www.ecjse.com
ISSN:2148-3736
El-Cezerî Fen ve Mühendislik Dergisi
Cilt: 3, No: 3, 2016 (521-532)

El-Cezerî Journal of Science and Engineering
Vol: 3, No: 3, 2016 (521-532)

ECJSE

Research Paper / Makale

Importance of Hydroelectric Power Plants In Terms of Environmental Policy

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Abstract: Although indispensable benefits of energy in our life, production, transmission and consumption of the energy also leads to extended environmental pollution during these process. Parallel to population growth and industrial developments, immense energy production and conversion system affect ecological balance beyond our borders. Therefore, environmental issues are international as well as they are national. In this context, advantage and disadvantage of hydroelectric plants has been mentioned in this work and the importance of environmental policies has been emphasized. Basically, sustainability and reliability issues of hydroelectric power plants (HPP) which has became a part of energy production from renewable natural source of water have been examined in the context of environmental policies.

KeyWords: Hydroelectric Power Plants, Renewable Energy, Environment

Hidroelektrik Santrallerinin Çevre Politikalari Açısından Önemi

Özet: Enerji insan yaşamındaki vazgeçilmez yararlarının yanı sıra üretim, çevrim, taşınım ve tüketim esnasında büyük oranda çevre kirlenmesine de yol açmaktadır. Nüfus artışı, sanayi gelişimine paralel olarak kurulan büyük ölçekli enerji üretim ve çevrim sistemleri ekolojik dengeyi büyük ölçüde etkiledikleri gibi sınırlar ötesi etkileri de beraberinde getirmektedir. Bu nedenle çevre sorunları ulusal olduğu gibi uluslararası nitelikler de taşımaktadır. Bu bağlamda çalışmada hidroelektrik santrallerinin avantaj ve dezavantajlarına değinilmiş, çevre politikaları açısından önemine vurgu yapılmıştır. Temel olarak yenilenebilir bir doğal kaynak olan suyun kullanılmasıyla elektrik enerjisine dönüşüm sürecinde devreye giren hidroelektrik santral (HES)'lerin sürdürülebilirliği ve güvenilirliği konuları çevre politikaları bağlamında incelenmiştir.

Anahtar kelimeler: Hidroelektrik Santralleri, Yenilenebilir Enerji, Çevre.

How to cite this article
Şahin, M., Güven Y.,Oğuz Y., Şahin E., *"Importance of Hydroelectric Power Plants In Terms of Environmental Policy*" El-Cezerî Journal of Science and Engineering, 2016, 3(3); 521-532.

Bu makaleye atıf yapmak için
Şahin, M., Güven Y.,Oğuz Y., Şahin E., *"Hidroelektrik Santrallerinin Çevre Politikalari Açisindan Önemi"* El-Cezerî Fen ve Mühendislik Dergisi 2016, 3(3);521-532.

1. Introduction

United Nations, 1987 Brundtland Report has defined sustainable development as "Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs." Sustainable development is an approach that it provides long term economical development with the rational usage of natural resources for leaving a physically and socially liveable environment to future generations. The adoption of such an approach requires integration of economical, social and environmental policies. Namely, a country that goals sustainable development must handle population, income distribution, education, law, industrialization, trade and public policies in compliance with the environmental policies [1].

The most important decision is the selection process of the best planning alternatives for dam and hydropower projects. The alternatives for dam and hydropower project must be assessed by taking into account the following points.

- Comparison of environmental impacts (air, water, soil, biological resource and socio-economic environment)
- Energy production, comparison of investment and operating costs
- Possible affects of inundated lands (forest areas, military establishment, protected areas, agriculture areas, residential areas) especially, the size of these areas and the number of the people who will have to move are important matters
- Comparison of the regional and national development

Analyzing of alternatives can be done by available information, scope of affects and sensibility of the project. The type of project, location, size and operation conditions should be also taken into account for dams and hydroelectric power project in the environmental impact assessment [2].

The main reasons why conventional technologies are abandoned and people are in search of new technologies for the generation and the use of energy are environmental problems. Steam power plants whose raw materials are coal and natural gas destroy the areas locally where they are establish and they also have globally threatening effects. Carbon dioxide, nitrogen dioxide, sulfur dioxide, soot and dust which are vented by the use of fossil fuels pollute the environment and cause deaths; carbon dioxide and greenhouse gases cause climate changes at a global level and becomes life threatening all over the world. In this point the search for a new energy source becomes inevitable [3]. Therefore, we need to head for using new energy resources which have less detrimental effects on environment to conserve natural resources while generating energy. These resources are defined as renewable energy resources. As the use of renewable energy resources become widespread, environmental pollution will decrease and in this way, technology will develop in line with the requirements. By this way, each country will use reliable, clean resources with less harmful effects by taking the advantages of its self resources and minimize the dependence of foreign sources [4].

Hydroelectric power is clean and renewable. Hydroelectric power plants' maintenance cost is low and they are durable. Therefore, hydroelectric power has less affects on environment compare to fossil fuels such as coal, natural gas and oil [5-6]. Our country has 216 billion kWh potential hydropower that can be evaluated technically. Total number of active hydropower plants is 572. These hydroelectric power plants have 26262.70 MW installed capacity and they produce 70582 GWh annually [7-8].

In this study, the importance of hydroelectric power plants has been emphasized in terms of environmental policies. Advantages and disadvantages of these power plants were mentioned and solutions to eliminate negative effects have been proposed. Furthermore, propounded ideas and solution from previous works have been mentioned to scrutinize.

2. Methodology

Water constitutes the keystone of life all around the world and on our geography. Life has started with water and it is going to end in the absence of water. Water is not a material to be bought and sold, and all living creatures have the right to access water [9]. Jean Robert summarizes this issue by saying; *"The basic relationship with soil can be summarized with the verb 'to have'. On the other hand, water removes the borders. It can not be possessed; it can only be shared and distributed before it vaporizes."* [10]. Natural process of water cycle is seen in Figure 1 below.

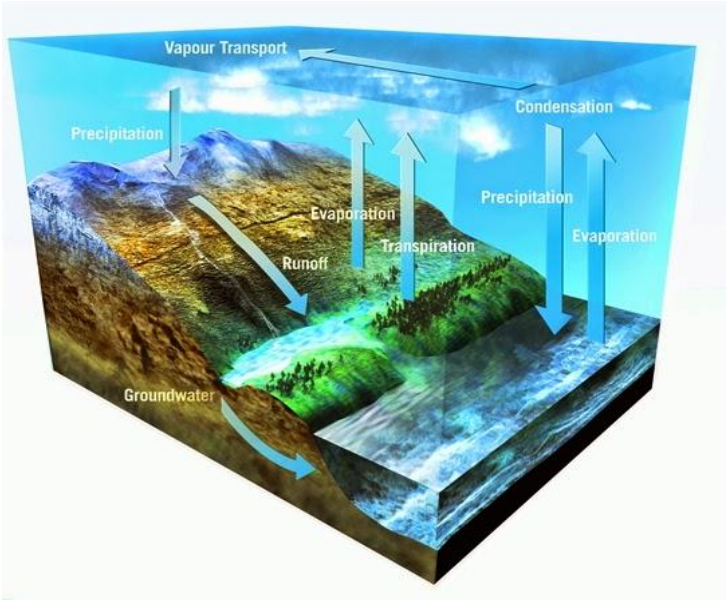

Figure 1. Water Cycle [11]

As it is seen in the figure, water reaches at any spot both underground and aboveground and in the atmosphere. Therefore, it is very important that to what extent the water is clean and it moves within the natural balance border. Within this context, hydroelectric power plants whose main component is water are going to be discussed and the importance of these plants in terms of environmental policy is going to be mentioned in this study.

2.1. Hydroelectric Power Plants

Water, whose power was utilized in water mills in ancient times, is an irreplaceable source of energy during that time period until today. Almost all sources of energy occur as a result of the physical and chemical effects of sun rays on substances. Hydraulic energy is a kind of energy that occurs due to the water cycle provided by solar power [12]. Electrical energy consumption is one of the most important indications of economic progress, industrialization and social wealth. Amount of electric which is generated by hydroelectric power is almost 20% of the total generated electric energy in the World. There has been hydroelectric potential which has not been used currently in Middle and Southern Asia, Latin America, some developing countries in Africa, Turkey, Canada

and Russia [13-14]. Hydroelectric power is an alternative for thermal, geothermal and natural gas plants, which generate electrical energy with fossil and nuclear fuel during operation and it has renewable and peak operation properties. Excluding natural gas plants, hydroelectric power plants are also capable to compete with other thermal and nuclear plants in terms of initial investment cost. Additionally they are easy to operate, economic and environmentalists [15].

Hydroelectric power plants are established on areas such as streambeds and waterfalls. When the water at a certain level is released from the dams, comes to the hydraulic turbine of the hydroelectric power plants by passing through the vents. Height between the level of water in the dam and the level of turbine is called head. If head rises, the amount of generated power increases, and if the accumulated level of water in the dam rises, total amount of energy to be generated increases. Hydroelectric power plants are established on the places where the head and slope is fine, where the rivers flow into the lakes or by the rivers. The purpose of the dam is to accumulate water. In some places, hydroelectric power can be generated without having large areas submerged. This is provided by rivers which flow in the valleys surrounded by high stones [16].

2.2 Types of Hydroelectric Power Plants

Hydroelectric power plants are divided into three groups called impoundment, run-of-the-river and pumped storage.

2.2.1 Impoundment Hydroelectric Power Plants – Dam

In impoundment types of hydroelectric power plants, water is blocked by a dam and a reservoir is constituted behind the dam (Figure 2). In this way, water that comes from the rain in rainy weather is accumulated in this pool. Necessary water is provided from this pool in dry and droughty seasons.

Figure 2. Impoundment Hydroelectric Power Plants (Dam) [17]

The biggest advantage of impoundment hydroelectric power plants is that they have regular flow rate. Fluctuating and irregular flow is controlled by storing and regulated in these kinds of plants, and due to this regular flow rate, reliable energy which is obtained from the river rises. Having stabilized flow rate is also important in terms of potable water and irrigation water. Dams regulate this flow rate yearly or in mid season periods. In this respect, dams are irreplaceable plants [12].
Dams reduce the loss of life and property resulting from the natural events such as floods or flood hazard by the river where these dams are established. This situation is very significant for the society and natural habitat around the dam. It reduces the spillway capacity, freeboard, risk of flood and provides services for the people living around it. When considered from this point of view,

dams are irrevocable facilities. The advantages of impoundment hydroelectric power plants are listed below;

- They provide the need of potable water, agricultural and irrigation water.
- They provide opportunity to store potential energy of water.
- They provide opportunity for fishing thanks to accumulated water in the pool.
- They prevent disasters such as spate and floods.
- They contribute to the tourism in environment where they are established. *Su Şehri* (Kılıçkaya Dam Reservoir) Dam in our country is an example of dams which contributes to the tourism (Figure 3.) [18].

Figure 3. Su Şehri dam (Kılıçkaya Dam Reservoir) that contributes to tourism [19-20-21].

2.2.2 Run- of- The River Hydroelectric Power Plants (Regulator)

Run- of- The River types of hydroelectric power plants are established on rivers and amount of water level is risen by a regulator (Figure 4). In this way, to get the water becomes easier and a little head is obtained. There is no flow rate regulation in these kinds of plants, therefore the amount of energy to be generated changes depending on the season. Majority of this energy is secondary energy. This incident is exact opposite in impoundment dams, that is to say majority of the generated energy is reliable (stabilized) energy. If there are big dams at source of the run-of-the-river plants and if regular flow rate, which is obtained from the pools of the dams, is used by run-of-the-river plants, the amount of generated reliable energy by run-of-the-river plants increases.

Figure 4. An example of run-of-the-river hydroelectric power plant (Regulator) [22]

In order to protect flora and fauna of the area where these types of plants are established, even in the driest time period, a little water (sap) should be left in the stream bed. The amount of sap to be left is defined by laws in our country. It does not matter if it is private sector or public sector these regulations are needed to be followed [12]. The advantages of run-of-the-river plants can be listed as below;

- Construction period is quite short when compared to other hydroelectric power plants. In parallel with having short construction periods, they are easy to establish. That means they do not cause much destruction during installation stage.
- Since they generate low capacity energy, they provide the energy requirements of the area, where they exist, without much cost.
- Since electric energy generated in these kinds of hydroelectric power plants is used the area where it is generated, there is no need for long transmission lines and in this way, forest destruction, which occurs as a result of the installation of transmission lines, is avoided.
- Operation and maintenance cost is low [18].

2.2.3. Pumped Storage Hydroelectric Power Plant

Another type of hydroelectric power plants is pumped storage plants (Figure 5). They store the water in the next pool by pumping the water with the energy obtained from grind when there is low energy demand. When there is high demand of energy, water accumulated in the upper pool is transferred to the pool below and this way energy is generated. In practice, pumped storage hydroelectric power plants do not increase total amount of energy generation of the country where it is established. They just help to ensure supply and demand equilibrium by transferring waste, disused energy to most valuable and most expensive time period. These types of energy have been used in developed industrial countries since the beginning of 1950s [12].

Figure 5. An example of Pumped Storage Hydroelectric Power Plant [23]

2.3. Advantages and Disadvantages of Hydroelectric Power Plants

The objective of the Electricity Market Law Numbered 4628 is making available enough electricity to the consumer with high quality, low cost, environmental-friendly and sustainable. However, "the environmental-friendly" part of this law has been remained secondary because of encouraging private sector investments. The short and long-term environmental impacts of HPP should be evaluated extensively if these HPP will effect areas such as agricultural and grass lands, natural and archaeological sites, national parks.

Another ecological problem is ensuring sap (the minimum amount of the water to be released into the rivers) to ensure the continuation of natural life. The amount of this water must be at least 10% of the last ten years average current. If the terms and conditions about the sap are not stated before the construction of HPP, it will be emerge as negative effects on the natural life in the coming period. This issue must be planned and supervised clearly [24].

They occupy an important position since they are renewable and clean sources of energy among the other types of electrical power plants. Hydroelectric power plants reach almost 90% in terms of energy efficiency. It has positive effects on energy sector and environment, flood prevention, agriculture, animal breeding, cultivation, fishing and forestation [25].

Generally hydroelectric power plants are important and come to the foreground because of the reasons below;

- They are local resources,
- They have low operational costs,
- They are long lasting,
- They pay for themselves in a short time.

When they are evaluated in terms of environment;

- They are compatible with nature,
- They supply potable, agricultural and irrigation water,
- They provide opportunity for fishing,
- They have the capacity to respond sudden water exchange, and in this way, to prevent disasters such as flood,
- To prevent erosion in a considerable extent.

In addition to having advantages, hydroelectric power plants also have disadvantages. These are hydraulic and biologic environment effects. The large surface of dam reservoir increases evaporation, and in this way, salinization and desertification occur in cultivated area. Water-borne parasitary illnesses increase. If tree and plants, which will submerge under the reservoir, are not cut and cleaned, the quality of water reduces. Expansion of water surface due to dam reservoir may cause bacteria, which is very harmful for people, to grow. Pathogens that multiply in water may cause illnesses such as malaria with or without conductor, schistosome and river blindness to spread. Large scale schistosome ‘explosion’, which occurred as a result of being activated of irrigation system installed in Aswan Dam, can be an example for this [15-25].

The disadvantages of hydroelectric power plants can be listed as below;

- Environmental destruction during the dam building,
- Forest destruction during energy transmission lines,
- To interfere natural river bed and cause a destruction in its flow and flow imbalances due to this interference,
- Ecosystem degradation as a result of flow imbalances,
- To put in pledge to water use right,
- To pay attention to minimum amount of sap this is necessary for living creatures.

The operation of large-capacity dam can change microclimate conditions such as the rate of evaporation, local fog formation, increase of wind speed. In addition, it should be expected that inundated areas will have high greenhouse gas emissions because of organic degradation. On the

other hand, loss of cultural values will be another issue if preservation of natural and historical presence is ignored [26].

Sometimes, architectures are flooded during the construction of the dam. These structures led to increase of touristic trips and in this way a disadvantage turns into advantage. For example, Figure 6 shows the minaret of a flooded masque in Halfeti, Şanlıurfa, Turkey. The touristic excursions are present since the construction of the Birecik dam.

Figure 6. A flooded village in Halfeti, Şanlıurfa [27]

It should not be forgotten that the biggest harm of hydroelectric power plants on nature is the people who do not pay necessary attention to nature [12-18].

3. Results and Discussion

The need for electrical energy is increasing due to population growth, flourish in the industry and technology to meet increasing standards of human lives. The supply of demanding electricity is a cornerstone of the country's energy policies. The primary energy sources such as coal, oil and natural gas are being widely used in the world. These resources are depleted and they also damage the environment. This increasing demand for energy will lead to the environmental issues if the renewable energy sources are not preferred.

It is essential to use the hydraulic energy potential of Turkey's with its current potential. That is why, it is expected to increase the number and capacity of the hydropower plants in our country. Hydroelectric energy is a renewable energy source that is obtained from water without post-production waste and greenhouse gases so it is totally environmental friendly. The European Union

and UNESCO support medium and small river type hydropower plants because of their social and economic benefits in the countryside.

Besides all these benefits, they can cause havoc in nature during the construction phase if not enough attention is paid to the environment. Equally, essential elements for hydroelectric power plants are water so it should be treated with extreme caution. The principles of nature and ecosystems will be faced with much bigger problem when it is not considered enough. Therefore, the maximum sensitivity to the environment must be shown while producing hydroelectric power.

On the other hand, water levels are quite high in hydroelectric power plants so it must be taken into consideration that water levels should not prevent crossing or migration routes of the animals in the area.

The level of sap can affect agriculture and animal husbandry. The possibility of diseases such as schistosome may increase if no measure is taken. Natural disasters such as floods and erosion may also occur. Especially in the summer, water level decrease because of evaporation and it asphyxiate the water. The reduction of oxygen may lead to mass fish death so living condition of the fish in the ecosystem should be also taken into account. The measures to be taken to prevent adverse effects of the hydroelectric power plants can be summarized as follows;

- Hydrological situation should be investigated
- Pilot landscaping and operation should be cared
- Environmental standard should be ensured and controlled in implementation
- Areas with high biodiversity should be saved
- The area of the organism at risk should be avoided
- Biodiversity supporting research should be done
- The obstruction of migration routes should be prevented
- Seasonal flow patterns must be protected
- The quality of water should be protected
- Habitats of the special species must be protected
- Contamination must be avoided
- Cumulative impacts of dams should be avoided
- Effects of the old and new dams should be monitored
- Turbine and control systems should be improved
- Leaks in the dam and irrigation systems should be prevented
- Expired dams should be disabled
- Migration events must be checked and monitored continuously
- The pump storage reservoir unit must be built if necessary
- The landscape should be taken care
- Protection zones should be established in water and land [26]

The environmental impact assessment legislation does not specify the necessary arrangements for power transmission and distribution lines. This legal gap leads to intense destruction on forest areas with the construction of transmission lines. Necessary legal arrangements should be made to prevent this situation.

As it is seen, the hydroelectric power plants have many advantages when we take due precautions in terms of both economical and environmental policy. However, when it is only focused for electricity production without other necessary measures, all these advantages can turn into huge

problems. Therefore, environment and nature must be protected with utmost senility in hydroelectric power generation facilities as well as in other energy producing techniques.

4. Conclusion

The necessary energy for people's need and technology of our time has been used in sectors such as industry, housing and transportation. However, production, transmission and distribution of energy also lead to a large extent on the environmental pollution as well as its benefits for human life. Parallel to population growth and development of heavy industry, large-scale power generation plants have been built and they are affecting the environment negatively. Therefore, environmental problems are becoming a major problem at national and international scale. It is known that hydroelectric power plants have less environmental impact compare to fossil fuel plants. These types of plants are clean and renewable. They also have many advantages such as long physical life, low operating and maintenance cost.

Water is indispensable for life and ecosystems. It is a natural source that benefits all living things. For this reason, any attempt for the use of water should be done by the preservation of the natural environment. It should also be aimed that new and renewable energy source should be considered for the purpose of natural conservation. People should easily access to environmental information to ensure the participation in the decision-making process of the planning and construction of the hydroelectric power plants. Such mechanisms should be created.

In line with these information, the environmental impact of hydroelectric power plants and the importance of environmental policies have been emphasized in this study. The advantages and disadvantages of these plants have been discussed. And solutions to eliminate the adverse effects have been proposed. In addition, it has been emphasized that the investment in the energy sector is not distant from the tourism sector that they can be achieved without any harm to each other.

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