

Environmental Impact of Nuclear Power Plants- The case study of Akkuyu-Turkey

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Abstract

Since 1976 Silifke Akkuyu Nuclear Power Plant had been discussing at the public opinion. Just now this study is on the planning part but as a result of substructure it seems to be on the award of contract. This research had been done to understand the environmental impact if a nuclear power plant is made to the region by this development but the certain results can be understand at the construction and operation parts. Before the construction of the disciplines nuclear plant the most come together to prepare the detailed Environmental Impact Assessment.

In Turkey the Ministry of the energy and natural resources has planned a nuclear power plant to satisfy a need of energy since 1960's. One of these projects was Akkuyu Nuclear Power plant project.

The study site is Akkuyu project site. This site is situated in Eastern Mediterranean Region and is a neighborhood of Akkuyu and Aksaz bays, in İçel province, Gülnar County and the site is 896 hectares wide. The Power Plant site is surrounded by small hills which are nearly 300 meters long because of them the site has natural distinct edges. In this study, we determine the impact of the nuclear power plant which will be built in Akkuyu to the area. For achieving this aim we firstly analyze the areas important landscape characteristics. We emphasize on the aspect of the issue in a multidiscipline view.

After the nuclear power plant project will be complete, the unique landscape values of the Akkuyu site will be degraded.

Keywords: Nuclear power plant, environmental impact, energy, Akkuyu.

1. Introduction

The global economic growth depends strongly on the power sectors, which plays a significant role in the consumption of non-renewable resources, as the electricity is one of the most important energy carriers for many industrial branches (Staneka, et al., 2016). The U.S., France, Japan, West Germany, Canada, the U.K. and Sweden account for almost 75% of the world's installed nuclear power capacity and over 61% of its spent fuel production (Solomon et. all. 2016). But there will be a problem with nuclear waste management. According to Solomon et all. (2016) regulations which are on rule may be because problems when authorities won't be participate. Another big problem with nuclear plants is accidents.

The Fukushima Daiichi Nuclear Power Plant (FDNPP) accident, which has been rated on the International Atomic Energy Agency (IAEA) International Nuclear and Radiological Event Scale (INES) as a "Major Accident" as INES 7 as did the Chernobyl accident, was one of the biggest environmental disasters in recent years (Hirose, 2016). The FDNPP accident caused huge socioeconomic impacts to Japan. About 150 000 people have been evacuated from the contaminated zone, mainly within a radius of 20 km from the FDNPP. Evacuation of hospitals faced difficulties and it has been estimated that some 60 patients died from complications related to the evacuation. Although some limited return has started, most of the residents in the major contaminated areas still face difficulties in returning at the end of 2015. These impacts are partly resulting from the radiological effects due to occurrence of highly radioactivity-contaminated areas and problems related to food safety. UNSCEAR report (2013) mentioned that a general-related increase in the incidence of health effects among the exposed population would not be expected to be discernible over the baseline (Hirose, 2016).

Högberg (2013) concluded that the FDNPP accident, as did the Chernobyl and TMI (Three Mile Island) accidents, had the root causes in system deficiencies indicative of poor safety management and poor safety culture in both the nuclear industry and government authorities (Hirose, 2016). In Turkey nuclear power plants are popular issue because of lack of energy production and government prefer nuclear energy.

The Akkuyu Nuclear Power Plant (Turkish: Akkuyu Nükleer Enerji Santrali) is a nuclear power plant under construction at Akkuyu, in Büyükeceli, Mersin Province, Turkey. It will be the country's first nuclear power plant (Anonymous, 2012). In May 2010, Russia and Turkey signed an agreement that a subsidiary of Rosatom — Akkuyu NGS Elektrik Uretim Corp. (APC: Akkuyu Project Company) — would build, own, and operate a power plant at Akkuyu comprising four 1,200 MW VVER units (Anonymous, 2011a). The agreement was ratified by the Turkish Parliament in July 2010 (Anonymous, 2011a).

This study is to determine the potential impact of Akkuyu Nuclear Power Plant on environment. For achieving to this aim we investigate basic literature about nuclear power plants and make a matrix about impact of the power plant on environment.

2. Materials and Methods

The Akkuyu Nuclear Power Plant (Turkish: Akkuyu Nükleer Enerji Santrali) is a nuclear power plant under construction at Akkuyu, in Büyükeceli, Mersin Province, Turkey (Figure 1, 2).

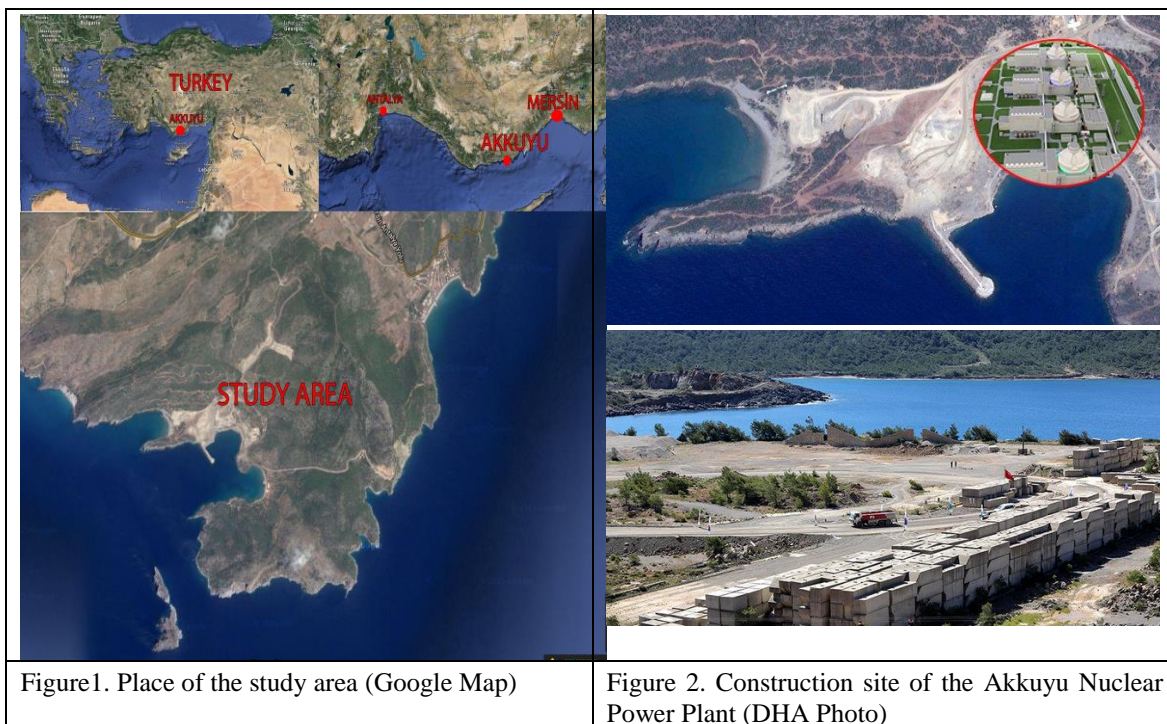


Figure1. Place of the study area (Google Map)

Figure 2. Construction site of the Akkuyu Nuclear Power Plant (DHA Photo)

Engineering and survey work started at the site in 2011 (Anonymous, 2011b). The construction of the first unit will begin in 2016, with the four units put into service in 2022–25.

In 2013, Russian nuclear construction company Atomstroyexport (ASE) and Turkish construction company Ozdogu signed the site preparation contract for the proposed Akkuyu nuclear power plant. The contract includes excavation work at the site (Dalton, 2013).

The official launch ceremony took place in April 2015, and the first unit is expected to be completed in 2022.

Akkuyu Nuclear Power Plant Project features are given in below:

- First Nuclear Power Plant in Turkey
- First Rosatom BOO (build-own-operate)project Under the IGA, Rosatom is responsible for engineering, construction, operation and maintenance of the plant
- Legal basis: AES-2006 (VVER-1200)
- Total capacity: 4800 MW (4x1200 MW)
- Implementation period: 2011-2023
- Total cost 20 000 Dollar
- Power Purchase Agreement for 15 years, fixed price terms
- Support of the Russian and Turkish Governments
- Maximization of Turkish personnel involvement in construction and operation of the plant.
- Job creation potential-up to 10000 for construction only (Smirnov and Kirillova, 2015).

This study tries to determine the potential impact of Akkuyu Nuclear Power Plant on environment in the context of soil, water and air. This topic has been divided two main sections. The first one investigates impact of the power plant while power plant is under construction. The other one investigate operation phase of power plant. For achieving to this aim we investigate basic literature about nuclear power plants and make a matrix about impact of the power plant on environment.

3. Results and Discussion

3.1. Important Features of Akkuyu

3.1.1. Seismic station

The government chose this site because of the low population density and low risk of earthquakes. Seismic hazard in Mersin Province, in terms of peak ground acceleration with a 10% chance of being exceeded (or a 90% chance of not being exceeded) within the next 50 years, is a 1.6 %g (percent of gravity) peak acceleration (Figure 3).

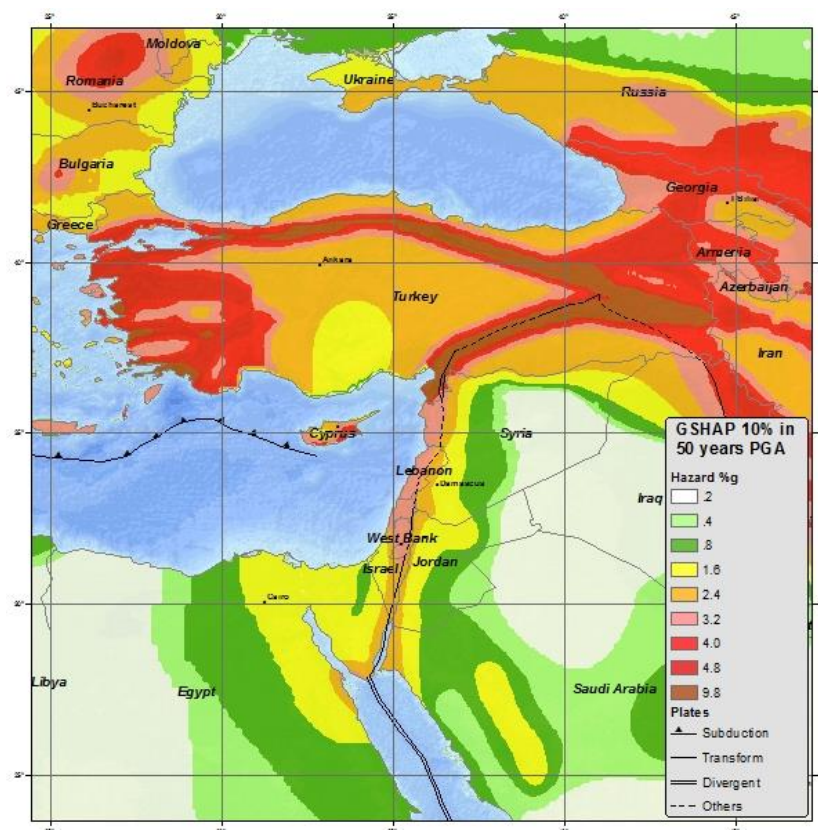


Figure 3. Turkey seismic hazard map (Anonymous, 2016)

3.1.2. Vegetation

The study area shows that typical turkish pine forest, maquis and frigana, garrigue vegetation cover. *Rosmarinus officinalis*, *Sarcopoterium spinosum*, *Coridothymus capitatus*, *Lavandula stoechas*, *Thymus* sp. and *Phagnalon rupestre* are important species of shallow and gravel soil type (Figure,4,5).



Figure 4. A view of *Pinus brutia* forest



Figure 5. A view of road side vegetation

Maquis species are *Olea europes* var. *sylvestris*, *Phagnalan graecum* and *Nerium oleander*. *Crocus reticulatus*, *Fritillaria assyriaca* and *Hyacinthus orientalis* geofits are seen as under maquis and frigana vegetation cover.

Capparis spinosa, *Inula viscosa*, *Echinops ritro*, *Hypherrinia hirta*, *Carthamus lanatus*, *Polygonum equisetifolium*, *Carthamus dentatus*, *Avena sterilis*, *Echium angustifolium*, *Opuntia ficus-indica* and *Verbascum inulifolium* are garrigue vegetation cover.

In Akkuyu and its surrounding forest area has the species that *Pinus brutia*, *Cupressus sempervirens*, *Juniperus oxycedrus*, *Juniperus excelsa*, *Juniperus communis*, *Quercus coccifera*, *Quercus infectoria*, *Quercus ithaburensis*, *Cercis siliquastrum*, *Ceratonia siliqua*, *Pistacia terebinthus*, *Phillyrea latifolia*, *Phillyrea media*, *Styrax officinalis*, *Myrtus communis*, *Cistus creticus* and *Cistus salviifolius*.

3.1.3.Fauna

The vegetation type which is seen in study area is big structural habitat for fauna. Mammals which is seen in study area are *Canis aureus*, *Hystrix indica*, *Lepus europaeus*, *Sus scrofa*, *Apodemus flavicollis*, *Apodemus mystacinus*.

Frogs and reptiles are *Coluber jugularis*, *Lacerta saxicola*, *Hyla arborea*, *Bufo viridis*, *Rana ridibunda*, *Trionyx euphraticus*, *Trionyx triunguis*, *Triturus vulgaris*, *Triturus vittatus cilicensis*.

In the coast of the study area, there are *Caretta caretta* and *Chelonis mydas* species which are distinct species and they leave their eggs in this coast.

3.2. Environmental impact of Nuclear Power Plants

According to ROSATOM, (2016), Nuclear plants do not pollute the environment. The radiation effect of nuclear power plants on the environment and the population is much smaller compared to power plants operating based on oil, coal and fuel oil, which emit harmful combustion products into the atmosphere. A nuclear power plant is an enterprise of closed technological cycle. This means that all the burning fuel remains inside the nuclear power plant, and is then taken away in very strong containers. Only pure water enters the atmosphere from a nuclear plant.

In opposition of this nuclear energy has some advantages too: There is no safe disposal of nuclear waste. Nuclear power creates extremely harmful radioactive waste (used uranium), and there is no safe disposal method for it. The current method of dealing with nuclear waste is to put it in a canister and submerge it in a pond constructed for this purpose, or to contain it in a concrete cylinder. After 40 or 50 years, when its radioactivity begins to decay, the waste is buried underground. Nuclear waste has a radioactive half-life of 250,000 years, which means that it remains extremely dangerous until the end of that period, posing grave risks to humans and the environment if exposed (Ecospark, 2016).

There are serious issues of safety and exposure during nuclear electricity generation. Today's nuclear power plants employ improved technologies and stricter safety regulations, greatly reducing the risk of future accidents, but there is still the potential for serious catastrophe. In the past, nuclear accidents have resulted in death, serious illness, and extreme environmental damage, and their impact continues for generations. Nuclear power plants routinely emit low level radioactivity that may pose cancer risks for nearby communities. Plants can also leak other hazardous materials.

Mining and transporting uranium is destructive. Mining uranium is a dangerous process, exposing humans and the environment to radioactivity. Mining uranium contributes to water pollution and land damage. Mining disrupts, even destroys, the area being mined. The mining process results in both the deliberate routine release and accidental spill of contaminated water, leading to the potential poisoning of nearby waterways and threatening the local environment and human residents (Ecospark, 2016).

Nuclear power operations involve large quantities of water, as well as thermal discharge. Huge amounts of water are needed for cooling the plant during operation, and to create steam to turn turbines. Water used for cooling is released back into the environment after cycling through the plant. This alters the temperature of the local body of water and may harm or kill aquatic life. This is called thermal discharge.

Uranium is a non-renewable resource. It doesn't take a lot of uranium to generate electricity, and plants need to be refueled only once a year, but there is a finite amount of uranium on the planet.

Nuclear power plants are very expensive and take a long time to complete. For example, the Darlington Nuclear Plant in Ontario cost \$15 billion and took over ten years to build. Nuclear waste disposal is also extremely expensive. Canada estimates that it will need as much as \$24 billion to dispose of its nuclear waste (Ecospark, 2016).

3.3. Environmental impact of Akkuyu Nuclear Power Plant

Environmental safety at all stages of NPP construction is the main principle and the basic condition for the development of the nuclear industry. Priorities in the field of environmental safety are identified as part of implementation of nuclear power projects (Akkuyu Nuclear, 2016):

- Compliance with all applicable laws, rules and regulations of the Republic of Turkey, the Russian Federation, and international organizations such as IAEA and EUR;
- Prompt obtaining of necessary permits for the Akkuyu NPP project implementation from relevant institutions of the Republic of Turkey;

- Unconditional fulfillment of all requirements and standards of safe operation of NPP;
- Continuous environmental monitoring at the Akkuyu NPP and surrounding territories;
- Publication of annual report on environmental safety;
- Regular provision of information to the public about the facts of impact of NPP on the health of the personnel, population and environment.

There are environmental measures meant for environmental monitoring during the project implementation:

Reclamation and revegetation of land disturbed during construction;

Protection of the environment against radioactive and chemical waste during normal operation of the facility;

Organization of air emissions from the premises with a high degree of purity from radioactive products;

Preventing radionuclides getting into the environment with water;

Secure storage of waste without contact with the environment;

Exclusion of non-radioactive emissions of environment pollutants;

Continuous comprehensive environmental monitoring.

Specially equipped posts for continuous environmental monitoring of the Akkuyu NPP will be created around the plant. Environmental monitoring will cover the following matters (Akkuyu Nuclear, 2016):

- hydrological observations;
- weather observations;
- monitoring the level, temperature and chemical composition of surface and ground water;
- seismometry;
- monitoring of foundations settlement and deformation of structures;
- monitoring of the current movements of the Earth's crust and gravitational field;
- radiation monitoring;
- monitoring the health of the population.

The Akkuyu NPP project is implemented in compliance with all of the above priorities and measures to ensure a safe and reliable operation of the NPP with minimum impact on the environment, population and personnel (Table 1).

Environmental accountability starts with the design of NPP and is a mandatory requirement for environmental safety in construction and operation of nuclear power plant. Indicators of environmental conditions shall be in focus of the project implementation participants at all stages of the life cycle of the NPP – from planning and designing up to decommissioning (Akkuyu Nuclear, 2016). The most important objection is that Büyükeceli (Akkuyu is near Büyükeceli) and the surrounding coastline may lose its touristic potential after the realization of the project. Büyükeceli residents are also worried that the already low population of the town may further decrease and the town may lose its township status.

Table 1. Nuclear power plant radiation effect and non-radiation effect (Akkuyu Nuclear, 2016)

NPP			
RADIATION EFFECT		NON-RADIATION EFFECT	
Normal operation	Emergency situation	Thermal Effect	Chemical Effect
The NPP is designed in such a way that the radiation effect on the population and the environment during normal prolonged operation does not exceed the established exposure dose through all possible effects.	The project virtually eliminates occurrence of accidents with radiological effects. The safety (a link to the section of NPP safety) of the population and environment of the Akkuyu NPP is reliably guaranteed in accordance with the implementation of requirements and recommendations of Turkish, Russian and international standards and regulations.	The maximum estimated effect comes from technical water supply systems and shows that operation of those does not affect the microclimate adjoining the NPP territory	Technical and organizational solutions adopted in the project prevent the flow of emission of pollutants from the NPP into the environment and water

In our study we determined environmental impact of Akkuyu NPP as on Table 2.

Table2. Environmental impact of Akkuyu Nuclear Power Plants.

Construction Phase of Power Plant																			Working Phase of Power Plant											
Akkuyu Nuclear Power Plant		Activities depend on project																												
		excavation	Fill	Use of Explosion	Pruning of Plants	Build Worksite	Destruction of Earthworks	Building Basement construction	Enlargements of existing buildings	Building of new roads	Building of Harbor	Works of Heavy construction equipment	construction of power plant	Construction of concrete coridor	Building of Cooling water supplement	Building of cooling water discharge unit	Building of Power grids	infrastructure and social buildings for Stuff		Inner power plant works	Transportation of Nuclear Waste	Nuclear fuel use in power plant	Radioactive waste storage	Fill of the power plant cooling water	Discharge of the power plant cooling water	Cleaning of power plant	energy transmission	Social Works	Storage of Final nuclear wastes	
Negative Impacts																														
Pollution of Soil	Loss of field	*	*			*		*	*	*	*	*	*	*	*	*	*	*				*							*	
	The change of soil chemistry			*							*	*		*				*			*				*			*	*	
	The change of soil physical quality	*	*	*							*	*		*								*				*			*	
	The change of soil biological character	*	*	*	*			*			*	*	*	*	*			*				*					*		*	
	Degradation of geomorphology	*	*	*					*	*	*	*			*														*	
Pollution of Water	Pollution of surface water	*	*								*				*	*		*							*	*			*	
	Be hot																				*				*					
	Chemical and radiological pollution			*																*		*			*	*				
	Increase of unsettled particulars	*	*	*		*		*		*	*														*	*		*	*	
	Increase of resolvable material	*	*					*			*								*			*		*	*	*		*	*	
Pollution of Air	Pollution of underground water	*	*	*				*						*				*					*		*	*		*	*	
	Increase on air particular materials	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*			*	*	*		*	*	*	*	*	
	Increase of gas emission			*						*	*		*							*	*	*			*	*		*	*	
	Increase of radioactivity on air																			*	*	*			*	*		*	*	
	Increase of weather														*						*	*	*		*	*		*	*	
Accumulation of radioactive material on Environment																				*	*	*	*	*	*	*		*	*	
Quake		*	*	*				*	*	*	*	*	*	*						*	*	*				*	*		*	*
Noise		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*
Solid waste constitution																									*	*		*	*	
Destruction of natural and ornamental plants		*	*	*	*	*			*	*		*		*	*	*	*	*	*			*		*	*	*		*	*	*
preclusion of plant growing														*							*	*	*	*	*	*	*	*	*	
Impairment of Fauna		*	*	*	*				*	*	*	*		*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*
Destruction of habitats on Land		*	*	*	*	*			*	*		*	*	*	*	*	*	*		*	*		*	*	*	*	*	*	*	*
Destruction of habitats in Water		*									*			*	*	*	*	*				*	*		*	*		*	*	
Division of Biotopes										*			*	*																
Ailing of animal species		*	*	*				*		*	*	*	*	*	*						*	*	*	*	*	*	*	*	*	*
Destruction of natural landscape		*	*		*	*					*	*	*	*	*		*	*				*	*	*	*	*	*	*	*	
Recreational areas will be affected negatively		*	*		*						*	*	*	*					*	*	*	*	*	*	*	*	*	*	*	
Decrease of Living quality																				*	*	*	*	*	*	*	*	*	*	
Repression on Public																				*	*	*	*	*	*	*	*	*	*	
Changes on Socio-cultural structure																											*	*	*	
Damage on human health																				*	*	*	*	*	*	*	*	*	*	
Damage on health of working stuff																				*	*	*	*	*	*	*	*	*	*	

On 17 April 2011 a human chain was formed in Mersin to protest the decision (Anonymous, 2011c). It was planned that there would be 30 locations to form chains along the highway connecting Mersin to Akkuyu. But the participation was higher than the expected and several of these chains were merged with. The east end of the chain was in Mersin midtown and it reached some 20 kilometers (12 mi) west along the highway uninterrupted. Also the settlements at the west including the district centers of Silifke and Erdemli as well as Büyükeceli, the town nearest to construction site participated. "The earthquake and tsunami in Japan proved how dangerous nuclear technology is," said Sabahat Aslan, a spokesperson for the Mersin Anti-Nuclear Platform. "We organized this protest to say 'no' to nuclear power plants, which will put future generations in danger (Anonymous, 2011c) (Figure 6, 7).



Figure 6. Anti-nuclear demonstrations in Akkuyu



Figure 7. A view of Anti-nuclear demonstrations

On 12 January 2015, it was reported that the signatures of specialists on a government-sanctioned environmental impact report had been forged. The specialists had resigned six months prior to its submission, and the contracting company had then made unilateral changes to the report (Anonymous, 2015a). The revelation sparked protest in North Nicosia. The construction of the Akkuyu plant is controversial in Cyprus, due to its close proximity to the island (Anonymous, 2015b).

4. Conclusions

The construction phase and operation of Akkuyu Nuclear Power Plant will have a lot of environmental impact to the area. Moreover this project has a lot of social resistance. Because of them the project will affect public.

The total land area involved in the actual construction of Akkuyu Nuclear Power Plant and related facilities will be approximately 896 hectares. The site is a bay that being surrounded by small hills of altitudes about 200 meter, is naturally secluded from surroundings. The shore area within the site consists of sandy beach limited around rock on the west and east. The beaches in the vicinity and the site can be considered scenic. The site has an aesthetic value.

The shore will be disturbed by the installation of intake and discharge lines. Impacts associated with dredging and constructions in the water are more difficult to control and therefore have more potential for causing damage. As the areas that will be impacted by dredging are wide and because large populations of valuable organisms are present, the impacts of construction on the marine environment should be major.

Present land use would be altered as a result of the construction of the transmission lines. Most of proposed transmission corridor passes through forested areas, cultivated land and pasture.

Potential adverse impacts to the environment from operation of Akkuyu Nuclear Power Plant would be associated with the withdrawal of condenser cooling water and the discharge of water (thermal effects). The discharge of heated water from Akkuyu Nuclear Power Plant into the Mediterranean Sea will be affect the marine ecology.

License security requirements which are updated after the accidents of Three Mile Island, Chernobyl and Fukushima I Nuclear Power Plant should be taken to the Akkuyu Nuclear Power Plant too.

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