



## STORING WATER IN DAM RESERVOIRS: WHY IS IT NECESSARY?

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TURKEY

### **Abstract**

From the beginning of human history, for almost 5 000 years, dams have served to ensure an adequate supply of water by storing water in times of surplus and releasing it in times of scarcity, thus also preventing or mitigating floods and making a significant contribution to the efficient management of finite water resources that are unevenly distributed and subject to large seasonal fluctuations.

Purposes to be served by such a project usually include water supply, irrigation, flood control, hydropower generation, navigation, recreation, pollution abatement, industrial use, fish and wildlife conservation, and other environmental considerations, salinity, and sediment control, and recharge of groundwater. To meet these purposes, several dams are constructed to control and regulate the natural flows. This regulation function is the main reason for creating reservoirs by constructing dams.

Water storage facilities are being constructed in Turkey as in any other country in the world, to make benefit of water resources which are not regular in terms of time and space, being aware of the fact that total level of the amount may be enough in any given year or long term period. Water storage facilities are also being constructed in order to prevent floods and other water damages. So far in our country, 195 large dams and 941 smaller *dams* (that have heights lower than 25 m.) have been constructed. At present, the number of 110 large dams and the number of 237 smaller dams are being constructed. The number of diversion dams, however, is not considered in this total number.

Giving some figures from the water resources projects in Turkey, this paper generally presents the role of dams in water resource management.

**Keywords:** Dam, Water storage, Dam reservoir, Dam's benefits, Large dams



## 1. INTRODUCTION

### 1.1 Basic Concepts of Dam Reservoirs

The word of “reservoir” is originally stemming from “to reserve”. In this meaning, this word implies to keep something for a special purpose. Accordingly, keeping the water for some special purposes, dams are a major source of hydroelectric power, flood protection, recreation, and domestic, agricultural, and industrial water supplies.

A dam is a structure built across a stream, river, or estuary to retain water. Its purposes are to meet demands for water for human consumption, irrigation, or industry; to reduce peak discharge of floodwater; to increase available water stored for generating hydroelectric power, or to increase the depth of water in a river to improve navigation. An incidental purpose can be to provide a lake for recreation **(1)**.

While water demand is steadily increasing throughout the world, freshwater resources remain limited and unevenly distributed. Water availability is critical to any further development above the present unsatisfactorily low level, and even to the mere survival of existing communities or to meet the continuously growing demand originating from the rapid increase of their population **(2)**.

Dams are considered as an important issue in the sustainable management of our finite water resources. Those resources are subject to increasingly competitive demands as global population growth exacerbates tensions over the water needed to produce energy and to ensure food security.

Dams store water in the reservoir during times of excess flow, so that water can be released from the reservoir during the times that natural flows are inadequate to meet the needs of water users. Dams are important because they help people have water to drink and provide water for industry, water for irrigation, water for fishing and recreation, water for hydroelectric power production, water for navigation in rivers, and other needs. Dams also serve people by reducing or preventing floods.

### 1.2 Purposes of Dam Reservoirs

There are various water demands, including irrigation; domestic uses (*showering, watering lawns and gardens, etc.*); industrial uses (*water used for processing, washing, and cooling in facilities that manufacture products*); thermoelectric power uses (*water used for cooling to condense the steam that drives turbines in the generation of electric power with fossil fuels and nuclear or geothermal energy*); and in-stream water uses (*water used for hydroelectric power generation, navigation, recreation, and ecosystems*) **(1)**.



The purposes of dams are grouped into two main categories, single-purpose dams and multipurpose dams (3).

According to the World Commission on Dams (WCD) Study conducted all over the world, most (48% approx.) dams in the first category are for irrigation and therefore contribute greatly to food production. A considerable proportion (15% approx.) of single-purpose dams serve for domestic and industrial water supply. A substantially smaller number (20% approx.) generate electricity. The same study informs that other purposes include, in decreasing order of importance, flood control (8%), recreation (4%) and, to a lesser degree, inland navigation and fish farming, and that multi-purpose dams account for a large proportion of the total - 7 400 out of the 25 400 reported - nearly 30 percent of the total. It is also added that multi-purpose dams are increasingly important for regional economic development.

The majority of large dams are built for irrigation; almost all major dams are built for hydropower. Nearly one-fifth of the world's electricity is generated by dams. Dams also provide flood control, supply water to cities, and can assist river navigation. Many dams are multipurpose, providing two or more of the above benefits.

Irrigation comes first in this category also, followed by flood control, hydropower, domestic and industrial water supply, and recreation, with fish farming and navigation.

Since the groundwater reservoirs presently tapped to provide about half of the irrigation, drinking and industrial water supply are already heavily overdraw in many parts of the world, the only large-scale solution apart from saving water is to increase the share of surface water from the storage reservoir.

According to the WCD Study, flood control has always been a particularly significant motive for dam construction and frequently its primary purpose. In the WCD Report, it is informed that it will continue to be so, as long as about 40 percent of all fatalities from natural catastrophes worldwide are caused by flooding.

Compared with the main requirements of irrigation, domestic and industrial water supply, energy production, and flood control, the other purposes and benefits of dams such as navigation, fisheries and tourism, improvements to the infrastructure, job creation, and on-site training, are of generally minor importance, but must nevertheless not be disregarded or underrated.

### **1.3 Major Benefits of Dam Reservoirs**

According to study (4) conducted by United States Committee on Large Dams (USCOLD), today living conditions of billions of people are certainly improved by the construction of dams. Besides the essential need for potable water, production of food through irrigation, energy, and power production, flood control, provision of recreational facilities are among



the major benefits of dams. Regarding the benefits of the dams, the following aspects could be listed as follows:

- In general meaning, dams allow rivers to be used for navigation.
- Dams create lakes for fishing and recreation.
- Dams are important because they provide water for irrigation.
- Large storage dams regulate the flow of water and sediments down the river and impact the functions and services of downstream ecosystems and their biodiversity in many different ways, especially for wildlife or for fisheries for example.
- As we are all well aware, one of the major benefits of dams is the production of hydroelectric energy. Generating clean energy of hydropower, dams contribute significantly to reducing air pollution. Hydropower is the most plentiful and most efficient renewable energy resource, contributing a considerable percent of all renewable electric energy produced all over the World. According to the study realized by the USCLD in the USA, the efficiency of a modern hydropower plant exceeds 90 percent, which is more than twice the efficiency of a thermal plant.
- Dams provide "cheap" and "clean" energy, increase food production, and control flooding. Examples of this preconceived bias include: The rationale for the development of large dams is based on the generation of clean power and improved management of water resources
- According to the World Bank Report (5), namely "*The World Bank's Experience With Large Dams: A Preliminary Review of Impacts*", without the exploitation of rivers, the world would be a much different place and would be able to support fewer viable human settlements. Life for many people in the great river basins of the world would be a cycle of drought, floods, and famines.

However, this report which was prepared by WB Operations Evaluation Department has been heavily criticized by another study (6) conducted by International Rivers Network (IRN).

- Availability of water can also lead to significant greening of barren lands. Yet another benefit often cited is the creation of habitats for water bodies. As an example, it is informed in the different sources that many of India's bird sanctuaries are located on and round artificial reservoirs.
- On the plus side again, the dam will be capable of pumping out electricity from the generators, each equal to a medium-sized nuclear reactor. This cleaner hydroelectric power would offset the burning of polluting coal, prevent catastrophic flooding.

#### 1.4 Concerns on the Dam Reservoirs

Prof. Kader Asmal states that dams provide electricity and fill irrigation canals to boost industrial and agricultural growth, as well as managing floods and storing waters for times of drought. He also stresses that these benefits sometimes come at certain costs in social, economic, and environmental terms, implying the adversarial debate over dams illustrates the tensions between nations (*over shared waterways*) and within nations (*as environmentalists, communities displaced by dam reservoirs, and other affected people battle government, utilities, and farm interests*).



Dams can provide hydropower, irrigation, and flood control. These are developmental benefits, but there are also costs in human, environmental and economic terms. The public debate on large dams has been characterized by the increasingly adversarial tone adopted by dam advocates and opponents. The breakdown in constructive dialogue between interested parties in the dams debate has had ramifications in areas ranging from the achievement of civil society consensus on sustainable development to the availability of financing for dams and their alternatives.

- There are some concerns that water uses is contributing to drought. This is believed as mainly a result of the considerable amount of evaporation losses from the huge sizes of surface areas of reservoirs.
- Large dams have provoked opposition for numerous social, environmental, economic, and safety reasons. The main reason for opposition worldwide is the huge numbers of people evicted from their lands and homes to make way for reservoirs.
- The livelihoods of many millions of people also suffer because of the downstream effects of dams: the loss of fisheries, contaminated water, decreased amounts of water, and a reduction in the fertility of farmlands and forests due to the loss of natural fertilizers and irrigation in seasonal floods. Dams also spread waterborne diseases such as malaria, leishmaniasis, and schistosomiasis.
- According to study (7) conducted by Ron Corso, Mead & Hunt, Inc., dams can stop regular annual floods but often fail to hold back exceptionally large floods. Because dams lead people to believe that floods are controlled, they lead to increased development of flood plains. When a large flood does come, damages caused are often greater than they would have been without the dam.
- When these high costs, delays, and risks of low river flows are factored into calculations of the costs of electricity it can be seen that hydropower is now an expensive form of power generation. Some scientists do not consider hydropower as clean power because of the destruction of river ecosystems and its many social impacts. Internationally, private investors in power projects are largely avoiding large dams and prefer to invest in cheaper and less risky gas-fired power plants.

### **1.5 The Advantages of Hydropower and The Role of Dams in Hydropower Generation**

It is a well-known fact that energy is one of the most important commodities for the satisfaction of physical needs and for providing economic development of modern society. Meanwhile, energy needs are continuously growing. The demand for electric power continues to grow rapidly.

Recently, new problems have evolved with the exponential growth of electrical energy demands. However, these are the issues of water supply for energy production and the impact of energy developments on climate and the global environment.

Dams do help mitigate climate change by avoiding the emission of greenhouse gases. According to the study (8), Seyhan Dam is found as a good example of adaptation to climate



change impacts by storing water for irrigations and enabling farmers to cope with the variability of the rainfall while adapting to the reduced water resources available in Turkey where water potential changes substantially at temporal and spatial scales as does the climate (9).

To date, the world energy market has depended almost entirely upon non-renewable, but low-cost, fossil fuels. According to the report (10) by International Energy Agency, released in March 1999, the energy produced by hydroelectric developments throughout the world provides approximately one-fifth of the world's total electrical energy.

Hydropower is solar energy in naturally and ideally concentrated form that can be utilized with the help of a mature and familiar technology with unsurpassed rates of efficiency and without depriving future generations in any way of raw materials or burdening them with pollutants or wastes. According to the study (11) prepared for Water and Sustainable Development International Conference, in March 1998, it is informed that, with a total annual generation of 2.1 million GWh, hydropower accounts today for 20 percent of electricity production and about 7 percent of total energy production worldwide. It is also given that, even at a conservative estimate, the total exploitable hydro-potential in the world amounts to at least six times as much.

Given the foreseeable depletion of fossil fuels, which presently are used to satisfy three-quarters of primary energy requirements worldwide, plus the problem of the greenhouse effect and global warming, there is an urgent need to gradually replace them with methods of energy production which do not release CO<sub>2</sub>, (or airborne mercury from coal-fired plants) into the atmosphere and which draw on renewable sources of energy. In the short and medium-term, however, the predominant sources of renewable energy that will permit large-scale exploitation will be biomass and hydropower, before new sources like the direct harnessing of the sun's energy by photovoltaics will be ready to make contributions of the same order of magnitude (12).

Conventional electricity supply options include thermal (*coal, oil, and gas*), nuclear, and hydropower of different scales. These technologies currently dominate global electricity generation (*thermal 62%, hydraulic 20%, nuclear 17%, and all other 1%*) (3). The use of co-generation particularly, and geothermal and wind generation both for isolated supply and small to medium scale grid feeding applications is small but increasing on a global level.

Hydropower has a long list of positive characteristics that explain its strong support and promotion. For one thing, it is highly efficient. In addition to the power generated, the advantages of hydropower are many – such as flood protection (commonly undervalued), flow regulation, multiple-use, and fossil fuel avoidance. The other major beneficial aspects of hydropower can be listed as follows:

- Because hydro is a domestic resource, governments and utilities in developing countries often prefer hydro generation over electricity produced from fossil fuels, which must be imported or, if the nation has its supplies, are valuable sources of export revenues.

- In addition, the relatively low maintenance cost and simplicity of operation associated with hydro projects are strong pluses in countries where the more complex maintenance and operating logistics of thermal plants pose serious problems.
- Although water is one of the two essential components in the production of hydroelectric energy, this is essentially a non-consumptive use as well as a non-polluting one. For example, in the production of thermal-electric energy, water is required in practically all technical stages from the boring of test wells in oil and gas exploration to the transformation of fossil and nuclear fuels into electrical energy at thermal power stations - uses which are largely consumptive and/or polluting.
- Hydropower is a source of electrical energy that is continually renewed and available in the runoff segment of the hydrological cycle. Energy from flowing water offers something unique to a nation's economic development.
- In the report (13) prepared for the Big Dams Debate of World Bank, Robert Goodland states that hydropower is more efficient than most methods of converting mechanical energy to electrical energy, averaging 85 percent efficiency (*versus 50 percent for the best gas turbines*) and it is more reliable (*for example, fewer outages*) than any fossil-fueled plant, responding to rapid changes in load and is lower in cost than other types of power.
- Hydroelectric plants have a long life, require very little maintenance, and use water, a renewable energy resource. As long as the water continues to flow, nothing else is needed, so no consumption of fuel or production of heat is involved in the electricity generation. After the construction of the plant, very few people are required for the maintenance of the project.
- In addition to these good points, because it was possible to transport the energy produced at dams for such great distances, hydroelectric power is commonly considered as a very attractive and economically logical option.

Besides this, very often, hydropower pays for multipurpose benefits. When this is taken into account, and when all environmental and social costs are internalized, hydropower compares favorably with other sources of energy. When compared to other sources of energy, hydropower can be superior, similar, or deficient in comparison. When compared to fossil fuels, a non-renewable resource, hydropower does not produce nearly as much energy. However, hydropower does have the preferable characteristics of being efficient, non-polluting, and renewable (while fossil fuels are quickly becoming scarce and depleted). Hydropower exhibits the same beneficial characteristics over the other non-renewable energy source, nuclear energy. While nuclear energy has the advantage of being able to exist in areas that hydropower cannot (areas of low relief and inadequate amounts of water), "it cannot compare to the cleanliness and inexhaustible amount of fuel used in a hydroelectric plant". In comparison to other renewable sources of energy, hydropower shares much in common. Both solar power and hydropower need the sun to create energy. Solar power uses the sun's power directly, while the sun evaporates water and deposits it upstream, indirectly making hydropower possible. Hydropower has the advantage of creating recreational areas for visitors to enjoy. Hydropower, solar power, and wind power all require large amounts of land to generate electricity. Wind power, hydropower, tidal power, and geothermal energy are all limited to locations where the elements needed to fuel the project are available. Successful tidal power projects, however, are restricted to very specific coastline

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configurations, and as a result, are not as numerous as hydropower plants. Hydropower has an advantage over geothermal energy in that it has a continuous supply of fuel. Geothermal plants must consider the "shifting of geothermal activity and the possible exhaustion of the exploited fuel from that area." Biomass too, is renewable, however, it has the disadvantage of producing pollution when burned (14).

## **2 WATER RESOURCES OF TURKEY**

### **2.1 General Information**

According to the statistics (15) conducted by the General Directorate of State Hydraulic Works (*DSI*) of Turkey, all water resources in Turkey are thoroughly observed and evaluated through the hydrological and meteorological network extended all over the country. With mean annual precipitation of 643 mm, it is assumed that yearly precipitation brings 501 km<sup>3</sup> of water. While 274 km<sup>3</sup> of this quantity returns to the atmosphere through evapotranspiration from ground and water surfaces as well as from plants, 69 km<sup>3</sup> feed the underground water reserves through infiltration from the surface, therefore a total of 186 km<sup>3</sup> of which 158 km<sup>3</sup> come from the precipitation and 28 km<sup>3</sup> come from the underground water reserves, flow into the sea and the lakes through rivers and streams of various sizes.

Furthermore, based on flow observations it is determined that 7 km<sup>3</sup> water flows into Turkey every year through the rivers from neighboring countries. Accordingly, Turkey's surface flow potential is calculated as 193 km<sup>3</sup> keeping in mind that significant changes may occur every year depending on meteorological conditions. On the other hand, consumable water potential based on current technology and economics is 110 km<sup>3</sup>.

There are 26 hydrologic basins in Turkey. The largest five basins concerning yearly water potential are Euphrates (31.61 km<sup>3</sup>). Keeping water under control or making arrangements for beneficial use of water constitute the object and aim of the projects intended for developing water resources. Development of water resources including the production of electricity has always been considered to be a national policy and the General Directorate of DSI was established in the year 1954 for the execution of projects under the leadership of a governmental institution.

Owing to considerable variations observed in the run-offs in terms of seasons and years, it is necessary on the major rivers in Turkey to have water storage to ensure the use of the water, when it is necessary. Consequently, for these reasons, priority has always been given to the construction of water storage facilities. Significant progress was registered in the construction of dams throughout more than 50 years elapsed since the establishment of DSI.

However, projects which further to their national nature also have an international character owing to water flowing into the lands beyond the national borders often show multipurpose and complex characteristics, as being in the Euphrates River.





## **2.2 Hydropower Potential of Turkey and Needs for the Dam Construction in Turkey**

In order to meet the increasing demand, Turkey showing a rapid social and economic progress must produce, continuous high-quality, reliable and economical electricity by taking into consideration all environmental effects. Development of projects by making use of the energy resources available in Turkey and making necessary investments for this purpose is therefore required. The local energy sources are hydro, mainly in the eastern part of the country, and lignite. Turkey has a large potential for renewable energy sources.

As stressed in the previous sections, for the production of electrical energy, hydroelectric power plants, in comparison with fossil and nuclear fuel thermal, geothermal, and natural gas power plants have two significant advantages as they can be used for peak operation as well as they are renewable. In terms of initial investment cost except for natural gas power plants and some special cases hydroelectric power plants are in a position to compete with other thermal and nuclear power plants. They are the most economically operated power plants causing very little damage to the environment.

### **3. CONCLUSION**

Today, most of the world's large rivers are dammed. The original purposes of dams were to improve human quality of life by providing drinking water and to support economic growth by diverting water for power, navigation, flood control, and irrigation. In addition to the water they provide, dams also provide energy in the form of electrical hydropower which is regarded as a clean, renewable, and reliable energy source.

Dams and the reservoirs they create protects growing populations from the unpredictability and violence of rivers' seasons. In warm regions, stored floodwaters can supply enough irrigation for a year-round growing season. But the adverse effects of river impoundment-disruption of ecosystems, the decline of fish stocks, forced settlements, and water-borne diseases could be listed as the possible negative effects.

To conclude, with respect to regional considerations, the need for development is obvious. The economy is almost entirely oriented to agriculture in the region. The summer drought, being very long and severe, has a negative effect on agricultural production and product variety. In order to reduce the burden of the region on the national economy, agricultural production has to be increased. This can only be achieved with the development of the region's land and water resources.



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