Cooling Tower Thermal Performance Improvement Through Installation of Additional Splash Fill

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Abstract

This project evaluated and implemented the installation of additional splash fill in the air inlet region of each cooling tower cell at a thermoelectric power plant to improve cooling tower thermal performance. Historical operating data showed that elevated circulating water outlet temperatures under high ambient temperature and humidity conditions increased condenser pressure, reduced condenser vacuum, and negatively affected plant heat rate and overall unit efficiency. The modification consisted of installing eight feet of D-Bar splash fill below the existing fill configuration to improve air-water contact and increase heat rejection capability. Baseline conditions were established using plant distributed control system data, including cooling water temperatures, condenser pressure, wet-bulb temperature, unit load, and cooling tower fan operation. After implementation, the project achieved the expected thermal performance improvement by reducing circulating water outlet temperature, lowering condenser pressure, improving heat rate, and supporting more efficient and stable operation of auxiliary systems that rely on closed cooling water.

Introduction

Thermal power generation facilities depend on large cooling systems to remove heat from the steam cycle and maintain efficient turbine operation. A critical component of this process is the cooling tower, which dissipates heat from circulating condenser water through evaporative cooling and air–water heat exchange. In a utility-scale thermoelectric generating station, cooling towers operate continuously and have a direct influence on condenser pressure, turbine efficiency, and overall plant heat rate.

The cooling tower system analyzed in this project is part of a large baseload power plant that uses induced-draft counterflow cooling towers to cool circulating water before it returns to the condenser. Under typical operating conditions, hot water enters the tower at approximately 114°F and is cooled as it flows through splash fill where air and water interact to remove heat. The performance of this process depends on environmental conditions such as wet-bulb temperature and on the internal configuration of the tower fill material.

Historical operating data indicate that cooling tower performance varies significantly during different seasonal conditions, particularly during periods of high humidity and elevated ambient temperatures. When cooling efficiency decreases, the temperature of the cooling water returning to the condenser increases, which raises condenser pressure and reduces the thermodynamic efficiency of the steam cycle.

The objective of this project was to evaluate the potential performance improvement resulting from installing additional splash fill in the air inlet region of each cooling tower cell. The evaluation included quantifying the expected reduction in cooling water outlet temperature and estimating the resulting impact on condenser pressure and overall plant heat rate. By analyzing historical operating data and applying engineering performance relationships, the study sought to determine whether the proposed cooling tower modification could improve thermal performance and provide measurable efficiency benefits for the generating unit

Problem

Key System Limitations:

- Elevated ambient temperature and humidity reduce cooling tower heat rejection capability.
- Higher circulating water outlet temperature increases condenser pressure and reduces condenser vacuum.
- Reduced cooling tower performance negatively affects plant heat rate and overall unit efficiency.

Methodology

This project was developed using an engineering management approach supported by the Project Management Body of Knowledge (PMBOK) framework and technical performance evaluation of the cooling tower system. The methodology was structured to guide the project from problem identification through planning, implementation, and performance verification after the modification was completed. Through this approach, the project integrated operational data analysis, technical validation, execution planning, and performance monitoring to ensure that the selected solution was practical, technically sound, and beneficial for plant operation.

Initiation
- Project scope and objectives definition
- Cooling tower system performance problem identification
- Stakeholder identification and project framing
- Baseline operational impact assessment

Planning & Design
- Historical DCS data collection and analysis
- Cooling tower range and approach evaluation
- Condenser pressure and heat rate relationship assessment
- Alternative comparison and economic evaluation
- Selection of additional splash fill solution

Execution
- Finalization of D-Bar splash fill configuration
- Material, labor, and installation planning
- Alignment with plant operating requirements
- Implementation of additional splash fill
- Post-installation performance verification

Closeout
- Final results documentation
- Economic benefit and payback confirmation
- Scope and execution review
- Lessons learned documentation
- Future cooling tower improvement support

Results

The installation of additional splash fill in the air inlet region of each cooling tower cell produced measurable improvements in cooling tower thermal performance. Prior to the modification, historical operating data showed that elevated circulating water outlet temperatures were associated with higher condenser pressure, reduced condenser vacuum, and lower overall plant efficiency, particularly during periods of high ambient temperature and humidity.

After the D-Bar splash fill was installed in April 2026, the cooling tower showed improved heat rejection capability. As shown in Figure 1, circulating water outlet temperature and condenser pressure followed the expected downward trend after the modification. The operating data indicated that the final circulating water outlet temperature decreased to approximately 93.8 °F, while condenser pressure decreased to approximately 4.85 inHg abs. These results confirmed that the additional splash fill improved the air-water contact process within the tower and enhanced thermal performance under representative operating conditions.

The reduction in circulating water outlet temperature contributed directly to improved condenser operating conditions. Lower condenser pressure supported better vacuum conditions in the condenser and improved the efficiency of the steam cycle. This improvement also contributed to a lower plant heat rate and more stable unit operation, especially during demanding environmental conditions. The installed D-Bar splash fill configuration is shown in Figure 2.

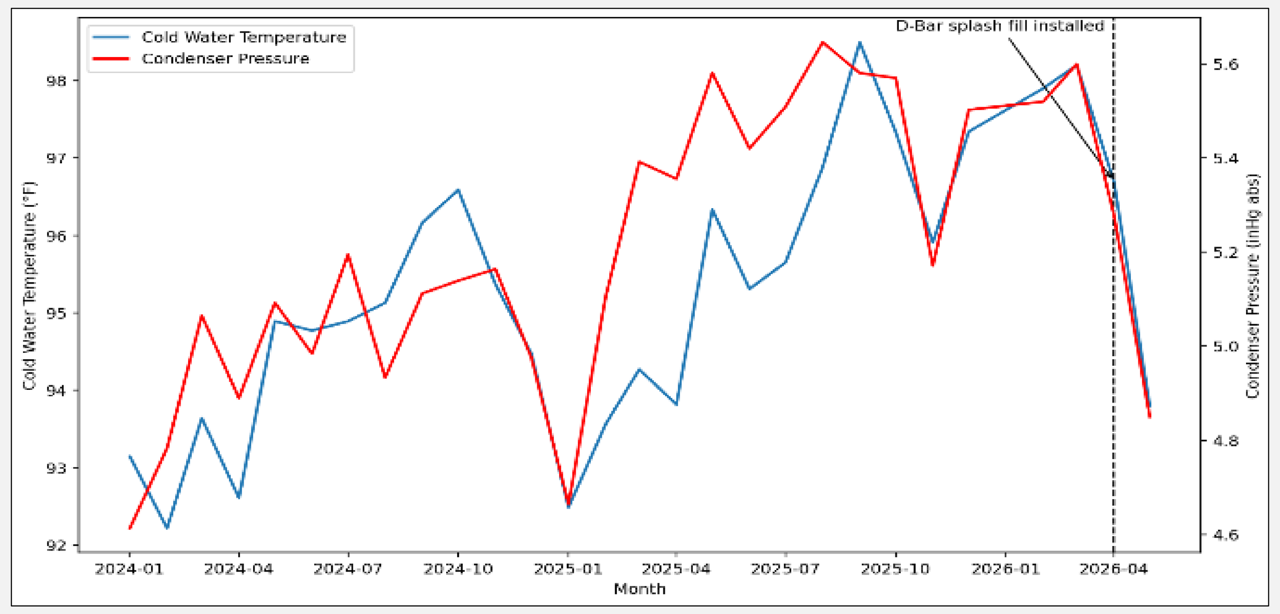

Figure 1
Circulating water outlet temperature and condenser pressure after installation of additional splash fill

Figure 2
D- Bar splash fill installed in the air inlet section of the cooling tower cell after project implementation

Project Budget Allocation

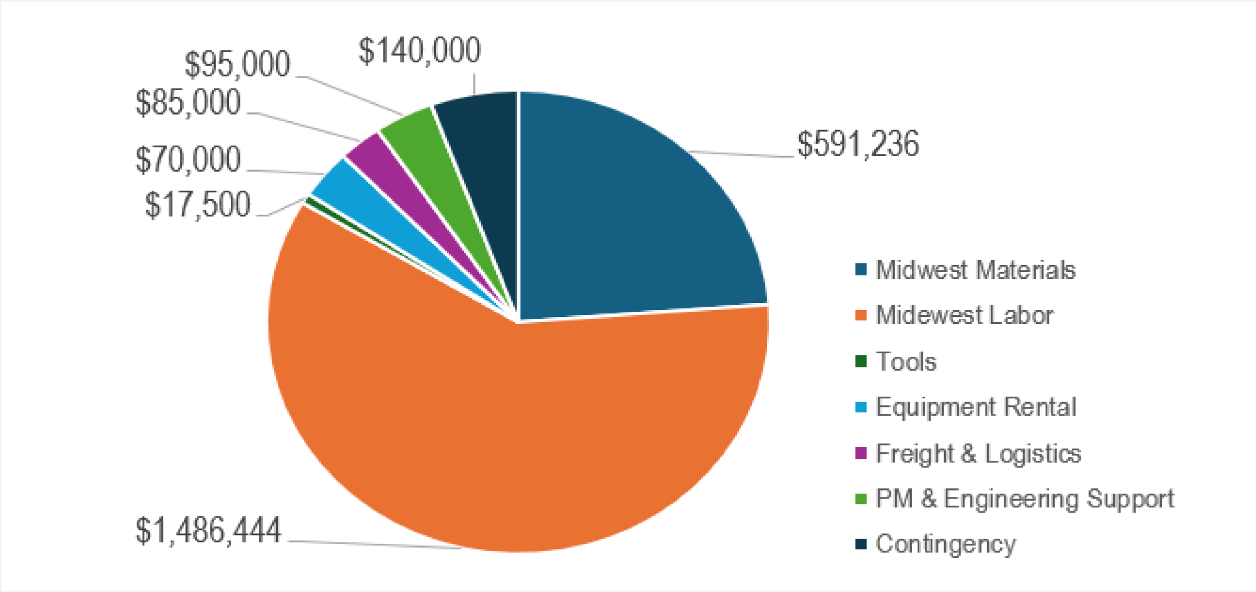

Figure 3
Estimated Project Budget Allocation

Budget Summary

Direct Costs Materials, Engineering & Execution)	$2,250,180
Project management & Overhead	$95,000
Contingency	$140,000
Total Estimated Budget	**$2,450,180**

Project Payback

Parameter	Value	Calculated Basis
Total project budget	$2,485,180	Approved project cost including direct cost, project management and contingency
Heat rate value	$3.50/hour per point	Economic criterion used in project evaluation
Representative heat rate improvement	18 points	Estimated improvement after splash fill installation
Hourly economic benefit	$551,880/year	$63.00 x 24 x 365
Simple payback period	4.5 years	$2,485,180 ÷ $551,880

Conclusions

The project demonstrated that the installation of additional splash fill in the air inlet region of the cooling tower cells was an effective solution for improving cooling tower thermal performance in the evaluated thermoelectric power plant. The implemented modification increased the heat rejection capability of the system, reduced circulating water outlet temperature, and improved condenser operating conditions. These results supported lower condenser pressure, improved plant heat rate, and better overall unit efficiency under representative operating conditions.

The study also confirmed the importance of combining historical plant operating data with engineering performance relationships and supplier technical information to support decision-making and validate the proposed modification. The reduction in circulating water temperature not only improved condenser performance but was also expected to support better heat exchange in auxiliary systems that depend on closed cooling water. As a result, the modification may provide an indirect operational benefit during periods of high ambient temperature and humidity.

From an engineering management perspective, the selected solution provided a practical balance among technical benefit, implementation feasibility, and economic justification. The project was developed in accordance with the planned scope and implementation approach, and the estimated economic evaluation supported the financial justification of the modification. The estimated simple payback period indicated that the project could recover its cost in approximately 4.5 years. Overall, the project confirmed that the installation of additional splash fill was a technically sound, operationally beneficial, and economically justified improvement for supporting more efficient, stable, and reliable plant operation.

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