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Comparative analysis on decision making in the case of nuclear power plant development in the Republic of Kazakhstan

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Comparative analysis on decision making in the case of nuclear power plant development in the Republic of Kazakhstan

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Abstract

Despite that almost all former USSR republics refused Soviet nuclear weapons, only Kazakhstan could reap the maximum of reputational benefits from this and make the nuclear-free status a part of its international reputation.

Being among largest producers and exporters of uranium in the world, Kazakhstan is directly interested in the development of the nuclear industry.

The abundance of uranium resources and the provision of continuous supplies of low-enriched uranium provides an additional incentive for the development of domestic nuclear programs.

As a result, the issue of necessity of a nuclear power plant in Kazakhstan is occasionally discussed in the government.

In this regard, there are many questions that have to be answered before the construction of the nuclear power plant could begin. This research tries to investigate and rank the assessment criteria and factors that should be taken into account for the construction of a nuclear power plant in Kazakhstan.

The methodology of this study consists of two steps: First, a detailed literature review is conducted in order to identify the assessment criteria and sub-criteria for government officials in decision making. The second step covers obtaining opinions from the experts in energy-related area. The collected information is analyzed using Analytic Hierarchy Process (AHP).

With the help of the AHP, the weight of each criterion and sub-criterion is calculated.

The results show that among all four criteria, the Economic criterion is the most crucial for decision makers from the Ministry for Investments and Development. On the other hand, the Environmental criterion is the most important among decision makers from the Ministry of Energy.

The Environmental criterion was assessed by the Ministry for Investments and Development as the least important factor in the construction of a nuclear power plant. Interestingly, both decision making groups did not assess the Socio-Political criterion as an important barrier.

Moreover, government officials from the Ministry for Investment and Development believe that Construction cost and Payback period are the most important barriers in the development of a nuclear power plant, however, Social Acceptance and Noise play only an insignificant role in the decision making. In the case of the Ministry of Energy, criteria such as Impact on environment and Land use are the most significant, while Efficiency and R&D were assessed with a low importance.

Key words: Analytic Hierarchy Process (AHP), Republic of Kazakhstan, Criteria, Decision making, Nuclear energy, Nuclear power plant.

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Chapter 1. Introduction

This section of the research contains a general introduction of this master thesis. It highlights the development of the energy sector in Kazakhstan, purpose of study, research motivation and research question and thesis structure.

1.1 Overall introduction

It is well known that today the most widely used energy sources are fossil fuels. However, the reserves of minerals are rather limited and quite unevenly distributed on the Earth from a geopolitical point of view. Also, energy sources such as wood are not efficient enough, and its wide use leads to an ecological catastrophe.

The nuclear industry is developing and expanding with about 50 reactors under construction ("Plans for New Nuclear Reactors Worldwide - World Nuclear Association," n.d.). Therefore, a promising direction for the development of energy systems in the nearest future will still remain nuclear power, despite the possible dangers associated with the use of radioactive materials as the main fuel of nuclear power plants.

There are some contradictions in case of dislocation of a nuclear power plant, on which the cost of the project will depend on. Both supporters and opponents of the expansion of the country's nuclear potential speak about the ecological aspect (ecological risks and environmental benefits of nuclear energy). Opponents appeal to the cases of Fukushima, Japan and Chernobyl, Soviet Union (Kim, Kim, & Kim, 2013), while supporters remind that nuclear energy with a proper use of its facilities results in zero emissions to the environment (Sims, Rogner, & Gregory, 2003).

Despite this discussion, the perspectives of nuclear power become more evident every year. Moreover, the results of research convincingly testify that the creation of sufficiently reliable nuclear power plants is quite possible today (Locatelli & Mancini, 2012).

The main content of the modernization of the nuclear sector in some countries in recent years has been the further development of new approaches to ensuring the safety of nuclear power plants.

Meanwhile, government officials and citizens cannot find consensus about the expansion of the nuclear industry which will satisfy both sides.

1.2 Development of the energy sector in Kazakhstan

The development of the nuclear industry in the Republic of Kazakhstan started after the Second World War. Irreconcilable and tough political contradiction between the USA and the USSR led to a new international conflict called “Cold War”. Driven by fears of the beginning armed conflict both sides initiated the nuclear arms race. Despite its terrible aims it led to discoveries in the scientific world and influenced economic development particularly in the Republic of Kazakhstan.

Among all the resolutions of USSR’s authority, the Decree of Council of Ministers of USSR #3434-1127 on August 21, 1947 plays the most meaningful role in a history of the Republic of Kazakhstan. Particularly, the Decree provided construction of the first nuclear center on Kazakhstan’s territory (“State archive of the East Kazakhstan region. Kurchatov,” n.d.). The realization of that project was planned in two stages by the year 1949. The first stage implied the processing of chemical concentrate with a capacity of 30 tons, while the second stage implied the processing of additional 20 tons.

Due to the strategic importance of the project, the authority of the USSR decided to found a satellite city. As a result, the town with the “closed” name Semipalatinsk-21 or Kurchatov was built back in 1947 (Figure 1). The city was named after the Soviet physicist Igor Kurchatov, who lived and worked there.

Figure 1 The location of the Kurchatov test site

Source: ("State archive of the East Kazakhstan region. Kurchatov," n.d.)

At the same time, the construction of the Semipalatinsk nuclear test site for testing developments in the nuclear area for the interests of the defense complex of the Soviet Union. The builders of the military were the first who arrived in the city. Almost simultaneously with the builders, scientists began to gather here. They lived in temporary houses, putting up with the discomfort of life.

The scope of work at the test site expanded involving more labor into its process. Kurchatov grew as well. Next to the constructed headquarters, dormitory and canteen, social facilities began to appear and be operated. From that period, it was no longer a military facility, as previously conceived, but a city with all its characteristics.

In those years, the best scientific and research laboratories, centers of physicians, biologists and mathematicians of the USSR were concentrated in Kurchatov. The test site functioned until the end of existence of the USSR.

In parallel with the construction of infrastructure in Kurchatov, in 1959, the country's authorities made a decision about the realization of a second nuclear project in Kazakhstan called BN-350. The reactor was intended to produce plutonium and electricity and the extraction of fresh water. As a result, in 1972, the first Soviet nuclear power plant (BN 350) with a fast neutron reactor was constructed in the city of Shevchenko ("BN-350, first nuclear power plant," n.d.). At that time, it was a major technological breakthrough. Besides generating electricity, the factory supplied drinking water to the Western region where there was a lack of such water.

For more than a quarter of a century, the first fast-energy neutron reactor BN-350 was operated until 1999. The experience of its operation was a confirmation of the scientific and technical ideas that were laid in it.

After the USSR's collapse in 1991, Kazakhstan's economy experienced heavy depression (Gleason, 1991). The country just recently got independence, as a result, international relations that linked the Republic with other countries were broken. Main indicator of economic activity – growth domestic product (GDP) had a negative trend until the year 1996 (see Table 1). Along with real GDP, the inflation rate reached almost 80% in 1991. That trend of GDP incline stopped only in 1998.

Table 1 Growth in Real GDP

	1991	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2002* (1989 = 100)
Growth in Real GDP	−11	−5	−9	−13	−8	1	2	−2	3	10	14	10	9	86
Inflation	79	1,381	1,662	1,892	176	39	17	7	8	13	8	6	6	

Source: ("International Monetary Fund Country Report No 03211, July 2003.pdf," n.d.)

This event was worsened by the fact that Kazakhstan's economy was based on raw materials' export, so the lack of efficient factories for the processing of primary products heavy dependence on other countries (Pomfret, 2005).

All this led to a decline in all economic sectors and a reduction in the total volume of production. The collapse of the USSR was accompanied by an increase in unemployment rate, inflation and devaluation of the ruble, deficit and the loosing previous economic relations. Total deficit became a normal sight. The historical event of the appearance of long waiting lines for food products and the introduction of a food card system in industrial cities continued. In all cities and rural areas there was an acute shortage of basic food products.

It became clear that without global structural transformations in the whole economic model, the national economy of Kazakhstan could not come out of the crisis. These and other obvious problems of the Republic of Kazakhstan's economy required urgent actions on the part of the government.

Accordingly, the USSR government took decisive methods to stabilize the economy of the country (Junisbai, n.d.). The adopted regulations included the refusal of governmental regulation of prices for basic foodstuffs and consumer goods, the bankruptcy of unprofitable companies and the privatization of governmental assets. Also, some measures were taken to liberalize the economy, such as removing barriers to the promotion of many goods, attraction foreign direct investment, etc. Over the next years, steps to build the institutional and legal framework for market relations and economic liberalization have continued.

In 1992, the Strategy for the Establishment of Kazakhstan as a Sovereign State was adopted. A distinctive feature of this document was the formation of a social market economy, taking into account the combination of state and private ownership. That strategy implied the transformation of all spheres of the economy in several stages (Junisbai, n.d.). Despite the fact that each stage consisted of manipulation on a certain industry, the strengthening of the country's energy sector was the main condition for each stage.

The fast switch from a planned economy to a market economy for Kazakhstan was accompanied by a deep economic crisis and could not pass perfectly (Pomfret, 2005). However, carrying out "shock" market reforms for the post-Soviet society was necessary on the way to a future exit from the created difficult financial situation and deep economic crisis. The continued devaluation of the ruble and the strong dependence on the foreign exchange issue from the neighboring state, which itself was not stable, led to the idea of the inevitability of the process of introducing a new national currency (Pomfret, 2005).

Figure 2 represents the consequences of continuous economic depression was a decrease of country's population influenced by massive emigration during the 90s (Pomfret, 2005).

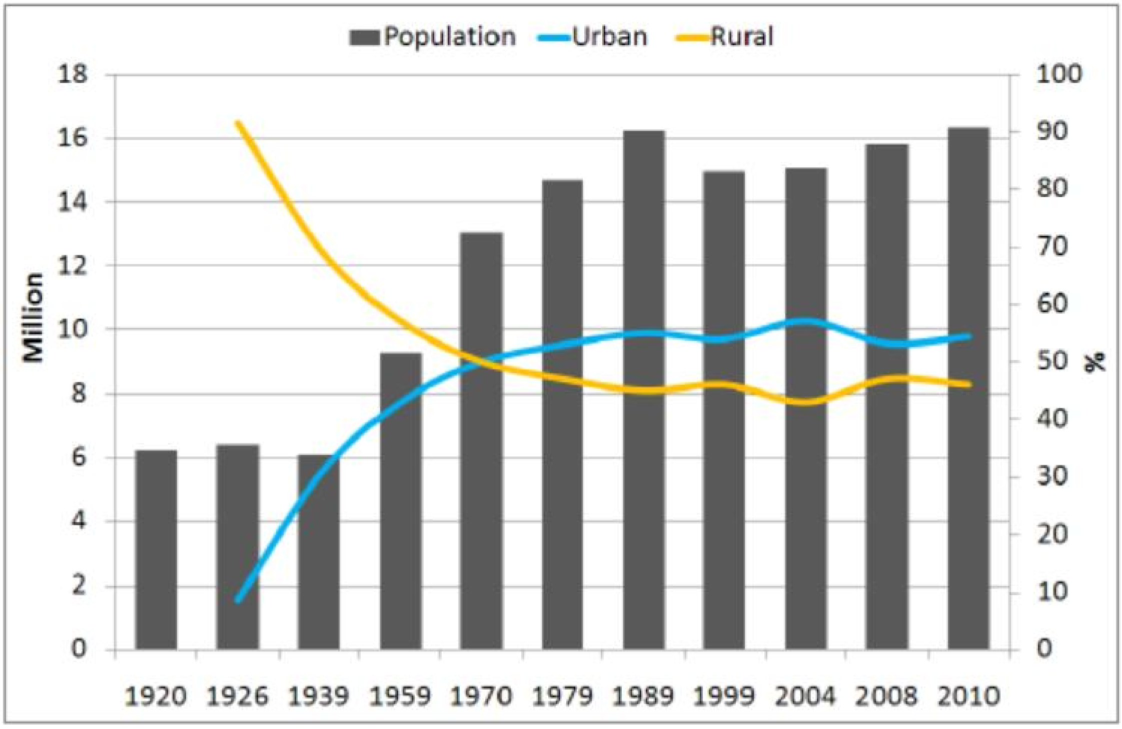

Figure 2 Growth in Real GDP

Source: (population census 1999, 2009)

Since the 00s, the Republic of Kazakhstan started recovering affected by high oil prices. As a result, there is a stable increase of oil production as well as of oil exports (Table 2).

Table 2 Oil production and oil export (1998-2002)

	1998	*1999*	*2000*	*2001*	*2002*
Oil production (mmt)	25.6	29.4	35.4	39.3	47.3
Oil exports (mmt)	20.4	23.7	29.4	31.7	39.5
Oil exports ($m)	1,650	2,164	4,429	4,463	5,157
World oil price ($/barrel)	13.1	18.0	28.2	24.3	24.9
Natural gas production (bcm)	7.9	9.9	11.5	11.6	13.1

Source: (International Energy Agency, 2018)

1.3 Energy sector in the Republic of Kazakhstan

Today, energy became a key factor of the economic progress and it influenced the level of welfare of all people. Development of energy sector causes directly on to the all sectors of economy. Global energy demand during the last 10 years demonstrates a stable growth trend by 2,1% per year (Figure 3). Moreover, such trend will continue in the nearest future (Suganthi & Samuel, 2012).

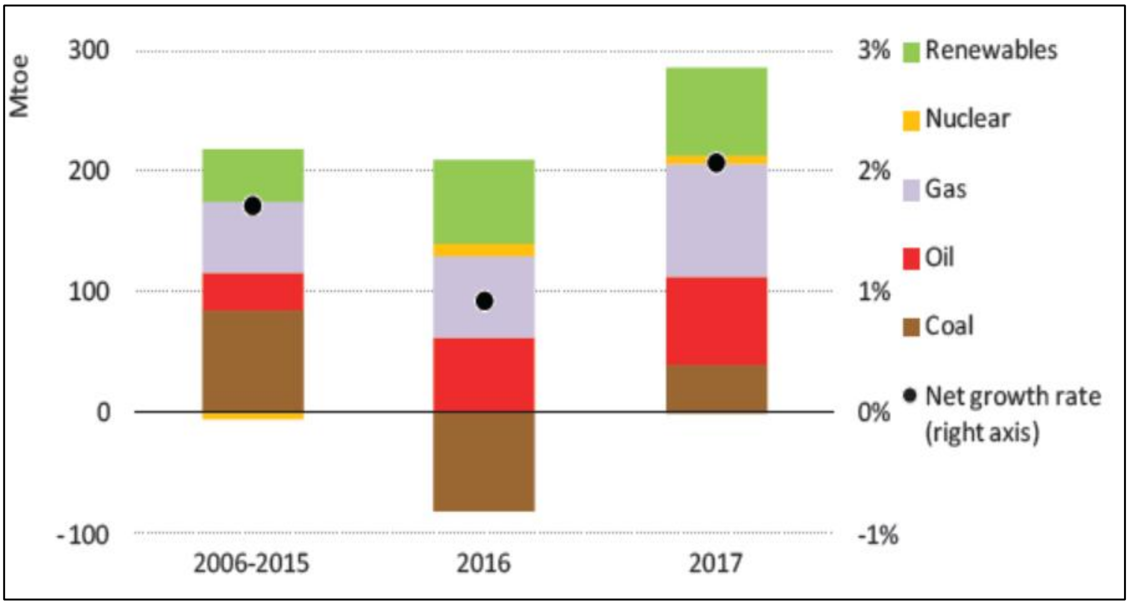

Figure 3 Energy demand world-wide

Source (IEA, 2018)

Kazakhstan is not an exception in this competitive environment and it is a participant with dependency on fossil fuels.

Prior to describe energy sector in Kazakhstan it should be noted the disconnection of the whole power grid is the main problem of Kazakhstan's government. Domestic energy sector considered to be classified into two largest areas: Central and Northern regions. It includes Akmolinskiy region, East Kazakhstan region, Karaganda region, Kostanay region and Pavlodar region (Figure 4).

Figure 4 Kazakhstan's energy grid

Source: ("Map of Kazakhstanian Electricity Grid - Kazakhstan - National Energy Grids - Library - GENI - Global Energy Network Institute," n.d.)

Nowadays Kazakhstan is considered an upper middle income country (Karatayev & Clarke, 2014).

Generally, the central budget of Kazakhstan highly effected by the income from the export of natural resources such as crude oil, gas, uranium and coal (Table 3). The Republic of Kazakhstan is certainly abandoned in natural resources, in other words, the entire periodic table can be found on the territory of Kazakhstan. The constantly increasing demand for energy resources in the nearest future will lead to the fact that the amount of natural resources will decrease and at the same time the ecological situation will worsen.

Table 3 Kazakhstan's share of GDP

	1993	1998	2002
Share of GDP			
Industry	28.7	24.4	29.3
Agriculture	16.4	8.6	7.9
Construction	8.3	4.9	6.1
Transport and communication	10.0	13.8	11.5
Trade and catering	7.9	15.2	12.0
Other (mainly services)	28.8	33.2	33.1
Share of industry			
Manufacturing		55.1	44.5
— ag. processing	(11.4)	(20.6)	(13.4)
— metallurgy	(23.9)	(18.7)	(17.3)
Mining	15.7	24.3	46.5
— coal		(3.3)	(1.4)
— petroleum		(14.6)	(38.2)
Electricity, gas and water	14.4	20.7	8.7

Source: ("International Monetary Fund Country Report No 03211, July 2003.pdf," n.d.)

The energy sector in Kazakhstan is a fundamental sphere for the economy of the country. Stable and reliable functioning of whole system and sustainable supply of electricity are the main aims of Kazakhstan's economy.

The Republic of Kazakhstan is a rich country in terms of energy resources. Such common types of fossil fuels as crude oil, natural gas, coal and uranium are in abundance. This condition predetermined Kazakhstan as an export-oriented country and benefits by selling mineral resources (79% of country's exports are minerals, while the share of industrial goods is decreasing annually) (Figure 5).

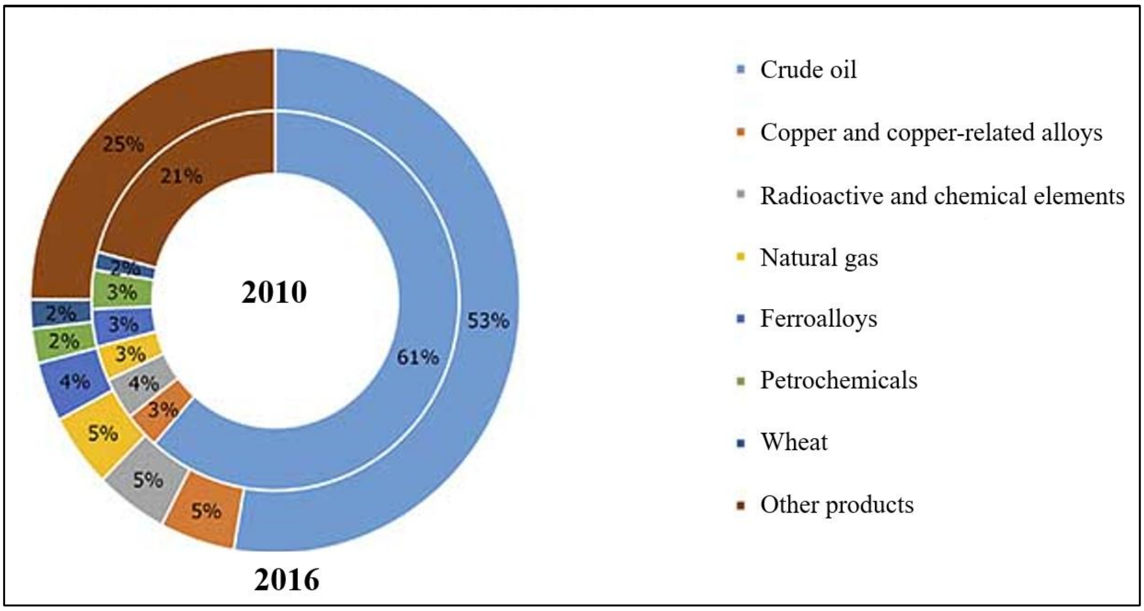

Figure 5 Export's structure in Kazakhstan (2010 and 2016)

Source: ("Export strucrure of the Republic of Kazakhstan," n.d.)

Before 2010 and after 2013, Kazakhstan was a net electricity exporter, however between 2010 - 2013 it was a net importer as the country consumed more electricity than produced. The electricity produced on Ekibastuz GRES-1 in the Northern part of Kazakhstan is transmitted to the Russian Federation, while due to the deficit of electricity in the Southern areas, electricity is imported from the other countries such as Uzbekistan and Kyrgyzstan.

Total capacity of Kazakhstan's energy sector is 20 thousand MW which generates 92 billion KWh of electricity per year.

In 2017, the share of coal consumption was about 54% of primary energy consumption in Kazakhstan (Figure 6). The share of oil and natural gas is about 14,6% and 14% respectively. The share of hydro is approximately 4% of total primary energy consumption. However, the share of renewable energy sources is insignificant about 0,1%. Thus, power plants based on fossil fuel cycle generate 99.9% of electricity, while "green" technologies produce less than 0.1%.

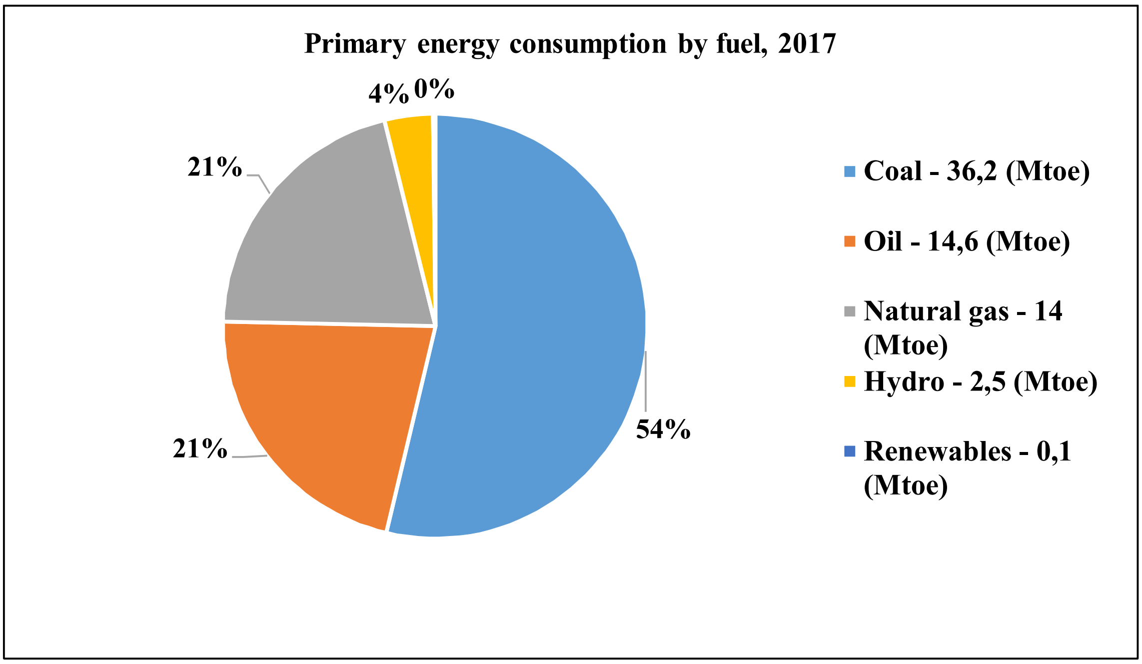

Figure 6 Primary energy consumption in Kazakhstan

Source: (BP Statistics, 2018)

All existing power plants in Kazakhstan are classified into national power plants, industrial power plants and local power plants (Figure 7). Major national power plants are large thermal power plants that supply, distribute and sell electricity to consumers on the wholesale electricity sector of the Republic of Kazakhstan:

- Ekibastuz GRES-1 (4 billion KW);
- Ekibastuz GRES-2 (1 billion KW);
- Aksu GRES-1 (2,1 billion KW);
- Kazakhmys GRES-1 (1,2 billion KW);
- Zhambyl GRES (1,2 billion KW).

Among national power plants there are also hydro power plants. The electricity from hydro power plants is used to regulate peak load on the national grid.

- Bukhtarminskaya HES (0,7 billion KW);
- Oskemen HES (0,3 billion KW);
- Shulba HES (0,7 billion KW).

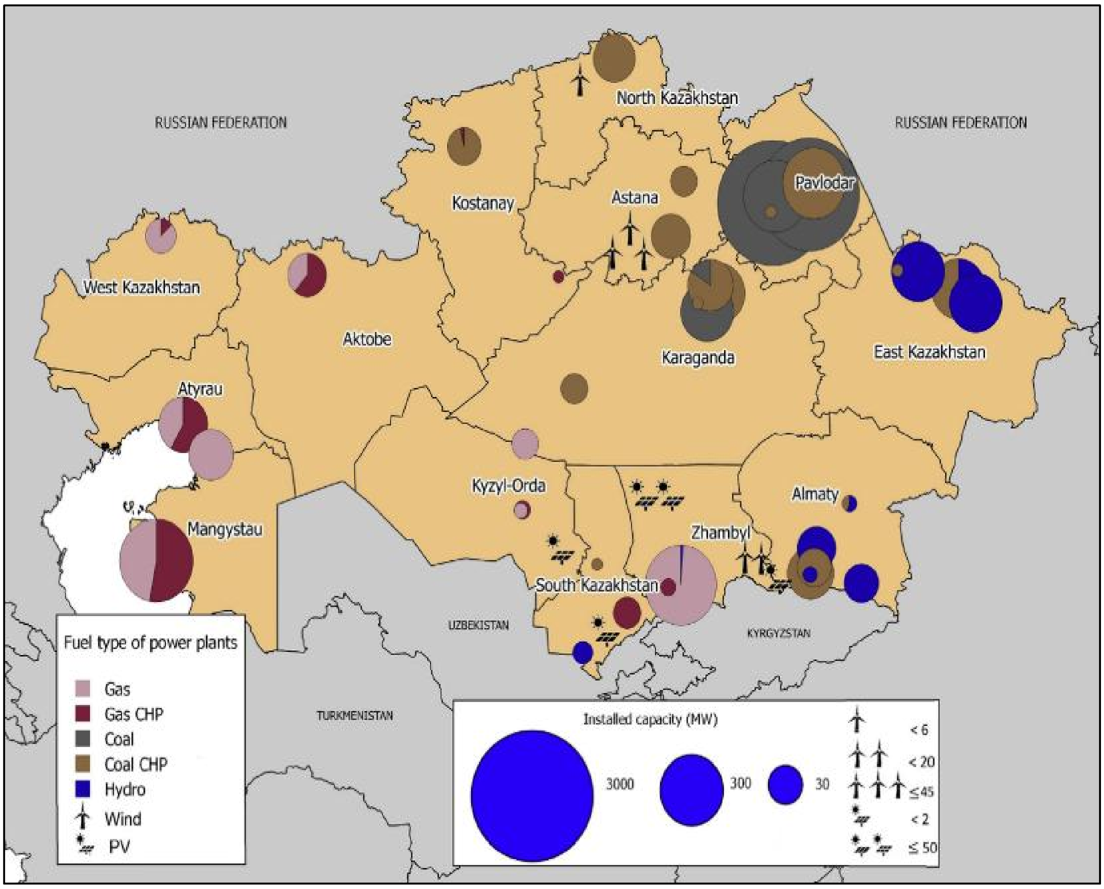

Figure 7 Power plants in Kazakhstan

Source: (Assembayeva, Egerer, Mendelevitch, & Zhakiyev, 2018)

The power plants of industrial importance include the Central Heating Power Plants (CHP), with combined production of electric and heat energy, which serve for electric heat supply of large industrial enterprises and nearby settlements:

- CHP-3 Karaganda-Zhylu;
- CHP-2 Arcelor Mittal;
- Rudnenskaya CHP;
- Kazakhmys CHP;
- Pavlodar CHP-1;
- Shymkent CHP-1,2.

Power plants of regional importance are CHP integrated with the territories that supply electricity through the regional electric grid companies and energy transmission organizations, as well as the heat supply of nearby cities.

1.4 Purpose of study

Nuclear energy plays a significant role in many developed countries. Nowadays, around 450 nuclear power plants are operated (Figure 8). It is generally understood that nuclear energy is considered ambiguously. Some people believe that nuclear power energy is a potentially dangerous and unreliable source which people cannot control in unpredictable situations. On the other hand, there are many papers and tests that show a so called “nuclear renaissance” (Goodfellow, Williams, & Azapagic, 2011).

In the case of Kazakhstan, there are two major regulatory bodies responsible for the energy sector: The Ministry of Energy takes care of the management of the energy cluster, while the responsibilities of the Ministry for Investments and Development are providing favorable assistance of strategic projects and managing the investment climate in Kazakhstan. Accordingly, prior to project realization it is necessary to compare the point of views of main performers.

Thus, analyzing the difference between two regulators based on the weight of each criteria is the main purpose of this study.

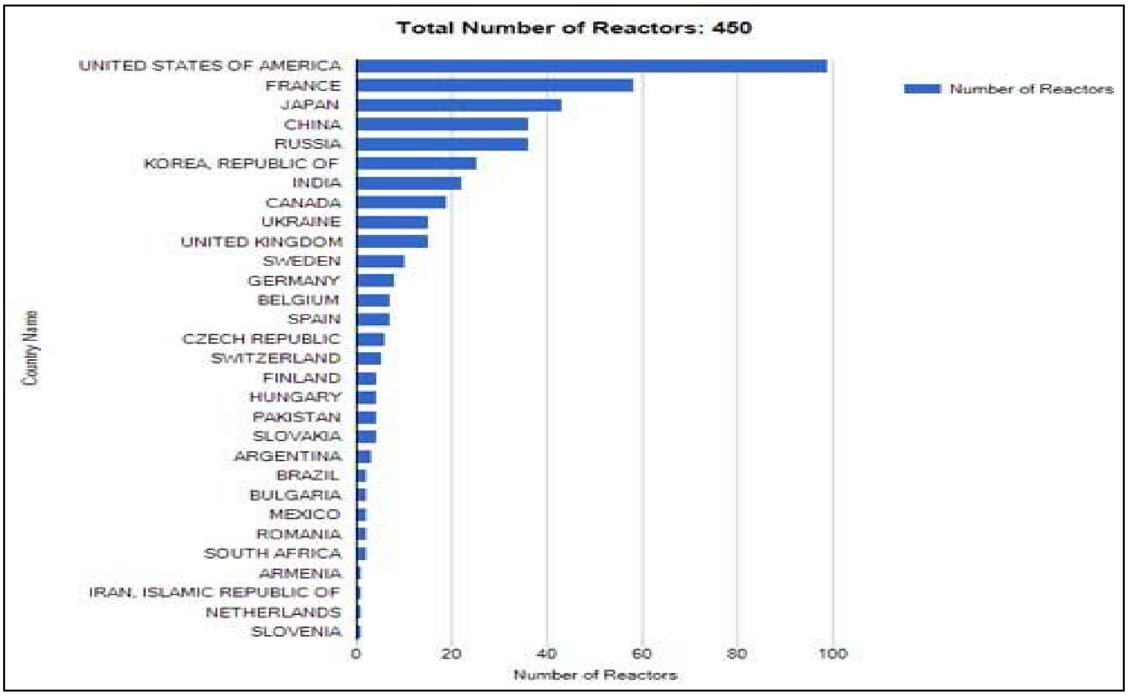

Figure 8 Nuclear power plants world-wide

Source: (World Nuclear Association, n.d.)

One of the most important reason to discuss about nuclear project is the president's decree from January, 2014. Affecting by the future increase in energy deficit and Kazakhstan's advantageous position in the nuclear industry, Kazakhstan has to develop its own nuclear sector ("Address of the President of the Republic of Kazakhstan to the nation," 2014). 2014 is considered to be the starting point of a new era for Kazakhstan.

Another evidence of the importance of nuclear energy is its international expansion. More than 10% of electricity is generated by nuclear power plants (World Nuclear Association, 2018). Figure 9 represents the amount of electricity produced by nuclear power plants worldwide in 2016. Nearly 2500TWh of electricity were produced by 450 nuclear power plants. These days, almost 60 nuclear power reactors are in the construction stage in the world. Moreover, countries are planning to expand the number of new reactors by around 160 new power plants in the nearest future, which will generate additional 50 % of generated electricity (World Nuclear Association, 2018).

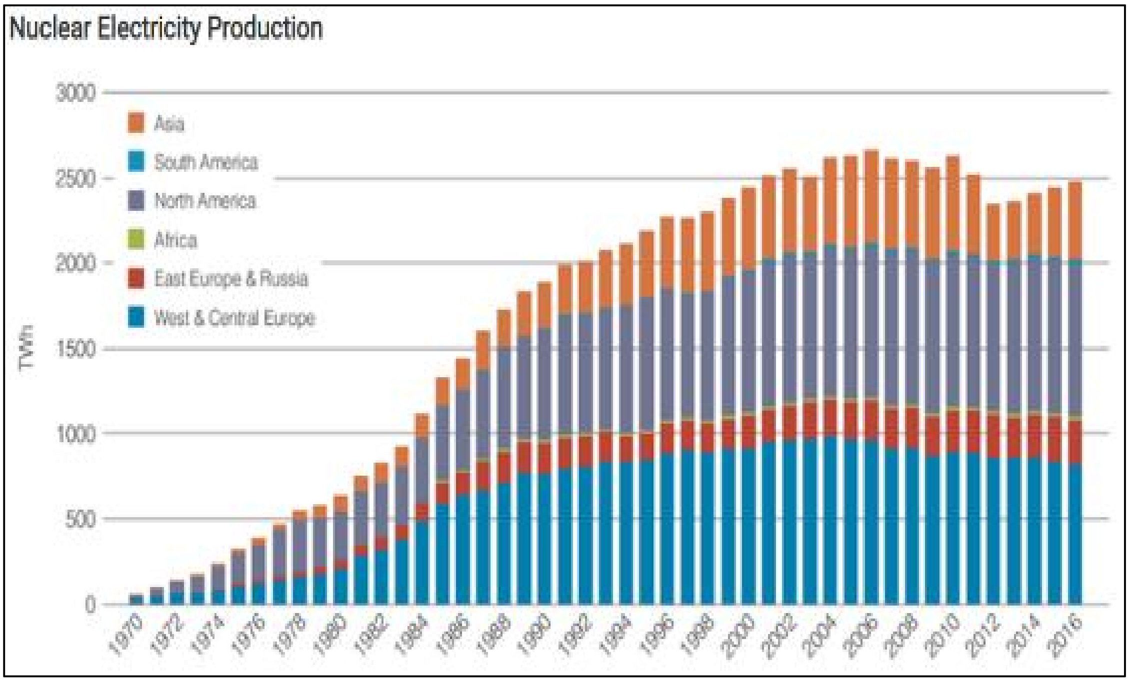

Figure 9 Electricity produced by nuclear power plants world-wide

Source: (World Nuclear Association, n.d.)

The second not less important aim of this study is to provide comprehensive suggestions for policy makers to help them in decision making cases. Ranking barriers can help policy makers to understand explicit gaps in order to operate nuclear projects taking into account those factors.

When we think about nuclear energy, we have to mention giant capacity. As we can see on Figure 10, the capacity of uranium is three times higher than that of other fossil fuels such as coal or crude oil. Related to 1 kg of energy source, uranium-235 is equal to 2-3 billion times of the energy equivalent of oil or coal ("Fuel comparison, nuclear power plant," n.d.).

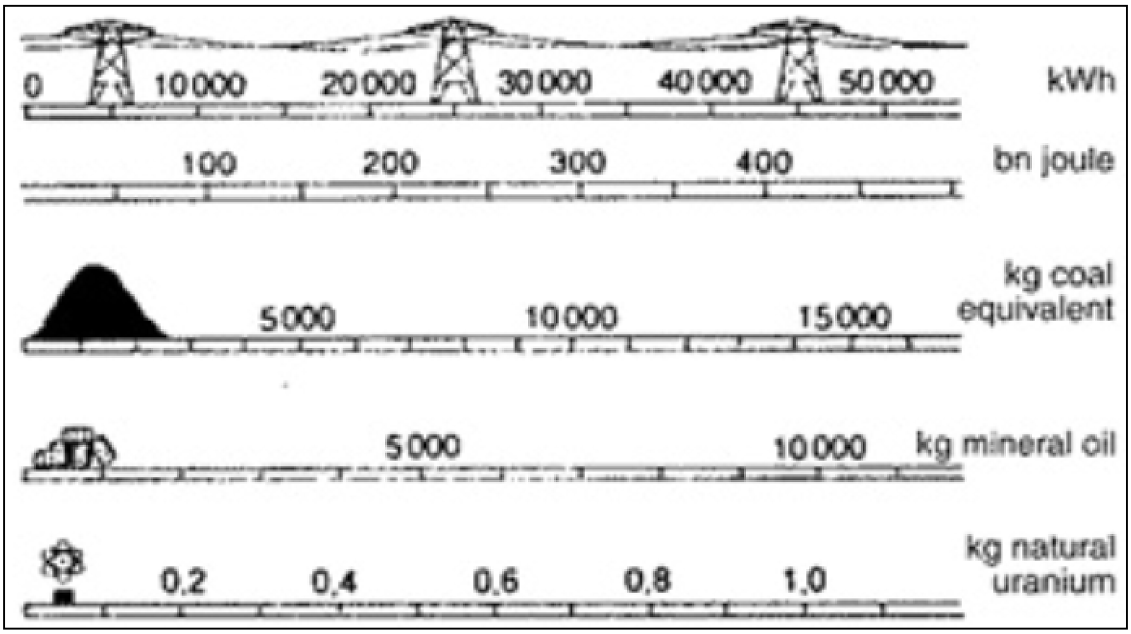

Figure 10 Comparison of the input volumes of various primary energy carriers for the generation of a certain quantity of electricity
Source: (European Nuclear Society, 2016)

Another important issue about uranium is that it does reduce CO2 emissions (Figure 11). Today, a reduction of global warming is considered as the priority task which should be accomplished by all nations around the world. Nuclear energy emits 40 to 100 times less CO2 than currently combusted fossil fuels, also less than some RES such wind, hydro and biomass (Breeze, 2017).

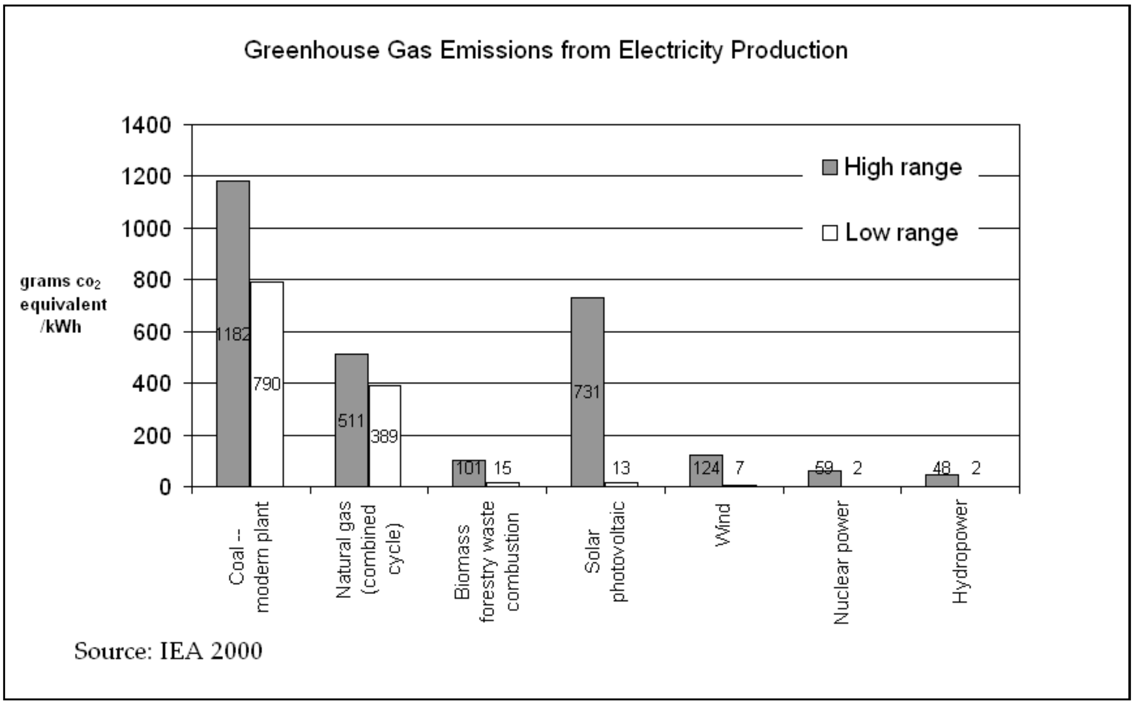

Figure 11 CO2 emissions for different energy sources

Source: (IAEA, 2000)

Despite the fact that currently there is no economic feasibility for the nuclear project, the government decided to consider the possibility of it. Thus, the project for the construction of plants for the deep processing of uranium ore and the creation of nuclear products of high added value remains relevant. Developing the nuclear sector will contribute to the escape of Kazakhstan from being a simple supplier of nuclear uranium raw material to joining the more technological and advanced side of the industry.

Moreover, facts such as growth of population and economic development require a stable supply of electricity and heating (Locatelli & Mancini, 2012). In addition, traditional fossil fuels such as coal, crude oil and natural gas are limited and many scientists predict the end of fossil fuels' era. All these factors made Kazakhstan's government consider about an alternative scenario for the modernization of outdated energy facilities and further development of the energy sector.

The government has been assigned the strategic task of accelerating the pace of economic development in Kazakhstan, primarily due to the large-scale introduction of high-tech and knowledge-intensive industries, which would be a reliable foundation for the sustainable development of the economy.

Among the most important areas the government set energy resource development and the creation of the foundations of nuclear energy. Establishing the nuclear sector will lead to engaging a complex of cutting-edge technologies based on revolutionary development and international standardization which will increase the competitiveness in the global market.

Kazakhstan's growing economy requires fundamentally new approaches of development and management of fossil fuels and the establishing of nuclear energy.

Considering that this is complex and expensive project that will be implemented over a long time, the analysis of possibility of establishing the nuclear project should be done carefully taking into account all the risks and benefits.

An interesting point of view about considering uranium as a renewable energy source was presented by (Cohen, 1983). The author analyzed nuclear and solar energy over its life time. Professor Cohen believes that the lifetime of the sun is about 5 billion years, in this case solar energy is renewable until the existence of the sun ceases. In this case, nuclear energy can be considered as a renewable source due to its reusability and ability to supply the world for 5 billion years, just as solar energy does.

It is obvious that the Republic of Kazakhstan has a potential in developing the nuclear sector. On one hand, there are advantageous conditions related to geological benefits – reserves of uranium. On the other hand, there are numerous obstacles in the way of a nuclear power plant's construction and in developing the domestic nuclear sphere (Dittmar, 2012).

The main purpose of this study is to determine the main barriers for policy makers in the decision making process for the construction of the nuclear power plant.

1.5 Research motivation

The energy sector, being one of the fundamental unit of the economy plays a crucial role in the economic, social and political spheres of all countries and Kazakhstan is no exception. In the next decades, huge structural and technological changes are expected in the world and Kazakhstan should prepare for the new challenges. The motivation of this study is to highlight the most acute gaps of the Kazakhstan's electric power industry.

Among all the problems which the Republic of Kazakhstan faces, some should be resolved in the nearest future. For example, Figure 12 shows the primary energy consumption in Kazakhstan during the last 16 years. As we can see, there is a stable increase in energy consumption in the Republic of Kazakhstan from the year 2000. According to experts' estimates, the existing power plants will experience challenges which will cause the electricity supply for a long time (Atakhanova & Howie, 2007). Thus, in the event of failure to take measures for rehabilitation, reconstruction of existing generating facilities and construction of new generating capacities, there is inevitably a deficit of energy and capacity in the Northern and Southern zones of the single electric power system of Kazakhstan. Another significant challenge of the domestic energy sector is an increase of dependency of the Western region on the foreign supply of electric power.

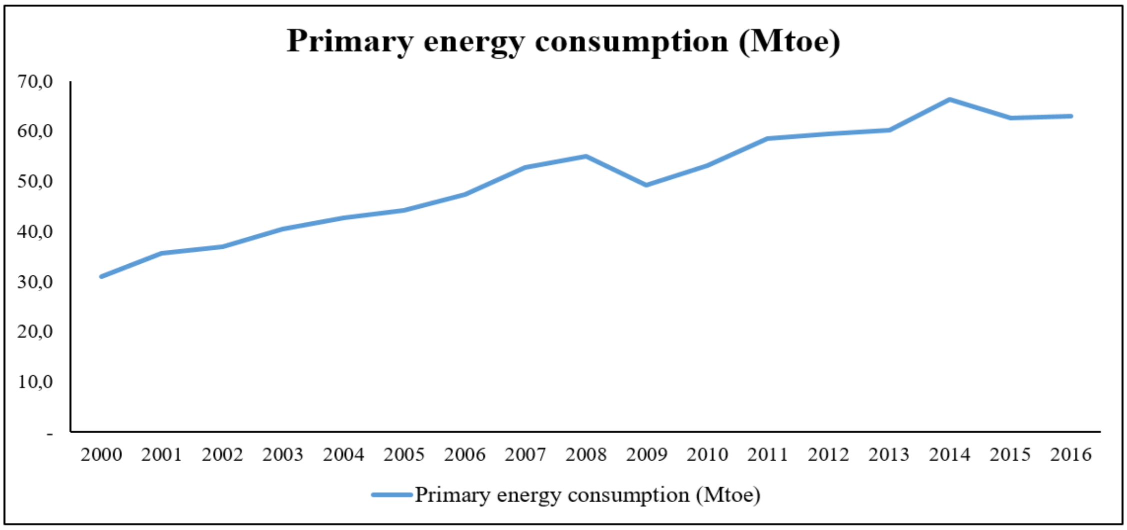

Figure 12 Primary energy consumption in Kazakhstan

Source: (International Energy Agency, 2018)

Analyzing the weight of each barrier to the nuclear power plant's construction is one of the main objective of this thesis. From the intensive literature review, I highlight 4 main barriers for the development of the nuclear industry and within these 4 criteria, there are 12 sub criteria. Using criteria and sub criteria a hierarchy chain was compiled.

Another significant objective of this thesis is to conduct the ranking of barriers based on respondents' answers.

Ultimately, this study also provides suggestions for policy makers based on the results of the survey and the ranking of barriers.

1.6 Research questions and thesis structure

This thesis aims to answer the following research questions:

1) What is the weight of each barrier?

2) Is there any difference in the attitude of policy makers between the Ministry of Energy and Ministry for Investments and Development in a case of construction nuclear power plant?

The outcomes of this study can be used for future decision making in Kazakhstan. Based on the results, the suggestions for the policy makers are provided in order to develop nuclear sector and modernize current energy system.

This thesis consists of six chapters (Table 4).

Chapter 1 covers the general introduction of the analyzed topic and the development and current status of energy sector in the Republic of Kazakhstan. Purpose of study, research motivation and research questions are also discussed in Chapter 1.

Chapter 2 consists of the information covering literature review, precise explanation of the AHP, pros and cons AHP and previous studies.

Chapter 3 represents the results of the consistency tests.

Chapter 4 presents the results, weights of each criteria and global priorities.

Chapter 5 contains the conclusion and study limitations

Table 4 Structure of the present thesis

Chapter	Title	Information
Chapter 1	Introduction	Brief overview, Kazakhstan's energy sector
Chapter 2	Methodology	Existing literature about the topic
Chapter 3	Model and Data	Previous studies and results of consistency tests

Chapter 4	Results of AHP	Results of calculated weights of AHP and comparative analysis
Chapter 5	Conclusion	Conclusion, policy implications and limitation of study

Chapter 2. Literature review and methodology for comparative analysis

This sections covers the information about literature review, AHP method and its application, basic concept of barriers related to the construction of nuclear power plants and description of each criterion.

2.1 Literature review

Nowadays, in a routine life people face decision making processes every day. Some decisions can be accepted automatically without deep understanding, while others need to be carefully understood by decision maker in order to choose the best variant among provided options. Good examples of decision making processes are a management board of a company which has to determine the best development strategy among some options, a typical consumer who should buy the best product in the supermarket or a government official who is responsible for a particular project and should choose best option.

Such decision making processes need specific technique in order to analyze priority weights of each category, rank them and choose the most appropriate one. Sometimes such complicated process can be done very quickly without mathematic calculations in our daily life, however complex and serious decisions should be carefully analyzed and proved by calculations.

Decision making in management of governmental projects is a sophisticated and very often unstructured process which relies on fragmented substantiations and estimated guess. This evidence-based practice is usually based on evidence provided by the project initiators (Lee & Chan, 2008).

Simultaneously, a large number of disparate and sometimes ambiguous evidence do not simplified decision-making process, vice versa it aggravates decision making process. Thereby, it seems essential to take into account an existence of well-ordered influence of certain evidence on the decision-making process. So, it is very complicated to determine ideal results among all possible options (Lindskog, Cato, & Sjoblom, 2008).

Prior to discuss about AHP, the large group of related methodologies called Multi-Criteria Decision Analysis (MCDA) should be describe. A group of similar methods belongs to MCDA which is deeply observed by many researchers such as Kolios et al. (2016) and Peng et al. (2015). MCDA methods are useful in order to identify important decisions which cannot be directly calculated (Lee & Chan, 2008). Today, there is a variety of transformations of MCDA methods. Depending on the purpose of study various MCDA methods could be applied. Thus, the MCDA can be defined as a method supporting and facilitating the process decision making as an approach based on using multiple criteria and providing choice of one or another alternative.

The MCDA is a mathematic tool of systematic approach with psychological and marketing parts for the decision making process. A diversity of the MCDA allows people to use this method in many areas such as social aspects or policy making (Guitouni & Martel, 1998). In other words, the MCDA is a complex of decision methods which allows to consider many criteria taking into account the importance of each factor.

In the tasks of MCDA, an essential role play the preferences of the decision makers (Thokala & Duenas, 2012). The MCDA does not prescribe to the decision maker any right or wrong decision, but allows him to find an option among those considered that best fits his understanding of the nature of the problem and the requirements for its solution.

The main advantage and distinctive feature ensuring maximum transparency of decisions in of the MCDA is the translation of qualitative criteria described by values of various types and scales into quantitative values (weights). This leads to a possibility of comparing completely heterogeneous alternatives by comparing their weights. The main functions of the MCDA are the ranking of alternatives or the assignment of alternatives to one or another category.

Through literature review, several problems with the implementation of the MCDA are identified.

Providing comprehensive description of each factor is a problem which has to be solved in an initial stage of the MCDA. The main reason of this is providing deep explanation of each criteria and sub criteria to the decision makers (Wallenius et al., 2008).

Problem of sorting is one of the most significant factor due to its fundamentality (Zopounidis & Doumpos, 1999). This group of problems includes factors that are grouped based on corresponding characteristics. A good example of this group of problems is a judgement of a movie which is analyzed by its genre such as comedy, action or horror. An essence of sorting group can be explained by the need of limitation the number of choices.

Problem of choice is another factor which allows to understand the purpose of choice. Obviously, we may suppose that a decision maker makes his decision in order to maximize a value that depends on the criterion (Wallenius et al., 2008).

Another group of problems is a ranking challenges. In this group the chosen criteria and sub criteria are ranked based on weights through pair-wise comparison from the weakest to the most significant (Wallenius et al., 2008).

Moreover, except these four main groups of problems related to the MCDA, there problems which are also explained in some papers such as real-world problems and elimination problems. Real-world problems can be explained as difficulty of getting real point of views of decision makers excluding psycho-emotional factors (French, 1993). On the other hand, elimination problem is a modification of the problem of sorting.

Qualitative component of the MCDA allows to develop decision support tool (i.e. ranking alternatives or assigning alternatives to one category or another) based on a preliminary assessment of the relative importance of various criteria (weights of criteria) and taking into account their values, also expressed quantitatively (Kolios et al., 2016).

The development of a quantitative factor of the MCDA methodology for solving a specific problem includes the defining a set of criteria that are then combined into a single mathematical function, weighting vectors for selected criteria, scales for measuring the values of each of the criteria, the method of classifying the assessment obtained for each solution to the appropriate level of priority (Podinovski, 2002).

According to Guitouni & Martel (1998), MCDA methods are divided into 4 Elementary methods, Single synthesizing criterion, Outranking methods and Mixed methods. Among them, methods of Single synthesizing criterion group are more popular. Table 4 represents various methods of Single synthesizing criterion group of MCDA.

Table 5 Types of the MCDA

Method	Description
TOPSIS (technique for order by similarity to ideal solution)	Selected alternatives should be similar to the ideal and negative options
MAVT (multi-attribute value theory)	In order to determine global priority V it is necessary to aggregate partial values of criteria. In some cases, global priority V can be resulted from multiplicative, additive or mixed manner
ELECTRE	Criterion among other alternatives should be co mpared by method of "outranking relationship
UTA (utility theory additive)	An estimation of total value of each factor through ordinal regression. The global priority function is determined in addicted manner
SMART (simple multi-attribute rating technique)	SMART is a useful tool for implementation an multi attribute utility theory through weighted li near averages. The result allows to obtain precis e results to utility functions. There are several si milar modifications such as SMART or SMART ER, etc.
VIKOR	Ranking based on compromise solution
MAUT (multi-attribute utility theory)	In order to calculate an aggregation of the values it is essential to assess partial utility functions of each criterion. It will resulted the global utility function U. In some cases, global utility function can be

	determined using distributive or multiplicative ways
EVAMIX	EVAMIX allows to determine ordinal and cardinal evaluations of the factors. In order to determine domination rate between pair of factors it is useful to combine ordinal and cardinal evaluations
Fuzzy weighted sum	Fuzzy weighted sum method requires to use a-cut technique. Such unusual sets are necessary in order to calculate fuzzy utility function.
Fuzzy maximin	Fuzzy maximin method is a modernization of the standard maximin method where the evaluation of alternatives are fuzzy numbers
AHP (Analytic hierarchy process)	Analytic hierarchy process method allows to ass ess the relative importance of each criterion. AH P requires pairwise comparison way in order to measure relative importance.

Source: (Guitouni & Martel, 1998)

The TOPSIS method determines results having small space to the best result and the highest space of negative-ideal solutions. The minus of TOPSIS can be an absence of relative importance of distances.

MAVT method assumes about possible existence of value function U of decision-making. The results of application MAVT is the ranking of criteria based on the judgement of f unction U. An evident results shows. The axiomatic analysis shows an independence among pr eferences of decision makers. Significant flaw of MAVT can be Allais paradox.

Another widely used method ELECTRE belongs to MCDA family. The best application of EL ECTRE is a social choice theory (Guitouni & Martel, 1998).

UTA methods are based on regression approaches were modernized from the commonly used MAVT technique. Nowadays, UTA is considered as preference disaggregation method. In classic aggregation theory main aggregation model plays significant role. On the other hand, disaggregation based models implies separate manipulation of preference methods and global preferences (Siskos, Grigoroudis, & Matsatsinis, 2005). UTA models allows decision makers add functions from proposed options (Zopounidis & Doumpos, 1999).

SMART (simple multi-attribute rating technique) another MAUT based method. Main idea is to estimate ‘utility and preferential independence (Chen, Okudan, & Riley, 2010). SMART is a user-friendly method for decision makers, however cons of SMART can be complicated calculations (Konidari & Mavrakis, 2007).

VIKOR allows to conduct ranking based on compromise solution rule for “majority” and a minimizes individual opinion (Opricovic & Tzeng, 2004).

MAUT (multi-attribute utility theory) allows decision makers structuring hierarchy form of a problem and evaluate them.

EVAMIX divides cardinal and official data in the original matrixes. Its algorithms are suitable for all levels of hierarchy. Based on pairwise comparison, EVAMIX allows to determine scores for each criterion (Hajkowicz, 2007).

Fuzzy weighted sum method based on Pareto optimal set. Despite the Fuzzy weighted sum method user friendly, it allows to use only linear approximation of function (Marler & Arora, 2010).

Fuzzy maximin methods works when interpretation of fuzzy series using. Fuzzy maximin method is useful if its application is used in assessment fuzzy sets as flexible measurement without an ability of replacement each other (Dubois, Fargier, & Prade, 1996).

AHP method based on pairwise comparisons in order to determine decision-making criteria (R. W. Saaty, 1987; T. L. Saaty, 1994, 2008b; T. L. Saaty & Takizawa, 1986). AHP is can be applied in many areas, however collecting a data is complicated. Thus, among all methods listed in the table, the AHP is the widely spread due to its fulfillment, quality of results and strict structure (Bryson & Mobolurin, 1997).

2.2 The Analytic Hierarchy Process

In the case of the AHP, there are no general rules for forming the structure of the decision-making model. This is a modification of the actual situation of decision-making process, because always for the same problem there is a whole spectrum of opinions. The AHP allows to consider this circumstance with the help of constructing an additional model for reconciling different opinions, by determining their priorities (R. W. Saaty, 1987). Thus, the method allows to take into account the "human factor" when preparing a decision. This is one of the important advantages of the AHP method over other decision making techniques.

Formation of the structure of the AHP is a rather complicated process. However, as a result, it is possible to get a detailed idea of how exactly the factors influencing the decisions. It becomes clear how exactly are the ratings of possible decisions and ratings reflecting the importance of factors (Al Khalil, 2002). The procedures for calculating ratings in the AHP are quite simple, which distinguishes this method from other decision-making methods.

Data collection to support decision-making is mainly carried out using a pairwise comparison procedure (T. L. Saaty, 1980). The results of pairwise comparisons can be contradictory. (The method provides great opportunities for identifying data inconsistencies.) However, it becomes necessary to revise data to minimize inconsistencies. The procedure of pairwise comparisons and the process of revising the results of comparisons to minimize contradictions are often time consuming (T. L. Saaty, 1977). However, finally, decision maker becomes confident that the data used is quite meaningful.

As part of the AHP there is no purpose to confirm the data. Such fact is important drawback, limiting in part the possibilities of applying the method. However, the method is mainly used in of there is no objective data and the motives for making decisions are people's preferences (Wang, Jing, Zhang, Zhang, & Shi, 2008). Simultaneously, the procedure of pairwise comparisons for data collection has practically no worthy choices. If the data set was assessed by well qualified applicants and significant contradictions in the data are absent, thus, the degree of such data set is considered as satisfied (Kahraman & Kaya, 2010).

The scheme of application of the AHP approach is completely independent of the sphere of activity in which the decision is made. Therefore, the AHP technique is universal and can be applied widely. Such assessment allows user to systemize an assessment of decision process.

Decision making process is often too much labor intensive for one person. A model created using the AHP method always has a criteria structure (T. L. Saaty, 1977). The application of the AHP allows to build a large task into a number of small independent tasks. Therefore, it is possible to involve experts working independently on each other for local tasks to prepare a decision. Experts may not know anything about the nature of the decision which is partly conducive to preservation. In particular, it is possible to keep secret information about the preparation of the decision (T. L. Saaty, 1980).

The AHP method gives only a method of rating alternatives, but does not suggest internal means for interpreting ratings, i.e. it is considered that a person making a decision, knowing the rating of possible decisions should make a conclusion depending on the situation. This should be recognized as a disadvantage of the method (T. L. Saaty, 1990).

In fact, the AHP method can serve as an add-on for other methods designed to solve poorly formalized problems, where human experience and intuition are more appropriately suited than complex mathematical calculations. The AHP provides convenient tools of accounting for expert information for solving various problems.

The AHP method reflects the natural course of human thinking and gives a more general approach than other methods. It provides not only a way to assess the most preferred option, but also allows quantitatively expressing the degree of preference through rating. This contributes to the full and adequate identification of the priority of the decision maker. In addition, the evaluation of the inconsistency measure of the data used allows to establish the degree of confidence in the result obtained (T. L. Saaty, 1977).

After scrupulous literature review the AHP was selected and adopted based on the main purpose of this study. The logical four steps plan is used in order to explain the process of applying the AHP.

2.3 Why the Analytic Hierarchy Process?

Nowadays, group discussion is still most commonly used approach in resolving problem situations. The evaluator often consciously or subconsciously have to use methods designed for expert analysis. It's obvious that through brainstorming people can express their personal point of view and come to consensus (Cray & Inglis, 2011). However, there are some controversial moments such as time consuming or other factors have to be covered.

It is common situation when people in decision making chose one option instead another one taking into account intuitions based on his/her personal knowledges and experience. In this case, such decisions are indefinite, inefficient and informationally not completed. As a result, the question "How to make the decision-making process right and effective?" is opened.

In governmental management, economy or telecommunications, the design process is often associated with considering two or more options for project implementation and choosing the best option among others (Gasparatos & Scolobig, 2012).

The choice of options is based on the comparison of several parameters that characterize them to one degree or another.

One of the problems faced by researchers starting their work is the choice of a judgement method adequate to the object of study. Usually the choice in such cases is made based on subjective preferences or imposed from outside. In addition, there is a problem in the complexity of comparing all criteria simultaneously (Zanakis, Solomon, Wishart, & Dublish, 1998).

An alternative option in decision making could be Analytic Hierarchy Process (AHP) (T. L. Saaty, 1977). The Analytic Hierarchy Process allows to conduct an understandable comparison of the considered options according to several criteria and choose the optimal.

The AHP is a criterion class approach which became very widespread and is still being actively used. The AHP is a mathematical tool of a systematic approach of solving decision-making problems (Beynon, 2002). The AHP does not prescribe to the decision makers any "correct" decision, however it allows decision makers to interactively find an option or alternative that best fits his/her understanding of the essence of the problem and the requirements for solving it (Wedley, 2014).

The AHP can be used as a comparative or forecasting method. Main aims of the AHP are comparative analysis of criteria (sub criteria) and multi-criteria selection of the best object (Vargas, 1990). For efficient application the AHP requires that interviewees must be sufficiently qualified experts which do not allow significant errors in the estimates. Moreover, the group of experts should have common positions and striving for the consistency of their assessments. Moreover, consistency test allows to understand the manners of the respondents as a group and get exact opinion of each person (Alonso & Lamata, 2006).

All research methodologies for different spheres are located on the boundary between objective, ambiguous, vague information and applied clear, rigid processing methods. As a result, it becomes necessary to use the appropriate language to translate the studied market problems into an acceptable form for the information processing methods (Hajkowicz, 2007).

The role of such a language in the AHP is performed by various hierarchical structures. Accordingly, in the AHP any task or problem is pre-structured and represented as a hierarchy of a tree or network hierarchy. Thus, in the AHP method the main goal of the study is to assess the main goal and all the factors that influence the goal (Lee & Chan, 2008).

The AHP allows to collect data on the problem. In accordance with the results of hierarchical decomposition, the model of a situation of decision making has a cluster structure. The set of possible decisions and all the factors influencing the priorities of decisions are divided into relatively small groups - criteria. The procedure of comparisons allows determining the priorities of objects included in each criteria. For this, the eigenvector method is used (T. L. Saaty, 1977). So, the complex problem of data collection is divided into a number of simpler ones that can be solved for criteria.

Evaluation the inconsistency of data and minimization it are two benefits of the AHP. For this purpose, coordination procedures have been developed in the hierarchy analysis method (T. L. Saaty, 2008). In particular, identifying the most controversial data makes it possible to determine the least clear parts of the problem.

After analyzing the problem and collecting data for all criteria, the final rating is calculated using a special algorithm — a set of priorities for alternative solutions. The properties of this rating allow to support decision-making. Thus, a decision is made with the highest priority. In addition, the method allows to build ranking for groups of factors, which will lead to evaluation the importance of each factor.

2.4 Main steps of the AHP

2.4.1 Representing the initial problem in the form of a hierarchical structure

Thus, the first step in solving the tasks of the AHP is the decomposition of the problem through the definition of its components and the relations between them.

The main purpose of the AHP is placed at the top of the hierarchy tree (Figure 10). At this level there can be only one object. The following levels below are the criteria. According to the system of these criteria, the compared objects or alternatives are evaluated (T. L. Saaty, 1980). Alternatives are located at the lowest level. The AHP allows to have several levels of criteria.

The construction of such structure allows to analyze all aspects of the existing problem and to understand deeper into the essence of the problem. The hierarchical structure is a structural representation of the problem in the form of a tree, where each element (except the highest one) depends on one or more elements located above.

Hierarchical structure is used to better understand complex reality. While considering each step it is important to focus on understanding the current element temporarily abstracting from all other components. Carrying out this analysis an understanding of the complexity of the subject appears because the hierarchical structure used in the AHP is a tool designed for modeling complex problems.

Using available data, literature review and in-depth knowledge the hierarchy structure was built. The hierarchy tree is used for evaluation of the priority weight of each factor and sub factor based on the pairwise comparison and to rank them according to the weights (Chatzimouratidis & Pilavachi, 2008).

General recommendations when building a hierarchy can be as follows: the main objectives are set at the top of the hierarchy then the criteria form the body of the structure and sub criteria are placed at the bottom.

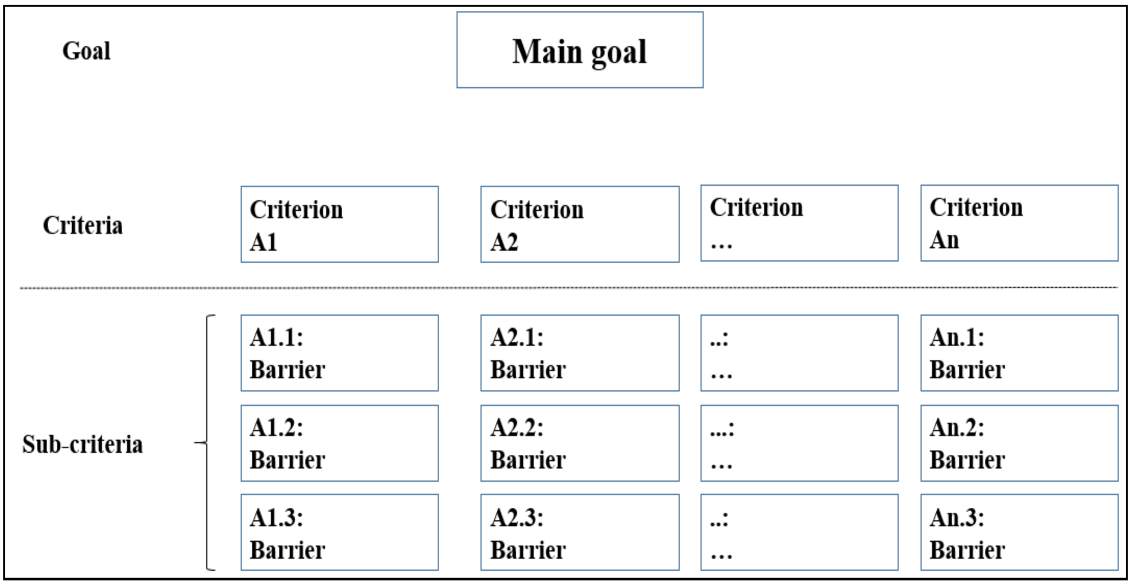

Figure 13 Hierarchy structure

Source: (R. W. Saaty, 1987; T. L. Saaty, 1977, 1980, 1990, 1994, 2008a, 2008b; T. L. Saaty & Takizawa, 1986)

2.4.2 Pairwise comparison of individual hierarchy component

Second stage of the AHP is the implementation of a pairwise comparison of individual hierarchy component based on the nine point scale (T. L. Saaty, 2008).

In this stage, the individuals have to assess criteria using numerical method. Judgements of each criterion should be done using following 9-point scale (Table 6). Respondents should evaluate an importance of each factor with the ratio ≥1, while the highest point should be no more than 9 (T. L. Saaty, 1977).

System of information about pairwise comparison leads to a result that can be represented as an inverse symmetric matrix (T. L. Saaty, 1977).

Suppose that it is necessary to determine the composition of some object. Let A1, A2, ..., An be the main factors determining the composition of the object. Then, to determine the structure of the object a matrix of pairwise comparisons is filled (Table 7).

Table 6. AHP scale

Definition	Descriptions	Intensity of importance
Options A and B are equally important	Equally important	1
Option A is moderately more important than option B	Moderately more important	3
Option A is strongly more important th an option B	Strongly more important	5
Option A is very strongly more important than option B	Very strongly more important	7
Option A is extremely more important than option B	Extremely more important	9
A is more important than option B but at intermediate values of more importa nt scale	Intermediate values	2,4,6,8

Table 7. AHP comparison matrix

	A1	**A2**	**…**	**An**
A1	1	a_{12}		a_{1n}
A2	a_{21}	1		a_{2n}
…			…	
An	a_{n1}	a_{n2}		1

Source: (R. W. Saaty, 1987; T. L. Saaty, 1977, 1980, 1990, 1994, 2008a, 2008b; T. L. Saaty & Takizawa, 1986)

If we denote the fraction of the factor A_i by w_i, then the element of the matrix $a_{ij} = \omega_i/\omega_j$. Th us, in the proposed application of the method of pairwise comparisons, it is not the values of t he differences of the values of the factors that are determined, but their ratio. It is obvious that $a_{ij} = 1/a_{ji}$. Consequently, the matrix of pairwise comparisons in this case is a positively defin ed, reciprocal-symmetric matrix, having a rank equal to 1 (T. L. Saaty, 1980).

The experts have to make a pair-wise comparison of the factors A_i, ..., A_n filling the table of pa irwise comparisons.

It's important to notice that, if $\omega_1, \omega_2, \dots \omega_n$ are unknown, then pairwise comparisons of eleme nts are made using subjective judgments, numerically evaluated on a scale and then the proble m of finding the component ω has to be solved.

Comparing an object A with an object B using one of the above using scale from 1 to 9, then, r espectively, the result comparison of object B with object A is the reverse value. For example, t he element of the matrix a_{ij} is the intensity of the application of the element of hierarchy i rela tive to the element of hierarchy j, estimated by the intensity scale from 1 to 9. When comparing one factor i with another j, the $a_{ij} = b$ is obtained, then comparing j and i the result will be $a_{ij} = 1/b$

2.4.3 Obtaining normalized matrix

Next step in the AHP is obtaining normalized matrix using Equation 1. The correct transformation to normalized matrix will have sum of each column is equal 1, as it is presented in Table 8.

$$\bar{a}_{jk} = \frac{a_{jk}}{\sum_{l=1}^{m} a_{lk}} \qquad \text{Eq. (1)}$$

Next step is to determine normalized eigenvector for each criterion using Equation 2. The normalized eigenvector introduces the final weight of each criterion and sub criterion which effects on the main goal (T. L. Saaty, 1980).

$$W_j = \frac{\sum_{l=1}^{m} \bar{a}_{jl}}{m} \qquad \text{Eq. (1)}$$

Normalized eigenvector is a final weight of criteria. Table 9 represents an example of obtaining eigenvector.

Table 8. Example of normalized matrix

	A	B	C	D
A	0,10	0,11	0,09	0,10
B	0,40	0,44	0,45	0,43
C	0,50	0,44	0,45	0,47
D	0,10	0,11	0,09	0,10
SUM	1,00	1,00	1,00	1,00

Table 9. Example of normalized eigenvector

Criteria	Weights (W)
Socio-Political	0,24
Technical	0,14
Economic	0,04
Environmental	0,58
SUM	1

From the table 9, we can conclude that the Environmental factor is the most important and it should be placed on the first place with 58% of importance. Next to the Environmental criterion, the Socio-Political criterion (24%) – 2^{nd} place, Technical criterion (14%) and Econo mic criterion (4%) is the least important.

Despite we calculated the weights for each interviewee, we need to calculate the overall weight of barriers which is our final aim of the AHP method.

2.4.4 Consistency index and consistency ratio

A very useful and final stage of the AHP method is calculation consistency index (CI), which gives information about the degree of inconsistency. Together with the matrix of pairwise comparisons, we have a measure of the degree of deviation from consistency. If such deviations exceed the established limits ($CI \leq 0{,}1$), then the person who makes the judgments should double-check them in the matrix.

In order to determine the Consistency index, λmax should be determined first (Equation 3). Let $A_w = \lambda max * w$where x is an eigenvector (T. L. Saaty, 1990).

$$\begin{pmatrix} a_{11} & \dots & a_{1n} \\ \dots & \dots & \dots \\ a_{n1} & \dots & a_{nn} \end{pmatrix} \begin{bmatrix} w_1 \\ \dots \\ w_n \end{bmatrix} = A \times W = \begin{pmatrix} (Aw)_1 \\ \dots \\ (Aw)_n \end{pmatrix} = \lambda max \begin{bmatrix} w_1 \\ \dots \\ w_n \end{bmatrix} \qquad \text{Eq. (2)}$$

Then,

$$\lambda max = average \left\{ \frac{(Aw)_1}{(w)_1}, \dots\dots\dots\dots\dots., (Aw)_n / W_n \right\} \qquad \text{Eq. (3)}$$

Finally, the Consistency index can be calculated as follows (Equation 4):

$$CI = (\lambda max - n)/(n - 1) \qquad \text{Eq. (4)}$$

An ideal Consistency index should be equal zero, however in practice small variance is accepted. For example, CI/RI ≤ 0,1, which means 10% of inconsistency. Otherwise, the quality of the answers is low and data must be renew (T. L. Saaty, 1990).

Table 10. Random consistency index

# of criteria	2	3	4	5	6	7	8	9	10
R.I	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Source: (R. W. Saaty, 1987)

Chapter 3. Model and Data

This section consists of the information about previous studies and basic concept of barriers related to the construction of nuclear power plants. Moreover, description of criteria and sub criteria and results of consistency tests belong to Chapter 3.

3.1 Previous studies

Despite the fact that nuclear industry is well-known among people, nobody can predict risks related to that area. In a case of nuclear power plant's construction not many policy makers would take responsibility to consider realization such kind of projects (Lindskog et al., 2008). Moreover, expansion of nuclear power can be a taboo topic for some countries due to historical experience or decisions of authorities of those countries (Tannenwald, 2008).

Recently, a similar situation happened in Kazakhstan where people organized anti-nuclear social movements (Luong & Weinthal, 1999). In early 90-s majority of population in Kazakhstan were against any nuclear project due to negative impacts from testing nuclear bombs.

Due to Kazakhstan moved from planned economy to the market economy, people started to think from the economic point of view (Shaw & Oldfield, 1998). Moreover, privatization affected individuals which caused an emergence of business environment. All these factors influenced the growth of national economy from the one side and rapid increase of energy consumption from another side (Apergis & Payne, 2009). To provide sustainable energy supply for people and satisfy them, the government of Kazakhstan works on improving legislation and implementing new projects.

Since independence of Kazakhstan the issue of nuclear power plant is constantly being raised. If position of people we can imagine, the policy makers' opinions are unknown. Therefore, this study is about analyzing key barriers on the way of development nuclear sector in Kazakhstan and difference between point of views of two different regulators.

To analyze decision making different methods of variations of the MCDA are commonly used (Zhou & Ang, 2009). Each method has its own pros and cons (Hajkowicz, 2007). One fact about MCDA is undisputed that it provides clear analysis with precise aggregation.

In case of energy sector, MCDA finds its application in selection the most appropriate innovations in energy area based on proposed options (Beccali, Cellura, & Mistretta, 2003).

In practice, project development in energy sector is centralized and automotive. There are different models of so called Decentralized Energy Planning (DEP) are being implemented. In order to choose the most suitable government should carefully analyze each of them (Hiremath, Shikha, & Ravindranath, 2007).

Moreover, policy makers should resolve problems with providing electricity access to the remote areas. Such cases can be easily ignored due to the less preferences for decision makers (Silva Herran & Nakata, 2012).

Often, policy makers face problems related to forecasting demand due to unpredictable circumstances or limited competences (Huang, Yu, Peng, & Zhao, 2015).

Moreover, in more precise case there are four main factors (environmental, social, economic and technical) have to be considered prior to the project realization (Talinli, Topuz, & Uygar Akbay, 2010).

Application of combination, subjective and objective weighting on analyzing technical, economic, environmental and social factors is another type of application MCDA in energy area (Wang, Jing, Zhang, & Zhao, 2009).

Most of existing quantitative tools are limited due to they use exact number of variables which a person chooses. However, due to there are many acting parties interact in the energy system, it is become impossible to gather and analyze all essential criteria. These factors simply cannot be determined prior because majority of them are non-market values (Greening & Bernow, 2004).

Nowadays, energy modelling plays significant role in analyzing future directions in energy sector. Using MCDA, key parameters are analyzed and proposed possible issues (Samouilidis &

Mitropoulos, 1982).

To judge each factor effects on nuclear project development in Kazakhstan it is important to compare them in one hierarchy system. Each criterion has its own weight and can be judged differently depends on situation, person and other factors. Such kind of judgement based on pairwise comparisons is productive in solving decision making cases (T. L. Saaty, 1980).

Decision making was analyzed not in simple decomposition of problems based on classic AHP method, but also examined by determination of the extent of criteria Mosadeghi, Warnken, Tomlinson, & Mirfenderesk (2015) examined political transition in Australia. The outcomes of such approach is that AHP method is useful in the early stage of project development.

Additionaly, AHP was used in order to determine best energy scenario for Egypt. The results of the study show suggestions for increasing number nuclear reactors by 25 percent and possibility for construction solar power station for additional 5 percent to current energy mix (Hefny et al., 2013).

Definitely, that the evaluation of organizational performance is a complicated process due to large number of criteria and other factors which effect on economic activities. Shaverdi, Heshmati, & Ramezani, (2014) evaluated organizational performance of petrochemical industry in Iran. They divided analysis in to two main stages, where analyzing of the problem was done in the first stage. Then, based on the obtained results, the required framework for an effective decision making process was suggested.

Despite, there large number of studies analyzing energy sector using AHP, usually the process of decomposition the problem based on four-criteria judgement. Cavallaro & Ciraolo, (2005) used economic, environmental, social and technical factors to evaluate pros and cons of wind energy turbines' construction in Italy.

Sometimes, AHP is used to determine existing side effects of industrial activities on neighboring spheres. An evaluation the effects of different power plants on life standards was done by Chatzimouratidis & Pilavachi, (2009). They carried out assessment of negative and positive influences using the Analytic hierarchy process.

Decision making of social aspects has to be done precisely due to its serious social pressure and possible risks for people. Using AHP, Nigim, Munier, & Green, (2004), analyzed key factors for renewable energy in order to reduce country's energy dependence.

Some countries have high potential in developing renewable energy sources by providing appropriate conditions for investors. (Baris & Kucukali, 2012) studied possibility for establishing renewable energy scenarios in Turkey. Using AHP they assess current national programs and governmental policies in energy and environmental sectors.

Another significant observation of various renewable energy scenario was done by Amer & Daim, (2011). The findings of that study suggested decision model for energy diversity in Pakistan and development long-run renewable energy policy.

Darmani, Arvidsson, Hidalgo, & Albors, (2014) observes renewable energy technologies in order to propose universal driving force in technological innovation system in seven European countries and the Ireland. The study proposed different categorization for drivers and explored multilateral drivers within renewable energy technologies. Moreover, results show different patterns in different countries.

Problems of decentralization of energy grids are complicated and have many variations. The study on implementation new approach for comprehension has done by Papadopoulos & Karagiannidis (2008). Using AHP they analyzed different options for utilization appropriate energy system and proposed issues for electrification remote area. The study includes analysis of geological, climate and morphological aspects of areas in order to provide resolutions for government.

Andiç, Yurt, & Baltacioğlu, (2012) observed an effectiveness of green supply chain in electrical and electronic equipment (EEE) sector in Turkey. The outcomes of the study show that EEE market can afford to implement own model for the delivery of green economy to other sectors.

The suggested model includes down-stream and up-stream involvement of participants into the green economy.

Another study was done by Mathiyazhagan, Govindan, & Noorul Haq, (2014), who observed industrial sector of South India. They determined forty seven barriers in green supply chain management. Each barrier was assessed by experts and the final step was suggestions for government officials to promote and provide significant help for the development of green supply chain management.

Today, there is a trend for reduction of emissions, as a result, the complication of existing environmental regulations. Bouzon, Govindan, Rodriguez, & Campos, (2016) carried out analysis on barriers for development energy system in Brazil as the largest economy in Latin America. Despite, persistent modernization of energy regulation, the country faces challenges related to inefficient logistics system and enacted governmental regulation for promoting waste management. The results of the study found unexpected tax and other economic related issues are the main barriers for development waste management in Brazil.

Adoption of renewable and sustainable energy technologies face many challenges. Luthra, Kumar, Garg, & Haleem, (2015) observed 28 barriers India face with. The study was conducted by the assessment of experts from science and energy industry. All barriers were divided in to seven major groups (economic, information, technical, ecological, geographical, cultural and political.

The worldwide trend of increasing renewable energy in energy mix is widely observed. Heo, Kim, & Boo, (2010), analyzed green energy dissemination program in Korea using AHP approach. The barriers were divided in to five main groups. i.e. policy, economic, environmental, technical and market. Not standard market criterion was chosen in order to assess willingness of market participants to implement new technologies. The results show the uncompromising domination of economic barrier for the implementation renewable technologies.

Shen, Lin, Li, & Yuan, (2010) analyzed existing renewable energy supporting programs in

Taiwan, taking into account energy, environment and economy (3E) factors. Results of the study show an importance of environmental goal and suggested some issues based on the outcomes of the study.

Another study on the establishing effective renewable energy approach for development green energy sector. For this task, the Greek Technology Foresight Program was analyzed by Doukas, Andreas, & Psarras, (2007).

Table 11 represents papers listed above and brief explanation of the main goals of those papers.

To summarize, despite geological and geopolitical benefits, there is not many studies on analysis the barriers of development nuclear industry in Kazakhstan. Although, there are many questions have to be answered prior to project implementation. First of all, nuclear industry is a hazardous potentially, which means that ecological factor should be studied as well as technical. Also, due to nuclear technologies are capital intensive, economic barriers have to be observed. Finally, Kazakhstan experienced a rich history related to development nuclear industry and government is familiar with public point of view. In this case, social acceptance must be included in observation area.

Thus, this study will be the first particular attempt to analyze possible barriers and the difference in point of views between two governmental regulators.

Table 11. List of related papers

Paper	Author	Contribution
Estimations of costs for dismantling, decommissioning and associated waste management of nuclear facilities, and associated impact on decision processes, functioning of markets and the distribution of responsibilities between generations	Lindskog, S. Cato, A. Sjoblom, R.	Decomposition of waste management of nuclear power facilities
The Nuclear Taboo: The United States and the Normative Basis of Nuclear Non-Use	Tannenwald, Nina	Examination of effects of nuclear power industry in the USA

The NGO Paradox: Democratic Goals and Non- democratic Outcomes in Kazakhstan	Pauline Jones Luong & Erika Weinthal	Analysis of NGO's in Kazakhstan
The Natural Environment of the CIS in the Transition from Communism	Denis J. B. Shaw and Jonathan Oldfield	Comparative analysis of environmental aspects in CIS countries
Energy consumption and economic growth: Evidence from the Commonwealth of Independent States	Nicholas Apergis, James E. Payne	Comparative analysis on energy consumption and economic growth in 11 CIS countries
A comparison of multiple criteria analysis and unaided approaches to environmental decision making	Stefan Hajkowicz	Analysis on environmental aspects using multiple criteria analysis (MCA)
Comparing MCDA Aggregation Methods in Constructing Composite Indicators Using the Shannon-Spearman Measure	P. Zhou, B. W. Ang	Analysis on Shannon-Spearman measure (SSM) using Monte Carlo approach-based uncertain analysis
Decentralized energy planning; modeling and application—a review	R.B. Hiremath, S. Shikha, N.H. Ravindranath	Analysis on various decentralized energy models used worldwide
Design of decentralized energy systems for rural electrification in developing countries considering regional disparity	Diego Silva Herran, Toshihiko Nakata	Analysis on energy planning of developing countries using optimization energy model
Methods and tools for community energy planning: A review	Zishuo Huang, Hang Yu, Zhenwei Peng, Mei Zhao	Analysis on Community Energy Planning method at the Community Master Plan
Comparative analysis for energy production processes (EPPs): Sustainable energy futures for Turkey	Ilhan Talinli, Emel Topuz, Mehmet Uygar Akbay	Assessment of energy policies for different types of energy

		sources

3.2 Basic concept of barriers related to the construction of nuclear power plants

It is generally understood that the further development of nuclear industry has supporters and opponents. If everything is clear with benefits of expansion of nuclear energy, the cons are not obvious.

Due to the fact that the value of electricity in all spheres of modern society is colossal, the barriers such as social, technical, environmental and economic are extremely important and relevant at the moment. In order to develop nuclear industry in any country, the basic essential steps has to be done.

All countries realize responsibilities for the environmental preservation, therefore current and new energy facilities should be maximum clean and environmental friendly. Thus, the reduction of CO2 emissions is one of the most significant benefit for the further development of nuclear industry (Apergis, Payne, Menyah, & Wolde-Rufael, 2010). Properly managing nuclear power produce zero emissions which could be considered as an environmental conservation measures.

Technological advance is another concept which can be supported by nuclear energy (Nian, 2015). Latest international tendencies show that the atomic industry started new stage of scientific development and majority of them have been implemented and adopted by related industries.

Analyzing nuclear power plant's development it should be noted that without governmental support the project is doomed to failure (Vegel & Quinn, 2017). Thus, there is no chance for existence on the market if the energy project is economically inefficient (Yildiz & Kazimi, 2006).

Another key factor of acceptance of nuclear projects. It is understood that after accidents of nuclear power plants such Chernobyl and Fukushima, society incredulously think about nuclear expansion. On the other hand, analysis on public acceptance of nuclear projects shows positive trend since early 1990s (Kim et al., 2013).

The events and situations listed above lead to generation barriers for the development of nuclear industry. These factors can be used to explain some phenomena in Kazakhstan and in other countries. In case of Kazakhstan, the barriers may be classified into the following four groups: (i) social Acceptance; (ii) Technical; (iii) Economic; (iv) Environmental.

Thorough study of literature materials have been done. As a main source for related papers the Google Scholar, Science Direct Online, Google web browser were used. In case of Kazakhstan, 4 criteria and 12 sub criteria were highlighted and extracted from the relevant papers (Figure 14).

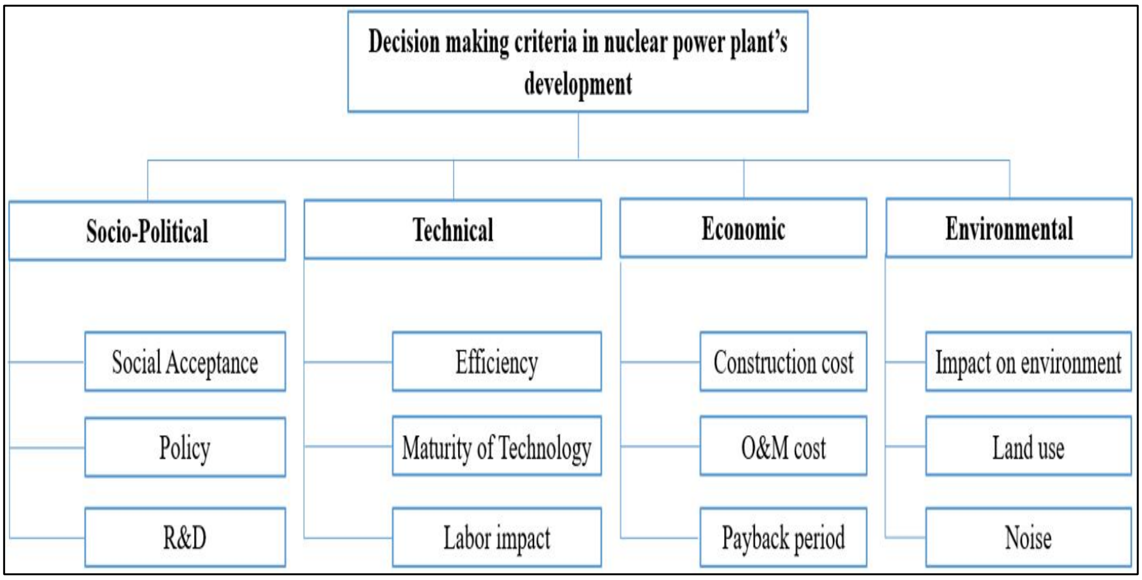

Figure 14. Hierarchy tree

3.3 Description of criteria

This subsection provides an explanation of the criteria that will be used to evaluate decision making. The criteria and sub criteria are the instruments that needs to evaluate energy project from the decision maker's view. Certainly, choosing appropriate criteria and sub criteria is a sensitive process which effects on the final result of the evaluation of project. Consequently, it has to be thoroughly analyzed prior to the implementation of energy project (Cavallaro & Ciraolo, 2005). The amount of barriers depends on available data, observed literature review and conditions.

3.3.1 **Socio-Political criterion**

Project implementation in energy sector includes many judgements of socio-political issues. The Socio-Political barrier is a criterion which is sensitive and reflects social and political mood. The barrier shows whether or not society and political parties are satisfied in reforms and current political situation (Cavallaro & Ciraolo, 2005).

The Socio-Political criterion strengthens role of society takes into account predictable reactions from social groups (Kahraman & Kaya, 2010).

Social Acceptance

"Social Acceptance" barrier represents the level of people's attitude related to proposed energy power plant from the consumer's point of view. This barrier plays crucial role because an implementation of any project is sensitive to the opinion of citizens and pressure classes. Consequently, it is very important to collect people's opinion about suggested project beforehand. It is impossible to analyze using quantitative methods, nevertheless the qualitative analysis can be used in assessment of energy project.

Policy

The "Policy" barrier represents the level of comprehension of existing legislation which energy sector is regulated by (Abdulrahman et. al., 2014). Due to the absence of nuclear power plant in the Republic of Kazakhstan, there is no comprehensive policy. The legislation has to be issued prior to the implementation of the energy project.

R&D

Necessity of the "R&D" barrier can be conditioned by the absence of nuclear industry in the Republic of Kazakhstan. The high level of the "R&D" barrier affects an implementation of nuclear project is complicated.

3.3.2 Technical criterion

It is generally understood that the nuclear energy has to be managed carefully and it is high risky industry. Several accidents which were happened around the world show society the consequences of disregarding safety rules which leads to such catastrophes. Technical barrier is definitely one of the most important criterion due to it is complexity and importance (Cavallaro & Ciraolo, 2005).

Efficiency

The "Efficiency" barrier represents the amount of energy which can be benefited from the implementation of the energy project. The efficiency index is a ratio between the energy spent and energy generated (Wang et. al., 2009). The efficiency is important for deceleration of energy demand rise. This barrier is the most useful technical criterion for assessment of energy project.

Maturity

This barrier evaluates complexity of proposed technology and the capacity of local professionals using qualitative analysis. The main reason for that is to analyze whether local manpower guarantees suitable operational service and setting facilities, machinery and operation system for managing the energy power plant.

Labor impact

The barrier "Labor impact" is used to examine the readiness of local manpower to implement proposed energy project. It includes educational and practical skills of local agents. In addition, this barrier can be helpful in order to analyze an direct and indirect effect on the rate of employment (Tasri & Susilawati, 2014). In order to implement the project, the need of technically trained labors is obvious.

3.3.3 Economic criterion

It is no doubt that the energy sector is capital intensive one. Consequently, financial aspect dominates in decisions making to involve in technological innovation. Competitive environment in the energy market compels companies to schedule their business strategies concerning market trends for operative reaction and sustain efficiency (Darmani et al., 2014).
The Economic barrier is a criterion represents the judgement of the proposed energy project using economic tools such as net present value (NPV), internal rate of return (IRR), cost and benefit analysis (CB) and payback period (Kahraman & Kaya, 2010). This refers to the amount of budget in order to realize energy project.

Construction cost

Construction cost can be interpreted as an amount of required investment for the implementation the energy project. It includes all expenses needed from the beginning until the power plant will be fully operational. The list of expenses can include purchasing the machinery, installation works, construction of highways, engineering works, drilling and other construction works.

O&M cost

The “Operation and maintenance cost” involves all the actions related to energy project such as salary and hiring expenses, purchasing materials, parts and fuels, transportation, installation works etc. The average O&M cost equals 2 percent of the total investment.

Payback period

“Payback period” criterion represents of regeneration or the time frame from the initial investment till all the expenses will be recovered. This means how fast the invested funds will be benefited from the operated energy power plant. Generally, shorter payback period is preferably accepted rather than the long one. The payback period is recognized as an essential factor in economic assessment in project evaluation.

3.3.4 Environmental criterion

The “Environmental” criterion is used to describe expected hazard of environmental accidents affected by the energy power plant. This barrier measures protection and safety measures for environmental conservation. For analyzing these barriers the qualitative analysis has to be done. Considering environmental barrier should be taking into account the reduction of hazardous impact on environment such as CO_2 emission, noise, land use etc. (Luthra, Mangla, & Kharb, 2015).

Impact on environment

The “Impact on environment” barrier represents an evaluation of harmful effect influenced by power plant in operational process. The barrier includes all kinds of hazardous material which has negative impact on environment, gasiform, liquid and solid types of waste etc.

Land use

The “Land use” barrier represents the territory required for nuclear power plant. In most cases this barrier can have strong influence on energy projects. Usually, the land occupation by the power plant causes ecological and health problems because of the permanent and wide pollutions. An appropriate management of land use can be explained use of an adequate land (soil erosion areas, polluted, remote etc.). However, insufficient management of land use leads to ecological accidents.

Noise

There are two different kinds of noise related to energy projects such as aerodynamic and mechanical (Cavallaro & Ciraolo, 2005). Aerodynamic noise is generated on operated power plant by the movements of turbine-types mechanisms, while mechanical noise is produced by mechanical actions of facilities or people working on power plant. The level of noise can be regulated using cutting-edge technologies and noise insulation materials (Crighton, 1971).

Finally, Table 12 represents list of references with each criterion and sub criterion.

Table 12. List of criteria and sub criteria

Criteria	Sub criteria	Source
Socio-political	Social Acceptance	Cavallaro and Ciraolo, 2005; Chatzimouratidis & Pilavachi, 2008; Darmani et al., 2014; Heo et al., 2010; J.P. Painuly, 2001; Kabir and Shihan, 2003; ; Kaya and Kahraman, 2010; Luthra et al., 2015; Talinli et al., 2010; Wang, Jing, Zhang, & Zhao, 2009
	Policy	Kahraman and Kaya, 2010; Bhattacharya & Jana, 2009; Brown, 2001; Dulal et al., 2013; Singh, 2013
	R&D	Poong Oh Kim, Kun Jai Lee and Byong Whi Lee, 1998;
Technical	Efficiency	Salman Ahmad, Razman Mat Tahar, 2013; Savvas Theodorou, Georgios Florides, Savvas Tassou, 2010
	Maturity of technology	Cavallaro and Ciraolo, 2005; Chatzimouratidis and Pilavachi, 2008; Talinli et al., 2010; Heo et al., 2010;

		Kaya and Kahraman, 2010
	Labor impact	Kahraman and Kaya, 2010; Tasri and Susilawati, 2014; Kahraman et. Al., 2009; J.P. Painuly, 2001.
Economic	Construction cost	Adhikari et al., 2008; Cavallaro and Ciraolo, 2005; Talinli et al., 2010; Tolga Kaya Cengiz Kahraman, 2015; Karatayev et. al., 2015.
	O&M cost	Cavallaro and Ciraolo, 2005; Talinli et al., 2010; Tolga Kaya Cengiz Kahraman, 2015;
	Payback period	Tolga Kaya Cengiz Kahraman, 2015; Heo et al., 2010; J.P. Painuly, 2001; Luthra et al., 2015; Wang et al., 2014; Karatayev et. al., 2015.
Environmental	Impact on environment	Cavallaro and Ciraolo, 2005; Heo et al., 2010; Kaya and Kahraman, 2010; Luthra et al., 2015; Tasri and Susilawati, 2014; Talinli et al., 2010.
	Land use	Carrion et al., 2007; Kaya and Kahraman, 2010; Uyan, 2013; Tasri and Susilawati, 2014; Wang et al., 2014; Massimo et al., 2014; Luthra et al., 2015; Garni and Awasthi, 2017; Sabo et al., 2017
	Noise	Cavallaro & Ciraolo, 2005, Callego and Mack, 2009; Kaya and Kahraman, 2010; Wang et al., 2014.

3.4 Consistency test

Considering the AHP as a whole structured system the nature of reliability and consistency should be clearly understood.

The consistency ratio of answers was checked using the Consistency Ratio (CR) proposed by T. L. Saaty (1980).

Consistency ratio (CR) is an index of assessment of an inconsistency of the comparison's results. It is influenced on the number of pairwise comparisons and it should be positive. The fewer contradictions in the comparisons the smaller the value of the consistency ratio. When comparing ideal parameters of the pairwise comparisons the value of consistency ratio equals zero. Interestingly, that to accept results of pairwise comparisons the CR should be about 10 percent or even less (T. L. Saaty, 1980). If CR is more that 10% the results of pairwise comparison is unreliable and base data should be modified until reaching 10% of threshold value of the CR. Therefore, consistency of results were tested using CR method (T. L. Saaty, 1980).

For this study, 22 employees of the Ministry for Investments and Development and 25 employees from the Ministry of Energy were asked to answer the questioners related this study. Due to the time limitation or other unpredictable circumstances, 21 answers were received from the Ministry for Investments and Development and 24 answers from the Ministry of Energy.

Figure 15 represents the value of CR in Main criteria among 21 respondents from the Ministry for Investments and Development. As it is shown that 3 questioners have CR value more than 0,1. Thus these 3 questioners are not included in this thesis.

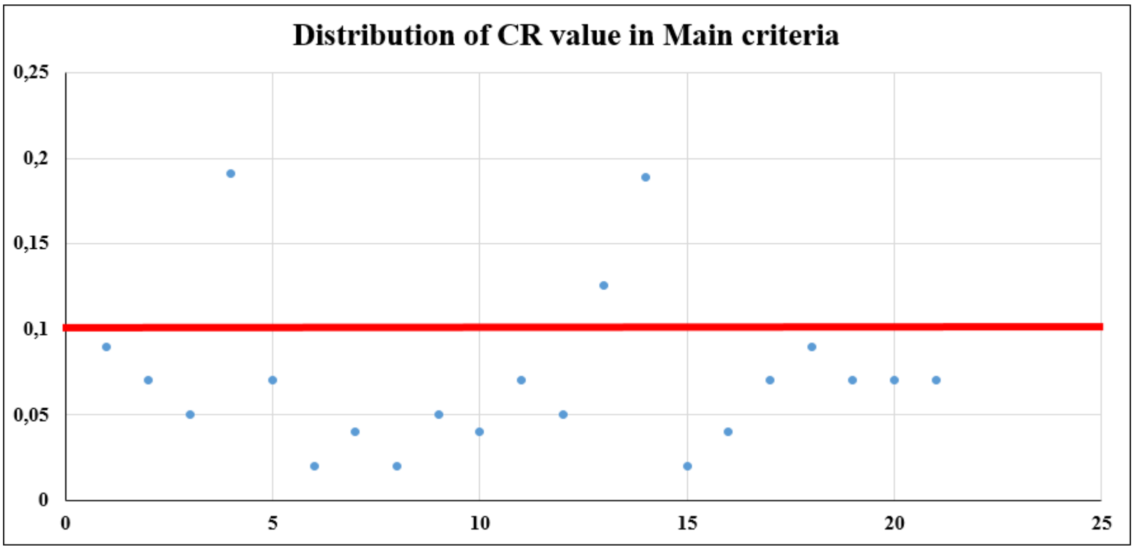

Figure 15 CR value of the answers from the Ministry for Investments and Development

Figure 16 represents the value of CR in Main criteria among 24 respondents from the Ministry of Energy. As it is shown that 4 questioners have CR value more than 0,1. Such wise, these 4 questioners are not included in this study.

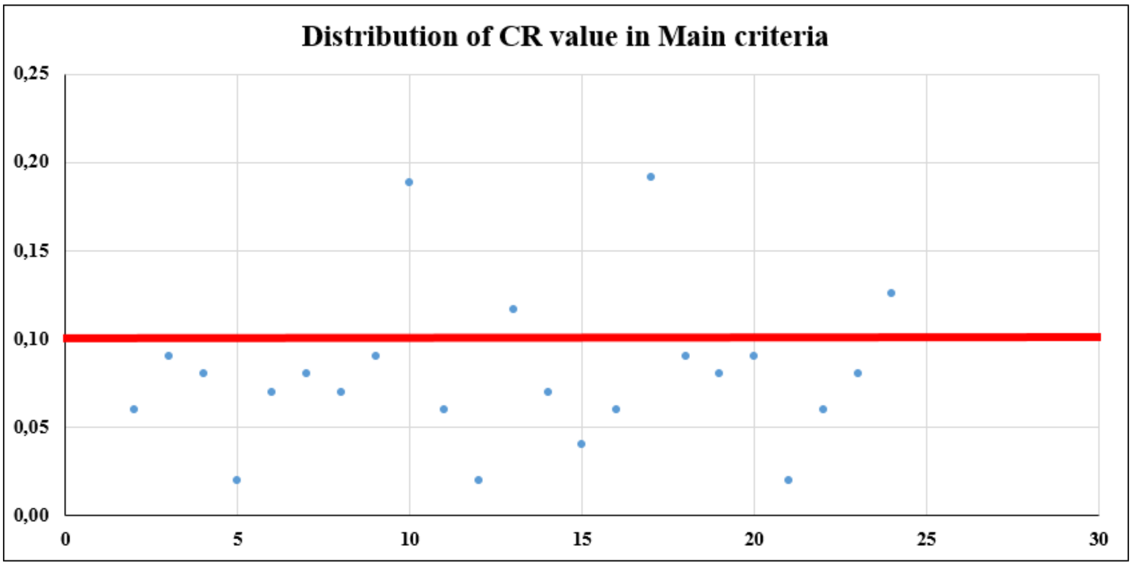

Figure 16 CR value of the answers from the Ministry of Energy

Figure 17 shows the value of CR in Socio-Political criteria among 21 respondents from the Ministry for Investments and Development. Only 1 questioner has CR value more than 0,1. Thereby, questioner is excluded from this study.

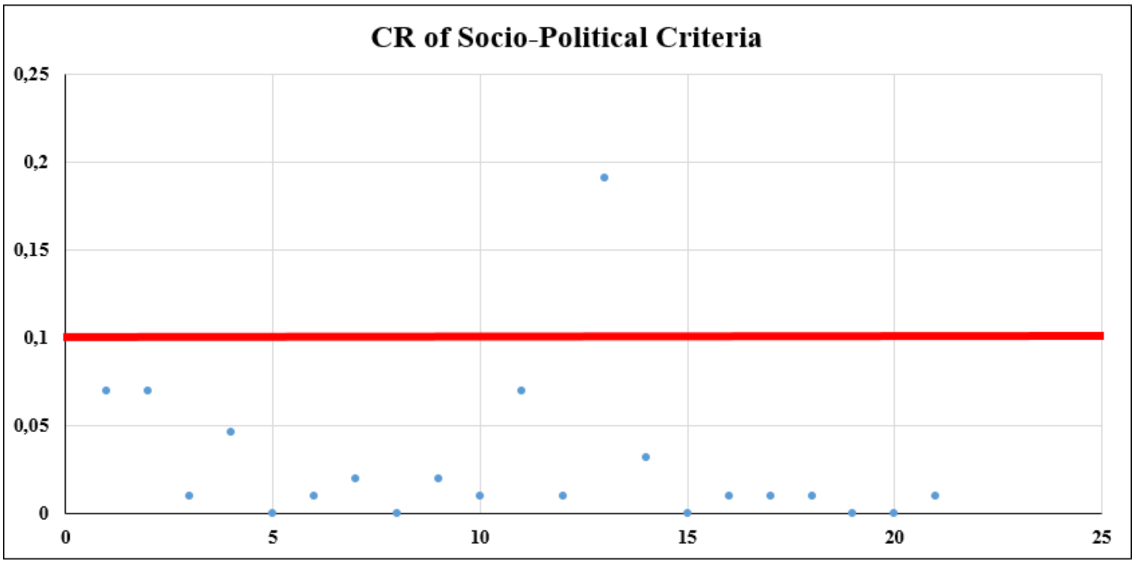

Figure 17 CR value of the answers from the Ministry for Investments and Development

Figure 18 depicts the value of CR in Socio-Political criteria among 24 respondents from the Ministry of Energy. As we can see, only 2 questioners have CR value more than 0,1. Thus, these 2 questioners are not included in this study.

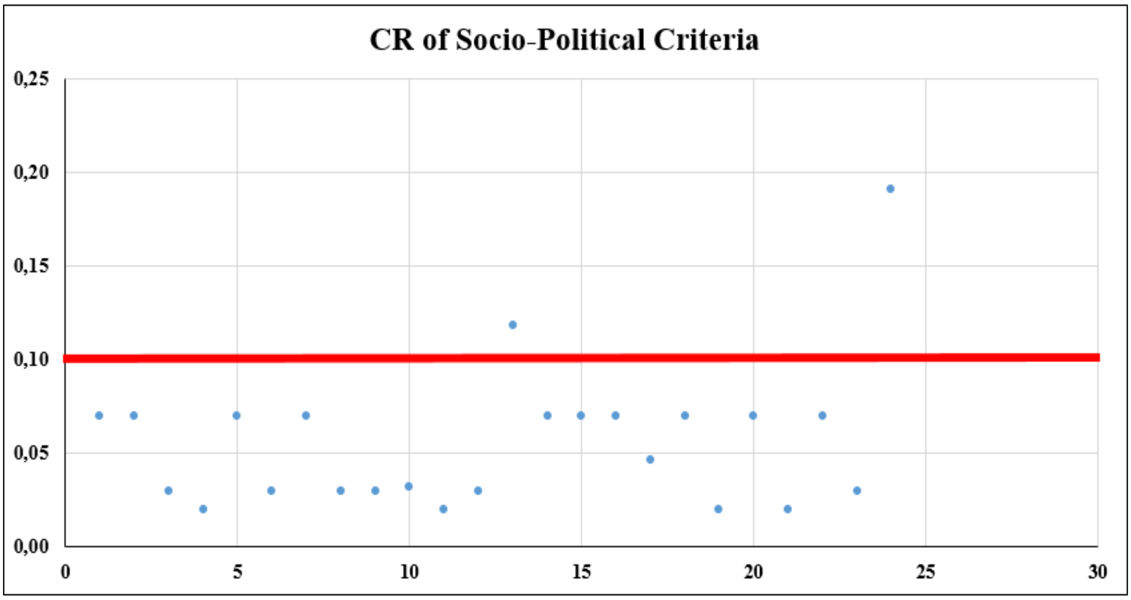

Figure 18 CR value of the answers from the Ministry of Energy

Figure 19 illustrates the value of CR in Technical criteria among 21 respondents from the

Ministry for Investments and Development. There are 2 questioners with CR value more than 0,1, therefore we cannot accept them.

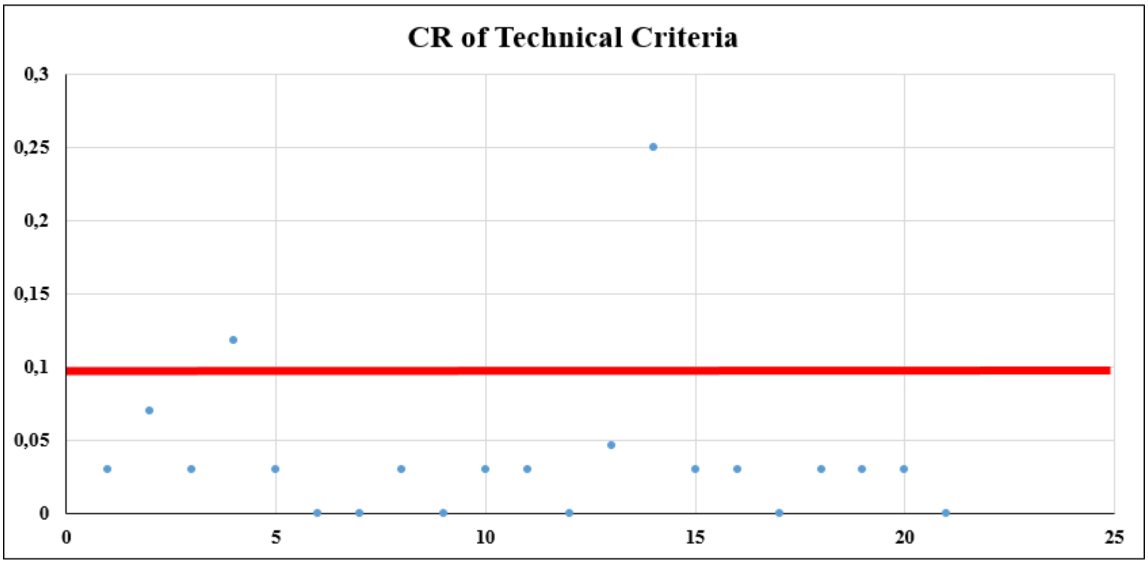

Figure 19 CR value of the answers from the Ministry for Investments and Development

Figure 20 presents the value of CR in Technical criteria among 24 respondents from the Ministry of Energy. 2 questioners have CR value more than 0,1, so these questioners are excluded from this study.

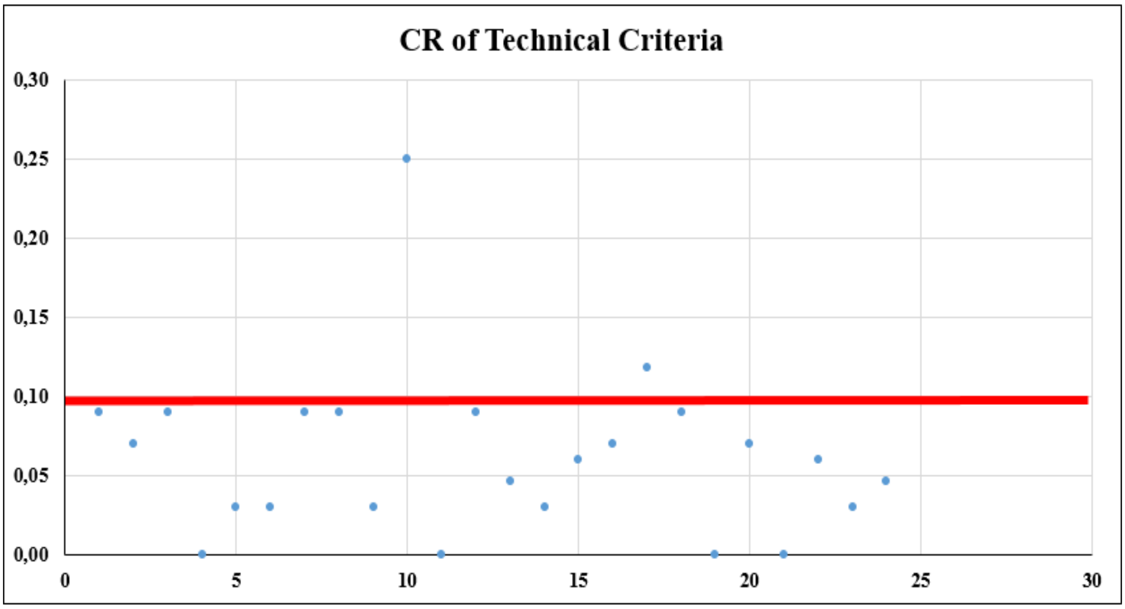

Figure 20 CR value of the answers from the Ministry of Energy

Figure 21 expresses the value of CR in Economic criteria among 21 respondents from the Ministry for Investments and Development. Due to there are 2 questioners with CR value more than 0,1, we cannot use them.

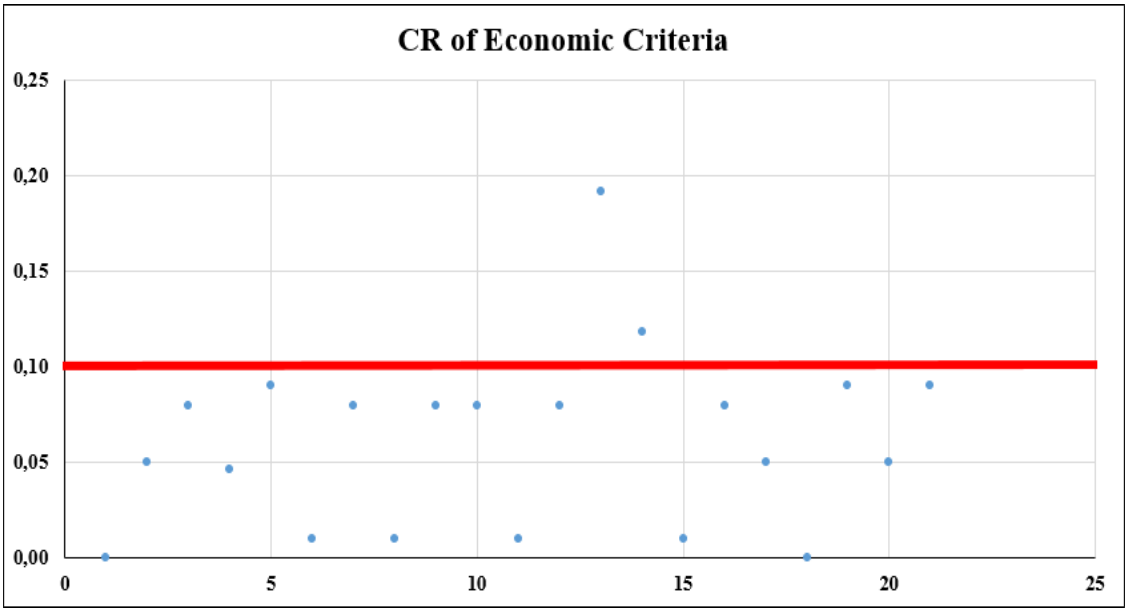

Figure 21 CR value of the answers from the Ministry for Investments and Development

Figure 22 gives data on the value of CR in Economic criteria among 24 respondents from the Ministry of Energy. As we can see, there are 2 questioners have CR value more than 0,1, so these questioners are not included in this study.

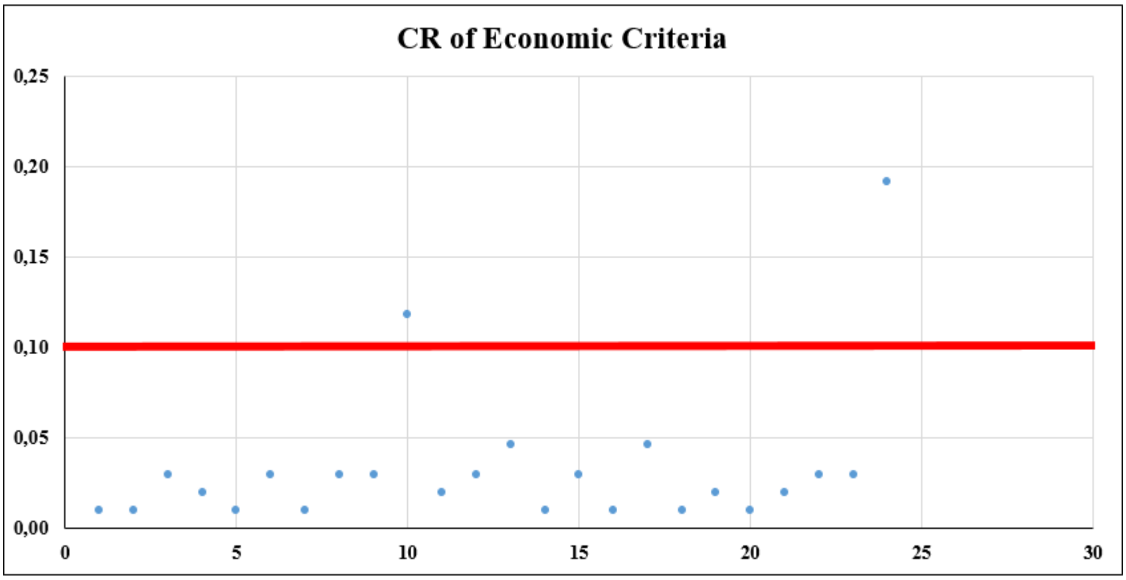

Figure 22 CR value of the answers from the Ministry of Energy

Figure 23 presents information about the value of CR in Environmental criteria among 21 respondents from the Ministry for Investments and Development. All 21 answers have the value less than 0,1, therefore we accept them.

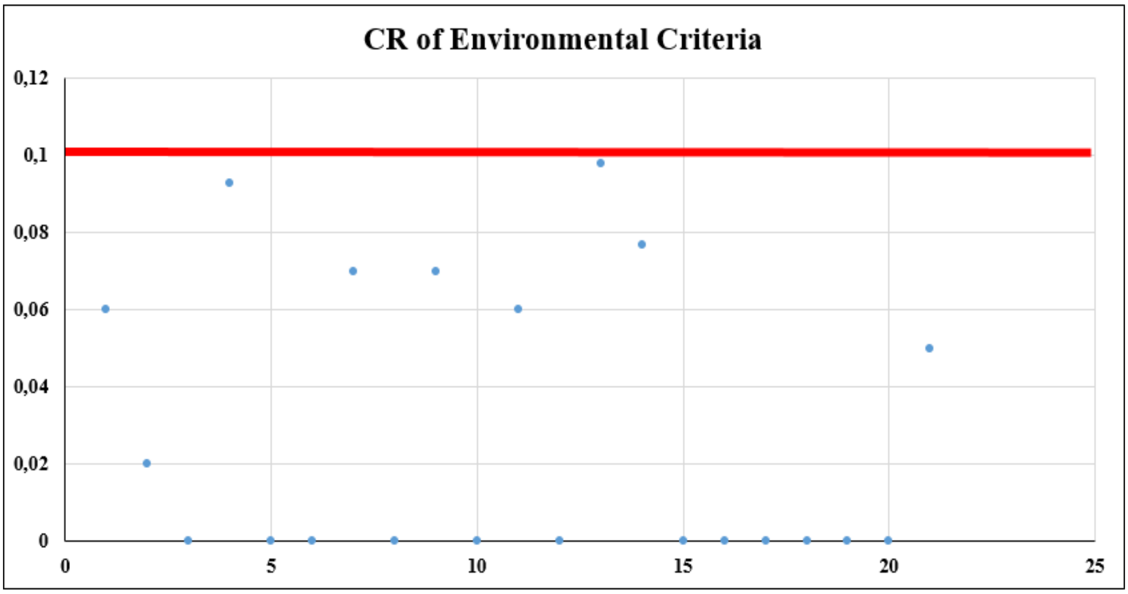

Figure 23 CR value of the answers from the Ministry for Investments and Development

Figure 24 demonstrates the data on the value of CR in Environmental criteria among 24 respondents from the Ministry of Energy. Only 1 answer has CR value more than 0,1, so cannot include accept it.

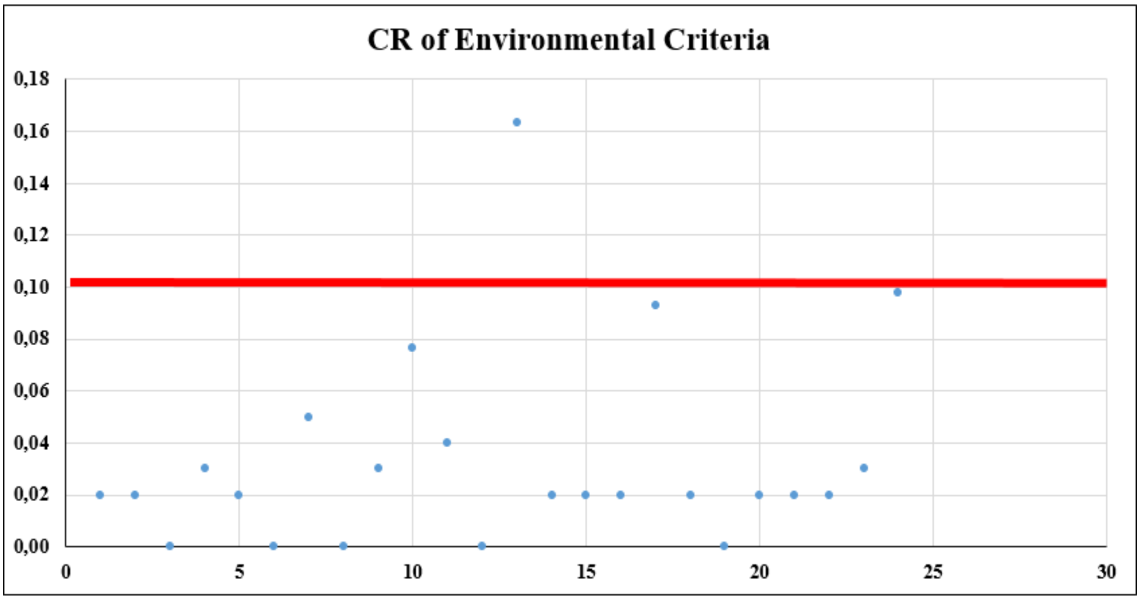

Figure 24 CR value of the answers from the Ministry of Energy

Hereby, after analyzing all results of consistency tests, we cannot accept answers with consistency ratio more than 10%. Thus, only 18 samples from the Ministry for Investments and Development and 20 samples from the Ministry of Energy can be further analyzed.

Chapter 4. Results of AHP

This section discusses the calculation results about pairwise comparisons toward four main criteria and sub criteria. Also, the calculated results of global priorities are presented.

4.1 Weights of main criteria

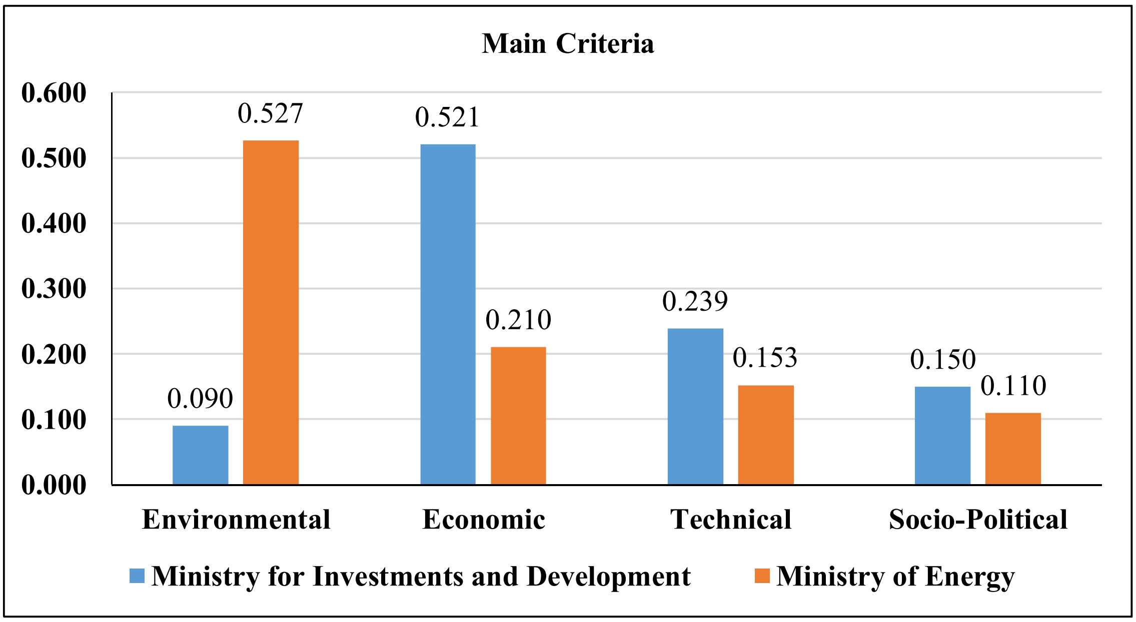

Figure 25. Estimated weights of Main criteria

Table 13 Calculated weights of Main criteria

Barrier	**Priority weight**	**Share**	**Rank**
Economic	0,521	52%	1
Technical	0,239	24%	2
Socio-Political	0,150	15%	3
Environmental	0,090	9%	4

Table 14 Calculated weights of Main criteria

Barrier	Priority weight	Share	Rank
Environmental	0,527	53%	1
Socio-Political	0,210	21%	2
Technical	0,153	15%	3
Economic	0,110	11%	4

The aggregated results from the Ministry for Investments and Development and the Ministry of Energy are presented in Figure 25.

For the Ministry for Investments and Development, the aggregated results of the judgement of main criteria show a dominated importance of Economic criterion (0,521), while Socio-political and Environmental criteria are the weakest among all four dimensions with the weights of 0,150 and 0,090 respectively.

On the other hand, for the Ministry of Energy, the aggregated results of the judgement of main criteria show a dominated importance of Environmental criterion (0,527), while Technical and Economic criteria are the weakest among all four dimensions with the weights of 0,153 and 0,110 respectively.

Policy makers from the Ministry for Investments and Development assess that the weights of Socio-Political and Environmental criteria were low, however the importance of Economic and Technical criteria was high. The calculation results of the weights together with ranking for the answers from the Ministry for Investments and Development are shown in table 13.

Government officials from the Ministry of Energy estimated that an importance of Technical and Socio-Political criteria was low, while the importance of Environmental and Economic criteria was the highest among all four criteria.

Such significant difference in assessment of Environmental and Economic criteria is justified by different responsibilities and functional duties. For instance, experts from the Ministry for Investments and Development usually work with investment related issues. Thus, they assessed Economic factor as the most important among other due to their background and current affiliation.

The Ministry for Investments and Development of the Republic of Kazakhstan is a state authority of the Republic of Kazakhstan leading in the sphere of industry and state innovation policy and policy of investments support, creating a favorable investment climate; creating, functioning and abolishment of special economic zones ("Ministry for Investments and Development," n.d.). Once they have their own obligations and duties, they cannot be responsible for the Environmental related aspects.

On the other hand, government officials from the Ministry of Energy take care of environmental conservation, nature management, protection, control and supervision of the rational use of natural resources, solid waste management, the development of renewable energy sources, control over the state policy of developing a "green economy" ("Ministry of Energy," n.d.). Thus, according to their functions environmental conservation is one of the priority directions.

The calculation results of the weights together with ranking for the answers from the Ministry of Energy are shown in table 14.

4.2 Weights of sub criteria within Socio-Political criterion

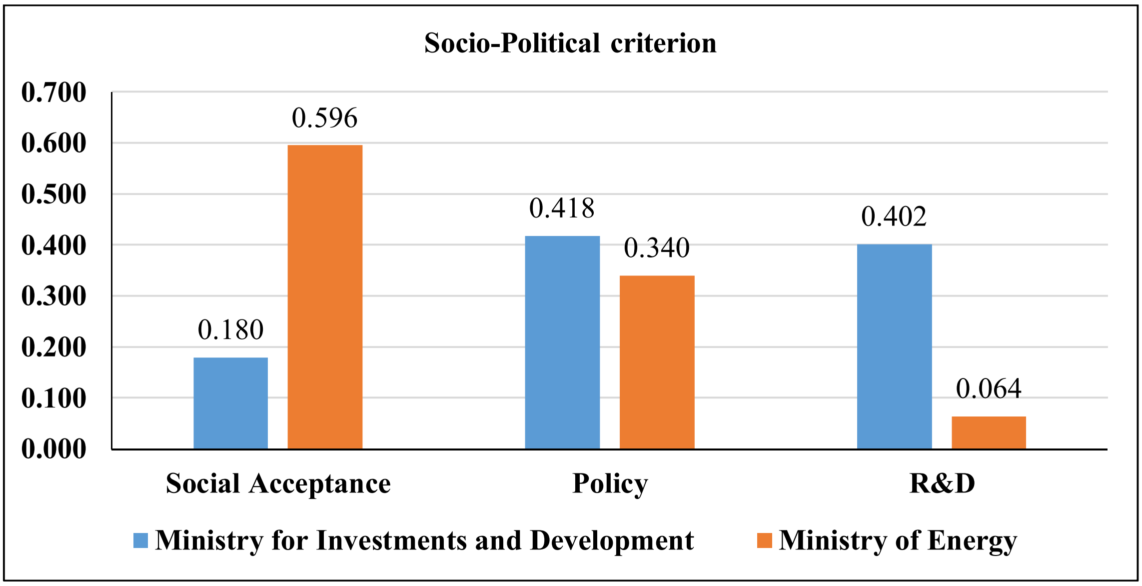

Figure 26. Estimated Weights of three sub criteria within Socio-Political Criterion

Table 15. Estimated Weights within Socio-Political Criterion

Barrier	**Priority weight**	**Share**	**Rank**
Policy	0,418	42%	1
R&D	0,402	40%	2
Social Acceptance	0,180	18%	3

Table 16. Estimated Weights within Socio-Political Criterion

Barrier	Priority weight	Share	Rank
Social Acceptance	0,596	60%	1
Policy	0,340	34%	2
R&D	0,0,064	6%	3

The aggregated results from the Ministry for Investments and Development and the Ministry of Energy are presented in Figure 26.

For the Ministry for Investments and Development**,** the aggregated results of the judgement of three sub criteria within Socio-Political criterion show dominated importance of "Policy" sub criterion (0,418). "R&D" sub criterion has medium level of importance (0,402) and "Social Acceptance" sub criterion (0,180) is the weakest among all three dimensions.

On the other hand, for the Ministry of Energy**, "**Social Acceptance" sub criterion plays the most significant role (0,596). "Policy" criterion has medium importance (0,340) and "R&D" is the least important sub criterion (0,064).

The situation with assessment of R&D barrier can be also explained by functional difference. The Technology and Innovation Development Department is a structural unit of the Ministry for Investments and Development. Their main functional obligation is manage industrial-innovative development and scientific and technological development in Kazakhstan. Consequently, the respondents assessed R&D sub criterion as the most important.

Social acceptance sub criterion was highly assessed by the employees from the Ministry of Energy due to their daily work. As it was mentioned before, the policy makers fro, the Ministry of Energy monitor and contact non-governmental organizations in environmental issues. Also, historical experience with nuclear related projects shows high importance of public opinion, as a result it has the highest priority for the policy makers from the Ministry of Energy.

Thus, the ranking of sub criteria for the Ministry for Investments and Development is presented in Table 15, and the ranking of sub criteria for the Ministry of Energy is shown in Table 16.

4.3 Weights of sub criteria within Technical criterion

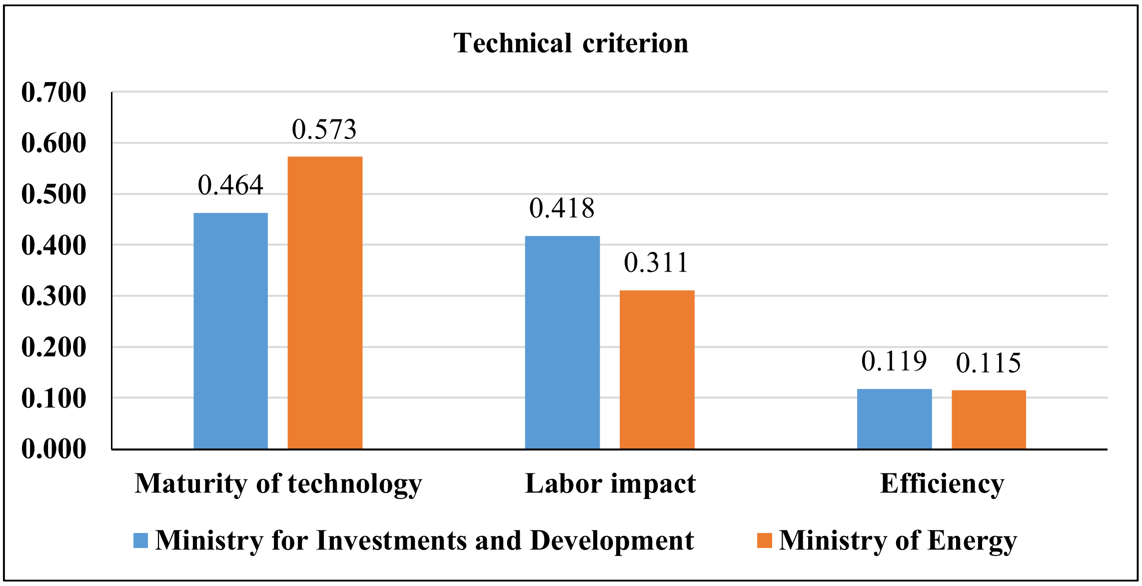

Figure 27 Estimated Weights of three sub criteria within Technical Criterion

Barrier	Priority weight	Share	Rank
Maturity of technology	0,464	46%	1
Labor impact	0,418	42%	2
Efficiency	0,119	12%	3

Table 17. Estimated Weights within Technical Criterion

Barrier	Priority weight	Share	Rank
Maturity of technology	0,573	57%	1
Labor impact	0,311	31%	2
Efficiency	0,115	12%	3

Table 18. Estimated Weights within Technical Criterion

The aggregated results from the Ministry for Investments and Development and the Ministry of Energy are presented in Figure 27.

For the Ministry for Investments and Development**,** the aggregated results of the judgement of three sub criteria within Technical criterion represent high importance of “Maturity of technology” sub criterion (0,464). “Labor impact” sub criterion (0,418) has medium level of importance and “Efficiency” sub criterion (0,119) is the weakest among all three dimensions.

For the Ministry of Energy, **“**Maturity of technology” sub criterion (0,573) is the most important. “Labor impact” sub criterion has medium importance (0,311) and “Efficiency” sub criterion (0,115) has the smallest importance.

Surprisingly, both groups of respondents show similar attitude to the assessment of Technical criterion. The Maturity of technology was ranked first, then middle place was given to Labor impact sub criterion. Efficiency sub criterion was put on the last place.

Thus, the ranking of sub criteria for the Ministry for Investments and Development is presented in Table 17, and the ranking of sub criteria for the Ministry of Energy is shown in Table 18.

4.4 Weights of sub criteria within Economic criterion

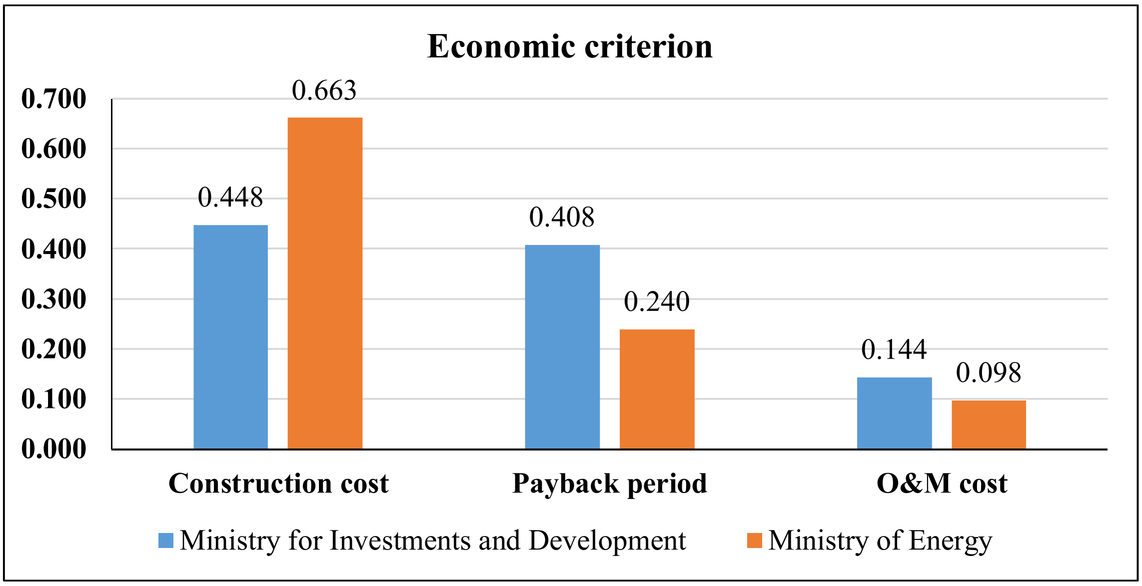

Figure 28 Estimated Weights of three sub criteria within Economic Criterion

Barrier	Priority weight	Share	Rank
Construction cost	0,448	45%	1
Payback period	0,408	41%	2
O&M cost	0,144	14%	3

Table 19. Estimated Weights within Economic Criterion

Barrier	Priority weight	Share	Rank
O&M cost	0,663	66%	1
Payback period	0,240	24%	2
Construction cost	0,098	10%	3

Table 20. Estimated Weights within Economic Criterion

The aggregated results from the Ministry for Investments and Development and the Ministry of Energy are presented in Figure 28.

The aggregated results of the judgement of three sub criteria within Economic criterion shows same habits of government officials from both ministries Ministry for Investments and Development and Ministry of Energy. Employees from Ministry for Investments and Development access “Construction cost” sub criterion as the most important with the weight of 0,488, while Ministry of Energy policy makers estimate “Construction cost” sub criterion with the weight of 0,663.

“Payback period” sub criterion has a medium level of importance for policy makers from Ministry for Investments and Development (0,408) and Ministry of Energy (0,240).

Lastly, government officials from both ministries estimate O&M cost as an inconsiderable factor Ministry for Investments and Development (0,144) and Ministry of Energy (0,098).

Within the Economic criterion, there is the same trend of assessment factors. First place belongs to Construction cost sub criterion, Payback period is on the second place and O&M cost they put on the last place.

Thus, the ranking of sub criteria for the Ministry for Investments and Development is presented in Table 19, and the ranking of sub criteria for the Ministry of Energy is shown in Table 20.

4.5 Weights of sub criteria within Environmental criterion

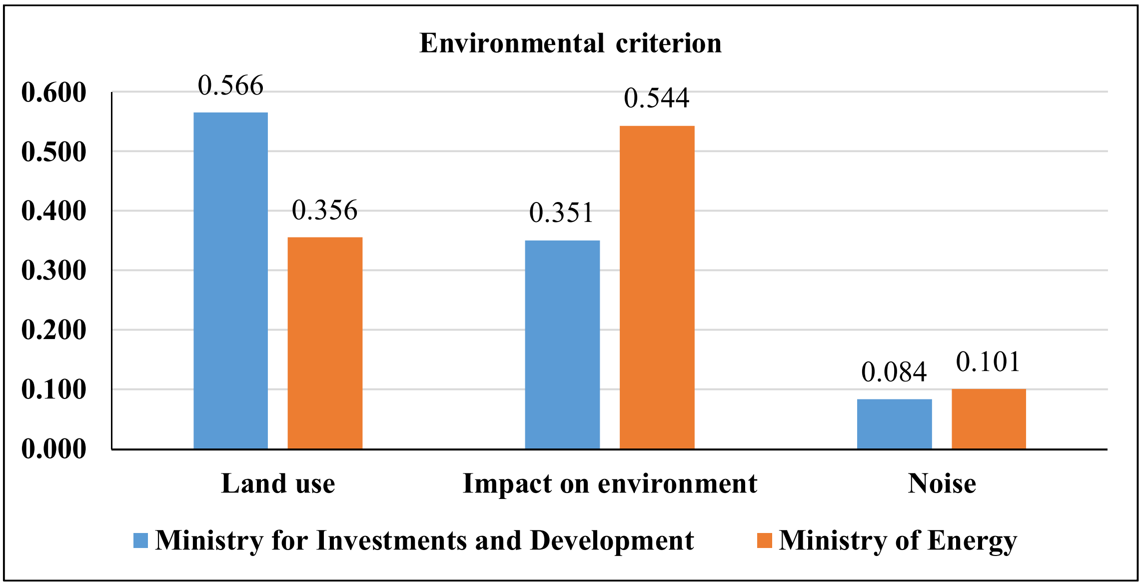

Figure 29 Estimated Weights of three sub criteria within Environmental Criterion

Barrier	Priority weight	Share	Rank
Land use	0,566	57%	1
Impact on environment	0,351	35%	2
Noise	0,084	8%	3

Table 21. Estimated Weights within Environmental Criterion

Barrier	Priority weight	Share	Rank
Impact on environment	0,544	54%	1
Land use	0,356	36%	2
Noise	0,101	10%	3

Table 22. Estimated Weights within Environmental Criterion

The aggregated results from the Ministry for Investments and Development and the Ministry of Energy are presented in Figure 29.

For the Ministry for Investments and Development, the aggregated results of the judgement of three sub criteria within Environmental criterion represent high importance of “Land use” sub criterion (0,566). “Impact on environment” sub criterion (0,351) has medium level of importance and “Noise” sub criterion (0,101) is the weakest among all three dimensions.

For the Ministry of Energy**, “**Impact on environment” sub criterion (0,544) is the most important. “Land use” sub criterion has medium importance (0,356) and “Noise” sub criterion (0,101) has the smallest importance.

Within the Environmental criterion, the difference is not significant. While policy makers from the Ministry for Investments and Development assessed Land use as the most important and Impact on environment as a second most important, employees from the Ministry of Energy gave first place to the Impact on environment factor and Land use they put on the second place. Both groups defined Noise sub criterion as the least important factor.

Thus, the ranking of sub criteria for the Ministry for Investments and Development is presented in Table 21, and the ranking of sub criteria for the Ministry of Energy is shown in Table 22.

4.6 Results of Global Priorities

As it was described in the previous chapters, we conducted hierarchy tree based on the four criteria and 12 sub criteria which were found in related papers (Table23). Second step was pairwise comparisons of criteria and sub criteria using Analytic Hierarchy Process. This section contains the results of global priorities.

Criteria	Sub criteria
Socio-political	Social Acceptance
	Policy
	R&D
Technical	Efficiency
	Maturity of technology
	Labor impact
Economic	Construction cost
	O&M cost
	Payback period
Environmental	Impact on environment
	Land use
	Noise

Table 23. List of criteria and sub criteria

To determine actual weight of each sub criterion within total number of sub criteria, the weight of each sub criterion should be multiplied by the weight of its criterion (Heo et al., 2010). Table 23 shows 4 criteria and 12 sub criteria that were assessed by decision makers.

The calculated weights and rankings are represented in Figure 30, Table 24 and Table 25.

From the aggregated results, the "Construction cost" is the most important barrier for decision makers from the Ministry for Investments and Development. "Payback period" is ranked 2nd by its importance. "Maturity of technology" barrier is placed 3rd in this ranking by its weight based on employees from the Ministry for Investments and Development. On the other hand, "Noise" and "Social Acceptance" are the least important barriers for the officials from the Ministry for Investments and Development.

Calculated results show, that the "Impact on environment" barrier is placed at the top of the ranking by the assessment of decision makers from the Ministry of Energy. Second place of the ranking belongs to the "Land use" criterion. Interestingly, that decision makers from the Ministry of Energy put "Construction cost" on the 3rd place, thereby agreed with employees from the Ministry for Investments and Development that it should be in a TOP 3 category.

Although some similarities, decision makers from the Ministry of Energy put "Efficiency" and "R&D" barriers at the bottom of the ranking.

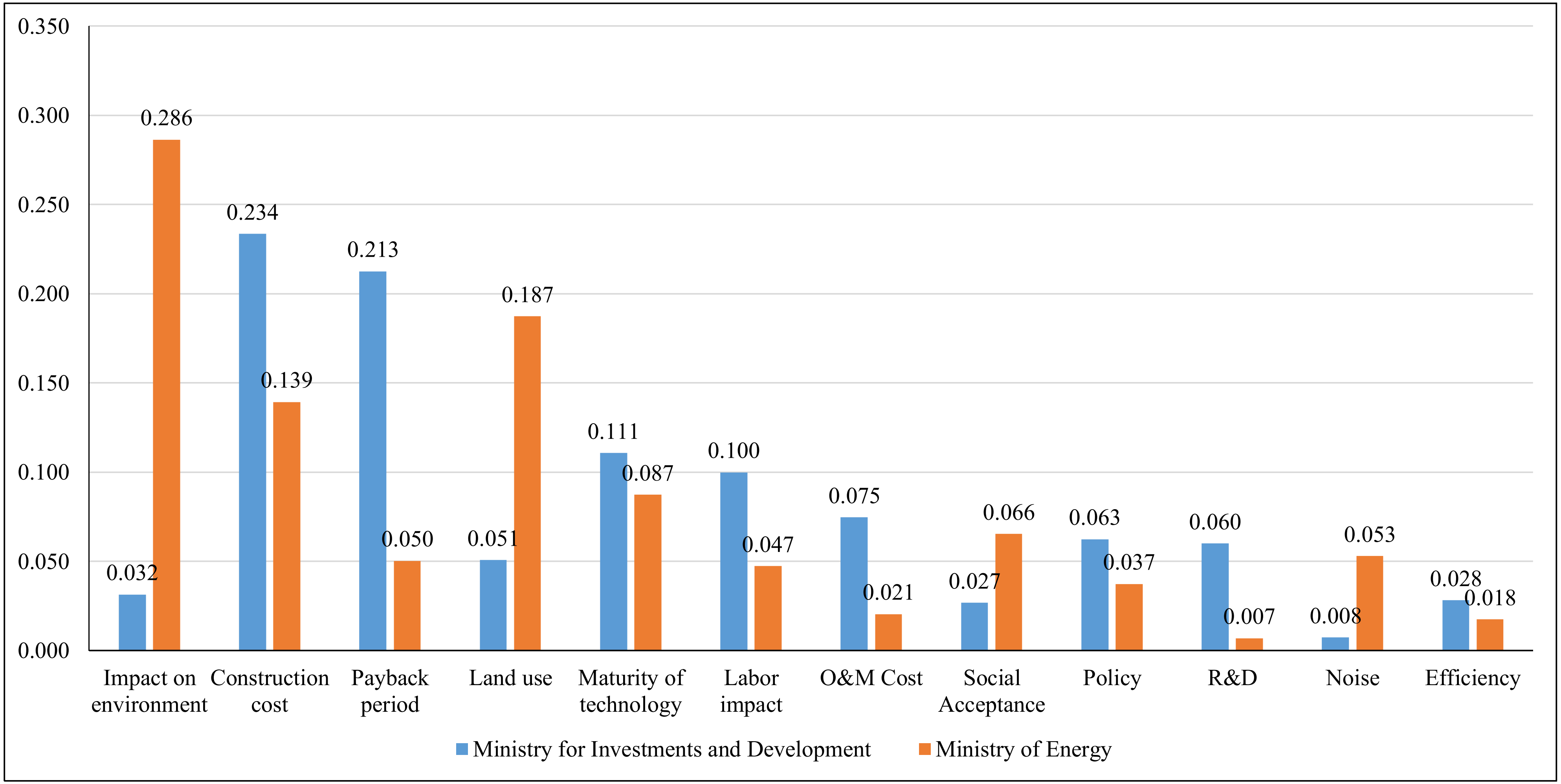

Figure 30. Weights of Global priorities

Barrier	Priority weight	Share	Rank
Construction cost	0,234	23%	1
Payback period	0,213	21%	2
Maturity of technology	0,111	11%	3
Labor impact	0,100	10%	4
O&M Cost	0,075	8%	5
Policy	0,063	6%	6
R&D	0,060	6%	7
Land use	0,051	5%	8
Impact on environment	0,032	3%	9
Efficiency	0,028	3%	10
Social Acceptance	0,027	3%	11
Noise	0,008	1%	12

Table 24. Global priorities of the Ministry for Investments and Development

Barrier	Priority weight	Share	Rank
Impact on environment	0,286	28,6%	1
Land use	0,187	18,7%	2
Construction cost	0,139	13,9%	3
Maturity of technology	0,087	8,7%	4
Social Acceptance	0,066	6,6%	5
Noise	0,053	5,3%	6
Payback period	0,050	5,0%	7
Labor impact	0,047	4,7%	8
Policy	0,037	3,7%	9
O&M Cost	0,021	2,1%	10
Efficiency	0,018	1,8%	11
R&D	0,007	0,7%	12

Table 25. Global priorities of the Ministry of Energy

4.7 Comparative analysis

In previous section, the results about global priorities of the Ministry for Investments and Development and the Ministry of Energy were explained.

As it was mentioned in Chapter 1 of this study, in order to answer research questions the unique characteristics of each ministry should be analyzed.

The reason for choosing these regulation bodies is in their competences and responsibilities. According to the National Strategy "100 steps" ("National Strategy 100 steps" n.d.) the government planned to construct nuclear power plant in Kazakhstan. Based on the governmental distribution of authorities, the Ministry for Investments and development should be responsible for the investment sector while the Ministry of Energy will take care of the technical realization of the project.

Therefore, following sub sections will analyze results of this study and compare them.

4.7.1 Ministry for Investments and development

The results obtained from this study show difference in point of views of policy makers of the Ministry for Investments and Development and the Ministry of Energy.

As we mentioned earlier, decision makers from the Ministry for Investments and Development assessed the weight of Economic criterion (52%) as the highest criterion on the way of nuclear power plant's development. This finding is similar to those of Ahmad et al., (2017) who stated that economic criterion is the most important criterion factor in both renewable and nuclear energy planning in Kazakhstan. (Ahmad et al., 2017)

The second highest criterion is Technical criterion with it's priority weight of 24%, so it is placed on the second place of the criteria ranking. Such importance of Technical criterion in energy management can be found in the study Ahmad et al., (2017). They found that Technical criterion is second most important factor for the development of energy sector. Similar to our results, Ahmad et al., (2017) put Economic and Technical factors on the first and second place respectively.

Moreover, Socio-Political (15%) and Environmental (9%) criteria are placed on the third and fourth place respectively. These findings reflect similar results found by Ahmad et al., (2017).

Also, the results from the decision makers from the Ministry for Investments and Development are similar with the findings from the paper of Heo et al., (2010). They found that the Economic criterion is the most important for policy makers and specialist group assessed Technical criterion as the most important. Like the findings of this study, Heo et al., (2010) convinced that, policy makers and specialist group found that the importance of the Environmental and Policy related criteria were low.

Amer & Daim, (2011) found that Environmental, Social and Political criteria are the least important barriers in the selection of renewable energy technologies in Pakistan.

In the case of sub criteria, Construction cost and Payback period are placed on the first and second place respectively in the ranking of the most important barriers for energy development. Similar findings can be found in the study of Ahmad et al., (2017) who claimed that Construction cost and Payback period are the most important factors for development renewable and nuclear energy in Kazakhstan.

The results of our study show the importance of Noise sub criterion is the lowest among all criteria. Policy makers from the Ministry for Investments and Development placed Social acceptance and Efficiency criteria on the second and third lowest places respectively. Such order of importance is similar to those of Ahmad et al., (2017) who found that Efficiency and Public acceptance are in the group of "less important criteria".

The lowest importance of Efficiency can be found from Talinli et al., (2010). They convinced that Efficiency factor does not significantly influence energy sector in Turkey.

Such arrangement of criteria finds its reflection if the National Strategy "100 steps" ("National Strategy 100 steps" n.d.). Paragraph 51 of the National Strategy states that Economic and

Technical aspects should be priority directions for development of energy sector.

Moreover, management of investment sector in Kazakhstan belongs to the Ministry for Investments and development and regulation of industrial sector is in tasks of the Industrial development and industrial safety Committee of the Ministry of Investments and development. Thus, decision makers from that organizations answered based on their backgrounds.

4.7.2 Ministry of Energy

For the employees from the Ministry of Energy the Environmental criterion is the most crucial with its weight of 51 %. Luthra, Kumar, et al., (2015) found that the Environmental criterion is the most significant criterion for the sustainability of renewable energy technologies. Shen et al., (2010) also found that the importance of Environmental criterion is the highest one for geothermal energy.

Additionally, such high importance of Environmental criterion can be justified by the commitment of policy makers from the Ministry of Energy to reduce negative impact of energy sector on environment. The government of the Republic of Kazakhstan at the Paris Climate Conference in 2015 set a task - 15% reduction of GHG emissions by 31 December 2030 (COP, 2015). Furthermore, according to the paragraph 3 of chapter 4 of the national strategy "Kazakhstan-2030" of 1997, ecological standards should be constantly improved.

Second place of the ranking belongs to Economic criterion which weight is equal to 21%. The importance of Economic criterion in development nuclear power plants is obvious due to it is capital intensive industry which requires significant investment (Keepin & Kats, 1988). Tasri & Susilawati, (2014) also found that Economic criterion is second most important factor in selection energy alternatives in Indonesia.

Decision makers assessed Technical criterion as not significant with the weight of 15%. The findings are similar to those of Luthra, Kumar, et al., (2015) who found that Technical barrier takes third place for sustainable energy technologies in India. In contrast, Shen et al., (2010) also concluded that Technical criterion is not crucial in sustainable energy in Turkey. Similar results were obtained by Heo et al., (2010) who found that importance of Technical criterion in renewable energy dissemination program is relatively high. Such difference can be explained due to difference between countries. Certainly, the difference in economic development between developed and developing countries affects adjacent sectors and energy sector is not an exception. In case of Kazakhstan, there is no existing nuclear industry as well as strong R&D sector. As a result, new technologies and advanced projects are implemented by adopting best existing international technologies. Than is justified by the fact that government wants to minimize failure risks and implement competitive and efficient industry.

Socio-Political criterion with its 11% was put on the last place of the ranking. Such small importance of Socio-Political criterion is found in the study of Ahmad & Tahar, (2014). They convinced that Social factor is the least important for renewable and nuclear resources for electricity generation in Malaysia. Despite the findings of Ahmad & Tahar, (2014), we did not expect similar results due to several facts. First of all Malaysia and Kazakhstan are on the different level of economic development. Secondly, Malaysia has different budget sources and industrial sectors. Moreover, Kazakhstan experienced public pressure and incompliance with the nuclear programs as it was discussed in Chapter 1. Public opinion is supposed to be the key determinant in any national projects.

In case of sub criteria, result allowed us to place Impact on environment, Land use and Construction cost on the first, second and third place respectively. The importance of the Impact on environment is found by Luthra, Kumar, et al., (2015) who convince that environmental aspects as well as geographic conditions are the main factors influence sustainable energy sector in India. Talinli et al., (2010) also found that Impact on environment plays significant role in energy production in Turkey.

Similar to the judgements of government officials from the Ministry for Investments and development policy makers from the Ministry of Energy assessed Construction cost relatively high.

On the other hand, R&D, Efficiency and O&M cost criteria are assessed as the least important barriers in development nuclear sector in Kazakhstan. Such situation can be found in the study conducted by Luthra, Kumar, et al., (2015). They claim that R&D factor is not much important barrier for development energy technologies in India. Luthra, Kumar, et al., (2015) also found that the Efficiency criterion should not be considered for the development of energy sector in India due to its low importance. To the point of view that O&M cost is not significantly important can be approached the results by Talinli et al., (2010). Another interesting study was conducted by Chatzimouratidis & Pilavachi, (2009). They claim that the importance of O&M cost barrier is low for ten types of power plants.

4.7.3 Weight of each barrier and analysis of differences between two decision making groups

After assessment of weights of each criterion and conducting rankings for the Ministry for Investments and Development and for the Ministry of Energy, it is essential to analyze and compare the results between two decision making groups.

According to the experts from the Ministry for Investments and Development, the Economic criterion was assessed as the most important barrier for nuclear development in Kazakhstan. Such judgement can be explained by the background of decision makers who judge barriers. Development the investment sector through industrial diversification is one of the priorities of the Ministry. Interestingly, Technical and Socio-Political barriers were placed on the second and third place respectively.

Last place of the ranking belongs to the Environmental criterion. Again, we can explain that based on the lack of background of the experts in environmental related sphere.

On the other hand, decision making group from the Ministry of Energy placed Environmental barrier at the top of the ranking due to the economic background and job responsibilities of the respondents. The Committee of Environmental regulation and control which is responsible for the managing environmental conservation sector belongs to the Ministry of Energy.

Economic barrier was placed on the second place. Despite respondents from the Ministry of Energy don't manage financial aspect of projects, however it's clear that economic efficiency plays significant role in any project.

Similar with experts from the Ministry for Investments and Development, respondents from the Ministry of Energy placed Technical and Socio-Political criterion on the third and fourth place respectively. Despite the fact that those respondents have to decide issues related with technical side, they assessed Economic factor much higher than Technical and Socio-Political criteria.

Uncommonly, none of the decision-making groups believe that Socio-Political criterion should be considered as a priority one. Despite the social opinion is a key-factor in developed countries which should be evaluated prior to the project implementation, there is not much attention to social acceptance in Kazakhstan.

Interesting difference we can observe from the results of assessment of the Impact on Environment, Construction cost, Payback period Land use, Noise and Efficiency factors.

For example, the most significant factor for the employees from the Ministry of Energy is the Impact on environment barrier which weight is almost 30%, although the judgement of the experts from the Ministry for Investments and Development gave to this criterion 3% of importance.

Interestingly, policy makers from the Ministry for Investments and Development placed Construction cost (23%) and Payback period (21%) on the first and second place respectively.

Ambiguous situation with the assessment of Land use sub criterion. While government officials from the Ministry of Energy put that factor on the second place of ranking, policy makers from the Ministry for Investments and Development judged this factor as an outsider of that ranking with its weight 5%.Also, both groups of respondents placed Noise and Efficiency sub criteria on the last places of ranking.

Chapter 5. Conclusion

This chapter contains the conclusion of this study. Also, the policy implications and study limitation are explained.

Barrier	Priority weight	Rank
Construction cost	0,234	1
Payback period	0,213	2
Maturity of technology	0,111	3
Labor impact	0,100	4
O&M Cost	0,075	5
Policy	0,063	6
R&D	0,060	7
Land use	0,051	8
Impact on environment	0,032	9
Efficiency	0,028	10
Social Acceptance	0,027	11
Noise	0,008	12

Table 26. Weights of Global Priorities (MID)

Barrier	Priority weight	Rank
Impact on environment	0,286	1
Land use	0,187	2
Construction cost	0,139	3
Maturity of technology	0,087	4
Social Acceptance	0,066	5
Noise	0,053	6
Payback period	0,050	7
Labor impact	0,047	8
Policy	0,037	9
O&M Cost	0,021	10
Efficiency	0,018	11
R&D	0,007	12

Table 27. Weights of Global Priorities (ME)

5.1 Overall Conclusion

Kazakhstan's energy sector fully relies on fossil fuels. According to the national forecasts, there will be an increase of energy demand in the nearest future influenced by economic growth. For this reason, the issue of construction of a nuclear power plant is approached systematically and the government is still struggling with making a final decision.

According to the national strategy "100 steps" ("National Strategy '100 steps';," n.d.), the Government should analyze the current energy situation and economic conditions in order to conduct a road map of development of the nuclear power plant.

Thus, in this study I analyzed various barriers the Ministry of Energy and Ministry for Investments and Development will face, and determined the most critical for both ministries.

Through an analysis of answers of policy officials from the two key-ministries responsible for the regulation of the energy and investments sectors, I supposed that those applicants are the main source of collecting data for this study. Moreover, the literature review and current national legislation were taken into account for providing explanations and comments.

A multi-criteria analysis approach was selected for ranking the barriers for the development of the nuclear sector. The model framework consists of four criteria and twelve sub-criteria based on Kazakhstan's policies regarding the future composition of the country's energy sector and relevant literature.

The results of Chapter 4 of this thesis show that Construction cost and Impact on environment are the two most crucial barriers for decision makers from the two ministries. Thus, prior to the project implementation, the government should overcome them or decrease their importance.

Since financial aspects of any project play a crucial role in project realization, the construction of a nuclear power plant can be subsidize partly by governmental funds and the private sector.

The investment for the planned nuclear project in Kazakhstan can be found following an investment scheme for the ongoing construction of a nuclear power plant in the Republic of Belarus. The projected capacity of that project in Belarus is 2400 MW will it cost about $9 billion (Naviny.by, n.d.). Governmental loans will be provided by the Russian government.

In 2018, the opening ceremony of the Low Enriched Uranium Bank (LEUB) took place in Kazakhstan. The International Atomic Energy Agency (IAEA) is a coordinator of that project. Construction of the LEUB is one of the breakthrough projects for supporting the nuclear sector in Kazakhstan. The goal of LEUB is to create a guaranteed stock of low-enriched uranium from which nuclear fuel will be produced for the nuclear power plants of any IAEA Member State. Such supporting projects will help to reduce the financial pressure at the beginning of project realization. Moreover, eliminating the barriers will lead to a sustainable and economically efficient development of nuclear projects.

Another possible way is to adopt current governmental policy in order to support project implementation through decreasing financial obligations, tax preferences and other stimulating methods.

Last, controversial differences in point of views of the decision makers were obtained which can be influenced by the background of these government officials and responsibilities of two different decision groups. For example, government officials from the Ministry for Investments and Development are managing the investment and industrial sectors in Kazakhstan. On the other side, the Ministry of Energy is responsible for the energy sector in Kazakhstan. Such differences result from the competences of policy makers.

In order to gather opinions and effectively collect information from different governmental institutions, it is necessary to develop a synchronous intergovernmental institute which will include representatives from all involved institutions. Such mechanism is not new and is a common way for international project implementation.

The core results obtained by this thesis can be used for the assessment of risks in project implementation. The calculated weights of criteria and sub criteria are useful for decision makers for establishing the first nuclear power plant project in Kazakhstan and can be a good starting point for other related projects.

5.2 Limitations of Study

The first goal of this study is to determine the most significant criteria for two Ministries, while the second aim is identifying the difference in point of views of decision makers.

However, in any project, it is necessary to consider both sides, such as governmental and non-governmental. Although, this study identified the barriers for the governmental side and compares the opinion from two different ministries, in order to analyze this issue as a whole, an analysis of the opinions of NGOs and citizens would be helpful.

Precise analysis of the barriers for the construction of a nuclear power plant in Kazakhstan should be analyzed and the policy suggestions based on that analysis have to be proposed as well.

Although the Social Acceptance barrier was not assessed high by both decision-making groups, based on the historical battles between the anti-nuclear movement and government in Kazakhstan, it should be considered as a main possible ba rrier. Thus, the government of Kazakhstan should emphasize an analysis of the social opinion an d include it as a main part of the whole study.

Additionally, this topic can be transformed in order to obtain specific results such as power plant's capacity, type of reactors and the location of construction.

Considering that the result of this study is specific to the Republic of Kazakhstan, they cannot b e easily applied for analysis in any other country due to the local context.

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Appendix 1: Questionnaire

Analysis on decision making in the case of nuclear power plant Aid Methodology

Mr. Kim Alexandr is performing this research under the supervision of Director of the International Energy Policy Program (IEPP) Seoul National University, Professor Eunnyeong Heo. This survey is carrying out with the cooperation of IEPP of Seoul National University, South Korea, in order to study barriers of Nuclear Power Plant's development and for the purpose of the ranking barriers in Republic of Kazakhstan.

The main goal of this questionnaire is to identify main barriers and rank the according to the importance. This questionnaire includes pair-wise comparison questions addressed to the government officials in energy sector, to seek their judgments representing the relative influence of pre-identified barrier dimensions and sub dimensions. All your response to this survey will be confidential and used only for academic research purpose. The answers provided by participants will be confidential. The information obtained from the participants will only be for writing a master thesis.

If you have any comments, suggestions or questions about this survey, do not hesitate to contact me via e-mail alexandr@snu.ac.kr or kimalexandr.ast.kz@gmail.com

Using Analytic Hierarchy Process model (AHP), I will analyze the government officials' opinions. AHP allows to compare the importance of alternative factors effect on decision making process. Through the questionnaire, the interviewees will express their thoughts about barriers of nuclear power plant's development.

Kim Alexandr

Seoul National University

Instructions.

This questionnaire aims to determine the difference in decision-making between the Ministry of Energy and the Ministry for Investments and Development.

You should answer the questions through pairwise comparison based on the hierarchy structure. There are four main criteria and twelve sub criteria should be evaluated using the Analytic Hierarchy Process.

Your task is to evaluate each pairwise comparison based on your personal preferences and choose the best option.

Example: You will be comparing the relative importance of the options A and B in order to answer question. Using nine-scale judgement, you have to evaluate importance between A and B.

A	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**B**

1. If option A is **EXTREMELY MORE IMPORTANT** that option B

2. If option A is **VERY STRONGLY MORE IMPORTANT** that option B

3. If option A is **STRONGLY MORE IMPORTANT** that option B

4. If option A is **MODERATELY MORE IMPORTANT** that option B

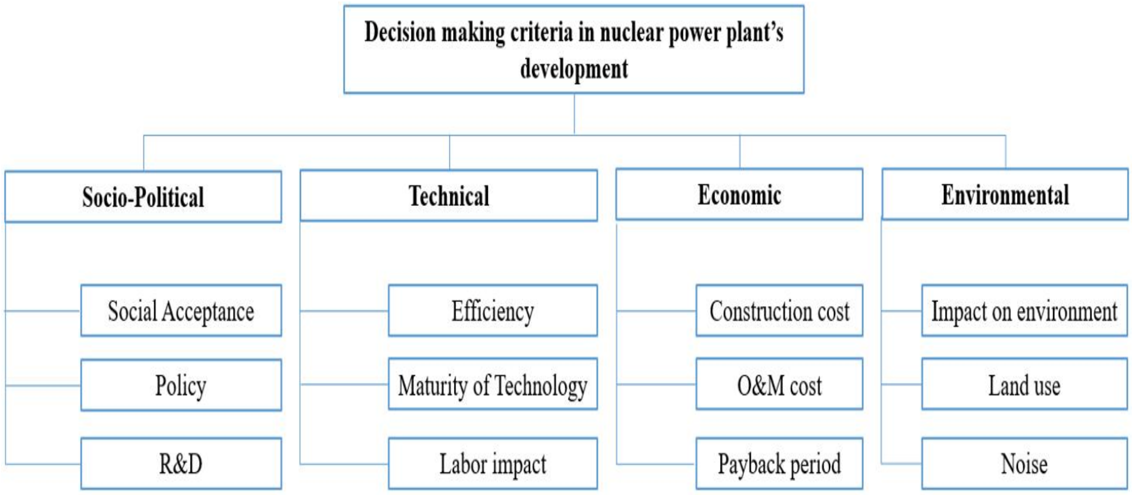
5. If options A and B are **EQUALLY IMPORTANT**

6. 4. If option B is **MODERATELY MORE IMPORTANT** that option A

7. If option B is **STRONGLY MORE IMPORTANT** that option A

8. If option B is **VERY STRONGLY MORE IMPORTANT** that option A

9. If option B is **EXTREMELY MORE IMPORTANT** that option A



NOTE! You must note that the degree of importance for the left side (in our case is criterion A), continues to reduce from 1 to 2, while the importance of the right side (in our case is criterion B) continues to increase from 6 to 9. However, you must put 5 if options A and B are equally important.

If you understand the way to answer this questionnaire, then let's move to the real questions.

Assessment barriers in decision making in the case of nuclear power plant's development.

Nowadays, expansion of nuclear energy is a challenging questions. Undoubtedly, nuclear power plants are efficient. Nuclear reactors provide electricity without CO_2 emissions. On the other hand, emergency situations can lead to significant damages of the land and can pollute an environment. Thus, prior to the project implementation it is necessary to determine barriers for establishing nuclear industry in Kazakhstan.

In this section you will be given four main criteria (barriers) for comparing.

Description of main criteria

A. Socio-Political

Project implementation in energy sector includes many judgements of socio-political issues. The Socio-Political barrier is a criterion which is sensitive and reflects social and political mood. The barrier shows whether or not society and political parties are satisfied in reforms and current political situation.

B. Technical

It is generally understood that the nuclear energy has to be managed carefully and it is high risky industry. Several accidents which were happened around the world show society the consequences of disregarding safety rules which leads to such catastrophes. Technical barrier is definitely one of the most important criterion due to it is complexity and importance

C. Economic

It is no doubt that the energy sector is capital intensive one. Consequently, financial aspect dominates in decisions making to involve in technological innovation. Competitive environment in the energy market compels companies to schedule their business strategies concerning market trends for operative reaction and sustain efficiency.

The Economic barrier is a criterion represents the judgement of the proposed energy project using economic tools such as net present value (NPV), internal rate of return (IRR), cost and benefit analysis (CB) and payback period. This refers to the amount of budget in order to realize energy project.

D. Environmental

The "Environmental" criterion is used to describe expected hazard of environmental accidents affected by the energy power plant. This barrier measures protection and safety measures for environmental conservation. For analyzing these barriers the qualitative analysis has to be done.

Considering environmental barrier should be taking into account the reduction of hazardous impact on environment such as CO_2 emission, noise, land use etc.

Question:

In decision-making process of construction nuclear power plant which criterion is the most important?

	1	2	3	4	5	6	7	8	9	
Socio-Political	○	○	○	○	○	○	○	○	○	Technical
Socio-Political	○	○	○	○	○	○	○	○	○	Economic
Socio-Political	○	○	○	○	○	○	○	○	○	Environmental
Technical	○	○	○	○	○	○	○	○	○	Economic
Technical	○	○	○	○	○	○	○	○	○	Environmental

Description of Socio-Political criteria

A. Social Acceptance

"Social Acceptance" barrier represents the level of people's attitude related to proposed energy power plant from the consumer's point of view. This barrier plays crucial role because an implementation of any project is sensitive to the opinion of citizens and pressure classes. Consequently, it is very important to collect people's opinion about suggested project beforehand. It is impossible to analyze using quantitative methods, nevertheless the qualitative analysis can be used in assessment of energy project.

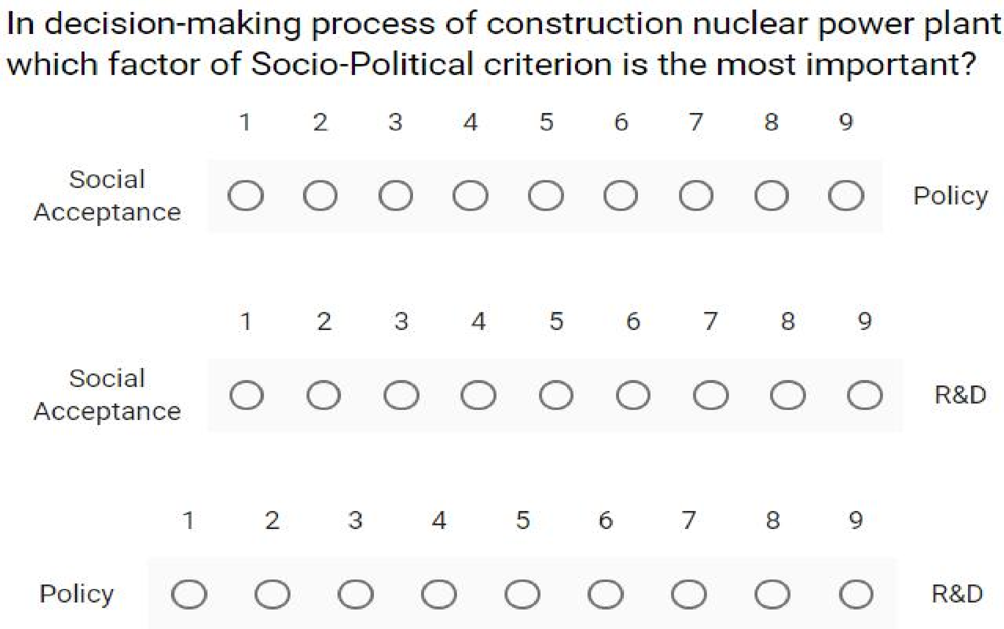
B. Policy

The "Policy" barrier represents the level of comprehension of existing legislation which energy sector is regulated by (Abdulrahman et. al., 2014). Due to the absence of nuclear power plant in the Republic of Kazakhstan, there is no comprehensive policy. The legislation has to be issued prior to the implementation of the energy project.

C. R&D

Necessity of the "R&D" barrier can be conditioned by the absence of nuclear industry in the Republic of Kazakhstan. The high level of the "R&D" barrier affects an implementation of nuclear project is complicated.

Question:


In decision-making process of construction nuclear power plant which factor of Socio-Political criterion is the most important?

	1	2	3	4	5	6	7	8	9	
Social Acceptance	○	○	○	○	○	○	○	○	○	Policy
Social Acceptance	○	○	○	○	○	○	○	○	○	R&D
Policy	○	○	○	○	○	○	○	○	○	R&D

Technical criterion

It is generally understood that the nuclear energy has to be managed carefully and it is high risky industry. Several accidents which were happened around the world show society the consequences of disregarding safety rules which leads to such catastrophes. Technical barrier is definitely one of the most important criterion due to it is complexity and importance.

A. Efficiency

The "Efficiency" barrier represents the amount of energy which can be benefited from the implementation of the energy project. The efficiency index is a ratio between the energy spent and energy generated (Wang et. al., 2009). The efficiency is important for deceleration of energy demand rise. This barrier is the most useful technical criterion for assessment of energy project.

B. Maturity

This barrier evaluates complexity of proposed technology and the capacity of local professionals using qualitative analysis. The main reason for that is to analyze whether local manpower guarantees suitable operational service and setting facilities, machinery and operation system for managing the energy power plant.

C. Labor impact

The barrier "Labor impact" is used to examine the readiness of local manpower to implement proposed energy project. It includes educational and practical skills of local agents. In addition, this barrier can be helpful in order to analyze an direct and indirect effect on the rate of employment. In order to implement the project, the need of technically trained labors is obvious.

Question:

In decision-making process of construction nuclear power plant which factor of Technical criterion is the most important?

	1	2	3	4	5	6	7	8	9	
Efficiency	○	○	○	○	○	○	○	○	○	Maturity of technology
Efficiency	○	○	○	○	○	○	○	○	○	Labor impact
Maturity of technology	○	○	○	○	○	○	○	○	○	Labor impact

Economic criterion

It is no doubt that the energy sector is capital intensive one. Consequently, financial aspect dominates in decisions making to involve in technological innovation. Competitive environment in the energy market compels companies to schedule their business strategies concerning market trends for operative reaction and sustain efficiency.

The Economic barrier is a criterion represents the judgement of the proposed energy project using economic tools such as net present value (NPV), internal rate of return (IRR), cost and benefit analysis (CB) and payback period. This refers to the amount of budget in order to realize energy project.

A. Construction cost

Construction cost can be interpreted as an amount of required investment for the implementation the energy project. It includes all expenses needed from the beginning until the power plant will be fully operational. The list of expenses can include purchasing the machinery, installation works, construction of highways, engineering works, drilling and other construction works.

B. O&M cost

The “Operation and maintenance cost” involves all the actions related to energy project such as salary and hiring expenses, purchasing materials, parts and fuels, transportation, installation works etc. The average O&M cost equals 2 percent of the total investment.

C. Payback period

"Payback period" criterion represents of regeneration or the time frame from the initial investment till all the expenses will be recovered. This means how fast the invested funds will be benefited from the operated energy power plant. Generally, shorter payback period is preferably accepted rather than the long one. The payback period is recognized as an essential factor in economic assessment in project evaluation.

Question:

In decision-making process of construction nuclear power plant which factor of Economic criterion is the most important?

	1	2	3	4	5	6	7	8	9	
Construction cost	○	○	○	○	○	○	○	○	○	O&M cost

	1	2	3	4	5	6	7	8	9	
Construction cost	○	○	○	○	○	○	○	○	○	Payback period

	1	2	3	4	5	6	7	8	9	
O&M cost	○	○	○	○	○	○	○	○	○	Payback period

Environmental criterion

The "Environmental" criterion is used to describe expected hazard of environmental accidents affected by the energy power plant. This barrier measures protection and safety measures for environmental conservation. For analyzing these barriers the qualitative analysis has to be done.

Considering environmental barrier should be taking into account the reduction of hazardous impact on environment such as CO_2 emission, noise, land use etc.

A. Impact on environment

The “Impact on environment” barrier represents an evaluation of harmful effect influenced by power plant in operational process. The barrier includes all kinds of hazardous material which has negative impact on environment, gasiform, liquid and solid types of waste etc.

B. Land use

The “Land use” barrier represents the territory required for nuclear power plant. In most cases this barrier can have strong influence on energy projects. Usually, the land occupation by the power plant causes ecological and health problems because of the permanent and wide pollutions. An appropriate management of land use can be explained use of an adequate land (soil erosion areas, polluted, remote etc.). However, insufficient management of land use leads to ecological accidents.

C. Noise

There are two different kinds of noise related to energy projects such as aerodynamic and mechanical. Aerodynamic noise is generated on operated power plant by the movements of turbine-types mechanisms, while mechanical noise is produced by mechanical actions of facilities or people working on power plant. The level of noise can be regulated using cutting-edge technologies and noise insulation materials.

Question:

In decision-making process of construction nuclear power plant which factor of Environmental criterion is the most important?

	1	2	3	4	5	6	7	8	9	
Impact on environment	○	○	○	○	○	○	○	○	○	Land use

	1	2	3	4	5	6	7	8	9	
Impact on environment	○	○	○	○	○	○	○	○	○	Noise

	1	2	3	4	5	6	7	8	9	
Land use	○	○	○	○	○	○	○	○	○	Noise

Abstract (Korean)

카자흐스탄은 우라늄 최대생산국이자 수출국이면서 동시에 구 소련연방국가이기에 원자력산업의 개발에 대한 관심이 크다. 풍부한 우라늄 매장량은 특히 카자흐스탄 정부가 원자력발전에 대한 정책을 지속적으로 논의하여온 대표적인 이유이다. 그러나 원자력발전이 실제로 카자흐스탄에서 개시되기 위해는 많은 제약과 한계를 넘어야 한다.

본 논문은 이러한 배경을 바탕으로 하여, 카자흐스탄에서 원자력 발전을 시작하기 위한 전제조건들이 무엇인지 찾고 또한 찾은 조건들의 중요도를 비교 분석하였다. 분석방법론으로는 복잡한 의사결정구조를 평가하는 분석에 활발히 사용되고 있는 Analytic Hierarchy Process (AHP)를 사용하였다. 본 연구에서는 먼저 관련 문헌을 분석하여 전제조건들을 나열하고, 이들을 전문가설문을 통하여 4개의 중분류 조건과 12개의 세부조건으로 정리하였다. 다음으로, 카자흐스탄 정부 중 실무를 담당하는 에너지부와 재정을 담당하는 투자개발부 소속 공무원들을 대상으로 하여 4개 중분류 조건 및 12개 세부조건들을 대상으로 AHP 분석을 실시하여 이들간의 중요도를 비교 분석하였다.

분석결과, 투자개발부 공무원들은 4개 중분류 중 경제성이 가증 중요도가 높다고 판단한 반면, 에너지부 공무원들은 환경성이 가장 중요하다고 판단하고 있음을 확인할 수 있었다. 두 부처 공무원들 모두 사회정치적 조건들은 중요하지 않다고 판단하였다. 세부 기준 중에는 건설비용과 회수기간 등이 투자개발부 공무원들이 가장 중요하게 생각한 조건인 반면 에너지부 공무원들은 소음과 주민수용성을 들었다. 한편 연구개발이나 효율성 등은 중요도가 낮게 나와 카자흐스탄 정부의 원자력에 대한 태도를 확인할 수 있었다.

주요어 : Analytic Hierarchy Process (AHP), 카자흐스탄, 원자력발전, 정부정책.

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