INVESTMENT DECISION MAKING IN HPP PROJECTS: COMPARISON OF DOMESTIC AND INTERNATIONAL PRACTICES

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ABSTRACT

INVESTMENT DECISION MAKING IN HPP PROJECTS: COMPARISON OF DOMESTIC AND INTERNATIONAL PRACTICES

Energy has been a very important value in the development of modern world. Nations that have been using the energy resources efficiently have successfully increased their welfare. It is often speculated that energy resources are the main factors of the global political debates. Energy resources have continuously been searched. Consequently, thermal, hydro, wind and solar energy are widely being harvested all around the world. Each of these has several advantages and disadvantages, but all have one point in common: mankind needs to use them, and every little piece (single watt) has become more and more valuable. Obviously, the value always comes with a price, which means an investment should be done. The main focus of this study is Hydro Power Plants (HPP's). The objective is to analyze the lifecycle costing of these projects and investigate the challenges at the feasibility stage, which shapes the major part of the costs. In this respect, domestic and international practices in terms of feasibility reports have been investigated through an extensive literature survey. In order to further examine the differences, several interviews were performed with experts and a number of actual feasibility reports were reviewed. In addition, other international practices which have been available from the literature survey have been reviewed including many countries all over the world such as USA, Australia, Georgia, Albenia, Spain, etc. One of the main objectives of this thesis has been to compare the domestic and international practices to provide recommendations for Turkish Feasibility Reports (TFRs). To achieve the objectives of this thesis, several feasibility reports have been reviewed and these are presented as case studies. The shortcomings and the root causes of problems were searched, and the findings were evaluated. One of the key findings is that investors do not realize the importance of the initial steps of a HPP project. The necessary funding for site exploration and engineering consultancy works is not being allocated in the earlier stages of the project.

ÖZET

HİDROELEKTRİK PROJELERİNDE YATIRIM KARARI ALINMASI: YEREL VE ULUSLARARASI YAKLAŞIMLARIN KARŞILAŞTIRILMASI

Modern dünyanın gelişiminde enerji çok önemli bir değer olmuştur. Enerji kaynaklarını efektif bir şekilde kullanabilen toplumlar refah seviyelerini başarılı bir şekilde yükseltmiştir. Enerji kaynaklarının günümüz küresel politikalarına yön verdiği görüşü pek çok yerde tekrarlanmaktadır. Enerjinin nasıl elde edilebileceği konusu sürekli olarak araştırılmış, bunun sonucunda ise günümüz imkanlarında termik, hidroelektrik, rüzgar ve güneş türü kaynaklardan tüm dünyada geniş oranlarda faydalanılabilmektedir. Belirtilen her farklı kaynağın kendine gore avantaj ve dezavantajları bulunmakla birlikte tümü için ortak olan bir nokta; insanlığın bunları kullanma zorunluluğudur. En küçük parçalar dahi her gün daha değerli hale gelmektedir. Doğal olarak, üretilen bu değerlerin bir de maliyeti olmaktadır, ki bu da bir yatırım yapılması anlamına gelir. Bu tez çalışmasının odak noktası hidro elektrik santralleri olacaktır. Çalışmanın amacı bu projelerin toplam yatırım ömrü için maliyetlerinin incelenmesi ve fizibilite aşamasında yaşanan zorlukların araştırılmasıdır. Bu aşamanın toplam maliyet üzerinde önemli bir belirleyici etkisi olduğu düşünülmektedir. Bu çerçevede, ulusal ve uluslararası uygulamalar yoğun bir literature taraması ile araştırılmıştır. Farlılıkları daha detaylı inceleyebilmek için konu hakkında uzman kişilerle görüşmeler yapılmış ve bazı projelere ait fizibilite raporları incelenmiştir. Buna ilave olarak literatür taraması sonucu Amerika Birleşik Devletleri, Avustralya, Gürcistan, Arnavutluk İspanya gibi ülkelerdeki uluslararası uygulamalarla ilgili elde edilen diğer kaynaklar da incelenmiştir. Bu çalışmanın diğer bir odak noktası ulusal ve uluslararası uygulamaların farklarının karşılaştırılması ve lokal uygulamalar için önerilerde bulunulmasıdır. Tezin amaçlarına ulaşılabilmesi için bazı örnek olay incelemeleri yapılmıştır. Karşılaşılan eksiklikler ve temel nedenler araştırılmış ve bulgular değerlendirilmiştir. Önemli bulgulardan biri, yatırımcıların hidro elektrik santral projelerindeki başlangıç adımlarının ne denli önemli olduğunu tam olarak fark edemediğidir. Yatırımların başlangıç aşamalarında gerekli olan saha incelemeleri ve mühendislik danışmanlıklarına yeterince yer verilmediği görülmüştür.

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LIST OF ACRONYMS / ABBREVIATIONS

CAPEX	Capital Expenditure
COD	Commercial Operation Date
DSI	Devlet Su İşleri (State Hydraulic Works)
EIA	Environmental Impact Assessment
EIE	Elektrik İşleri Etüt İdaresi (Electrical Power Resources Survey and Development Administration)
EPC	Engineering Procurement Construction
ESIA	Environmental and Social Impact Assessment
ETL	Energy Transmission Line
EUAS	Elektrik Üretim A.Ş. (The Electricity Generation Company)
FGS	Flow Gauging Stations
FS	Feasibility Study
GRP	Glass Fiber Reinforced Plastic
HPP	Hydropower Plant
IRR	Internal Rate of Return
NATM	New Austrian Tunneling Method
NRCan	Natural Resources Canada's
OE	Owner’s Engineer
OECD	Organization for Economic Co-operation and Development
OPEX	Operating Expense
O&M	Operation and Maintenance
PMBOK	Project Management Body of Knowledge
PMI	Project Management Institute
RCC	Roller Compacted Concrete
SEA	Sectorial Environmental Assessment
TBM	Tunnel Boring Machine
TEK	Türkiye Elektrik Kurumu (Turkish Electricity Authority)
TFR	Turkish Feasibility Report

1. INTRODUCTION

1.1.Background of the Research

Energy has a key role in the evolution of mankind. Its importance has been increased especially in the last decades. Energy sources are now a very important subject for governments. According to World Economic Outlook (IEA, 2012):

- Either by taking all new developments and policies into account, the world is still failing to put the global energy system onto a more sustainable path. As indicated in the same document; global energy demand grows by more than one-third over the period to 2035 in the New Policies Scenario , with China, India and the Middle East accounting for 60% of the increase.

- Energy demand barely rises in Organization for Economic Co-operation and Development (OECD) countries, although there is a pronounced shift away from oil, coal (and, in some countries, nuclear) towards natural gas and renewables. Despite the growth in low carbon sources of energy, fossil fuels remain dominant in the global energy mix, supported by subsidies that amounted to $523 billion in 2011, up almost 30% on 2010 and six times more than subsidies to renewable. The cost of fossil-fuel subsidies has been driven up by higher oil prices; they remain most prevalent in the Middle East and North Africa, where momentum towards their reform appears to have been lost.

- Emissions in the New Policies Scenario correspond to a long-term average global temperature increase of 3.6 °C.

In the past, hydropower has acted as a catalyst for economic and social development by providing both energy and water management services, and it can continue to do so in the future (IPCC, 2011).

The renewable energy resources are becoming more important in today's world. Hydropower is the largest renewable resource used for electricity as stated by Frey *et al.*

(2002). Huber (1991) states that large and small hydroelectric energy generation still remains by far the most important of the "renewable" electrical energy production worldwide, providing 19% of the earth's electricity. Obviously, this percentage has changed with the increase in the wind and solar projects worldwide.

HPP's have been among the first methods of generating electricity. In the initial stages, the focus has been to successfully generate electricity, and the costs would not necessarily be among the priorities. With the involvement of private investors, the cost and benefits of these projects have more and more become important in the decision-making progress.

Today, there are several ways to generate energy, and these are mostly done by private investors. The feasibility of the project is the first question for the investor, or his shareholders. Due to the nature of HPP projects, and mainly that they depend highly on the project site, physical and environmental conditions, there are various unknowns and risks at the initial decision making phase.

Previous experiences from HPP projects have defined the potential risks that could be faced through the project implementation. These play an important role on the investment decisions in the field of Hydropower.

1.2. Problem Determination

With the changes of the development plans by the Turkish Government; a significant number of hydropower projects have been implemented by the private investors. This development is still continuing.

From the general knowledge and unofficial information, it is known that in many of these projects minor or major deviations from the investment plan have been experienced. Some of them are even in the order that the whole investment has become not feasible anymore.

The analysis of the reasons of this statement should involve many different aspects of each project.

1.3. Problem Statement

The mentioned deviations from the investment plan are mostly related with the investment budget, or the project implementation schedule. Obviously, there could be many reasons for these results. Within this thesis, only one of the possible reasons will be evaluated, which is the possible shortcomings of initial feasibility reports.

The initial tool for the investment decision on a hydropower project is the Feasibility Study. Within this study, the anticipated project budget and schedule is already included. It is observed that an important number of hydropower projects deviated from the estimations of their Feasibility Study figures.

As the result of this situation, the new projects are becoming more and more questionable by the investors, lenders, or other parties that will be involved.

1.4. Related Studies

The ongoing or recently developed hydropower projects are owned by many different investors. Each investor is believed to obtain their own experience and "lessons learned" from their projects. There are only a limited number of investors who could combine the experience of several projects. Some of the design or consulting companies do have the chance to observe and create a sound study on this problem. All these parties are business oriented and naturally would not prefer to share their knowledge.

A number of theses are available in the literature about the feasibility studies. Examples can be given as Mutlu (2010), Korkmaz (2007), Küçükbeycan (2008) and Aydın (2010). These studies have focused on the feasibility of a single project. However, there are no studies where several feasibility reports from domestic and international market has been searched and the differences were analyzed.

1.5. Aim and Objectives of the Research

The aim of this research is to analyze the different approaches followed for the preparation of a feasibility report. An initial search on how the lifecycle costs of a hydropower project are calculated will be done. The parts of a standard Turkish Feasibility Report (TFR) will be explained. The expected content and detail level will be evaluated. For the comparison, the parts of an International feasibility report will be investigated through the available examples. The content and the detail levels of information will also be evaluated.

The objectives of this research can be listed as follows;

- Investigating how the lifecycle costs of hydropower projects are calculated,
- Explaining and analysis of TFR in detail,
- Examining the International Feasibility Reports (IFRs),
- Comparing the domestic and international practices and identifying the major differences,
- Analyzing the possible consequences of these differences in terms of cost and schedule overruns (in domestic projects),
- Searching the actual projects and finding case studies, assessment of the case studies and evaluating if and how they support the previous findings.

1.6. Method of the Research

The research will be performed in two steps. In the first step, the standard Devlet Su İşleri (State Hydraulic Works – DSI) forms and report templates will be obtained. Example reports which have been prepared according to these templates will be searched through experts from private companies. In the second step, an extensive literature survey will be carried out to present international examples of feasibility reports. Their content will be investigated. In addition, examples from actual projects in the International market will be searched through the interviews with experts. These findings will be incorporated within the other reports.

The case studies will be obtained from the private resources. Interviews will be done with experts from private companies, experts from design side and construction side of the projects to obtain information of real project data.

1.7. Scope and Limitations

The stated problem of experiencing budget overruns and schedule delays is a very general issue. It can be linked to many different reasons at each step of investment planning and project execution. Obviously, it would be very difficult to generalize a common reason for the results. At most cases, the project specific evaluation should be done.

The focus of this research is only to evaluate the different approaches at the preparation of the feasibility report. It is believed that the misleading information at this initial step can have the biggest impacts on the investments. Therefore the findings are limited with only the analyzed data set. Other researches can result and identify different points of concerns and root causes.

However, this research can contribute to the initiation of a more detailed research by corresponding government institutions. With the help of the actual cases, and also the available database; the major causes of the budget and schedule overrun problems in the hydropower field can be analyzed. The results can be used to take important steps to update the permitting system.

1.8. Organization of the Thesis

In the second chapter of this study, lifecycle costing of hydropower projects are explained. In the third chapter, the process of investment decision making is presented. Also in this part, the TFR and IFRs will be evaluated in detail. The major differences will be highlighted.

The fourth chapter will include eight case studies which will include problems related to the observed differences on feasibility reports. Also the findings of the analysis will be discussed. In the final chapter, the conclusions will be explained.

2. LIFECYCLE COSTING OF HPP PROJECTS

Hydropower projects are among the investments that need careful examination and especially an extensive preparation process. Due to the nature of these projects; all the components should be tailor made to the specific project requirements. As Penche (1998) states; an investor decides to develop a small hydro site in order to obtain a reasonable profit. To do that his decision should be based on sound economic principles.

The decision on the layout, configuration and installed capacity of a typical hydropower project will be based on several investigation and considerations. With competent engineering, the findings will be evaluated and the project characteristics will be fixed. According to the interviews with experts, some of the major topics during this process can be mentioned as below:

- The Water Usage Rights: This subject might be the first step, or the key information for the designer. Most of the times, the boundary conditions define the main characteristics of a HPP.

  The river, connecting tributaries, geographical water elevations between which the project is limited, residential settlements, environmentally protected areas are the major points which defines the limits of a project. The investor would be subject to these conditions and the project could only be developed within these limits.

- The project topography: The engineer will carefully evaluate the project area. At the initial stages, topographical maps of 1/20.000 scale could generally be acceptable for the purpose. At the later stages, more detailed maps will be used.

  The engineer will be able to evaluate different project layouts, such as tunnels, conveyance channels, buried or above ground penstocks, etc.

  Also the access to various project sites will be evaluated in the light of the existing or possible new roads.

- Climate & flow regimes: The altitude of the project structures, therefore the climate conditions during the construction and operation will be evaluated by the engineer.

  The flow regimes will be important on the evaluation of a reservoir, probable maximum flood, the design floods for construction and operation, etc.

- Geological and Geotechnical conditions: These will be decisive for the design of various project structures. The earthquake and landslide risks will be evaluated and reflected to the project layout and structures.

- Electromechanical, hydromechanical and electrical equipment: The engineer will select the optimum type, number and capacity of the turbines. Accordingly the generators and other equipment will be selected.

  The investor, at the initial stages will be asked about the operation scheme of the plant. Accordingly, the engineer will design the various gates, stoplogs, cranes, and other auxiliary equipment.

- Energy Transmission Lines (ETL): The input on how the plant will be connected to the main grid will also be necessary at the very early stages of the project. With this input, the voltage levels, transmission line, and related structures will be determined by the engineer.

The initial costs of the plant will form the major part of the investment. However, the operation and maintenance (O&M) costs throughout the service life will be as important as the initial costs. These costs will be carefully detailed by the engineer at the early stages of the investment.

Figure 2.1 shows the investment cost trend for a large number of investigated projects of different sizes in the USA. The figure is from a study by Hall *et al*. (2003) that presents typical plant investment costs for new sites.

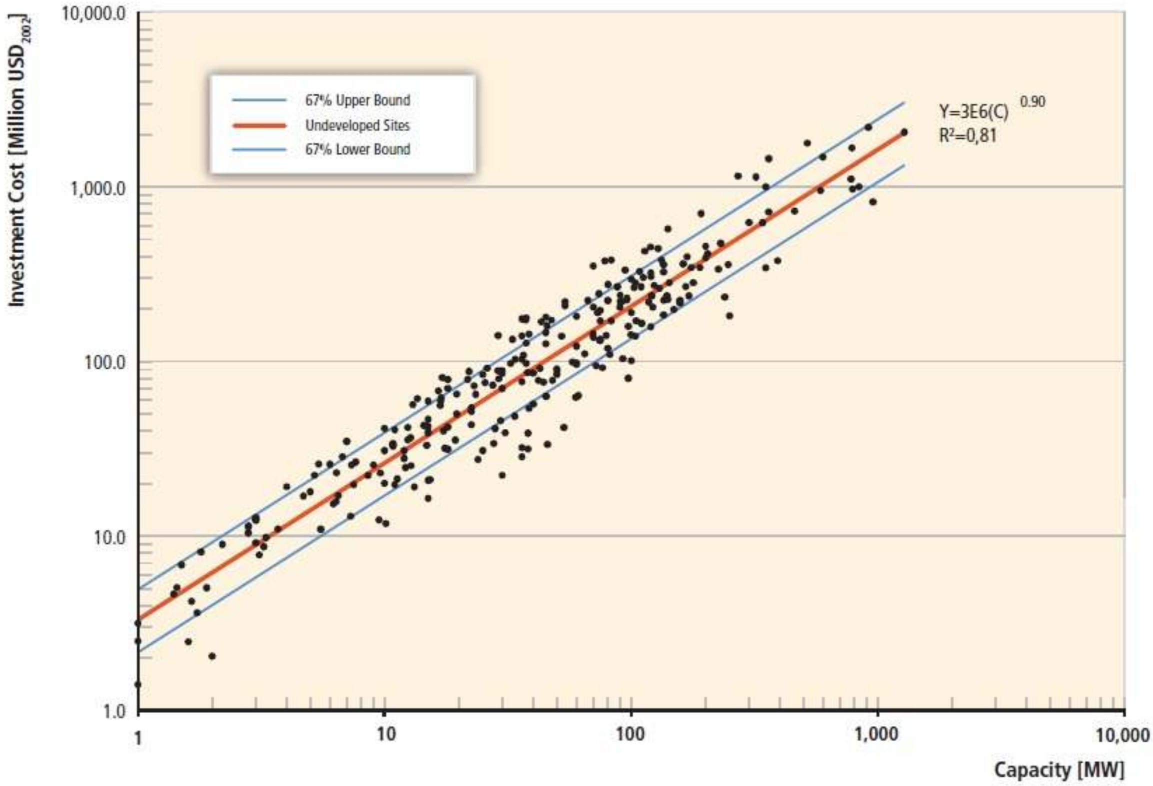

Figure 2.1. HPP investment cost as a function of plant capacity for undeveloped sites (adapted from Hall *et al.* (2003)).

With the total cost, the investor will be able to make a decision on either to continue with the project or to cancel his plans. At this stage, the Internal Rate of Return (IRR) and the Net Present Value of the project will be evaluated by the investor. These values will be the most important factors for a general evaluation.

An investment in a small hydropower scheme entails a certain number of payments, extended over the project life, and procures some revenues also distributed over the same period. The payments include a fixed component; the capital cost, insurance, taxes other than the income taxes, etc. and a variable component; O&M expenses. At the end of the project, in general limited by the authorization period, the residual value will usually be positive, although some administrative authorizations demand the abandonment of all the facilities which revert to the State. The economic analysis compares the different possible alternatives to allow the choice of the most advantageous or to abandon the project (Penche, 1998).

2.1. Project Development, Design & Management Costs

These costs form one of the first expenditures for a hydropower project. According to the nature and experience of the investor; the scope of different project participants would change. This study will focus on one of the options and briefly give the details of each cost. The option is selected for a HPP of approximately 40 MW installed capacity, as this size of a project would have almost all possible components of a typical HPP project. The scheme for construction is selected to be lot wise, and not an Engineering Procurement Construction (EPC) type.

(i) Investor or the Owner: Investor would have his own team for the overall management of the project. This will include main activities, such as: Selection and management of Owner's Engineer (OE), Contractor, Lender, and other advisors (legal, public relations, etc.). Such a team could be composed of less than ten persons, including technical, financial and legal experts.

According to Ravlo (2003), the owner is the entity holding the required licenses and approvals to regulate the actual water-resources and in most cases, the entity that initiated the analysis and investigations prior to the preliminary studies. In contract terminology this is frequently referred to as the employer.

(ii) OE at Design Stage: This will be the technical consultant of the investor who will review and give guidance on all the technical decisions of the Investor. The number of persons involved might be less than ten persons. However many more experts can be included in the project for short durations. They would be very much useful for the evaluation of specific details, which are normally, cannot be covered by permanent personnel.

(iii) Designer: The designer will hold the most important role on the success of the project. A competent designer will already have a team of significant experience and specific expertise.

According to Ravlo (2003), costs in the pre-construction stage are modest as compared to the construction period. It is also an accepted fact that the decisions made during the pre-construction stage influence 70-80 % of the implementation costs.

Designer has a very critical role for the investor because his performance and reliability will be decisive on the future benefits or risks of the Investor.

From the financing institution's perspective, another important fact is that, for the life of any dam, the owner has full responsibility for the safety of the dam, irrespective of its funding sources or construction status. Because there are serious consequences if a dam does not function properly or fails, the Bank is concerned about the safety of new dams it finances and existing dams on which a Bank-financed project is directly dependent (The World Bank, 1996).

(iv) OE at Construction Stage: The overall management of the construction will be performed by the OE. This will include the correct implementation of the project according to the design. Also the quality assurance and control, schedule management, cost control and similar tasks will be performed by this organization.

According to Ravlo (2003), whilst the implementing agency has the overall responsibility for the project development, the Engineer is the assigned head of an "independent" organization with the necessary expertise and capacity to ensure that contracts are executed as agreed.

The costs for the project development, design and management will take an important part of the overall investment budget. This will include the obtaining of the project license, necessary permits and royalty fees at the initial stage.

The allocation of necessary budget for this part of the project is crucial for the success of the project. The author believes that the optimizations done at this stage could save hundreds of thousands of dollars. The main decisions, when a competent engineering is used would save even more. On the other hand, a poor design and management could create major problems and additional costs. Therefore the budget allocated for this part of the projects would possibly have a positive return to the investor.

2.2. Procurement of Equipment

One of the significant costs for a hydropower project will be the electromechanical equipment, mainly the turbine and generators. According to the total water head, sediment characteristics, design flow and several other parameters, the turbine type will be selected by the engineer. The main types can be listed as Francis, Kaplan, and Pelton turbines. Each type has different advantages and ranges of usage. Brief information will be given in the following paragraphs.

As explained by Westgaard *et al*. (1994), the design concepts used for hydropower generators depend on rated power, speed range and type of turbine. As continued in his explanations:

- The Pelton turbine is used for high-head plants and is characterized by high rated speed, medium overspeed ratios and no axial thrust apart from the weight of the turbine. The turbine wheel runs in the air. The natural braking torque is small and the generator braking equipment must be dimensioned accordingly.

- The Francis turbine is used for the intermediate speed range, with relatively low overspeed ratios, but a substantial axial water thrust. The axial thrust requires a sturdy axial bearing with strong brackets and stator frame. The overspeed requirements affect the design of the rotor since the shaft must have a high critical speed. The turbine wheel is always submerged and the natural braking torque considerable.

- The Kaplan type gives very high axial thrust which varies considerably with the load. The overspeed ratio may also be high, but since the rated speed is low this will normally not influence the design in a significant way. The turbine wheel is always submerged.

The choice of turbine type and design is dictated by a series of conditions and demands that have to be defined and considered (evaluated) at the planning stage. As always, an important goal is to build an effective and reliable powerplant at reasonable cost, but even more important is it to achieve low "lifecycle cost". Hydropower machinery is a long-term investment, and the service life is very long when the design is well adapted to the operating conditions and expected maintenance demand (Vinogg *et al*., 2003).

Water resources, topography and geology are determining factors for the reservoir size and the main plant dimensions. The power demand pattern and the transmission line capacity are decisive for the machinery (number of units, type and design) and its ability to regulate the power output. The water quality may sometimes call for extra attention to design, choice of materials and maintenance possibilities (Vinogg *et al*., 2003).

On the selection of the supplier, several aspects can be considered. These can be the price, guaranteed efficiencies, maintenance periods, references of the supplier on similar equipment, delivery lead times, etc.

The OE will guide the investor for the selection of the most beneficial supplier. Through the tender evaluation, many aspects would be reviewed and commented such as efficiencies, model tests, applicable standards, material compositions, delivery terms, O&M terms, spare parts, etc. The decision would be expected to include the evaluation of all these issues.

The other component for the equipment will be the hydromechanical equipment. These would mainly be the gates, stoplogs, trashrack cleaning mechanisms, overhead, or gantry cranes, etc. These would have less importance on the performance of the plant. However they are essential for the O&M activities.

The cost for the equipment would form an important part of the investment cost. The cost deviations can be relatively high mainly because of the origin of the supplier. European suppliers are expected to be more expensive than the Chinese suppliers. Some of the key reasons why the European suppliers are preferred can be given as:

(i) They have a proven track record. Some of their equipment are under operation for decades.

(ii) Their performance and efficiencies are more reliable.

(iii) They have higher quality, therefore their O&M costs are expected to be less.

(iv) The contract structures, site supervision, delivery conditions would be better structured. In other words, the investor would have an easier process until the plant becomes operational.

On the other hand, Chinese or Far East suppliers can have other benefits such as:

(i) Their prices are less than other suppliers.

(ii) Their delivery times would generally be less than western suppliers.

(iii) They would be more flexible on the contracts; investor can have the higher ability to set the contract structure.

The other electrical and hydromechanical equipment are generally purchased from the local market. However, this still might change as per the complexity and importance of the specific equipment.

Alvarado-Ancieta (2009) presents the typical cost of electromechanical equipment from various hydropower projects in Figure 2.2. This table can give an indication about the real costs that are valid in the actual projects.

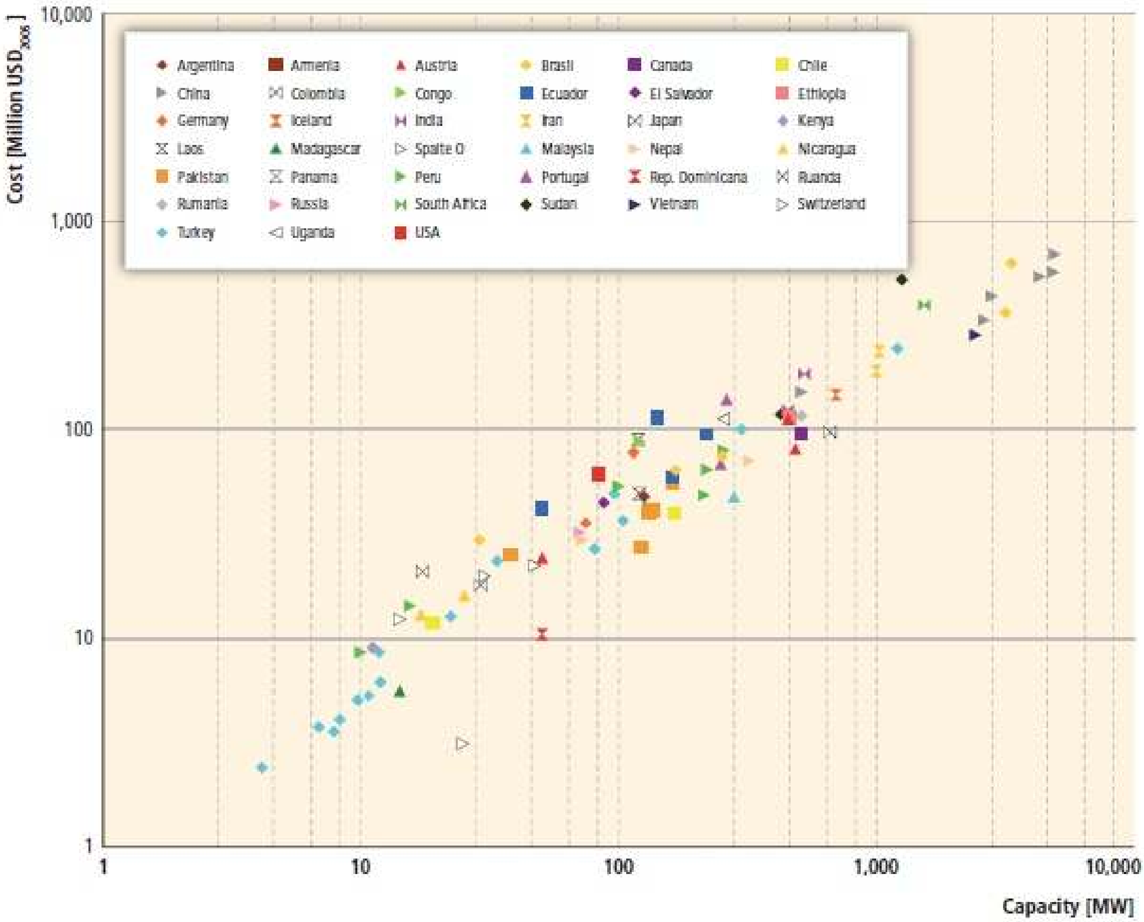

Figure 2.2. Costs of electrical and mechanical equipment as a function of installed capacity in 81 HPP's in America, Asia, Europe and Africa in USD2008 (Alvarado-Ancieta, 2009).

2.3. Construction Costs

Construction costs form the biggest part of a hydropower project investment. In addition, this part is subject to higher contingencies, which makes the overall budget more sensible in the case of an increase on the construction costs. In this chapter, the main parts of the construction costs will be briefly mentioned. In order to determine the main cost groups under construction cost; the example projects obtained as the result of the interviews from domestic and international experts have been reviewed. Total of two international and four domestic projects has been taken into consideration. As the result, six main cost components for the construction were identified. The following information should be a basis for the easy understanding of the following chapters.

According to IPCC (2011), it is stated that basically, there are two major cost groups for hydropower projects: (i) the civil construction costs, which normally are the major costs of the hydropower project, and (ii) the cost related to electromechanical equipment for energy transformation. Additionally, investment costs include the costs of planning, environmental impact analysis, licensing, fish and wildlife mitigation, recreation mitigation, historical and archaeological mitigation and water quality monitoring and mitigation.

Civil construction costs are always site specific, mainly due to the inherent characteristics of the topography, geological conditions and the construction design of the project. This could lead to different investment cost even for projects of the same capacity.

The basis for the different cost components are given for a hydropower project which consists of a dam, energy tunnel, penstock, powerhouse and tailrace channel. The scheme for construction is selected to be lot wise, and not an EPC type.

The expropriation, environmental, legal and permit costs will also be reviewed within this chapter. These can be a wide discussion topic, even another research area. However, these are beyond the scope of this study.

2.3.1 Mobilization Costs

These costs can be the first expenditures for the project implementation. First of all, access to the project structures will be necessary. In some projects, the construction of access roads can have significant costs and also can consume several months, or even more.

During the mobilization period; the construction equipment, the concrete batching plant, accommodation facilities (dormitory, canteen, kitchen, etc.) will be brought and installed. Also the warehouses will be constructed to store the construction materials, as well as the project equipment. Workshops will be established. If the construction site is in a remote place; workshops will have the capability to repair most of the construction equipment.

A well planned and equipped construction site is known to increase the work efficiency and also reduce the cost and time of the construction. However this is always dependent on the topography, climate, relations with local residents, etc.

2.3.2 Tunnel or Conveyance System Costs

Tunnel, conveyance channel or other conveyance systems exist on most of the hydropower projects. The exclusions would be the run of river type projects, and also ones with a dam and a toe powerhouse.

Tunnel construction is an area where specialized contractor or teams of workers are essential. Due to the nature of these works, there can always be some unknowns and risks especially during the excavation periods. The excavation can be done with a Tunnel Boring Machine (TBM), or conventional Drill & Blast method.

The contractor would evaluate the design, site conditions, geology and the time constraints to select the TBM or the Drill & Blast method. In Turkey, a TBM is rarely selected in the recent projects.

A TBM is mostly preferred because of the high progress rates that can be achieved per one day. Also the other advantage would be that no tunnel adits would be necessary for the tunnel construction.

For the Drill & Blast method, mostly the New Austrian Tunneling Method (NATM) is preferred. As per this method, the geologists at site will make an evaluation after each excavation progress (each blasting and mucking). For this method, the overall tunnel will be divided into smaller parts using adits. This approach makes the excavation and construction progress easier and faster. The number of adits will be dependent on the access capabilities on the site, the length of the tunnel, the diameter of the tunnel, schedule and also the experience of the tunnel contractor.

The main challenges in tunnel construction will be the different geology that might be encountered during the excavation. The corresponding support types will be given by the designer. The decision on which one should be applied at each specific tunnel section will be decided by the geologist at the site.

The construction progress and also the cost are directly dependent on the geology and the support type. For a conventional tunnel of approximately 6 meters diameter, the daily progress rate at single excavation face, during a two shift (24 hour) working time would be approximately 6 meters under favorable geological conditions. This value is used by most of the contractors for an initial assessment of excavation duration. When the geology is challenging, this rate can drop down to 2 meters. In some specific geological formations, and together with significant water intrusions, this rate can even drop to several centimeters per day. Obviously these zones are expected to be less and would not be dominant on the overall progress and cost.

The tunnel costs for the conventional Drill & Blast method would be in the range of 1,000,000 US$ - 1,500,000 US$ per kilometer (IPCC, 2010). This value is given here to give an opinion about the possible portion of the tunnel cost within the overall investment cost. In the later chapters, this figure will be used to comment on the risks on this part of the project, versus the contingencies that are generally overseen. According to the selected project scheme, the total cost of the tunnel would be expected to take a relatively smaller part of the overall investment cost.

The conveyance channels or other systems would be expected to have lower costs when compared to the tunnels. On the other hand, the design flow, water head, site geology and access availability are some of the main issues which determines the overall cost.

2.3.3 Dam, Spillway and Water Intake

These are the major and important parts of a hydropower project. Obviously, some projects might have a weir instead of a dam. In this study, the alternative with a dam will be taken within the project layout.

The type of the dam will be selected by the engineer according to several restraints. Among these are; the subsoil conditions and geology of the dam site, the availability of material such as rock, clay, fly ash, etc., the options of access to the site, availability of an experienced contractor, the climate conditions, reliability of hydrology data, risks level of a landslide, O&M decisions can be given.

The construction of the dam should be done by an experienced contractor. Usually, the costs for repairs, even the access would be too expensive after the construction is completed. Moreover, such cases will result in outage of energy production; therefore will have even higher impacts on the cost and revenues. Also a failure in a dam would mean a possible flood on the downstream part and the settlements. For these and several other reasons, the construction quality on a dam has crucial importance.

Several dam types can be applied as the result of the analysis on the feasibility of each type. Clay Core Rock Fill dam, Concrete Faced Rock Fill Dam, Concrete Gravity Dam, Concrete Arch Dam, Double Arc Dam, Roller Compacted Concrete (RCC) Dam are among the widely used dam types. Each type would have their advantages and disadvantages according to the specific project characteristics.

The spillway and the water intake will be designed as the most suitable type and orientation for the specific dam type and also the topography at the dam location. Obviously the design flood will take an important role in the dimensioning of the spillway. In the model project an uncontrolled spillway is assumed.

2.3.4 Powerhouse, Penstock and Tailrace Channel

Powerhouse is among the most important parts of a HPP, especially on the performance. All the energy is generated within this building. The controlling and operation equipment are mostly situated in this area.

Powerhouse buildings are generally situated on the same bank with the penstock; and therefore the energy tunnels. It is preferred that the powerhouse is founded on the bedrock, where possible. If not, special measures on the design will be taken by the engineer to withstand the heavy loads from the equipment, and also the dynamic forces acting on the foundations.

The size of the powerhouse would be determined as the result of the number of turbines, their types and capacities, and also the operation plans of the investor.

The tailrace channel will also be designed to the most suitable form and geometry. Tailrace will have special importance on the performance of the turbines. Cavitations in the turbine blades is a commonly seen problem, which reduces the overall efficiency (therefore the amount of produced energy), and increases the maintenance cost. The tailrace channel design has high importance on the prevention of possible cavitation problems.

The penstock will also be designed specifically for the project. According to the water head and topography; the material type (different grades of steel, Glass Fiber Reinforced Plastic (GRP), etc.), support type and intervals, connection details will be determined by the designer. A competent designer would analyze the different options and select the most feasible one considering the investment, and operation & maintenance costs.

The possible cost for the structures under this section will be expected to have a relatively smaller part of the overall investment cost.

2.3.5 Road Relocation, Expropriation, etc. Costs

As the selected hydro project will have a reservoir, most probably some of the public roads will be impounded. In addition, private lands as well as farms and forests might also be impounded.

The road relocation is an important cost for hydropower projects. Its effect on the budget would be limited if the project is in a distant area without any main roads or highways. However, in some cases, the cost for the road relocation might become too high, taking a significant part of the investment budget.

Expropriation is also important, and sometimes can become a bottleneck for the project. The laws in force will have to be followed. The settlement of agreements with local residents will take time and also will have corresponding costs.

2.3.6 Energy Transmission Line Cost

This part of the project will be dependent on the connection agreements with the grid operator.

According to the projects output, location, and availability in the operation period; related grid operator (either government, or private) will define the connection point, voltage level and other characteristics of the connection.

2.4. Contingencies

Hydropower projects generally need high contingency budgets due to their uniqueness. As previously mentioned; each project will have its own characteristics, different topography, geology, hydrology, local conditions, etc. Even at the design stage, some of the input parameters may not be clear. Especially subsoil investigations play an important role on the budget risks. In most of the projects, necessary borings, and in-situ tests will be performed. However, it is almost never possible to find out the exact conditions that are assumed, or observed through the tests.

In line with the research hypothesis by Sudirman *et al*. (2011), the internal initial risk sources, represented by construction risks, physical risks, and performance risks are the greatest risks categories in hydropower construction projects. These are concluded to be (i) subsurface conditions of geology, (ii) subsurface conditions of ground water, (iii) third party delays, (iv) poor site management and supervision, (v) low speed of decision making involving all project teams, and (vi) delayed site access.

The contingency for each component of investment should be evaluated separately. Respectively, the allocation of budget for each part will be different. Some highlights will be given in the following paragraphs.

For the design, management and project development costs; a contingency is generally not allocated from the budget. The reason is that each investor would tend to hire experienced staff, and also employ a competent design engineer. Likewise, the management team and OE will also be experienced in their field. Moreover, the other parts of the project will be contracted to different parties under state of the art terms and conditions. It is assumed that these will eliminate the necessity of any extra effort and cost on this part of the investment.

On the procurement of equipment, the contingency will be mainly the result of the supplier. If a reliable, western supplier is selected, the contingency will generally be taken as low. On the other hand, if the intension is to select a Far East supplier, then the contingency can be taken higher. In the case of the model project, no contingency for the equipment is overseen.

Construction is the stage where risks and unknowns are mostly included. Several reasons have been mentioned at different parts of the previous sections. Most of the investors would take a 15 % contingency from the overall construction budget.

2.5. Financing Cost

A typical hydropower project would take at least 3 years from development decision until commercial operation. In the project of the selected model, this duration can increase up to 4 years. Today, almost all projects are being financed by local or international lenders. This has become the favorable option for the developers with the availability of financing from the Lenders and also to establish more successful project structures.

2.6. O&M Costs

HPP's have relatively low O&M costs. Due to the nature of the plant operation; the systems are much simpler than other types of power plants such as coal fired, or gas fired thermal power plants.

The information and especially the values specified within this chapter has been taken from an interview with one of the experts who is a senior mechanical engineer. He has worked for a turbine manufacturer for a certain time period. Afterwards acted within the technical department of a large scale energy producer who has also several HPP's in operation. Some of the information was also verified by another mechanical engineer who is working for an international consultant on energy and renewables.

In the operation of a regular hydro project, there should be a group of approximately 10 persons. The plant manager, mechanical, electrical engineers, technical support staff (mainly the technicians), crane operator, and other personnel (assistant, driver, etc.) can be named among this team. Operation persons generally start working even in the last stages of construction. It is preferred that they take over the information about the structures, what kind of maintenance should be planned and also specific follow up issues (if any).

The plant operators will be trained by the electromechanical equipment manufacturer. This is almost always a part of the supply contract. It is important to get the training on how to operate the plant directly from the manufacturer. Even small deviations from the planned operation modes can result with less efficiency rates on the turbines. This would cause a decrease on the revenues, as the energy production will be less with the same amount of water.

The other importance of the O&M team is to keep the plant operational at all times. Usually in the first year of operation, the availability of the plant for operation (which means that the plant is ready to operate and is functioning as planned performance) will be less. The outages of operation in this first year can drop down to 10 %, even to 20 % in some specific cases. There are several reasons for this radical value. Among these are:

(i) The plant is new. Even all the equipment is designed and manufactured to perform all together, some of the parts might need fine tuning. Several minor replacements and adjustments can be necessary. These are expected activities for a certain extent.

(ii) The operation team is not experienced with the plant and the equipment. Even each person might have operation experience, to perform as a team and to work efficiently will need some time. Also the equipment and the project characteristics are specific for each HPP. Therefore it is not always possible to resolve problems by considering another example from a different plant.

(iii) There might be some problems related with the design, and these might require some minor revisions or modification of project structures. This subject has less possibility, but would not be unexpected.

Normally, according to a general knowledge from the hydropower operators, the acceptable operation outages in the second and following years will be less than 5 %. This means that the plant will be ready to generate energy at more than 95 % of the times during the year.

The operation outages are very important for an HPP. The cost for the repair works is not the key factor. But the loss in the revenues because of not operating is generally too high. As an example, if we assume that the plant could not be operated for two weeks in the high flow season. For Turkey, this season is generally the months between March and June. As a benchmark, 60 % of the annual energy generation will be produced within these months. The exception will be some special plants, which have large reservoirs, or always receive regulated flow because of upstream power plants. With a rough calculation; the outage of two weeks in the high flow season will result with a loss of approximately 10 % of annual energy generation. When this is considered in the model project that is being evaluated within this thesis; the loss will be corresponding to the level of million US$ only for the outage of the mentioned two weeks. This example should represent the importance of the O&M activities, and also why the plant is required to be ready to operate at all times.

The O&M costs can be divided into two groups. One would be the electromechanical equipment; the other will be the rest of the plant structures and equipment. The contractual terms for the construction part will generally allow a guarantee period for two years after the Commercial Operation Date (COD). Within this duration, the contractors will be liable and have to repair, or replace the non performing parts or structures. After this period, the O&M team will keep the plant maintained and try to guarantee the expected performance.

The O&M costs are set as annual expenditures for the project. With the expected life time of the project, this cost will be spent every year. When the O&M costs are calculated, they are summed up for the life time and added to the initial investment cost. On the other hand, the overall revenue is also calculated for the whole life time of the project. The result is evaluated and the decision is given about the feasibility of the project.

During the preparation of the Financial Model for the investment, the developers will generally assign certain O&M budgets for the project. This budget will be the sum of several sub budgets. The annual costs will be summed up to the life time of the project. In the case of the model project, the lifetime is taken as 50 years. Some of the sub budgets will be explained in the following section:

(i) O&M team costs: This will be determined according to the size, scheme (dam with a reservoir, run-off-river, turbine type, etc.), location and several other characteristics of the project. If the investor has more than one HPP, he can consider an optimization of some resources. Also if there is more than one power plant close to each other, some of the personnel can be considered to serve for both plants.

In the case of the model project, a team of ten persons is estimated to be necessary. For such a team, throughout the total operation period (50 years), the total cost can sum up to 10 % of the initial investment cost.

(ii) Cost for the Civil Structures: This part is also project specific. Generally, the maintenance cost for the civil parts would be very less. The HPP structures are designed to withstand the different load combinations, as well as seasonal and long term effects. The most critical issue can be settlements or the problems because of the subsoil conditions. Even these are very rare and not normally expected if the design was performed correctly.

When the O&M budget for civil part is calculated, generally a fixed percentage from the initial investment cost (of the civil part) is taken. This is a common practice in hydropower projects. On the other hand, the OE can also give more reliable values based on their past experience on similar projects. Even more, some of the investors can be a subsidiary of large energy producers. These companies have many years of O&M experience on running plants. Their own O&M teams will also be able to give reliable figures for the future expenditures.

Obviously, the O&M cost for the civil part is also directly dependent on the quality of the civil contractor, and also the competence of the OE that will supervise this contractor. As a general expectation; if a less experienced combination is selected, the cost at the initial stages will be also less. However, it should be noted that the O&M expenses will be more in such case. At the end, in the long run, selecting a more experienced contractor and OE will possibly result with less overall cost. Some of the investors would have this perspective, and some would not. If the business model is established to develop the project and sell it off after the first years of operation, then the strategy can be to minimize the initial costs and put the others within the latest priorities. This is a decision and always would have pros and cons.

(iii) Cost for the electromechanical equipment: At the construction stage, the manufacturer will already supply a set of spare parts for the project. The list of these will be determined jointly with the supplier and also the investor. Each additional spare part will increase the cost. However, especially for the turbines and generators; these equipment are produced custom made for the specific project. For example the runner blade of the turbine will have a special size, geometry and chemical composition. This will be designed as per the installed capacity, water head, submergence of equipment, sediment characteristics of the river, etc. In the service life of the plant, it will not be easy to have another runner blade manufactured. Therefore investor, with the help of the OE will decide on how many of these parts should reasonably be stored as spare.

On the other hand, repairs and small refurbishment in hydropower projects are common and can be done. An example is the small repairs on the runners after erosions due to cavitation. Plant O&M team can remove the runner in certain time intervals (in the range of once in 5 – 10 years) and repair the steel blade by welding. Obviously the chemical composition should be selected from the beginning by the supplier, in such way to allow site welding.

Electrical equipment and also the equipment in the switchyard will probably have some maintenance and small replacement through the service life of the project. The budget under this section is planned to cover all these cost.

(iv) Other unexpected O&M Costs: As the life time of the plant is 50 years, some unexpected events can also happen within this duration. A flood is already considered and the project structures are designed to withstand the effects. Or an earthquake can happen. Again, this is included at the design inputs, and the plant would not get any damage from such an event. However, still a budget to cover the O&M contingencies should be allocated.

2.7. Renewal Costs for Equipment

Electromechanical equipment, especially the turbines are subject to heavy loads and continuous operation. Under these effects, the turbines will have a shorter service life than the overall power plant.

As a general approach, the main electromechanical equipment is expected to require major repairs after 25 – 30 years of operation. In the calculations, it is assumed that the initial cost of the turbines will be spent after this period.

2.8. Summary of the Lifecycle Costs

The aim of this chapter is to briefly explain the systematic approach while the lifecycle costing of a HPP is calculated. This information will be the basis for the following chapters, where Turkish and International approaches will be reviewed and also the case studies will be investigated.

It is worth to mention once more that the costs per each hydropower project are directly dependent on the project characteristics and specific requirements. The local conditions, as well as the investor's decisions and strategies on the distribution of the project work to different participants generally play an important role on the cost.

Experiences from the recent projects can be gathered to derive cost intervals for small, medium and large scale hydropower projects. Also the classification can be done for high head plants, plants with reservoir, plants with tunnel, as per the annual energy generation range, or as per the installed capacity. All these project groups would give specific ranges of investment cost per the total lifecycle of the project.

2.9. Effective Service Life of HPPs

The service period of a hydropower project would mean the total duration within which the plant would continue the performance. The reduction in the efficiencies should be expected as the plant gets older. However this will not be considered within this thesis.

As per the usual applications, the investor will have a generation license and water usage rights for a certain period. In Turkey, this period is given as 49 years including the development period.

According to Ravlo (2003), the hydropower project lifecycle usually extends over a period of 100 years or even more if well designed, constructed and maintained.

As per Hataldsson (2004), when discussing lifespan within a power hydro station, the first thing that strikes us is that the lifespan varies tremendously within the system. IT systems have a life span of approximately 8-10 years, turbines 60 years, generators 30 years, the water dam more than 100 years.

Normally the life of HPP’s is 40 to 80 years. Electromechanical equipment may need to be upgraded or replaced after 30 to 40 years, however, while civil structures like dams, tunnels etc. usually function longer before they requires renovation. The lifespan of properly maintained HPP’s can exceed 100 years. Using modern control and regulatory equipment leads to increased reliability (Prabhakar and Pathariya, 2007).

As cited, most of the HPP’s are capable to be operated more than 50 years, with necessary O&M activities, modernization and replacement of equipment or parts.

3. INVESTMENT DECISION MAKING: DOMESTIC & INTERNATIONAL PRACTICES

The first recorded use of water power (hydropower) was a clock, built around 250 BC. Since that time, humans have used falling water to provide power for grain and saw mills, as well as a host of other applications. Hydro has had a long and important historical role in providing mechanical energy, which was used in the every day's human activity. Specifically watermills were used in Mesopotamia as early as 3000 BC and since have harnessed the energy of water almost anywhere on the planet that boasts a river or stream. Anything approximating the strength of a horse that did not need to be fed or get tired was immensely valuable. The first use of moving water to produce electricity was a waterwheel at Appleton on the Fox River in Wisconsin in 1882. Hydropower continued to play a major role in the expansion of electrical service early in 20th century in the world (Gürbüz,2004).

Within the investment decision making process, many aspects of the potential project will be evaluated by the Investors. These will obviously pass through certain stages which will form the life cycle of the investment and the different risks will be estimated.

In the construction industry, the phases consist of pre-feasibility, feasibility, design, contract/procurement, implementation, commissioning, handover and operation (Smith *et al*., 2006). Moreover, Cohen and Palmer (2004) and the Project Management Body of Knowledge (PMBOK®) Guide (Project Management Institute - PMI, 2004) suggested dividing a project life cycle into four major stages and defined the 'typical' project life cycle as follows: feasibility, planning and design, construction, and turnover and start-up.

The construction stage of the project life cycle is the actual stage of the physical works carried out with the aim of achieving substantial completion of the project. The start of the construction phase signals the beginning of increasing effort and expenditure. Ward and Chapman (1995) claimed that the majority of expenditure of the project takes place in the construction phase, although sometimes the percentage of estimated cumulative cost may vary from one project to another. Furthermore, construction projects are usually represented as being complex and time consuming, particularly during the construction processes characterized by unforeseen circumstances (Ren, 1994).

In addition, it is well known that construction activities within the project life cycle are executed under ‘unique’ circumstances and continually face a variety of uncertainties which can result from ‘known’ (the risk events which occur frequently and an inevitable feature of all construction projects), ‘known-unknown’ (the risk events whose occurrence is foreseeable, and their probability of happening is known), and ‘unknown-unknown’ (the risk events whose probabilities of occurrence and effect are not foreseeable, considered moreover, as force majeure event conditions). In other words; the construction phase deals with many unknowns, unexpected and unpredictable factors (Akintoye and MacLeod, 1997; Smith *et al*., 2006), which sometimes put the project at risk.

In contrast, Abdul-Kadir and Price (1995) argued that the conceptual or feasibility phase of construction projects in relation to site production is more important than the construction phase in the construction industry. Moreover, Uher and Toakley (1999) supported this argument and stated that the conceptual phase of a new construction project is the most important phase, since decisions taken in this phase tend to have a significant impact on the final cost. It can be inferred then that both these research studies emphasized the importance of the conceptual phase of construction projects (Sudirman, 2011).

According to Harmancioğlu (2007), decision makers and planners are unfortunate in the sense that current problems have become multifold, multidimensional, and multifaceted. Similarly, there are numerous objectives, often of a conflicting nature, to be satisfied. Furthermore, technology has provided an abundant number of solutions that may be applied even though their consequences for a particular problem investigated are not known in advance.

In the following sections of this chapter; a general overview on the HPP development and potential inTurkey and the world will be briefly mentioned. Also the common tools and report which are used in the investment decision making process will be analyzed.

Finally, the content and details that would be existing in a Turkish and International feasibility report will be explained.

3.1. Hydropower Potential in Turkey

Electricity was first recognized in Ottoman Empire in Tarsus (south coast of Turkey) in 1902 with 120-horse power (1 hp=0,736 kW) installed capacity HPP of which privileges were belonging to a private company. A similar system had continued in very first years of the Turkish Republic till 1938. Then all plants were nationalized (Gürbüz, 2002).

Turkey has significant amount of hydropower potential. These resources have been identified initially by Elektrik İşleri Etüt İdaresi (Electrical Power Resources Survey and Development Administration – EIE), which has been established in the year 1935. Even today, some of the old studies of EIE are being used.

EIE has initialized a study for developing the unexploited part of the hydropower potential in 26 river basins in Turkey. In this context, Preliminary Survey Studies in the basins of Western Black Sea, Meriç, Marmara, Lake Burdur, K. Menderes River, Central Anotolian, Susurluk River, Gediz River, Rivers of Aegean Region, Eastern Blacksea, Büyük Mneredes River, Western Mediterrenean, Middle Mediterrenean Yeşilırmak River, Sakarya River, ceyhan River and Afyonkarahisar were completed (Gürbüz *et al*., 2007).

By the directives of Atatürk, EIE was founded on June 24, 1935 under the Law No: 2819. The basic policy of EIE is, while paying attention of other usage of water resources, generation of energy by the best projects of different levels which are economic, environmentally convenient and socially acceptable, and from the foundation to this day studies are carried on in this direction.

EIE, from the foundation to the early 1980s completed the projection and design studies of the HPP projects and the projects which are at the level of construction were delivered to the DSI. Construction investments governed by the “Public Procurement Law numbered 2886” are made by DSI and operations of completed construction were undertaken by Türkiye Elektrik Kurumu (Turkish Electricity Authority – TEK) (old TEK now Elektrik Üretim A.Ş. (The Electricity Generation Company – EUAS)). In 1980s, energy shortage was emerged and privatization discussions in energy sector were started again. Especially, to overcome difficulties of public financial potential, which was started in the early 1980s and to improve investment and operations of private part of the energy sector many regulations of law were laid down, different privatization models were implemented, rebuild of sector was brought on the agenda.

Considering the situation, while EIE delivered the projects, which were come out at the end of the studies, to DSI for doing construction in the past, at the 1980s, law numbered 3096 and with the scope of Built-Operate-Transfer model it served the projects to investors who accepted doing construction of plant and transferring to the public after operating for a while (Gürbüz *et al*., 2007).

After the identification by EIE, Turkish Government formed the DSI in the year 1953 to develop the planned projects. After this step many HPP's have been constructed under the management of DSI. At the meantime Turkish contractors obtained significant amount of knowledge and experience for the construction of such plants.

DSI has also constructed many other projects for irrigation, flood protection, and other purposes. These will not be detailed within the current study.

Turkey is the sixth largest electricity market in Europe, and one of the fastest growing globally (Kucukali and Baris, 2009).

In 2001, Turkish government decided to handover the development of new hydro projects to the private companies. Accordingly a new law was introduced. As per this law, DSI would not develop or construct any new plants. Only the ongoing plants would be completed.

After this initial step, DSI has lists of the projects available for development. There were many tenders for the private investors to take over the water usage rights and therefore the energy production licenses of these projects. The investors showed up most interest to these tenders and many project licenses were obtained. Obviously some of these investors only traded these licenses and did not construct, nor operate a HPP.

Many of these projects have been realized. Some are still at the design or construction stages. On the other hand, a group of these projects are not expected to be developed further. Some of the reasons are listed below:

- The project is not feasible in means of required cost and return period.
- The project area is situated at high altitudes (1,500 m or more), therefore access roads do not exist, construction is difficult because of winter conditions, etc.
- The projects do not have a large drainage area; therefore do not have a reliable flow regime.
- The project is situated in an environmentally or politically sensitive zone.

As per U. S. Commercial Service (2010), Turkey will need an investment of approximately USD 180 – 210 billion for power generation, USD 6-7 billion for transmission and USD 7-8 billion for distribution by 2030.

Also according to Yüksek *et al.* (2007); because of social and economic development of the country, the demand for energy and particularly for electricity is growing rapidly in Turkey. Depending on the applied scenario, Turkey's annual electric energy demand in 2010, 2015 and 2020 varies between 217 to 270 TWh, 294 to 410 TWh and 407 to 571 TWh, respectively.

It is evident according to projections that Turkey has to spend much more effort on water resources development in the future. Presently, Turkey has utilized approximately 40% of the water resources. (Alpaslan *et al.*, 2007).

The current vision of Turkey for hydropower can be summarized from the statement by Kibaroğlu *et al.* (2005) as; Turkey's water policy can best be characterized by her desire to gain independence from imported energy sources, to increase production levels of agriculture and to achieve food security, to satisfy increasing water demand from industry and urban and rural populations, and to correct regional economic and social imbalances in the country, thus raising the living standard of the population.

3.2. Hydropower Projects in Turkey as an Investment Tool

Hydropower projects have been developed by DSI until 2001. In this year, with the announcement of a new law, Turkish government has started handing over the project licenses to private investors. The total potential has been investigated by researchers and was the basis for many articles. Brief information on the statistics will be given in the following paragraphs.

Turkey has a total gross hydropower potential of 433 TWh/year and 140 TWh/year of this capacity can be used economically, corresponding to the second largest economic potential in Europe. Currently only 35% of economic hydro potential of the country is utilized. After completion of HPP's under construction, this figure will increase to 49%. It is obvious that even after the construction of all projects there will still be a huge hydro potential in Turkey (Erdogdu , 2010).

Table 3.1. HPP's is Turkey. (Erdogdu, 2010)

Current situation	Number of plants	Installed capacity	Electricity generation (GWh/year)	%
In operation	172	13.700	48.000	34
DSI	57	10.700		
Others	115	3.000		
Under construction	148	8.600	20.000	14
DSI	23	3.600		
Others	125	5.000		
Planned	1418	22.700	72.000	52
DSI	17	4.000		
Others	1401	18.700		
Total	1738	45.000	140.000	100

The gross and technical hydropower potential of Turkey are estimated at 433 and 216 TWh/year, respectively. The economic potentials for installed hydropower capacity and electricity output have been anticipated roughly as 45,000MW and 140 TWh/year, respectively. The gross hydroelectric potential of Turkey is about 1% of the world total and about 14% of the European total.

Table 3.2. Current HPP's above 100MW capacity in Turkey. (Erdogdu, 2010)

Table 5
Current hydropower plants above 100 MW capacity in Turkey.

No	Name of the plant	Construction started	Construction finished	River	City	Capacity (MW)	Generation (GWh/year)
1	Ataturk	1983	1992	Euphrates	Sanliurfa	2400	8900
2	Karakaya	1976	1987	Euphrates	Diyarbakir	1800	7354
3	Keban	1965	1975	Euphrates	Elazig	1330	6000
4	Altinkaya	1980	1988	Kizilirmak	Samsun	700	1632
5	Birecik (2)	1993	2000	Euphrates	Sanliurfa	672	2518
6	Oymapinar	1977	1984	Manavgat	Antalya	540	1620
7	Berke (2)	1991	2001	Ceyhan	K. Maras	510	1672
8	Hasan Ugurlu	1971	1981	Yesilirmak	Samsun	500	1217
24	Borcka	1999	2007	Coruh	Artvin	300	1039
9	Sir (2)	1987	1991	Ceyhan	K.Maras	284	725
10	Gokcekaya	1967	1972	Sakarya	Eskisehir	278	562
11	Batman	1986	2004	Batman	Batman	198	483
12	Karkamis	1996	1999	Euphrates	Maras	180	652
13	Ozluce	1985	1998	Peri	Bingol	170	413
14	Catalan	1982	1996	Seyhan	Adana	169	596
15	Sariyar (2)	1950	1956	Sakarya	Ankara	160	400
16	Gezende	1979	1990	Ermenek	Icel	159	528
17	Aslantas	1975	1984	Ceyhan	Adana	138	569
18	Hirfanli	1953	1959	Kizilirmak	Kirsehir	128	400
19	Menzelet	1980	1989	Ceyhan	K. Maras	124	515
20	Kilickaya	1980	1989	Kelkit	Sivas	124	332
21	Muratli	1999	2005	Coruh	Artvin	115	444
21	Dicle	1986	1997	Tigris	Diyarbakir	110	298
21	Yamula	1998	2005	Kizilirmak	Kayseri	100	422

In Turkey, hydro projects were initiated by the Ministry of Public Works in the early 1930s. EIE was established in 1935 to project Turkey's energy demand, carrying out surveys and studies to develop hydropower potential of the country and other energy resources. However, construction of the dams in real sense started after the end of the World War II except for a few small dams that had been built for irrigation purposes. Since then, the construction of dams and HPPs has increased to meet the demand for irrigation and electricity generation. Within 20 years after the establishment of DSI in 1954, hydropower production increased to 3255 GWh, corresponding to 25.3 of total production. Until the early 1990s, hydropower increased its share in total production. However, in the last two decades, the share of HPPs has decreased as a result of the rapid increase in natural gas plants (from 62% in 1988 to 19% in 2007). Figure 3.1 presents the development of hydropower generation in Turkey since 1974 (Erdogdu, 2010).

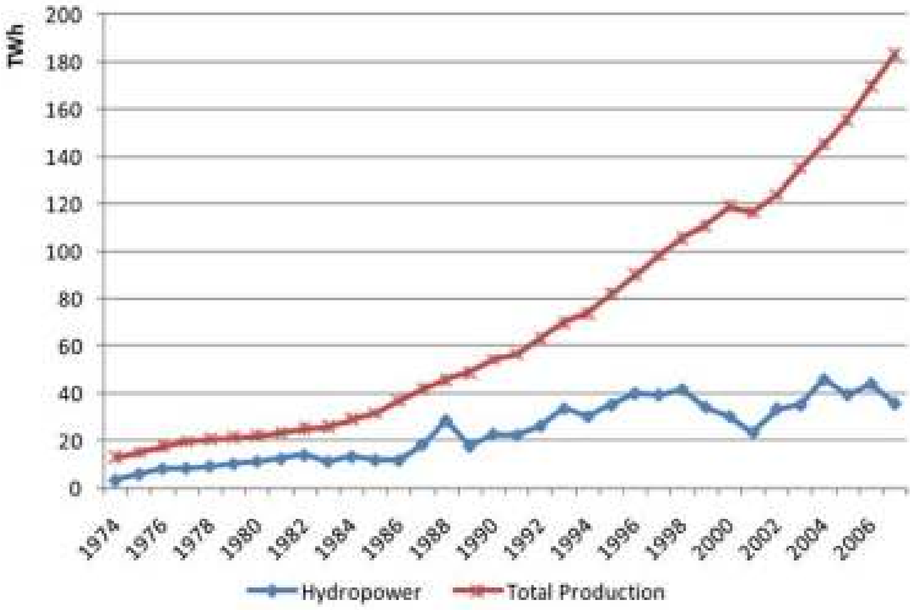

Figure 3.1. Hydropower utilization in Turkey since 1974. (Erdogdu, 2010)

Investors have shown a big interest to the hydropower projects. The benefit/cost ratios were seen attractive. Moreover, the government's energy policies encouraged them that the investments would be secured.

According to an expert who had been working for the government for approximately fourty years; hydropower might be among the first choice of the government to obtain energy. There are several reasons for giving the first priority to this resource. Some of them can be listed as below:

- Hydropower is the cheapest resource for the country economy. The cost of 1 KW is in the order of 0.004 US Cents.

- The unused water (if cannot be stored in reservoirs) are lost values for the national resources.

- The other energy resources such as gas fired thermal power plants consume significant amount of natural gas. This is an expensive and imported resource. Every year, the gas imports put a heavy load on the account balance of the country.

- HPPs are easy to start or stop production. The response times are in the order of several minutes. On the other hand gas fired thermal plants can start operation within 1-2 hours, and coal fired power plants only in 12-18 hours.

- HPPs have important benefits for the peak energy production. Therefore they can balance the increases or decreases on the capacity demands during the day.

Most of the large scale energy suppliers have formed joint ventures with international companies. This brought flexibility on the financing and also the experience on project implementation and plant operation. These companies own most of the large HPP’s. This enables them to diversify their production portfolio to become more competitive in the market and also to maximize their overall profit.

Middle scale companies own several medium or small scale projects. This is believed to be a good investment model for the companies, and they still can be competitive and profitable. Recently several of these companies were put on sale. The transactions are believed to create bigger suppliers or new players in the Turkish energy market.

Small scale companies own one or several small hydro projects. These companies are generally not from the energy field. The trend of having an energy generation license or operating a power plant has probably been the main reasons for these companies to invest on hydropower. Recently, many of these projects are being sold to other companies. A possibility is that initial investors might have realized the difficulties of the construction and operation processes. Moreover, the operation of a single power plant would bring essential operation cost, as there will be no synergy to use a management and an operation team for several plants.

The author is in the opinion that in the long run, small and middle scale companies will probably be acquired by bigger players. The energy market will be consolidated into several suppliers having 5,000 MW or more installed power in total.

3.3. Hydropower Potential in the World

As IPCC (2011) reported, the total worldwide technical potential for hydropower generation is 14,576 TWh/yr (52.47 EJ/yr) with a corresponding installed capacity of 3,721 GW, roughly four times the current installed capacity. Worldwide total installed hydropower capacity in 2009 was 926 GW, producing annual generation of 3,551 TWh/y (12.8 EJ/y), and representing a global average capacity factor of 44%. Of the total technical potential for hydropower, undeveloped capacity ranges from about 47% in Europe and North America to 92% in Africa, which indicates large opportunities for continued hydropower development worldwide, with the largest growth potential in Africa, Asia and Latin America.

HPP today span a very large range of scales, from a few watts to several GW. The largest projects, Itaipu in Brazil with 14,000 MW, and Three Gorges in China with 22,400 MW, both produce between 80 to 100 TWh /yr (288 to 360 PJ/yr). Hydropower projects are always site-specific and thus designed according to the river system they inhabit. Historical regional hydropower generation from 1965 to 2009 is shown in Figure 3.2 (IPCC, 2011).

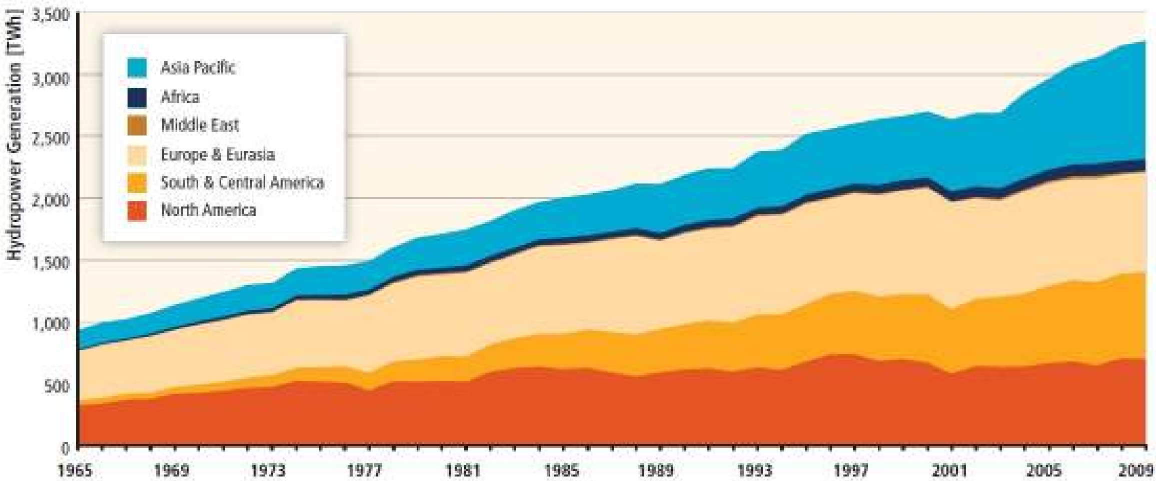

Figure 3.2. Hydropower generation by region. (BP, 2010).

The International Journal on Hydropower & Dams 2010 World Atlas & Industry Guide (IJHD, 2010) provides the most comprehensive inventory of current hydropower installed capacity and annual generation, and hydropower resource potential. The Atlas provides three measures of hydropower resource potential, all in terms of annual generation (TW/yr): gross theoretical, technically feasible, and economically feasible. The total worldwide technical potential for hydropower is estimated at 14,576 TWh/yr (52.47 EJ/yr) (IJHD, 2010), over four times the current worldwide annual generation.

This technical potential corresponds to a derived estimate of installed capacity of 3,721 GW.6 Technical potentials in terms of annual generation and estimated capacity for the six world regions7 are shown in Figure 3.3. Pie charts included in the figure provide a comparison of current annual generation to technical potential for each region and the percentage of undeveloped potential compared to total technical potential. These charts illustrate that the percentages of undeveloped potential range from 47% in Europe and North America to 92% in Africa, indicating large opportunities for hydropower development worldwide (IPCC, 2011).

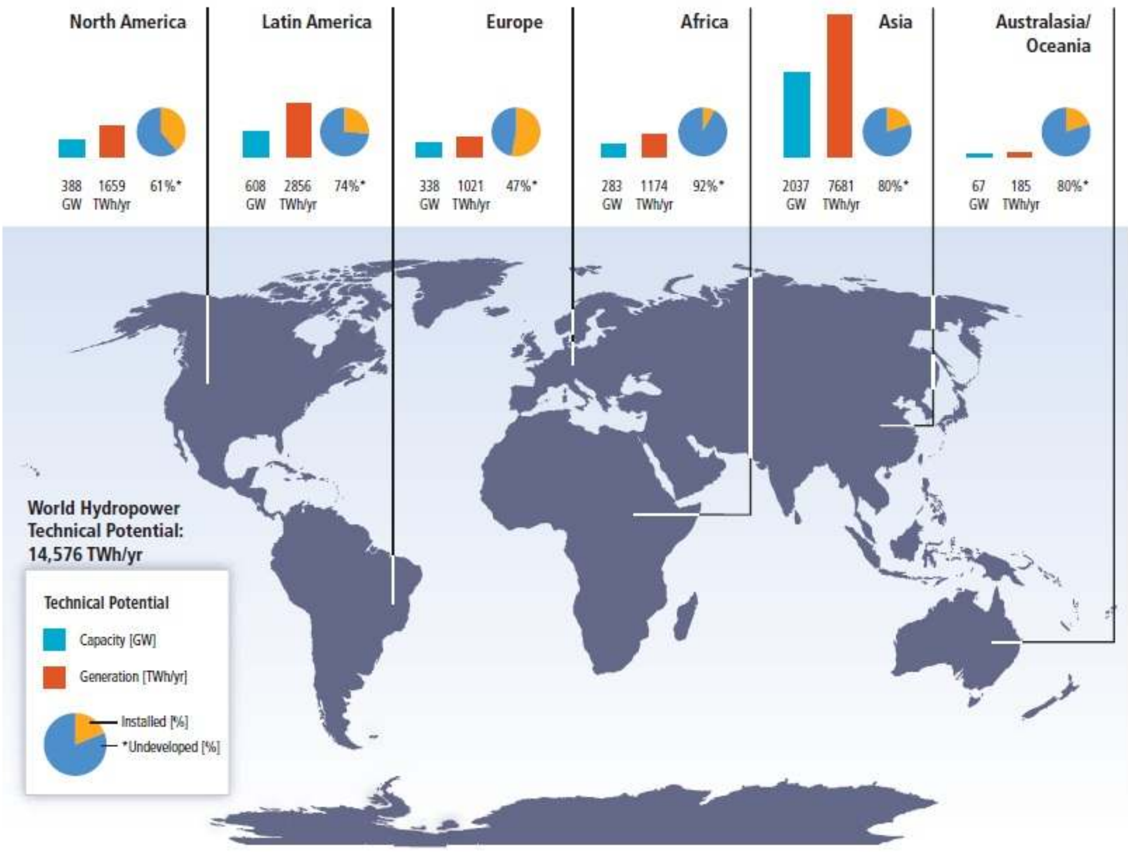

Figure 3.3. Regional hydropower technical potential. (IJHD, 2010)

3.4. Global Climate Change and Possible Effects on Hydropower

As reported by IPCC (2011), though the average global or continent-wide impacts of climate change on hydropower resource potential might be expected to be relatively small, more significant regional and local effects are possible. Hydropower resource potential depends on topography and the volume, variability and seasonal distribution of runoff. Not only are these regionally and locally determined, but an increase in climate variability, even with no change in average runoff, can lead to reduced hydropower production unless more reservoir capacity is built and operations are modified to account for the new hydrology that may result from climate change.

In order to make accurate quantitative predictions of regional effects it is therefore necessary to analyze both changes in average flow and changes in the temporal distribution of flow, using hydrological models to convert time series of climate scenarios into time series of runoff scenarios. In catchments with ice, snow and glaciers it is of particular importance to study the effects of changes in seasonality, because a warming climate will often lead to increasing winter runoff and decreasing runoff in spring and summer. A shift in winter precipitation from snow to rain due to increased air temperature may lead to a temporal shift in peak flow and winter conditions (Stickler and Alfredsen, 2009) in many continental and mountain regions. The spring snowmelt peak would then be brought forward or eliminated entirely, with winter flow increasing. As glaciers retreat due to warming, river flows would be expected to increase in the short term but decline once the glaciers disappear (Bates *et al*., 2008; Milly *et al*., 2008, cited in IPCC, 2011).

Summarizing available studies up to 2007, IPCC (2007) and Bates *et al*. (2008), found examples of both positive and negative regional effects on hydropower production, mainly following the expected changes in river runoff. Unfortunately, few quantitative estimates of the effects on technical potential for hydropower were found. The regional distribution of studies was also skewed, with most studies done in Europe and North America, and a weak literature base for most developing country regions, in particular for Africa (IPCC, 2011).

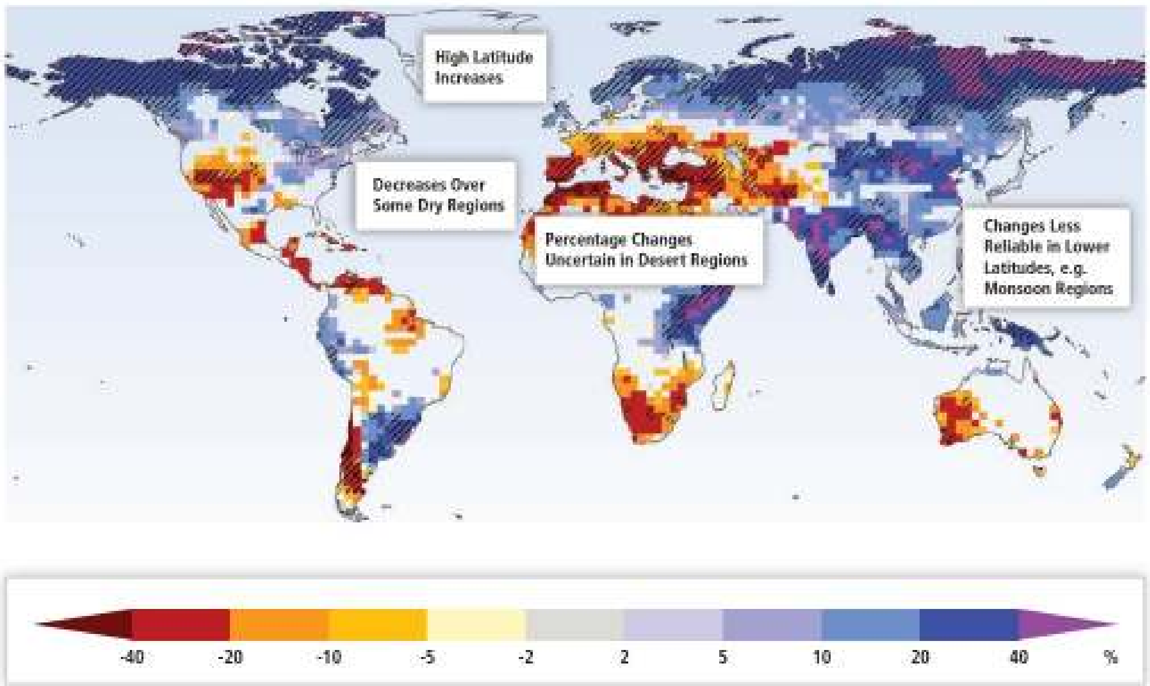

Figure 3.4. Large-scale changes in annual runoff (water availability, in percent) for the period 2090 to 2099, relative to 1980 to 1999 (IPCC, 2007)

Values represent the median of 12 climate model projections using the SRES A1B scenario. White areas are where less than 66% of the 12 models agree on the sign of change and hatched areas are where more than 90% of models agree on the sign of change. It can be concluded that the overall impacts of climate change on the existing global hydropower generation may be expected to be small, or even slightly positive. However, results also indicated substantial variations in changes in energy production across regions and even within countries (Hamududu and Killingtveit, 2010, cited in IPCC, 2011).

3.5. History of the Applications in Turkey

Most of the hydropower projects would have their origins from an initial designer or developer who is not necessarily involved in the project in the later stages. Once the potential is discovered, and the initial studies are completed, the project will probably handed over to the execution teams. Rest of the activities like design, construction and operation will be done by these teams.

First steps on the development of hydropower projects in Turkey were taken by the government. In 1935 EIE was formed with the law number 2819. EIE was the first organization to investigate the Hydropower potential of Turkey and to make plans for the development.

The next step was also taken by the government to form the organization which would develop the planned projects and manage the construction and operation. At this stage DSI was formed in 1953 with the law number 6200.

In Turkey, all the initial studies and investments were done by these two organizations until the last two decades. Afterwards, the private investors were allowed to participate within this process.

To be able to give the investment decision of a project, the cost for the investment is the main input. The general components of the investment cost were explained in detail at the previous chapter of this thesis. In the international practice; several manuals and costing programs are available to study the overall cost of a HPP. Most of these tools are only applicable on the small hydro projects. One of them will be briefly explained in the following paragraphs.

The most commonly used costing tool is RETScreen International. RETScreen is an Excel-based clean energy project analysis software tool that helps decision makers quickly and inexpensively determine the technical and financial viability of potential renewable energy, energy efficiency and cogeneration projects. The software is provided completely free-of-charge by the Government of Canada as part of Canada’s recognition of the need to take an integrated approach in addressing climate change and reducing pollution. The program is managed under the leadership and ongoing financial support of the Canmet ENERGY research centre of Natural Resources Canada's (NRCan). RETScreen is developed by a core team at Canmet ENERGY located in Varennes in collaboration with a number of other government and multilateral organisations, and with technical support from a large network of experts from industry, government and academia (Retscreen, 2012).

The software uses many of the characteristic parameters of the project as an input. Among these are: gross head, design flow, efficiency rate for the reservoir, downtime operational losses, number of frost days at site, turbine type and quantity, efficiency of the equipment, road construction length, penstock length, transmission line length, grid connection type, and voltage, etc. There are also a few parameters which should be estimated as lower and upper bounds, for example difficulty of terrain (on a 1–6 scale), and rock at dam site (yes or no). The software also requires the inputs of if a tunnel or a channel will be constructed, and also their lengths.

RETScreen takes into account the costs of financing, expropriation, feasibility study, design and also the operation, maintenance and equipment renewal costs. In this respect, it can be concluded that RETScreen aims to give a lifecycle cost estimate to the users. At the end, investors will be able to get an overall opinion for the decision making.

Even RETScreen uses an algorithm which takes many inputs into account; it still can have some shortcomings according to each project. For example; the tunnel diameter would be calculated by the software as per the design flow input. However in the design phase, this diameter can be different, which can significantly affect the overall cost. Also the equipment costs are taken from the database of the software. This database tends to include the western suppliers' costs. On the other hand, Chinese or other suppliers' costs are lower than these.

RETScreen can be mostly preferred in small hydro projects. Due to the nature of large hydropower projects, each characteristic of a project is very unique and cannot be estimated with a generalized approach. A due diligence or a pre-feasibility study will be necessary for these kinds of projects. The investment decision could only be made based on such a specific study.

With a pre-feasibility study, the site and project specific conditions will be included in the costing of the project. As mentioned by Stojmirovic *et al*. (2007), the pre-feasibility phase is the concept stage which defines at a high-level the capacity, demand estimation and community suitability. The details which will form a major part of the project will be identified and included in the costing with this study.

The project location and access possibilities will be searched. The findings will be incorporated with the costs. The project location will be evaluated according to general maps. Accordingly the location of the project structures like powerhouse, dam or weir will be suggested. Also the conveyance system (if any) will be decided and the orientation on the layout will be shown with simple drawings. Accordingly rough calculations will be done for the costing of additional access roads, excavation and other works.

The energy generation will be calculated according to the hydrology data, and the installed power optimization will be done. For the hydrology calculations, general data from nearby Flow Gauging Stations (FGS) will be used. According to the optimized installed power value, the project flow rate, number of turbine units, capacities, as well as, weir and powerhouse size, conveyance channel/tunnel diameter, penstock diameter, switchyard and ETL voltage and distance will be determined.

All these data will be included in the costing. In addition, the contingencies, financing, O&M, and renewal costs will also be included in the calculation. At this stage major risks (if any) will also be identified and included in the report. In some of the cases, the report will include more than one option on the project scheme. For example; the report can include first option as the Clay core rock fill dam with a tunnel on the right bank, and the second option as the Concrete faced rock fill dam with an open channel on the left bank. Both options will be included in the report together with the corresponding costs. This will enable the Investor to see different alternatives which can possibly be developed and their costs, pros and cons.

At the end, the investor will have a comprehensive report on the viability and lifecycle cost of the subject hydropower project. The report will be tailor made for the characteristics of the project. The costing calculations will be rough. However the project scheme will be a realistic one where all the boundary conditions and main restraints will be incorporated.

Investment decision is not only given for the Greenfield projects, but also for the ones which are at later stages of development. There are many cases that the feasibility of a project is already evaluated with a report, and the developer wants to sell the project rights to another Investor. In this case the Investors usually make a technical, financial and legal review of the projects before giving an investment decision. These activities are generally called a Due Diligence.

A technical due diligence will focus on all the technical details. Firstly the proposed layout of the project will be analyzed. Then the reasonableness of the input parameters in the calculations will be checked. In the next step, the calculation results will be generally checked if they are within the expected ranges. The energy generation capacity and also the reliability of the hydrological assumptions will be evaluated. At the end of the technical due diligence, a report will be prepared for the evaluation of the Investor. With this report, the Investor will be able to see the verified costs and benefits of the project. Also the major risks for the whole investment period will be explained to Investor for further evaluations.

In parallel, the financial due diligence will be performed to analyze the financial viability of the project. Each Investor might have different financial restraints and targets. Accordingly they will prepare their own financial model to see the results of the possible investment.

Likewise the legal due diligence will be performed by a legal advisor. This can be the Investor's own personnel, or third party consultant. The legal background of the project, and possible additional costs, risks and contingency amounts will be identified and a comprehensive report will be submitted to the Investor.

At the end of all these inputs, the Investor will be able to make a decision to proceed, or to withdraw from the project. Obviously, the mentioned plan is rather a more idealized plan and some of the investors might prefer to follow a shorter process. In this case the risks in the investment decision will be hidden in the mentioned details. The Investor can make good profits, or lose significant amounts of revenues. The major problem with this situation is to follow a way with many unknowns which also mean risks. Maybe the last thing that would be preferred within a business model is "Unknown risks".

3.6. Feasibility Studies

Preparing a feasibility report is a more detailed form of analyzing the viability of a hydropower project. In this study the individual aspects of the project are evaluated in more detail within a longer preparation time.

For the preparation of this chapter and the following chapters, several interviews have been conducted. These interviews were done with senior engineers or experts from different parts of the sector have been selected. The list of them and some important qualifications has been given in Table 3.3. This should give an opinion about the reliability of the resource information.

Table 3.3. List of experts who have been interviewed.

EXPERT	SECTOR	EXPERIENCE		FOCUS
A	Private	20+ Years	International	Design & Construction
B	Public	20+ Years	Local	Design & Construction
C	Private	20+ Years	International	Design
D	Private	15+ Years	Local & International	Design & Construction
E	Private	10+ Years	Local	Construction
F	Private	10+ Years	Local	Design & Construction
G	Private	20+ Years	International	Electromechanical
H	Private	5 Years	International	Electromechanical

In Turkey, the Feasibility Report of a project is generally taken as the basis for all the future actions or decisions for the project. The license is obtained according to this report. The water usage rights, conditions for the grid connection, the Environmental Impact Assessment (EIA) Report, and other similar major subjects are all shaped with the data from the feasibility report.

In the international terminology, the feasibility report also stands for a similar meaning. The expected performance from this report is similar, however with a higher level of expectations.

Both Turkish and International Feasibility reports have one common function. They form the basis for the Investor to shape the investment plan and understand the life-cycle cost of the project. Therefore regardless of the approach; they always define boundary conditions and have to include adequate detail for this purpose. A misleading feasibility report, either because of poor data set, or wrong engineering approach, or the result of wrong estimations will always lead the Investor to failures in their business plans. This can be in the form of budget overruns, schedule delays, lost in revenues, or brand image.

In the following sections, the content and the detail level that will be expected from a typical Turkish and International Feasibility Report will be explained. The basis for the explanations will be:

- The general knowledge and reviews from more than ten feasibility reports which were prepared by different companies in the field of hydropower. The reports include various types and sizes of HPP's.

- The standard form and content described in DSI for a feasibility report to obtain an approval.

- Various information are obtained from the interviews with the experts that are listed in Table 3.3. The comments and explanations from these interviews are based on many years of experiences of the experts. Therefore the obtained information can be evaluated as a summary from many local and international projects.

  In addition, the experts has shown several actual TFR examples. They were reviewed and the expected content was evaluated. The explanations given in the following chapters are also based on these reviews.

- Feasibility reports prepared for commercial or thesis purposes for the projects in USA, Australia, Georgia, Albenia and Spain. These documents are cited in the corresponding paragraphs where information from them is given.

- Feasibility reports that were prepared by European companies, for individual investors about international projects. The information derived from these reports will not be cited and detailed for the rights of intellectual property, and confidentiality. However, it is intended that these information will be useful to show important points about the different expectations or understandings at the international perspective.

The aim is that; at the end of the information for these different approaches, what level of detail and what kind of inputs are requested for investment decision making can be clarified. At the meantime the expectations in Turkey, as well as in the International markets can be investigated.

3.7. Turkish Feasibility Report

The current applications of Feasibility Reports in Turkey are based on the DSI, and EIE practices and formats. To obtain a hydropower project license, it is a condition that each project has a Feasibility Report. Furthermore, the table of contents in this report is also defined and announced by DSI. This will be named as a typical TFR in the following parts of this thesis.

As per DSI, 2012; a typical TFR is expected to include the following chapters: Summary, General description of the Project Area, Development Plan, Climate and Water Resources, Geological Conditions, Project Structures, Environmental Impacts, Cost of the Plant, Economic Analysis, Cost Distribution for Multi-Purpose Projects and Alternative Solutions.

The general expectation from this report is to be in the range of 70-100 pages. In addition, more pages can be expected which would include the records of the FGS that were used in the basis of the report. The detail level and how realistic the results in the report would obviously be different at each report.

In the positive side, there are many TFR’s that have been prepared using prudent engineering practices. These probably have been studied within a reasonable time. Also with enough budget to enable the preparing team to analyze various details of the project. These feasibility reports have been very useful for the corresponding investors to set up their business model, prepare their budgets and execute the project with minor deviations from the initial plans. The financing of these projects has been relatively easier as no major risks were incorporated with the project by the lenders, or their technical advisors.

In the negative side, there are many TFR's that have been prepared using very less time and by companies which had poor engineering skills. These feasibility reports had less or wrong inputs about the hydrology, geology and energy potential. Moreover the proposed structures and related costs were sometimes wrongly assessed. Many Investors had major difficulties on realizing these projects. Some has seen that the project was not feasible at all. Some had significant deviations from the investment plans; either by cost overruns, or by schedule delays. Moreover; the financing of these projects have been difficult and also brought problems for the Lenders.

During the preparation of this thesis, participation to an event about hydropower was done. During the verbal interviews with some of the big Turkish lenders; it was understood that most of the big Turkish lenders today believe that the hydropower projects are very risky. They also believe that a hydropower project can only be financed if the Investor is a big company with proven liabilities. Still, there could be a handful of hydropower projects that are worth to be financed. These unfortunate opinions are the result of many problems that were not expected in the already financed hydropower projects. Obviously the origins of most of these problems have been initiated with the poorly prepared feasibility reports.

In the following paragraphs, the content and detail level of a generally acceptable TFR will be explained based on DSI (2012). The exceptional feasibility reports will not be mentioned. It should be noted that most of these exceptional reports were prepared for relatively big HPPs. They almost always had a professional Investor, competent engineer, and experienced management teams.

3.3.1 Turkish Feasibility Report Chapter 1: Summary

This is a general summary of the hydropower project. The location and general characteristics of the plant is given in this chapter. Most of the times, it serves as the executive summary for the higher management.

In this chapter there are five sub sections. These are namely:

i. Management information form, which include the general characteristics of the proposed plant.

ii. Location of the project, which describe the geographical location of the plant within the country.

iii. The layout plan, which show the relation of the project with the other HPP's in the same river basin.

iv. The proposed structures, which include the general explanations about the proposed structures, such as the powerhouse, weir or dam, conveyance tunnel, etc.

v. Project characteristics, which include the general characteristics of the proposed plant.

3.3.2 Turkish Feasibility Report Chapter 2: Description of the Project Area

This chapter includes the information about the project area. Among this information are:

- The geographical location of the site, the project coordinates, topography, general geology of the area, seismic conditions at the project site, and the general description of the climate.

- The social conditions at the project site; this part includes the population, education and cultural situation, hospitals and healthcare facilities, transportation and communication ways.

- The economic conditions at the project area; where general information on agriculture, livestock, local industry, tourism, trade and mining is given.

- Also the land ownership status at the area, and information about how the land is being used will be included.

- Finally there will be information about the previous studies for hydro projects in the area.

This chapter is rather a generalized chapter which does not give specific information on the project. However, in some of the cases, it can highlight some of the challenges about the access routes, expropriation and seismic conditions.

3.3.3 Turkish Feasibility Report Chapter 3: Development Plan.

This is also a general chapter as required for the license applications. Brief information will be given on the reasons to develop a hydropower project at this area, existing plants, the plants under construction, proposed structures within the project and possible impacts of the development plan.

This chapter would not have any significance for the investment decision of the Investor.

3.3.4 Turkish Feasibility Report Chapter 4: Climate and Water Resources

This chapter will include the details about the water potential of the project. It is very critical to make a thorough evaluation in this chapter. The results will directly affect the outcome of the annual energy generation.

Within this chapter climate will be reviewed under sections of meteorological stations close to the project site, precipitation, temperature and evaporation. All these information are generally summaries of the related subjects for the project site. The precipitation data is rarely used for the estimation of annual water potential.

Water potential will be evaluated according to the available FGS close to the project site. The data from the FGS's are generally obtained from DSI or EIE records. The previous years will normally be evaluated within the study. If the data is old, or do not exist for an acceptable duration, then other methods also might be used. Among these can be the hydrology model of the project area. However, this method is rarely used. If the FGS data is not existent for the river (of the project); then statistical methods are mostly used.

The water usage rights and the ecological flow amount will also be stated under this sub chapter. The ecological flow amount is the water that the plant must release to the river bed without taking in to the system. This amount is defined by the related government institutions and is directly proportional to the average flow rate in the last five years in the river. A certain percentage of this rate is requested to be released directly to the river for the ecological flow. The correct assessment of these values is also critical in means of the annual energy productions.

Within this chapter, water demands and future projections will also be given. The regulations in Turkey set the priorities for the usage of water resources. According to this: the first priority is the domestic and drinking water demands, second one is the wildlife and continuation of natural habitat, third priority is water demand for irrigation, fourth priority is flood protection, and the fifth priority is energy generation and industrial water demand. As it can be understood; water demand for the earlier priorities should be correctly assessed so that the feasibility figures can base on realistic inputs.

Also the maximum and minimum water elevations on the reservoir and the tailwater side will be given in this part. Flood analysis will be performed, which is the basis for the design of related structures within the project. This will have cost impacts. Lastly the sedimentation subject will be evaluated. This is important for the service life of the plant and also the cost of electromechanical equipment.

3.3.5 Turkish Feasibility Report Chapter 5: Geological Conditions

This chapter will give the general information about the site geology. The data is expected to be obtained from the geology maps for the project region. It is very rare that a site specific test program is applied and the results are reflected during the typical TFR stage.

The geological formations that are existent at the job site will be briefly explained. Each project structure such as weir, channel or powerhouse area will be reviewed separately. This information will be used as the basis for the structural evaluations, recommended types and sizes of the project components. Also existence of the materials that will be necessary for the construction, such as clay, rock quarry, etc. will be evaluated and mentioned here.

This part has significant importance on the overall costing of the project. The generic geology maps do not always reflect the site specific conditions. As the result, major deviations might become necessary through the later stages of the design development. All these have cost impacts, some of which can even jeopardize the whole investment plan.

Finally in this chapter, the seismic conditions are also evaluated. Again, the information is obtained from general seismic hazard maps. In the best case, there is additional data about the nearby fault lines, which is again rarely observed in TFR's. Seismicity also has significant importance and using general information can bring some unknowns and causes risky situations to the project.

3.3.6 Turkish Feasibility Report Chapter 6: Project Structures

In this part of the feasibility report, the optimization of the installed power will be analyzed and the proposed structures will briefly be explained. The overall concept of the project is described here, generally with some dimensions and sizes. Some parts might be precise, like the diameter of a tunnel or a penstock. The others will be rather rough numbers which will only give a general idea about overall sizing, positioning and costing of each project structure.

Within this chapter, the ETL, access roads and other cost items will also be explained. Among these are electromechanical equipment and switchyard costs as well.

This chapter is expected to include the discussions on various project optimizations. Different types of structures (i.e concrete dam, rock fill dam), different turbine types, where to locate the structures, which bank to use for the conveyance tunnel or channel will all be evaluated to decide on the optimum alternative. The Investor normally would do the selection together with the designer. In most of the TFR's, only one option will be selected after the evaluations and the project cost will be calculated based on this option. Therefore, the feasibility of the project will be according to this option.

The level of detail in this chapter generally does not go into the components of each structure. Generally only the turbine and generator data is provided within the electromechanical part. Individual systems, other equipment and related sizes, capacities, etc. will not be given in detail. Depending on the size of the plant, this chapter would be expected in the range of twenty pages within the feasibility report.

3.3.7 Turkish Feasibility Report Chapter 7: Environmental Impacts

Within this chapter, the relation of the project with the environment will be evaluated. First part is expected to include information on the existing situation at the project area.

The types of species living in the surrounding areas will be mentioned. It is important to know if there are any endemic types, and if the project will have any impact on those.

The existence of mining areas in the vicinity will be checked. This can have other usage rights and might become a conflict in the future. Turkish laws generally protect the mining activities more than the energy generation projects.

The agricultural areas will also be evaluated. It is important to have the amount of areas that will be affected from the project. At the end, these areas will need to be expropriated, which will be a cost item for the investment. Sometimes significant amount of cost can be generated from expropriation. Also it can cause delays on the project schedule.

Environmentally protected zones will be checked. This part is critical as such zones might even cause cancellation of project license and the investment.

The social situation at the site will be evaluated together with the transportation roads, flora and fauna at the project site.

At the end of this chapter, the environmental impacts of the project and the suggested preventive actions will be evaluated.

3.3.8 Turkish Feasibility Report Chapter 8: Cost of the Project

The details of the costing of the project will be given in this chapter. Generally there will be several drawings for the sizing of individual project structures. In most cases the number of drawings will be approximately fifteen, in the A3 form. Based on these drawings, the bill of quantities will be generated.

The unit rates will be taken from the DSI database. Each year, DSI updates the unit prices as per the actual conditions in the market, or according to the increase in the price of raw materials. It is common that the potential contractors apply a certain discount from these rates. However in some cases, due to the complexity and challenging site conditions, these rates might be not sufficient for the contractors. In the feasibility report, it will be expected that a realistic estimation is given.

On top of the cost of the project structures, other parts such as electromechanical and hydromechanical equipment will be added. These are also based on estimations and basic drawings.

ETL costs will also be given. The voltage level is generally dependent on the installed capacity. When the voltage level is known, and together with the data on the connection agreement, the total cost will be estimated.

The costs for the road relocations will be calculated.

In most of the TFRs, the sum of above mentioned cost items are summarized and a contingency is applied on top of these costs. This contingency is generally taken as 15%.

In addition to these costs, design, engineering, project management and expropriation costs are added. Also the financing costs will be estimated.

As the conclusion, total investment costs will be shown in the end of this chapter.

3.3.9 Turkish Feasibility Report Chapter 9: Economic Analysis

In this chapter, Capital Expenditure (CAPEX) and Operating Expense (OPEX) will be given in detail. This should include the annual benefits with regards to irrigation, flood protection, energy generation and others. Generally the annual energy generation and the total revenues will be given. The selling rate for the electricity is estimated and the calculations are done based on this assumption.

The annual costs will also be given, especially for the interest, amortization, O&M costs, and the renewal costs.

As the result, the annual revenues and expenditures will be shown. According to these figures the IRR will be calculated.

3.3.10 Turkish Feasibility Report Chapter 10: Cost for Projects

When the project has several purposes, such as energy generation and irrigation, the project cost is generally distributed within these parts of usage. In such projects, this chapter will be prepared, otherwise it would still exist, but as void.

In most of the TFR's, there will not be a combined usage of the plant, rather than the energy generation.

3.3.11 Turkish Feasibility Report Chapter 11: Alternative Solutions

This chapter is expected to include alternates for the plant layout or the structures. As previously mentioned, alternatives are generally evaluated at the previous chapters and only one is selected. All the costing and other evaluations are based on this single alternative.

3.8. International Feasibility Study

In the international projects, the first step for the Investors will be a pre-feasibility report. The initial ideas and basic calculations according to some draft schemes will be evaluated and included in this report. At this stage, the intention is rather to have a Due Diligence study, and not a full technical statement. The Pre-Feasibility report would be a slightly simplified version of a TFR.

As Ravn (1992) states, at the earlier stages, preferable projects are already identified. The studies among the selected ones from these projects will be continued. A prefeasibility study is where the plans for developing the project are formulated. Identified projects normally have alternative solutions, layouts and structures which were not properly investigated in the first phase. In the second phase, during the prefeasibility investigations, such alternative solutions, even the concepts, will be studied and tested in order to improve the project plans. Various layouts, features and structures will be identified, adapted to site conditions, analyzed and tested to arrive at plans and designs which are sufficiently firm to merit detailed field investigations.

Prefeasibility investigations are usually based on available information and data, often of varied quality, supplemented, where needed, by a minimum of reconnaissance grade field surveys (Ravn 1992).

As per the findings of the initial step, the Investor would decide if a Feasibility Study should be prepared. The focus for the Investor will be to analyze and decide if there are major risks, or restraints for the project realization. In addition this initial report will indicate if the project might be feasible at the end.

In the next step, the Feasibility Report will be prepared. This report will include more details than a typical TFR. One of the main differences will be the site survey and site specific geological and geotechnical investigations, as well as geophysical studies to analyze the seismicity at the project site.

In this study; usually several project schemes will be investigated to determine the most feasible option for the investment.

According to Ravn (1992), a feasibility investigation is a comprehensive analysis and detailed study of the contemplated project, directed towards its ultimate authorization, financing, design and construction. The feasibility study is carried out in order to determine the engineering (technical), economic and environmental feasibility of the project. The feasibility study report will provide the necessary information from which the Owners can decide whether or not to go for implementation of the project, i.e. to proceed with the definite plan studies, final design and construction of the project. It also serves as application documentation for the development license. The report will also provide a basis for appropriation of funds and for negotiations of loans from financing institutions for design and construction of the project.

Ravn (1992) emphasized a significant difference of the feasibility stage to be a detailed geological assessment. According to him, geo-investigations are normally the costliest part of the field investigations. Up to the feasibility study phase the planners have relied on surface investigations using geological mapping assisted by boreholes, trenches and similar. In some cases, the occasional seismic refraction profiles have been shot. But the real costly subsurface investigations were not used. For feasibility level investigations, however, subsurface exploration will be necessary.

He also highlighted the inclusion of the environmental studies such that the environmental study is performed as a part of, and in close coordination with the feasibility study. Much of the findings and recommendations of the study are therefore already taken into account and incorporated in project formulation and project plans.

International finance institutions and similar organizations have rules and quality requirements for feasibility studies. A study conducted according to these rules for a project which comply with normal feasibility requirements is termed “bankable”. Such studies are generally accepted as basis for loan applications (Ravn, 1992).

As mentioned previously, the International Feasibility Report (IFR) will have more details; however the basic structure and the chapters will be similar to a TFR. In the following parts of this section, the content of an international feasibility report for a HPP will be explained briefly. To gather the following information, the data collected during an interview with Expert A was used. In addition, an actual IFR which was prepared for a HPP in Asia, with a reservoir was reviewed.

The expected information or parts within a feasibility study is mentioned according to Ravn (1992) as:

- Data and information; on hydrology, meteorology, geology, soil and materials, socio-economic conditions, existing infrastructure, etc.

- Project formulation; adjusted according to the final version of the plans.

- Field investigations; that are carried out during the preparation of the feasibility report.

- Project layout.

- Engineering design; main project components (intake, water channels, power house, transmission lines, etc.), turbines and valves, generators and switchgears, transformer, switchyard, auxiliary equipment, etc.

- Scheduling and estimates: construction schedule, bill of quantities, unit prices, contingencies, cost estimates.

- Economic and financial analysis; IRR, etc.

- Additional and optional works: Miscellaneous other parts.

Also the report prepared for the Advisory Assistance to the Ministry of Energy of Georgia, Georgia's Namakhvani Cascade of HPP's project concept as a potential investment opportunity was reviewed (P.E.D. IQC – Contract No. DOT-I-00-04-00020-00 Task Order # 800) 2006. This study also follows a similar structure for the evaluation of the key parameters. The individual chapters support the content of the IFR that are shown within this thesis.

The classification given by Rayn (1992) is mostly parallel to the list of the chapters that will be explained for an IFR. As mentioned before, the chapters that are generally followed within the current market was searched through actual feasibility reports. These reports include the similar chapters in maybe a more Investor favored manner. The details within this chapter will be given in line with these actual reports. The differences from the TFR will also be justified according to several resources, which highlight the involvement of detail information at feasibility stage.

Accordingly, the content that will be expected from an IFR is as follows;

3.4.1. Executive Summary

This chapter of the IFR is intended to give a general summary for the management. It includes brief information about various aspects of the report. The Investor can get an idea about the findings and the overall feasibility from this chapter.

In the executive summary there will be one or two paragraphs about project location, project description and features, recommended project schemes, energy production, environmental and social impacts, project cost and schedule. Also it can include recommendations and conclusions at a summary level.

3.4.2. Introduction and Project Description

In this part, the development of the project will be explained. The older studies that were performed and previous reports will be emphasized. Scope and boundary conditions of the feasibility report will be mentioned.

The project will be described with the main characteristics. The purpose of the development, the license structure and other regional conditions will be given.

3.4.3. Physical Conditions for the Project Area

First the project location will be explained in detail. The ways to access to the site for personnel and also for the project materials will be given. Generally, the explanations will be based on a site visit and its findings. The details about the roads, the slopes, physical conditions, bridges and capacities will be given. The parts of the access route that have to be improved will be mentioned in the report. Also the seasonal changes on the conditions will also be included in this part. The current and future developments which can support or affect the project will be evaluated.

The data set which is used for the hydrology calculations will be explained. Firstly, the existing FGS data will be used. If the existent data is not reliable, hydrology models will be used. To support these models, various climate data will be obtained about annual precipitations. Additionally database of the international resources such as satellite surveys, global rainfall data, NASA database, government databases, etc. will be analyzed. These will be combined with the site specific topographical survey and corresponding maps. The engineer might introduce their own modeling or calculation methods. At the end of these studies, the project flow rate and the design flood will be obtained. These will be the basis for the calculations on the energy generation and also the related project structures.

Sedimentation is the other important part of the feasibility report. In this part, the sediment characteristics will be investigated. The focus will be on two aspects. First one is the sediment potential that can fill the reservoir, or how this should be flushed in a run of river case. The amount is important for the effective service life of the reservoir. The second issue will be about the possible effects of the sediments on the conveyance structures and the turbines. According to the findings, the type and size of structures might change. All these changes will be affecting the overall cost of the project. Generally, a site specific sediment analysis will be used. If these are not available, empirical methods will be used.

The maps about the topography will be presented. One main difference in the IFR will be that there will be more detailed maps for the critical project areas. These can be in the scale of 1/5000. These maps increase the precision on the feasibility studies and give much realistic results. Generally a site specific topographical survey will be done. The areas to be surveyed will be decided according to the pre-feasibility report which is the previous step before the IFR.

The general available maps about geology will be shown. The formations will be explained like in the TFR. Their characteristics and effects on the slope stability, leakages and proposed project structures will be analyzed. Unlike the TFR, in most of the cases, there will be site specific geological and geotechnical tests performed. Similarly; the seismic hazard maps will be evaluated, and site specific geophysical tests results will be used.

In this part, the details of the site tests will also be given. This will include the test locations, testing methods, time and duration of tests, results and the related logs and reports, samples, how and where they were stored, related pictures and daily logs. The results of these tests will also be given such as, groundwater elevations, bearing capacities, rock strength parameters, soil parameters and permeability. Various other aspects for slope stability, grouting requirements, construction materials, etc. will also be evaluated.

Generally, the performed tests will enable the engineer to give decisions on the design parameters and also to location of the structures. The test program will include different locations which can be alternatively used for the critical structures. Sometimes, additional tests can also be suggested to clarify specific points. However these would probably not have any significant effects on the project location or characteristics.

3.4.4. Comparison of Project Layout Alternatives

The location of the project structures and the maximum and minimum operation elevations will be mentioned. The boundary conditions such as expropriation, resettlement, as well as constraints and findings from the previous chapters (like geological or seismic concerns) will be evaluated. Different alternatives on the project structures (i.e dam type, conveyance tunnel diameter, etc.) will be analyzed and the positive and negative aspects will be stated. At the end of these evaluations, two or more layout alternatives will be suggested in the report.

As per each alternative, the components of the layout and suggested methods of construction will be explained. Construction duration and its effects on the overall project benefits will be estimated. Construction materials, challenges on physical conditions, operational risks and mitigation methods will be mentioned. As the result, the type and sizes of the corresponding structures, such as diversion tunnel and spillway will be defined.

For each alternative, the basic characteristics of the project structures and the bill of quantities for their construction will be prepared. This will be the basis for the cost calculations which will be given in the following stages.

At the end of this part the engineer will give a comparison about the different alternatives. Both the technical and financial feasibility of alternatives will be evaluated and one of them will be chosen. The selected alternative will then be developed in the following chapters of the feasibility report.

3.4.5. Energy Generation Calculations

In this part of the feasibility report, the electricity market will briefly be analyzed. The overall generation capacities that currently exist in the region, the demand, and the selling prices will be evaluated. The plans of the country for future development will be mentioned. In parallel, the operation term and possible generation – selling strategy will be checked.

If the project includes a reservoir, then a reservoir operation model will be established to analyze the benefits of different operation modes. Accordingly, the installed capacity will be determined, which would give the optimum results.

3.4.6. Civil Engineering and Design

Within this chapter, based on the selected layout alternative, the details of each project structure will be explained. This will include the capacities, sizes, elevations and specific design methods that should be used in the future stages of the project development. Also the construction methods and recommended equipment on specific tasks will be explained. The construction sequence will also be defined. Other information on river diversion and excavation slopes, etc. will also be given here.

3.4.7. Design of Mechanical Equipment

This chapter will focus on the selection of the main mechanical equipment. According to the information on the previous chapters (design flow, reservoir elevations, locations of project structures, sediment amount and characteristics, etc.), the type, number and capacity of the units will be determined. The gross head and head losses will be calculated. Turbine size, layout and mechanical characteristics will be given. These data will be in the level of precision so as to state the boundary conditions for the suppliers. Also the expected efficiencies will also be mentioned here. These estimations will form the basis for the annual energy generation calculations which affect the overall feasibility of the project.

Similar study will also be given for the governor, main gates and valves. An overall description for the auxiliary mechanical systems will be given. The key issues on the overhead cranes, other secondary cranes, Heating Ventilating and Air Conditioning systems, stoplogs, spillway gates, trashrack mechanisms, etc. will be mentioned.

3.4.8. Design of Electrical Equipment

The design criteria for the main electrical equipment will firstly be given. This will be based on the characteristics of selected mechanical equipment, grid and sometimes the plant operation.

A single line diagram is generally shown here to give the details of how the system is planned to operate. Afterwards, the details on the selection of generator, transformers, rated voltage, sizes and main characteristics of the corresponding equipment will be given. Information about the planned excitation systems, grounding, fire protection, control and communication systems will be mentioned. Also, the details on the switchyard and connection to the main grid will be explained in this part.

3.4.9. Energy Transmission Line

In case there is a connection agreement; this part will analyze the possible route and the cost impacts. If this information is not existent, then possible alternatives on how to connect the plant to the grid will be evaluated. The voltage levels will be mentioned in the evaluations. For the route survey, a separate feasibility study is sometimes performed and the results of that report are incorporated in the IFR.

3.4.10. Recommended Project Layout and Characteristics

This chapter will summarize all the findings and selections of the previous chapters. A table including these information will generally be included. This will be similar to the "Management Information Form" which is included in the first parts of a TFR.

3.4.11. Social and EIA

In a typical IFR, this chapter will be an important part. Unlike the TFR, there will be an EIA, or an Environmental and Social Impact Assessment (ESIA) already performed and the findings are available at the time of the IFR.

During the development of the project, additional costs can be occurred because of the measures that will be necessary according to the ESIA report. In the case of major resettlements, the costs can significantly increase. This would affect the financial feasibility of the investment. A typical IFR is expected to incorporate these conditions into the cost/benefit calculations in a more serious manner.

Within this part of the IFR, firstly the summary of the ESIA will be given. Within this summary, the nearby settlements, agricultural areas, other land use, forests, socio-economic structure, infrastructure and water usage will be included. Also the amount of the effected land, houses, and other areas which will create cost for the project will be assessed.

The information about the social development plans, resettlement and expropriation will be analyzed and corresponding costs will be estimated.

Separately, similar studies will be conveyed for the temporary project facility areas, construction roads and also for the ETLs.

3.4.12. Quantities and Cost Estimates and Schedule

According to Goldsmith (1993); detailed cost estimates are needed for determining the economic merit of a project, appraising its financial implications and arranging financing for it. Where the feasibility study is undertaken in two stages, a pre-feasibility investigation followed by a feasibility review, cost estimates are likewise prepared in two separate steps. The estimates are made to a reasonable approximation in the pre-feasibility phase and they are then refined, on the basis of more extensive investigations, in the feasibility phase.

In this part of the IFR, the bill of quantities that were generated in the previous chapters will be used. The unit rates will be obtained either according to the local market conditions, or based on the experiences of the engineer. As the result, the overall project cost will be calculated and given in this chapter. Inclusion or exclusion of specific development costs such as financing and permitting can be changed from one project to the other.

Within this part of the report, an indicative construction and project development schedules will also be given. The economic analysis should take into consideration the time spent during the project execution.

3.4.13. Economic and Financial Analysis

In this chapter, the investment cost and other inputs are taken to create a financial model. The results are used to give indications about the overall feasibility of the investment. Several assumptions is done in the models about the feed in tariffs, interest rates, equity and loan amounts, pay back periods, etc. IRR will also be calculated as a result within this chapter.

3.4.14. Conclusions and Recommendations

Project feasibility will be evaluated and engineer's conclusions will be given in this chapter. The potential risks about the project implementation will be mentioned. Also the improvements that can positively affect the financial viability of the project will be suggested. Various other statements can also be included according to the engineer's own interpretation of this part.

3.9. The Main Differences Between TFR and IFR

In this part of the thesis, the main differences of the two approaches will be summarized.

First and the most important difference is the purpose of the reports. In TFRs, the aim is to analyze the technical and financial feasibility of the investment. An investor would take this report and would use it as a basis for the investment decision. Based on the figures, the investment is generally started and initial steps are taken. On the other hand, the corresponding report for an international investment is a pre-feasibility report. In other words, the content and reliability would be more similar in these two reports. The International pre-feasibility report is not evaluated as a sufficient report to start the investment activities. The following full feasibility report will be necessary for an investment decision.

One of the main differences is the level of details about the geology, geotechnical and seismic data. In the TFR, these data are obtained from general maps and databases. A site specific test program is rarely done at the feasibility stage. The generalized data might be misleading and affect the overall feasibility of the project. On the other hand, in the IFR; these data are generally obtained from site specific tests. The issues and parameters that affect the technical and financial feasibility are taken into consideration. Necessary adjustments are done according to the findings. This step is also done in projects based on TFR. However, this takes place at later stages of the investment. In this case the investor will already have spent some resources to the project, and will have difficulties to change decisions or mitigate the results of these unexpected negative effects.

The other difference is the level of detail on the ESIAs. An IFR will base its findings and cost estimates for this part according to a EIA or ESIA report. This report would generally give precise results on the evaluations. This would eliminate the risks of the investor in the later stages of the project. Obviously, the necessary actions will still be taken, however the cost impacts of these actions will be given at the feasibility stage before the investment decision. On the other hand, the TFR will rarely be based on a completed EIA. The author of the feasibility report would give his best estimates on the impacts and would conclude on the costing part.

The last difference would be the inclusion of a financial model in the report. Also the conclusion and recommendations are not included in a TFR.

Table 3.4 shows a general summary of the main aspects in both TFR and IFR. For each item, level of detail that is considered in each feasibility report is mentioned.

Table 3.4. Summary of main aspects of TFR and IFR.

ITEM / CHAPTER	TFR	IFR
General desciption of project, conditions of project area	A brief information on the project location and the other conditions.	A more detailed information on the project location. Especially about the access roads and related costs.
Climate and water resources	Detailed review of existing FGS database. Rarely a hydrology model is established.	Similar review of available FGS data. A hydrology model is also used in case of any doubt.
Geology	Explanation of the general characteristics and formations at project site, based on general geology maps. Not site spesific.	Explanations on the geological characteristics of project site. Based on general geology maps and site spesific test results.
Geotechnics and seismic	Explanations and indications on main design inputs. Based on general maps.	Explanations and indications on main design inputs. Based on site investigations and tests.
Proposed structues	General details of the selected project scheme and structures.	General details of the evaluated project schemes and structures.
Electromechanical Equipment	A comprehensive section for the type, quantity, capacity and efficiency. Preliminary sizing.	Similar content with TFR.
Environmental Impacs	General overview of the project area, evaluation of the necessity of an EIA, the expected expropriation, etc.	The evaluation of project together with the findings of the already completed EIA.
Calculation of CAPEX	Calculation of CAPEX based on the general project BOQ's.	Calculation of CAPEX based on the general project BOQ's.
Economic analysis	Analysis based on the previous findings.	Analysis based on the previous findings.
Conclusion and recommendations	Not included.	Recommendations. Most important is the identified risks for the implementation of the project.

4. CHALLENGES FOR FEASIBILITY STUDIES & INVESTMENT DECISIONS

Several differences of IFR and TFR have been highlighted in the previous chapters. The market has been searched to find cases related to these differences. Within this part of the thesis; these cases will be studied. Several interviews were performed with persons from the designers, project owners (Investors) and also with a person formerly employed by DSI. Main resource of the data in this chapter is company specific. Most of the information is not open to public sharing. The confidentiality terms and conditions in the relations with these companies do not allow this information to be given openly and in detail. Accordingly, most of the project details will be hidden. The focus will be given to the consequences and how they are related with the initial feasibility reports.

On the other hand the actual cases were observed to have strong relations to the evaluated subjects, and do support the previous findings. Therefore even with a very limited data, they are still shared here. The idea behind was that; this kind of information is rarely being conveyed out of the investment cycle. By the emphasis on this chapter, one can at least get an initial awareness that there are actual cases which can be further studied. This can be a subject for another detailed study and thesis.

The most important finding in the case studies was the problems arising from the effects of geology and geotechnical situations at the project. The projects, where there was no site specific testing was done at the feasibility stage, had major deviations in the investment budget and on the schedule. For this reason, site geology will be the focus for the case studies.

As mentioned by Gündüz *et al*. (2010), in order to calculate the cost of a HPP project accurately, a detailed hydrological study, site investigation, good basin planning, geotechnical survey and various tests are essential.

Due to the uniqueness of each hydro project site, there are always some unknowns and risks. The biggest impact from these risks can be caused by the geological conditions.

If the project is at the execution stage, and the site works has started; this means that the project layout is fixed; accordingly the design is advanced, structural calculations are done, permits have been initiated, and even the financing is arranged, or is in the progress. At this stage, if unexpected geological conditions are seen at site, this will possibly have impacts on all these steps. This can be very costly, depending on the nature of the problem. And also it would definitely have some schedule impacts.

The studied cases have been selected among a pool of actual projects. Only the projects where an unexpected geological event or condition was experienced were evaluated. The general finding has been that the schedule impact was more challenging than the cost impact. As an average figure, several months delays on the COD were observed. Obviously, this is a value that cannot be generalized, or justified at each new case that can be brought in addition. Moreover, there can be other conditions that can contribute the project delays at each case. However, the investigated projects showed that the impacts are not in the order of some days or weeks, but several months. The cost impacts were also significant. Here the additional project cost is the first part, and the second part is the loss of energy generation because of late start of production. When both parts are combined, the annual revenue of the first year could easily be lost. This is a major deviation which would create a series of problems for the Investor.

4.1. Case Study 1

Within this case study, the damage on the Powerhouse (close to the COD) because of a landslide will be evaluated.

Description of HPP and Developer. The project is situated on a mountainous area. Due to the project layout, structures have to be crossing or be placed near to steep slopes. There are no major landslides that were existent at the time when the feasibility report has been prepared. However the rainfall regime is such that the starting of runoff and its rate is high when compared with similar projects.

The developer was new on the energy field. The studied case is the first project to be developed under the management of the investor.

Brief explanation on Feasibility Study (FS). The feasibility report of the project was based on the general geological maps and also on site observations. At the stage of the investment decision, the investor probably did not have detailed information on the site specific conditions and possible risks.

Explanation of Case & Mistakes. The initial feasibility report included advices for site tests. However, no test was performed at the landslide area.

After the completion of the civil works at powerhouse, a landslide has hit the building resulting with severe damage on the structural system. The structural elements had to be replaced. All the electromechanical equipment had to be checked for damages. Additional protection measures had to be taken to protect this equipment from the seasonal weather conditions.

The excavation of the powerhouse area was done according to the site supervision's evaluations on the soil conditions. The specific parameters of the soil such as friction angle, cohesion, and also the subsurface layering, soil and rock conditions were not considered. If these would have been available at the feasibility stage, the powerhouse could be located to a different location. The cost impact of such change would be evaluated by the investor at that stage and would be incorporated with the budget.

Effects on Investment Cost. The incident caused a delay on the project COD. This resulted as the loss of the energy generation for a significant part of the first year of production. In addition, the replacement of the structural system and also the protection of the equipment created additional costs. The overall increase together with the loss of the revenues due to the delay on COD added up to 24% of the initial investment cost. These were partially taken from the contingency budget of the investment.

Effects on Investment Schedule. As mentioned, the schedule was delayed for several months. When compared with the overall construction period, the delay was already approximately 30% of the total duration.

4.2. Case Study 2

Within this case study, the cost increases due to the geological conditions at the conveyance channel will be evaluated.

Description of HPP, Developer. The project is situated at the black sea region, where the general geological characteristics are such that landslides at steep sloped are often experienced. The project includes a relatively long conveyance structure. There is no reservoir within the project.

The developer is not experienced in the hydropower field. This plant will be their first plant to be completed.

Brief explanation on FS. The feasibility report of the project was based on the general geological maps and also on site observations. The conveyance channel route was not reviewed in necessary detail level from the slope stability perspective.

Explanation of Case & Mistakes. The excavation slopes for the conveyance channel was taken as one vertical to three horizontal. This was not based on site specific information but only to the general geology maps and limited observations. The cost was calculated according to this assumption and the overall feasibility of the project was concluded.

In the actual case, the excavations could not be performed with the planned slopes. Local landslides occurred at several places through the conveyance channel route. These created additional cost for the remedial works and to form a sustainable platform for the channel. The slopes had to be taken less steep, which increased the total excavation amount.

In the case of the IFR approach, the site specific tests would have been performed before or during the feasibility stage. The soil parameters would be obtained from these tests and the slope stability would have been analyzed in detail. At the end, a realistic design would be given. These would give the Investor the additional costs which were stated above. Therefore the investment plan could have been done accordingly and the decisions would be given based on realistic figures.

Effects on Investment Cost. The additional works for excavation resulted with approximately 16% increase on the construction budget. This was already more than the reserved contingency budget.

Effects on Investment Schedule. The project schedule was affected for the conveyance channel. However, the overall COD date was not delayed because of this problem.

4.3. Case Study 3

Within this case study, the unexpected geological conditions at the energy tunnel and the powerhouse, and the related cost increases will be evaluated.

Description of HPP, Developer. The project does not have reservoir. It includes a weir, energy tunnel and powerhouse. The tunnel length is relatively long when compared to the projects with similar installed capacity. Therefore they form an important amount of the project budget. The tunnel route passes from mountainous areas and access to each part is not much convenient.

The developer has an internal team for the project management. This is one of their first projects on the hydropower field. However, the corresponding team members have previous experiences on similar projects.

Brief explanation on FS. The feasibility study was performed according to the TFR practices. The project layout is rather simple. As the boundary conditions such as the elevation of the weir, powerhouse, the possible tunnel route, places of access tunnels are fixed, there have not been many options for changing the location of structures with more convenient areas. However, the initial design inputs were not based on site specific test.

Explanation of Case & Mistakes. The geology in the tunnel alignment has been estimated according to general geological maps. No site borings were performed during or after the feasibility report. This has been a bottleneck for the excavation and support requirements for the tunnel. Also the long term performance of the tunnel due to its pressurized working scheme was questioned. According to these inputs, the cost for the excavation, temporary and permanent supporting costs were increased. These effects also had consequences on the project schedule and a significant amount of delay was experienced.

Also the subsoil conditions at the location of the powerhouse were not investigated in detail during the feasibility stage. At the execution phase, layers of unfavorable soil were encountered. Additional soil improvement measures had to be taken so that the powerhouse can perform under the dynamic loads during the energy generation. These additional measures brought an unforeseen cost, and also a delay on the project schedule.

In the case of the IFR, site specific soil tests would have been done approximately at each 500 m – 1000 m section of the energy tunnel. This would eliminate most of the unknowns about the geology. Therefore the additional costs would have been shown to the Investor at before the decision making stage.

Effects on Investment Cost. The additional efforts for the tunnel excavation, supporting and the soil improvement at the powerhouse location resulted with an increase of 10 % on the project budget. Moreover, due to the delay on the schedule, another loss has occurred because of not generating energy for a certain period. This amount corresponded to approximately 7 % of the project budget. When both are considered, the cost summed up to 17 % of the project budget, which is an important amount.

Effects on Investment Schedule. As mentioned, the project schedule was also affected. When the initial estimation for the overall schedule is considered; a delay of approximately 35 % was experienced. This, probably had other impacts on the cost of financing as well.

4.4. Case Study 4

Within this case study, similar to the previous case; the unexpected geological conditions at the energy tunnel and the powerhouse, and the related cost increases will be evaluated.

Description of HPP, Developer. The project does not have reservoir. It includes a weir, energy tunnel and powerhouse. The project structures are located at higher altitudes which makes the construction process to depend on the seasonal weather conditions. The area is also an environmentally sensitive zone for the wild life protection.

The developer does not have previous experience on similar projects.

Brief explanation on FS. The feasibility report was prepared in line with TFR practices. The initial design inputs were not based on site specific test. Especially on the tunnel route, only the surface geology was examined and overburden thickness, fault zones and access tunnel lengths were studied in detail. The costs for the tunnel were estimated with an optimistic approach.

Explanation of Case & Mistakes. The geology in the tunnel alignment has been estimated according to general geological maps. No site borings were performed during or after the feasibility report. This has been a bottleneck for the excavation and support requirements for the tunnel. Also the long term performance of the tunnel due to its pressurized working scheme was questioned. According to these inputs, the cost for the excavation, temporary and permanent supporting costs were increased. These effects also had consequences on the project schedule and a delay of several months was experienced.

Also the subsoil conditions at the location of the powerhouse were not investigated in detail during the feasibility stage. At the execution phase, layers of unfavorable soil were encountered. Because of this, large amounts of additional excavation were performed. These areas had to be filled with concrete afterwards. This brought a significant cost for the powerhouse.

Effects on Investment Cost. The additional efforts for the tunnel excavation, supporting and the soil improvement at the powerhouse location resulted with an increase of 8 % on the project budget. Moreover, due to the delay on the schedule, another loss has occurred because of not generating energy for a certain period. This amount corresponded to approximately 6 % of the project budget. When both are considered, the cost summed up to 13 % of the project budget, which is an important amount.

Effects on Investment Schedule. As mentioned, the project schedule was also affected. When the initial estimation for the overall schedule is considered; a delay of approximately 29 % was experienced.

4.5. Case Study 5

Within this case study, the radical change of the investment plans because of site geology will be evaluated.

Description of HPP, Developer. The project scheme is composed of a dam, short energy tunnel, penstock and the powerhouse. It is located at the south part of Turkey. The installed capacity and the estimated annual energy generation is relatively high. This makes the project important for the developer for the future targets on total project portfolio, and annual production targets. The developer has more than two hydropower projects, at planning stage, or under operation.

Brief explanation on FS. The feasibility study was performed in a short time period. The energy production calculations were based on actual data collected from the reliable FGS. The costs for the construction of the project structures were estimated thoroughly with an acceptable level of detail.

On the other hand, no site specific tests for the verification of geology and geotechnical inputs were performed. The general maps and other experiences from nearby projects were used.

Explanation of Case & Mistakes. The Investor had acquired the project based on the initial feasibility report. The costs and the benefits that were shown in this report concluded that the project could be realized in a profitable manner, with an acceptable IRR.

However, the site inspections at the later stages showed that carstic formations dominate the dam location, and the reservoir operation is not possible as planned at the feasibility stage. This has been a major problem which caused the suspension of the plans.

The possible ways to mitigate the losses and to form another project scheme which can reasonably be implemented is still being evaluated.

Effects on Investment Cost. The biggest effect has been the cost of obtaining the project license. In addition, the Investor is obliged to develop the project and generate energy within a certain time. According to the agreements with the government, other conditions may exist for paying penalties, or even the cancellation of the rights of the Investor on the project.

An indirect loss for the Investor can be that the total energy generation target within a certain time has to be revised. This can have other consequences.

Effects on Investment Schedule. No effect on the project schedule was evaluated in this case.

4.6. Case Study 6

Within this case study, the change of Dam type (during construction period) because of site geology will be evaluated. This case study does not emphasize the difference of the TFR and the IFR. However, it is an important case, which shows an example for the cost increases in case of a problem in the site geology.

Description of HPP, Developer. The project has a reservoir, and therefore a dam is involved. The dam design was performed according to the initial findings from the site investigations. It has a regulated inflow, so the investor will have a good chance to generate energy according to the planned figures. The developer has more than two projects which include a reservoir. The selected dam type is not new for the developer.

Brief explanation on FS. The feasibility study was performed in an appropriate manner. The site specific geology and geotechnical parameters were investigated at the feasibility stage. The findings have been incorporated and the dam type was selected accordingly.

Explanation of Case & Mistakes. The performed geological tests showed a favorable subsoil type and characteristics which led the designer to choose the initial dam type. However, during the excavations of the dam area for the preparation of dam construction, a different soil type was encountered. This soil did not allow the selected dam type to be constructed on top of it. Also this newly found layer could not be removed or improved due to its nature and cost impacts.

A comparison with other similar projects showed that the amount of the initial site specific tests have been less than expected. This was attributed to the main cause of the problem. For the critical structures of a hydropower project, it is expectable that the subsoil conditions are investigated in a very detailed manner. These parts have essential role in the project success.

Effects on Investment Cost. The new soil information caused for the change of the dam type. Together with this, the dam layout had to be changed. All these had to be incorporated in a new and updated design. This had an important cost impact, as the previously done studies and site fabrications could not be used. The effect of the cost increase has been in the order of 7 % of the project budget. In addition, the losses due to the late start of the commercial operation reached to an approximately level of 12 %.

Effects on Investment Schedule. The project schedule was also affected. Certain time had been necessary to analyze the situation, to perform additional site tests to understand the limits of the problem. After this stage, the design had to be updated, and the cost impacts had to be accepted by the investor. Similarly the contracts had to be reevaluated and necessary adjustments were done. All these steps took some time before fully starting to the execution of the new design. The overall schedule was affected about 17 % from the initial plans.

4.7. Case Study 7

Within this case study, change of dam design (during construction period) because of a landslide will be evaluated. This case study does not emphasize the difference of the

TFR and the IFR. However, it is an important case, which shows an example for the cost increases in case of a problem in the site geology.

Description of HPP, Developer. The project scheme includes a dam and a reservoir. The water intake and spillway are located on either banks of the dam body. Like the previous case study; the design of the dam was performed according to the initial findings from the site investigations. This investor also has more than two projects which include a reservoir, and the selected dam type is not new for the investor.

Brief explanation on FS. The feasibility study was performed in an appropriate manner. The site specific geology and geotechnical parameters were investigated at the feasibility stage. The findings have been incorporated and the dam layout has been arranged accordingly.

Explanation of Case & Mistakes. On one bank of the dam, after a certain time of starting the construction activities, a landslide has occurred. This was not expected and has been large in size which affected the whole project layout. The amount of slid material was too much to be cleaned, or to take any action on soil improvement.

Site specific tests were conducted at this area; however the setup of these tests did not include the objective to identify the landslide potential of the area.

Effects on Investment Cost. The effects of the event on the investment cost have been less when compared with the other cases studied above. However, it still had an effect of approximately 5 % of the project budget. This could be paid from the contingency budget.

Effects on Investment Schedule. Similarly, the effects on the schedule were moderate. And as the event happened at an early stage of the construction, investor had the chance to eliminate the schedule impacts.

4.8. Case Study 8

Within this case study, change of the project parameters because of Wild Life Protection Zone and resultant energy generation revisions. Change on investment plan will be evaluated.

Description of HPP, Developer. The project is situated very close to an environmental sensitive zone. The scheme of the project does not include a reservoir, and it was already formulated to create the minimum impact on the environment. The stretch of the river that is used for the project is relatively short when compared to the similar other projects. The investor has experience on the field and the project is one of their new projects. They have developed more than two projects before the studied case.

Brief explanation on FS. The feasibility report was prepared by an experienced team and reflects a quality higher than the generally experienced standard within Turkey. The report was based on the generalized maps and information. A site specific EIA report was not performed at the feasibility report stage. The existence of the environmentally protection zone has been noted at this stage. However the relation with the project layout has not been investigated in detail.

Explanation of Case & Mistakes. At the final design stage of the project, the legal approvals from the government authorities could not be taken. The prepared EIA report was not approved. The feasibility report was based on the boundary conditions which allowed a higher water head value. The investment decision was made accordingly. With the EIA study, the boundaries of the project had to be changed and the head value has been decreased.

Effects on Investment Cost. The result of the changes did not affect the investment cost too much. However, the annual revenues and IRR were decreased due to the change on the project characteristics. Another negative effect was because of the delay on the investment COD. This has significantly reduced the revenues on the first years of the operation, as the plant could not be operated. The loss from this effect was approximately 15 % of the project budget.

Effects on Investment Schedule. The schedule was revised due to the change on the layout. All the steps such as application for project license, EIA, other legal and regulatory application and permits had to be updated. These steps are among the most time consuming activities on an investment. Therefore the whole schedule was rearranged. The delay was about 43 % of the overall project duration.

4.9. Analysis of the Case Studies

A brief summary of the above mentioned cases is presented in Table 4.1.

Table 4.1. Summary of case studies.

CASE #	DEVELOPER	FEASIBILITY REPORT	MISTAKES / CAUSES OF DEVIATIONS	IMPACT ON COST	IMPACT ON SCHEDULE
1	Not experienced.	Standard TFR.	Lack of geology asessment.	24%	30%
2	Not experienced.	Standard TFR.	Lack of detailed geological and geotechnical survey.	16%	5%
3	Not experienced.	Standard TFR.	Lack of detailed geological and geotechnical survey.	17%	35%
4	Not experienced.	Standard TFR.	Lack of detailed geological and geotechnical survey.	13%	29%
5	Not experienced.	Standard TFR.	Lack of detailed geological and geotechnical survey.	Unknown (Project almost suspended)	Unknown (Project almost suspended)
6	Experienced.	Better quality and content than TFR.	Less amount of geological and geotechnical survey.	12%	17%
7	Experienced.	Better quality and content than TFR.	Less amount of geological and geotechnical survey.	5%	N/A
8	Experienced.	Better quality and content than TFR.	Omission of a potential wild life protection zone.	15%	43%

As seen from the above table, the major reason for the deviations from the initial investment plans have been the additional costs and schedule delays due to geological reasons. According to the findings on these case studies; the impact on cost varies in between 5 – 24 %, and the impact on the project schedule between 5 – 43 %.

HPP projects in Turkey have been an important investment tool in the last decade. Hundreds of projects of different size have been licensed. Many of these projects have been realized, or still being developed at the time of preparation of this thesis.

A collective knowledge on the effects of initial decisions to the investments is believed to be highly beneficial for the future projects. One of the research objectives was identified as the shortcomings of the initial feasibility reports on the investment decision making process. As a study for the possible reasons; the difference of the TFRs with the International examples has been analyzed in this research.

The limitations were mainly the number of available examples for both approaches. The feasibility studies are mainly prepared specifically for the use of investment companies. These reports are generally not disclosed for the public use or third parties. Although the reports do exist in the related government authorities, the problems encountered during the project execution is not necessarily being reported to them. As the result, a more comprehensive research, which could involve many more examples could not be performed.

The differences of domestic and international feasibility reports have highlighted two main aspects. One is the inclusion of a site specific geological and geotechnical test report, and the other is the existence of a complete EIA report. As the research methodology, the relation of both subjects with the challenges on the investments has been analyzed. This showed a strong relation and effect on the possible challenges. The case studies which were investigated all had cost overruns and schedule delays from the initial plans, mainly because of this difference.

Penche (1998) expressed the importance as: "Frequently, the need to proceed with detailed geological studies of the site is underestimated. In many cases with regrettable consequences .seepage under the weir, open channel slides, etc".

Fell *et al*. (2005) emphasized the importance of the site geology by mentioning that in almost every foundation failure and contractual dispute over "changed geological conditions", it is found that a major contributing factor has been the failure of project planners and site investigators to fully understand and define all of the geotechnical questions which needed to be answered by the site investigations.

On the other hand; as the second main difference of TFR and IFR approaches, environmental impacts is also a possible reason for the challenges through the investment process of hydropower projects.

As per Rapp *et al*. (2009) early work on integration of design and environmental requirements is critical to reduce permitting risk, ensure field studies are properly scoped and timed, and to reduce construction risk.

Isambert (2009) states that, HPP projects have always been made for the sake of human welfare. However, in the past, a few projects were built and provoked negative impacts. Nowadays, EIA has become an issue to be treated as a must before the project is built. Mitigation measures are incorporated in the project cost and new projects should have a minimum impact on the environment.

Also according to Tamargo (2007) people need to know the challenges faced in the basin, participate in the decision making process and evaluate the progress achieved with the programs and actions carried out. In this sense, it is necessary to develop and reinforce the mechanisms and institutions that allow the population to be informed in a clear and opportune way.

The importance of the EIA is also emphasized by Ledec *et al*. (2003). He mentioned that before a dam site is chosen (with a project-specific EIA), sector-level environmental analysis can rank potential sites according to their degree of environmental desirability. A sectorial environmental assessment (SEA) should be carried out prior to making major power sector planning decisions, especially in the comparison of hydroelectric and other power generation (and demand management) alternatives.

In addition, several other resources do support the conclusion about the main differences of TFR and IFR approaches. A pre-feasibility study was conducted using

RETScreen by Alonso-Tristán *et al*. (2011). The content of the study shows more similarities to a TFR, which supports the discussions about the difference of TFR and IFR.

Stojmirovic *et al*. (2007) explain that one of the essential components of a feasibility study are Field Investigations dependent on the topographic data obtained in the prefeasibility study, it may be necessary to conduct a topographic survey to confirm the net head of the scheme. Survey of the potential location of the intake structure and powerhouse should be conducted, with spot heights recorded. This is particularly important for low head schemes when a reasonable amount of confidence is required for the level of accuracy of the net head. Geotechnical boreholes will be required to finalize the location of the intake structure, powerhouse and associated infrastructure and to allow input into the final design drawings.

Also the pre-feasibility and feasibility stages of a project as given in the following paragraphs by Stojmirovic *et al*. (2007):

- Three distinct phases exist for the assessment of small hydro which includes a desktop pre-feasibility assessment; feasibility study; and an implementation phase.

- The pre-feasibility phase is the concept stage which defines at a high-level the capacity, demand estimation and community suitability. Assessing the water resource and obtaining all available existing data and information is critical in assessing the certainty of the energy production potential.

- Hydrological data is one of the most important parameters in determining the feasibility of a site. Hydrology at some sites is questionable, and where monitoring at a particular site does not exist, adjacent catchment data may be used. Further feasibility studies will need to refine the hydrological data.

- The feasibility assessment is a technical and commercial analysis which will allow the owner to decide whether to proceed with implementation of the scheme. The feasibility study assessment should consider as a minimum, a site inspection;

hydrological modeling; field investigations; hydropower assessment; social and environmental issues; preliminary design; costing and financial analysis.

A careful overview on this would highlight the same differences of the TFR and the IFR.

Another example for comparison can be given from a pre-feasibility report prepared by Tingleff *et al*. (2007). As followed for this pre-feasibility study for an actual case studied on a Small-Scale Hydropower for the Yurok Nation, the structuring of a TFR is similarly done. However the included chapters are distributed in a different order.

5. CONCLUSION

The starting point of this research was to identify the differences of feasibility reports prepared based on the Turkish practice and international practices and how they could affect the investors.

It is very common that the hydropower projects in Turkey experience deviations from the initial investment plan. In most of the cases there are significant cost overruns. Likewise, the projects are delayed and commercial operation starts later. This also has cost impacts both for the construction period, and also for the loss of revenues from the plant operation. The inputs of the investment plan in this respect were considered to have a key importance to the result.

The first and main input for the hydropower investments is the feasibility report. In the domestic cases; the projects are evaluated with the figures in these reports. The viability and profitability of the projects are evaluated as per these reports and the project acquisitions are done based on their conclusions. The aim of this thesis was to analyze the content and detail level of these reports. As the next step to compare them with international feasibility reports to understand what kind of differences existed.

One of the main conclusions from this study was that the usage of the feasibility reports and their contents is significantly different in domestic and international reports. The domestic feasibility reports are regarded as a pre-feasibility step in the international understanding for the reviewed examples. With their content, the investors do not sign off an agreement, fully start investing on the project or commercially trade the project as a development opportunity. The content of an international feasibility is far more advanced when compared with the domestic ones. It was also observed that the chapters included in both of the approaches generally matched each other. This means that the important subjects for a hydropower project are the same regardless the approach. This might be because of the nature of these kind of projects. The technology and knowledge is widely used for decades in many countries of the world. Therefore the experience on how to evaluate a hydropower project is known, and is similar in the domestic and international markets.

As the most important finding; the geological and geotechnical inputs can be given. Based on the investigated feasibility reports within this research; it can be concluded that the IFR includes site specific test reports as almost a must. With this approach, the report can evaluate all the possible negative and positive effects of the site conditions. By this way, the investment cost and schedule becomes more reliable. When the investment decision is given after incorporating these facts, the initial cost and time to complete might seem higher. However, the investors have minimum risks for a major deviation from the initial investment plans.

In the domestic applications, the first findings from the general maps and literature are accepted. The investors, by knowing this fact or not, start with the projects and carry the risks to the next step. With the light of the analyzed case studies, it can be concluded that there is a high possibility that these risks are realized throughout the execution of the project. In that case, the investment is negatively affected.

Another similar case is observed with the EIAs. These are also prepared and effects are incorporated in the international feasibility reports. In the domestic ones, the EIA report is prepared after the investment decision is given. The risks of any change due to this part are again carried to the next stage in the investment. These can also negatively affect the whole investment, and even prevent the realization of the projects.

The studied cases showed a strong relation with the deviations from the initial investment plans and the above mentioned two aspects. This study can be useful by forming a basis for a more detailed survey and study. Such detailed study reports should be sponsored by the related authorities, and the results should be carefully evaluated. The standard forms and contents can be optimized by these authorities and the expectations from a feasibility report can be updated. This shall help on a sustainable and reliable growth in the field of hydropower, while the investors are kept safer against the budget overruns in their projects.

As another method, other projects which have significant deviations from planned budgets and schedule can be searched. The findings can be analyzed to figure out the root causes. This can result in a more comprehensive conclusion and highlight other reasons for these deviations.

As a further study, it can be recommended that the databases of the government authorities are opened to the researcher’s use. By this way the actual cases can be analyzed which showed similar consequences for the schedule delays. Then the identified projects can be checked one by one. For this, the investors of each project needs to be found out and a certain questionnaire can be used to get more information from them. The results obtained from these questionnaires should be analyzed carefully. And then the causes of the delays are expected to show how the investment costs were impacted. The findings can be categorized for each reason for delay; such as geology, management, unexpected conditions, etc. After this, the ones related with the structure of the feasibility reports can be checked and discussed. This data can also be used to optimize the related permitting and legal structures.

According to the findings of this study; it is also recommended that the purpose, content, scheduling and detail level of the feasibility reports are re evaluated by DSI and revised in order to prevent the losses because of the proceeding of the licensing process. This is believed to be much more favorable both for the investors to have a sound investment plan, and for the government for the usage of the natural resources in a much efficient way.

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