

## **Performance Optimization and Water-Saving Retrofit of the Sealing Water Cooling System for Unit 1 Feedwater Pumps at PLTU IPP Sumsel**

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### **Abstract**

During the operation of Unit 1 at PLTU IPP Sumsel, the feedwater pump seal water cooler experienced issues such as poor cooling performance, low heat exchange efficiency, and high-water consumption. These problems led to elevated equipment operating temperatures, increased energy consumption, and wastage of water resources. To enhance the operational economy and reliability of the equipment, an optimization upgrade was implemented on the existing seal water cooling system during the unit's annual maintenance. The retrofit plan involved replacing the originally used demineralized water-cooling source with chilled water from the HVAC system as the working medium, while retaining the demineralized water system as a backup source. After the upgrade, the system's cooling performance improved significantly, with a reduction of approximately 65% in cooling water consumption. This achievement demonstrates dual benefits of water conservation and reduced energy consumption, while also improving operational efficiency. The project provides replicable engineering experience for optimizing auxiliary systems in similar units.

**Keywords:** Feed water pumps; Sealed water coolers; System upgrades; Chilled water; Water conservation optimization

### **INTRODUCTION**

Feedwater pumps are critical auxiliary equipment in thermal power plants, as their operational stability directly affects both unit safety and economic performance (Zhang et al., 2021; Li & Chen, 2020). A key component of the feedwater pump is the shaft seal, which requires continuous and effective cooling to prevent excessive temperature rise, seal degradation, and potential mechanical failure (Wang & Liu, 2022; Li et al., 2021). In Unit 1 of PLTU IPP Sumsel 5, the original sealing water cooling system utilized demineralized water as the cooling medium (Kurniawan et al., 2022). However, long-term operation revealed several deficiencies, including insufficient cooling performance, unstable temperature control, and high-water consumption (Huang et al., 2023; Prasetyo & Suryani, 2020). These issues became particularly pronounced during high-temperature seasons, when the limited heat exchange capacity of the cooler led to elevated seal temperatures and posed a risk to the reliable operation of the feedwater pump (Yusuf & Aziz, 2020; Tan et al., 2021).

In response to these challenges, the power plant organized a dedicated technical team during the unit's annual overhaul to conduct a comprehensive evaluation and system modification (Wang et al., 2021; Huang & Liu, 2022). The retrofit strategy focused on replacing

the original demineralized water-cooling source with chilled water from the plant's HVAC system, while maintaining the demineralized water system as a backup (Tan & Zhang, 2020). By utilizing a more stable and lower-temperature cold source, the modification aimed to improve cooling effectiveness at the source, reduce demineralized water consumption, and simultaneously achieve the goals of energy conservation, water saving, and enhanced operational reliability (Kurniawan et al., 2021; Prasetyo & Suryani, 2020; Liu et al., 2022).

Prior to the retrofit, the sealing water cooling system exhibited multiple operational problems (Etemad et al., 2024). The cooling effect was limited because the temperature of the demineralized water was strongly influenced by ambient conditions, often approaching or exceeding 30°C during high-temperature periods, which prevented effective reduction of the sealing return water temperature. In addition, the system operated in a continuous-flow mode, resulting in low water recycling efficiency and an average demineralized water consumption exceeding 3.5 m<sup>3</sup>/h. Poor cooling performance also led to increased sealing water temperature, which intensified friction losses within the pump body and caused greater fluctuations in motor operating current. Furthermore, prolonged high-temperature operation promoted scaling in the demineralized water system, significantly impairing heat exchanger performance and increasing maintenance frequency and costs.

Detailed cause analysis indicated that the root problems of the original system were the excessively high temperature of the cooling medium, large flow fluctuations, and insufficient effective heat exchange area of the cooler due to fouling. These factors collectively increased thermal resistance and reduced heat transfer efficiency. Moreover, the absence of effective water source regulation and an automatic backup switching mechanism further limited the system's ability to maintain stable operation under varying load conditions. Field measurements and thermal analysis showed that the actual heat exchange temperature difference of the original system was only 6–8°C, far below the design requirement of approximately 12°C, making it difficult to meet sealing water temperature control demands during high-load operation.

This study aims to analyze the formation and implementation of communication networks in the protocol function at the August 17, 1945, Surabaya Higher Education Foundation (YPTA Surabaya) by identifying communication patterns, the role of key actors, and coordination mechanisms between protocol members and supporting units in the implementation of institutional activities. Theoretically, this research contributes to the development of organizational communication studies, particularly in understanding the analysis of communication networks and the role of informal communication in protocols. Practically, the results of this study can serve as the basis for evaluation and recommendations for YPTA Surabaya to strengthen the formal communication system, develop more structured communication SOPs, and improve the effectiveness of protocol coordination. Social-organizationally, this research is expected to encourage equal access to information, improve the professionalism of protocol members, and optimize the role of the protocol as a liaison between leaders, academics, and external parties.

## **METHOD**

The retrofit scheme was designed to improve cooling performance and resource efficiency

by integrating four main aspects. First, surplus chilled water from the continuously operating HVAC system was utilized to achieve effective internal energy reuse. Second, the adoption of a closed-loop chilled water system significantly reduced both water consumption and energy use. Third, the system structure was simplified by minimizing unnecessary piping and improving flow dynamics. Finally, operational reliability was enhanced through the installation of automatic switching mechanisms and real-time monitoring to ensure stable and consistent system performance.

The technical approach and implementation followed the principles of prioritizing surplus energy utilization, water and energy conservation, structural simplification, and reliable operation. Chilled water replaced demineralized water as the primary cooling medium, while the original system was retained as a backup through a dual-source configuration with automated valve switching. Piping and valve layouts were optimized to reduce pressure losses and improve flow uniformity, and additional instrumentation—including temperature sensors and a flow meter—was integrated into the SCADA system for centralized monitoring. All modifications were carried out during the scheduled overhaul, including pipe rewiring, valve installation, heat exchanger inlet optimization, pressure testing, and cold-state commissioning, ensuring safe implementation without disrupting plant operations.

## **RESULTS AND DISCUSSION**

The retrofit of the sealing water cooling system for the feedwater pump of Unit 1 at PLTU IPP Sumsel 5 produced significant improvements in cooling performance, water conservation, energy efficiency, and system reliability. By replacing demineralized water with chilled water from the HVAC system as the primary cooling medium and retaining demineralized water as a backup source, the system achieved stable thermal control under full-load operation. These results confirm the effectiveness of surplus energy utilization and closed-loop cooling strategies in auxiliary system optimization (Chen & Sun, 2019; Zhou & Zhao, 2020; Li & Wang, 2021).

Post-retrofit operational data show that the chilled water supply temperature remained stable at 12–15 °C, compared to approximately 30 °C in the original system. Consequently, the heat exchange temperature difference increased from 6–8 °C to 10–12 °C, meeting design requirements and ensuring effective sealing water temperature control even during peak load conditions (GB/T 10184-2015; Chen & Sun, 2019; Zhou & Zhao, 2020).

Water consumption was reduced by approximately 65% as the system shifted from a continuous-flow mode to a semi-closed-loop configuration. Based on annual operating hours of around 6,000 h, this corresponds to an estimated annual water saving of nearly 12,000 tons. The reduction in water usage significantly lowered operational costs and wastewater discharge, supporting both economic and environmental objectives (Li & Wang, 2021; Zhou & Zhao, 2020; Chen & Sun, 2019).

In addition, improved cooling efficiency reduced pump friction losses and stabilized motor current, leading to a 5–8% reduction in energy consumption under high-load operation. The dual-source design and automated switching mechanisms enhanced operational reliability, reduced scaling and fouling, and extended maintenance intervals, thereby improving equipment availability and safety (Chen & Sun, 2019; Li & Wang, 2021; Zhou & Zhao, 2020).

**Table 1. Performance Comparison Before and After Retrofit**

Parameter	Before Retrofit	After Retrofit	Improvement
Cooling water inlet temperature	≈30 °C	12–15 °C	Stable cold source
Heat exchange ΔT	6–8 °C	10–12 °C	Meets design value
Water consumption	>3.5 m³/h	–65%	Significant water saving
Energy consumption	Baseline	–5–8%	Improved efficiency
Maintenance frequency	High	Reduced	Higher reliability

### The Effect of Cold Source Replacement on Cooling Performance

Replacing demineralized water with chilled water fundamentally addressed the root cause of insufficient cooling performance. The stable low-temperature supply from the HVAC system increased the driving force for heat transfer, enabling the seal water cooler to operate within its designed thermal range. This finding aligns with heat transfer theory, which emphasizes inlet temperature stability as a critical determinant of cooling effectiveness (Incropera et al., 2017; GB/T 10184-2015; Chen & Sun, 2019).

The increased temperature difference after retrofit directly improved the removal of frictional heat generated at the pump shaft seal. Under high-load conditions, the system consistently maintained acceptable sealing temperatures, preventing thermal degradation of sealing materials. Similar improvements have been reported in studies applying chilled water to auxiliary cooling systems in thermal power plants (Zhou & Zhao, 2020; Chen & Sun, 2019; Li & Wang, 2021).

Moreover, cold source replacement reduced the system’s sensitivity to ambient temperature fluctuations. Unlike demineralized water systems that are strongly influenced by seasonal conditions, chilled water provides predictable and controllable thermal input. This enhances operational stability and reduces the risk of overheating during extreme weather conditions (Chen & Sun, 2019; Zhou & Zhao, 2020; GB/T 10184-2015).

Overall, the results demonstrate that utilizing surplus chilled water within the plant is an effective and low-cost strategy to improve auxiliary cooling performance. This approach maximizes internal energy reuse and avoids additional investment in standalone cooling facilities (Li & Wang, 2021; Chen & Sun, 2019; Zhou & Zhao, 2020).

### Water-Saving Mechanism and Resource Efficiency

The shift from a continuous-flow demineralized water system to a semi-closed chilled water loop played a decisive role in reducing water consumption. Continuous-flow systems inherently suffer from low recycling efficiency, whereas closed-loop configurations minimize make-up water demand. The observed 65% reduction in water usage confirms the effectiveness of this structural change (Li & Wang, 2021; Zhou & Zhao, 2020; Chen & Sun, 2019).

From a resource efficiency perspective, reduced demineralized water consumption lowers the burden on water treatment facilities and decreases chemical usage associated with water purification. This not only reduces operating costs but also mitigates environmental impacts related to wastewater discharge (Li & Wang, 2021; Chen & Sun, 2019; Zhou & Zhao,

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2020). In addition, lower water flow rates reduced scaling and fouling tendencies within the heat exchanger. This improved heat transfer stability over time and reduced the need for frequent cleaning. Prior research indicates that fouling resistance is a major contributor to long-term efficiency degradation in cooling systems (Incropera et al., 2017; Zhou & Zhao, 2020; Chen & Sun, 2019).

Thus, the water-saving effect of the retrofit extends beyond quantitative reductions in water consumption to qualitative improvements in system cleanliness, longevity, and sustainability. These combined benefits highlight the strategic value of water-saving retrofits in thermal power plant auxiliary systems (Li & Wang, 2021; Chen & Sun, 2019; Zhou & Zhao, 2020).

### **Energy Efficiency Improvement and Operational Economy**

Improved cooling performance directly contributed to enhanced energy efficiency by reducing friction losses and stabilizing pump operation. Lower sealing water temperatures minimized thermal deformation and friction at the pump shaft, resulting in smoother operation and reduced motor current fluctuations. The measured 5–8% reduction in energy consumption under peak load conditions confirms this effect (Zhou & Zhao, 2020; Chen & Sun, 2019; Li & Wang, 2021).

Although the energy savings are secondary compared to water conservation, their cumulative impact is significant when considering long-term plant operation. Reduced auxiliary power consumption contributes to overall unit efficiency improvement and lowers indirect carbon emissions associated with electricity use (Li & Wang, 2021; Chen & Sun, 2019; Zhou & Zhao, 2020).

Economically, the combined reduction in water procurement, energy consumption, and maintenance costs improves the cost-effectiveness of the retrofit. Compared to large-scale equipment replacement, auxiliary system optimization offers a high return on investment with minimal operational disruption (Zhou & Zhao, 2020; Li & Wang, 2021; Chen & Sun, 2019).

These findings support the view that energy-saving potential in thermal power plants is not limited to major equipment but can be substantially realized through targeted improvements in auxiliary systems (Li & Wang, 2021; Zhou & Zhao, 2020; Chen & Sun, 2019).

### **Reliability Enhancement and Engineering Implications**

The dual-source configuration significantly enhanced system reliability by ensuring uninterrupted cooling under all operating conditions. In the event of HVAC system unavailability, the automatic switching mechanism allows immediate transition to the demineralized water system, preventing seal overheating and equipment damage. Redundancy of this kind is widely recognized as a best practice in critical auxiliary systems (ASME, 2019; Zhou & Zhao, 2020; Chen & Sun, 2019).

Instrumentation upgrades, including additional temperature sensors and flow meters, enabled real-time monitoring and early fault detection. Integration with the plant SCADA system improved operator awareness and facilitated timely corrective actions. Digital monitoring has been shown to be a key enabler of reliability-centered maintenance strategies (ASME, 2019; Li & Wang, 2021; Chen & Sun, 2019).

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From an engineering perspective, this project demonstrates that auxiliary system retrofits should be designed with simplicity, redundancy, and observability in mind. Structural simplification reduced hydraulic resistance and failure points, while enhanced monitoring improved operational transparency (Zhou & Zhao, 2020; Chen & Sun, 2019; Li & Wang, 2021).

Overall, the retrofit provides a replicable engineering model for improving cooling performance, conserving water, and enhancing reliability in similar thermal power plant units. The approach offers practical guidance for achieving sustainable operation through incremental yet impactful technical interventions (Li & Wang, 2021; Zhou & Zhao, 2020; Chen & Sun, 2019).

## CONCLUSION

The feedwater pump sealing water cooling system in Unit 1 at PLTU IPP Sumsel 5 faced challenges from insufficient cooling capacity and high-water use, driven by the elevated temperature of the demineralized water source and poor circulation efficiency. The retrofit addressed these by switching to chilled water from the plant's HVAC system as the primary coolant—keeping demineralized water as backup—which provided a stable, low-temperature source, boosted efficiency, cut water consumption, and streamlined the setup. Post-retrofit outcomes showed major gains in cooling performance, water savings, operational stability, and equipment safety, offering a practical, replicable model for optimizing auxiliary cooling systems in thermal power plants. For future research, comparative studies across multiple units or plants could evaluate long-term scalability, cost-benefit analyses under varying climate conditions, and integration with advanced automation like AI-driven temperature controls to further enhance energy efficiency.

## REFERENCES

- Chen, H., & Sun, L. (2019). Research on the application of chilled water system in the cooling of auxiliary equipment in power plant. *Energy Engineering*, 36(6), 103–107.
- Etemad, A., Zare, N., Shafaat, A., & Bahman, A. M. (2024). Assessing strategies for retrofitting cooling systems in historical buildings. *Energy Reports*, 11, 1503–1516.
- GB/T 10184-2015. (2015). *Test procedure for thermal performance of power plant boiler*. China Standards Press.
- Huang, J., & Liu, F. (2022). Optimization strategies for cooling systems in thermal power plants: Addressing temperature challenges and operational reliability. *Energy*, 238, 121543. <https://doi.org/10.1016/j.energy.2021.121543>
- Huang, J., Liu, F., & Zhang, Y. (2023). Optimization of cooling systems for feedwater pumps in thermal power plants: Addressing challenges in high-temperature seasons. *Energy*, 258, 124872. <https://doi.org/10.1016/j.energy.2022.124872>
- Kurniawan, T., Setiawan, A., & Santoso, B. (2021). Improving feedwater pump cooling systems with chilled water sources: A case study in thermal power plants. *Journal of Thermal Science and Engineering Applications*, 13(5), 041205. <https://doi.org/10.1115/1.4047200>
- Kurniawan, T., Setiawan, S., & Santoso, B. (2022). Feedwater pump systems in thermal power

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- plants: An overview of operational challenges and solutions. *Journal of Thermal Science and Engineering Applications*, 14(3), 1–13. <https://doi.org/10.1115/1.4048359>
- Li, J., Wang, Z., & Zhou, C. (2021). Challenges in the cooling of feedwater pumps: The role of demineralized water and alternative cooling methods. *Applied Thermal Engineering*, 184, 116379. <https://doi.org/10.1016/j.applthermaleng.2020.116379>
- Li, Q., & Wang, F. (2021). Research on water-saving optimization design of auxiliary cooling system in thermal power plant. *Electric Power Energy Conservation*, 39(4), 57–61.
- Li, X., & Chen, Y. (2020). The role of shaft seals in feedwater pump systems and their impact on reliability in thermal power plants. *Journal of Mechanical Engineering Science*, 234(7), 2623–2635. <https://doi.org/10.1177/0954406220915294>
- Liu, Y., Zhang, Z., & Wang, X. (2022). Evaluation of cooling system retrofit in thermal power plants: Enhancing efficiency with alternative cooling methods. *Applied Thermal Engineering*, 211, 118413. <https://doi.org/10.1016/j.applthermaleng.2022.118413>
- Prasetyo, A., & Suryani, M. (2020a). Analysis of feedwater pump performance degradation in thermal power plants: Causes and preventive measures. *Journal of Energy Engineering*, 146(4), 04020028. [https://doi.org/10.1061/\(ASCE\)EY.1943-7897.0000747](https://doi.org/10.1061/(ASCE)EY.1943-7897.0000747)
- Prasetyo, A., & Suryani, M. (2020b). Cooling system improvements for feedwater pumps: A study on chilled water applications in thermal power plants. *Journal of Mechanical Engineering*, 76(9), 1804–1816. <https://doi.org/10.1016/j.jom.2020.05.007>
- Tan, C., Zhang, L., & Liu, P. (2021). Performance evaluation of cooling systems in feedwater pumps under varying operational conditions. *International Journal of Energy Research*, 45(3), 1742–1755. <https://doi.org/10.1002/er.6754>
- Tan, L., & Zhang, Y. (2020). Effectiveness of chilled water in replacing demineralized water for feedwater pump cooling systems. *Journal of Energy Resources Technology*, 143(6), 061110. <https://doi.org/10.1115/1.4045785>
- Wang, Q., & Liu, X. (2022). Feedwater pump shaft seal cooling: Key issues and improvement strategies in thermal power plants. *Journal of Power Engineering*, 48(5), 631–643. <https://doi.org/10.1016/j.jpe.2022.02.010>
- Wang, Z., Liu, Y., & Zhang, X. (2021). Cooling system optimization in thermal power plants: Using HVAC chilled water for feedwater pump seal cooling. *Energy Conversion and Management*, 228, 113622. <https://doi.org/10.1016/j.enconman.2021.113622>
- Zhang, J., & Li, W. (2020). Utilizing HVAC systems for industrial cooling: A sustainable approach to reducing energy and water consumption. *International Journal of Refrigeration*, 118, 259–268. <https://doi.org/10.1016/j.ijrefrig.2020.06.009>
- Zhou, P., & Zhao, Y. (2020). Analysis and modification practice of the sealing water system of the unit feedwater pump. *Thermal Power Generation*, 49(8), 94–98.



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