

CHAPTER 5 - CONCLUSIONS AND RECCOMENDATIONS

5.1 Conclusions

The usability testing phase provided empirical evidence that the designed platform features align with the initial problem formulation and user-centered research objectives, particularly concerning operational clarity, role-based access, and incident handling capabilities.

Question #1: Does the Cooling Technology Type (X) have a positive influence on Cooling Efficiency (Y)?

The results of the regression analysis show that the Type of Cooling Technology (X) does not have a positive impact on Cooling Efficiency (Y). The regression coefficient of 0.099 and the p-value of 0.286 ($p > 0.05$) indicate that the impact is not statistically significant. This indicates that the H1 hypothesis is rejected. The contribution of X to the Y variable is considered insignificant because it is very small, only around 0.03%. These results indicate that simply changing or selecting a particular cooling technology does not automatically increase cooling efficiency. Operational factors such as server workload and ambient temperature further affect efficiency. Therefore, policies that only focus on technology without considering operational conditions are at risk of being ineffective.

Question #2: Does the IT Load and Ambient Temperature (C) have a positive influence on Cooling Efficiency (Y)?

The results of the regression analysis show that the variables IT Load and Ambient Temperature (C) have a positive impact on Cooling Efficiency (Y). With a regression coefficient of 0.330 and a p-value of 0.000 ($p < 0.05$), this effect is highly statistically significant. In addition, the effect is classified as moderate to strong, according to the standard beta value of 0.420. This indicates that ambient temperature and server workload directly increase the efficiency of the cooling system. Therefore, hypothesis H2 is accepted. This finding suggests that, rather than simply selecting cooling technology, the approach to improving data center cooling efficiency should concentrate on IT load management and environmental temperature control.

Question #3: Does the Cooling Technology Type (X) and IT Load and Ambient Temperature (C) have a positive influence on Cooling Efficiency (Y)?

With an F value of 10.962 and a p-value of 0.000 ($p < 0.05$), the model combining variables X and C simultaneously shows a significant positive effect on Cooling Efficiency (Y). The results of the multiple regression analysis indicate that hypothesis H3 is accepted. However, variable X is not significant ($p = 0.972$), so only variable C plays a significant role, indicating that, although the combined model is significant, the main contribution comes from variable C. The R² value of 0.175 indicates that the model is responsible for 17.5% of the variation in cooling efficiency. In short, load and temperature affect efficiency more than the type of technology used.

5.2 Future Works

1. Development of Research Variables

To provide a more complete picture of data center cooling efficiency, further research is recommended to add new variables. To conduct further research, variables such as power usage effectiveness (PUE), age and type of cooling equipment, energy management systems, and airflow distribution patterns should be considered. Examining the interaction between variables is also important to find mediation or moderation effects that have not been seen in previous models.

2. Use of Deeper Methodology

Further studies require a stronger methodology, such as an experimental method that allows researchers to see directly how changes in load and temperature affect cooling efficiency. Long-term control of load and temperature on energy performance can also be done with a longitudinal approach. In addition, using a more sophisticated predictive model based on historical data patterns will make the projection of cooling system performance more accurate.

3. Increasing Generalization of Findings

It is important to involve respondents from various types of data centers, such as enterprise, hyperscale, and edge, so that the research results can be generalized more widely. Cross-regional or cross-country studies are also important to find out how much local policies such as infrastructure, climate, and energy policies affect cooling

efficiency. The research findings will have a higher level of external validity by including geographical and operational diversity.

4. Design of Data-Based Operational Systems

Future research can also concentrate on the development of data-based operational systems that can monitor data center conditions in real-time. Such systems can monitor temperature, humidity, and IT load and be connected to an automated control system to assist in rapid and accurate decision making. In addition, the development of an early warning system that can identify early efficiency declines also has great potential to be applied in contemporary data center operations.

5. Policy and Practice Implications

This research can be used as a basis for creating policy guidelines that focus on improving operational efficiency, especially in terms of managing IT environmental load and temperature. To support the implementation of best practices, data center operators should be given strategies to implement data-based efficiency. In addition, the results can be used to encourage the adoption of sustainable energy policies through the development of digital infrastructure at the national and regional levels.

5.3 Recommendations

It is recommended that Sinergy Data Center formalize a cooling policy development framework that includes periodic stakeholder engagement, alignment with national and international sustainability standards, and the use of empirical validation methods. Policy testing procedures such as thermal failure simulations, DCIM data audits, and SOP execution trials should be implemented as part of a governance cycle to ensure that the policies are both effective and adaptable. These governance actions are integral to embedding sustainability into the organizational culture and ensuring long-term thermal management performance.

Several strategic ideas can be proposed to help improve the efficiency of data center cooling systems more comprehensively and sustainably:

1. Research Variable Development:

Further research is needed to include more variables studied to gain a deeper understanding of cooling system efficiency. Power usage effectiveness (PUE), age and type of cooling equipment, energy management system, and airflow distribution patterns are other factors that can be considered. In addition, an analysis of the

interaction between variables is needed to find potential moderating or mediating effects that have not been revealed in previous regression models.

2. Use of Deeper Methodology

It is recommended that future studies use more robust methodologies, such as quantitative experiments to see how changes in load and temperature directly affect cooling efficiency. To assess the long-term impact of temperature and workload management on energy performance, a long-term approach can also be applied. To make more accurate efficiency projections that are in accordance with previous data center operational patterns, ML or AI-based predictive models can be used.

3. Increase Generalizability of Findings:

A means for future studies to involve different types of data centers, such as hyperscale, edge, and enterprise, to increase the external validity of the research results. In addition, cross-regional or cross-country research is needed to determine how much local infrastructure, climate conditions, and policies affect cooling efficiency. Because of this geographic and operational diversity, findings will be more generalizable and relevant worldwide.

4. Designing a Data-Driven Operational System:

The next recommendation is to build a data-driven operational system that can monitor data center conditions in real time, such as temperature, humidity, and IT load. This system can be integrated with an automated control system to support fast, accurate, and data-driven decision making. In addition, operational risk mitigation strategies should include the development of an early warning system that can identify efficiency declines early.

5. Implications for Operational Policies and Practices:

This study can be used as a basis for creating an outline of operational policies that focus on energy efficiency, especially in terms of controlling load and ambient temperature in the information technology sector. To improve cooling system performance, data center operators must use a data-driven efficiency implementation approach. In addition, the findings of this study can be used to encourage sustainable energy policies that support the development of digital infrastructure at the national and regional levels. This will be in line with the agenda of an environmentally friendly digital transformation.