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Analyses of Nuclear Power Plant Waste In Terms of Environmental Policies

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Abstract: In recent years, the diversity and quantity of wastes have increased parallel to rapid industrialization of countries and it is becoming a major problem day by day. Radioactive waste has taken its place among major waste problems of the century such as industrial wastes, municipal wastes and scrap metals. Radioactive wastes are type of waste which are caused by research, medical and industrial application. Usage of nuclear material in nuclear reactors, medical and industrial application results the formation of radioactive waste. In this context, wastes of nuclear power plant have been studied under the title of radioactive waste types in this work. The environmental impact of nuclear power plant has been researched and techniques for preventing and reducing these effects were also included.

Keywords: Nuclear Power Plant; Nuclear Waste; Storage; Environmental Pollution

Nükleer Enerji Santrali Atiklarinin Çevre Politikalari Açisindan İncelenmesi

Özet: Son yıllarda, ülkelerin hızla endüstrileşmesine paralel olarak artan atık çeşitliliği ve miktarı her geçen gün daha da büyük bir sorun haline gelmektedir. Endüstriyel atıklar, evsel atıklar, madeni atıklar ve radyoaktif atıklar gibi belli başlı atık türlerinden radyoaktif atıklar yüzyılın önemli atık problemleri arasında yerini almıştır. Radyoaktif atıklar tıp, endüstri, araştırma gibi alanlardaki uygulamalar nedeniyle ortaya çıkan atık türleridir. Gerek nükleer reaktörlerde gerekse tıbbi ve endüstriyel kullanımlar sonucunda nükleer madde kullanımı radyoaktif atıkların oluşumuna sebep olmaktadır. Bu nedenle, çalışmada radyoaktif atık türleri başlığı adı altında, nükleer santral atıkları incelenmiştir. Nükleer enerji santrallerinin çevresel etkileri araştırılmış ve bu etkileri önlemeye ve azaltmaya yönelik tekniklere yer verilmiştir.

Anahtar kelimeler: Nükleer Enerji Santrali, Nükleer Atıklar, Depolama, Çevre Kirliliği.

1. Introductıon

It has become definite that apart from the importance and benefits of energy, it has also risks in terms of human health and environment. These risks are especially about air, soil, water pollution and resulting health problems. Therefore, the subject of environmental safety has become the main

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Bu makaleye atıf yapmak için
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topic of conversation for the first time, with the thesis of Lester R. Brown the consumption of natural sources and environmental destruction have become an important threat that will necessitate countries to redefine natural security [1] and in this way sustainable development policies has been one of the most privileged topics of twenty first century. Thanks to these policies, economic and social developments are led up. In order to follow these policies, developing an approach which includes the titles of economy, sociology and environment is a must. The issue of energy demands guarantee which is at the intersection point of all these titles is crucial to reach sustainable development objectives. Additionally, it is defined as a national security issue for most of the developed or developing countries [2-3].

The importance of "analysis of nuclear power plant waste in terms of environmental policies" comes to the foreground at this point. People, who adopt "Nuclear Renaissance" opinion in the world, support that the cleanest way of protecting the world from global warming is nuclear power plants. On the other hand, people who support "Nuclear Nightmare" exemplify Chernobyl nuclear accident which happened in 1986, proposing the issues of "security" and "not disposing waste" [4]. In the light of this information, in this study, nuclear energy which is proposed as an important alternative for fossil fuels and to what extent it is a sustainable source of energy are going to be discussed with its positive and negative aspects. In this respect, along with the fuel obtained from nuclear energy, problems such as waste management and safety hazards are going to be mentioned.

2. Methodology

Rapid growth in world population accompanies a lot of problems. Foremost of these problems is the need of energy sources. Countries use different energy sources to meet these needs [5]. The increase in the consumption based on the increasing demand is one of the most significant indicators of economic and social development. By which way this demanded energy is provided meaning the determination of energy sources, constitutes the basis of energy policies of the countries [6].

Primary energy sources such as coal, petroleum and natural gas are commonly used in energy generation in the world [7]. These sources, which are also known as conventional sources, are consumed and devastate environment by generating waste in some degree. As it can be seen in Figure 1, 33% of energy generation of the world has been obtained from petroleum, 30% from coal, 24% from natural gas, 7% from hydroelectric, 2% from renewable energy sources and 4% from nuclear energy since 2013 [8].

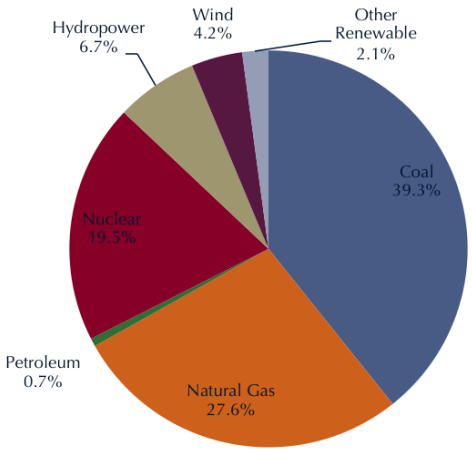

Figure 1. Percentages of annual energy generation by resources in the world since 2013 [8]

As for the percentages of energy generation by resources in Turkey since 2013, coal has been 26,3%, natural gas 43,8 %, geothermal 0.6%, hydraulic 24,8 %, wind 3,1%, other thermal sources 1,4% [9-10] (Figure 2).

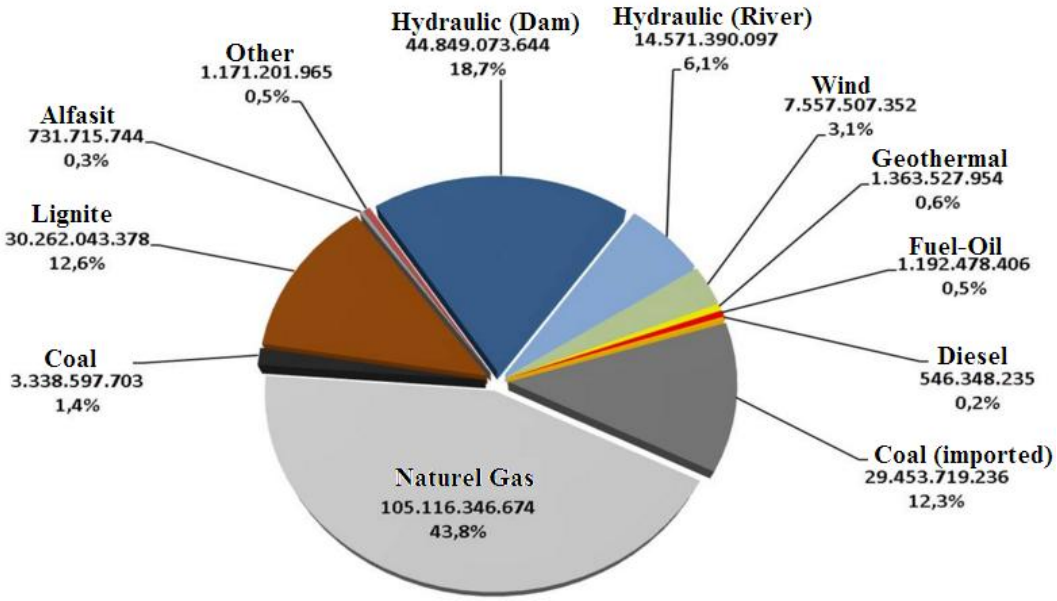

Figure 2. Percentages of energy generation by resources in Turkey since 2013 (kWh) [10]

2.1 Nuclear Energy

Core sources used while generating nuclear energy are uranium and thorium. Extractable uranium reserve in the world in 2011 was 5327.2 thousand tons. The richest countries with regard to reserves are Australia (1661 thousand tons), Kazakhstan (629 thousand tons), Russia (487.2 thousand tons), and Canada (468.7 thousand tons); uranium reserve in Turkey (9129 tons) is quite low compared to these countries. Extractable thorium reserve in the world in 2011 was 5385 thousand tons. The richest countries with regard to thorium reserves are India (521 thousand tons), Turkey (744 thousand tons), Brazil (606 thousand tons), Australia (521 thousand tons) and USA (434 thousand tons). In Figure 3 below, distribution of nuclear power plants in the world can be seen [11].

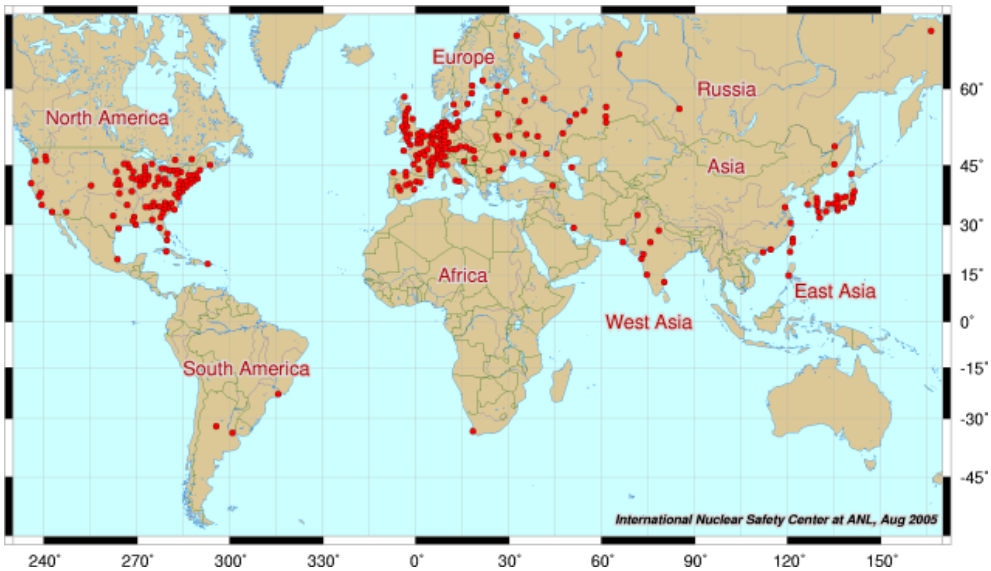

Figure 3. Nuclear power plants in the world [12]

Although the classification changes from country to country, according to their half-lives and radioactivity levels, radioactive wastes are collected under three main titles called low, middle and high level wastes. As a result of high energy density, nuclear energy generation creates less waste volumetrically per unit energy generated when compared to other energy generation alternatives. 440 nuclear reactors have been operating with 373.673 MW installed power in 29 countries in the world since 2011. They meet 15 % of need of electric energy in the world. Numeric data related to nuclear reactors which have been under the construction can be seen in Table 1.

Table 1. The number of units, total power and share in electric generation of nuclear reactors, which have been under the construction in the world since 2015 [2].

Country	Units	MWe (net) (Megawatt electric)	Construction Start	Planned Grid Connection	Delayed Startup (Units)
China	24	23,738	2009-2015	2015-2021	15
Russia	8	6,262	1983-2010	2015-2019	8
India	6	3,907	2002-2011	2015-2019	6
USA	5	5,633	1972-2013	2016-2020	5
South Korea	4	5,360	2008-2013	2016-2018	4
UAE	3	4,035	2012-2014	2017-2019	?
Belarus	2	2,218	2013-2014	2019-2020	?
Pakistan	2	630	2011	2016-2017	2
Slovakia	2	880	1985	2016-2017	2
Ukraine	2	1,900	1986-1987	2019	2
Argentina	1	25	2014	2018	?
Brazil	1	1,245	2010	2018	1
Finland	1	1,600	2005	2018	1
France	1	1,600	2007	2017	1
Total	**62**	**59,033**	**1972-2015**	**2015-2021**	**47**

Nuclear power plants use almost one per one hundred thousand of the fuel used by a thermal power plant with the same power level and provide the same amount of energy. However, three different levels of radioactive wastes are generated as low, middle and high levels of wastes in nuclear power generation plants. Wastes that can be turned into normal industrial waste are low and middle level wastes. After being kept a period of time, these types of wastes are being processed as radioactive industrial waste. A great majority of high level nuclear waste is consisted of fuel materials which are found in spent fuel and become radioactive. Uranium in spent fuel is just at the rate of 3 or 4%. The rest of the spent fuel is renewable material. However, whether countries choose to recycle or not to recycle this renewable material depends on the policy they adopt and it still changes from country to country.

There is no combustion reaction in nuclear power plants as it is in other conventional plants. In order not to experience any radioactive elements to diffuse via process steam in an uncontrolled way from a leakage that may occur in the first or the second cycle in the plants or especially in reactor building, these buildings are kept under low pressure. In other words, air in these buildings are exhausted, since the internal pressure is lower than the external pressure, air stream from the leakages is inwards not outwards [13]. Exhausted air is continuously measured and filtered. Later it was released to environment via flues in a controlled way. Nuclear reactors which generate 17% of

world's electric power are presented as an alternative for petroleum which is about to be consumed rapidly. 440 nuclear power plants have been operating actively in various countries since 1996. When they are analyzed in terms of environmental effects, waste generated by nuclear power in 40-50 year is about 200 m^3 [14] Since radioactive waste resulting from nuclear power is stored in a controlled way, they do not create hazard for environment. Additionally, nuclear waste storage technology is developing progressively. Using nuclear power plays a significant role in reduction of CO_2 emission and it also prevents of SO_2 and NO_x emissions [15]. Risk ratio data of energy systems are given in Table 2 [16].

Table 2. Risk ratio data of energy systems [17]

Energy Systems	**The Number of Fatal Accidents**	**The Total Number of Sudden Deaths**	**Annual Energy Production(GW)**
Coal (including mining accidents)	62	3600	10000
Oil (including production and transportation)	63	2070	21000
Natural-Gas (explosion)	24	1440	8600
Hydroelectric (dambreak)	8	3839	2700
Nuclear (chernobyl accident)	1	31	1000

2.2 Advantages and Disadvantages of Nuclear Energy

Studies on filling up energy gap cause nuclear power plants, which release less greenhouse gases to the atmosphere, and technologies related to this to become important. As a result of the petroleum crisis in 1970s, industrial countries around the world consider nuclear power plants important. Today, the usage and construction of many nuclear power plants are being prevented. The reasons for that are the disasters in the past (Chernobyl and Fukushima) and negative effects of plants on people and environment. The advantages of nuclear energy are listed below [18];

- Nuclear energy causes less carbon dioxide emission compared to coal, natural gas and petroleum.
- Unfavorable effects on global warming are low since they have less greenhouse gas emission.
- Storing of the nuclear fuel, which can be used for the operation of nuclear power plants for many years, is relatively easier and more economic.
- Variety of imported sources can be extended for energy generation by integrating nuclear power plants to the system.
- Nuclear power technology is a ready-to-use technology becasue its development stage is completed.
- A large amount of electric power can be obtained from a single nuclear power plant. It is also possible to store nuclear fuel for decades. By this way, nuclear power plants help to maintain stability of electrical energy in long term.
- Potential reserves of nuclear fuels are high. It is calculated that the reserves existing today can maintain nuclear power plants for 150 years.
- It provides a large amount of energy in respect to volume of the raw material. 1 kg of uranium can provide 50000 kWh electrical energy while 1 kg of coal can provide 3 kWh and 1 kg of petroleum can provide 4 kWh electrical energy.
- They occupy smaller spaces for establishment.
- Raw material prime costs are relatively low because a little amount of raw material is enough for energy generation [19-20].

In spite of the advantages, nuclear energy has disadvantages as well. These can be summarized as below;

- The issue of the nuclear waste generated by nuclear power plants is still a question mark. These very hazardous wastes should be stored very carefully.
- Despite high security standards, nuclear energy is still a very hazardous technology. There is no 100 % reliable nuclear power plant. The results of accidents can be quiet devastating both for humanity and environment.
- Nuclear power plants also create danger for the outer attacks. Any terrorist attacks can end up with unfortunate results.
- Radioactive waste generated by nuclear power plants can be used for the production of nuclear weapons.
- Uranium which is the main source of nuclear power is a rare material. In accordance to the estimation, uranium reserves in the world will be consumed in about 30 or 60 years.
- It takes almost 20 to 30 years to complete a nuclear power plant when all necessary bureaucratic and technical details are considered for the construction and establishment [21].

2.3 Problem of Nuclear Waste

Radioactivity is a part of our world and it has existed since the beginning of the world. Natural radioactive elements exist in earth's crust, in the walls and grounds of our houses, schools and offices, in our food and drink. There are radioactive gases in the air we breathe. Our body naturally contains radioactive elements in muscles, bones and tissues.

Radiation Dose Limits: It is observed that the environmental hazards resulting from the establishment of a nuclear power plants can be minimized. According to the regulations by NRC in USA, dose limits for flue gas emissions for the whole body is 0.05 mSv/year, for thyroid it is 0.15 mSv/year. Maximum permitted dose for liquid waste is 0.03 mSv/year. However, what is recommended is that the processed doses should be as low as possible. According to the principle called ALARA (as low as reasonably achievable), observed doses in USA in practice are 0.001 mSv/year for whole body and 0.01 mSv/year for thyroid. Total effect of nuclear industry in England is stated as 0.002 mSv/year. However, it is know that the radiation effect of flue gases of coal power plants in this country is 0.004 mSv/year [22].

Since initial investment costs and operation costs of nuclear power are quite expensive, it is an expensive kind of energy compared to other energy generation plants. Economic lives of them are short (25-30years). They do not have elasticity of operation. To make a dead unit functional again may take days or even weeks. Therefore, they are operated for 24 hours to meet the basis demand. Used or burned out uranium is still radioactive and it will continue to be radioactive for thousands of years. To transport and store them safely is an unsolved problem all over the world. To take an expired nuclear power plant off is also a difficult and an expensive process. It has a great risk of radiation in case of an accident [23]. The most important distinctive feature of nuclear power plants is that nuclear power plants have radioactive elements. In the process of generating electric power from fusion power in normal operation, there is radioactivity emission under natural radiation [24]. In conjunction with being relate to the development of problems about increase in the demand of energy in the world, global warming and climate changes; radioactive waste, safety and proliferation of nuclear weapons and cost of energy are the most important causes that prevent new plants to be established [25]. The biggest of these problems, which has not been solved, and probably will not be solved in the future, is nuclear waste [26]. There are some unscientific speculations in our press that, the construction time of nuclear power plants in our country will take 5-7 years, after operation being started, accumulated nuclear waste will be kept in power plants' reservoirs and in this long process western countries will find a solution for this. However, it takes a

lot of time for high level radioactive wastes resulting from spent fuels that contain half-life radioactive and toxin element to become neutralized by being radioactively discomposed. It needs to be kept isolated from people and environments and store safely for thousands of years which reaches a geological scale. To manage these generated wastes is the responsibility of each country. Geological storage units are planned for permanent storage in the countries with nuclear power plants. They are composed of layers of stones, clay or salt and 500 meters below the Earth's surface. However it is still being investigated. Nuclear wastes are still kept in temporary storage units in nuclear power plants [17].

3. Conclusion and Discussion

Whatever the type of radioactive waste is, it needs to be purified from all kinds of problems that threaten the lives of people while trying to increase the quality of their life. It should not harm economy, functions and natural selection. Therefore, the measures to be taken to store radioactive waste safely should be considered differently form other types of wastes, because radioactive waste packages have self-perpetuating radioactivity, and while storing these wastes, special attention should be paid to prevent radioactive emission. The most important factor on processing, transporting and storing nuclear waste is to divide them according to their levels of radioactivity and take necessary precautions accordingly.

Due to these serious problems, to provide initial establishment conditions is inevitable before start constructing a nuclear power plant and take the first step towards nuclear power. To analyze all scientific, technologic, economic and social justifications is a prior condition. Once all these prior conditions are justified, nuclear power plants are more eco-friendly than other fossil fuelled power plants.

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