Chapter – 7
Reservoir and Power

7.0 General

The River Ponnaiyar originates from Nandidurg in Karnataka state at an altitude of 900 m above MSL and traverses through Karnataka and Tamil Nadu. In Karnataka it is known as 'Dakshina Pinakini'. The Krishnagiri reservoir was constructed across the Ponnaiyar river near Periyamuthur village about 7 km from Krishnagiri town in Krishnagiri district, Tamil Nadu. The reservoir is one of the earliest projects constructed in post-independence India.

The Ponnaiyar (Nedungal) - Palar intra-state link canal off-takes from the left flank of the existing Nedungal Anicut located across the Ponnaiyar river downstream of Krishnagiri dam. No new reservoir is contemplated under this link project. A link canal of 54.150 km length is proposed for diverting 86 Mm^3 flood waters of Ponnaiyar river to Kal Ar, a tributary of Palar river. A portion of the above water will be utilised to meet en-route demand for stabilisation of existing irrigation and also for drinking water supply. The existing Krishnagiri dam will act as a regulating structure to release the flood water.

The Nedungal Anicut located at 16 km d/s of Krishnagiri dam on the Ponnaiyar river is in operation since 1887-88. The length of the Anicut is about 278 m with its crest level at 434.71 m. Two sets of scouring sluices are located in the body of the Anicut, one at the extreme left end of the Anicut and the other at a distance of about 27 m from the left flank of the river. The catchment area of the Ponnaiyar river upto Nedungal Anicut is 5694 km^2 and the maximum observed flood discharge during 1903 was 3040.66 cumec. The Anicut supplies water to Barur Tank through feeder canal by regulated supply from its head sluice.

Though no new reservoirs or diversion structures are contemplated in the present project proposals, since the flood water (to be diverted through the proposed link canal) are regulated from the existing Krishnagiri reservoir, the brief particulars of the structure are discussed in following paras:

7.1 Fixation of Storage and Reservoir Levels

The Krishnagiri dam was constructed across Ponnaiyar River between Krishnagiri and Dharmapuri towns, during the years 1955 to 1958. The catchment area of the Ponnaiyar river upto Krishnagiri reservoir is 5428 km^2. The length of dam is 990.60 m comprising 712.93 m long earthen dam and 277.67 m masonry dam. The maximum height of Masonry cum earth dam from the deepest foundation level is 29.26 m. The design flood of Krishnagiri dam is 4234 cumec. In the present proposal, the existing Krishnagiri dam is used as a controlling structure for regulating the flood flows/spills to the link canal through Nedungal Anicut. The dam is a medium size storage and distribution structure and regulates the water supply from the Krishnagiri Reservoir to meet the demands of several channels off taking from the Ponnaiyar between the reservoir and the Nedungal Anicut, including the Barur tank system. The dam/reservoir falls under seismic zone-II.

Details of various other controlling levels of Krishnagiri dam are discussed in the following paras:

7.1.1 Full Reservoir Level

The FRL of the dam is 483.11 m. The submergence area at FRL of the dam is 10.723 km^2, with a corresponding storage of 68.20 Mm^3. The FRL is kept unaltered for regulating diversion of flood flows in to the proposed link canal.

7.1.2 Dead Storage Level

The Krishnagiri dam is provided with a spillway (8 gates) along with 3 River sluices and 2 Canal sluices. The Bed level of the river at dam site is 464.63 m. The sill level of the River sluices is 467.26 m and that of canal sluices is 474.73 m. Therefore, the level of 467.26 m is considered as Dead Storage Level (DSL) of the dam.

7.1.3 Minimum Draw Down Level

The Minimum Draw Down Level (MDDL) of the dam for river sluices is at 467.26 m, whereas the same for canal sluices is 474.73 m.

7.1.4 Maximum Water Level (MWL)

The Maximum Water level (MWL) of the dam is at 484.63 m. The submergence area at its MWL is about 15.04 km^2. The top level of the dam is at 487.38 m.

7.1.5 Spillway

The dam has 8 spillway gates of size 12.19m x 6.10m. The spillway is of Ogee type. The capacity of spillway is 4061m^3/sec. The crest level is 477.01 m.

Various controlling levels pertaining to Krishnagiri Dam are given in **Table 7.1.**

Table 7.1

Controlling Levels of the Krishnagiri Dam

Sl. No.	Details	Elevation (m)
1.	River B.L.at Dam site	464.63
2.	River Sluice Sill Level	467.26
3.	Canal Sluice Sill Level	474.73
4.	MDDL/DSL	467.26
5.	Crest level of Spillway	477.01
6.	FRL	483.11
7.	MWL	484.63
8.	Top level of Road way	487.38

***Source**: PWD, WRD, Govt. of Tamil Nadu*

The salient features of Krishnagiri dam and Nedungal Anicut are given at **Annexures 7.1 and 7.2** respectively.

7.2 Water Quality

Public Works Department (PWD), Govt. of Tamil Nadu collects the water samples of Krishnagiri dam during all the months from different points such as from reservoir, seepage water from drainage galleries, toe-drain of earthen section, as per the prescribed procedure for analysis at Soil Mechanics and Research Division, WRO, PWD, Chennai, for both chemical and physio-chemical analysis for ascertaining the water quality status. The latest data for the period from 2009 to 2013 on laboratory test results of the water samples of Krishnagiri reservoir have been collected and the average of results (2009 to 2013) of the samples for the months of October, November and December given in **Table-7.2.**

Table-7.2

Average of Test Results of Water Samples from Krishnagiri Dam

Sl. No	Parameter	Average observed Values			Limits as per IS 10500 - 1991 for drinking and domestic uses
		Oct	Nov	Dec	
1.	pH Value	7.79	7.85	7.86	6.5 to 8.5
2.	Colour (visual)	Colour less	Colour less	Colour less	Colour less
3.	Specific conductivity at 25^0C (Micro mhos/cm)	857	813.5	888.25	-
4.	Bicarbonate alkalinity as $CaCo_3$ (mg/l)	258	246.25	272.5	600
5.	Carbonate alkalinity as $CaCo_3$ (mg/l)	Nil	Nil	Nil	-
6.	Total solids (mg/l)	540	505.25	590.75	-
7.	Total dissolved salts (mg/l)	462.6	439.5	480	500
8.	Suspended soils (mg/l)	77.4	65.75	110.75	-
9.	Total hardness (mg/l)	255	257.5	273.75	600
10.	Calcium hardness(mg/l)	51.2	53	64.5	200
11.	Magnesium hardness (mg/l)	30.48	30	27	-
12.	Sulphates (mg/l)	21.70	21.1	23.04	400
13	Chlorides (mg/l)	151.73	136.48	152.43	1000

It is observed that the pH level of water in Ponnaiyar river ranges between 7.79 to 7.86 during October to December months (North-East Monsoon). The pH level indicates neutral nature of the water and the values are within permissible limits of 6.5 to 8.5 as per IS 10500-1991 specified for drinking and domestic uses. The levels of total dissolved salts in various collected samples are well below the permissible limit of 500 mg/l, i.e., ranging from 439.5 to 480 mg/l during October to December months. It indicates that the water is suitable for drinking and domestic uses. The range of total hardness of the water is from 255 to 273.75 mg/l, which is well below the permissible limit of 600 mg/l specified for drinking and domestic uses. The range of calcium hardness level of the above water samples is from 51.2 to 64.5 mg/l which is well within the permissible limit of 200 mg/l specified for drinking water. The concentration of Sulphate is in the range of 21.1 to

23.04 mg/l which is within the permissible limit of 400 mg/l. The concentration of chlorides also is within the range of 136.48 to 152.43 mg/l which is within the permissible limit of 1000 mg/l as per IS 10500-1991 for drinking water quality standards. The lime content as $CaCO_3$ in the above water samples is well within the permissible limit of 600 mg/l which is ranging from 246.25 to 272.5 mg/l. Though the water is suitable for drinking and domestic uses, it cannot be supplied directly without proper filtration and chlorination. Therefore, water filtration plants with chlorination are required for water purification to make it potable.

As per the test results of water samples from Krishnagiri reservoir the conductivity of water which is less than 1000 micro mhos/cm indicates that the water is 'Excellent to Good-Class-1' for irrigation purpose. The pH is within the limits of 6.5 to 8.5 i.e, neutral nature of water and fit for irrigation use. As the levels of total dissolved salts in various samples collected are well below the permissible limits of less than 700 ppm, the same is 'Excellent to Good-Class-1' for irrigation. The range of Chlorides in the water is less than 175 ppm indicates as 'Excellent to Good-Class-1' for irrigation. Also, the other parameters such as Carbonate/Bi-carbonate alkalinity, total hardness, Calcium/Magnesium/including Sulphates are within the limits for irrigation water. Hence, the divertable water proposed through the link canal is found to be suitable for irrigation purpose.

7.3 Sedimentation

Sediment observation is being carried out by Central Water Commission (CWC) at Gummanur G&D site (C.A: 4620 km^2) and at Valavachchanur G&D site (C.A: 10780 km^2). Since the existing Krishnagiri dam (C.A: 5428 km^2) is proposed as controlling structure to divert the spills of flood flows of Ponnaiyar river, the data on sediment inflow at Gummanur G&D site, located u/s of Krishnagiri dam for the period from 1982-83 to 2012-13 is collected from the Office of the Executive Engineer, SR Division, CWC, Coimbatore, Tamil Nadu. As per the sediment data collected, the average annual sediment inflow rate in to the reservoir works out to 67222 M.T, of which 65343 M.T is during the monsoon period. The data on sediment inflow at Gummanur G&D site for the period from 1982-83 to 2012-13 is furnished at **Table-5.3** in **Chapter-5 'Hydrology and Water Assessment'.**

From the above data, the average annual sediment inflow at Gummanur works out to 14.55 MT/sq km.

The Krishnagiri dam is existing since 1958 and is in operation now for more than 50 years and continues to serve the purpose in the region successfully. The sedimentation studies (4th Capacity Survey) of Krishnagiri reservoir were carried out by the Institute of Hydraulics and Hydrology (I.H.H), Poondi, PWD, WRO, Govt. of Tamil Nadu during 2006. As per the I.H.H Report No.2/2007, it has been concluded that the average annual loss in Krishnagiri Reservoir capacity is at the rate of 0.5816 Mm^3, indicating 41.79% of loss in capacity over a period of 49 years since 1957. Based on these sedimentation studies, the present annual average silting rate in percentage was given as 0.85. The same were 1.36, 1.24 and 1.18 vide earlier sedimentation surveys conducted during 1976, 1981 and 1983 respectively, which reveals a declining trend in siltation which is not as much as that in the beginning. Also, the I.H.H, Poondi, mentioned that the trap efficiency is 88% and the probable useful future life of Krishnagiri reservoir is 101 years.

7.4 Life of Reservoir

The Krishnagiri dam and reservoir have been designed for a life period of 100 years. It is operational since 1958, and serving the designed purposes successfully.

7.5 Capacities

The Krishnagiri dam is a medium size storage and distribution structure with a gross storage capacity of 47.184 Mm^3 at FRL 483.11 m. The capacity of reservoir at MWL 484.63 m is 68.20 Mm^3.

7.6 Area of Submergence (ha)

The water spread area of Krishnagiri reservoir at FRL and MWL are 10.723 km^2 and 15.04 km^2 respectively.

The Elevation-Area-Capacity values of the existing Krishnagiri dam, as in the year 1983 are furnished in **Table 7.3.**

Table 7.3

Elevation – Area-Capacity Table of Krishnagiri Dam

Level(m)	Area(km^2)	Capacity (Mm^3)	Remarks
470.9	0.059	0.000	
472.1	0.223	0.112	
472.7	0.435	0.288	
473.4	0.700	0.620	
474.0	1.018	1.108	
474.6	1.364	1.835	
475.2	1.714	2.783	
475.8	2.085	3.957	
476.4	2.525	5.336	
477.0	2.947	6.991	477.01 Crest Level
477.6	3.358	8.961	
478.2	3.910	11.231	
478.8	4.654	13.839	
479.5	5.630	16.905	
480.1	6.522	20.617	
480.7	7.367	24.922	
481.3	8.153	29.749	
481.9	8.938	35.058	
482.5	9.754	40.826	
483.1	10.723	47.184	FRL
484.63	15.040	68.200	MWL

Source: *Upper Ponnaiyar Division, WRO, Tamil Nadu PWD, Dharmapuri.*

The Elevation – Area - Capacity curves of Krishnagiri reservoir are presented in **Fig.-5.12** under **para 5.9.3.2 of Chapter-5 'Hydrology and Water Assessment'.**

7.7 Flood Absorption/Reservoir Operation Policy

While the crest level of the spillway is at 477.01 m and FRL is at 483.11 m, the flood absorption upto a reservoir level of 481.56 m (1580') is created. As soon as the

reservoir level reaches 1.55 m below FRL, 'the state of extraordinary emergency of flood situation' shall be declared by the Krishnagiri dam controlling officer.

As per the Rules and Regulations and Flood Rules for Krishnagiri Reservoir Project vide Authority No: G.O.Ms No.1733, P.W.D, Govt. of Tamil Nadu (Appendix-N), dated 22.08.1984, the limits for impounding the Krishnagiri reservoir during the floods are furnished as follows:

1. Upto 481.56 m (1580') : Without any limit in rise of water
2. Above 481.56 m (1580') Upto 482.78 m (1584') : Not exceeding 60 cm (2') per day
3. Above 482.78 m (1584') Upto 483.11 m (1585') : Not exceeding 30 cm (1') per day
4. When the reservoir level is above the crest of the spillway, the spillway gates alone should be operated to pass down the required discharge into the river. The operation of river sluices on such occasions should be done only in case when it is not possible to send down the required discharge through spillway.
5. If the water level of the reservoir is at 481.56m (1580') and the rate of rise increases to 15cm (1/2') per hour, the flood discharge to be regulated till the reservoir level remain stationery at 481.56m(1580') or the flood warning is called off.
6. If the reservoir level shows a tendency to rise above 481.56m(1580') and the inflows is of the order of 420 cumec (15000cusec) and more or the rate of rise is more than 15cm (1/2') in 6 hours, the flood discharges needs to be regulated till the level falls to 481.56m (1580') or the flood warning is called off.

7.8 Power

Since the diversion of water into the Ponnaiyar -Palar link canal is proposed from the existing Nedungal Anicut with minimum driving head and also since no canal falls are located along the link canal alignment, hydro power generation though canal power house is not possible. However, in line with the latest initiatives from Ministry of New and Renewable Energy, an attempt has been made to explore the possibility of installing Grid connected Solar PV power plants on canal top/banks along the proposed Ponnaiyar - Palar link canal.

7.8.1 World's First Canal Top Solar Power Plant

It is learnt that the world's first and only canal top solar power plant is installed in Gujarat on Narmada Canal as a pilot project by M/s Sun Edison Energy India Pvt. Ltd., Chennai. Another such pilot project is presently being installed on Almatti Right Bank Canal in Karnataka by the same company.

In case of Narmada Canal, 16 m wide panel trusses were erected over 10 m wide canal over a length of 750 m for an installed capacity of 1 MW.

On the Almatti Right Bank Canal, the top width is 9.40 m and the solar panels are erected over a stretch of 2.8 km for an installed capacity of 1 MW.

7.8.2 Canal Top Solar Power (PV) Generation - Ponnaiyar - Palar Link Canal

With a view to assess the possibility of installing canal top Solar Power Plant on the Ponnaiyar - Palar link canal, preliminary enquiries are made with M/s Sun Edison Energy India Pvt. Ltd., Chennai. It is ascertained that the canal top Solar panels could be installed for a maximum width of 25 m (The designed bed width of the Ponnaiyar - Palar link canal is 25 m). For achieving maximum efficiency it is preferable that the canal runs in north south direction in balanced section. It is seen that in case of Ponnaiyar - Palar link, out of 54.15 km length about 10 km length of canal runs in north-south direction if $\pm 15^0$ deviation from north is considered. However, considering only those reaches of canal with balanced section, the length of canal conducive for solar power generation will be even less. Further, it is also learnt that the total cost of installation of 1 MW capacity canal top solar power (PV) plant would be around Rs.10 crore. The comparative capital cost per 1 MW capacity and maximum total tariff per unit for different types of generating plants are given below in **Table 7.4**.

Table-7.4

Capital Cost and Tariff for Different Types of Power Generating Plants

Sl. No.	Type of power generation	Capital cost in Rs. Crore/ MW	Maximum tariff in Rs. per unit *
1	Coal based plant	3.8 to 4.0	5.29
2	Gas based plant	3.5	3.99 to 4.52
3	Hydropower plant	5.0	5.77
4	Wind power plant	5.6	6.00
5	Solar (PV) power Plant**	10.0	7.72
6	Nuclear power Plant	6.0	3.41

** Reply to unstarred question No. 5072 in Loksabha on 13.08.2014.*

*** M/s SunEdison Energy India Pvt. Ltd., Chennai.*

Even with prevailing Government subsidies, due to low efficiencies (with currently available technology) in the range of 10% to 17%, the Solar Power (PV) generation is yet to attain economic viability, even without cost of land (for canal top power plants).

In view of above, it is proposed to take up power potential study for canal top solar power (PV) generation on Ponnaiyar - Palar link canal at pre-construction stage.

7.8.3 Advantages and Limitations of Solar Power (PV) Generation

The relative advantages and limitations of solar power (PV) generation are enumerated as below.

A. Advantages

- It is an abundant Renewable Energy
- This technology is Omnipresent and it can be captured for conversion on a daily basis.
- It is a Non-polluting technology, which does not release green house gases.
- It is a Noiseless technology as there are no moving parts involved in energy generation.
- This technology requires Low-maintenance because of lack of moving parts.
- It can be installed on modular basis and expanded over a period of time.
- Most viable alternative for providing electricity in remote rural areas as it can be installed where the energy demand is high and can be expanded on modular basis.

B. Limitations

- As the technology is in an evolving stage, the efficiency levels of conversion from light to electricity is in the range of 10 to 17%, depending on the technology used.
- The initial investment cost of this technology is high. At present the technology is basically surviving because of subsidy schemes available by the government.
- Solar energy is available only during daytime. Most load profiles indicate peak load in the evening/night time. This necessitates expensive storage devices like battery, which need to be replaced every 3 to 5 years. Generally, the cost of the Battery is 30 to 40% of the system cost.
- As the efficiency levels are low, the space required is relatively high. For instance, with the existing levels of technologies, the land required for putting up a 1 MW solar PV power plant is between 6 to 9 acres (2.5 to 3.5 ha). However, research is going on to increase the efficiency levels of the cell.
- Solar energy is heavily dependent on atmospheric conditions.
- Solar insolation varies from location to location, so there are certain geographic limitations in generating solar power.
- With the existing module and inverter manufacturing technologies, it may not be worthwhile in terms of costs to deploy solar energy for certain loads which require very high starting power (e.g. air conditioners).