-51%
OUTFLOW	5	Cost of Construction :	TL	9.259.310,69	11.388.851,43	23%
	6	Loan Installments :	TL	1.752.164,36	2.155.143,10	23%
	7	Annual Expense :	TL	205.784,77	232.416,84	13%

Figure 6.9: 27th repetition of the simulation of hypothetical case

OUTPUT - NEW SCENARIO

			UNIT	REFERENCE CASE	PROBAB. CASE	CHANGE %
	1	IRR :	%	14,47%	#SAYI!	#SAYI!
INCOME	2	Annual Production :	GWh	12,66	9,49	-25%
	3	Sale Price :	TL/kWh	0,16	0,10	-38%
	4	Annual Income :	TL	2.025.522,87	949.463,85	-53%
OUTFLOW	5	Cost of Construction :	TL	9.259.310,69	12.654.147,67	37%
	6	Loan Installments :	TL	1.752.164,36	2.478.983,96	41%
	7	Annual Expense :	TL	205.784,77	261.872,77	27%

Figure 6.10: 32nd repetition of the simulation of hypothetical case

OUTPUT - NEW SCENARIO

			UNIT	REFERENCE CASE	PROBAB. CASE	CHANGE %
	1	IRR :	%	14,47%	#SAYI/0!	#SAYI/0!
INCOME	2	Annual Production :	GWh	12,66	3,16	-75%
	3	Sale Price :	TL/kWh	0,16	0,14	-13%
	4	Annual Income :	TL	2.025.522,87	443.083,13	-78%
OUTFLOW	5	Cost of Construction :	TL	9.259.310,69	9.766.426,85	5%
	6	Loan Installments :	TL	1.752.164,36	1.848.127,32	5%
	7	Annual Expense :	TL	205.784,77	231.841,58	13%

Figure 6.11: 46th repetition of the simulation of hypothetical case

The biggest IRR is observed in the 24^{th} repetition. When the Income/Outflow table of 24^{th} repetition is analyzed, it is detected that annual income is increased 23%. However, this increase is supported with the 18% decrease of the cost of construction, 18% decrease of loan installments and 24% decrease of annual expenses. The combined effects of those parameters increase the IRR 82%.

OUTPUT - NEW SCENARIO

			UNIT	REFERENCE CASE	PROBAB. CASE	CHANGE %
	1	IRR :	%	14,47%	26,41%	82%
INCOME	2	Annual Production :	GWh	12,66	12,79	1%
	3	Sale Price :	TL/kWh	0,16	0,20	25%
	4	Annual Income :	TL	2.025.522,87	2.557.285,92	26%
OUTFLOW	5	Cost of Construction :	TL	9.259.310,69	7.606.391,34	-18%
	6	Loan Installments :	TL	1.752.164,36	1.439.377,97	-18%
	7	Annual Expense :	TL	205.784,77	156.572,40	-24%

Figure 6.12: 24^{th} repetition of the simulation of hypothetical case

When all 50 repetitions are averaged, the value of IRR is found to be 10,26%, which is lower than the reference case IRR. The interpretation of this decrease may change from user to user. But it can roughly be said that, since the IRR is calculated to be less than the initial IRR, either the change probability of the variables are entered conservatively or the uncertainty of the investment and construction conditions are dominant over the project.

CHAPTER 7

APPLICATION OF THE TOOL TO A REAL CASE

7.1 Application of the Tool to the Real Case

For the real case study, a hydro-electrical power plant investment project built by a contracting company in the Black Sea region of Turkey was investigated. The project is aimed to be completed in 2 years and a bank credit was withdrawn for financial aid. The major project characteristics are: 2,81 m^3/s average discharge of the river, 80 m fall, and 3,05 MW installed capacity. According to the company executives' initial estimates, the IRR of the project was 28,48 % with a 5.322.000, 00 TL project cost, 2.206.500,00 TL annual income, 1.625.456,50 TL loan installments and 14.71 GWh annual energy production. Construction phase finished in 2010 and power plant is producing electricity for 1,5 years.

Interviews were conducted with two different partners of the company and took about 1,5 hours. Since the company is middle size family business, the partners are closely related and have full responsibility on every aspect of the project, including the construction work, the purchases/sales, the bidding and investment decisions and the business development activities. The senior partner is a mechanical engineer and has been running the contracting company for over 30 years. He has extensive experience in hydraulic structures and has been building them all around Turkey for many years. Therefore, he had a thorough knowledge in constructions costs. The junior partner was civil engineer with an MBA degree. The financial calculations are his area of expertise. His experience in evaluating the cost and quantity expectations of the investment at the beginning of the construction and estimations for the finalized cost and quantity right before the power plant starts to operate was invaluable for the reliability of this tool.

In this case study, firstly a reference case was created using the data obtained by the profitability studies of the company at the bidding decision stage and the data were input to the tool. The output of reference case is shown in Figure 7.1.

OUTPUT - REFERENCE CASE			
1	IRR (%)	29,85%	
2	Annual Production (GWh) :	14,74	INCOME
3	Sale Price (TL/kWh) :	0,16	
4	Annual Income (TL) :	2.358.873,30	
5	Cost of Construction (TL) :	5.322.404,87	OUTFLOW
6	Loan Installments (TL) :	1.625.389,19	
7	Annual Expense (TL) :	200.193,98	

Figure 7.1: Output of Reference Case

When the output of the tool was compared with the expectations of company in the decision making stage, close similarities were observed. The IRR was found to be 28,48 % according to the companies calculations and the proposed tool computed it to be 29,85 %. The 1,37 % difference in IRR between the companies' calculations and the proposed tool was due to the slight difference between the annual expenses, which is composed of operational, maintenance and renewal costs. In this case study, the operational and the maintenance costs were the same as the company calculations and the tool projections. However, in the company calculations, a fixed renewal cost was taken once in every eight years, whereas in the proposed tool, it was a function of the facility cost and taken annually. Table 7.1 compares both of the outputs.

Table 7.1: Comparison of Company output and Tool output for the Reference Case

		COMPANY	TOOL
1	**IRR (%) :**	28,48%	29,85%
2	**Annual Production (GWh) :**	14,71	14,74
4	**Annual Income (TL) :**	2.206.500,00	2.358.873,30
5	**Cost of Construction (TL) :**	5.322.625,00	5.322.404,87
6	**Loan Installments (TL) :**	1.625.456,50	1.625.389,19
7	**Annual Expense (TL) :**	162.000,00	200.193,97

Once the interviews were over, the senior partner of the firm acknowledged that the close IRR calculations between the company's reference case and the tools reference case addressed some of his suspicions towards the tool and increased the reliability of the tool for him.

Once the reference case was created, the interviewees completed the change probability table. Since there were two interviewees, their inputs on the decision support tool were different, potentially altering the final results. It was observed that the senior partner created a more conservative change probability table compared to the junior partner, hence the less profitable output for the senior partner. 100 simulations were run for each partner and the results of the senior and junior partners are shown in Table 7.2 and 7.3, respectively.

Table 7.2: The output of 100 simulations (the senior partner)

1	14,55	**26**	49,32	**51**	10,71	**76**	17,85
2	6,78	**27**	7,70	**52**	20,57	**77**	22,52
3	28,33	**28**	19,30	**53**	14,57	**78**	23,53
4	17,97	**29**	22,87	**54**	15,51	**79**	9,39
5	12,75	**30**	**0,00**	**55**	14,52	**80**	17,50
6	16,64	**31**	15,88	**56**	**0,00**	**81**	10,96
7	**0,00**	**32**	30,88	**57**	25,95	**82**	28,27
8	11,39	**33**	36,93	**58**	20,07	**83**	20,06
9	20,75	**34**	22,63	**59**	28,33	**84**	36,80
10	19,35	**35**	15,42	**60**	45,59	**85**	20,85
11	25,19	**36**	20,23	**61**	**0,00**	**86**	23,25
12	7,24	**37**	14,90	**62**	17,85	**87**	7,63
13	8,40	**38**	7,87	**63**	12,48	**88**	16,62

Table 7.2 Continued

14	25,44	**39**	27,83	**64**	12,91	**89**	19,88
15	11,26	**40**	**0,00**	**65**	13,16	**90**	12,21
16	18,99	**41**	14,04	**66**	13,61	**91**	7,97
17	6,07	**42**	24,23	**67**	22,45	**92**	17,14
18	20,66	**43**	18,66	**68**	24,35	**93**	**0,00**
19	**0,00**	**44**	**0,00**	**69**	12,31	**94**	**0,00**
20	35,58	**45**	9,44	**70**	11,96	**95**	17,52
21	16,47	**46**	**0,00**	**71**	9,01	**96**	22,35
22	24,05	**47**	22,47	**72**	25,87	**97**	3,91
23	25,61	**48**	6,12	**73**	5,02	**98**	19,19
24	6,84	**49**	20,36	**74**	7,55	**99**	31,53
25	18,14	**50**	10,69	**75**	31,24	**100**	18,07
AVERAGE:		**16,57 %**					

Table 7.3: The output of 100 simulations (the junior partner)

1	21,95	**26**	28,84	**51**	11,22	**76**	25,33
2	19,89	**27**	19,38	**52**	7,18	**77**	22,18
3	30,70	**28**	30,97	**53**	17,99	**78**	25,53
4	23,34	**29**	34,72	**54**	22,47	**79**	4,91
5	25,00	**30**	11,26	**55**	22,26	**80**	28,78
6	21,00	**31**	18,32	**56**	16,20	**81**	15,97
7	30,26	**32**	23,65	**57**	39,03	**82**	31,62
8	23,00	**33**	22,71	**58**	17,16	**83**	23,03
9	32,33	**34**	19,01	**59**	28,15	**84**	16,76
10	21,07	**35**	24,99	**60**	13,94	**85**	15,89
11	20,84	**36**	20,31	**61**	38,59	**86**	17,28
12	27,16	**37**	23,92	**62**	22,53	**87**	19,80
13	35,08	**38**	26,53	**63**	23,06	**88**	16,48
14	16,86	**39**	12,67	**64**	22,95	**89**	29,58
15	17,01	**40**	23,89	**65**	26,10	**90**	29,57
16	11,90	**41**	33,38	**66**	33,54	**91**	23,96
17	20,19	**42**	26,98	**67**	15,11	**92**	24,92
18	26,30	**43**	29,00	**68**	27,18	**93**	26,06
19	27,34	**44**	26,33	**69**	31,41	**94**	24,48
20	25,44	**45**	14,87	**70**	20,27	**95**	13,89
21	24,68	**46**	15,24	**71**	29,97	**96**	22,71
22	19,23	**47**	45,56	**72**	11,93	**97**	25,27

Table 7.3 Continued

23	13,48	**48**	31,47	**73**	24,72	**98**	8,98
24	15,50	**49**	25,02	**74**	15,50	**99**	36,74
25	21,62	**50**	**0,00**	**75**	25,51	**100**	14,99
AVERAGE:		**22,69 %**					

The average IRR value for the simulations of the senior partner is 16,57 % and for the junior partner it is 22,69 %. As mentioned previously in this chapter, the differences in the "Change Probability" table caused this remarkable difference in the IRRs. For the senior partner, there are 10 simulations that output 0 % IRR yet, for the junior partner, only 1 simulation outputs 0% IRR. Since this tool based on subjective "Change Probability" judgments of the users, it is not surprising to output two different IRR for two different users in the same project.

At the end of the interview, both partners told that the estimated cost of construction elevated by approximately 15% and up to the end of summer 2011, the energy production haven't reach the designed values due to the weather conditions and probable misdesign.

7.2 User Comments for the Decision Support Tool

At the end of the case study, both users gave their feedback on the proposed decision support tool.

On one hand, the tool was found user-friendly. The lack of pop-ups, advertisements, warning messages and other disturbing interfaces was specifically stressed by both users. In addition, they commented on the simple and understandable steps of the model and remarked on its utility and practicality.

Output format was found to be most impressing by users. Sensitivity analysis, which helps the user to investigate the components for every IRR value, was found very helpful for the decision makers.

Most importantly, as stated in the previous part, the similarity between the reference case outputs greatly increased their trust in the results of the tool. Also, the average

IRR data was found to be very realistic when compared with the final and actual IRR of the investment.

On the other hand, the users gave some constructive criticism. It was mentioned that there were too many inputs required for the tool to calculate the IRR. Though asking more input enhances the accuracy of the tool, any loss of concentration filling the input data (especially in the second stage for the duration data) can be troubling and significantly affect the output of the tool. .

Moreover, for the proposed decision support tool, the accuracy of the IRR results greatly depends on the number of runs, where various repetitions (at least 50) are recommended to obtain highly accurate results. It should be noted that to increase the accuracy of the test one such improvement is developing a user interface through a more advanced programming language (i.e. C++), which could automatically run the test for a preset number. This would not only enhance the accuracy, but also eliminate the cumbersome nature of manually running the test over and over

In addition, one another shortcoming of the tool was the use of a template for calculation of investment cost. Users may sometimes feel limited with the IRR component input table. In various projects, different construction methods could be used during the construction of power plant and users may need to input some additional components such as tunnel boarding, rock excavation, piling etc. “A user, who executes different construction methods for the power plants, could not benefit from this tool”, stated by the senior partner.

Moreover, it is important to note that the proposed decision support tool merely simplifies the investor go through the IRR calculation. The input data are still filled by the users and the software is inherent to any miscalculation due to false input. It is the users own responsibility to enter the input data as accurate as possible. Moreover, the software does not make the final decision for the investigator to start a project or not, depending on the average IRR, since there is no universal minimum IRR to bid. It only outputs the calculated IRR. One company can decide on bidding on the project, whereas the other one prefer not to bid on it. Again, it is the investors’ own responsibility to bid on the project.

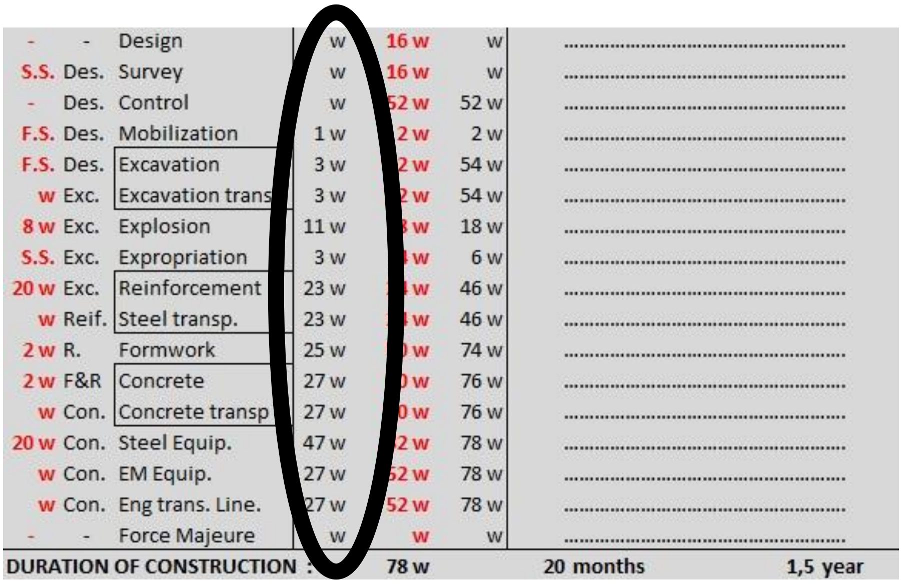
To sum up, the reliability, usability and sensitivity analysis structure were found to be satisfying; whereas a revised coding and a more professional appearance are required for the proposed decision support tool to be more effective.

CHAPTER 8

REVISION OF THE DECISION SUPPORT TOOL BASED ON TEST RESULTS

8.1 Enhancements on the Structure of the Model

After conducting interviews and taking feedbacks from the users, significant changes are made to the program. First of all, the interface has been modified to be user-friendly. The cost, quantity, duration and change probability data are used to be in different places and the users may need to be fully guided in order to fulfill the related data correctly. Previous version of the model doesn't have an organized users interface and the input boxes were so complex.



-	-	Design	w	16 w	w	…
S.S.	Des.	Survey	w	16 w	w	…
-	Des.	Control	w	52 w	52 w	…
F.S.	Des.	Mobilization	1 w	2 w	2 w	…
F.S.	Des.	Excavation	3 w	2 w	54 w	…
w	Exc.	Excavation trans	3 w	2 w	54 w	…
8 w	Exc.	Explosion	11 w	w	18 w	…
S.S.	Exc.	Expropriation	3 w	w	6 w	…
20 w	Exc.	Reinforcement	23 w	w	46 w	…
w	Reif.	Steel transp.	23 w	w	46 w	…
2 w	R.	Formwork	25 w	w	74 w	…
2 w	F&R	Concrete	27 w	0 w	76 w	…
w	Con.	Concrete transp	27 w	0 w	76 w	…
20 w	Con.	Steel Equip.	47 w	2 w	78 w	…
w	Con.	EM Equip.	27 w	52 w	78 w	…
w	Con.	Eng trans. Line.	27 w	52 w	78 w	…
-	-	Force Majeure	w	w	w	…
DURATION OF CONSTRUCTION :				78 w	20 months	1,5 year

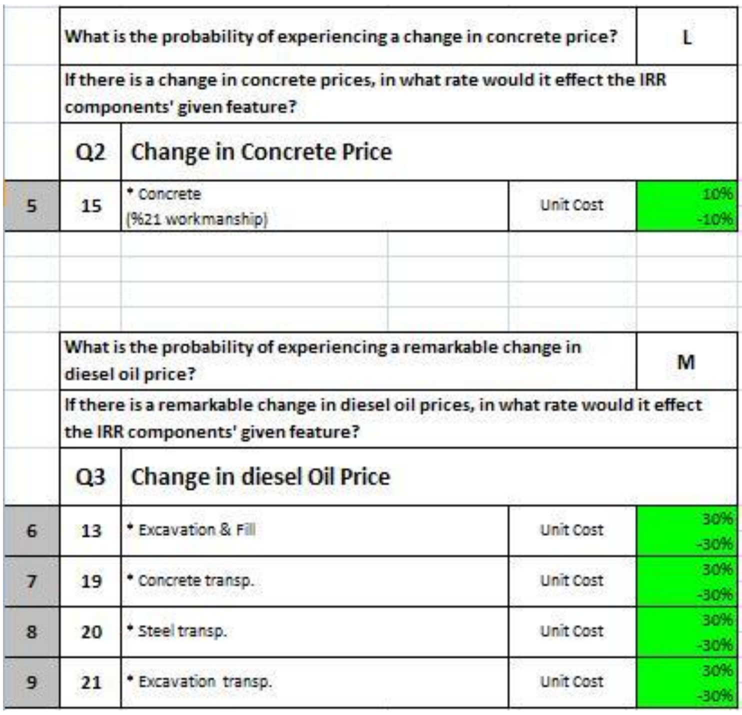
Figure 8.1: Duration input table in the older version

Figure 8.1 was the duration input table of the tool before the revisions. There were three main columns. The left side of the middle column which is taken into bold frame was the input places of the duration data. Also the activities were listed in a sequence related to their construction steps on the right side of the working schedule. In the revised version, the structure of the duration input table had changed to be more organized form as shown in Figure 8.2. It is now in table format and numbered as “STEP 2”. Furthermore, it is placed in the middle of the user interface as seen in Figure 5.10 and Figure 5.11.

STEP 2		
WORK SCHEDULE COMPONENTS		
Activity Name	Duration	
Mobilization	2	week
Excavation	52	week
Explosion	8	week
Expropriation	4	week
Reinforcement	24	week
Formwork	50	week
Concrete	50	week
Steel Equip.	32	week
EM Equip.	52	week
Eng trans. Line.	52	week

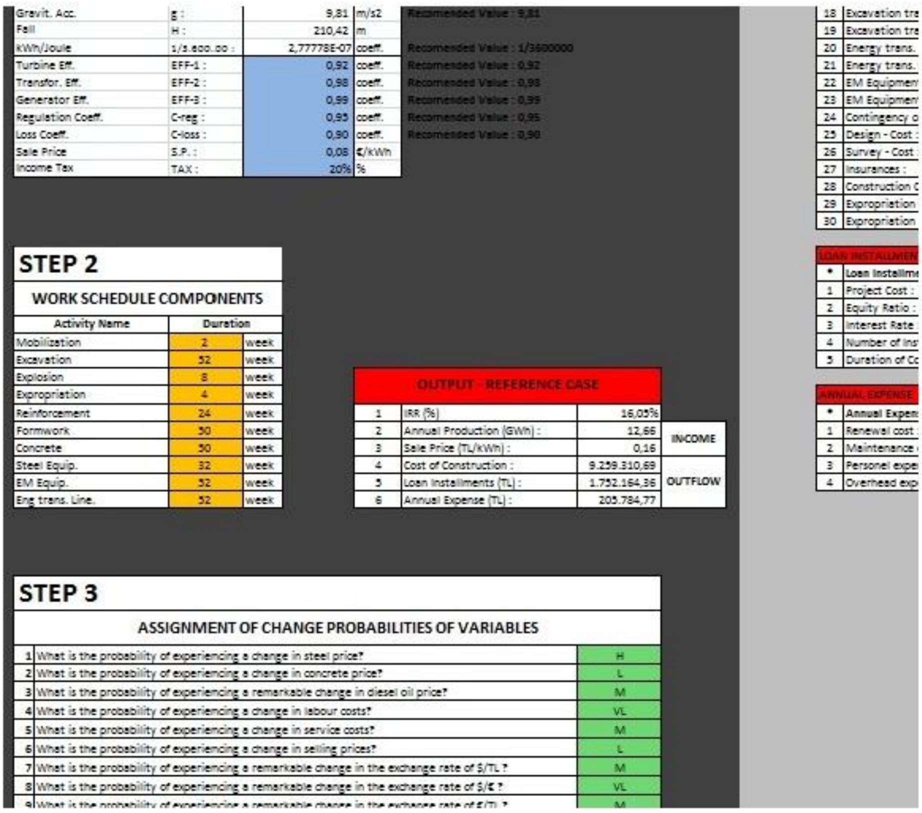
Figure 8.2: Duration input table in the revised version

In the older version of the program, the structure of change probability rating table was not in a proper order as seen in Figure 8.3 and definitely needs to be revised. On the top right corner of the tables, there is a cell mentioning H, M, L or VL which used to be the cell in which users input the change probability of the related variable. In the revised version, an independent table is created and linked to the database. The new change probability table on the user interface is numbered as “STEP 3” and can be seen in the bottom of Figure 8.4.



	What is the probability of experiencing a change in concrete price?			L
	If there is a change in concrete prices, in what rate would it effect the IRR components' given feature?			
	Q2	Change in Concrete Price		
5	15	* Concrete (%21 workmanship)	Unit Cost	10% -10%
	What is the probability of experiencing a remarkable change in diesel oil price?			M
	If there is a remarkable change in diesel oil prices, in what rate would it effect the IRR components' given feature?			
	Q3	Change in diesel Oil Price		
6	13	* Excavation & Fill	Unit Cost	30% -30%
7	19	* Concrete transp.	Unit Cost	30% -30%
8	20	* Steel transp.	Unit Cost	30% -30%
9	21	* Excavation transp.	Unit Cost	30% -30%

Figure 8.3: Change probability input table in the older version



Gravit. Acc.	g :	9,81	m/s2	Recomended Value : 9,81
Fall	H :	210,42	m	
kWh/Joule	1/3.600.00 :	2,77778E-07	coeff.	Recomended Value : 1/3600000
Turbine Eff.	EFF-1 :	0,92	coeff.	Recomended Value : 0,92
Transfor. Eff.	EFF-2 :	0,98	coeff.	Recomended Value : 0,98
Generator Eff.	EFF-3 :	0,99	coeff.	Recomended Value : 0,99
Regulation Coeff.	C-reg :	0,95	coeff.	Recomended Value : 0,95
Loss Coeff.	C-loss :	0,90	coeff.	Recomended Value : 0,90
Sale Price	S.P. :	0,08	€/kWh	
Income Tax	TAX :	20%	%	

18	Excavation tra
19	Excavation tra
20	Energy trans.
21	Energy trans.
22	EM Equipmen
23	EM Equipmen
24	Contingency o
25	Design - Cost :
26	Survey - Cost :
27	Insurances :
28	Construction C
29	Expropriation
30	Expropriation

LOAN INSTALLMEN	
*	Loan Installme
1	Project Cost :
2	Equity Ratio :
3	Interest Rate
4	Number of Ins
5	Duration of Co

ANNUAL EXPENSE	
*	Annual Expen
1	Renewal cost :
2	Maintenance
3	Personel expe
4	Overhead exp

STEP 2

WORK SCHEDULE COMPONENTS

Activity Name	Duration	
Mobilization	2	week
Excavation	52	week
Explosion	8	week
Expropriation	4	week
Reinforcement	24	week
Formwork	30	week
Concrete	30	week
Steel Equip.	32	week
EM Equip.	52	week
Eng trans. Line.	52	week

OUTPUT - REFERENCE CASE			
1	IRR (%)	16,05%	
2	Annual Production (GWh) :	12,66	INCOME
3	Sale Price (TL/kWh) :	0,16	INCOME
4	Cost of Construction :	9.259.310,69	OUTFLOW
5	Loan Installments (TL) :	1.752.164,36	OUTFLOW
6	Annual Expense (TL) :	205.784,77	OUTFLOW

STEP 3

ASSIGNMENT OF CHANGE PROBABILITIES OF VARIABLES

1	What is the probability of experiencing a change in steel price?	H
2	What is the probability of experiencing a change in concrete price?	L
3	What is the probability of experiencing a remarkable change in diesel oil price?	M
4	What is the probability of experiencing a change in labour costs?	VL
5	What is the probability of experiencing a change in service costs?	M
6	What is the probability of experiencing a change in selling prices?	L
7	What is the probability of experiencing a remarkable change in the exchange rate of $/TL ?	M
8	What is the probability of experiencing a remarkable change in the exchange rate of $/€ ?	VL
9	What is the probability of experiencing a remarkable change in the exchange rate of €/TL ?	M

Figure 8.4: Closer picture of new version

Furthermore, the output is modified to be more detailed and user friendly than the older version. It is placed in the user interface sheet as displayed in the right portion of Figure 5.10.

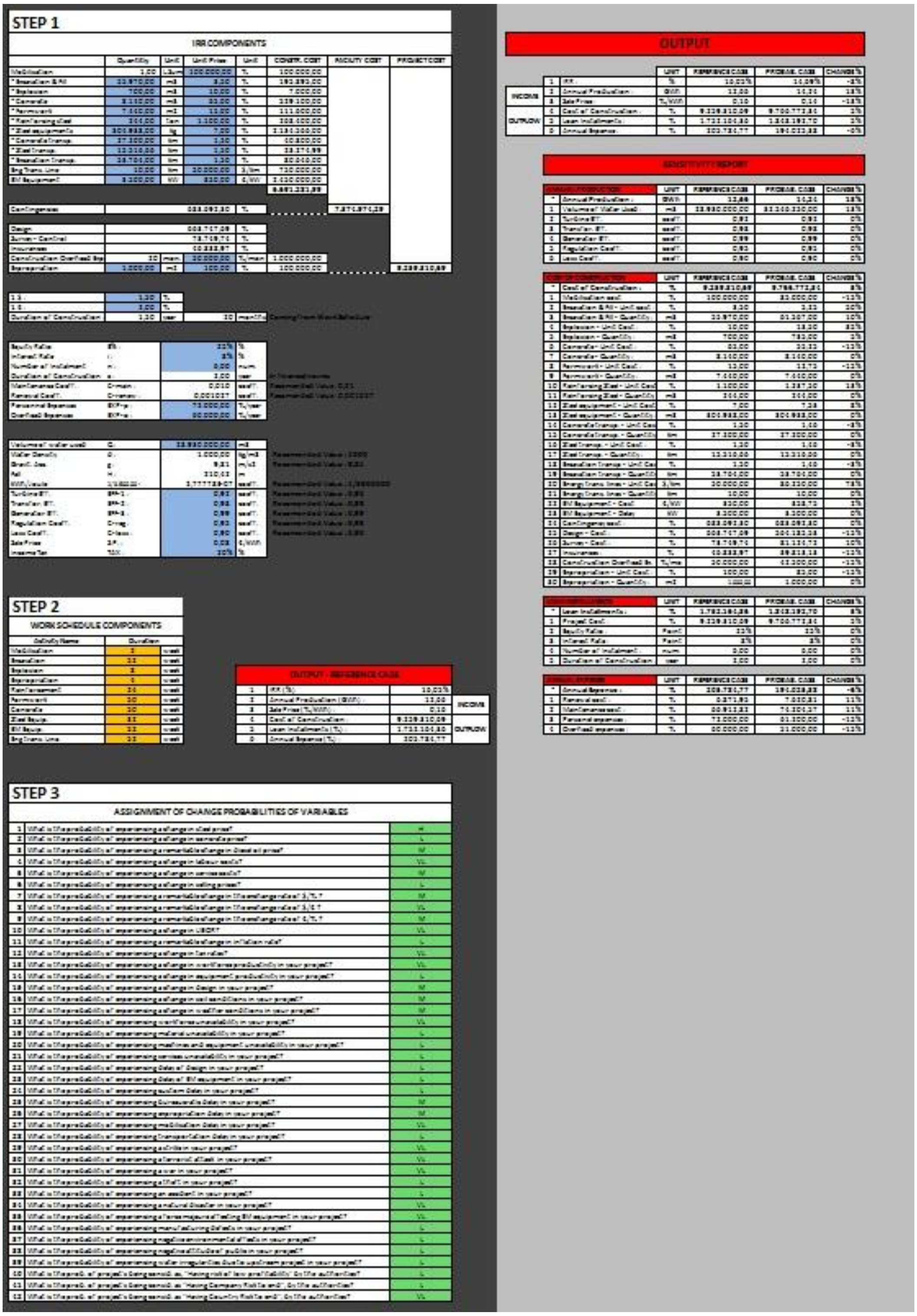


Figure 8.5: New version of the users interface

CHAPTER 9

RESULTS AND DISCUSSIONS

This chapter summarizes the thesis by indicating the development of the model, pointing out the significant parts and concludes by explaining the benefits of the model.

In the investment projects, the future profits and the costs are always hard to foresee. Therefore, the risk and uncertainty of carrying out a medium to long-term investment can be high. Similarly, in this study, IRR components display different variability under the influence of different variables. For that reason, this study has three main goals:

- Identifying the main components and subcomponents of the IRR
- Finding out which variables/components of IRR affect the IRR most and magnitude of their impacts.
- Developing a decision support tool to estimate IRR under different scenarios.

In order to achieve these goals, the whole study is divided into three main parts: first, collecting data and building a database by conducting surveys and interviews; second, developing a modeling framework by using the created database for the assessment of IRR and developing a decision support tool and third, testing the tool and revising it in the light of case study findings.

The output of this study is a decision support tool. In the tool, when a user opens the user's interface, first, the program requests from the user to input data related to IRR component values which are most probable to happen (expected values). Consequently, using these expected values it calculates "The First IRR" (expected

IRR). Afterwards, the user has to input changing probabilities for all the IRR components. Then, the tool outputs the "New IRR" under a different scenario than the initial set conditions. By changing the values of parameters, the user can create new scenarios and find other "IRR" values. In other words, if an IRR component has a probability to change (which is defined by the user), the tool changes that value between the boundary which is determined by the experts during interviews and outputs a new IRR value along with its components. This gives the users the opportunity to foresee other possible scenarios and determine the necessary precautions if necessary.

The biggest benefit of this decision support tool is that for every simulation, the program gives the user the opportunity of monitoring the potential positive or negative change on the IRR components that leads the change of IRR. Also at the same time, users can see the effect of change of any variable on the IRR. By this way, users may have a chance to know the points that need to be taken into consideration for that specific project and become more careful while making an investment decision. This tool may enhance the accuracy of the investment decisions.

Briefly, this study explains the change of IRR components by changing the value of independent variables. However, one important shortcoming of the tool is the undefined interrelations/correlations between the IRR components. For further studies, researchers can enhance the program by writing new codes which take into account of interrelations. Also, more comprehensive surveys can be carried out to define more accurate boundaries for IRR components. Another important shortcoming of the tool is the ability of making only one simulation at a time. In practice, users may prefer to make 100, 1000 or more simulations in one time by pressing just one button and take the average of those in order to minimize the effect of extraordinary simulation results.

To conclude, experience is one of the most essential assets for an investor in the business life. To gain an effective experience, people or companies usually spend lots of money and time. This tool uses the knowledge of experts who are experienced in the HEPP business to guide the potential users about possible scenarios and results of a scenario can be calculated by the tool by pressing just one button. Thus, the user has a change to analyze various scenarios that minimizes the risk of losing time and money.

REFERENCES

Alam, Md. N. E. and Doucette, J. (2010), "Stochastic Investment Decision Making with Dynamic Programming", 2010 International Conference on Industrial Engineering and Operations Management, Dhaka, Bangladesh, January 2010.

Bu-Qammaz, A. S., Dikmen, I., and Birgonul, M. T., (2009), "Risk assessment of international construction projects using the analytic network process", NRC Research Press, pp.1170-1181

Bas, E., Kahraman, C., (2009), "Internal rate of return decision rules in case of uncertainty", itüdergisi/d, 8(4), pp.119-126.s

Begum, R. A., Siwar, C., Pereira, J. J., and Jaafar, A. H., (2006), "A benefit-cost analysis on the economic feasibility of construction waste minimization: The case of Malaysia", Resources, Conservation and Recycling 48 (2006), pp. 86-98.

Brealey, R. A., and S.C. Myers. (2003), Capital Investment and Valuation. 7th ed., McGraw-Hill, New York, ISBN 0-07-138377-8

CIA – The World Factbook, "https://www.cia.gov/library/publications/the-world-factbook/", last accessed on 12 July 2011

Demirhan, E., Aydemir, O., Inkaya, A., (2011), "The Diretion of Causality between Financial Development and Economic Growth: Evidence from Turkey", International Journal of Management, 28 (1), pp. 3-19

Dikmen, I., Birgonul, M.T., Anac, C., Tah, J.H.M. and Aouad, G. (2008), "Learning from risks: A tool for post-project risk assessment", Automation in Construction, 18, pp.42-50.

Dikmen, I. and Birgonul, M.T. (2006), "An analytic hierarchy process based model for risk and opportunity assessment of international construction projects", NRC Research Press, 33, pp.58-68

Dikmen, I., Birgonul, M. T. and Gur, A. K. (2007), "A case-based decision support tool for bid mark-up estimation of international construction projects", Automation in Construction, 17, pp.30-44.

Electricity Consumption Per Capita, "https://www.cia.gov/library/publications/the-world-factbook/", last accessed on 12 July 2011

Electricity Generation & Transmission Statistics of Turkey, "http://www.teias.gov.tr/istatistik2009/index.htm", last accessed on 9 July 2011

Fong, Q. S. W., Ellis, S. and Haws, M. (2005), "Economic Feasibility of Small Scale Black Lipped Pearl Oyster (Pinctada margaretifera) Pearl Farming In The Central Pacific", Aquaculture Economics & Management, 9, pp.347-368.

Forouzbakhsh, F., Hosseini, S.M.H and Vakilian, M., (2006), "An approach to the investment analysis of small and medium hydro-power plants", Energy Policy, 35(2), pp.1013-1024

General Directorate of State Hydraulic Works, (2009), "Turkey Water Report 2009", General Directorate of State Hydraulic Works

Kucukali, S. and Baris, K., (2009), "Assessment of Small Hydropowr (SHP) Development in Turkey: Laws, Regulations and EU Policy Perspective", Energy Policy, 37(10), pp.3872-3879

Lin, Bo. Q., (2003), "Electricity Demand in the People's Republic of China: Investment Requirement and Environmental Impact", Asian Development Bank, Philippines.

Johnstone, D., (2008), “What Does an IRR (or Two) Mean?”, The Journal of Economic Education, 39(1), pp.78-87

Huang, Y.H., Wu, J.H., (2007), “A Portfolio Risk Analysis on Electricity Supply Planning”, Energy Policy, 36(2), pp. 627-641

Jordan, T.J. (2009). “An innovation for the financial markets”, Swiss National Bank, Berne, Zurich

Khan, S., Mushtaq, M. and Chen, C. (2010), “A Decision Support Tool For Irrigation Infrastructure Investments”, Irrigation and Drainage, 59, pp.404-418.

Kilanc, G. P. and Or, I. (2008), “A decision support tool for the analysis of pricing, investment and regulatory processes in a decentralized electricity market”, Energy Policy, 36, pp.3036-3044

Kim, S. (2008), “Analysis of economic feasibility of integrated gasification combined cycle (IGCC) as a next generation power supply in Korea”, Journal of Economic Research, 13, pp.149-174.

Küçükbeycan, M. (2008), “Retscreen Decision Support System For Prefeasibility Analysis of Small Hydropower Projects”, M.S. Thesis, METU

Liang, X. and Dijk, M. P. (2010), “Financial and economical feasibility of decentralized wastewater reuse systems in Beijing”, Water Science and Technology, 61.8, pp.1965-1973

Munoz, J.I., Contreras, J., Caamano, J. and Correia, P.F. (2011), “A decision-making tool for project investments based on real options: the case of wind power generation”, Ann Oper Res, 186, pp.465-490.

Munoz, J.I., Nieta, A.A.S., Contreras,J. and Bernal-Agustin, J.L., (2009), “Optimal Investment Portofilo in Renewable Energy: The Spanish Case”, Energy Policy, 37(12), pp.5273-5284

Ogayar, B., Vidal, P.G., Hernandez, J.C., (2009), “Analysis of the cost for the refurbishment of small hydropower plants”, Renewable Energy, 34(11), pp. 2501-2509

Ozorhon, B., Dikmen, I. and Birgonul, M.T. (2006), “Case-Based Reasoning Model for International Market Selection”, Journal of Construction Engineering and Management, 132:9, pp.940-948.

Paepe, M. D. and Mertens, D. (2007), “Combined heat and power in a liberalized energy market”, Energy Conversion and Management, 48, pp.2542-2555.

Pantaleo, A., Pellerano, A., Ruggiero, F. and Trovato, M. (2005), “Feasibility study of off-shore wind farms: an application to Puglia region”, Solar Energy, 79, pp.321-331

Rebiasz, B. (2005), “Fuzziness and randomness in investment project risk appraisal”, Computers & Operations Research, 34, pp.199-210.

Ruta, R.K., Apanaviciene, R. and Butauskas, A. (2010), “Evaluation of road investment project effectiveness”, Inzinerine Ekonomika-Engineering Economics, 21, pp.368-376.

Sarper, H., Palak, G., Chacon, P.R. and Fraser, J.M. (2010), “Probability Distribution Function of the Internal Rate of Return For Short-Term Projects With Some Random Cash Flows and Extentions”, The Engineering Economist, 55, pp.350-378

Shinoda, T. (2010), “Capital budgeting management practices in Japan”, Econ. J. of Hokkaido Univ., 39, pp.39-50

The Basics of Libor, “http://www.bbalibor.com/bbalibor-explained/the-basics”, last accessed on 14 May 2011

Turkey GDP Growth Rate, “http://www.tradingeconomics.com/Economics/GDP-Growth.aspx?Symbol=TRY”, last accessed on 12 July 2011

Van Den Bergh, J.C.J.M., (2008), “The GDP paradox”, Journal of Economic Psychology, 30 (2), pp.117-135

Van der Sluijs, J.P., Janssen, P.H.M, Petersen, A.C., Kloprogge, P., Risbey, J.S., Tuinstra, W., Ravetz, J.R., (2004), “Tool Catalouge for Uncertainty Assessment”, Utrecht University, Utrecht, Netherlands

Xing, W. and Wu, F.F., (2002), “Economic evaluation of private power production under uncertainties”, International Journal of Electrical Power & Energy Systems, 25(2), pp.167-172

Yumurtaci, Z. and Erdem, H.H., (2006), “Economical analyses of build-operate-transfer model in establishing alternative power plants”, Energy Conversion and Management, 48(1), pp.234-241