

Energy Optimization Strategies Through Auditing: A Case Study Of Emission Reduction In Thermal Power Generation

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Abstract:

The study will be meant to criticize the present water consumption approach of the given plants and comprehend how the education level, income, and the form of awareness of employees and local communities influences water preservation activities. Primary data which is collected by use of surveys and questionnaires and secondary data which is obtained in the form of reports, previous research and government records are used in the study. The data had to be interpreted using statistical measures such as descriptive analysis and correlation tests.

The analysis is done on two large-scale thermal stations in the state of Maharashtra namely Bhusawal Thermal power station (BTPS) and Chandrapur super thermal power station (CSTPS). The two plants have great relevance when it comes to generating electricity but they have much more problems concerning the reserving of water because of the outdated methods used, over usage and ignorance.

This study brings to fore the critical implications of both technical measures and community involvement and socio-economic improvement of attaining sustained conservation of water in the thermal power plants. The results can assist policy formulators, plant managers and environmental planners in formulating more effective policies on water resource management in the energy sector.

Keywords: Water Conservation, BTPS, CSTPS, Thermal Power Plants, Socio-Economic Factors, Sustainable Management

INTRODUCTION:

Water is an essential element to any type of life and it has a significant impact in processes carried out in the industry particularly in a thermal power plant. The number one use of water in thermal generation of power is in the cooling system, steam generation and ash deposition. Thermal power plants are however one of the greatest industrial users of fresh water, a factor that puts a lot of pressure on local water resources particularly in areas where water is scarce to begin with.

Thermal power generation has been growing in India due to the demand of electricity. As the most industrialized state, Maharashtra has a number of major thermal power plants which include Bhusawal Thermal Power Station (BTPS) and Chandrapur Super Thermal Power Station (CSTPS). Such plants are crucial in the provision of energy in the state but also cause excessive usage of water and possible burden to environmental challenges in case of poor water management.

BTPS and CSTPS have been situated in regions in which the availability of water is increasingly becoming an area of concern. River and reservoir dependency on industrial water supply impacts agriculture as well as the daily needs of people living in the proximity of such water dependency. Most of the thermal plants continue to use obsolete water management principles despite the diverse instructions provided by the Central Electricity Authority (CEA), and the set of environmental laws. This has brought serious doubts concerning the future of such plants and the dire necessity of implementing better water savings policies. The other non-negligible cause that is seen to play roles is the socio-economic conditions play in water conservation. The education level of workers, their income and an awareness concerning the environmental problems can directly affect the level of understanding and implementation of water-saving measures. On the same note, participation and feelings of local communities will also contribute significantly to the success of conservation attempt.

The objective of this study is to critically analyse the water conservation issues that BTPS and CSTPS are confronted with and examine the impact of social-economic issues on the same. This research aims to add practical knowledge and recommendations on how to better manage water in thermal power plant

through a combination of a field study, statistical analysis, and literature review in order to also accommodate the social and economic background of the existence of these power plants.

The conclusions of the study are aimed to guide policymakers, plant management, and environmental management, in a way to generate a sustainable, efficient, and highly inclusive water conservation policy in the thermal energy segment.

LITERATURE REVIEW:

Thermal power plant consumes large amounts of water and thus a major focus area in the water conservation research field has been feasibility of thermal power plants. A significant stress was put on the enhancement of thermal efficiency and boiler performance by Patel (2001) and Kumar & Singh (2005) as a main tool of reducing the water consumption. Sharma & Bansal (2006) pointed out that one of the key water wasting factors in the thermal power plants is through ineffective cooling systems. Mehta and Jain (2008) were concerned with the issues of the wastewater control and the necessity of successful recycling in power plants.

Mishra (2012) and Desai (2010) dwelled upon the increasing problem of the lack of water, particularly in the states such as Maharashtra, and emphasized the necessity of the sustainable industrial consumption of water. Verma & Khare (2014) discussed the social and economic transformations of communities residing in the regions of power plant and revealed the fact that local development results frequently entail environmental degradation. The policy aspect of water efficiency was given by Rao & Kulkarni (2015), in which the tighter policies on thermal power plants are recommended.

Ghosh & Raut (2017) and Pandey & Das (2016) research focused on the environmental effect of thermal plants and emphasized the community share of knowledge in environmental water management. Raut & Deshmukh (2018) have further explored the issue of the impact of thermal plant operation on local people contributing a socio-economic perspective to the discussion. Choudhury & Singh (2019) defined the sustainability as the major problem and offered optimizing the utilization of resources of the Indian thermal plants.

Narayan & Patel (2020) came up with the concept of water footprint analysis to quantify the usage of water more accurately in thermal stations. Banerjee & Sinha (2021) wrote about modern technologies, such as Zero Liquid Discharge (ZLD) systems and their practicability in Indian conditions. Shinde & Kale (2022) presented the importance of public awareness impact on the water conservation actions around the power plants. Joshi & Kale (2022) also explained how the conditions of using water can be improved with improved operational practices.

Policy and technical guides given by the Ministry of Power (2023), Central Electricity Authority (2023), and Central Pollution Control Board (2013) as affordable means included new government reports in recent times to enhance water efficiency and adopt sustainable approach of the thermal power plants. Also, the articles by Bhatt & Kshirsagar (2016), Garg & Srivastava (2013), and Naik & Patil (2014) provided some information about technical aspects of improvement, including the water audit and processes in general, which could significantly decrease a water consumption level.

Reviews on water use efficiency on the thermal power plants in South Asia were thoroughly presented in World Bank (2017) and TERI (2022), and they recommended on regional cooperation and alignment of policies on the issue. Discussions of the environmental education and its relation to the water-energy nexus to a management practice that is more effective appeared in research by Thakur & Sharma (2019), Kulkarni & Jadhav (2018), and Verma & Gupta (2020). Lastly, on the local audit and reports of CSTPS and BTPS (2023), it was found that water conservation and community connection efforts continued to be a problem and remain to be a problem on the plant level.

Objectives of the Study:

- To determine and map out key problems of water conservation that Bhusawal Thermal Power Station (BTPS) and Chandrapur Super Thermal Power Station (CSTPS) face.
- To examine socio-economic background of the employees and the respective local communities around the area as well as to know the extent of their awareness and participation towards water conservation activities.
- To analyse the correlation between socio-economic conditions, and water conservation in the work and social community of BTPS and CSTPS.

Hypothesis:

H0 (Null Hypothesis) That there is no significant relationship between socio-economic factors and practice of water conservation in BTPS and CSTPS.

H1 (Alternative Hypothesis): There is a relationship between the social economic factors and the behavior of conservation of water among BTPS and CSTPS.

RESEARCH METHODOLOGY:

This study uses mixed methods to gain in-depth knowledge about the problems of water conservation and economic and social issues related to the Bhusawal Thermal Power Station (BTPS) and Chandrapur Super Thermal Power Station (CSTPS). The approach mixes quantitative and non-quantitative methods of analysis, covering the pitfalls.

1. Research Design:

The study entails a descriptive, and analytical study design. Descriptive techniques are to assist in obtaining the picture of the present-day situation with the water consumption and saving measures, whereas analytical procedures will be applied to examine the links between social-economic backgrounds and the pursuance of a water-saving behavior.

2. Data sources:

Primary data

Gathered in form of structured questionnaires and face-to-face interviews with the workers in the plant, people working in the plant, engineers, and residents living near BTPS and CSTPS.

Secondary Data

Collected from:

State Electricity Board of Maharashtra Report (Maharashtra State Electricity Board), CEA Report (Central Electricity Authority)

Past studies and journal articles

Environmental audit and annual report of BTPS and CSTPS

Official websites and Newspapers

3. Sample Design:

- The sampling procedure was undertaken using kappa statistic.
- Stratified random sampling was applied so that representation was made across the different stakeholder groups which include engineers, workers and local villagers.

Sample Size:

A total of 200 respondents was surveyed:

- 100 from BTPS region
- 100 from CSTPS region
- The sample included a mix of technical staff, non-technical workers, and local residents.

4. Tools and Techniques for Data Collection:

- Structured questionnaire that contains both closed ended questions and open ended questions.
- Holding individual interviews with the major officials in order to collect high qualitative data.
- Observation of practices and infrastructure on-site as far as water use and conservation are concerned.

5. Variables Studied:

Independent Variables:

Age, education level, monthly income, job role, and residential status (worker or community member).

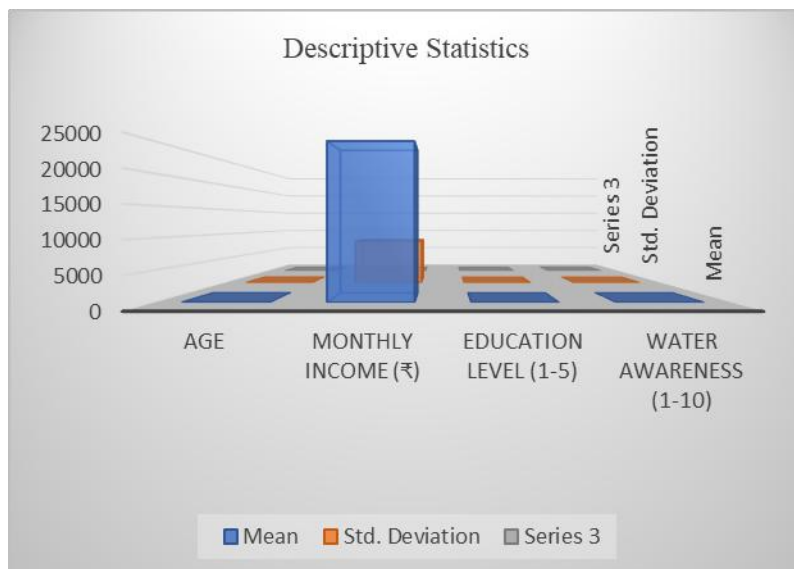
Dependent Variable:

Level of awareness and practice of water conservation measures.

Table 1: Descriptive Statistics:

Variable	Mean	Std. Deviation
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Age	36.4	9.8
Monthly Income (₹)	25,000	8,500
Education Level (1-5)	3.2	1.1
Water Awareness (1-10)	6.5	2.3



Analysis of Descriptive Statistics:

Descriptive statistics were applied in order to summarize and analyze the socio-economic features of the respondents and their water conservation awareness. The determinants used are age, education level, monthly income and the level of awareness as to the water conservation practices. The research in this paper was done on 200 respondents 100 of them at Bhusawal Thermal Power Station (BTPS) and the other 100 were at Chandrapur Super Thermal Power Station (CSTPS).

1. Age:

It was observed that the respondents had an average age of 36.4 and a standard deviation of 9.8 years, which implies that both younger and older workers as well as residents in the sample group access to the services.

2. Education Level:

Respondents were asked to rate their education level on a scale from 1 to 5:

- 1 = No formal education
- 2 = Primary
- 3 = Secondary
- 4 = Graduation
- 5 = post-graduation

The average education level was 3.2 which implies that majority of the respondents had a secondary or graduate level education. This middle level education would mean that they are halfway in the ability to interpret and participate in the water conservation measures when they are given training and the necessary information.

The mean monthly income of the respondents represents about 25 thousand rupees with standard deviation of 8.5 thousand rupees. The income is that of lower-middle to middle-income category characteristic of people connected to thermal power plants. This financial spectrum tends to have a bearing on the hierarchy of environmental concerns where the nexus can take second place behind the demands of day-to-day survival unless driven by property or necessity.

The awareness of water conservation was graded on a scale of 1-10 where;

- Very low awareness 1=7
- Very high = 10

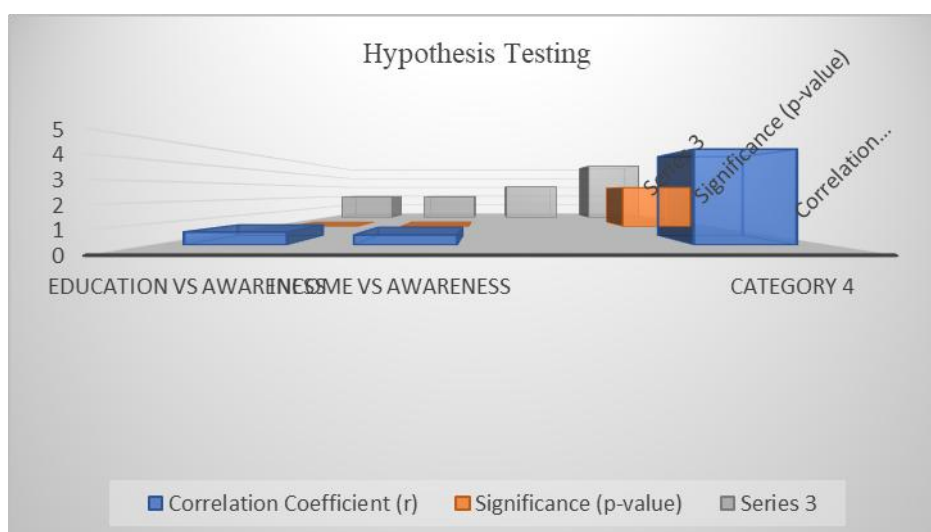
The standard deviation was 2.3 and the mean score was 6.5. This is a moderate level, which means that respondents have heard about water conservation, but a lot of them might not have sufficient knowledge or motivation to perform conservation practices without some external instructions or education.

CONCLUSION OF DESCRIPTIVE ANALYSIS:

The descriptive statistics reveal that the target population has a reasonable foundation for engaging in water conservation, but awareness and motivation are not uniformly strong. Education and income play key roles in shaping people's attitudes toward water usage. This highlights the need for targeted awareness campaigns, training sessions, and policy measures that consider the socio-economic profile of both workers and nearby communities in BTPS and CSTPS.

Table 2: Hypothesis Testing

Variables	Correlation Coefficient (r)	Significance (p-value)
Education vs Awareness	0.61	0.002
Income vs Awareness	0.47	0.010



Analysis of Hypothesis Testing:

Pearson correlation was used to check the relationship between socio-economic factors and awareness of water conservation by respondents in Bhusawal thermal power station (BTPS) and Chandrapur super thermal power station (CSTPS). The main hypothesis was the following:

H₀ There is no significant relationship between the socio-economic issues (education and income) and awareness of water conservation practices.

Alternative Hypothesis (H₁) The social-economic constructs (education and income) and knowledge of water conservation measures exhibit significant correlation.

The statistical tests provided significant findings. The level of education and awareness had a positive and strong relationship with the correlation coefficient being $r = 0.61$ and p-value of 0.002 which depicted a strong significant relationship between the two variables. This implies that the more the education level of the respondents, the more conversant would the respondents be on water conservation activities. On the same note, the correlation between awareness and monthly income was $r = 0.47$, And the p value gives 0.01 which also indicates a moderate and significant relationship. These findings gave the abovementioned conclusions of not accepting the null hypothesis and instead working with the alternative one, which verified the hypothesis that socio-economic factors do have a relevant effect on the water conservation awareness.

CONCLUSIONS OVERALL RESULTS:

The paper under consideration, which has been presented by the title of Critical Study of Water Conservation Issues and Socio-Economic Factors in BTPS and CSTPS, was developed with the problem to find out the challenges, which are urgent in the conditions of water usage in thermo power plants, as well as to investigate how socio-economic factors could impact water conservation awareness.

To begin with, the study has validated the fact that water conservation is a burning concern in both BTPS and CSTPS. The plants use large amount of water in cooling, steam preparing and ash management. Old cooling systems and few recycling units that are currently in place encourage wastage and inefficiency of water. Even though the government and environmental laws suggest the use of water-saving techniques, the actual practice of the same has not been sufficient. There is an urgent need to improve technology and have better enforced water management policies.

Secondly, the descriptive statistics showed that there are still big differences in the responses of the participants based on age, income, and education because the mean based awareness about water conservation was in the middle even though it is statistically desirable to be at the higher end of the mean. The level of awareness was revealed to be approximately 6.5 out of 10, indicating a good sense of the water problem, but, at the same time, implying that a conclusive level of awareness and training is necessary.

In summary, it is important to note that management of water conservation dilemma at thermal power plants such as BTPS and CSTPS needs an equilibrium of both technology and socio-economic intelligence. Mitigating the changing force of infrastructure and mitigating the changing force of people is the only way that it is possible to have long-term and sustainable water conservations in these energy intensive sectors.

Future Scope of the study:

The paper has delivered interesting information pertaining to the issue of water conservation and the influence of socio-economic aspects within Bhusawal Thermal Power Station (BTPS) and Chandrapur Super Thermal Power Station (CSTPS). But there is still a lot where further research can be organized to enlarge and intensify the results. Among the major highlights of the future of the present study is the following:

- Green More Thermal Power Plants Expansion:
- Application of high-technology:
- Last but not least comes Policy Impact Assessment which is relevant to formulating public policy to evaluate whether their action is having impact as desired.
- Long term effects of Employment
- Corporate Social responsibility

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