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Water Use and Efficiency in THERMAL POWER PLANTS

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This report is a product of FICCI Water Mission's interaction with the members of the Power Committee and case studies submitted to the Mission.

This compendium of case studies of water usage and management in the power sector is published under the auspices of the 'FICCI-HSBC Knowledge Initiative'. Executed by FICCI and sponsored by HSBC, the Knowledge Initiative of the Water Mission is an attempt by FICCI and HSBC to highlight best practices in water usage across key water intensive sectors within Indian industry such as power, agriculture, steel, chemicals, cement, etc.

Content

Foreword

Water is fast becoming a scarce commodity. According to a recent estimate by the International Food Policy Research Institute (IFPRI) and Veolia, around 36% of the world's population is already living in water-scarce regions. Looking forward to 2050, around 52% of the world's population, producing 45% of its GDP, is expected to be living in such regions.

Among the G-20 nations, emerging economies such as Saudi Arabia, South Africa, South Korea and India face the largest water stress. In one of HSBC's reports entitled Scoring Climate Change Risk, 9 August 2011, we identified India as the most vulnerable nation to climate change among the G-20. India, once a water abundant country, with per capita water availability of around 4,100 m^3/capita/year (1960) has now turned 'water stressed' with per capita water availability poised at a meagre 1580 m^3/capita/year (2009). Given a highly uneven distribution of water resources between its eastern and western halves, the national average therefore masks acute shortage of water in various states across the country.

Among various sectors, power generation depends heavily on water and is one of the largest consumers of water. It therefore comes as no surprise that water shortages are increasingly causing power generation losses. The impact of water shortages on the power sector was clearly visible in the 2010 summer, when not only hydro capacity but also over 6,400MW of thermal capacity was adversely affected by water shortages. A joint analysis by World Resource Institute (WRI) and HSBC presented in a report entitled Over Heating, April 2010 suggests that 79% of the new generation capacity to be built by three key power generation companies in India is located in water scarce or stressed areas.

Businesses and investors across the world are fast awakening to the reality of water scarcity and its potential to jeopardize economic growth. Increasing significance of water for industry is reflected in a sudden jump in institutional investors' interest in the Global Water Disclosure Project initiative.

This study by FICCI on Water Use and Efficiency in Thermal Power Plants is therefore important in highlighting some of the best industry practices and examples for water conservation in thermal power plants.

Naina Lal Kidwai
Senior Vice President, FICCI
& Country Head, HSBC India

Message

The thermal power sector accounts for 65 per cent of the total power generated in India. Thermal power plants (TPPs) will play a crucial role in meeting the energy requirements in future with the per capita electricity consumption expected to reach 1,895 Kwh in 2030.

Water is a key component in TPPs and is required for multiple processes. It is used for ash handling, cooling tower, drinking and domestic use and for service uses like fire fighting, cleaning etc. It is said that the thermal power sector accounts for the highest share of freshwater use in the industrial sector.

Over the past few decades, there has been a decline in freshwater water availability for TPPs. There is also a growing realisation amongst the plant owners to conserve water and minimise the use of freshwater through water harvesting, wastewater treatment and reuse.

FICCI Power Committee has identified water conservation as an important area of work. Member industries of the committee have undertaken water conservation measures in their organisations. While the scale and nature of work may vary amongst different companies, it is true that Indian power companies are seriously taking steps to reduce their water footprint.

The publication 'Water Use and Efficiency on Thermal Power Plants' is an attempt to highlight some of the efforts of Indian companies in the area of water management. The case studies documented in the publication depict a variety of measures various power companies have undertaken. These range from desalination, rainwater harvesting, wastewater treatment, optimising ash-water ratio and introduction of less water intensive technology. Power companies are committed to reducing their freshwater intake thereby contributing to the cause of environmental protection.

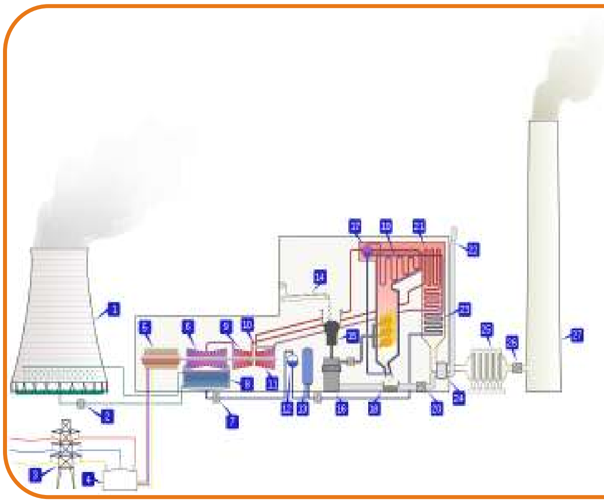
I hope that the publication will serve as a valuable resource and would enable sharing of best practices within the thermal power sector.

RS Sharma
Chair - FICCI Power Committee
& MD, Jindal Power Limited

Introduction

With 3.4 per cent of global energy consumption, India is the sixth largest energy consumer in the world[1]. Experiencing an average growth rate of 3.6 per cent in the past few decades, the country's total demand for electricity is likely to cross 950,000 MW by 2030[2]. The annual per capita consumption of power is expected to grow from 704.2 Kwh in 2008 to 1,000 Kwh by 2012 and 75 per cent of the total planned power capacity expansion is projected to come from thermal power. Of the total power generation in the country, 65 per cent is from coal fired thermal power plants[3].

The major component of a thermal power plant includes the power system (power source, turbine, generator etc) and associated facilities such as cooling system, stack gas cleaning equipment, fuel handling areas, fuel delivery systems, solid waste management areas and others. A typical schematic diagram of the thermal power plant is given in Figure 1.



1. Cooling tower
2. Cooling water pump
3. transmission line (3-phase)
4. Step-up transformer (3-phase)
5. Electrical generator (3-phase)
6. Low pressure steam turbine
7. Condensate pump
8. Surface condenser
9. Intermediate pressure steam turbine
10. Steam Control valve
11. High pressure steam turbine
12. Deaerator
13. Feedwater heater
14. Coal conveyor
15. Coal hopper
16. Coal pulverizer
17. Boiler steam drum
18. Bottom ash hopper
19. Superheater
20. Forced draught (draft) fan
21. Reheater
22. Combustion air intake
23. Economiser
24. Air preheater
25. Precipitator
26. Induced draught (draft) fan
27. Flue gas stack

Figure 1: Schematic diagram of thermal power plant[1]

There lies a close nexus between water and energy in the production cycle. Water is used in energy production and supply, and in turn energy is used for pumping, moving and treating water. Freshwater is required for energy extraction and production, refining and processing, transportation and storage and generation of electric power itself. With increasing water scarcity, the power sector too is faced with dwindling supplies of freshwater and increasing costs of water on the one hand, and increasing pollution of water sources on the other.

[1] http://en.wikipedia.org/wiki/Electricity_sector_in_India
[2] The Integrated Energy Policy, Govt. of India
[3] www.indiapower.org - accessed on June 30, 2011

Water Use in Thermal Power Plants

The water use in TPPs can be majorly classified into the following types depending upon the quality of water and end use considerations:

- **Cooling Tower Water:** water used in the cooling towers.
- **Make-up Water:** water used to compensate the loss due to evaporation of water in the cooling tower.
- **Demineralised Water (DM water):** water used in the boilers for generating steam is demineralised. DM Water comes at a higher cost as compared to cooling tower water and its use is limited for specific function.
- **Ash Handling Water:** water used for handling ash generated during the combustion process into slurry for disposal. It is ideal to use treated water for ash handling and coal dust suppression.
- **Service Water:** water used for processes like coal dust suppression, fire fighting measures, use in toilets and other utilities, plantation and greening activities. It is ideal to use treated water instead of freshwater for these purposes
- **Potable Water:** water used for drinking water for the plant and the colony is known as potable water.

The main source of water for Indian TPPs is surface water sources through rivers, canals and ponds while in some cases groundwater sources are also used to meet the water requirements of the TPP. The cooling water system may either be a direct cooling system for condenser i.e without cooling towers where a substantial quantity of water is returned back to the source, or an indirect cooling system with cooling towers which are a part of a closed circuit system and in which case only the make-up water drawn from the source becomes consumptive.

A typical water balance for a 660 MW coal based plant is shown in Figure 2. As seen, around 56 percent of the water goes in evaporation and unaccounted loss while ash handling takes the remaining share of water. There is some amount of water used for the drinking water purposes. However, this constitutes a small portion of the total water use.

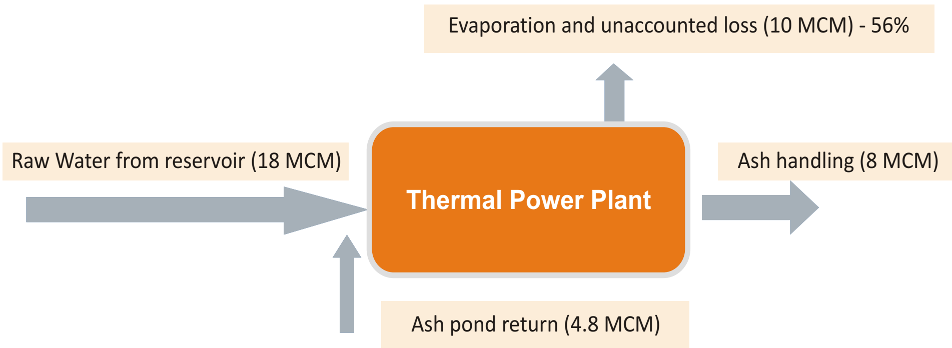


Figure 2: Water balance of a coal based power plant

A study by NGO, Centre for Science and Environment has estimated the volume of water used in TPPs to the tune of 35,157.4 million cubic metres (MCM) annually which constitute 87.8 per cent of the total industrial water use. The same study using the Central Pollution Control Board (CPCB) data has observed that the total wastewater discharged by all major industrial sources is 83,048 million litres per day (mld). This includes 66,700 mld of cooling water discharged by TPPs. Out of the remaining 16,348 mld of wastewater, TPPs generates another 7,275 mld as boiler blow down water and overflow from ash pond.[4]

The figures of water use in TPPs have been computed using the specific water consumption which is the key indicator for comparing and assessing the performance of different thermal power stations. The specific water consumption is generally expressed as m^3/MW or litre/kWh. Table 1 below gives the specific water consumption for different power plants.

Table 1: Specific water consumption of power plants

Power plant type	Range m^3*/MW
Gas based power plants	1.7 - 2.0
200 MW coal based thermal power plants	4.5 - 5.0
660 MW coal based thermal power plants	4.0 - 4.5
200 MW coal based power plants with ash water recycling	3.5 - 4.0
660 MW coal based super thermal power plants with ash water recycling	3.0 - 4.0
110 MW coal based old power plants	7.0 - 8.0

*1 M^3 = 1000 litres
Data Source: The Bulletin on Energy Efficiency, 2006, Volume 7, Issue 3

[4] Industrial Water Use, Down to Earth, 2004

As observed the specific water consumption figures vary from 1.7 to 8.0 m^3/MW. This is mainly due to the variation in size, age and the type of the plant (either coal based or gas based), type of water circulation (once through system or cooling tower based), dry ash handling system or wet ash handling system, provision for ash water recycling, etc.

The specific water consumption in a coal based thermal power plant used in various processes is given in Table 2. Ash handling requires the maximum volume of water (40 per cent) followed by the cooling towers which take up 30 per cent of the water use. The gas based thermal power plants will have maximum water consumption in the cooling towers.

Table 2: Water use for specific purposes

Area	Consumption m^3/MW	Water use (%)
Ash handling	2.0	41.4
Cooling towers	1.5	30.4
DM water	0.13	2.6
Drinking water	0.32	6.3
Coal handling	0.065	1.3
Fire fighting	0.37	4.7
Others	0.66	13.2
Total	**5**	**100**

Data Source: The Bulletin on Energy Efficiency, 2006, Volume 7, Issue 3

Future water demand

The increasing demand for electricity in the country will essentially be met from the thermal power plants. Projections on water demand by the power sector by the standing sub-committee of Ministry of Water Resources (MoWR), Government of India and the National Commission on Integrated Water Resources Development (NCIWRD) indicate manifold rise in water demand by the power sector. While the standing sub-committee of MoWR indicate a enormous increase of thirty times in the volume of water used in 2050 from the 2010 levels, the NCIWRD indicate a gradual increase in water demand from 19 BCM in 2010 to 33 BCM and 70 BCM in 2025 and 2050 respectively (See Figure 3).

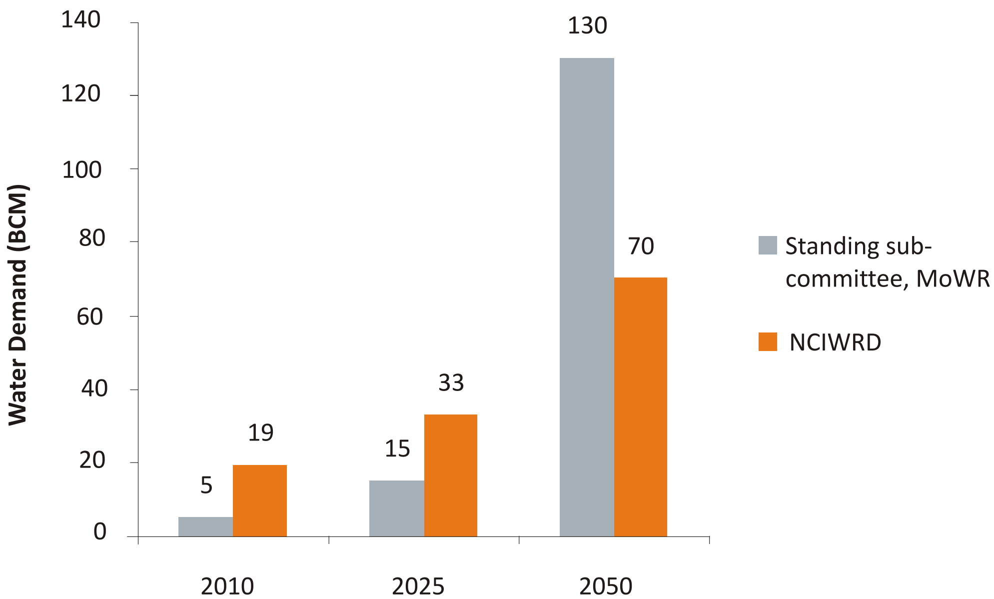


Figure 3: Water demand for power sector

Data Source: Report of the Steering Committee on Water Resources for XI Five Year Plan

The NCIWRD has used a water requirement norm of 0.001 BCM/100 MW based on estimates collected from various sources for thermal power. On the basis of this calculation projections have been made about the water required for India's power generation capacities. The findings have been enumerated below (See Table 3).

Table 3: Water required for power development

	2010		2025		2050	
Category	Low (Economic Growth)	High (Economic Growth)	Low (Economic	High (Economic	Low (Economic	High (Economic
Thermal	2.81	3.43	7.85	9.59	28.71	35.07
Hydropower	15.00	15.00	22.00	22.00	30.00	30.00
Nuclear	0.29	0.36	1.13	1.38	3.68	4.50
Solar / Wind	0.00	0.00	0.01	0.01	0.04	0.04
Gas Based	0.02	0.02	0.06	0.07	0.18	0.22
Total	18.10	18.80	31.10	33.10	62.60	69.80

Data Source: Phansalkar Sanjiv and Verma Shilp; India's Water Future 2050: Potential Deviations from Business as Usual, International Journal of Rural Management (2007) 3: 14

Water conservation in thermal power plants

The use of high volumes of water in the thermal power plants necessitates undertaking water conservation measures. A precursor to undertaking these is a systematic water audit and quantifying water flows at each pumping station and drawing up a water balance. Water audits will help in quantifying the inflows and outflows, the losses or wastage which can be optimised by taking appropriate water conservation measures. The following measures can be undertaken for conserving water in thermal power plants:

a. **Increasing cycles of concentration:** Maximum water loss in the thermal power plants occurs in the cooling towers, in the form of evaporation. Make up water is provided to compensate for this evaporation loss, the blow down losses and drift losses. There is a requirement of 135 m^3/hr cooling water flow to the condenser to generate 1 MW. The expected evaporation ratio for every 1 MW of power generation is 2.0 m^3/hr. Since the water is circulated many times in the closed loop, the concentration of dissolved solids increases over a period of time. The cycles of concentration (COC) is the ratio of dissolved solids in the circulating water to the make-up water. Cooling towers are normally designed for a COC of around 5. By increasing COC, the blow down quantity can be reduced by external water treatment and adding water treatment chemicals, COC of even 10 can be reached. Increasing COC can result in significant saving of water in TPPs.

b. **Optimising ash-water ratio**: Around 45-50 per cent of the total water use is consumed in ash handling. Using the condenser outlet water instead of freshwater reduces the intake of freshwater. Bottom ash and fly ash is flushed by high pressure water while low pressure water is used for ash hopper filling. Bottom ash and fly ash can be handled separately or together by mixing in a common pit. The ash slurry is then evacuated by a series of ash slurry disposal pumps to an ash dyke. Typical design ash water ratios are around 1:5 for fly ash and 1:8 for bottom ash. However, the actual combined ash water ratios are found to be around1:20 or even more. For every percent reduction of ash water ratio, there is a saving potential of 60 m^3/hr of water.

c. **Recycling ash water from the ash dyke:** Once the ash gets settled in the dykes, the decanted water can be recycled and re-used for ash handling purpose after minor treatment.

d. **Using air cooled condensers:** in water scarce areas. A typical 660 MW unit requires approx 18 MCM of water per year with water cooled condenser. This requirement can be brought down to only 3 MCM with air cooled condenser. However, there is a corresponding 12 per cent increase in capital costs in using air cooled condenser. There are two types of air cooled condenser are available based on means of draft creation - mechanical and natural draft air cooled condenser.

e. **Reducing leaks and over flows:** Leakages from valves, taps, fire fighting hoses, underground fire fighting lines, cooling tower basin, gardening hoses area also a source of water loss. Overflows from cooling towers of AC plants, and overhead tanks due to non-functioning of float systems are also a common feature in thermal power plants. There lies a possibility of reducing the water consumption by plugging the leakages

f. **Wastewater recycling:** Studies across various power plants have indicated a high per capita availability of water, sometimes even in the range of 600-700 litres per capita per day. This is much higher than the WHO norm of 110 litres per capita per day. A 25 per cent reduction in the running hours for the water pumps will reduce the overuse of water. The pumps also operate at lower efficiencies as compared to their design values. The corresponding problem with overuse of water lies in the high amount of wastewater generated. The installation of wastewater treatment plants will enable recycling 60-80 per cent of the wastewater generated which can be used for purposes like gardening, green belt development, dust suppression and fire fighting.

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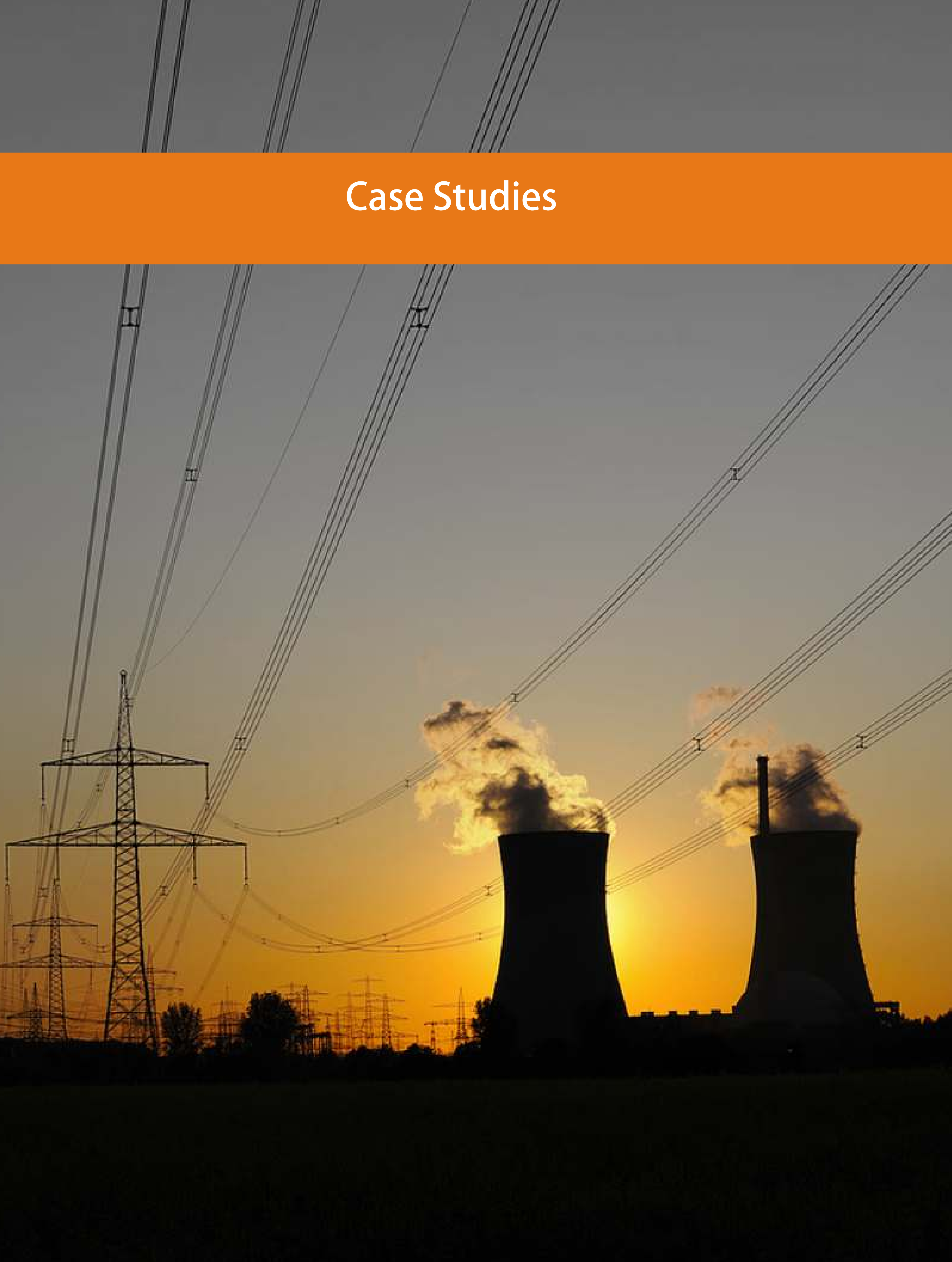
http://www.energymanagertraining.com/Journal/05102007/WaterBalanceandWaterConservationin ThermalPowerStations.pdf - last accessed on July 31, 2011

The Bulletin on Energy Efficiency, Volume 7, Issue 3, December 2006

Technical EIA Guidance Manual for Thermal Power Plants, MoEF, 2009

Case Studies



Case Study 1: Adani Power Limited

Location and capacity:

Adani Power Limited is setting up the largest power plant at single location in India with a total capacity of 4620 MW (4x330 MW + 5 x660 MW) in Tunda village, Mundra block of Kutchh district. The power plant is coming up in three phases -

- Phase I (2x330 MW)
  Unit # I (330 MW) & Unit # II (330 MW): Commissioned
- Phase II (2x330 MW+2x660 MW)
  Unit # III & IV (330 MW each) Commissioned
  Unit # V (660 MW) Commissioned
  Unit # VI (660 MW) in Commissioning Stage
- Phase III (3x660 MW) are in erection stage.

Volume of water used:

Plant capacity	Water use - Condenser Cooling (Sea Water) make up	Water use - Boiler make up (DM water)	Total water use (m^3/Hr)
4x330 MW	4 * 2500 m^3/Hr	4 * 25 m^3/Hr	10,100
2x 660 MW	2* 4304 m^3/Hr	2* 40 m^3/Hr	8,688
3x 660MW	3 * 4601 m^3/Hr	3 * 40 m^3/Hr	13,923
			32,711

The total volume of water used is 32,711 m^3/Hr.

Water efficiency and conservation measures:

The following water conservation measures have been undertaken by Adani Power Limited in the 4x330 MW & 2x660 MW units of the power plant:

- Construction of effluent treatment plants (ETP): The effluent from 4x330 MW unit is being diverted to 2x660 MW units ETP having a capacity of 50 m^3/Hr. Effluents form the floor washing area, boiler area and boiler blown down water is treated at the ETP and the treated water is used for gardening and plantation.

- Secondary Reverse Osmosis (RO) Plant (DM Plant- phase II) has been set up for Units 2 * 660 MW: This has helped to meet the DM requirements for the plant saving significant volumes of water. The reject water from the RO is diverted for water sprinkling on roads and coal stack yard. The volume of secondary RO reject water generation is to the tune of 30 m^3/Hr and the TDS of RO reject water is normally 1500 mg/l.
- Sewage Treatment Plant (STP) for Units 4* 330 MW & 2 * 660 MW: The capacity of the STP is of the order 8 m^3/Hr and the treated water is used for horticulture.
- Coal run off treatment plant has been set up for the 2* 660 MW plant having a capacity of 10 m^3/Hr. Treated water from the plant is to be used for sprinkling in coal stockyards and roads.

Volume of water saved:

The above measures have resulted in saving significant amount of the water in the units. The breakups of savings is given below:

System description	Quantity of water saved in KL/Annum
Effluent Treatment Plant(ETP) for Units 2 * 660 MW	4,00,000
Secondary RO Plant for Units 2 * 660 MW	2,40,000
Sewage treatment Plant for Units 4* 330 MW and 2 * 660 MW	64,000
Coal run off treatment Plant for 2 * 660 MW	80,000
Total	**7,84,000**

The following water conservation measures are proposed to be undertaken for the 3*660 MW Units which will be undertaken in the coming months. These will further add to the savings.

Proposed systems	Quantity of water saved in KL/Annum (anticipated)
Effluent Treatment Plant(ETP) with a plant capacity of 50 m^3/Hr	4,00,000
Secondary RO Plant (DM Plant- phase III)	2,40,000
Sewage Treatment Plant having a capacity of 08 m^3/Hr.	64,000
Coal run off treatment Plant having a capacity: 10 m^3/Hr	80,000
Total	**7,84,000**

With the implementation of the proposed measures listed above and the ongoing measures the plant envisages a total saving of 15.68 lac KL per annum resulting in financial savings to the tune INR 31.36 lacs (See table below)

Total volume of water and costs saved:

Measure undertaken	Quantity of water saved (including the ongoing and proposed measures) KL/annum	Costs saved in lacs (INR)
Effluent Treatment Plant (ETP)	8,00,000	16.00
Secondary RO Plant	4,80,000	9.60
Sewage Treatment Plant	1,28,000	2.56
Coal run off Treatment Plant	1,60,000	3.20
Total	15,68,000	31.36

Case Study 2: Essar Power Limited

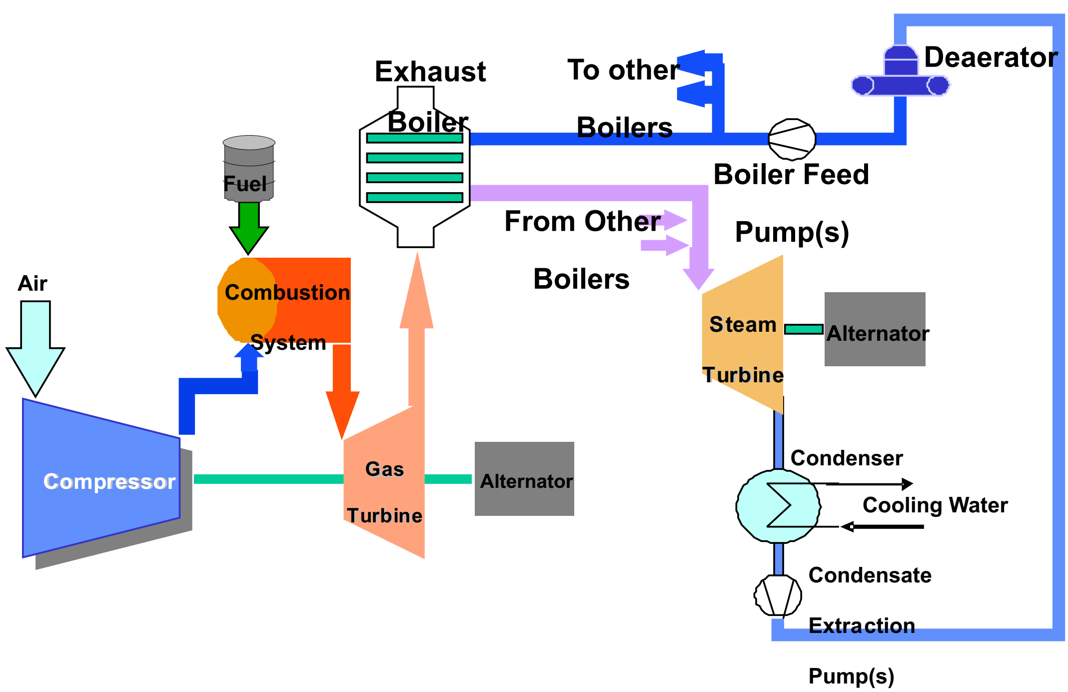
Location and capacity:

Essar Power has a thermal power plant located in Hazira in Surat district of Gujarat. Commissioned in 1997, it has a capacity of 515 MW and is the country's first multi-fuel plant, operating simultaneously on naphtha and gas. Of the 515 MW of power generated, 215MW is captive to the Essar steel plant and 300MW is supplied to Gujarat Urja Vikas Nigam.

Process detail:

Natural gas and or naphtha are used as fuel for the plant. The fuel is taken inside the combustion chamber and is expanded in the gas turbine. The gas turbine rotates at 3,000 rpm and is directly coupled to the generator through which electricity is generated.

The exhaust gas from the gas turbine can be released either in the atmosphere (during the open cycle mode) or its heat is recovered in HRSG to generate steam (combine cycle mode). The steam is fed into the steam turbine which in turn generates electricity. The steam expanded in stages of the steam turbine goes to the condenser and gets condensed with the help of cooling tower. The condensate is extracted and fed back to HRSG. This cycle is repeated periodically. The process flow diagram is shown below:



Water use and wastewater generated:

- Total raw water in-take to the power plant - 38.6 lacs m^3/annum
- Total wastewater generated - 13.52 lacs m^3/annum
- Volume of wastewater treated and re-used - 11.56 lacs m^3/annum (85 per cent of total wastewater is being recycled and reused)

Water efficiency and conservation measures:

Essar Power has undertaken the following water conservation measures in its Hazira Plant:

- Increased cooling tower Cycles of Concentration (COC): Condenser is used to cool steam from steam turbine exhaust through cooling tower water. Circulation rate of cooling tower is 39,000 m^3/hr. Cooling water circuit was earlier operated at an average COC of 3.68. The COC is controlled by stainless steel tubes (comprising 5 per cent of total numbers of tubes and remaining 95 per cent are made up of brass) inside the condenser. It is well known that chloride ion concentration has a direct impact on stainless steel as it leads to corrosion. Based on the COC of 3.68, cooling tower blow down water was 205 m^3/hr. Several options were studied and based on a detailed analysis study, it was decided to replace the existing stainless steel tubes with Cu-Ni material of construction (MOC). This has resulted in operating the cooling water system with average of 5 COC and has enabled major savings in terms of water use and dozing chemicals. The condenser tube MOC was changed at a total cost in Rs 62.5 lacs and the payback period for the project was less than a year.
- Cooling tower blow down water is recovered and reused as make- up water for the steel plant and for horticulture and plantation in the township. This project attracted an investment of Rs. 35 lacs and yielded significant savings in terms of water use for the steel plant, around 80 per cent less use of chemical (acid) dosing. During the last year around 72,550 m^3 cooling water blow down water has been effectively re-used at Essar township for gardening and horticulture.
- Use of Pressure Sand Filters (PSF) and softeners for back wash water recovery. The wastewater generated from the PSF and Softener back wash is collected in back wash water recovery pit and is pumped to the raw water sump through the clarifiers. This back wash water is able to substitute for 2-3 per cent of total raw water intake. The pits were constructed at a total cost of Rs. 20 lacs.


- Construction of swale for purification of wastewater and using it for watering. The waste water generated from the plant process is diverted to a channel with gravel and sand bed (swale). This water is passed through multi-grade filtration media and filtered water is used as plant horticulture water. The company has planted 6,700 plants and no fresh water is used for watering the plantation.
- Recycle of clarifiers sludge and recovery of water through thickener. Based on the quality test report of sludge and water and no presence of heavy metals, re-use of sludge and water is practiced. Thickener is installed to extract water out of sludge. Remaining sludge is used as a top soil for plant horticulture.

Volume of water and costs saved:

System Description	Investment made in lacs (INR)	Qty of water saved in KL/annum	Cost saving lacs (INR)*
Cooling tower blow down water utilization in HBI and township horticulture	60	644,000	96.6
Pressure Sand Filters (PSF) and Sand Filters (SF) back wash water recovery	20	349,000	52.3
Swale water utilization for horticulture	9	22,000	3.3
Thickener water recycle	35	105,000	15.7
Cooling tower cycle of concentration increase	62.5	381,000	57.1
Total	**186.5**	**1,501, 000**	**225**

*cost of freshwater is approx Rs. 15 per KL

Future plans:

Installations of a Reverse Osmosis (RO) plant of capacity 120 m^3/hr with 75 per cent permeate recovery for treating cooling tower blow down water. Once the RO plant becomes operational (slated for September 2011) Essar Power Plant will almost be a Zero Discharge Company.
There are plans to feed Reverse Osmosis (RO) permeate water to the DM plant to increase the efficiency of DM plant operations. The resulting water and cost savings will be:

Volume of water and costs saved:

System Description	Qty of water saved in KL/annum	Cost saving in lacs (INR)
Water recovery and reuse with Reverse Osmosis process	629,625	94.44
Total	**629,625**	**94.44**

Case Study 3: Jindal Power Limited

Location and capacity:

Jindal Power Limited's power plant located in Tamnar village in Raigarh district is a coal based plant with a capacity of 1,000 MW.

Water used and wastewater generated:

- Volume of water used - The total requirement of water is approx 55,634 KL per day and the breakup of water use is given below

Area	Water Use
Cooling tower make up water	52,553 KLD
Demineralised water	1,145 KLD
Potable water	1,500 KLD
Service water	436 KLD
Total	**55,634 KLD**

- Amount of wastewater generated and recycled

  The power plant generates wastewater to the tune of 2,680 KL per day. This entire volume of wastewater (Approx 2,500 KL) is used for ash slurry preparation and the remaining 180 KL is used for watering plantations around the power plant after treatment.

Water efficiency and conservation measures:

- Construction of ponds for treating wastewater used for ash handling plant – Jindal Power has constructed two ponds which act as equalization and settling ponds. Wastewater/ effluent generated from the DM plant, cooling tower blow down, boiler blow down, service runoff is collected in these ponds and is treated through setting of solid particles and ultimately discharged to treated ash water pond.

  Water from treated ash water pond is sent to ash handling plant where it is used for ash slurry preparation. Ash slurry is sent to two ash dykes located outside the premises through ash slurry pipeline and the decanted ash water from ash dyke is recycled back to the treated ash water pond for further ash slurry preparation.

- Setting up sewage treatment plant (STP): The wastewater generated from the residential areas is treated in STP of 400KL per day capacity and thereafter the treated water is used for green belt development.

Volume of water and costs saved:

System description	Qty of water saved KL/ annum	Costs saved in INR
Treatment of water is ponds and used for ash slurry	900,000	90,000
Wastewater recycling through sewage treatment plant and its use in green belt development**	65,000	3,250
Total	**965,000**	**93,250**

**cost calculated by using the price for disposal of domestic wastewater which is 5 paisa per KL as per the provisions of Water (Prevention and Control of Pollution) Cess Rules*

*** cost calculated by using the price for disposal of domestic wastewater which is 5 paisa per KL as per the provisions of Water (Prevention and Control of Pollution) Cess Rules*

Future plans:

- A sewage treatment plant having a capacity of 400 KL per day is being installed at Sakti Vihar - II for the 2,400 MW plant for of domestic waste.
- A 2,500 KL per day capacity sewage treatment plant will be set up at Urjanagar Colony to fully treat the domestic wastewater and move towards zero discharge.

Case Study 4: NTPC Ltd.

Location and capacity:

National Thermal Power Corporation's (NTPCs) Vindhyachal Super Thermal Power Station (VSTPS) is situated in Singrauli district of Madhya Pradesh. It is the largest coal based thermal power station in the country. The power plant has been running on a plant load factor of 92 per cent. Power generated from this plant caters to electricity requirements of Madhya Pradesh, Chhattisgarh, Maharashtra, Gujarat, Goa, Daman and Diu and Dadar Nagar Haveli.

The station has a commissioned capacity of 3,260 MW which utilises coal from Nigahi mines and water from discharge of Singrauli super thermal power station. The approved investment for the plant is Rs. 4,053.42 crores (Stage I & II) and Rs. 4,201.5 crores for Stage-III. The capacity of the VSTPS at Stage I is 1260 (6x 210) MW while that of Stage-II & III is 1000 (2x500) MW each.

Water audit:

The Vindhyachal power plant draws sizable amount of water for various processes in power generation system. To enhance its effort towards water conservation and management VSTPS conducted a water balance in all the units of the power plant (Stage-I, II & III). The study was undertaken during April-July 2010, with the following objectives:

- To conserve water and enhance the re-use and recycling of effluents;
- To reduces costs in accessing freshwater by implementing a series of water conservation measures identified through the audit; and
- To assess existing provisions and options for further conservation of water and to achieve near zero discharge of effluents.

The NTPC team conducted field visits, involving one reconnaissance survey of the entire plant, collection of preliminary information and two detailed field surveys including monitoring/measurements of flows and water quality at several important identified locations of the entire water supply pipeline network, open channels and wastewater discharge locations at the all the stages of the plant as well as the township area.

Flow measurement at study region included monitoring of the water flows at all the existing major water sources and usage areas at all the three plants (Stage-I, II & III). The flow measurements were undertaken covering the following important locations:

- Source water intake points from water reservoirs at Stage-I & III

- Raw water treatment plants of Stages-I, II & III
- Filter houses of each stage (I, II & III)
- Drinking water supply to the townships and the plant
- Service line water supply
- DM plant water supply
- Ash water recirculation system (AWRS) of all the three stages
- Cooling Towers at all the three stages (I, II & III)
- Boilers and auxiliary usage
- OAC channels
- ETP (Effluent Treatment Plant) and major drains of plant

Flow was also measured at the inlet and outlet of STP (sewage treatment plant) in the township. This exercise was undertaken to understand the quantum of water being drawn and consumed in the plant processes and account for leakages and losses as well as wastewater being discharged. The flow measurement exercise involved validation of the mechanical meters (wherever possible) already present and installation of ultrasonic flow meters at selected locations of distribution pipelines.

Based on the water audit, the specific water consumption for the various processes was obtained and the findings are given below. The maximum water use was in the cooling towers followed by ash handling.

Usage	Actual Water Consumption (m^3/hr)	Specific Water Consumption (m^3/MW)	Percent (%)	Typical Water Consumption (m^3/MW)*
Ash Handling	4570	1.42	29.6	2.00
Cooling Towers	8130	2.51(it includes the equipment cooling, AC system and other misc. use)	52.4	1.50
DM water	174	0.05	1.1	0.13
Drinking water	902	0.24	5.09	0.32
Fire Fighting	1068	0.31	6.5	0.37
Others	961	0.26	5.3	0.66
Total	**15,805**	**4.80**	**100**	**5.0**

* Reference value as per BEE

The overall specific water consumption at VSTPS is 4.80 m^3/M which is within the reference value of the typical water consumption pattern in India of about 5.0 m^3/MW as per Bureau of Energy Efficiency norms.

The cycle of concentration (COC) for Stage-I, II & III (power plants) was of the following order -

- Cycle of Concentration (COC) Stage-I = 1.99 = 2
- Cycle of Concentration (COC) Stage-II = 2.01 = 2
- Cycle of Concentration (COC) Stage-III = 2.50 = 2.5

Therefore the overall COC for all three stages of Vindhyachal Super Thermal Power Station is 2.2.

Recommendations of the water audit:

The water audit helped in identifying a plan for water conservation for the plant in the following processes:

a. Cooling process (Cooling Towers): Overflows from the cooling towers needs to be prevented to save the high volumes of water being lost. This can be redirected into the cooling process.

b. Drinking water supply: The audit findings highlighted the high per capita intake of water in the residential areas much above the 110 litres per capita per day norm. There was a need to rationalise the water use at township by optimising the water demand supply situation and reducing the existing per capita water consumption.

c. Minimising leakages: An estimated 335 m^3/day of water was lost due to leakages in the water supply network within the plant. These leakages needed to be immediately plugged to save water.

d. Fire fighting water: The amount of water being misused through fire hydrants was to be brought down and there should be a separate arrangement for using treated wastewater for fire fighting purposes.

e. Wastewater management at the power plant: The wastewater at present was being treated/handled at four different systems. It was recommended that a separate central common effluent treatment plant should be established. The existing drains could be diverted to this common location. About 63,933 m^3/day of wastewater is being discharged from the plant which should be recycled completely to achieve zero discharge and reuse the water. A centralised effluent treatment plant (ETP) to recycle 63,933 m^3/day or 63.9 MLD (Million litres per day) of water discharged (unused) should be considered.

f. Wastewater (STP) management at Township: STP outlet water is suitable for horticultural uses (which have a huge scope given the vast land area of the power plant) and can be reused entirely thus saving water to the tune of about 3,836 m^3/day and ensuring zero discharge. Presently only 1,231 m^3/day is being used. It was also proposed to use the treated water from STP for use in ash water handling system.

Cost Benefit analysis:

There is an enormous scope of saving significant amount of water by water conservation, recycling and reuse (as discussed earlier). The Vindhyachal power plant procures water from the irrigation department for its use at Rs. 4 per m^3. Considering about 80% of potential water saving is achieved through the water conservation measures implemented, the potential cost savings from different interventions would be as follows.

Intervention	Potential water saving (m^3/day)	Volume of water saved (considering 80% of savings can be obtained)	Volume of water saved (m^3/month)	Potential savings in cost per month (considering water is sourced at Rs. 4 per m^3)	Potential savings in cost per annum (Rs. Crore)
Recycling wastewater from STP in township	3,836	3,069	95,133	380,531	0.45
Plugging leakages within the plant	335	268	8,308	33,232	0.04
Recycling wastewater from four major drains at once point and adoption of zero discharge	63,933	51,146	1,585,538	6,342,153	7.61
Savings from efficient water distribution in the township	13,106	10,485	325,029	1,300,115	1.56
Recycling 70% of water lost in ash handling (for all the three stages)	73,731	58,985	1,828,529	7,314,115	8.77
Reducing specific consumption of water in cooling towers from 2.5 to 1.5 (BEE typical consumption value)	78,048	62,438	1,935,590	7,742,361	9.29
Total	**232,989**	**186,391**	**5,778,127**	**23,112,509**	**28**

Following the water audit recommendations the Vindhyachal plant has undertaken measures to improve the ash water recirculation and additional quantity of 1,000 m^3/hr r of ash water from dyke is reused, thereby saving Rs. 3 crore per annum. Close monitoring and plugging leakages has enabled minimising hot water overflow in the cooling towers and reducing water loss in the fire fighting system.

Future plans:

A centralized ETP for all the stages of the power plant is being planned and the discharge will be used for ash handling , washing and coal yard spraying.

Case Study 5: NTPC Ltd.

Location and capacity:

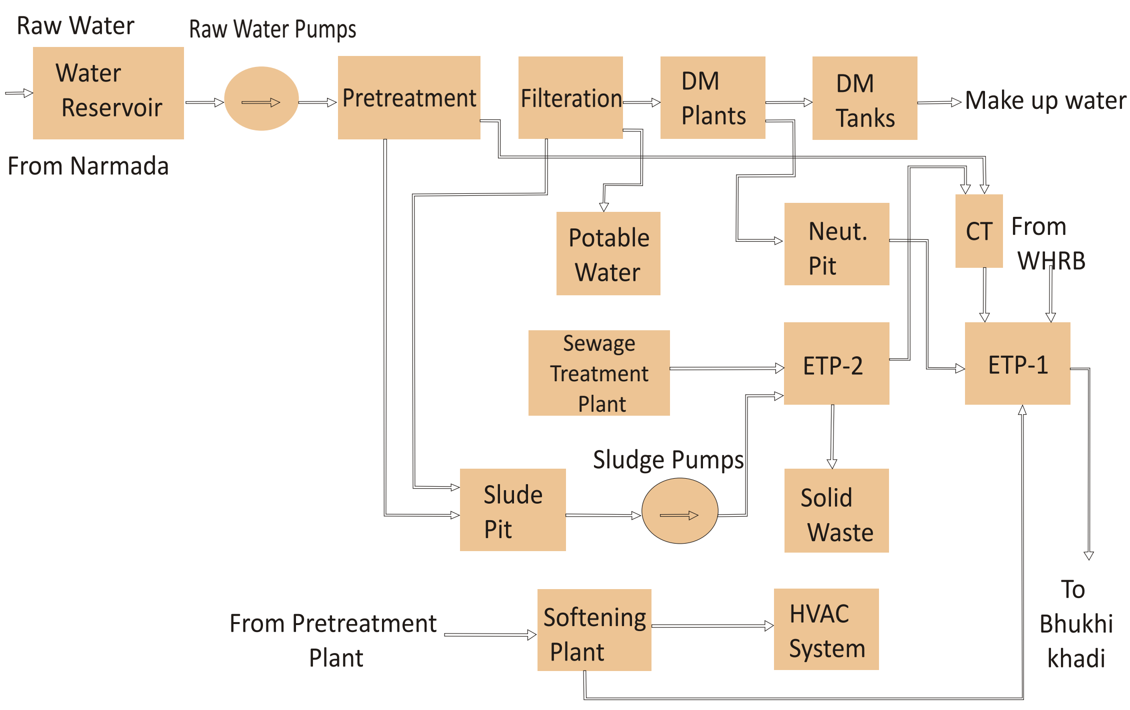
National Thermal Power Corporation has a 657 MW gas based power plant located in Bharuch district of Gujarat. Commissioned in 1994, the Jhanor - Gandhar plant caters to the power demands of Madhya Pradesh, Gujarat, Maharashtra, Goa, Daman, Diu, Dadar and Nagar Haveli, Chhattisgarh.

Volume of water use and wastewater generated:

Water for the power plant is sourced from the Narmada River. The volume of water used in the cooling tower is to the tune of 40,000 m^3/hr, the makeup rate is 1,000 m^3/hr (the plant has a COC value of 4). DM water requirement for water injection amounts to 165 m^3/hr.

The discharge from the power plant as cooling tower blown water is of the order 150 - 200 m^3/hr and DM plant regeneration waste is 8-13 m^3/hr.

Figure below illustrates the process flow chart of water use and wastewater generated in the Gandhar power plant.



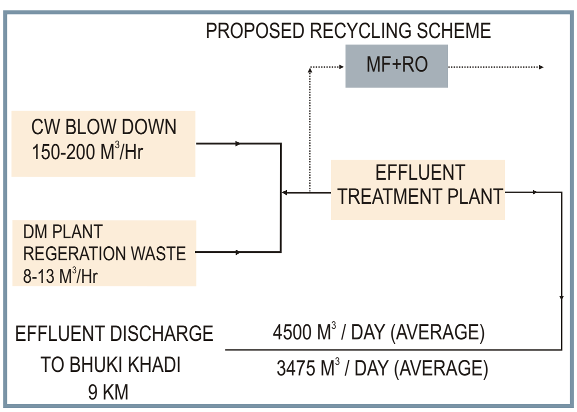
The total volume of wastewater generated in the plant is of the order 3,475 m^3/day. Table below gives the breakup of wastewater generated:

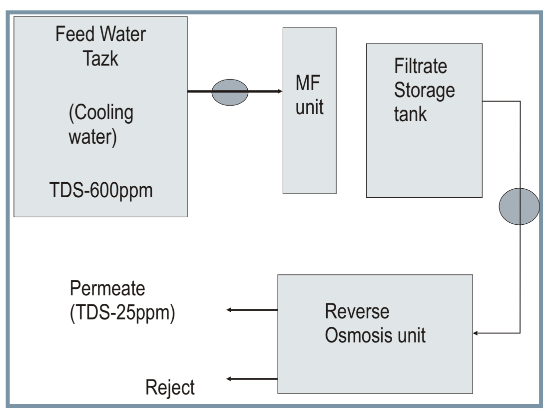
Wastewater source	Volume of wastewater generated (m^3/day) - average figures for the last three years
DM Wastewater	180
Cooling Tower Blown Down Water	3,140
Hot drain water	2
Soft effluent	3
Clarifier underflow/ backwash water	80
Side filter backwash	70
Total	**3,475**

Considering the high volume of wastewater generated, the NTPC management thought of installing a membrane filtration and reverse osmosis plant to reuse the treated water (mainly the cooling tower blown down water) for use as DM plant inlet water. The DM water requirement was estimated at 2,100 m^3/day. Therefore there was a possibility to treat the wastewater and use it as an inlet to the DM plant.

Water efficiency and conservation measures:

- An effluent treatment plant having a capacity of 4,500 m^3/day has been installed. Currently there is no mechanisms to use the treated water but there is a plan to use it for cleaning and fire fighting purposes in the future.
- A pilot study involving membrane filtration (MF) and reverse osmosis (RO) has been undertaken to reuse the effluent from the cooling tower blown down water. The schematic diagram of the intervention is given below:





The water quality of the RO outlet was compared with the raw water and was found to be better than the raw water. A comparison of the CT blown down water, raw water with the RO outlet water indicates the suitability of the RO water for use in the DM plant as compared to raw water.

Parameter	pH	Cond. (Us/cm)	Hardness (ppm $CaCO_3$)	Silica (ppm)	M-alkalinity (ppm)	Chloride (ppm)
CT Blow Down	7.84	1,016	415.7	57.8	46.6	133.8
RO Outlet	**6.1**	**18.4**	**Nil**	**0.6**	**4.3**	**3.8**
Raw water	8-9.3		175	21	192	34

Volume of water and costs saved:

Parameter	Unit cost	Savings in cost per month (INR)	Savings in cost per year (INR)
Pumping cost to Bhukhi Khadi	0.6 KWh/m^3 @ Rs. 2.20/- per KWh for 2260 m^3 /Day *	1,30,176	1,073,952
Water Charges on a/c of raw water	Rs. 12.10/- per m^3 for 2,500 M^3 daily	825,000	10,890,000
Cess charges	Rs. 0.05 per m^3 for 2,500 m^3 daily	3,750	45,000
Saving in Regeneration chemicals	Rs. 3.0/- per m^3	203,400	2,440,800
Pretreatment chemicals and power consumption	Rs. 1.30 per m^3	97,500	11,70,000
Total			**1,56,19,752**

* the consumption of 0.6 Kwh/ m^3 has been calculated from energy meter reading and quantity of effluent treated and disposed from ETP and EDPH.

The estimated cost of the entire operation is valued at Rs. 6 crore and the pay back period is likely to be within 3-4 years.

Case Study 6: TATA Power Company Limited

Location and capacity:

TATA Power has a 547.5 MW (1*67.5 MW+4*120 MW) coal based thermal power plant located in Jojobera, Jamshedpur.

Amount of water use:

The amount of water used is 1,520 tonnes / hr (T/hr) which correspond to _ m^3 per day.

Amount of wastewater generated:

The Jojobera plant generates wastewater to the tune of 357 tonnes/ hr. This does not include the unrecoverable evaporation loss of 1,100 tonnes/ hr from cooling towers.

Amount of wastewater recycled:

The pumping of Unit 1/Unit 4 CT basin water to Units 2&3 CT basins has enabled recycling 54 T/hr of wastewater (Unit 2 and Unit 3 have common CT basin) and its reuse as blow down water. Another 203 T/hr of wastewater is reused in ash plant for boiler bottom ash handling and disposal.

Water conservation measures undertaken:

- Pumping of Unit 1/Unit 4 CT basin water to Units 2&3 CT basin (Unit 2 and Unit 3 have common CT basin) to reuse blow down water of U 1/U 4 in U 2&3 basin.
- An effluent treatment plant (ETP) is being commissioned at Jojobera Power Plant and it has started functioning from August, 2011. This plant will recycle 100 per cent effluent generated and will ensure zero discharge to inland surfaces. The details are provided below -

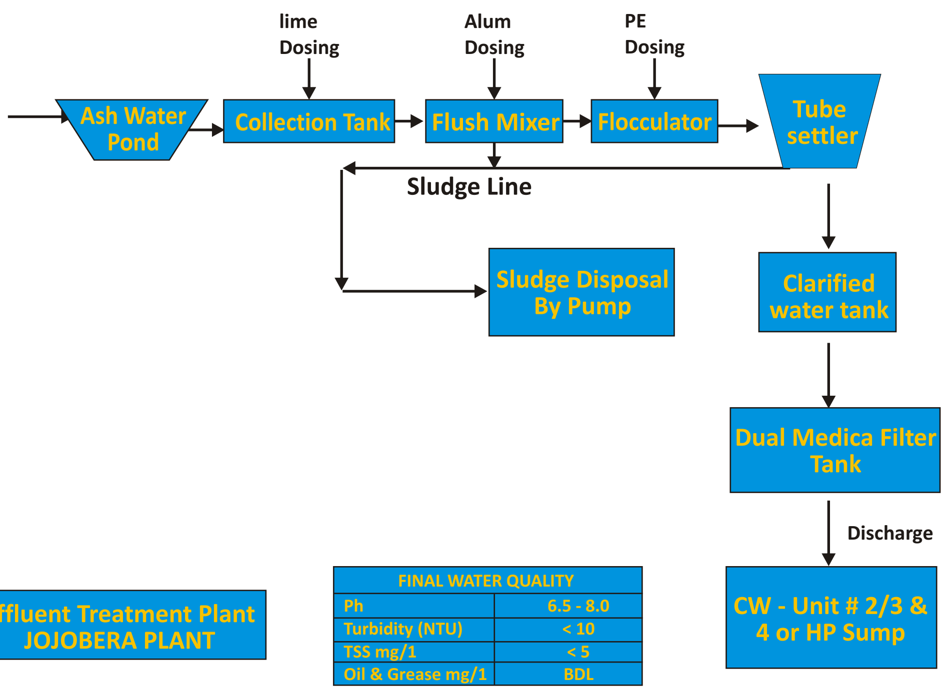
The present arrangement for the disposal of ash water consists of:

- Collection pond of approximate dimension 115m long x 40m width;
- Chamber adjoining the pump house to receive the over flow from the collection pond;
- Pumping station with three pumps to pump out water from the chamber to disposal;
- Pumps are located in a dry pit approximately 15 meters below ground level and a provision for a sump pump is observed to pump out any water flooding the dry pit;
- Adjoining the pump house, a separate room to house the electrical switch gear Cable gallery etc. is provided;

- Out-door transformer station exists next to the MCC room (towards the fencing side of the area)

Ash water which is presently being sent to drain is to be recovered for reuse. The system is designed for making de-sludging of collection pond convenient; recover and reuse for ash handling and for use as cooling tower make up.

The schematic diagram of the effluent treatment plant is shown below:



The treatment system for the recovery of water works on the following:

1. With the upgrading of the inlet ash water handling system, the water to be treated for recovery is expected to have the following characteristics: -

   - Total suspended solids (TSS) 1,000 ppm max.
   - pH - 6 - 8.5
   - Temperature 18°c - 30°C

2. The plant is designed to work on gravity flow and treated water will be collected in a sump. This collected water will be pumped through a dual media filter for use in cooling towers.
3. The scheme for each stream of 100 m^3/hr consists of:
   a. Stilling chamber to receive water from the existing pump - 1no. - 1.4m x 1.4m x 1.5m liquid depth.
   b. Parshall flume to measure the flow in to the plant – 1no.
   c. Flush mixer to mix water with added chemicals 1 no. - 2.2m x 2.2m x 2.5m SWD RCC make.
   d. Flocculator for forming flocs - 1no. 3.6m x 3.6m x 3.5m SWD. RCC make
   e. Tube settler type static clarifiers to settle out all settle able matter 2nos / stream each for 50 m^3/h 5.2m x 4.6m x 3.5m Hopper Bottom RCC make
   f. Chemical dosing system to dose -
      i. Alum - 2 nos. common to both streams 2 m diameter 5.78 m^3 capacity MSEP tank
      ii. Poly electrolyte - 2 nos. common to both streams 1 m diameter 3.37 m^3 capacity MSEP tank
      iii. Lime for pH correction - 2 nos. common to both streams 2.5m diameter 6.38 m^3 capacity MSEP tank
      iv. Each system is provided with 2 nos. dosing pumps and agitators.
   g. Clarified water collection sump (filter feed tank) 5m x 3.5 m x 3 m SWD RCC make
   h. Filter feed pump 2 nos 120 m^3/h each & 70 MMWC
   i. Pressure type dual media filter as per enclosed specification – 2 nos. to filter clarified water to make it suitable for use in cooling towers. With 3.3 m X 2.2 m X T/T pipe up to cooling tower (IS3589)
   j. Blowers are provided to Backwash filters and also to agitate tube settler - 2 nos. 650m^3/h at 0.5kg/cm^2 each system to clean the clogged tube
   k. Raw effluent Transfer pump 120 m^3/Hr and 25 MMWC
   l. A flow totalizer is provided at the outlet of filter

m. One common sludge thickener to receive the blow down from various units and to recover water and return the same to ash pond or any other point - 1 no 6.1m dia x 3 MLD

n. Sludge pumps to deliver thickened sludge to designated area.

o. 2 nos. sludge transfer pump 7.6 m^3/Hr at 15 MMWC to transfer sludge from tube settlers and sludge thickener.

This plant will recycle 100 per cent effluent generated and will ensure zero discharge to inland surfaces.

Volume of water and costs saved:

Measure undertaken	Qty of water saved unit / annum	Costs saved in INR
Pumping of Unit 1/Unit 4 CT basin water to Units 2&3 CT basin to reuse blow down water of U 1/U 4 in U 2&3 basin.	434,160 Tonnes /annum (54 T/hr.*24 hours*335 days, considering 30 days for ASD of two Units)	Rs. 2,396,563.2 (cost of clarified water being Rs.5.52 per T)
Total	**434,160 Tonnes / annum**	**23 lacs**

Case Study 7: TATA Power Company Limited

Location and capacity:

Tata Power Company Limited (TPC) is installing a thermal power plant of 4,000 MW capacity (5 x 800 MW) at Mundra in Kutch district of Gujarat. The plant site is located on the northern shore of the Gulf of Kutch of the Arabian Sea and is about 25 km west of Mundra port. This ultra mega project will establish India's first 800-megawatt unit super-critical technology thermal power plant, which is likely to be the most energy-efficient, coal-based thermal power plant in the country.

Amount of water use:

The power plant will use desalinated water to the tune of 630,000 m^3/hr for cooling purpose and 25,000 m^3/day to meet operations, service and drinking water needs during full load operation.

Amount of wastewater generated and recycled:

In the ongoing construction phase, wastewater to the tune of 3.5 lakh litres per day is generated from the labour colony. This entire volume is recycled through a sewage treatment plant set up having a capacity of 10 lakh litres per day.

Water conservation measures undertaken

Kutch, a semi-arid district in the state of Gujarat and is known for its water scarcity. For the industries which are set up in Kutch, water scarcity has been a regular affair resulting in huge production losses. According to the Federation of Kutch Industries Association (FOKIA), water from the Narmada being supplied through the Saurashtra branch canal since 2005 is inadequate to meet the requirements of the industry. The Coastal Gujarat Power Limited a SPV of TATA Power has taken the following intervention to limit the usage of groundwater and other freshwater sources:

- There is a self moratorium on not using groundwater during construction as well as operation stages.
- Sea water desalination: is being undertaken to meet the plant cooling, service and potable water requirements. At full plant operation, 630,000 m^3/hr (630 million litres/hr) of cooling water will be required for which 10 numbers, concrete volute pumps each of 63,000 m^3 /hr capacity have been provided to meet the condenser, desalination and auxiliary cooling water requirements. The 550 meters intake channel

feeding this requirement of sea water along with the 2.5 km outfall channel for discharging the water back to sea are concrete lined to prevent ingress of sea water in to the water table and thus prevent groundwater salination.

- A sea water based Reverse Osmosis (RO) plant of capacity 25 million litres/day capacity along with downstream demineralization plant to produce DM water has been installed. Demineralised water is required to make good the loss of inventory from the TG Cycle of the power plant. The RO plant along with a re-mineralization plant based on the DM water plant output serves the total plant service and potable water requirements.
- Wastewater treatment and recycling: Sea water is being used to separate ash from water in specially designed ash pond (to prevent ingress of sea water into the water table) and the clear water is discharged back to sea. A Sewage Treatment Plant (STP) of 10 lakh litres/day capacity has been set up. This meets the water requirements for the extensive vegetation screen development along the plant periphery and landscaping.
- Construction / improvement of structures to store rain treated water: old nullahs have been widened and re-routed to channelize rain water to catchment area. Further numerous small ponds have been dug up to conserve the treated water from STP. Rainwater harvesting system is installed in all major buildings in plant and colony

Volume of water and costs saved

Measure undertaken	Qty of water saved unit / annum	Costs saved in INR
Recycled water from STP being used for green vegetation purpose and ground water charging	12,77 MLD (3,50,000 litres per day x 365)	56 lakhs / Annum (@ Rs 44/KL)
Total	**12,77 MLD**	**5,600, 000**

FICCI Water Mission

Access to safe water is one of the essential elements for sustainable development and poverty reduction. However, the past few decades has seen an increase in demand amongst various water using sectors putting enormous stress on the natural resource.

FICCI constituted a 'Water Mission' to promote and provide thought leadership in the area of water efficiency. It aims to facilitate the sharing and dissemination of best practices across industry sectors in order to encourage corporate and industry players to imbibe a culture of water conservation within their organizations.

The Mission is working to create awareness on the existing situation pertaining to water scarcity, quality and generate a discourse on sustainable use of water amongst various users. With growing and extensive depletion and pollution of our water resources, our current work is being restructured to bring this issue back in focus to provide a sense of urgency to the debate of water management.

The objectives of the divisions work are:

- To formulate suggestions for changes in policy framework in India for better water resource allocation, conservation and management;
- To promote fresh water conservation strategies across the irrigation, industry and domestic sectors;
- To document and disseminate best practices across various sectors and create a forum to facilitate exchange of information and experiences in the country;
- To promote new innovative technologies of water saving and management like rainwater harvesting, watershed management, desalination, water auditing and accounting across water intensive sectors through projects, workshops, conferences and training programmes.

Queries to FICCI may be directed to:

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