CHAPTER 6
CONCLUSION AND FUTURE WORK

6.1 Conclusion

In this thesis, an alternative life cycle assessment model with the inclusion of technical and financial requirements of a power transformer considering the budgetary constraint has been proposed and tested. The model is considered to be a linkage of a knowledge based model with a financial model under the decision rules. Nepal Electricity Authority (NEA) was chosen as a case study, but the research was not limited to this case only. The research was conducted based on the assumptions that the procurement of a power transformer is undertaken within the power utility through soft loan payment and also that the transportation cost within the substations is the same.

6.1.1 Knowledge Management Context

This thesis offers knowledge engineering and management framework to develop knowledge based system for an effective life cycle assessment of a power transformer. It also identifies and characterizes the reusable knowledge of the power transformer during its life cycle. The aim of the knowledge based system is to support utility companies in managing the knowledge they currently possess, and to focus their operations towards knowledge reuse. Knowledge engineering is one approach in the development of knowledge based system. By using the CommonKADS model, hidden knowledge embedded within the power transformer is characterized, modeled, and utilized within the power utility and is consequently implemented for sharing and dissemination.

The results of this study show that the hidden knowledge of the power transformer can be categorized into two stages and hidden knowledge can be explained in one of three different levels. Hence, the utility company can fully utilize the hidden knowledge, achieving both financial and technical values, to be used during the life cycle decision on the power transformer in order to maximize its utilization on the network.

6.1.2 Financial Model Context

It provides the EVA modeling of the power transformer to evaluate its net profit over its life cycle. The net profit is used in decision rules during the decision making process. The main component in net profit determination is gross revenue of the power transformer. The gross revenue generated from each power transformer depends on its wheeling charge and is determined with the help of the equation provided in Chapter 4. A case study of a single power transformer is used to test the model. The results show the financial status of each power transformer over its life cycle. In addition, the power utility company can identify when its power transformer will return back its investment after being kept on the network.

6.1.3 Decision Making Context

This thesis provides a novel decision model to the power utilities in order to make optimal decision on a power transformer during load violation. The main objective of this model is to maximize the profit and minimize the cost of keeping the power transformer on stock. Three scenarios (use up, replacement and relocation) have been considered to establish decision rules. The decision rules are the combination of net profit, mortgage cost and net savings of utilizing hidden knowledge. This model is tested in three different cases to verify its consistency. It can be clearly seen from the results of the study that the novel decision model can provide necessary and useful information about the decision of a power transformer. With the help of this model, the power utility can effectively assess the life cycle of power transformers on the network with their maximum utilization satisfying both engineering and financial requirements.

6.1.4 Asset Planning Context

A contribution of this research is the development of a rule-based algorithm to demonstrate the operability of the proposed model in a systematic way. The decision process becomes complex when testing the large number of power transformers case by case since there is one power transformer affects another. This is verified by the results obtained case by case. The results show that this simulation software provides more efficient and better decision on power transformers to the executives or planning engineers. Thus, they can make more appropriate contingency plans of their power transformers with an automated system.

Furthermore, the research offers theoretical, practical and academic contributions as follows:

Theoretical Perspective: The novel decision model has been investigated based on the financial measures of the asset with the utilization of reusable knowledge. Some of the existing theories have been applied in this research to meet the objectives.

Practical Perspective: The proposed decision model can solve the practical problems of an asset investment decision. The utility authority is informed about the financial and technical condition of each asset in the portfolio so that the provided decisions are relevant to the organizational context.

Academic Perspective: The proposed decision model can be applied to many kinds of substation assets, although this model is provided to effectively assess the life cycle of asset which primarily focuses on the power transformer. The researchers need to capture, analyze and model the knowledge components required for these domains. However, the financial model and knowledge based model frameworks, and decision rules can be straightforwardly applied to attain the required knowledge and fit into the decision model to effectively assess the life cycle of these assets.

6.2 Future Work

The future work related to this research can be summarized as follows:

- The main focus of this research is to propose methodologies to effectively assess the life cycle of the power transformer during load violation and highlight the optimal decision. The proposed methodology can be extended to apply to the whole assets in the substation. The procedures and knowledge required for these assets need to be identified and categorized. The operation and maintenance behavior, and health index differ from power transformer. In this way, future research can be carried out through the extension of the proposed methodology to the whole assets of substations.

- The proposed methodology has attempted to maximize the utilization of assets during their financial designed life. It is interesting to investigate the life cycle assessment of assets beyond their financial designed life because the assets still have technical life remaining and the power utility can achieve further financial benefits. This can be investigated in the following ways:
    - Assess and manage the risk of the asset.
    - Identify the remnant life of the asset.
    - Include a refurbishment scenario in the decision rule and modify the decision rule
- In this research, hidden knowledge is used to provide both technical and financial benefits during life cycle assessment. In order to fully utilize the knowledge, engineers or technician from the power utility must learn the skills and techniques from the experts to operate and maintain the asset. It is important to understand the learning rate of the employees for each tasks involved during the life cycle of the asset. Thus, there is a requirement to investigate the learning curve of asset over its life cycle.
- This research has been conducted based on some assumptions and applied to a Nepalese context. It would certainly offer benefits to power utility companies and can be adapted to other power utility contexts if the proposed framework can be extended by removing the assumptions and undertaking the necessary adaptations.
- Considering some of the limitations in the rule-based algorithm, other optimization techniques such as genetic algorithm, decision tree or graph algorithms could be investigated to solve the optimization problem of power transformers with large number and more scenarios.