Nuclear energy and raw material reserves in Turkey

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Abstract

The lack of an established nuclear power plant in Turkey even today show that although radioactive raw materials not needed, the lack of domestic energy resources, the fossils may be depleted of origin, on the other hand, as a result of the increase depending on factors such as population growth and development, the need for energy is clear that we would turn to nuclear energy. This is why it is important to complete a very short time in the knowledge of our country's uranium and thorium reserves base entry of nuclear power generation to meet the domestic market in all of the uranium and thorium ores known as radioactive materials.

Key words: *Nuclear energy, uranium, thorium, nuclear power plants*

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Türkiye'de nükleer enerji ve hammadde rezervleri

Öz

Türkiye'de kurulu bir nükleer santralin olmaması halen radyoaktif hammaddelere gereksinim duyulmadığını gösterse dahi, yerli enerji kaynaklarının yetersiz olması, fosil kökenli kaynakların tükenebilir olması, diğer taraftan da enerjiye duyulan ihtiyacın gelişmeye ve nüfus artışı gibi etkenlere bağlı olarak artması sonucu nükleer enerjiye yöneleceğimiz aşikardır. Bundan dolayıdır ki, nükleer enerji üretiminin temel girdileri radyoaktif hammaddeler olarak bilinen uranyum ve toryum cevherlerinin tümünün yurt içinden karşılanabilmesi için ülkemizin uranyum ve toryum rezervlerinin tam olarak çok kısa zamanda bilinmesi önem arz etmektedir.

Anahtar Kelimeler: *Nükleer enerji, uranyum, toryum, nükleer santraller.*

Introduction

Developing countries such as Turkey, oil, as natural gas and coal will be depleted in the near future, to meet the renewable energy source known as fossil fuels increased energy needs as an alternative to nuclear power is to the forefront (Karataşlı et al., 2016). In addition, the importance given to nuclear energy is increasing within the scope of energy diversity art which is an important energy policy in the world.

Today, radioactive materials and radiation, as well as many other areas for peaceful purposes, such as nuclear power, electricity production, diagnosis or treatment in medicine, radiographic non-destructive examination in industry, radioactivity analysis, automatic level and thickness measurement, radioisotope monitoring techniques are widely used as a wide range (Karataşlı and Özer, 2016; Uğurlu, 2009).

Uranium and Thorium compounds, which are used as raw materials of nuclear energy, are naturally present in the structure of many minerals in the Earth's crust. Uranium, which is never free in nature and has three isotopes, is combined with various elements and after the uranium minerals are removed from nature, they are subjected to many separations, purification and shaping processes. Thorium compounds, which are used for energy production after a number of technological processes, cannot be used directly in the reactor after they are fueled as fuel such as uranium since they need to operate at a more expensive economic size than uranium and require difficult technological process. Therefore, thorium remains a raw material of nuclear fuel that is still waiting for its turn. by MTA and various organizations from 1956 since the scientific and technological work carried out in Turkey it was observed to have a certain level of radioactive raw potential results of our country.

Nuclear energy in electricity generation

Fossil fuels will certainly run out one day; a new source of energy, including new, clean and renewable resources and technologies (Baykara, 2006). Nuclear power plants play an important role in reducing greenhouse gas emissions and meeting increasing energy needs. The electrical energy produced by nuclear power plants since the beginning of 1950, 17% of the electricity produced in the world, and 35% in Europe is supplied from nuclear reactors. 450 nuclear power plants are operating in 31 different countries and 60 nuclear power plants are under construction in 16 countries.

Table 1. *Nuclear power plants in operation and under construction in the world (Eroğlu and Şahiner, 2017).*

Country	Operational reactors		Reactors under construction	
	No of unitis	Net capacity MW(e)	No of unitis	Net capacity MW(e)
USA	99	98.868	4	4.468
France	58	63.130	1	1.630
Japan	43	40.290	2	2.650
China	36	31.402	20	20.500
Russia	36	26.557	7	5.468
South Korea	25	23.133	3	4.020
India	22	6.225	5	2.990
Canada	19	13.524	_	_
Ukraine	15	13.107	2	1.900

Compound Kingdom	15	8.918	_	_
Sweden	10	9.651	_	_
Germany	8	10.799	_	_
Spain	7	7.121	_	_
Belgium	7	5.913	_	_
Taiwan	6	5.052	2	2.600
Czech Republic	6	3.930	_	_
Switzerland	5	3.333	_	_
Hungary	4	1.899	_	_
Slovakia	4	1.814	2	880
Pakistan	4	1.005	3	2.343
Finland	4	2.752	1	1.600
Argentina	3	1.632	1	25
Brazil	2	1.884	1	1.245
Bulgaria	2	1.926	_	_
South Africa	2	1.860	_	_
Mexican	2	1.440	_	_
Romania	2	1.300	_	_
Iranian	1	915	_	_
Slovenia	1	688	_	_
Netherlands	1	482	_	_
Armenia	1	375	_	_
United Arab Emirates	_	_	4	5.380
Belarus	_	_	2	2.218
Total	450	390.915	60	59.917

France, with its 58 reactors, provides 76% of its electrical energy from nuclear power plants, and is ranked first among the countries with 99 nuclear reactors in terms of nuclear reactor production in terms of nuclear construction. The contribution of these reactors to the total energy produced is 20% in the USA (Eroğlu and Şahiner, 2017).

On May 12, 2010, the Governments of the Russian Federation and the Republic of Turkey signed a Cooperation Agreement providing for the construction of Akkuyu nuclear power plant comprised of four power units with VVER-1200 reactors with a total capacity of 4800 MW on the southern coast of Turkey in Mersin province. Akkuyu Nuclear Power Plant is to be built in Gulnar district of Mersin province will be Turkey's first nuclear power plant in the completion of construction. It is planned to produce approximately 35 billion kWh of electricity annually from the power plant.

Conversion of uranium ınto fuel

Uranium extracted from the soil cannot be used as fuel in direct reactors as it is removed from the mine. In order to be used as a fuel from uranium ore, it has to undergo certain lengthy processes. Uranium, which is the heaviest metal in the nature, produces a very easy compound and contains approximately one hundred uranium containing minerals. They contain varying degrees of uranium oxide (Temurçin and Aliağaoğlu, 2003).

For the enrichment process, the uranium in the form of a yellow cake is converted to the uranium hexafluoride (UF_6) as a result of chemical processes. In the international markets, at least 60% of the yellowcake is required to contain uranium and the other elements should not be more than 300 ppm in 1 gram uranium in the total of uranium compound. Uranium hexafluoride is often converted to powdered uranium dioxide (UO_2) after being enriched using centrifugation or diffusion method.

The powdered uranium dioxide is converted into fuel pallets by pressing and heating to 1400 degrees. These fuel pallets are often placed into the fuel envelope of the fuel envelope elements made of zirconium alloy to form the fuel rods. The rods are brought together and form fuel bundles (DEK-TMK, 2010).

Reuse and storage of radioactive waste

Radioactive elements due to their ability to break down, continue to radiate in the environment they are discarded and damage the environment. Therefore, it is desired to reduce the occurrence of radioactive wastes and to ensure that the resulting wastes are arranged in such a way that they do not harm the environment (Altın and Kaptan, 2006).

The harmful substances contained in the wastes (except plutonium) have a half-life of 30 years. So 300 years later, the radioactivity of waste falls to one thousandth of its initial radioactivity. At the end of this period, substances are considered not to pose a health risk for human and nature Bağdatlıoğlu, 2011).

The fuel source used in the nuclear power plant is depleted or diminished over time as in other plants. At this point, the energy of the uranium, which is the fuel source, decreases in time and needs to be changed. Uranium is decomposed by chemical methods and is taken from the required core and used. Reuse of used uranium is generally used in closed loop systems. However, these systems are not widely used in the world. Because the chemicals that will be used with the recovery of fuel become radioactive and cause the increase in the amount of radioactive material is a big problem (Ölme et al., 2004).

It is made of armored by concrete or steel-like structures until it is in an environment that is inactive and does not work, and that contains a high amount of radioactive parts that do not harm the environment. At a nuclear plant with an average capacity of 1000 MWe, uranium waste after use is around 30 tons per year. The amount of raw materials required for a coal-fired plant with the same capacity is around 2 million tons.

Reserve status of nuclear raw materials in the world

Uranium

According to uranium reserves in the world, the first four countries are Australia, Kazakhistan, Canada and Russia. Table 2 shows the reserve status and shares of countries (OECD NEA & IAEA, Uranium 2016).

Table 2. *World uranium reserve.*

Country	Rezerv (TON)	Share in the world (%)
Australia	1.666.100	29
Kazakhistan	745.300	13
Canada	509.000	9
Russia	507.800	9

South Africa	322.400	6
China	272.500	5
Brazil	276.800	5
Niger	291.500	5
Namibia	267.000	5
Uzbekistan	130.100	2
Ukraine	115.800	2
Mongolia	141.500	2
USA	62.900	1
Tanzania	58.100	1
Bostvana	73.500	1
Other countries	280.100	5
Total	5.718.400	

Thorium

Thorium, discovered by Jons Jacob Berzelius in 1828, is not found in nature as free as uranium, but other radioactive minerals include Allanite, Monazite, Bastnasit, Cerite, Polikras, Pirochlor, Betafite, Euksenite, Samarskit and Torit which contain thorium. When thorium mine is used as a domestic reserve in nuclear power plants, it is thought that it can be a very serious alternative in meeting the energy needs of countries. Thorium is a candidate for being the most important strategic item of the 21st century. In the future, it is aimed to use thorium to replace uranium in new type of nuclear power plants. Considering the studies conducted in the world to use thorium as a fuel, it is seen that preliminary research studies are finished and the feasibility studies are completed in 1998. Thorium is a greener radioactive element than uranium. 90% of uranium used in nuclear energy is becoming waste and causing great damage to the environment. Thorium minimizes this loss with a low waste rate. Thorium, such as uranium, is not free in nature. Thorium is found in about 60 minerals (Yıldırım and Örnek, 2007)

According to 2016 data, it is estimated that the total thorium reserve known in the world is approximately 6.35 million tons and contains around 6-7% thorium. Table 3 shows the reserves mainly as India, Brazil, Australia, located in the United States and Turkey. The Lemhi Pass deposit, located on the Idaho-Montana border, is the largest thorium deposit in the United States.

There are 64.000 tons of definite monazite reserves in the mineralization zone which is spread over 5.5 km^2 area. The possible reserve is estimated to be 121.000 tons. The NTE concentration of this bed varies between 0.073% and 2.2%. Thorium concentration was calculated as 0.43% on average. The other important thorium deposit is the Wet mountains bed in Colorado. Cyanotic and carbonate is an advanced mineralization with veinlets in dykes. The average tenor ranges between 0.04-0.6%, with 58.200 tonnes being exact, 145.600 tons of possible reserves (Eroğlu and Şahiner 2017).

Table 3. *World Thorium reserves and shares*

Country	Total thorium reseources/ ton	World share of thorium reserve (%)
India	846.000	13
Brazil	632.000	10
Australia	595.000	9
USA	595.000	9
Egypt	380.000	6
Turkey	374.000	6
Venezuela	300.000	5
Canada	172.000	3
Russia	155.000	2
South Africa	148.000	2
China	100.000	2
Norway	87.000	1
Greenland (Denmark)	86.000	1
Finland	60.000	1
Sweden	50.000	1
Kazakhistan	50.000	1
Other countries	1.725.000	27
Total	6.355.000	

Although there is no commercial scale nuclear power plant operating in the world with thorium, due to the problems related to the nuclear fuel cycle, it is waiting for its order as raw material. The USA, England, Germany continue in the experimental plants working with thorium. Research and development efforts are ongoing in the working test power plants TAEK, 2007). As a result of research conducted by MTA for the reserve of thorium of our country, in a 15 km^2 area between Kızılcaören, Karkın and Okçu villages in the north west of Sivrihisar district of Eskişehir, complex beds containing rare earth elements, barite and fluorite were found as well as thorium. According to the report prepared in 1977, the average grade of the ore in the region in question was determined as 0,21% ThO_2 and the total reserve was determined as 374.000 tons ThO_2 (Eroğlu and Şahiner 2017).

Thorium was also found in the Kayseri-Felahiye, Malatya-Darende-Kuluncak, Diyarbakır and Sivas provinces (TAEK, 2007). In sample selection grade thorium in Turkey even lo up to 3%, the average grade is 0,21% of the bed. The average grade of having a complex structure and low in bearings in Turkey thorium reserves are to conclude that it is difficult to economically remove alone.

Turkey's nuclear material resources

Uranium

Radioactive uranium in Turkey in search of raw materials, generally in the form of short-term studies by the MTA in 1953 was initiated. In 1956, systematic studies were carried out by MTA and significant results were reached. Sedimentary type uranium searches have been started in 1960 and continued in 1970 for covered beds (Yüksel, 1987; Nakoman, 1979).

Turkey uranium removal in the years 1966-1990, the production of yellow cake uranium ore, yellow if the cake all stages up to making nuclear fuel is uranium are carried out in pilot scale and in vitro the search was stopped in 1990. The long-term interruptions were resumed in 2004. Drilling uranium exploration continues in Western Anatolia (Yörükoğlu, 2014).

During these searches, an airborne prospect was obtained on an area of 317620 km^2 and anomaly was obtained at many points. For the examination of these anomalies, 146226 km^2 of pedestrian exploration and 337733 m of drilling were performed (TAEK, 2007; DPT, 2001).

Sedimentary uranium mattress and ınserts

Salihli Köprübaşı, sedimentary uranium deposits with 0,4-07% U_3O_8 environment take the lead in this type of occurrence. In this basin, the Phosphate Stone type is the type and the average tungor of this type of uranium aggregate is between 0,05-0.1%. The average grade of bleach type and meta- otunite mineralization is 0,05% U_3O_8. The total reserve of the visible uranium reserve in Manisa Bridge is 3.487 tons, a part of which is Ecinlitas type. In Çanakkale-Ayvacık, volcano sedimanter rocks and consecutive sandstones have uranium deposits up to 0,1%. In Uşak-Fakıllı, the presence of 490 tons of U_3O_8 with an average grade of 0,44% is known in the alternation between the tuff interbedded sandstone and siltstones. It was observed that there was an average of 0,05% U_3O_8 in the sediments of Cenozoic aged, gravel, sand, silt, clay and coal formation in Aydın-Koçarlı-Küçükçavdar (TAEK, 2007; DPT, 1996).

The uranium reserves in Sorgun-Temrezli bed in terms of economic uranium mineralization known in Turkey and content is the highest bed. Uranium mineralization is in the form of lenses, the depth of these lenses varying from 25 to 215 m. As a result of the economic pre-evaluation studies carried out, the amount of uranium contained in the source is estimated to be around 6.700 tons (Eroğlu and Şahiner 2017).

Table 4. *Visible uranium reserves in Turkey*

NO	Field Name	Average Tenor	Reserve(% U_3O_8)
		(% U_3O_8)	(Ton)
1	Manisa-Köprübaşı	0,04-0,07	3.487
2	Uşak-Eşme-Fakılı	0,05	490
3	Aydın-Küçükçavdar	0,04	208

4	Aydın-Demirtepe	0,08	1.729
5	Yozgat-Sorgun	0,10	6.700
Total			12.614

Conclusion

We have to include nuclear energy in our energy supply portfolio as well as our domestic and renewable energy resources to strengthen supply security in energy, which is an important locomotive of the economy. Nuclear power plants are not only electricity generation facilities, but employment, human resources, technology, etc. It also provides important contributions in many fields. High calorie huge reserves of coal to be used in power generation in Turkey not contaminated or oil-rich natural gas resources. For years, nuclear energy has been used with great care in meeting the energy needs of developed and developing countries and it is still waiting to be evaluated in our country. Even though nuclear energy has an important environmental and individual impact such as radiation, it is necessary to meet our increasing energy demand with our own efforts and accordingly to reduce our energy imports. With the evaluation of nuclear energy, our dependence on foreign energy will be reduced and our country will be able to overcome a barrier to development. Since it will be necessary to utilize its own resources in order to overcome the energy shortage that may be encountered in the coming years, for the nuclear power plants or power plants to be established, our country should start to search for uranium again as it does not seem to have sufficient raw material source. In the light of the work done up to this day, re-examination of Turkey's geological structure, minimizing the limitations arising from the Mining Law, preparing joint projects with the International Atomic Energy Agency, made the division of tasks in specialized institutions and organizations in their area should be carried out as the search for re prospective uranium deposits with the necessary equipment. In addition, Turkey's thorium accelerator-driven systems that are still in the development stage of technological structure that is conducive claim to be (HGS) should follow closely, and should make efforts to come to the knowledge level of experience.

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