INVESTMENT DECISION MAKING IN RENEWABLE ENERGY INVESTMENTS

by

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ABSTRACT

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Energy sector plays an important role in today's world due to the economic, social and political effects of it. By the increase of the world population and gross domestic product, energy consumption of the world has increased significantly. Although, conventional fossil fuelled power plants are still dominating the energy generation of the world, there is a considerable increase in the renewable energy investments. Main objective of this study is to identify and prioritize the critical criteria that shape the renewable energy investment decision making process. In the scope of this study, firstly development of the energy sector is summarized. Afterwards, main criteria which affect the investment decisions of the investors on renewable energy are given based on an extensive literature survey and investigation of sector practice. Those criteria are categorized under three main groups as technical, economic, and environmental and social. Then, with the support of experienced expert team, interrelations and relative importance rates of them are calculated. Finally, by using the Super Decisions software and applying analytic network process method, importance weights of all criteria on investment decisions of renewable energy are calculated. Based on the findings of this research, economic criteria such as policies and regulations, availability of funds and investment cost are found to be the most significant factors in the decision process of renewable energy investments. Moreover, reliability of the suggested model is tested and found to be sufficient. Consequently, in order to develop successful renewable energy investments, investors should assess the competencies of their investments regarding those three factors. Additionally, governments should shape their policies and incentives in line with the needs of renewable energy investments in order to increase the usage of renewable energy.

ÖZET

YENİLENEBİLİR ENERJİ YATIRIMLARINDA KARAR ALMA

Enerji sektörü, ekonomik, sosyal ve politik boyutları düşünüldüğünde günümüz dünyasında önemli bir rol oynamaktadır. Dünya nüfusunun artması ve gayri safi milli hasılasının artması dünyadaki enerji tüketimini önemli ölçüde artırmıştır. Her ne kadar fosil yakıt tüketen santraller hala dünyadaki enerji üretiminin çoğunluğunu oluştursa da yenilenebilir enerji yatırımlarında kayda değer bir artış görülmektedir. Bu çalışmanın temel amacı, yenilenebilir enerji yatırımlarındaki karar alma süreçlerini şekillendiren faktörleri belirlemek ve bunları önceliklendirmektir. Bu kapsamda, ilk olarak enerji sektörünün gelişimi özetlenmektedir. Daha sonra, kapsamlı bir literatür taraması ve sektör uygulamalarının incelenmesi sonucunda, yatırımcıların yenilenebilir enerji yatırımlarına ilişkin yatırım kararlarını etkileyen ana kriterler ortaya konulmaktadır. Bu kriterler; teknolojik, ekonomik, ve çevresel ve sosyal olmak üzere üç ana grupta toplanmıştır. Deneyimli sektör uzmanlarından oluşan bir ekibin katkılarıyla bu kriterler arasındaki ilişkiler ve göreli önem dereceleri belirtilmektedir. Son olarak, Super Decisions yazılımı ve analitik ağ süreci metodu uygulanarak yenilenebilir enerji yatırımlarına ilişkin kriterlerin göreli önem dereceleri hesaplanmaktadır. Araştırmanın sonuçlarına göre, politika ve regülasyonalar, maddi kaynakların erişilebilirliği ve yatırım tutarı, yenilenebilir enerji yatırımlarındaki en önemli unsurlar olarak göze çarpmaktadır. Bunlara ek olarak, önerilen modelin güvenilirliği test edilmiş olup, elde edilen sonuçlar doğrultusunda yeterli bulunmuştur. Sonuç olarak, başarılı yenilenebilir enerji yatırımları geliştirebilmek için yatırımcılar, planladıkları yatırımların bu kriterlerin gereklerini sağladığından emin olmalıdır. Ayrıca, yenilenebilir enerji kullanımını artırmak için, hükümetler politikalarını ve teşvik mekanizmalarını yenilenebilir enerji yatırımlarının gereklerine paralel olarak şekillendirmelidir.

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LIST OF ACRONYMS / ABBREVIATIONS

ANP	Analytic Network Process
AHP	Analytic Hierarchy Process
CFO	Chief Financial Officer
DSI	State Hydraulic Works of Turkey
EIA	Environmental Impact Assessment
ELECTRE	Elimination and Choice Translating
EP	Equator Principles
EPO	European Patent Office
FIT	Feed-in Tariff
GDP	Gross Domestic Product
GPP	Geothermal Power Plant
GW	Gigawatts
HPP	Hydroelectric Power Plant
IFC	International Finance Corporation
IRR	Internal Rate of Return
KWh	Kilowatt hours
MCDA	Multi Criteria Decision Analysis
MCDM	Multi Criteria Decision Making
NPV	Net Present Value
O&M	Operation and Maintenance
OECD	Organisation for Economic Co-operation and Development
PPP	Purchasing Power Parity
RAHP-MAHP	Revised (Multiplicative) AHP
R&D	Research and Development

RE	Renewable Energy
ROE	Return on Equity
SPP	Solar Power Plant
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution
TPES	Total Primary Energy Supply
TPP	Thermal Power Plant
WPM	Weight Product Model
WPP	Wind Power Plant
WSM	Weight Sum Model

1. INTRODUCTION

1.1. Background of the Study

Energy plays a key role in today's world due to its economic and socio-political effects. In the last decade, the trend of energy sector have shifted to renewable energy (RE) investments. This pattern could be explained by the negative effects of mostly used traditional fossil fuel consuming power plants. Climate change and air pollution are some of the major ones (Wang *et al*., 2009). Additionally, fossil fuels are finite energy sources which means that those sources will last one day in the future. Due to the fact that, majority of the energy supply in the world is generated by fossil fuel driven technologies, potential problems in terms of secure energy generation is inevitable (Wüstenhagen and Menichetti, 2012). As a consequence of all those reasons, agendas of most of the governments are filled with RE investments.

Energy sector contains participants from several disciplines such as investors, public authorities and financial institutions. Private sector investors are the most critical players among those. In order to increase the RE investments, main investment decision criteria should be identified and their priorities should be analyzed in detail. There are lots of academic and sectoral researches focusing on this subject. By benefiting from current literature and sector professionals, this study is offering a wide range of criteria that affect investment decisions of investors in RE. Moreover, priorities of those criteria is discussed with sector participants for a more accurate analysis.

1.2. Problem Statement

A large variety of stakeholders should participate in coordination in order to realize a successful RE investment. As the main component of this equation, investors are the ones who must examine complex conditions before investing in a RE project. Besides, public authorities, lenders and technical experts have also particular decision methodologies.

If successful RE investments are aimed, one should clearly be aware of every single component that is related to the investment and be able to analyze the pros and cons of each alternatives.

In the literature, there numerous respectable studies which identifies the main criteria for deciding to invest in RE projects. On the other hand, only a few of those studies are focusing on real sector experts' experiences from a comprehensive perspective. In other words, most of the studies in the literature are either relying on past studies or an expert group of with restricted specialties such as just academicians or just real sector participants. As a consequence of that those works are reflecting only a certain class of people's view. However, as mentioned earlier, RE investments requires experts from various discipline and institutions.

The most significant feature of this research is the support of energy sector participant group which includes foreign and local investors, lenders, technical consultants and former public officers. In this study, a detailed criteria analysis that affects investment decisions are done and importance of those factors are specified according to the judgement of experts.

1.3. Purpose of Research

The main aim of this research is to clarify the main criteria from a holistic point of view that have role on RE investment decisions and determine the priorities of those criteria by obtaining views of sector participants with different backgrounds.

Analytic network process (ANP) method is applied to identify the relations between the criteria and to review the judgements of respondents.

In order to reach the main aim, the following objectives are targeted to meet:

- To identify the main factors and sub-factors of RE investment decision making processes.

- To obtain the interdependencies among those categories.
- To determine the priorities and importance weights of those factors with respect to the investment decision.
- To decide on the most important factors affecting RE investments.

1.4. Literature Study

Investment decision criteria of RE and their judgement methods have been a subject to various research studies. Kahraman *et al*. (2009) suggested a fuzzy decision making approach to select the most suitable RE alternative in Turkey in terms of energy source. In the study of Afgan and Carvalho (2002), criteria for new RE technologies considering sustainability indicators are discussed. Aslani *et al.* (2012) focuses on the most important factors in order to improve the private sector investments in RE investments in the Middle East by using analytic hierarchy method (AHP). According to their findings, policies of governments, conditions of consumption markets and engineering efficiency are the most significant factors. Wang *et al*. (2009) investigated the sustainable energy decision making process by focusing on different multi criteria decision analyses (MCDA) methods such as weighted sum method, AHP and technique for order preference by similarity to ideal solution (TOPSIS) method. Kaya and Kahraman (2010) used a combined VIKOR and AHP method to determine the best RE alternative for Istanbul. They also suggested the best site to develop this type of project in Istanbul. Considering the outcomes of their study, the best RE alternative for Istanbul is wind energy and Çatalca is the most suitable area to develop a wind energy project. In the study of Cavallaro and Ciaolo (2005), feasibility of some wind turbines in a selected site on Salina Island is analyzed. Four different wind turbine formations were offered and the best alternative was chosen according to the selected criteria by using multi criteria analysis.

1.5. Methodology of Research

In order to identify the investment decision dynamics in the RE sector and to reach the objectives stated above, at the very beginning a comprehensive literature survey was performed. This process brought two important outcomes. First of all, it gave a chance to know about the main criteria in detail that are being considered by the sector participants before entering into a RE investment. Secondly, several decision making methodologies were obtained during the literature review which gave the idea of using a proper MCDA method to measure the importance rates of those criteria.

Having the pre knowledge on main criteria of RE investments, a detailed analysis of those led to a more precise criteria list. After the literature review over forty criteria were obtained under four main categories. Those criteria and factors were reviewed one by one and the list was reduced to three main categories with twenty three criteria underneath. Frequency of usage of those factors in the literature, comments of sector experts and real sector dynamics were the main components of this simplifying process. Hence, more to the point and striking list was obtained.

Due to the fact that obtaining the priorities of criteria of RE investments is the ultimate idea, MCDA methods mentioned in the literature were reviewed to choose a suitable technique. It was observed that AHP and ANP are the most commonly used methods for obtaining the weights of factors in RE investment decisions. Considering the context of those methods which will be explained in further sections, interdependency status of the obtained factors analyzed to choose the one of those approaches. By personal knowledge of myself and review of sector participants, it was confirmed that some of the criteria are linked to each other. Hence, ANP was the right choice to proceed. As stated, reasons of that will be mentioned for further knowledge in the structure of this study.

The next step was determining the relative importance rates of criteria on each other which have interdependencies. Reviews of experts was the key factor to do that. Comments of experts on each pairwise comparison matrices were obtained. In the further step, using the software called Super Decisions, priorities and importance weights were calculated. Finally, outcomes of the software were studied and suggestions for further researches and energy sector were underlined.

1.6. Organization of the Thesis

The structure of the thesis is formed in five main chapters excluding this introductory section. In the second chapter, a general review on the energy sector and its effects, usage of RE based power plants and approach of government’s policies on the development of RE investments are investigated. Chapter three is consisting of the detailed explanation of the criteria affecting the RE investments. Additionally, methods used to reduce the criteria number is discussed in that section. Research methodology is explained in the fourth chapter containing all the steps followed including but not limited to multi criteria decision making (MCDM) methodology selection and software applications. Discussion on the findings and comparison to the literature is given in the fifth chapter. Summary of the thesis and further suggestions are supplied in the final chapter.

2. FUTURE OF THE ENERGY SECTOR: RENEWABLE ENERGY

2.1. Development of the Energy Sector

Considering the wide range of its influence power including socio-economic and political aspects, it could be stated that energy is one of the most vital agenda topics for almost all governments. Internal and external policies of nations' are majorly shaped by energy strategies and goals.

Significance and usage of energy has increased throughout the history. In order to understand the reasons of that rise, it would be helpful to start with the main indicators behind it. Main drivers of the growth in energy are population growth and economic development in the world (World Energy Council, 2014). Development of energy sector and investments are related to the demand rate. Since both population and economic growth have positive effects on energy demand, those factors forced energy investments in a positive way.

It would be proper to start with population. World population from the year of 900 to 2014 is given in Figure 2.1 below.

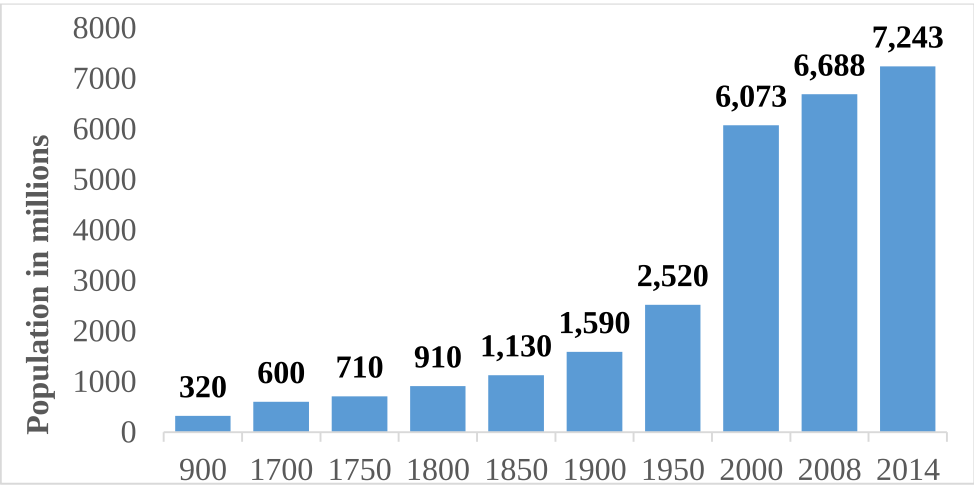

Figure 2.1 World Population in the Years 900-2014 (World Energy Council, 2014)

When the figure is examined it is seen that during the 1000 years between the years of 900 and 1900, the annual growth rate of population is only 0.16%. However, from the beginning of the 20th century, population of world increased dramatically. Population increased by approximately 5.7 billion within only 114 years from 1900 to 2014. This rise corresponds to 1.34% of annual growth rate.

In addition to the population effect, economic development should also be inspected. Gross domestic product (GDP) rates are one of the most considerable pointers of the level of economic growth. In Table 2.1, growth of GDP by regions from 1971 to 2011 is shown. The huge margin between the developed Organisation for Economic Co-operation and Development (OECD) member countries and less developed non-OECD countries is clearly seen. Although, GDP growth of non-OECD countries showed a better performance than OECD countries, when the effects of China and Asia is removed, the actual situation could be seen. On the other hand, one can easily state that there is a significant growth in GDP of the world from 1971 to 2011 which is 258% in terms of Purchasing Power Parities (PPP).

Table 2.1. Growth of GDP by World Regions 1971-2011 (World Energy Council, 2014)

Regions	**GDP by PPP (billion USD 2000)**		**1971= 100%**
	1971	**2011**	
A. OECD			
North America	4,492	14,325	319
Europe	5,300	13,495	255
Pacific	1,676	5,727	342
Total OECD	11,467	33,547	293
B. Non-OECD			
Africa	771	2,490	323
Latin America	1,152	3,897	338
Asia	1,253	7,743	618
China	471	9,103	1,933
Europe	175	519	297
Former USSR	1,666	2,725	164
Middle East	446	2,203	494
Total Non-OECD	5,934	28,680	483
C. World	17,401	62,227	358

The most critical triggering factors behind the increase in energy production is explained until know. Hence, it would be proper to see the results of those factors on energy consumption. In Table 2.2, values of population, primary energy production and production per capita is listed from 1860 to 2011. It is seen that population boost reflected to the primary energy production during the given period. Additionally, when the production per capita rates are considered, we could claim that energy production went up in an exponential way with respect to the population. If we add the effect of economic growth of the world throughout the history as explained before in terms of GDP, that huge rise in the energy production will seem more understandable.

Table 2.2. Growth of World Population and of Energy Production 1860-2011 (World Energy Council, 2014)

Years	**Population (million)**	**Primary Energy Production (Mtoe)**	**Production per capita (toe)**
1860	1,200	330	0.27
1913	1,721	900	0.52
1937	2,134	1,380	0.64
1950	2,513	1,850	0.74
1960	3,027	3,135	1.04
1970	3,678	4,816	1.30
1980	4,438	7,315	1.65
1990	5,252	8,795	1.68
2000	6,073	9,990	1.64
2008	6,536	12,369	1.89
2011	6,958	13,202	1.90

Interrelation between energy consumption and prosperity of countries' is undeniable and this fact reflects to the numbers as mentioned in prior parts of this section. Hence, it is claimed that energy plays an important role on a country's development and prosperity (Koç and Şenel, 2013). As a consequence of that one would expect developed countries which have higher GDP rates to produce and consume much more energy than the developing countries. In order to test that claim per capita electricity consumption ratios might help us. It is stated that per capita electricity consumption is one of the most important signs of the development level of a country in terms of social and economic aspects (Koç and Şenel, 2013). Electricity consumption per capita figures are given in Table 2.3. When the figures are considered the difference between OECD and non OECD countries are obvious. According to the values of 2011, electricity consumption per capita of OECD countries is more than 4.5 times higher than the figure of non OECD countries.

Table 2.3. Countries with High and Low Figures of Electricity Consumption per capita 1970/71-2011 [kWh] (World Energy Council, 2014)

OECD countries	**1970**	**2011**	**Non-OECD countries**	**1971**	**2011**
Australia	-	10,514	Angola	89	256
Austria	3,019	8,359	Benin	11	95
Belgium	3,041	8,072	Cameroon	145	270
Canada	8,962	16,406	Congo	157	99
Czech Republic	-	6,288	Ivory Coast	93	204
Denmark	2,888	6,124	Eritrea	-	53
Iceland	6,485	52,376	Ethiopia	17	55
Finland	4,571	15,742	Kenya	78	157
France	2,629	7,318	Nigeria	30	151
Germany	3,857	7,083	Senegal	71	195
Greece	1,006	5,292	Sudan	25	150
Ireland	1,755	5,701	Tanzania	30	92
Italy	2,073	5393	Togo	63	117
Japan	3,261	7,847	Bolivia	176	638
Korea (Rep.)	-	10,162	Guatemala	120	537
Luxembourg	10,655	15,511	Haiti	12	32
Netherlands	2,950	7,036	Nicaragua	244	525
New Zealand	4,257	9,378	Bangladesh	10	263
Norway	13,450	23,174	Cambodia	-	168
Poland	1,815	3,833	Burma	20	119
Spain	1,407	5,604	Nepal	6	94
Sweden	7,916	14,029	India	99	673
Switzerland	4,247	7,972	Pakistan	89	448
United Kingdom	4,169	5,518	Phillippines	231	648
USA	7,235	13,227	Yemen	32	182
OECD average	4,012	8,223	Non-OECD average	450	1,785

Energy intensity is another sign of a developed country which has a stable and mature energy market. It could be defined as the ratio of energy consumption of a country to the total GDP of that country (World Energy Council, 2014). Furthermore, energy intensity could be treated as indicator of energy efficiency of a particular country. Therefore, energy intensity of developed countries with efficient infrastructure and technology and also a stable market is expected to be lower when compared to the other type of countries. On the other hand, it should be noted that energy intensity might also depends on the climate and economic formations of countries. Hence, only energy intensity itself is not a measure of total energy efficiency of a country. Energy intensity figures of OECD and non OECD countries are given in Table 2.4. It is seen that total energy intensity rate of non OECD countries are 63% higher than the amount of OECD countries.

Table 2.4. Indicators of the Energy Intensity of GDP 1980-2011 (toe/1000 USD 200) (World Energy Council, 2014)

Regions	**Indicators related to GDP calculated by PPP**	
	1980	**2011**
A. OECD		
North America	0.34	0.18
Europe	0.22	0.14
Pacific	0.19	0.16
Total OECD	0.26	0.16
B. Non-OECD		
Africa	0.26	0.28
Latin America	0.16	0.15
Asia	0.25	0.20
China	0.74	0.31
Europe	0.40	0.19
Former USSR	0.45	0.40
Middle East	0.17	0.29
Total Non-OECD	0.33	0.26
C. World	0.29	0.21

2.2. Resources for Energy Generation and Their Usage

From a general point of view, energy resources could be grouped as renewable and non-renewable. While renewable energy resources are sustainable and might be considered as infinite to a certain level, non-renewable sources are finite and expected to become extinct in a certain time period (Koç and Şenel, 2013). Fossil fuels which are categorized under non-renewable energy sources are the most commonly used inputs for energy generation in spite of their restricted reserves. In addition to the limitation of reserves, fossil fuels have huge negative effects on the environment mostly by high level of CO_2 emissions.

In Figure 2.2, Total Primary Energy Supply (TPES) of the world depending on the fuel type for the year of 2014 is given. It is clearly seen that oil, coal and natural gas which are the members of fossil fuels dominated the primary energy supply in 2014 with a total sum of 81%. However, environment friendly and sustainable RE sources constitute less than 15% of primary energy supply in 2014

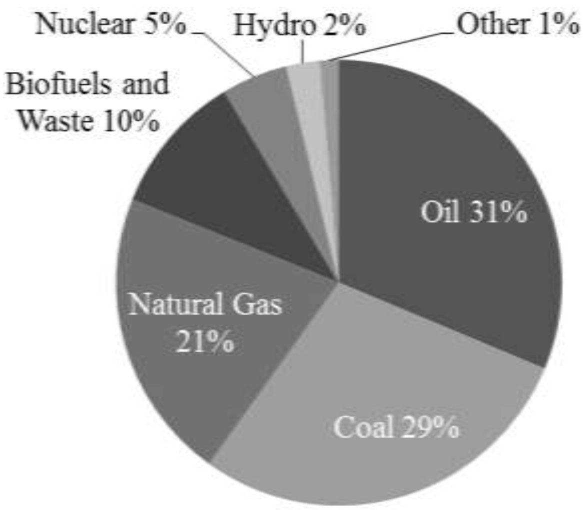

Figure 2.2. 2014 Fuel Shares of TPES (International Energy Agency, 2016)

Figure 2.3 shows the breakdown of electricity generation by fuel type in 2014. When the figures are considered, it is obvious that domination of fossil fuels in primary energy supply reflects to the energy generation as expected. Two third of the generated electricity is supplied by fossil fuels.

As explained, due to the environmental effects and finite available reserves, relying on fossil fuels is not a feasible strategy for both security of supply and environment. This is an undeniable fact and sector participants including the governments have understood and started to reshape their strategies in order to increase the RE share in total energy supply. With the help of technological developments in the field of RE and also concerns of climate change, RE investments will be accelerated (World Energy Council, 2014).

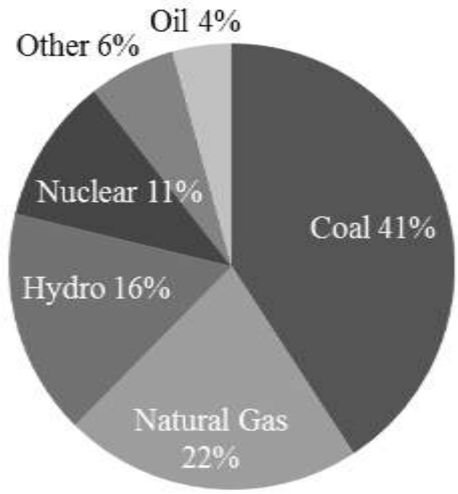

Figure 2.3. 2014 Fuel Shares of Electricity Generation (International Energy Agency, 2016)

The rise in RE investments could be seen from the figures of recent years. RE investments not including the large hydro projects are constituting 53.6% of the new installed power generation capacity of 2015 (McCrone *et al*., 2016). Figure 2.4 shows the share of RE in global power capacity and generation and also change of RE capacity from 2007 to 2015. It is seen from the graph that 2015 is the first year which capacity additions of RE exceeds 50% of all capacity additions globally. As a result of the increase in new capacity additions of RE, share of RE in global power capacity and generation also goes up. The generation percentage of 10.3% in 2015 means that emission of 1.5 billion tonnes equivalent CO_2 was prevented by the energy generated by RE sources (McCrone *et al*., 2016). In spite of the developments of new RE investments, total share of renewables is still a minority regarding the total global installed capacity and relatedly generation.

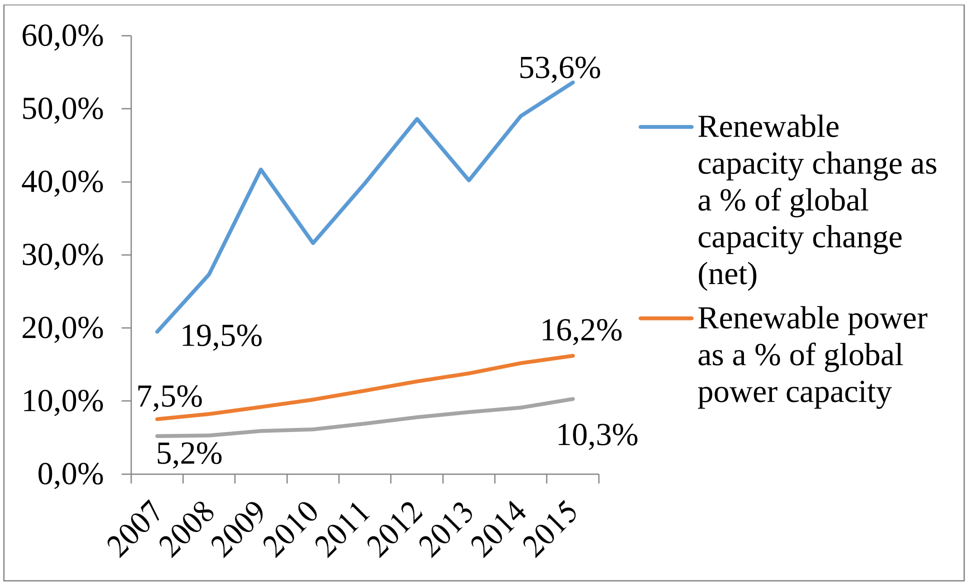

Figure 2.4. Renewable Energy Generation and Capacity as a Share of Global Power, (McCrone *et al*., 2016)

In Figure 2.5, breakdown of new capacity additions in 2015 could be seen. As mentioned, renewables excluding large scaled hydro power plants is forming 53% of the total additions. Wind Power Plants (WPP) is comprising 62 gigawatt (GW) of those renewable investments while Solar Power Plants (SPP) have a share of 56 GW. On the other hand, it is seen that interest on the fossil fuels is still progressing. 33% of the investments of 2015 realized for fossil fuels. This amount is significant if it is considered that total of coal and natural gas investments equal to 82 GW is the net increase amount. In other words, installed capacity of the power plants which got closed in 2015 has already been taken into account when preparing this data. Hence, it is clear that the new investments of fossil fuel based power plants have an installed capacity of more than 82 GW which is a concern for the climate (McCrone *et al*., 2016).

Investment amounts of last year in terms of fuel types confirms the increase of interest of RE investments. Investment budget allocated to RE investments is equal to USD 265 billion. On the other hand, that amount has realized as USD 130 billion for coal and natural gas investments in total (McCrone *et al*., 2016).

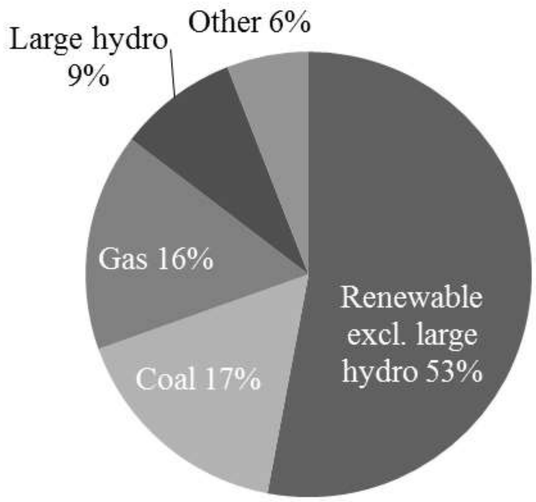

Figure 2.5. Net Power Generating Capacity Added in 2015 by Main Technology, GW (McCrone *et al*., 2016)

It is seen that focus of the energy sector investment is shifting from traditional fossil fuel consuming power plants to renewables which is a must for a more sustainable future. At this point, it would be proper to mention about an important concept in energy generation which is called balancing. Amount of RE resources are sometimes difficult to be estimated beforehand. In other words, since availability of sources like wind and solar light couldn't be predicted by 100% for every single moment, we cannot foresee the generation amount from those sources all the time. Consequently, a balancing mechanism should be formed to cover that gap. In terms of satisfying the electricity demand and preventing black outs, balancing plays a critical role. There are several ways of structuring a healthy balancing mechanism such as using interconnectors to convey the excessive electricity from one point to the point that electricity demand is not satisfied, managing the demand and supply according to the instant needs and using conventional natural gas and coal power plants as a tool for supply deficits (McCrone *et al*., 2016). Thermal power plants (TPP) which includes coal and natural gas consuming power plants, have the ability to produce electricity whenever needed in some certain time periods. Therefore, those fossil fuel based power plants are necessary for balancing proposes. Nevertheless, it does not mean that fossil fuel investments should be increased. Diversity of energy sources is helpful to form a good working energy generation mechanism. As a consequence of that both renewable and non-renewable energy sources are necessary in different aspects. However, considering all those environmental and economic reasons, capacity and new investments of fossil fuel based projects should be controlled and limited carefully considering each countries’ demand, technological and economic conditions.

In this section, energy generation by fuel types are discussed. We see that although the fossil fuels are still the main indicators of generation, share of renewable sources is improving. Main reasons behind this developments in RE investments will be explained in the next section.

2.3. Rise of the Renewable Energy Investments

Before starting to discuss the trends about the RE investments, RE sources especially in terms of electricity generation will be explained briefly. Electricity generation by RE sources means using the natural sources which are regenerated on a time period such as wind, sunlight, rain, geothermal sources, biomasses to produce electricity. WPPs use the wind power, hydroelectric power plants (HPPs) benefit from flow of the rivers, SPPs collect sunlight as input, geothermal power plants (GPP) takes the advantage of core of earth’s heat and bio energy power plants use bio wastes or gases in order to generate electricity. Those are the main RE power plants that are used to generate electricity all around the world. There are some other RE sources for electricity generation such as tidal power and wave power. However, those are not commonly applicable for electricity production at the moment.

As explained in the previous section, there is a significant increase in the usage of RE sources in the energy sector. In order to sustain and further improve those developments, reasons that excites the attention of investors should be understood clearly.

First of all, environmental awareness has increased all around the world. Although, current energy supply structure of the globe is still quite risky in terms of sustainable development, the situation was worse in the past. Those risks could be associated with several aspects such as global warming, damages in the ozone, high emission rates and acid precipitation (Dinçer, 2000). Lots of academic articles, publications of public and private institutions and governments have lead the process of awareness increase especially in the last decade. Additionally, reminders of probable danger causing from fossil based energy generation has been implied in media channels. As a consequence of that, starting from individuals to sector players, the message has been taken or at least the importance of the issue has been started to recognize.

Secondly, there are tremendous technological development in the field of RE technologies. Although, environmental concerns may seem enough to people, investments can't be developed without sufficient benefit. In other words, such RE investments wouldn't have realized unless particular financial returns were able to be obtained. Since it is a fact that generally, unit RE investment cost is higher than conventional methods, technological developments are inevitable for RE investments to become more feasible. In recent years, numerous studies and budget have been allocated to RE technologies. As a result of that, considerable improvements in efficiency, investment cost including initial and operation and maintenance (O&M) costs and reliability has been reached (Dinçer, 2000). With the aim of improving the existing level of RE technologies, research and development (R&D) works have been accelerated. Besides, technological innovation has been motivated by both public and private institutions. As a consequence of those R&D investments, total numbers of patent applications increased significantly (Johnstone *et al.*, 2009). In Figure 2.6, quantity of patent applications to European Patent Office (EPO) from 1979 to 2003 is given. It is worth to note that due to the limited number of applications when compared to the others, geothermal, ocean and biomass figures are given in the right axis. According to the figure, it is observed that total number of applications has increased dramatically over the years. As expected, applications related to solar and wind energy are the leading figures in terms of patent applications. Furthermore, there is an increase in ocean technology applications especially starting from 1995. By the contribution of developments in the R&D field, costs of RE technologies become more compatible versus fossil fuel based technologies when compared to the past especially in the field of solar energy.

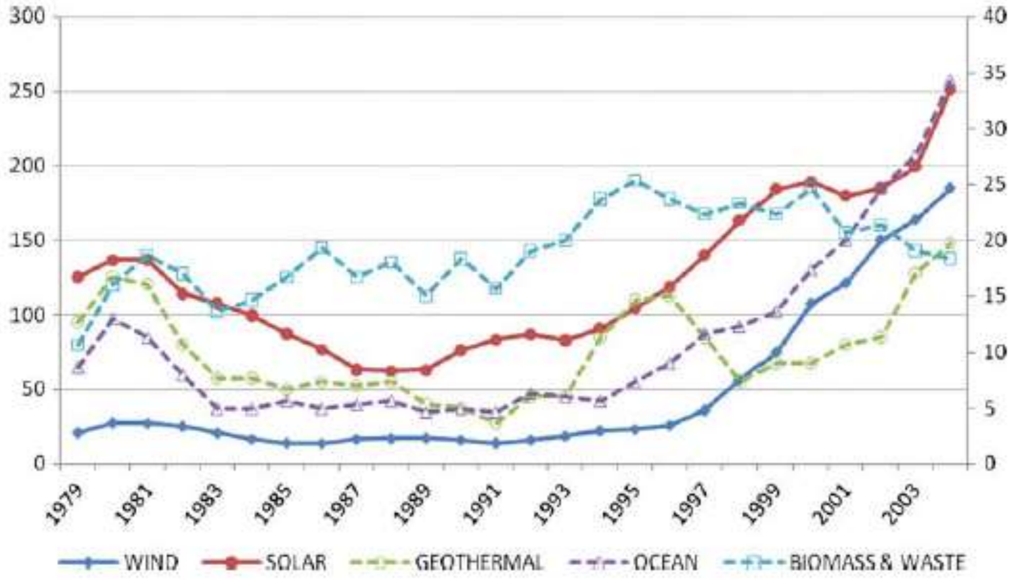

Figure 2.6. Number of EPO Patent Applications for Renewables (Johnstone *et al.*, 2009)

Up to now, awareness about the environmental risks and technological developing resulting with reduce of investments costs of RE investments are underlined. There is a factor that effects both indicators mentioned above and also further the sales prices for RE projects which is government policies. Without the incentives of governments about RE investments, those progress figures wouldn't be reached for sure. Hence, types of those policies should be understood in detail. There are several type of incentives supported by government policies for accelerating the investments in RE area. Those incentives may differ according to numerous reasons such as the internal conditions of the markets, aims after those incentives, economic conditions of the countries and status of the investors. However, there are some certain policies which applied all around the world. Support of R&D investments as explained, investment incentives such as low interest guarantees, tax incentives such as accelerated depreciation opportunities, tariff incentives like feed-in tariffs (FITs) and tradable certificates are some example for those policies (Johnstone *et al.*, 2009). Although, all of those applications have some certain effects on the RE investments, it is widely accepted that FITs are the most effective tool of governmental policies to support RE development. In order to understand the effects of those policies some of them will be explained.

In general, FITs are granted price incentives supplied by governments to RE operators in order to increase the RE investments. First of all, FITs could be categorized in two main groups as market independent and market dependent (Couture and Gagnon, 2010). In the market independent FITs, cost of electricity sale of the project owners is independent from the electricity market conditions. There are several applied models of market independent FITs. For instance, fixed price model is the most widely used one all around the world and also in Turkey. In this model, a guaranteed purchase price is granted to the investors for a certain period of time, for instance this period is restricted with 10 years in Turkey. Hence, for that given period, investors sell their produced electricity without having a concern on the market prices with their guaranteed prices. Those guaranteed prices may differ for each type of RE sources. For example, generally guaranteed price for solar energy is higher than wind energy because of its higher costs. In order to understand the effect of fixed price model, Turkish electricity market could be a proper example. In 2015, average electricity prices in the spot market was USD 5.1 cent per kilowatt hours (KWh) while WPPs sold their electricity for USD 7.3 cent per KWh thanks to the FIT mechanism. In addition to the fixed price model, there are some other methods of market independent FITs such as fixed price with inflation adjustments, front loaded model and spot market gap model (Couture and Gagnon, 2010). Although, each model have certain differences, main aim of all of them are supplying a guaranteed price independent from the spot market. The other group of FITs are categorized as market dependent as explained previously. Market dependent policies could be defined as policies in which a certain premium over the spot market prices is granted (Couture and Gagnon, 2010). Constant premium price and variable premium price models are the most commonly used market dependent FIT mechanisms. In the first one, a constant premium over the market price is guaranteed. However, in the second one that guaranteed premium is limited by cap and floor mechanisms. In the first case, the project owner always gets the granted amount over the market price. On the other hand, in the variable premium mechanism, certain maximum and minimum levels are given and the premium received by the owner, will be within that price corridor all the time.

As seen, there are many applicable FIT models and each of them have positive and negative part when compared to the other. Hence, it could be claimed that there is no only one correct FIT solution valid for every market. In order to form a helpful FIT mechanism, all sector participants such as private investors, public authorities, academicians and lenders should come together and analyze the conditions of the market and identify its needs. Afterwards, necessary FIT policies should be designed as a tailor made basis to fulfil the gap in the market.

In this second section of the study, development of the energy sector throughout the years, current situation of the sector in terms of resources and finally the reasons of RE movement are discussed. Remaining parts of this work will concentrate on the process to meet the objectives of the study which is obtaining the most important factors of RE investment decision phase and their priorities.

3. INVESTMENT CRITERIA OF RENEWABLE ENERGY

Importance of RE has been acknowledged by governments. Consequently, investments are supported by governments with several policies which were mentioned in the prior sections. With the help of those supports and environmental awareness, quantity of RE investments have increased. By the further development in technology, pace of those projects have been accelerated. Although, those results form a positive picture for RE investments, it should be admitted that RE investment process requires investors and other participants to consider many factors in order to develop a successful RE project. Those factors must be understood in detail and reviewed before triggering an investment to prevent financial problems and even bankruptcy. Hence, in this part of the study, most commonly used consideration criteria of RE investments will be given after giving some brief information about the RE sector participants.

3.1. Renewable Energy Investment Environment

First of all, it is evident that investment decisions and related criteria does not only depend on the investor itself. RE investments require participants from different disciplines to come together such as public authorities, lenders, technology suppliers and consultants. For instance, as stated before public policies and regulations are one of the most important factors affecting the RE investments. Hence, those investments must be realized in coordination with the public authorities starting from the planning phase. Considering the fact that certain regulations and legal steps should be made to finalize an investment in the RE sector, without communicating with the public institutions may cause serious problems in the investment phase of the project. Lenders are another important part of the RE investments. Due to the fact that equity power of the investors may not be sufficient to fulfil the investment cost of the RE projects itself, support of the creditors is inevitable. Besides, even the investor have the sufficient equity, it will not be feasible to develop a RE project with 100% equity because of the fact that it will prevent the investor to develop new projects since it has already allocated a major part of its equity to one single project. Therefore, investments must be bankable and this fact requires investors to satisfy the lending criteria of the borrowers. Technology suppliers are another significant component of the RE investments. If a WPP is considered, naturally, most critical part is the wind turbine both in technical and economic ways. Selection of a proper turbine model is vital for such a WPP investment. As a consequence of that efficient coordination between the turbine supplier and the investor is quite important for the outcomes of the project. Furthermore, turbine supplier and model are significant factors for the lenders when considering a loan request in WPPs. Moreover, technical, and environmental and social consultant firms are also worth mentioning. Technical consultants assist investors in almost all phases of an investment containing planning, implementation and operation phases in terms of technical aspects such as technical feasibility, equipment selection and construction planning. Similarly, environmental and social consultants act as the advisors of investors on environmental and social matters such as environmental risk analysis and expropriation plan. Additionally, those consultants are also required by the lenders before granting loans. In other words, both local and international lenders request their borrowers to assign independent technical, and environmental and social consultants during the due diligence phase. Reports of those consultants play a critical role on the credit committee decisions of the lenders. Relationship among those stakeholder are summarized in Figure 3.1.

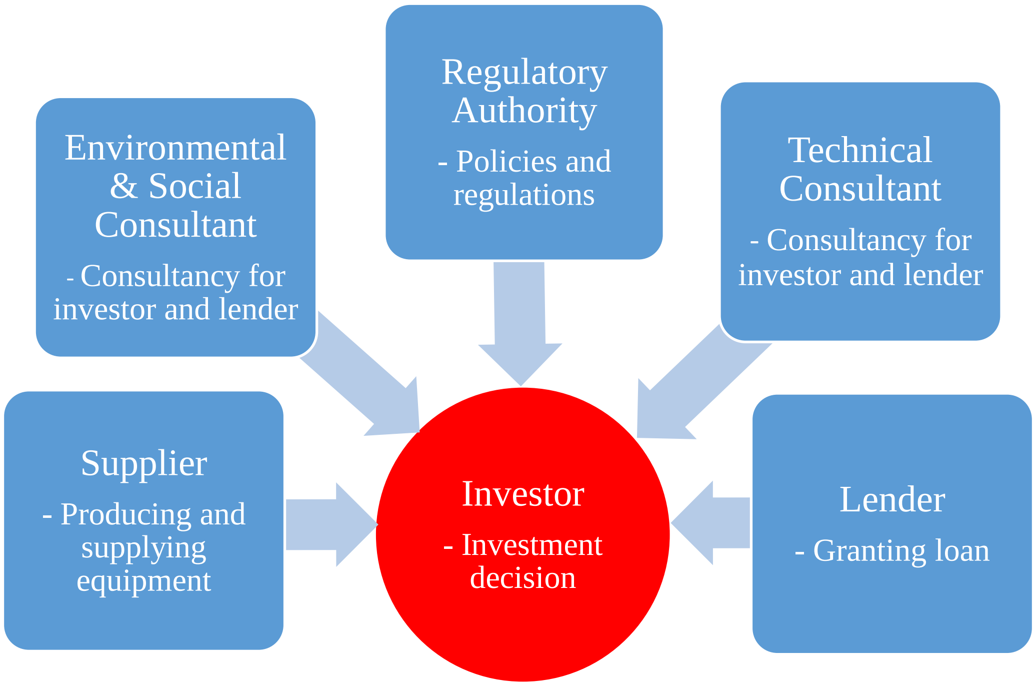

Figure 3.1. Relationship of Stakeholders Affecting Investment Decision of the Investor

It is understood that in order to plan, develop and operate an investable RE project requires several stakeholders coming from different disciplines to act as a team. Efficient coordination between those parties is the key for the project success. It could be claimed that when assessing the RE investment criteria, investors must take into account the expectations of those participants.

In the following part of the study, criteria that affects the RE investments will be given in detail.

3.2. Investment Decision Criteria of Renewable Energy

Investment decision criteria of RE investments were investigated by several researchers in the academic world. Wang *et al.* (2009) conducted a literature review in order to form a criteria shortlist for their study on multi-criteria decision analysis on sustainable energy decision making process. In their study, criteria that affects those investments were grouped under four main categories as technical, economic, environmental and social. Related sub criteria was listed under those main categories. Kaya and Kahraman (2010) made an analysis to find the best RE alternative in Istanbul and the optimum location within Istanbul in their research. They have used Wang's previously explained criteria categorization as a source. Cavallaro and Ciaolo (2005) worked on the feasibility of some wind turbines in Salina Island by taking into account several criteria. Kahraman *et al*. (2009) used fuzzy decision making analysis for the selection of best RE alternatives. They were focused on four main categories as in the previously explained works and concentrated on several sub categories. Aslani *et al.* (2012) investigated the criteria that investors assess when investing in RE projects in Iran. They formed their criteria list by both literature survey and investor responses. Masini and Menichetti (2012) proposed a model structure that investigates the structural and behavioural factors that affect investment decisions of the investors in RE. Wüstenhagen and Menichetti (2012) offered a framework about the RE strategic decisions. They focused on the effect of energy policies on those decisions. Cristobal (2011) realized a study for the selection of best RE project type in Spain by using VIKOR method. Haralambopoulos and Polatidis (2003) suggested a multi-criteria decision-making framework in RE projects. They further tested their suggested framework on a geothermal source located in Greece. Painuly (2001) investigated the barriers of RE energy penetration by selecting several criteria. In the study of Afgan and Carvalho (2002), multi-criteria selection of RE projects and their related criteria was investigated. Wiser and Pickle (1998) examines the financing of RE projects considering the policy effects.

After conducting an extensive literature survey, obtained criteria were reviewed in order to merge the criteria that have the same meaning and to remove some of them which are not applicable in the sector. Details of that process is explained in the upcoming section. By applying those modifications, the final criteria list was formed with 23 criteria under 3 main categories. The modified list of criteria and related sources are given in Table 3.1 below. Additionally, related stakeholders in other words parties that are directly effective on the given criteria are also shared.

Table 3.1. List of Criteria and Sources

Criteria		Source	Related Stakeholder
#	**Technical**		
1	Efficiency	Wang *et al.* (2009), Kaya and Kahraman (2010), Aslani *et al.* (2012), Afgan and Carvalho (2002)	Supplier
2	Reliability of technology	Wang *et al.* (2009), Kaya and Kahraman (2010), Kahraman *et al.* (2009)	Supplier
3	Production capacity of the plant	Wang *et al.* (2009), Cavallaro and Ciaolo (2005), Cristobal (2011)	Supplier, investor
4	Implementation and operational risk	Kahraman *et al.* (2009)	Investor
5	Local technical know-how	Kahraman *et al.* (2009), Painuly (2001)	Investor
6	Annual exploitability	Aslani *et al.* (2012)	Investor
#	**Economic**		

Table 3.1. List of Criteria and Sources (cont.)

1	Investment cost	Wang *et al.* (2009), Kaya and Kahraman (2010), Carvallaro and Ciaolo (2005), Kahraman *et al.* (2009), Cristobal (2011), Afgan and Carvalho (2002)	Investor, lender, supplier
2	Operation and maintenance cost	Wang *et al.* (2009), Kaya and Kahraman (2010), Carvallaro and Ciaolo (2005), Cristobal (2011),	Investor, lender, supplier
3	Realization time	Kahraman *et al.* (2009), Cristobal (2011),	Investor, supplier
4	Financial indicators	Wang *et al.* (2009), Kaya and Kahraman (2010)	Investor, lender
5	Service life	Wang *et al.* (2009), Kaya and Kahraman (2010), Cristobal (2011)	Investor, supplier
6	Policies and regulations	Kahraman *et al.* (2009), Aslani *et al.* (2012), Masini and Menichetti (2012), Wüstenhagen and Menichetti (2012), Painuly (2001), Wiser and Pickle (1998)	Regulatory authority
7	Risk attitude of the investors	Masini and Menichetti (2012)	Investor
8	Confidence in market	Masini and Menichetti (2012)	Investor, lender
9	Macro-economic environment	Painuly (2001)	Investor, lender
10	Availability of funds	Kahraman *et al.* (2009), Painuly (2001)	Lender
#	**Environmental and Social**		
1	Emission rates	Wang *et al.* (2009), Kaya and Kahraman (2010)	Investor, supplier
2	Land use	Wang *et al.* (2009), Kaya and Kahraman (2010), Kahraman *et al.* (2009), Afgan and Carvalho (2002)	Investor

Table 3.1. List of Criteria and Sources (cont.)

3	Noise	Wang *et al.* (2009), Kaya and Kahraman (2010), Cavallaro and Ciaolo (2005),	Investor, supplier
4	Effects on natural environment	Wang *et al.* (2009), Painuly (2001)	Investor, supplier
5	Social acceptability	Wang *et al.* (2009), Kaya and Kahraman (2010), Cavallaro and Ciaolo (2005), Kahraman *et al.* (2009), Painuly (2001)	Investor
6	Job creation	Wang *et al.* (2009), Kaya and Kahraman (2010), Kahraman *et al.* (2009), Haralambopoulos and Polatidis (2003)	Investor
7	Safety	Wang *et al.* (2009), Kaya and Kahraman (2010)	Investor

After giving the list of criteria and categories, it would be helpful to introduce those criteria one by one for further understanding.

3.2.1. Technical Aspects

Technical aspects of RE investments are quite significant since those are main indicators of the electricity production. Assessment of the technical factors should commence at the very beginning of a RE project. Criteria under the technical category directly affects the economic outcomes. As a result of that in addition to the investors, lenders are also very interested in the technical details of a RE project. Criteria under the technical category are; efficiency, reliability of technology, production capacity of the plant, implementation and operational risk, local technical know-how and annual exploitability.

<u>3.2.1.1. Efficiency</u>. It could be defined as the ratio of output energy to the input energy. In other words, efficiency shows us how much energy could be produced by using a particular energy source (Kaya and Kahraman, 2010). Energy efficiency is a key factor on determining the production rates of a RE system. With the developments in the field

of RE technologies, efficiency of RE power plants have increased recently. Due to the fact that investment cost per MW is higher in RE projects when compared to the conventional power plants, efficiency could be a key element for RE investments.

3.2.1.2. Reliability of Technology. This term refers to the stability of the technology in terms of production throughout its lifetime. Investors allocate a significant amount of fund on RE projects. Hence, it is a crucial point that the technology of the RE power plant is trustable. Energy production of the power plants is projected by the company and this is one of the most important figures in the project cash flow since the revenue of the project depends on the production rate. If there is a fluctuation on the production rates, this will affect the project cash flow negatively. Additionally, O&M performance of the project is another issue which is related to the reliability of technology. If there are too many failures in the operation phase of an investment, in addition to the production rates, O&M costs may increase accordingly. Hence, it is another component of the potential negative reflections to the cash flows. As a consequence of that, investors and also lenders look for a sufficient track record of the technology that will be used.

3.2.1.3. Production Capacity of the Plant. Production capacity or the capacity factor of the power plant underlines the electricity generation capacity of a RE project. It is related to yearly working hour of the project considering both technical and economic reasons. Since the electricity production and consequently the revenue and project cash flow is highly dependent on the capacity factor, it is a critical component of the project which should be calculated at the initiation phase of the planning period.

3.2.1.4. Implementation and Operational Risk. This term is used to determine the risk in the implementation and also operational phase of a RE project. Investments are quite fragile in the investment period. In the investment phase of a project, construction works are ongoing and debt amounts are high due to the utilized loans. As a result of that a problem in this phase may cause cost and time overruns which may stress the cash flows of the projects. For those reasons, investment phase risks of the projects must be identified clearly with both technical and its legal aspects. For instance, construction works of HPPs could be highly risks depending on the height and type of the dam, geography and topography of the location. Additionally, legal processes such as expropriation works could be problematic. Hence, implementation phase is a critical factor effecting the success of an investment. Besides, risks may occur during the operational phase when the production is started as curtailments and failures. Consequently, potential risk in both implementation and operation phases must be analysed beforehand.

3.2.1.5. Local Technical Know-How. Technical know-how is a significant determinant that is critical for the RE investments. For investors having the technical know-how in their teams will be helpful in both investment and operational phases. If there is sufficient know-how in the team, then number of technical problems will be less and in the case that a problem occurs, team could be able to take actions to recover.

3.2.1.6. Annual Exploitability. Energy generation capacity of a RE project depends on variation of availability of resources such as wind, solar power and water inflow. Stability and fluctuations of those factors must be determined in detail before investing in a RE project. In short, this term refers to the energy generation capacity of a project depending on the availability of the resources in a specific project site.

3.2.2. Economic Aspects

Economic aspects are the foundations of an investment. All investors develop a project to make profit. Since, they allocate certain amount of money and time for investing in a project, financial figures must be satisfying. Hence, all other aspects such as technical, and environmental and social stay secondary when compared to the economic outcomes. Furthermore, when confirming a loan request, a bank will firstly focus on the financial indicators of a project. Criteria under the economic category are; investment cost, operation and maintenance cost, realization time, financial indicators, service life, policies and regulations, risk attitude of the investors, confidence in the market, macro-economic and availability of funds.

3.2.2.1. Investment Cost. It contains all cost components of a RE investment to become operational. For instance, when a WPP is considered, turbine costs, construction works, electrical works, project development costs, expropriation costs and taxes are all calculated. Due to the fact that investment cost is critical for the financial outcomes, every detail of it must be calculated precisely. On top of it, investment cost is quite important for lenders when determining the required loan amount.

3.2.2.2. Operation and Maintenance Cost. Operation and maintenance cost is another crucial factor which affects the fiscal figures of an investment. A comprehensive and less costly operation and maintenance contract is beneficial for the investors. Unless the scope of the operation and maintenance services is sufficient, serious problems may occur when a problem about the turbines or other critical equipment is faced. Besides, operation and maintenance costs are one of the most important operational expenses of RE investments. Hence, an operation and maintenance contract with a high payment amount will be a burden for the project cash flow.

3.2.2.3. Realization Time. This term indicates the time necessary for a RE investment to become operational. Since, the power plant will not be able to produce electricity and generate cash without being operational, time overruns of the construction works will harm the project. As a result of that, construction schedule of the project must be prepared in detail considering some unexpected cases.

3.2.2.4. Financial Indicators. Indicators such as internal rate of return (IRR), net present value (NPV) and return on equity (ROE) are considered under this criteria. After making the initial plans and budgets, the first thing that an investor examines are the financial indicators. According to those figures, investors decide on investing in a project or not.

3.2.2.5. Service Life. Service life refers to the lifetime of a RE project. If the service life of a project is long enough, it means the time period which it will generate cash is long as well. Considering the fact that first years of the service life of a particular RE investment will be occupied by loan repayments, it could be claimed that a long lasted service life will be in the favour of the investor.

3.2.2.6. Policies and Regulations. As explained in the previous sections of this study, governmental policies are extremely effective on RE investments. When the increase of RE projects is investigated, it is seen that policies and related incentives are one of the most important determinants of that outcome. A RE investor must be aware of all the related policies and regulations before jumping into an investment. All positive and potential negative impacts of those policies must be calculated efficiently.

3.2.2.7. Risk Attitude of the Investors. Willingness for risk taking is a significant component in the RE investment decision process. Some investors look for higher risks in order to obtain higher amount of return. On the other hand, another group of investors concentrate on only the less risky investments to secure themselves. As a consequence of that the risk approach of the investors are quite critical about the investment decisions.

3.2.2.8. Confidence in Market. Similar to the risk attitude of the investors, their confidence in the market and its future is a decisive fact. If the investors recognise the market as stabile and mature their view will be more positive than investing in a fluctuating and unstable market. Besides, regulations and external intervention to a certain market are other important points that are investigated by the investors especially the foreign investors before triggering an investment.

3.2.2.9. Macro-economic Environment. Macro-economic conditions of a certain country may be effective on the single investments. Hence, macro-economic factors such as inflation rate, GDP growth rate, interest rates and employment levels might affect the RE investments. As a result of that investors examine those figures and project the situation in line with the expected project life.

3.2.2.10. Availability of Funds. As mentioned earlier, it is not feasible and also not affordable for the investors to realize an investment with 100% equity injections. Consequently, loan granted by the lenders are vital for investors. Therefore, credibility of an investment should be assessed before deciding to enter an investment. In order to that main criteria that banks are looking for must be understood clearly and investment plans should be shaped accordingly.

3.2.3. Environmental and Social Aspects

With the rise of awareness about the environmental and social issues, investors, public authorities and lenders have started to give much more importance on those aspects. Regulations of public authorities are stricter than they were in the past. Hence, obtaining the necessary environmental and social permits requires more time and funds of the investors. In addition to the local regulations, most of the lenders are looking for international environmental and social standards such as IFC standards and EP to be met in the projects which they finance. Criteria under the environmental and social category are; emission rates, land use, noise, effects on natural environment, social acceptability, job creation and safety.

3.2.3.1. Emission Rates. Considering the effects of the global climate change and greenhouse effects, emission rates and related regulations are getting tighter all the time. As a consequence of that emission rates of gases such as CO_2, NO_x, CO and SO_2 become one of the most significant criteria about the investments. Since, RE investments are generally not subject to emission issues, it may not seem as a matter of concern. However, in some cases such as GPPs emission rates must be considered.

3.2.3.2. Land Use. This term is related to the land that should be used in order to develop a RE investment. Since those projects require the usage of a considerable amount of land, type of the land becomes a matter of concern. For instance, if the land is registered as forestry land, then the necessary permits must be obtained. On the other hand, if the land is private then it should be expropriated properly in line with the international standards. Hence, investors must consider the land necessary for their investments and make their plans accordingly.

3.2.3.3. Noise. Noise could be an important issue in some cases. For instance, in WPPs noise generated by the wind turbines may create serious problems for the local people living nearby the project area. Especially in international standards such as IFC standards and EP noise effect is considered as a serious issue. Unless the turbine locations are selected considering the potential noise effect, consequences of that might be harmful such as relocation of the turbines which may cost a lot for the investors. Therefore, noise issue must be calculated when the exact turbine locations are determined.

3.2.3.4. Effects on Natural Environment. Any effect on the natural life in the environment must be considered by the investors to be in line with the standards. For instance, shadow flicker effect of wind turbines, fish passage necessities in HPPs and biodiversity requirements are some of those examples.

3.2.3.5. Social Acceptability. Investors must consider the reflections of the projects on the society. For instance, there are numerous examples about how HPPs ruined the daily life of the societies. As a consequence of that there are certain protests for those kind of effects. Therefore, social acceptability must be obtained before starting to an investment. Necessary meetings with the social entities and local people should be done in order to prevent such problems.

3.2.3.6. Job Creation. Creating employment opportunities for the local people is a must for the investors. It will also increase the acceptability level of the project in the local society. Additionally, considering that some people may be affected and lose their income channels because of the projects that are planning to be developed, international standards require the investors to supply job opportunities for those people to recover their losses. In short, investors must take into account the job creation chances of their investments.

3.2.3.7. Safety. Safety and human life must be the priority of every investment. Investors must consider the precautions for the safety issue in both construction and operational phases. Hence, necessary fund must be allocated for safety.

4. RESEARCH METHODOLOGY

After forming the list of main categories and criteria which take part in the investment decision making process of RE investments, a proper and efficient method should be applied in order to obtain priorities of those criteria.

There are 3 categorises and 23 criteria obtained in this study. Hence, first thing to do is selecting an efficient MCDM method. There are several methods are used for this purpose. Most common ones could be summarized as follows; AHP, ANP, Weight Sum Model (WSM), Weight Product Model (WPM), Elimination and Choice Translating (ELECTRE), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and Revised (Multiplicative) AHP (RAHP-MAHP) (Taslicali and Ercan, 2006). AHP and ANP two of the most frequently used methods in several sectors.

In this section, brief information about AHP and ANP and their comparison to each other will be given. After giving the reasons of using ANP, the methodology applied in this research will be explained step by step.

4.1. AHP and ANP

Selecting the right MCDM method is critical to obtain reliable outcomes. As stated before, AHP and ANP are widely used in different sectors. There are some reasons for selecting those methods rather than other MCDM methods. First of all, AHP and ANP have simpler structures when compared to other methods. This makes, AHP and ANP more understandable and manageable. Additionally, qualitative and quantitative factors are being used efficiently in AHP and ANP. Since hierarchical models and networks are used in AHP and ANP, they fit to complex decision making problems efficiently. Furthermore, AHP and ANP make it easier for several stakeholder to agree upon a decision or strategy in a more efficient way (Taslicali and Ercan, 2006). Considering those reasons and reviewing the criteria obtained which are suitable for network diagrams, it is decided to focus on AHP and ANP for this study.

It would be proper to give some brief information about both methods and the reasons for selecting ANP as the MCDM of this study. Before starting to explain those methods, two concepts that are used for both methods should be introduced. One of them is cluster and the other one is element. Clusters are groups that contain several elements. Elements with a similar category come together and form clusters. For instance, in our study, “Economic” is a cluster while “Investment Cost” is an element in the “Economic” cluster.

AHP could be explained as an assessment theory by applying pairwise comparisons and relying on the views of a group of experts in terms of judgement. Pairwise comparisons are applied through a judgement scale which indicates how much more one element is more important than another one in respect to a given parent element (Saaty, 2008). AHP simply decreases a multidimensional problem to a one dimensional basis (Saaty, 2008). A hierarchical model structure is formed to apply AHP. This hierarchy is working in a linear basis which means interdependencies between elements are ignored. A typical linear hierarchy which is used in AHP could be seen in Figure 4.1 below. The main goal is at the top of the hierarchy. After that, criteria, sub criteria and alternatives appear when going to the lower levels of hierarchy.

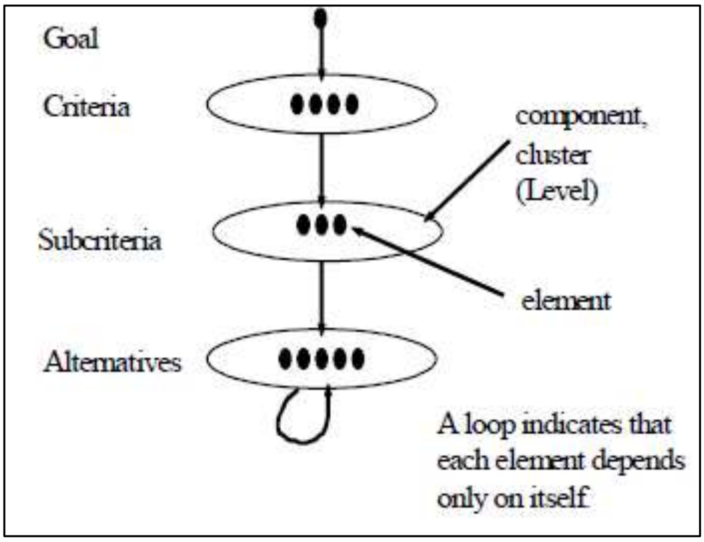

Figure 4.1. Linear Hierarchy (Saaty, 2008)

Several steps should be followed to apply AHP. First of all, the problem should be defined clearly and decision of what sort of information will be looking for should be made. Hierarchy must be formed afterwards. As explained hierarchy starts from the goal at the top and continues with lower level elements. The next step is forming the pairwise comparison matrices. By obtaining the priorities of each matrix, the final step is weighting each element according to its upper level element (Saaty, 2008). It should be noted that a scale structure is used when comparing the element forming the pairwise comparison matrices. Details of the scale is given in Table 4.1 below.

Table 4.1. The Fundamental Scale of Absolute Numbers (Saaty, 2008)

Intensity of Importance	Definition	Explanation
1	Equal	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate	Experience and judgement slightly favour one activity over another
4	Moderate plus	
5	Strong	Experience and judgement strongly favour one activity over another
6	Strong plus	
7	Very strong	An activity is favoured very strongly over another
8	Very, very strong	
9	Extreme	The evidence favouring one activity over another is of the highest possible order

There are several examples of AHP in real life. For instance, in 1998 British Airways applied AHP in order to choose the best entertainment system vendor for its airplanes. It was used in Adapazarı to decide on the best relocation side for after the devastating earthquake in Turkey. Department of Defence of the United States uses it often to allocate their sources to their activities (Saaty, 2008).

ANP could be defined as a generalized version of AHP which takes the interdependencies between the elements into account (Saaty, 2008). Since, ANP considers the effect of interdependencies, structure of ANP models are not hierarchical as they are in AHP. Rather than hierarchy, ANP models could be defined as networks due to the dependencies among lower level element and different clusters. Priorities are calculated as the same way as they are in AHP (Saaty, 2008). When the network structure is investigated, we could say that there are clusters of elements similar to the AHP. However, inner and outer dependencies are valid in AHP which symbolizes the interdependencies. If one element in a cluster is dependent to another in the same cluster, it means an inner dependency in AHP. When an element in a cluster is linked to another from a different cluster, then it forms an outer dependency in ANP approach. In ANP, determined priorities forms the supermatrix structures. There are 3 main types of supermatrix which are called unweighted supermatrix, weighted supermatrix and limit supermatrix. Unweighted supermatrix is formed by the priorities of the elements coming from pairwise comparisons. Weighted supermatrix is calculated by multiplying the priority of each element with its cluster's priority. Finally, the limit supermatrix is calculated by increasing the weighted supermatrix to the powers. In general the steps to be followed when applying ANP could be summarized as follows. First of all, the problem is defined by clarifying the main goal, main criteria and sub criteria. After that, the clusters and their related elements should be formed. The next step should be forming the interdependencies and pairwise comparison matrices accordingly. Then finally, the 3 supermatrices which are unweighted, weighted and limit supermatrices should be structured.

When ANP and AHP is compared, the first thing to say is ANP is considering the interdependencies within the network. In real life, things that we are assessing to make a decision are very rarely independent from themselves. Hence, in order to make a more accurate assessment we should consider the interdependencies in detail. As a result of that, we could say that ANP gives more realistic and accurate results when compares to AHP. According to a study which was conducted by a survey filled by professionals who applied AHP and ANP before, ANP represents the reality more than AHP (Taslicali and Ercan, 2006).

As stated before, elements of a network or hierarch generally affects another element. In other words, criteria affecting a decision or a goal at the top level, is not independent from other criteria in real life. When criteria of our study is investigated, it seen that many of them are affecting each other in different levels. Hence, we can say there is a dynamic relation among our criteria. As a result of that, the optimum solution would be proceeding with ANP rather than AHP to obtain more accurate outputs in our study.

4.2. Model Formation

Main purpose of this study is identifying the most important factors which shape the investment decisions in RE investments and determine their importance weights in that regard. In order to do that the first step was deciding on the main criteria related to the investment decisions. First of all, a comprehensive literature survey was performed. During the literature survey, it was observed that there are many criteria which affects RE investment decisions. When the literature was investigated, it was recognised that criteria which affects RE investments were grouped under four certain categories. Those main categories were; technical, economic, and environmental and social. In this study, same structure would be formed since the definitions of the criteria components would lead us into that formation. On the other hand, practical sector knowledge and experience may be helpful at this point. Criteria under the categories of technical and economic are recognized as they are in the energy sector. However, criteria under environmental and social are highly linked to each other. Consequently, many sector participant considers those two under one roof. Additionally, consultant firms of the energy sector in the environmental area, generally works on the social issues as well. Despite social issues require particular expertise and knowledge itself, since they are strictly linked to the environmental issues, consultant companies cover those two categories together. Although, there are some firms that only specializes in social issues consultancy, general sector approach is to determine those as the same category. In addition to the consultancy firms, investors' approach to the subject is exactly the same. Corporates generally form a team of specialists to deal with environmental and social matters together. Furthermore, lenders also recognize environmental and social factors as one section in line with the international standards. There are two main international and globally accepted standardization applied. Those are International Finance

Corporation (IFC) environmental and social performance standards and Equator Principals (EP) on the environmental and social risk management for projects. Headlines of the issues covered by the IFC environmental and social standards could be summarized as assessment and management of environmental and social risks, labour working conditions, resource efficiency and pollution prevention, community health & safety & security, land acquisition and involuntary resettlement, biodiversity, indigenous people and cultural heritage (Performance Standards on Environmental and Social Sustainability, 2012). EP contains principles such as review and categorization, environmental and social assessment, applicable environmental and social standards, environmental and social management system, stakeholder engagement, grievance mechanism, independent review, covenants, independent monitoring, reporting and transparency (The Equator Principles, 2013). Those two standard mechanisms are applicable all around the world. For example, although Turkey has its own environmental and social standards and Environmental Impact Assessment (EIA) process, most of the leading commercial banks of Turkey, requires IFC standards and EP in their projects that they finance. The reason behind this application is that those international standards are considering environmental and social issues from a more comprehensive perspective when compared to the local standards. Considering all of those issues it would be proper to merge the categories of environmental and social in order to be in line with the sector practice. Hence, headline list of the criteria of this study has been decided to be as follows; technical, economic, and environmental and social.

After deciding on the main category structure, it would be suitable to investigate the criteria one by one to form the most effective criteria list which will be the base of this study. After the literature survey, number of criteria were 49. 14 of them were related to the technical group, 18 were in economic and 17 in environmental and social category. It was observed that some of those criteria were referring to the same meaning. For instance, criteria of reliability, maturity of technology, technological feasibility and continuity and predictability of performance were all addressing the reliability of the technology which would be used. Hence, all of those criteria were merged and renamed under reliability of technology. Another example is related to the economic category.

Net present value, economic value, finance and return on investment were implying the importance of financial indicators. As a result of that one criteria is sufficient for them which is financial indicators. A similar case was observed in the category of environmental and social. NOx emission, CO_2 emission, CO emission and SO_2 emission were all related to the emission rates of the projects. Consequently, those criteria were named as emission rates for a more practical use. In the literature, there was criteria called fuel cost. Considering the mechanism of the RE projects, it has been decided that fuel cost criteria could be removed from the list. Due to the fact that, RE projects generally do not consume a particular fuel as in conventional electricity generation methods, fuel cost is not a common expenditure component of RE project. As a consequence of that, fuel cost has been excluded. Similar revisions have been made in order to obtain a more accurate criteria list. Finally, number of criteria have been reduced to 23. Before deciding on the last version of the list, it was shared with the energy sector experts who would also contribute to the assessment of the priorities of them which will be explained in the following parts of this study. Both the latest version of the criteria list and changes made have been confirmed by the experts. At the end, a list of 3 main categories also called as clusters and 23 criteria also called as elements are obtained. In table 4.2, final version of the criteria list could be seen.

Table 4.2. Criteria List

Investment Decision Making		
Technical	**Economic**	**Environmental and Social**
Efficiency	Investment cost	Emission rates
Reliability of technology	Operation and maintenance cost	Land use
Production capacity of the plant	Realization time	Noise
Implementation and operational risk	Financial indicators	Effects on natural environment
Local technical know-how	Service life	Social acceptability
Annual exploitability	Policies and regulations	Job creation
	Risk attitude of the investors	Safety
	Confidence in market	
	Macro-economic environment	
	Availability of funds	

4.3. Pairwise Comparisons

Assessing the relative importance rates is one of the most important steps of this research. After deciding on the criteria list, interrelations between elements should be obtained in order to realize the pairwise comparisons. In order to decide the dependencies among the elements, each of them must be considered in detail. Firstly, theoretical definitions were examined carefully. Then, an interrelation matrix was formed including all of the elements. Each element of the interrelation matrix should be reviewed one by one to decide whether there is an interrelation or not. When the interrelation matrix started to be filled, only direct relations where there are an input and output relations existing, should be considered as interrelation.

The interrelation matrix is formed by row and column elements. Main principle of the matrix is to put the sign of "+" if the row element is effective on the column element. In Table 4.3, a sample interrelation matrix could be seen. When we investigate the matrix below, it is seen that element A is effective on element B, however not effective on element C. While element B is not effective on any of those two elements, element C is effective on both element A and B. As it could be recognized, effects of each element on themselves should not be considered. Hence, those sections are highlighted with grey.

Table 4.3. Sample Interrelation Matrix

Sample Interrelation Matrix	A	B	C
A		+	
B			
C	+	+	

There are significant sources in the literature which are quite helpful to identify the interrelations. By benefiting from the literature, initial interrelations are decided.

However, filling the interrelation matrices with only theoretical knowledge may not be sufficient to obtain precise results for this research. As a consequence of that, participant of the energy sector experts becomes inevitable. When selecting the proper sector experts several criteria were followed. First of all, considering the multidisciplinary structure of the energy investments, a well-diversified expert team, containing professionals working in different stakeholders of the energy sector was formed. Secondly, experience level of those experts must be sufficient to contribute this study in a more efficient way. Experts who had a minimum experience of 5 years and experienced several RE investments were invited to contribute this study. Finally, it is important to form an expert team containing professionals on different career levels or titles. Views of the professionals may vary, evolve and change according to their career path. Hence, having an expert group of different titles could be beneficial to obtain more accurate results due to their varying perspectives. Considering all those factors, an expert team of 8 people were formed. Profile of the experts are given below.

Three of the experts are working as professionals in Turkish energy firms acting as local investors which are quite active in the RE investments. One of them are working as chief financial officer (CFO) in local company which is one of the most important companies in the wind energy investments in terms of installed capacity. He has an experience of 17 years and working in the energy sector for 12 years. Another participant is working as a manager in the energy division of a local holding which is active in several sectors such as energy, retail, electronics and textile. He has an experience of 8 years in the energy sector and experienced many RE projects especially HPPs and GPPs. The last expert in this category is working as a specialist in a medium sized energy company in Turkey. He has participated in wind energy and hydro energy and solar energy investments in his career and has an experience of 5 years.

One member of the expert team is working as a manager in a German energy company which could be categorized as a foreign investor that is quite active in RE investments in several countries. He has an experience of 8 years in the energy sector and participated in many WPP and HPP projects and recently some SPPs. His company also invested in Turkish energy sector via a WPP which is operational for 2 years.

Two of the sector professionals are participating in the local lender side of the energy sector. Both of them are working in two of the four biggest Turkish commercial banks. One of them is working as a manager in the project finance department of its bank. He has a banking experience of 10 years and 6 years of that period was spent in financing of energy projects in Turkey. He has experienced many energy projects such as HPPs, WPPs, GPPs and TPPS. The other participant of this category is also as a project finance specialists. He has an experience of 5 years in the financing of energy projects.

One of the experts is working at an international finance institution and responsible for financing of energy projects. He is working as a project finance associate and has an experience of 5 years in the energy investments.

One expert is working as a business development manager in a local technical consultancy firm. He has an experience of 19 years in the energy sector. He is a retired officer of State Hydraulic Works of Turkey (DSI). While working in DSI, he planned and managed many HPP projects. After retiring from DSI, he started to work at a technical consultancy firm which acts as a consultant to both investors and lenders.

After forming the expert team, information about the study, criteria list and methodology of filling the interrelation matrix were explained to the experts. Then, making one on one meetings, all experts were requested to review the interrelations obtained from the literature and fill the interrelation matrix from their perspectives. After obtaining responses from all experts, it was observed that there were some incompatibilities among them. Hence, all results obtained from the 8 experts were shared to each other and requested to review their answers. After their second review, a consensus has been reached. In Table 4.4, the filled interrelation matrix could be seen

Table 4.4. Interrelation Matrix

	T1	T2	T3	T4	T5	T6	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	ES1	ES2	ES3	ES4	ES5	ES6	ES7
T1			+							+													
T2			+					+		+	+					+							
T3										+						+			+				
T4								+			+		+			+				+			+
T5				+					+		+					+							+
T6			+																				
E1										+						+							
E2										+						+							
E3										+						+							
E4																+							
E5										+						+							
E6										+			+	+		+				+			
E7																							
E8													+										
E9												+	+	+		+							
E10																							
ES1							+									+				+	+		
ES2							+													+	+		
ES3							+													+	+		
ES4																+					+		
ES5																+							
ES6																					+		
ES7																+					+		

By obtaining the interrelation matrix, interdependencies among the elements were obtained. The next step is to decide the relative importance rates of those elements. Additionally, relative importance rates of the clusters should also be determined.

Pairwise comparisons are done via forming pairwise comparison matrices. Pairwise comparison matrices are formed by row and column element and a parent element. When filling the matrix, each row element or cluster is compared to the each column element or cluster in terms of their importance on the given parent element or cluster. When assessing the how many times an element is more important than the other, the scale format in Table 4.1 could be used. An illustration on how to fill the pairwise comparison matrix is given in Table 4.5 below for further understanding.

Table 4.5. Sample Pairwise Comparison Matrix

A	B	C	D
B		3	1/3
C			1/5
D			

A is the parent element in this matrix and relative importance rates of B, C and D should be assessed on the parent element A. Assessment should be done row by row. Starting with element B, the first question to be answered is “how much is element B more or less important than element C on the parent element A”. The digit of “3” is stating that element B is moderately more important when compared to element C on the parent element A. Then, the second question is; “how much element B is more or less important than element D on the parent element A” The digit of “1/3” is stating that, element B is moderately less important when compared to element D on the parent element A. Then the last question is; “how much element C is more or less important than element D on the parent element A”. The digit of “1/5” is stating that, element C is strongly less important when compared to element D on the parent element A. Since the relative importance rate of each element on themselves will be “1”, those sections will not be filled. Additionally, when an importance rate of an element on another one is determined, then the situation will be vice versa when it’s compared in the other way. For instance, importance rate of element B is “3” when compared to element C on the parent element A. Then, the importance rate of element C must be “1/3” when compared to the element B on the parent element A. Consequently, those sections does not need to be filled and highlighted with grey in the matrixes. Some examples of those matrices formed for this study are given in the tables below.

Table 4.6. Pairwise Comparison Matrix with Respect to the Production Capacity of the Plant

Production capacity of the plant	Efficiency	Reliability of technology	Annual exploitability
Efficiency		2	1/4
Reliability of technology			1/4
Annual exploitability			

Table 4.7. Pairwise Comparison Matrix with Respect to the Financial Indicators

Financial indicators	Efficiency	Reliability of technology	Production capacity of the plant
Efficiency		3	1/4
Reliability of technology			1/6
Production capacity of the plant			

Table 4.8. Pairwise Comparison Matrix with Respect to the Service Life

Service life	Reliability of technology	Implementation and operational risk	Local technical know-how
Reliability of technology		3	5
Implementation and operational risk			3
Local technical know-how			

Table 4.9. Pairwise Comparison Matrix with Respect to the Availability of Funds

Availability of funds	Reliability of technology	Production capacity of the plant	Implementation and operational risk	Local technical know-how
Reliability of technology		1/3	1/2	3
Production capacity of the plant			3	5
Implementation and operational risk				3
Local technical know-how				

Table 4.10. Pairwise Comparison Matrix with Respect to the Effects on Natural Environment

Effects on natural environment	Emission Rates	Land use	Noise
Emission Rates		2	4
Land use			4
Noise			

Table 4.11. Pairwise Comparison Matrix with Respect to the Technical Cluster

TECHNICAL	T1	T2	T3	T4	T5	T6
T1		1	1/3	3	5	1/3
T2			1/4	2	3	1/3
T3				5	7	2
T4					3	1/5
T5						1/7
T6						

Table 4.12. Pairwise Comparison Matrices of Clusters with Respect to the Main Goal: Investment Decision

INVESTMENT DECISION	TECHNICAL	ECONOMIC	ENVIRONMENTAL & SOCIAL
TECHNICAL		1/3	4
ECONOMIC			7
ENVIRONMENTAL & SOCIAL			

In short, the matrixes should be filled row by row by assessing the relative importance of the row element to the column element based on the parent element and after that this process should be continued until all the relative importance weights of row elements to each column element is assessed.

A second session of meetings were done with all experts to fill the pairwise comparison matrices. After obtaining their initial responses, results are compared and observed that there are only few matrices where certain amount of differences occurred. Hence, all the answers obtained from the experts were shared to each of them for a final review. After all the experts have reviewed their results, they sent their revised responses. When the amended results are obtained, it was observed that there were no major differences among them. Hence, relative importance rates of interrelated elements were obtained successfully after this phase.

4.4. Importance Weights

In the final step of the analysis, each element and cluster's effect on the investment decisions should be determined. As mentioned before, ANP is the selected as the solution method for this MCDM problem. For applying ANP, a software called "Super Decisions" is used.

The first step to do in the software is defining the network or hierarchical model. In this phase, all the clusters and related elements should be defined to the software. The formed network structure in the software could be seen in Figure 4.2 below.

After introducing the network, the next step is entering the result of pairwise comparison matrices derived from the responses of the experts. In order to do that each pairwise comparison matrix should be introduced to the software. In Figure 4.3, the interface of the Super Decisions for entering pairwise comparison matrices could be seen.

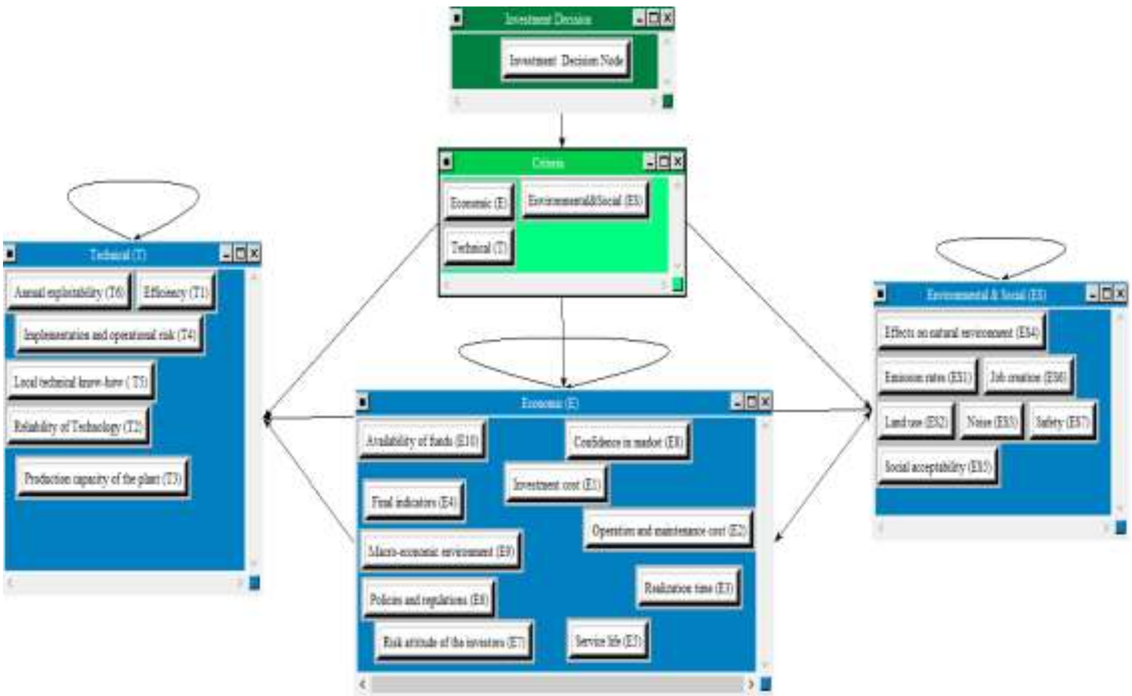

Figure 4.2. View of the Network Model in Super Decisions

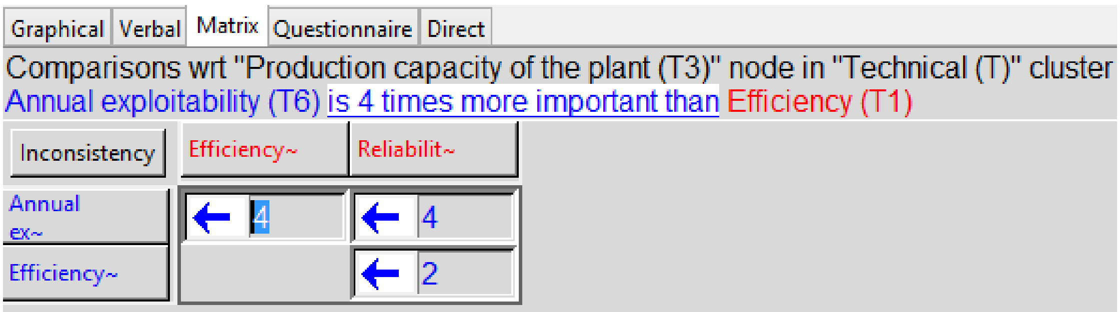

Figure 4.3. Pairwise Comparison Matrix Interface of Super Decisions

As stated before, the Super Decisions software forms 3 main supermatrices as unweighted supermatrix, weighted supermatrix and limiting supermatrix. Values of the limiting supermatrix reflect the priorities of each element of the network. Calculated priorities of each cluster and element could be seen in Table 4.13.

In order to find the importance weights of each element, we need to multiply their priority or in other words their limiting weights with limiting weights of their related clusters. For instance, limiting weight of element T1 is 0.12032 and the weight of its related cluster which is Technical is 0.26275. Hence, weighted importance rate of T1 is calculated by multiplying these two values as 0.03161408. In this way, importance weights of all elements are calculated. Importance weights of clusters and elements in respect to their influences of the investment decisions could be seen in Table 4.14 and 4.15 respectively.

Table 4.13. Priorities of Each Cluster and Element

Cluster/Element Name	Priority
Technical (T)	**0.26275**
Annual exploitability (T6)	0.28223
Production capacity of the plant (T3)	0.24834
Implementation and operational risk (T4)	0.15686
Reliability of Technology (T2)	0.15288
Efficiency (T1)	0.12032
Local technical know-how (T5)	0.03937
Economic (E)	**0.65863**
Policies and regulations (E6)	0.28859
Availability of funds (E10)	0.21963
Investment cost (E1)	0.11869
Financial indicators (E4)	0.09161
Macro-economic environment (E9)	0.07448
Confidence in market (E8)	0.05104
Risk attitude of the investors (E7)	0.04611
Realization time (E3)	0.03726
Operation and maintenance cost (E2)	0.03631
Service life (E5)	0.03629
Environmental and Social (ES)	**0.07862**
Land use (ES2)	0.32446
Emission rates (ES1)	0.17998
Social acceptability (ES5)	0.16033
Effects on natural environment (ES4)	0.09937
Job creation (ES6)	0.08281
Safety (ES7)	0.08150
Noise (ES3)	0.07155

In order to find the importance weights of each element, we need to multiply their priority or in other words their limiting weights with limiting weights of their related clusters. For instance, limiting weight of element T1 is 0.12032 and the weight of its related cluster which is Technical is 0.26275. Hence, weighted importance rate of T1 is calculated by multiplying these two values as 0.03161408. In this way, importance weights of all elements are calculated. Importance weights of clusters and elements in respect to their influences of the investment decisions could be seen in Table 4.14 and 4.15 respectively.

Table 4.14. Importance Weights of Clusters

Cluster Name	**Importance Weight**
Economic (E)	0.65863
Technical (T)	0.26275
Environmental and Social (ES)	0.07862

Table 4.15. Importance Weights of Elements

Element Name	**Importance Weight**
Policies and regulations (E6)	0.19007
Availability of funds (E10)	0.14465
Investment cost (E1)	0.07817
Annual exploitability (T6)	0.07416
Production capacity of the plant (T3)	0.06525
Financial indicators (E4)	0.06034
Macro-economic environment (E9)	0.04905
Implementation and operational risk (T4)	0.04121
Reliability of Technology (T2)	0.04017
Confidence in market (E8)	0.03362
Efficiency (T1)	0.03161
Risk attitude of the investors (E7)	0.03037
Land use (ES2)	0.02551
Realization time (E3)	0.02454

Table 4.15. Importance Weights of Elements (cont.)

Operation and maintenance cost (E2)	0.02391
Service life (E5)	0.02390
Emission rates (ES1)	0.01415
Social acceptability (ES5)	0.01261
Local technical know-how (T5)	0.01034
Effects on natural environment (ES4)	0.00781
Job creation (ES6)	0.00651
Safety (ES7)	0.00641
Noise (ES3)	0.00563

According to the importance weights, it is seen that the “Economic” cluster is the most important cluster among others. Then it is followed by the clusters “Technical”, and “Environmental and Social”. Importance weight of “Economic” cluster is by far higher than the other two cluster which is expected. Since, economic return is the most important factor for all investors, this result was expected. On the other hand, we see a significant margin between the clusters “Technical”, and “Environmental and Social”. Similarly, this result is not surprising. Technical factors are strongly linked to economic outcomes. Hence, one could expect the “Technical” cluster to be more important than “Environmental and Social” cluster. Although, there is a significant increase in the awareness of environmental and social issues, reflection of those to the economic factors are limited.

The situation in clusters reflect to the elements. The three most important elements are all in the “Economic” cluster. They are “Policies and regulations”, “Availability of funds” and “Investment cost”. Governmental policies are quite critical for the investment decisions. In the case of RE investments, incentives are the triggering factors for the investment. Without a proper incentive and regulation mechanism, RE investments may decrease sharply. Investors don’t prefer to finance all of the investment budget from their equities. Hence, a considerable percentage of the investments are financed by loans. As a result of that, credibility and availability of the investments for sufficient loans are quite important for the investment decisions. Following these two elements, the cost of investment is also a very important determinant for investment decisions. When the investment budget increases, it means that the loan amount and relatedly financing costs and also equity injection rates will increase. As a consequence of that, investors consider the "Investment cost" as one of the most important factors for their decision processes.

For the "Technical" cluster, "Annual exploitability", "Production capacity of the plant" and "Implementation and operational risk" seem as the most effective elements. The first two are directly related to the electricity generation amounts of the investments. Hence, it is understandable why they are important for the investors. The "Implementation and operational risk" element is also considerable for the investors. Problems in both implementation and operational phases may cause significant cost and time overruns on the investments.

In the cluster of "Environmental and Social", elements with the highest importance weights are "Land use", "Emission rates" and "Social acceptability". However, their influence effect on the investment decisions are limited when compared to the elements discussed above. On the other hand, with the rise of environmental and social awareness among the investors, we could say those factors become more important when compared to the past. Additionally, their limited importance weights are understandable when their limited effects on economical outcomes are considered.

4.5. Reliability of the Model

Since the importance weights of all criteria is obtained, reliability of the model should be checked for further usage. In order to do that 3 experts from the initial expert team were invited to participate in this testing process. One of them is a manager at a local investor holding. He has experienced 8 years in the energy sector especially in the fields of HPPs and GPPs. Another one is the foreign investor in the previous expert team. He has an experience of 8 years in the sector and his main field of specification is WPPs and HPPs. The final participant is a manager in the project finance department in one of the biggest commercial banks in Turkey. He has an experience of 10 years in the finance sector and spent 6 years in the financing of energy projects.

All participants were required to assess 1 project that they participated in by assessing each criteria considering their project and then they were requested to assign an overall score for their project. For this study, 1 GPP project, 1 WPP and 1 HPP project were selected. Experts assigned a score from 1 to 100 for each criteria and overall project. In Table 4.16, scores of all criteria which refer to the sufficiency rate of each criteria within selected projects and also overall project scores in terms of the feasibility level of each investment given by the experts could be seen. "Actual Project Score" represents the overall rating given by the experts while "Calculated Project Score" refers to the score calculated by multiplying the score of each criteria with its importance weight suggested in the model. Additionally, the error rate is calculated by measuring the difference between the actual and calculated project scores. According to those project case, suggested model seems quite sufficient. On the other hand, it shouldn't be forgotten that those results are subjective. For instance, in project 2, the expert who is a foreign investor assigns the overall project score or actual project score as 95. However, he gives scores below 95 to two of the most important factors which form 33% of the total score. It shows that the investor in this case recognizes the overall score in an optimistic way. On the contrary, in project 3 the local lender approaches to an unsuccessful project from a pessimistic perspective and consequently, actual project score remains below the calculated project score. However, those results are not surprising. Due to the fact that, approach and understanding of investors and lenders are quite different, reflections of this fact are easily seen from the results. Therefore, results of this test show that our suggested model is successful to determine the project scores in terms of feasibility of the RE investments. On the other hand, since those assessments are based on subjective determinations, number of cases should be increased in order to obtain more precise and effective results.

Table 4.16. Reliability Test of the Suggested Model

Criteria	Project 1	Project 2	Project 3
Policies and regulations (E6)	95	85	90
Availability of funds (E10)	85	90	75
Investment cost (E1)	75	95	40
Annual exploitability (T6)	85	95	60
Production capacity of the plant (T3)	75	95	60
Financial indicators (E4)	80	95	60
Macro-economic environment (E9)	75	75	65
Implementation and operational risk (T4)	65	85	40
Reliability of Technology (T2)	85	90	85
Confidence in market (E8)	80	75	75
Efficiency (T1)	75	95	65
Risk attitude of the investors (E7)	85	95	90
Land use (ES2)	95	80	65
Realization time (E3)	90	95	20
Operation and maintenance cost (E2)	75	95	60
Service life (E5)	85	95	85
Emission rates (ES1)	65	100	95
Social acceptability (ES5)	90	90	70
Local technical know-how (T5)	90	90	75
Effects on natural environment (ES4)	70	95	90
Job creation (ES6)	95	95	90
Safety (ES7)	95	95	55
Noise (ES3)	95	75	95
Calculated Project Score	**83**	**90**	**69**
Actual Project Score	**90**	**95**	**65**
Error Rate (%)	**7.9%**	**6.1%**	**6.4%**

5. DISCUSSION

Factors which are considered by the investors before investing in RE projects has been subject to various academic researches. In principal, main ideas of those work and this study may look similar. Although there are certain similarities, there also exists significant points where this study differs from the others.

First of all, main objective of this research is simply identify the most important factors that affect RE investment decisions. Choosing the optimum RE type and location or detailed analysis of MCDM methods are not the primary concerns of this study. On the other hand, in many studies it is observed that selection of the most proper RE alternative by analysing various MCDM methods is prior than the criteria. For instance, Kaya and Kahraman (2010) conducted a very valuable research in order to decide on the best RE alternative for Istanbul and the optimum location. An importance weight determination on the criteria of RE investment also realized in that study. However, obtaining the importance weights of criteria wasn’t the main aim, but only an ancillary tool for them. In the research of Cavallaro and Ciraolo (2005), selection of the best WPP alternative on an Italian Island was the main concern. Similarly, Cristobal (2011), made a research to specify the best RE alternative in Spain by using a limited list of criteria.

Secondly, list of RE investment decision criteria is more or less similar in many studies. For example, criteria list considered by Wang *et al*. (2009), Kaya and Kahraman (2010) and Kahraman *et al* (2009), contain 4 main categories such as technical, economic, environmental and social. Additionally, their list of criteria is quite similar. However, in the scope of this study criteria accepted by the majority of the literature are reshaped considering the sector practise. For instance, environmental and social categories are merged under the same roof considering the international standards and applications. In addition to that, initial criteria list of 49 factors is revised considering their exact definitions and sectoral applications. On the other hand, in the studies of Aslani *et al*. (2012), Cavallaro and Ciraolo (2005), Masini and Menichetti (2012) and Cristobal (2011) criteria lists are relatively restricted due to several reasons.

Several MCDM methods were applied in the literature for analysing RE investment decision purposes. Cristobal (2011) used VIKOR and AHP methods in his study, Kaya and Kahraman (2010) also combined VIKOR and AHP for their research. Kahraman *et al. (*2009) used fuzzy axiomatic design and fuzzy AHP. Aslani *et al*. (2012) applied AHP and and Wang *et al*. (2009) analysed several MCDA methods. Apart from the other studies, ANP is selected as the MCDM method for analysing RE investment decision criteria due to the interdependencies among elements.

In order to determine both the interrelations and pairwise comparisons of RE investment decision criteria, a proper weighting method should be used. General acceptance in various studies of the literature is to apply for sector experts' opinions. This view is quite logical and applied in this research. However, considering the extensive variety of stakeholders involved in the RE investments, a well-diversified expert team should be formed. In other words, on the contrary of the numerous studies where there are limited type of stakeholders such as only investors, several stakeholders other than investors such as lenders and technical experts should be included in the expert team in order to obtain more holistic results. This is the main philosophy of creating such an expert team in this study. There are only few examples where that kind of team is formed. For instance, Aslani *et al*. (2012) constituted an expert team of investors, energy experts and researchers.

Finally, importance weights of RE investment criteria may vary in different studies of the literature. According to Wang *et al*. (2009), investment cost and CO_2 emission rates are the most important factors. In the study of Kaya and Kahraman (2010), CO_2 and NO_x emission rates are found to be the criteria with the highest weights followed by job creation in terms of selecting the best RE alternative. In terms of clusters, technical and environmental groups are the most effective ones when assessing the best RE project type selection according to the work of Kahraman *et al.* (2009). Aslani *et al.* (2012) finds that governmental policies, consumption market conditions and engineering efficiency are the most significant factors for RE investments. For Cristobal (2011), power generation, CO_2 emission and service life are the most effective determinants for RE projects. On the other hand, policies and regulations, availability of funds and investment cost are determined as the prior criteria for RE investment decision making. Differences among those studies in the literature could be explained by the different perspectives and aims of those studies and type of the expert groups involved. Main goal of some of those studies were to select the best RE alternative under particular conditions. However, in this study the main objective is to find out the most important criteria for all type of RE alternatives which could be applied by all RE investors. Additionally, having a multi-disciplinary expert team, assessment perspective of this study is quite comprehensive. Hence criteria such as governmental policies and regulations and availability of funds occupy the first two rankings in the criteria list.

Another important issue might be the applicability of the model suggested in this study and its outcomes to all type of RE investments. It should be underlined that those results regarding the importance weights of RE investment decision making criteria is applicable for all RE types. On the other hand, it could be claimed that some changes may occur from a particular RE type to another. First of all, main results which are the key outcomes of this study will definitely be the same for all RE types. In other words, “Economic” cluster will be the most important criteria group among the others and “Technical” cluster will follow it. Additionally, criteria such as “Policies and regulations”, “Availability of funds” and “Investment cost” will remain their positions at the top. Due to the fact that RE investments will become unfeasible unless there are certain regulation support, one couldn’t expect a change in the ranking of “Policies and regulations”. Similarly, “Availability of funds” and “Investment cost” will also remain their importance weights as they are crucial for all types of RE investments. Apart from main results, there could be some revisions depending on the RE type. For instance, HPPs require complex civil engineering works such as dam body construction and energy tunnel works. Hence, it could be expected the criteria of “Implementation and operational risk” to become more important for those type of projects. As a result of that, importance weight of that criteria might increase and may find a position above the criteria of “Macro-economic environment”. Another example could be related to WPPs. Noise may have significant effects on the local people near to the project site. Consequently, criteria related to noise is assessed by both regulatory authorities and lenders in line with the international standards. As a result of that, importance weight of

“Noise” should be higher than it is for WPPs. However, its place will not change considerably. In short, it could be stated that suggested model in this study and its outcomes are applicable to all types of RE projects. For the avoidance of doubt, there may be some changes in the importance weights results of the criteria, however main results and general picture will remain the same.

6. CONCLUSION

6.1. Summary

Energy has a significant role in today's economic and social world. Due to the rising environmental concerns, RE investments become inevitable all around the world. The main purpose of this research is to identify the main factors which effect and shape the RE investment decisions and determining the priorities of those factors. In order to do that in addition to an extensive literature survey, meetings with energy sector experts including investors, lenders and technical consultants were conducted.

There are many factors that affect the RE investment decisions of the investors. In order to identify them, a detailed literature survey was conducted. After that a total of 49 criteria were listed. However, when the definitions of all the criteria was investigated, it was observed that some of them are implying the same points. Hence, those criteria are merged under one roof. Additionally, some of them were theoretically important, however they were not applicable in the sector practice of RE investments. Furthermore, in the literature those criteria were grouped under 4 main categories as technical, economic, environmental and social. However, in the practice environmental and social issues are highly linked to each other and considered under common international standards. As a consequence of those facts, total number of criteria (elements) was reduced to 23 with 3 main categories (clusters) as technical, economic, and environmental and social.

After deciding on the criteria list, a proper method to calculate the priorities of those should be selected. There are many applicable MCDM methods in the literature. AHP and ANP are two of the most widely used ones. AHP considers a hierarchical model and ignore the interdependencies among the elements. On the other hand, ANP forms a network model where the interdependencies are taken into account. When the obtained criteria list is investigated, it is seen that there are many dependencies among the elements. As a consequence of that ANP was selected as the MCDM method to be used.

In order to assess the priorities of the elements, interdependencies of them should be clarified. In order to do that an expert team of 8 professionals working at respectable local and also foreign investor firms, local and international lenders and technical consultancy firms were formed. By having their comments, the interrelations were decided. Afterwards, in order to decide on the relative importance rates of the interrelated elements on each other, pairwise comparison matrices were conducted by the support of the expert team. Finally, those inputs were entered into the Super Decisions software to obtain the importance weights of all clusters and elements in respect to the RE investment decisions. Results are not surprising. According to the importance weights, “Economic” cluster is by far the most significant cluster among others as “Technical” and “Environmental and Social” respectively. When the importance weights of the elements are investigated, it is seen that elements under “Economic” cluster is dominating the others. “Policies and regulations”, “Availability of funds” and “Investment cost” elements are the most important ones. “Annual exploitability” and “Production capacity of the plant” are the most significant elements under “Technical” cluster. When the elements under “Environmental and Social” is examined “Emission rates” and “Social acceptability” are the most important elements. However, it is worth mentioning that importance weights of elements under the “Environmental and Social” cluster is quite limited when compared to the others. It is understandable that economic outcomes are the most important factor for the investors. Since technical factors are more related to the economic outcomes when compared to the environmental and social criteria, it is expected that importance weight of the technical issues to be higher than the environmental and social ones.

6.2. Further Suggestions

RE investments are vital to have a sustainable future. Hence, all stakeholders in the sector should be aware of that and behave in line with it. On the other hand, results of this study show that there are numerous factors that should be considered before investing in RE projects.

First of all, investors should consider all the necessities and risks before making an investment decision. Starting to a RE investment without assessing the significant criteria may cause diminishing effects for the investors. When the responses of the sector participants are examined, it is obvious that economic factors are the most important ones for the RE investments.” Policies and regulations”, “Availability of funds” and “Investment cost” are constituting more than 40% of the importance weights for investment decisions in RE projects. As a consequence of that, without having sufficient conditions to satisfy those three factors, an investment decision will not be feasible under current conditions. In other words, investors should not invest in RE projects without having satisfying results for those three factors. Hence, those factors could be considered as absolute must for the investors. Additionally, “Annual exploitability” and “Production capacity of the plant” must be analyzed in detail before investing in a RE project. Those criteria are directly related to the electricity generation output which is the main return source of RE projects. If production rates of a RE is insufficient, then finding funds will also be challenging. As a result of that, the investment will become unfeasible. Furthermore, environmental and social concerns and requirements must be taken into account by the investors. Since, both governmental institutions and lenders are applying strict environmental and social requirements, investors must shape their investments to satisfy them. “Land use”, “Emission rates” and “Social acceptability” are the most important criteria in that regard. Type of land occupied, rate of CO_2 emissions and social concerns are investigated in detail by the lenders. Therefore, those factors must be covered in a sufficient level in order to have enough funds. Additionally, many governments apply international standards for those aspects. Hence, without satisfying those conditions obtaining the necessary permits will become quite hard. Finally, in terms “Social acceptability” and “Job creation” is vital in order to satisfy the local people near the project site. Without having the consents of majority of the local people, investments may face strong obstacles and protests. Hence, in order to have a successful investment, investors must be aware of that fact as well.

In addition to the investors, governmental institutions should be aware of the need for RE investments and increase their support on them. It is seen that “Policies and regulations” element is the most important criteria for the investors. This factor is totally related to the decisions of public institutions of the energy sector. Hence, public parties should reshape their policies and investment programs to satisfy this need of the investors in order to increase the RE share in the total energy production. If public authorities form efficient incentive mechanisms and policies and stand behind them under pressure such as economic and political fluctuations, both local and foreign investors feel more comfortable and increase their investments in the field of RE. It should not be forgotten that governmental policies and related incentives are the most vital points for investors to invest in RE.

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APPENDIX A: INITIAL CRITERIA LIST

Table A.1. Initial Criteria List After Literature Survey

Criteria		Source
#	**Technical**	
1	Efficiency	Wang *et al.* (2009), Kaya and Kahraman (2010), Aslani *et al.* (2012), Afgan and Carvalho (2002)
2	Exergy (rational) efficiency	Wang *et al.* (2009), Kaya and Kahraman (2010)
3	Primary energy ratio	Wang *et al.* (2009), Kaya and Kahraman (2010)
4	Safety	Wang *et al.* (2009), Kaya and Kahraman (2010)
5	Reliability	Wang *et al.* (2009), Kaya and Kahraman (2010), Kahraman *et al.* (2009)
6	Maturity	Wang *et al.* (2009), Kaya and Kahraman (2010), Carvallaro and Ciaolo (2005)
7	Energy production capacity	Wang *et al.* (2009), Carvallaro and Ciaolo (2005), Cristobal (2011)
8	Realization time	Kahraman *et al.* (2009), Cristobal (2011),
9	Feasibility	Kahraman *et al.* (2009)
10	Risk	Kahraman *et al.* (2009)
11	Continuity and predictability of performance	Kahraman *et al.* (2009)
12	Local technical know-how	Kahraman *et al.* (2009), Painuly (2001)
13	Regional energy potentials	Aslani *et al.* (2012)
14	Annual exploitability	Aslani *et al.* (2012)
#	**Economic**	
1	Investment cost	Wang *et al.* (2009), Kaya and Kahraman (2010), Carvallaro and Ciaolo (2005), Kahraman *et al.* (2009), Cristobal (2011), Afgan and Carvalho (2002)

Table A.1. Initial Criteria List After Literature Survey (cont.)

2	Operation and maintenance cost	Wang *et al.* (2009), Kaya and Kahraman (2010), Carvallaro and Ciaolo (2005), Cristobal (2011)
3	Fuel cost	Wang *et al.* (2009), Kaya and Kahraman (2010)
4	Electric cost	Wang *et al.* (2009), Kaya and Kahraman (2010)
5	Net present value	Wang *et al.* (2009), Kaya and Kahraman (2010)
6	Payback period	Wang *et al.* (2009), Kaya and Kahraman (2010)
7	Service life	Wang *et al.* (2009), Kaya and Kahraman (2010), Cristobal (2011)
8	Equivalent annual cost	Wang *et al.* (2009), Kaya and Kahraman (2010)
9	Implementation period	Cristobal (2011)
10	Availability of funds	Kahraman *et al.* (2009), Painuly (2001)
11	Economic value	Kahraman *et al.* (2009), Painuly (2001)
12	Policies and regulations	Kahraman *et al*. (2009), Aslani *et al.* (2012), Masini and Menichetti (2012), Wüstenhagen and Menichetti (2012), Painuly (2001), Wiser and Pickle (1998)
13	Consumption market divisions	Aslani *et al.* (2012), Painuly (2001)
14	Finance	Aslani *et al.* (2012), Painuly (2001), Wiser and Pickle (1998)
15	Risk attitude of the investors	Masini and Menichetti (2012)
16	Confidence in market	Masini and Menichetti (2012)
17	Return on investment	Haralambopoulos and Polatidis (2003), Painuly (2001), Wiser and Pickle (1998)
18	Macro-economic environment	Painuly (2001)
#	**Environmental**	
1	NO_x emission	Wang *et al.* (2009), Kaya and Kahraman (2010)
2	CO_2 emission	Wang *et al.* (2009), Kaya and Kahraman (2010), Carvallaro and Ciaolo (2005), Cristobal (2011), Afgan and Carvalho (2002)

Table A.1. Initial Criteria List After Literature Survey (cont.)

3	CO emission	Wang *et al.* (2009), Kaya and Kahraman (2010)
4	SO_2 emission	Wang *et al.* (2009), Kaya and Kahraman (2010)
5	Particles emission	Wang *et al.* (2009), Kaya and Kahraman (2010)
6	Non-methane volatile organic compounds	Wang *et al.* (2009), Kaya and Kahraman (2010)
7	Land use	Wang *et al.* (2009), Kaya and Kahraman (2010), Kahraman *et al.* (2009), Afgan and Carvalho (2002)
8	Noise	Wang *et al.* (2009), Kaya and Kahraman (2010), Cavallaro and Ciaolo (2005),
9	Effects on natural environment	Wang *et al.* (2009), Painuly (2001)
10	Climate change	Wang *et al.* (2009), Cavallaro and Ciaolo (2005)
11	Pollutant emission	Kahraman *et al.* (2009), Painuly (2001)
12	Need of waste disposal	Kahraman *et al.* (2009)
13	EPR	Aslani *et al.* (2012), Haralambopoulos and Polatidis (2003)
#	**Social**	
1	Social acceptability	Wang *et al.* (2009), Kaya and Kahraman (2010), Cavallaro and Ciaolo (2005), Kahraman *et al.* (2009), Painuly (2001)
2	Job creation	Wang *et al.* (2009), Kaya and Kahraman (2010), Kahraman *et al.* (2009), Haralambopoulos and Polatidis (2003)
3	Social benefits	Wang *et al.* (2009), Kaya and Kahraman (2010)
4	Political acceptance	Kahraman *et al.* (2009)

APPENDIX B: PAIRWISE COMPARISONS MATRICES

Table B.1. Pairwise Comparison Matrices

T3	T1	T2	T6
T1		2	1/4
T2			1/4
T6			

E1	ES1	ES2	ES3
ES1		1/3	2
ES2			3
ES3			

E2	T2	T4
T2		1
T4		

E4	T1	T2	T3
T1		3	1/4
T2			1/6
T3			

E4	E1	E2	E3	E5	E6
E1		6	4	4	2/5
E2			1	2/5	1/6
E3				1	1/5
E5					1/4
E6					

E5	T2	T4	T5
T2		3	5
T4			3
T5			

E7	E6	E8	E9
E6		4	5
E8			1/2
E9			

E8	E6	E9
E6		3
E9		

E10	T2	T3	T4	T5
T2		1/3	1/2	3
T3			3	5
T4				3
T5				

E10	E1	E2	E3	E4	E5	E6	E9
E1		5	5	5	7	1/3	2
E2			1	1	3	1/5	1/3
E3				1	3	1/5	1/3
E4					3	1/3	1/3
E5						1/5	1/3
E6							3
E9							

E10	ES1	ES4	ES5	ES7
ES1		1	2/5	1
ES4			1/2	1
ES5				2
ES7				

ES4	ES1	ES2	ES3
Emission Rates		2	4
Land use			4
Noise			

ES5	ES1	ES2	ES3	ES4	ES6	ES7
ES1		1/4	3	2/5	1/4	1
ES2			7	3	1	4
ES3				1/4	1/6	1/4
ES4					1/3	1
ES6						4
ES7						

ES7	T4	T5
T4		2
T5		

TECHNICAL	T1	T2	T3	T4	T5	T6
T1		1	1/3	3	5	1/3
T2			1/4	2	3	1/3
T3				5	7	2
T4					3	1/5
T5						1/7
T6						

ECONOMIC	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
E1		3	3	1	3	1/2	2	2	2	1/3
E2			1	1/3	1	1/5	1/2	1/2	1/2	1/5
E3				1/3	1	1/5	1/2	1/2	1/2	1/5
E4					3	1/2	2	2	2	1/3
E5						1/4	1/2	1/2	1/2	1/5
E6							5	5	5	1/2
E7								1	1	1/5
E8									1	1/5
E9										1/5
E10										

ENVIRONMENTAL & SOCIAL	ES1	ES2	ES3	ES4	ES5	ES6	ES7
ES1		1/3	4	1	1/3	1	1
ES2			4	2	1	2	2
ES3				1/4	1/5	1/4	1/4
ES4					1/2	2	2
ES5						3	3
ES6							2
ES7							

INVESTMENT DECISION	TECHNICAL	ECONOMIC	ENVIRONMENTAL & SOCIAL
TECHNICAL		1/3	4
ECONOMIC			7
ENVIRONMENTAL & SOCIAL			