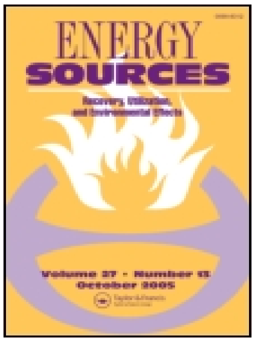

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Problems and Solutions Related to Hydroelectric Power Plants Constructed on the Buyuk Menderes and the West Mediterranean Basin

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Problems and Solutions Related to Hydroelectric Power Plants Constructed on the Buyuk Menderes and the West Mediterranean Basin

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Abstract *Hydropower is a key source for renewable electricity generation and it has an important potential to be marketed as green energy. There has been a substantial increase in the number of hydroelectric power plants in recent years in Turkey. While offering ecological advantages from a global perspective, such as climate change mitigation, emergency management, and reduction of flooding risk, the operation and construction of hydroelectric power plants may cause some environmental impacts on the local and regional level. These include harm to fish populations, a loss of aquatic habitat, a significant change in natural flow regimes, and deterioration of the landscape. The article aims to suggest various ways to resolve these issues, and to research the problems of 24 hydroelectric power plants operated and constructed on dams, rivers, and canals by the State Hydraulic Works (DSI) or private sector in the Buyuk Menderes Basin and in the West Mediterranean Basins in Turkey.*

Keywords construction, environmental impact, hydroelectric power plant, operation, Turkey

1. Introduction

Hydraulic power is considered to be the most important source of renewable energy for electricity production. The possible hydrostatic potential that is technically feasible in the world is approximated to be 14,370 TWhyear^{-1}, which is equivalent to the total electric demand. The amount that is considered as economically feasible is 8,089 TWhyear^{-1}. The amount of hydroelectric potential that was consumed in the world in 1999 is assumed to be 2,650 TWh, which constitutes 19% of the world's electricity (Paish, 2002). Canada is the world's biggest hydroelectric producer with its 350 TWhyear^{-1}, which constitutes 13% of the total produced electricity in 2001. The United States, Brazil, China, and Russia are behind Canada in electricity production (ERE, 2005). The World Bank has declared that the people who live in poor countries spend less than 12% of their total income for energy and that 1.7 billion people are living without electricity (Laguna et al., 2006).

Turkey has theoretically a 433 billion kWhyear^{-1} capacity, technically 216 billion kWhyear^{-1} and technical-economically 48.1 billion kWhyear^{-1} hydraulic energy production capacities. The 48.1 billion kWhyear^{-1} portion is the developed capacity (DSI,

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2010a). Today, 18.5% of electric power is produced in hydroelectric power plants. This production only accounts for 38% of hydraulic potential of the country (ETKB, 2010). Approximately, 50% of the total electrical energy consumed is utilized in the industry (DSI, 2010b).

Ecosystem destruction, physical habitat alteration, water chemistry alteration, direct species additions and removals (Malmqvist and Rundle, 2002), damage on freshwater habitats and organisms, depletion of floodplain wetlands, decrease in sediment transport (Kingsford, 2000), decrease and extinction in fish populations due to preventing fish migration and moves, and a significant change in natural flow regimes (SHERPA, 2010) are among the most well-known environmental threats of hydroelectric power plants (HEPPs). Some of the negative environmental impacts of HEPPs have led the public to develop a negative attitude towards HEPPs while they are usually preferred in regards to renewability, emergency management, and reduction in flood risk. As a result of the lawsuits filed by the citizens and non-governmental organizations who have observed the damage on the environment, some plant constructions were stopped by court decision.

This study has the purpose of researching and resolving the problems of 24 hydroelectric power plants, which have been constructed and operated by DSI or by the private sector, in the Buyuk Menderes and in the West Mediterranean Basins. As a result, some major problems due to the operation, construction, and planning of HEPPs have been identified, and some recommendations made.

2. Materials and Method

As a material, the 24 hydroelectric power plants in the Buyuk Menderes and in West Mediterranean Basin, which are under operation by the DSI or by the private sector, are taken into account (Figure 1). The provinces of Aydın and Denizli are in the Buyuk Menderes Basins, while the province of Muğla is in the West Mediterranean basin. The main water source of the Buyuk Menderes Basin is the Buyuk Menderes River, while the West Mediterranean Basin's source is the Dalaman stream. In the Buyuk Menderes and in the West Mediterranean Basin, there are 14 dams, 7 small-dams, with a total of 21 storage facilities. In both of the basins, 242,000 ha of area is under the irrigation service, due to 36 irrigation projects that are in operation by the DSI (Koç et al., 2010).

There are 14 HEPP facilities in the Buyuk Menderes Basin and 10 HEPP facilities in the West Mediterranean basin, which have been constructed and put into operation. The names of the HEPP, the province and municipality where they are constructed, the years when the agreements were signed, the date when they were put into operation, the organization responsible for the operation, the type of the HEPP, the location of the HEPP, and the total production capacity (MW) have been given in Table 1. Scientific and technical project documentation of these plants was obtained from the respective governmental institutions, namely, the Ministry of Environment and Forestry, Energy Market Regulatory Authority, and General Directorate of State Hydraulic Works (DSI). The compatibility of the initial project documentation data to the application on the ground was determined through on-site investigations. Generally, due to legal ramifications that have taken place in 2000, the private sector investments have shown a large increase starting in 2007, on projects approved and licensed by the Energy Markets Organizational Committee (EPDK) and by DSI. The first phase of applying and getting licensing of a HEPP facility is to prepare and send the feasibility reports to the DSI. With the companies, for which the reports have been analyzed and approved by the DSI, a Water Usage Agreement is signed and it is sent to the EPDK for getting an electricity

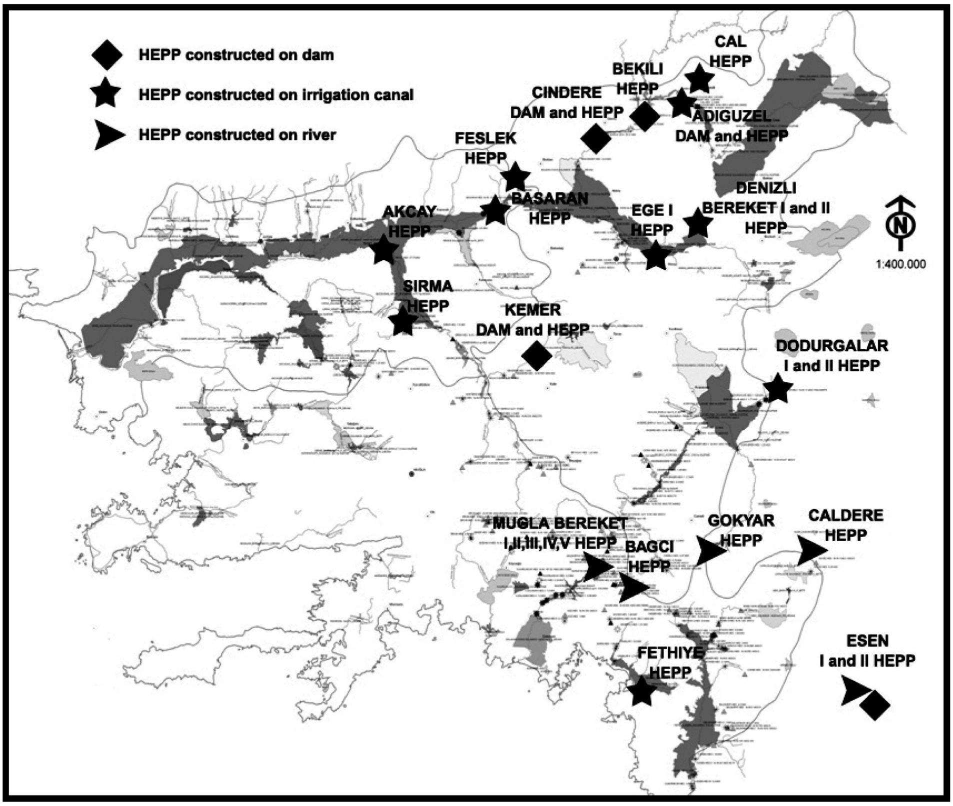

Figure 1. Location of 24 hydroelectric power plants (HEPP) in Buyuk Menderes and West Mediterranean Basin.

production license. Once the Environmental Impact Assessment report is prepared, then the facility is constructed; as soon as it is licensed and it then starts operating (Avcı, 2008; EÜAŞ, 2008). The HEPPs in Turkey are constructed and operated according to the code 4628 Electric Market Law according to the COT (Construction-Operation-Turnover) model as per law codes 3096–3996, and as per the code 4628 EPDK regulations for determining the production and operation of HEPP facilities according to the Water Usage Agreement. The installation and the operation of hydroelectric energy production facilities and the licenses for production, auto-production, and auto-production group are organized under the Water Usage Right Agreement (SKHA) between the DSI and third parties and these have been published in the official gazette numbered 25150 under the Regulations of "Electric Production for SKHA agreement." In addition, the regulations change has been put into effect with the Official Gazette dated May 25, 2004 with order no. 25472 and with the Official Gazette dated September 17, 2005 with order no. 25969.

3. Results and Discussion

The project production values and production values for the year 2010, of various HEPP facilities operating in Buyuk Menderes and in West Mediterranean Basin, have been

Table 1

Hydroelectric power stations (HEPP) constructed and operational in Buyuk Menderes and West Mediterranean Basin

Basin name	HPP name	Province	District	Year of water usage agreement	Operation	Organization	HEPP type	HEPP location	Total power capacity, MW	Project production, GWh/year
Büyük Menderes Basin	Feslek HPP	Aydın	Nazilli	1999	2004	Bereket Enerji Üretim A.Ş.	Electricity production	Nazilli right coast irrigation canal	8.84	41.00
	Başaran HPP	Aydın	Nazilli	2005	2006	Ekin Hidroelektrik Üretim Ltd. Şti.	Electricity production	Nazilli left coast irrigation canal	0.60	4.27
	Akçay HPP	Aydın	Bozdoğan	2009	2009	Akçay HPP Elektrik Üretim A.Ş.	Electricity production	Akçay stream	28.78	94.88
	Sırma HPP	Aydın	Bozdoğan	2006	2009	Beyobasi Enerji Üretim A.Ş.	Electricity production	Akçay irrigation left coast main channel	5.88	23.20
	Kemer HPP	Aydın	Bozdoğan	NA	1958	EÜAŞ	Electricity production	Akçay stream	48.00	143.00
	Cindere HPP	Denizli	Güney	2006	2008	Entek Enerji A.Ş.	Electricity production	Büyük Menderes River	28.50	88.10
	Adıgüzel HPP	Denizli	Güney	NA	1990	EÜAŞ	Electricity production	Büyük Menderes River	62.00	280.00
	Çal HPP	Denizli	Çal	1999	2001	Limak A.Ş.	Yid model	Büyük Menderes River	2.20	11.75
	Bereket I–II HPP	Denizli	Merkez	1995	1998	Bereket Enerji Üretim A.Ş.	Electricity production	Çürüksu right coast irrigation canal	3.15	12.00
	Dodurgalar I–II HPP	Denizli	Acıpayam	1995	2004	Elta Elekrik Üretim Ltd. Şti.	Electricity production	Dodurgalar I–II HPP transport canal	4.14	12.00
	Ege I HPP	Denizli	Merkez	2002	2009	Denizli Elektrik Üretim A.Ş.	Electricity production	Çürüksu Left Coast Main Canal	0.92	4.38
	Bekilli HPP	Denizli	Çal	NA	1954	Bekilli Belediyesi	Electricity production	Çal HPP Kuyruk water canal edge	0.33	0.40
West Mediterranean Basin	Dalaman I, II, III, IV, V HPP	Muğla	Dalaman	1996	1993–2003	Bereket Enerji Üretim A.Ş.	Electricity production	On Dalaman stream regulator	26.25	138.35
	Gökyar HPP	Muğla	Dalaman	2003	2006	Bereket Enerji Üretim A.Ş.	Electricity production	On Dalaman stream regulator	11.62	60.00
	Çaldere HPP	Muğla	Dalaman	2001	2008	Çaldere Elektrik Üretim A.Ş.	Electricity production	Çaldere bend	8.74	35.00
	Bağcı-Beyobası HPP	Muğla	Dalaman	1997	1998	Bağcı Balık Gıda En. Ür. San. Tic. A.Ş.	Electricity production	Yuvarlak stream Bağcı Balık prod. farm exit	0.34	1.70
	Fethiye HPP	Muğla	Fethiye	1997	1999	Fethiye Enerji ve Tic. A.Ş.	Yid model	Fethiye right coast irrigation canal	16.50	90.00
	Eşen (Göltaş) II HPP	Muğla	Fethiye	1999	2003	Göltaş Enerji Sanayi ve Tic. A.Ş.	Electricity production	Eşen regulator and transport system	43.40	187.50

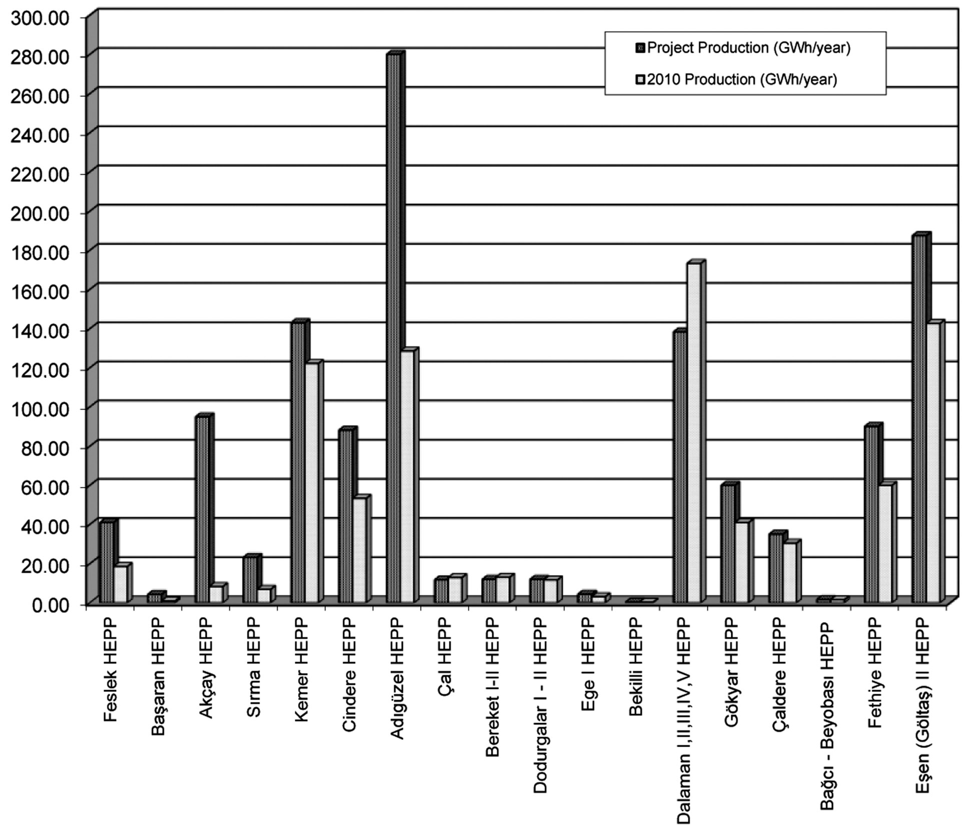

Figure 2. The realization values of HEP projects evaluated in 2010.

presented graphically (Figure 2). The project production values to real energy production values ratio show a change between 9 and 125% (Figure 3). In fact, the production values have been realized in a very different interval. Fulfillment ratio of the Çal, Bereket, and Dalaman HEPPs realized more than 100%. The real energy production values of these HEPPs are more than project production values. Therefore, it stems from the poor prepared feasibility report. The other reasons for this difference are due to the functionality of the water structure where the HEPP is constructed (river, dam, and construction on the canal); the lengthiness or the shortness of the irrigation periods; the present amount of the water source; the drought and rainy periods; the turbine capacity; and the optimum flow interval. The difference between project production values and real production values is more Kemer, Adıgüzel, Dalaman, and Esen HEPPs than other HEPPs researched. This difference stems from the insufficient water resources depending on the drought periods. The problems that are seen during construction, as well as in the operational stage in various HEPPs in basins, have been stated below.

3.1. *Problems Related to HEPPs*

- There are differences between the dimensional values realized in the operation and construction phases and the dimensional values (height of the regulator,

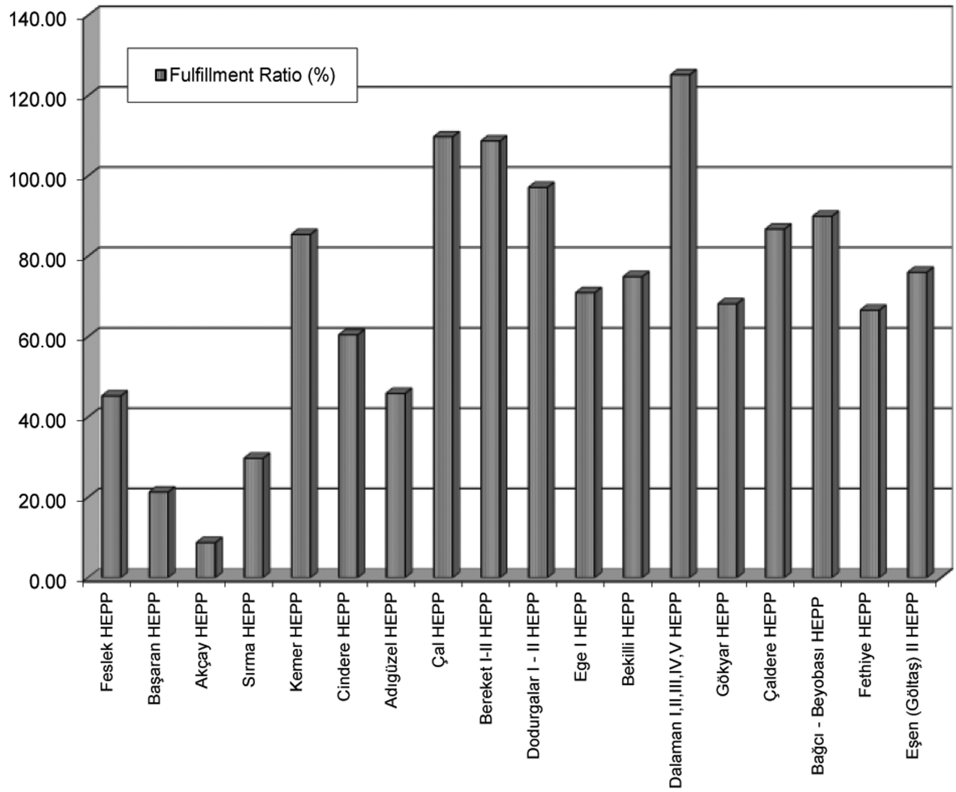

Figure 3. Fulfillment ratio of HEPP researched in 2010.

canal capacity, algebraic pipe diameter, plant power capacity) determined in the feasibility report of the HEPPs (the increasing of the height of the regulator in Bereket HEPP-I on Dalaman stream in the West Mediterranean Basin, and the fact that the main channel capacity is insufficient in Ege HEPP-I in Buyuk Menderes Basin). In addition, especially, HEPPs constructed to the COT model, taking money from energy funds causes the government losses due to the fact that the HEPPs do not attain their expected production capacity (Fetaş HEPP in West Mediterranean Basin).

- Since the energy sector has entered a fast liberalization phase, as soon as projects have been announced, private sector applications have been accepted in a short period of time. There are criticisms, which state that the proper basin analyses have not taken place and that sufficient technical analysis and evaluation have not been completed due to timing limitations put forward by the regulations. Due to the fact that the feasibility studies are generally carried out with water measurements, the fact of whether they are actually efficient projects is only seen after the revised work is completed after the licensing (Cindere HEPP in Buyuk Menderes Basin). Any changes completed in feasibility after licensing actually delays the construction process of the facilities.
- Many of the projects developed by the companies have used past measurements of the area instead of using current data. Companies prepare revised feasibility reports

for the projects after getting their license and this causes delays in the construction of the facilities, amendments in the licenses, as well as the reevaluation or changing of the relational concepts.

- In running waters, where the license application is made to Energy Markets Organizational Committee (EPDK), these licenses are given without taking into account the public's views and the views of local organizations, which causes problems to take place on social and technical levels with the local population (the constructions, which have been started, but stopped by the local social organizations in the Western Mediterranean basin, Yuvarlak Stream HEPP).
- The HEPP project areas are extremely sensitive to floods and landslides due to their geological, topological, and climatic conditions. The damage to the flora due to intervention in natural processes, roads constructed on steep shoulders, and the vibrations caused by explosions in stone quarries can have a negative effect on the soil and on the water equilibrium (Göltaş HEPP II in West Mediterranean Basin).
- The fact that the water utilization rights in springs and river beds are not placed in the agreements causes many disagreements concerning the amount of water used in irrigation and in energy production (Ege HEPP-I and Çal HEPP in Buyuk Menderes Basin).
- The protocol that deals with the Water Usage Agreement regulations concerning environmental water needs and its follow-up for ecological equilibrium flow rate has not been realized. The amount of water that is needed for an aqua life, along with enough ecological water sources to ensure continuity of the ecosystems as well as the conditions of releasing water, should be determined with a scientific method. The Tennant (Montana) Method, which is used more extensively than other methods with a rate of 30% worldwide (Tharme, 2003), is also the most widely used method in Turkey. It is stated that the Tennant Method should be used in rivers with a slope of less than 1% (Mann, 2006) and there should be differences concerning the use in every area or country (Orth and Maughan, 1981; Acreman and Dunbar, 2004). This value in Austria is the value between annual minimum flow and the annual maximum flow, in Greece it is 1/3 of the mean summer flow, and in England no standard method exists; the criteria are set by doing experimental work in field conditions before the license is given (ESHA, 2010), in Germany this is between 1/3 and 1/6 of the mean minimum flow, in France generally more than 1/10 of inter-annual mean flow, and more than 1/20 of inter-annual mean flow in high flow rivers larger than 80 m^3/s (SHERPA, 2010). In the beginning of the 2000s, the environmental flow was 1% of mean annual flow in Turkey; it was later raised to 2.5% and then to 5%, and at present it is 10%. HEPPs studied in Buyuk Menders and West Mediterranean Basin, the amount of the water released for the ecological life is 10% of mean annual flow of the stream on which the HEPP is constructed.

3.2. Problems during the Operation Phase

- The consecutive work hours of the HEPP facilities and the fact that water is also used in irrigation causes irregularities between the working hours of the HEPP (the hours when the electricity price is high) and between the relation of spring water and river beds along with the irregularities in irrigation water demands, as well as the fact that the water planning is not done properly in a level that is desired for irrigation and for energy production.

- The problems that take place in determining the amount of water that is to be released to the stream bed, as well as the governance and the authority of the organization that is responsible for the protection of the continuity of natural life along with the other needs in river mouths.
- The insufficiency of the Flow Observation Stations (FOS), which are used in determining the amount of water that is to be used for irrigation and energy or having measurement facilities that are insufficient digitally and functionally; not being operated properly in correct phases, and the fact that there are no alternative measurement devices or facilities, which can function when FOS are not in order.
- In some HEPP establishments with common facilities, the Water Usage Agreement regulation clauses concerning the operations, repair, and restoration expenses is not observed properly. Especially in COT model HEPP, there are HEPP facilities that try to abstain from signing an additional protocol and that have less participation in operations and maintenance costs due to the fact that less water comes to the power plants (Çal HEPP in Buyuk Menderes Basin).
- There are some difficulties associated with determining the turbine input mass flow rate as well as the determination of corresponding power and of specific water in canal plants.
- Being unable to determine the sediment amount and its behavior, which effects the ecology and the energy production negatively (Fetaş HEPP in West Mediterranean Basin).

4. Conclusion and Recommendations

The energy deficit and the dependency on foreign resources, which have become prominent in the recent years, have caused Turkey to pursue methods that aim to get results in a short period of time, instead of long-range energy policies. In this regard, increasing the hydroelectric production share, which has been 18.7% of total electric production in 2007, with river or canal type hydropower plants is one of the methods that have become popular recently. However, the fact that the region is mountainous and that it has a high slope rate, has shown clearly that the forests, soil, and water sources will be affected negatively. Taking these into consideration, the following suggestions have been stated to overcome these problems concerning the HEPP facilities in basins.

- In the areas where the project will be executed, there must be planning that takes integrated basin management into account. Integrated basin planning must incorporate various occupational disciplines, their representatives, local governance, and the civilian organizations. During the project's feasibility analysis, the DSI must take decisions taking integrated basin planning based upon the reservoir and not based upon the project. The present situation in the basin will need to be taken into account and the possible improvisations should be determined and executed.
- The flow rates for irrigation and the flow rates for the operation of the hydroelectric power plant should be planned in such a way that complements each other. In the irrigation process, the water that is released from the dam has its energy extracted first and then it is used for irrigation. In order to determine the optimal flow rates in the general reservoir irrigation plan, it is essential to take the minimum and maximum flow rates of the turbines belonging to the dam and to the canal hydroelectric plant (Koç et al., 2010b).

- During the preparation phase of HEPP projects, it is important to satisfactorily evaluate the needs of the local population living in the area; the water requirements of the flora and fauna; the continuance of the ecologic systems; the condition of the damage that can take place in the forests, pastures, and lands; as well as the selection of the facility that meets the needs of the region; and the geological, topographic, and the climactic conditions along with the social and cultural effects of the projects.
- In order to explain the advantages of using renewable energy in its environmental aspects, the necessary conferences, seminars, and panels should be conducted; the social dimension of the situation should be taken into consideration by companies; employment opportunities should be given primarily to the local population; and the restoration of the region should be assisted where the facilities are present. The local community should be informed about the HEPP projects and the companies should put out the maximum amount of effort, in order to comply with the environment regulations.
- The determination of the regional water supply, the arrangement and the control of situations, which can impede the utilization of water, arrangement of situations, such as upper and lower level power plants not wanting to produce at the same time, to create control over the water-environment relationship along with reservoir management systems. In the private sector production companies, there should be the same type of system that exists for DSI-EÜAS, like those facilities that are controlled through public processes.
- It is very difficult to find experienced/capable personnel who can work in various HEPP facilities. Universities, as well as occupational high schools should take note of this to organize their academic curriculum, and quality personnel (especially technicians and technical assistants) should be trained and those students who are seeing education in technical branches should be given more emphasis on engineering studies related to HEPP investments. Care should also be taken that graduates are equipped in order to be able to work in energy projects.
- For ecological purposes, a national method should be developed for deciding the amount of water that will be released to the river beds. While this method is being determined, every running water source characteristic and the properties of the ecosystems surrounding the water source should be taken into account and it should rely on scientific studies. The process of deploying life water and its timing should be clarified, as to the selection of the institution responsible and the necessary sanction mechanisms.
- Electricity, which is considered as the most important component of public welfare and sustainable development, should be procured in an economical way per the amount demanded, in a quality manner. The country's energy policy principles should give priority to an overall sustainable plan, which allows for our national resources to be used more efficiently with secure supplies and in peace with the environment.

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