Water Audit Case Study of a Gas Based Power Plant in India: Improving Water Use Efficiency

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INTRODUCTION

A detailed water audit & conservation study was conducted by FICCI for a 431 MW Gas based Power Plant with the objective of achieving systematic reduction in water consumption and net effluent discharge of the plant. The study includes assessment of total water intake in various processes; preparing the water balance as per the actual consumption; identification of water loss areas; evaluating the water saving potential in each section; identifying water/energy conservation opportunities and evolving zero water discharge scheme for the plant. The study methodology involved preparation of water circuit diagram; Secondary Data collection; conduction of field measurements through Quantification of water/wastewater streams, Power Measurement of Pumps/Motors and Measurement of suction & discharge pressure at various pumps; Analysis of water use; water quality sampling & testing; leak detection; Identification of Water Conservation (WATCON) options with techno-economic evaluation.

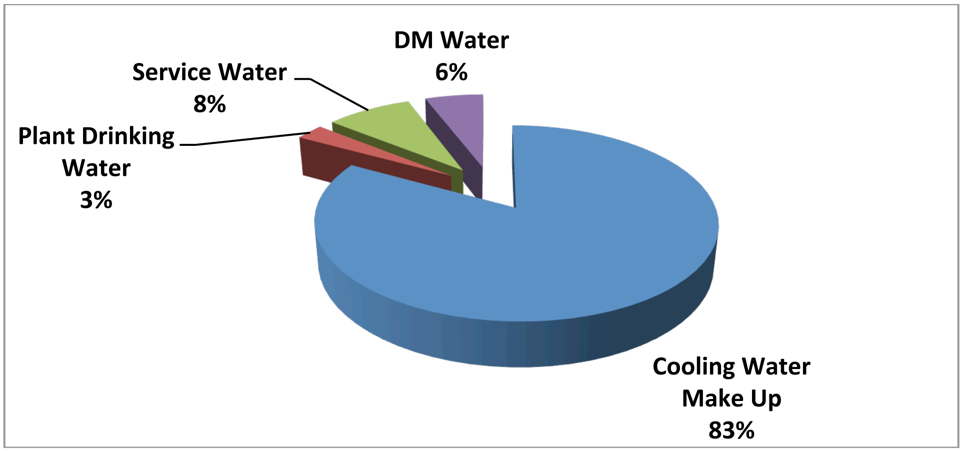
The study identifies the potential of about 20% saving of total water consumption by implementing the suggested schemes. The main study observations and highlights of the recommendations are discussed below:

WATER SOURCING & CONSUMPTION PATTERN OF THE PLANT

The main source of water for the studied Power Plant was Canal water located at the distance of 4 Km from the plant premises. The unit uses an average of about 12,600 cubic meter of water per day at the rate of Rs 3.57 per cubic meter. At this rate, the unit was paying about Rs 1.5 Crores per\annum of water user charges to the concerned authorities. However, the raw water drawn from the Canal was not fit for industrial use without primary treatment because of heavy pollution loads mainly due to discharged effluents by upstream users. Therefore, the raw water needs to be treated in various grades like filter water, soft water and demineralized water and needs to be pumped for its use in various sections of the plant further adding to water costs. The plant is using groundwater for meeting it’s drinking water requirements.

The main water use applications in the plant includes cooling tower make-up, condenser cooling, bearing & seal cooling, steam turbine generator cooling, boiler feed besides water for drinking and other utility sections. The major portion of water about 83% was used for cooling water make-up, 6% as DM water to be used in the boilers and about 11% is used for meeting other utility and service water requirements. The observed general water use pattern in the plant is given in figure 1:

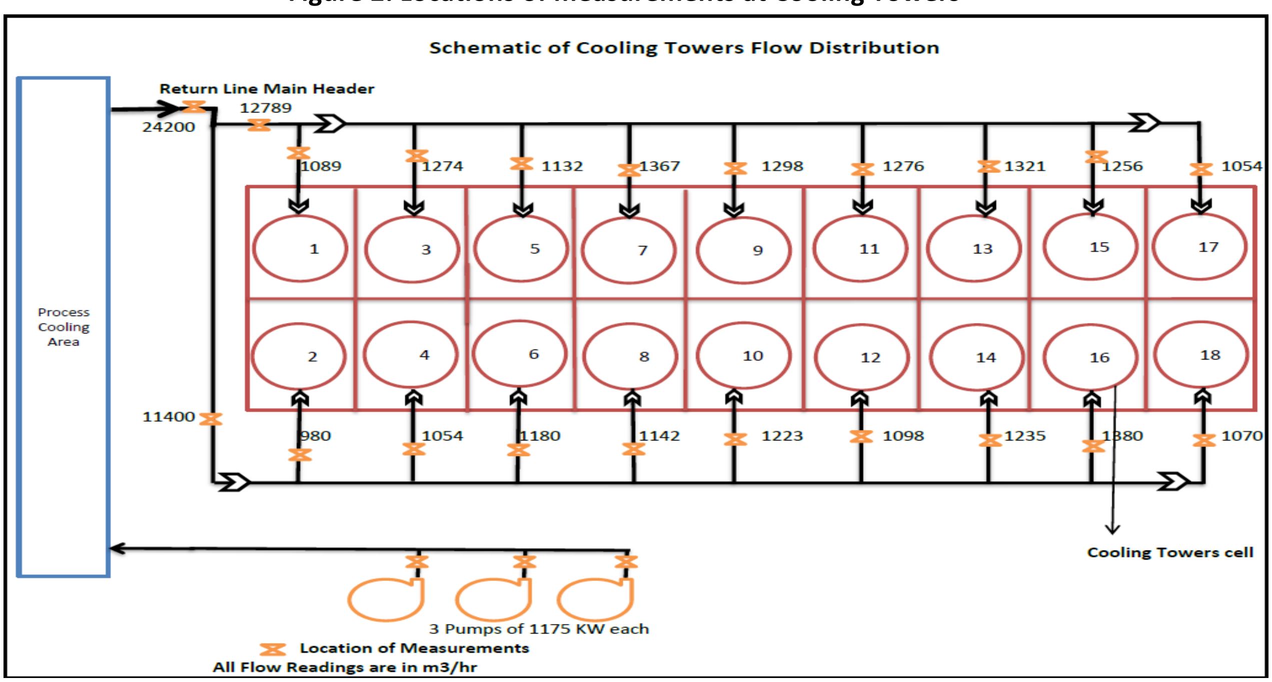
Figure 1: General Water Use Pattern



COOLING TOWERS ANALYSIS & SUGGESTIONS

The Cooling Tower (CT) was consuming 83% of total water used in the plant. The 18 celled Cooling Tower was cooling hot process water (with flow rate of about 24,200 m3/hr) from the plant in recirculation manner. The flow measurements at CT were done in the main header, bifurcated pipes and at each upriser with the help of portable ultrasonic flow meter. It was observed that the distribution of hot process water was not uniform in each CT cell and had large variations from the average flow values. The average flow rate in odd and even numbered cells was measured as 1227 m3/hr and 1142 m3/hr. Most of the CT cells are receiving either less flow or more flow than the average flow rate. Some of the CT cells are observed to be receiving the flow rate as high as 1380 m3/hr and as low as 980 m3/hr as shown in figures 2:

Figure 2: Locations of measurements at Cooling Towers



The percentage deviation of the hot process water distribution in most of the CT cells is > +10 % than the average flow rate as shown in figure 3 and table 1.

Figure 3: Process Water Flow Distribution in Cooling Towers

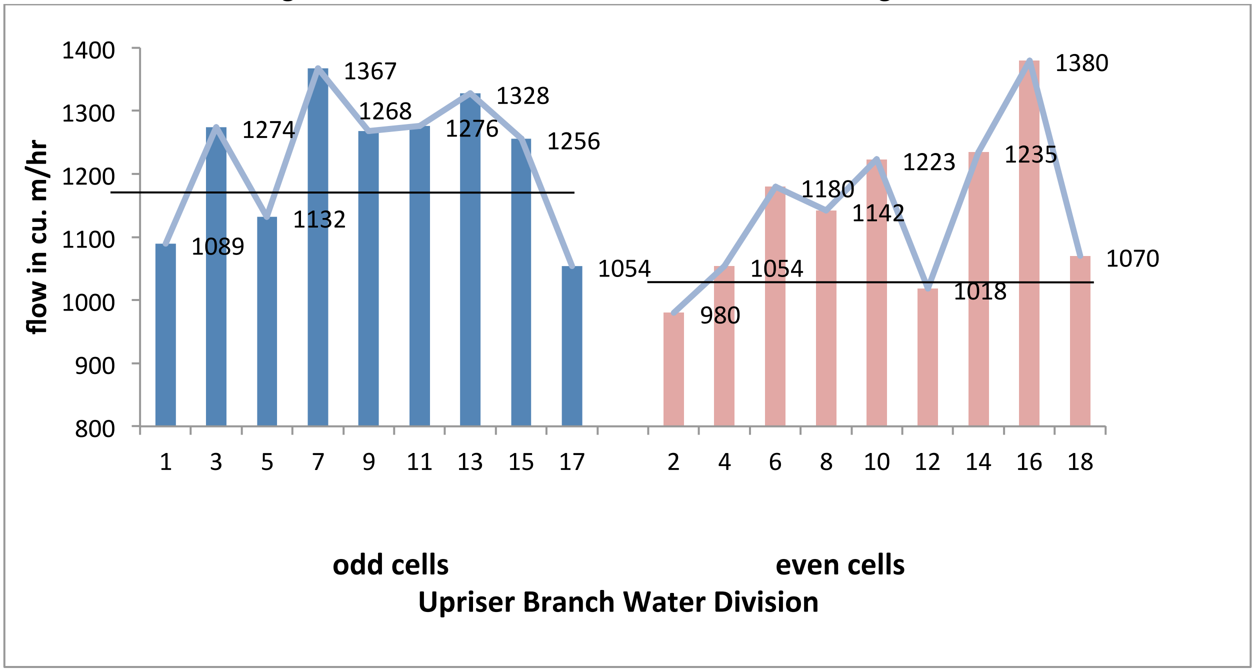


Table 1: Percentage deviation of the hot process water distribution in Cooling Towers

Odd Cells	flow(m^3/hr)	%	% Deviation from the Average
1	1089	88.75	-11.25
3	1274	103.82	3.82
5	1132	92.25	-7.75
7	1367	111.40	11.40
9	1268	103.33	3.33
11	1276	103.99	3.99
13	1328	108.22	8.22
15	1256	102.36	2.36
17	1054	85.89	-14.11
Even Cells			
2	980	85.78	-14.22
4	1054	92.26	-7.74
6	1180	103.29	3.29
8	1142	99.96	-0.04
10	1223	107.06	7.06
12	1018	89.11	-10.89
14	1235	108.11	8.11
16	1380	120.80	20.80
18	1070	93.66	-6.34

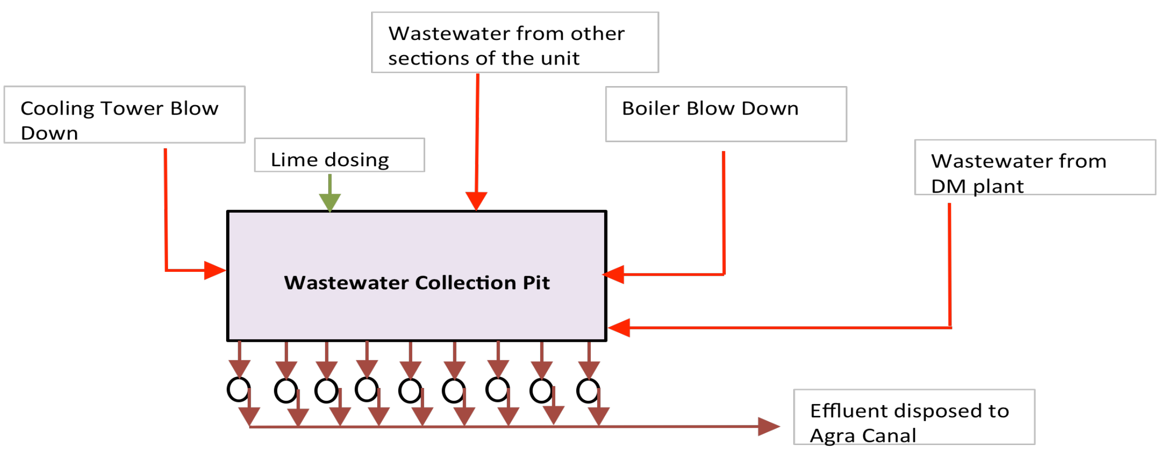
The CT cells receiving higher flow rate are expected to have increased drift losses, reduced cooling and overall low efficiency whereas the cells receiving lower flow rates would remain under utilized. Therefore, it is suggested that the unit should regulate equal flow rates in each CT cell so as to achieve higher cooling efficiency and optimum utilization of the Cooling Towers.

The flow should be equal in all the cells to prevent the drift loses and optimum utilization of CT. This can be achieved by adjustment in setting of valves in each CT cell so that the flow is equally distributed and regulated. The flow variation up to +5% is acceptable. In this case, out of the total 18 cells, 6 cells have variation in the range of 5 to 10%. For optimum performance of the cooling towers, the flow distribution should be as uniform as possible, within 5% variations. This would benefit in terms of increased cooling effect & increased overall efficiency of cooling towers.

WASTEWATER MANAGEMENT ANALYSIS AND SUGGESTIONS

The plant was generating about 2500-3000 m3 of wastewater per day. The wastewater from various sections was collected in a pit for pH correction and final discharge in the nearby surface water body. There is no segregation of wastewater steams and reuse in the plant. No treatment for colour removal, TDS reduction and removal of other impurities was followed. The effluent was discharged in to the water body after pH adjustment with the help of 9 nos. of pumps as shown in figure 4.

Figure no. 4: Wastewater Collection, Neutralization & Discharge

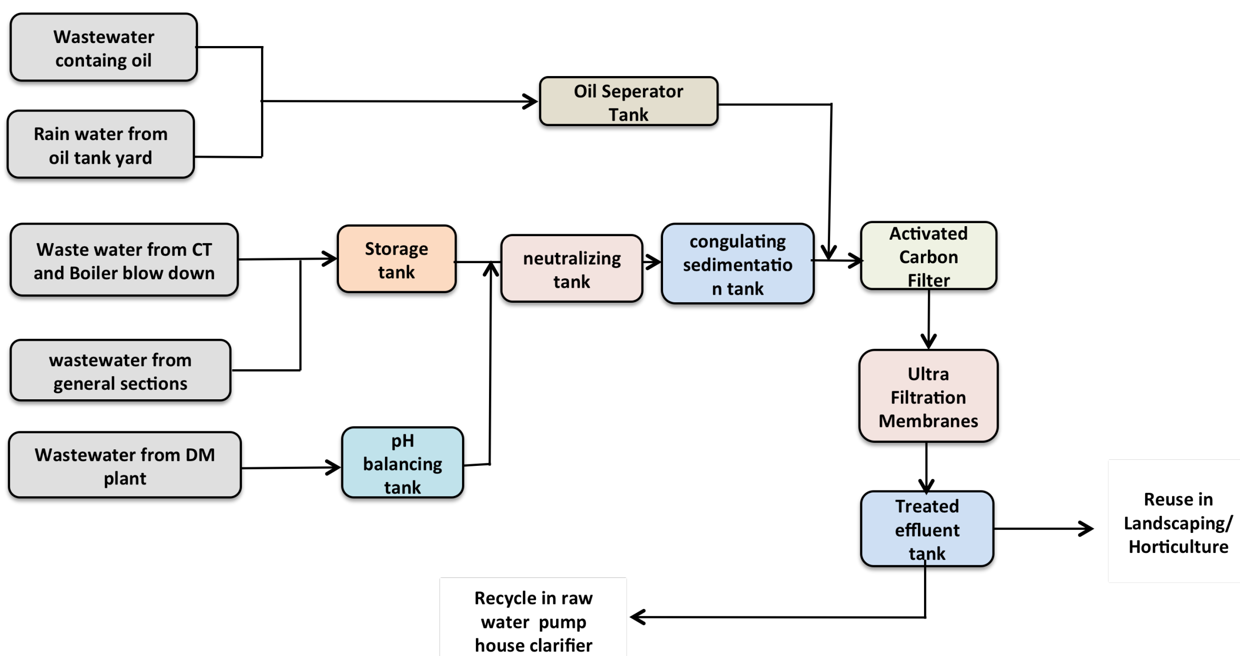


The unit did not have any effluent treatment plant and also have not implemented any scheme for recycling and reuse of effluent. Looking at the large requirements of fresh water in the unit mainly for cooling, it is suggested that the unit should adopt an Effluent Treatment Scheme for treating its effluent up to tertiary level so that the treated effluent can be directly recycled or reused in the plant as the cooling tower make-up water and other utility area to achieve Zero Discharge.

Zero Discharge Scheme 1: As already discussed, that the unit does not have an Effluent Treatment Plant (ETP) and discharges its effluent directly into surface water after pH adjustment and neutralization. Also the water quality of main source of raw water canal was poor. Therefore, it is suggested that the unit should adopt a general Effluent Treatment Scheme for treating its effluents. The treated effluent can be recycled in the raw water pump house clarifiers for further treatment and use in the cooling tower make-up and can also be used for landscaping & horticulture purposes. This would also reduce the fresh water requirement in the plant.

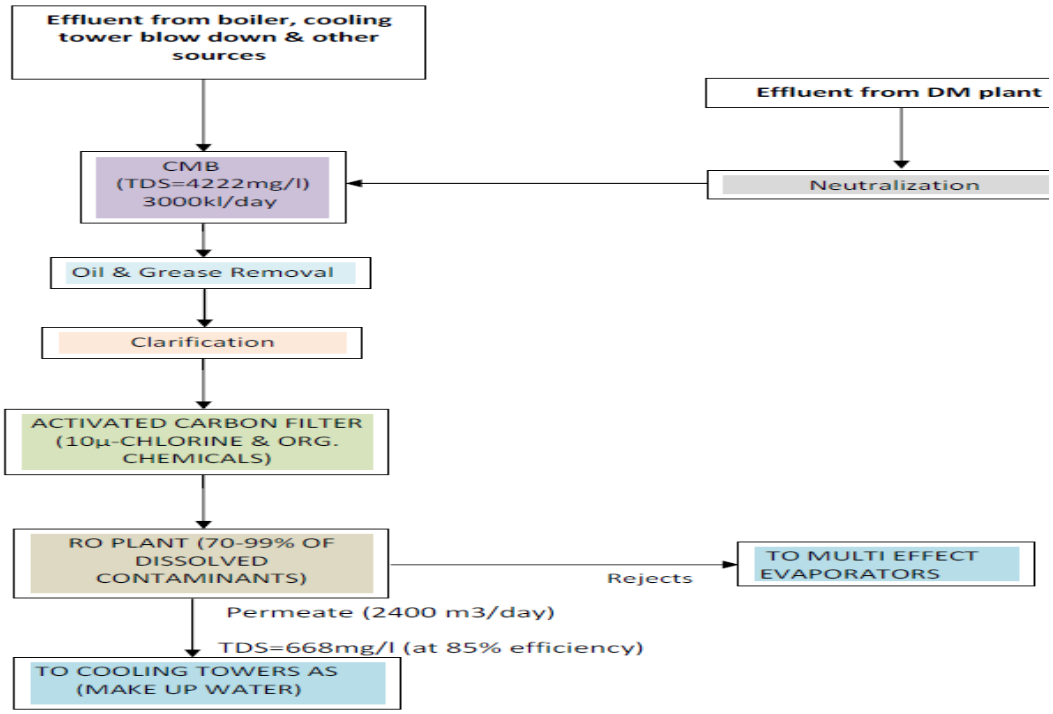
The unit should segregate its various wastewater steams before treatment. The oily wastewater should be collected separately and oil separation can be done using oil separators so as to reduce the load on ETP. The acidic and alkaline wastewater from DM plant should be adjusted for its pH before mixing with the effluent from other sections. The cooling tower and boiler blow down should be collected separately. The general scheme for the ETP includes coagulation and sedimentation followed by Activated carbon filter and neutralization. The treated effluent can be recycled back in the raw water pump house clarifiers and can also be reused for horticulture, gardening or flushing purposes. A schematic diagram of the proposed ETP scheme is given in figure 5.

Figure 5: Schematic Diagram of Proposed modified Effluent Treatment Scheme



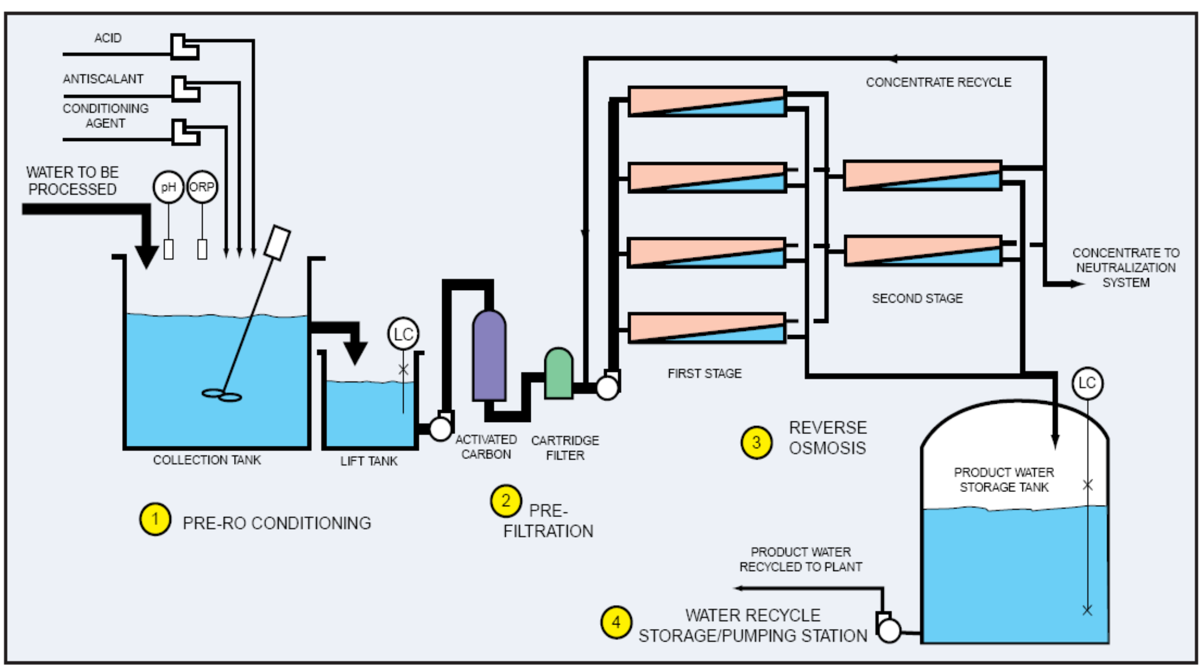
Zero Discharge Scheme 2: It was observed that the neutralized effluent of the unit has TDS in the range of 4000-4300 mg/l and objectionable colour. To remove the colour and reduce the TDS to acceptable levels, the setting up Reverse Osmosis (RO) plant with Multi Effect evaporator is recommended. The treated water quantity of about 2400 m3/day can be reused for CT make-up water & other utility areas and would benefit the unit in terms of reduced freshwater intake and making the plant as 'Zero Discharge'. A schematic diagram of the ETP based on RO system is given below in figure 6.

Figure 6: Schematic Diagram of proposed Effluent Treatment Scheme with Reverse Osmosis



The RO plant in a power plant consists of complete Pretreatment plant along with stilling chamber, Reactor clarifier, three Dual media filters, two sets of Ultra filtration (UF) membranes along with backwashing arrangement etc as shown in figure 7.

Figure 7: Schematic Diagram of RO plant with pre-treatment



WATER AUDIT RECOMMENDATIONS SUMMARY

The summary of the Water Audit Recommendations identifying the various opportunities for reducing the freshwater consumption to about 20% with pay-back period is given in Table 2.

Table 2: Water Audit Observations and Recommendations at a glance

S.No.	Observations	Recommendations	Pay Back period (years)
1	**Clarifier Operation:** • The efficiency of raw water treatment plant for use in the cooling towers is poor. • High turbidity in the clarifier. • One clarifier operational out of two, the other is in stand-by mode.	• Operate both the clarifiers simultaneously, would lead to improvement in the WTP efficiency and treated water quality. • This would also increase the COC in the cooling towers with less blow downs. • This would lead to reduction in pumping cost and water treatment cost.	Immediate
2	**Cooling Towers**: • Distribution of Water in Up risers is not balanced	• The unit should regulate equal flow rates in each CT cell so as to achieve higher cooling efficiency and optimum utilization of the Cooling Towers	Immediate
3	**Throttling At Raw Water Pump House and Cooling Water Make Up Pumps:** • Raw Water Pump House and Cooling Tower Make up sections are using Throttling system for flow control. • Due to throttling, it has been found that, there is substantial loss of energy	• Install VFD system for flow control at Raw Water Pump House and Cooling Tower Make up sections. This would lead to reduction in pumping cost and water treatment cost.	2 Years
4	**Wastewater Treatment & Zero Discharge:** • No segregation of wastewater generated from various sections. • The unit does not have an ETP for treating its waste water. All the wastewater is collected in a collection tank for neutralization and Final discharge to surface water body.	• Segregate CT & boiler blow down water from DM acidic & alkaline wastewater. The blow down water after TDS reduction can be reused for landscaping and after TDS removal and disinfection can be used for domestic purposes. • The unit should install general ETP for treating its wastewater and treated effluent can be reused and recycled within the system using membrane filtration. The treated water after membrane filtration can be reused in CT or other sections of the plant directly. This would lead to reduction in Sp. Water consumption and will make the plan a 'Zero Discharge' unit.	5 Years

5	**Rain Water Harvesting:** • The unit has implemented roof top collection system for few buildings. • The unit has four recharge pits to recharge the ground water, located within plant premises and township. • The plant is using groundwater with the help of 3 bore wells for domestic purpose and DM plant. • These bore wells have low yield than its rated capacity.	• Improve the RWH system in the unit • The existing recharge pit requires proper cleaning and maintenance. • To clean the catchment area (rooftops) is also very important for effective rainwater harvesting. • This would lead to water conservation and improvement in the groundwater quantity and quality.	1 year
6	**Evaluation of Pump Performance:** • Pump Efficiency Comparison of Rated V/s Actual Efficiency	• Replacement of less efficient Pumps – Filter water transfer pumps and tube well pumps • Proper maintenance and Operation of the pumps	2 Years

CONCLUSION

The above case study shows that the Water Audits are important for improved & sustainable water management in the industries and other water using organizations. A Water audit helps in reduced water losses from the system and improves water productivity. In addition to water saving, water audits also help in energy conservation, reduced effluent generation and associated treatment costs, thus reducing unit cost of production. Therefore, the industries especially water intensive sector like power plants should take-up periodic Water Audit & Conservation studies for continual improvement.

About the Authors

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M A Patil is the Director at Resource Conservation & Management Group of FICCI. He holds a mechanical engineering degree from Shivaji University and is a certified Energy Auditor. He has more than 22 years of experience of providing consultancy services across various industry sectors in the area of cleaner production/ waste minimization demonstration, Design of APCD systems, Developing EMS, Water Management, evolving National environmental standards & guidelines, Technology assessment, Evolving emission factors, Control of Fugitive emissions in Cement, Rice Mills, Stone Crushers, Induction melting, sponge iron, Sugar industries-baggasse fired boilers, Rice, Flour & Dal Mills, Secondary Lead & Zinc smelting industries etc.

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Karishma Bist is the Deputy Director at Resource Conservation & Management Group of FICCI. She holds a Masters degree in Environment Management from the GGSIP University, Delhi and is a certified lead auditor for EMS ISO 14001 and OHSAS 18001. She has more than 10 years of experience in planning & executing consultancy Projects and capacity building of industries in water audit & conservation projects, rainwater harvesting, air pollution control & monitoring, cleaner production and Human Health Risk Assessment studies.