

# Chapter 8

## CONCLUSION AND FUTURE SCOPE

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### 8.1 CONCLUSION

Methodology for offline ATC assessment and enhancement has been developed to utilize real-time ATC estimation using ANN-based architectures. The ANN-based systems require a huge amount of data, therefore to generate input PMU data for developing a real-time ATC estimator, a PMU emulation algorithm would be required. Thus, a PPMU algorithm for quasi-static analysis of power systems has been conceptualized. In changing scenarios, with large scale integration of renewable energy sources, the near-real-time load forecasting mechanisms becomes vital. Hence, a near-real-time load forecasting method has been proposed whose performance has been compared with that of SVM based estimator.

The developed method for PPMU emulation and offline ATC estimation has been utilized in amalgamation to obtain training data for creating an ANN-based ATC estimator. The radial basis function-based ANN architecture has been proposed whereby a sparse filter algorithm has been utilized for reducing the dimensionality of the input features to the ANN. The developed estimator has been tested for real time-application using RTDS communicating to MATLAB based command and control and sending GTNET PMU data through OPENECA interlink.

Analyzing the effect of transformation in the transportation and generation sectors at distribution levels requires the development of platforms for integrated analysis of transmission and distribution systems. For this, we have developed a multi-agent-based framework for integrated transmission and distribution system. This framework has been

employed to assess the impact of deploying Volt-VAR optimization through CVR, and DER penetration in the active distribution network. We have also analyzed the effect presence of Electric Vehicle and Micro-Grid as an element of the active distribution system and proposed two indices  $ATCV_{factor}$  and  $ATCE_{factor}$  for the same.

The effect of considering the blockchain-based energy transaction on the aggregated load profile and available distribution capability of the active distribution system has also been analyzed through the  $BC_{ef}$  factor. The technique presented has been applied to a modified IEEE 123 bus distribution system. It could be inferred from the results that the appropriate utilization of the blockchain-based system could help in managing both economic and operational aspects of the active distribution system.

## 8.2 FUTURE SCOPE

The research reported in this thesis extensively covers various aspects of monitoring, analysis, and control of integrated transmission and distribution systems under the purview of ATC/ADC. The blockchain-based energy transaction has also been considered at distribution levels for their impact assessment. Taking the research further would require the following aspects to be considered: -

- Analyzing the behavior of the proposed real-time ATC estimator under the umbrella of cyber-physical systems with due adherence to probable cyber-attacks.
- Upgrading the developed multi-agent system based framework of ITD to facilitate dynamic analysis.
- Developing full-scale blockchain-based distributed applications suitable for the Indian distribution sector.
- Developing Spatio-temporal models for electric vehicle charging stations depending upon the charging behavior and driving patterns of the EV owners and analyzing their aggregated impact of integrated transmission and distribution systems.
- Analyzing the effect of cyber-attacks on ATC/ADC assessed in real-time using real-time data streams.
- Analyzing the effect of probable cyber-attacks on ADMS (Advanced distribution management servers) systems operating at distribution levels and its likely impact on the ITD system.