

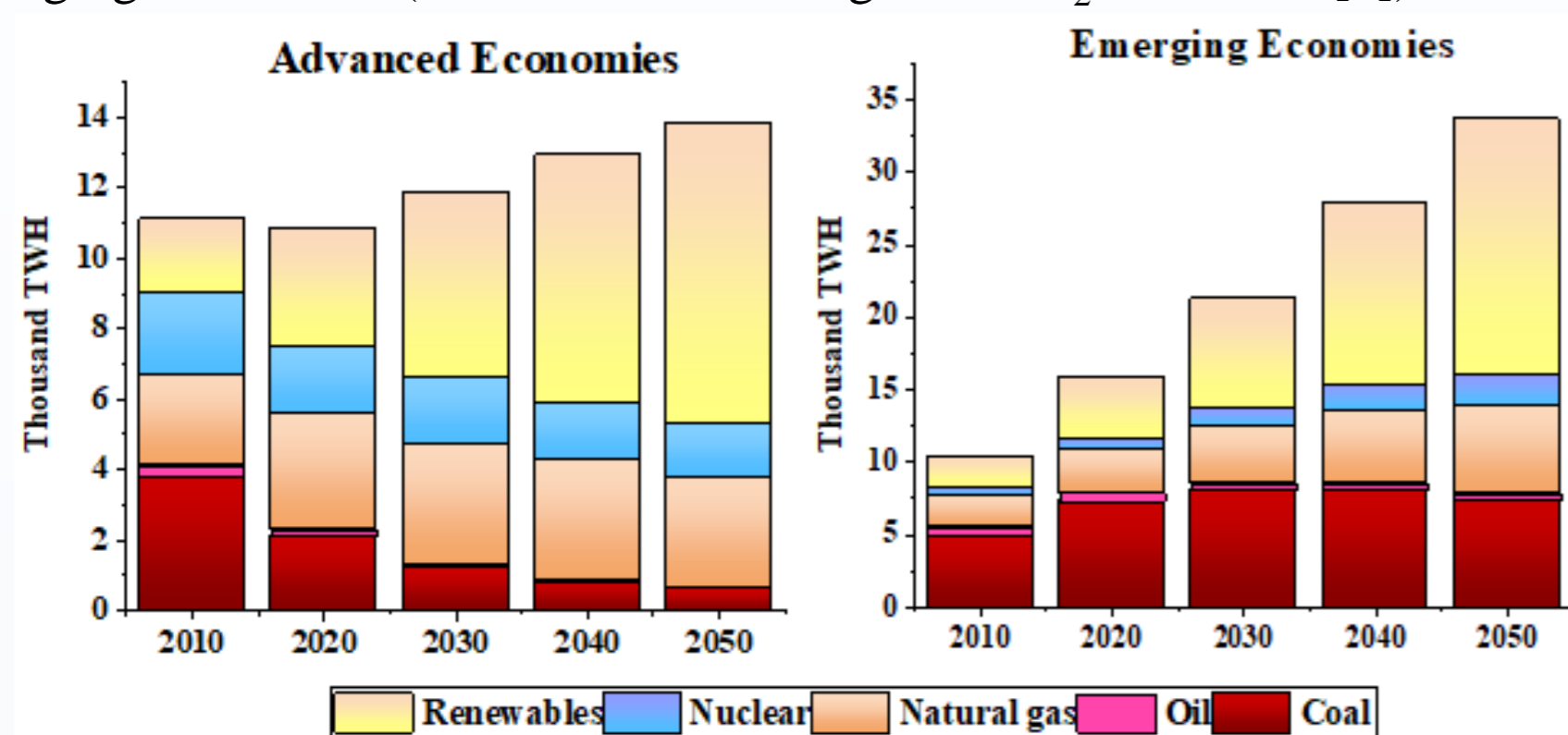
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Introduction

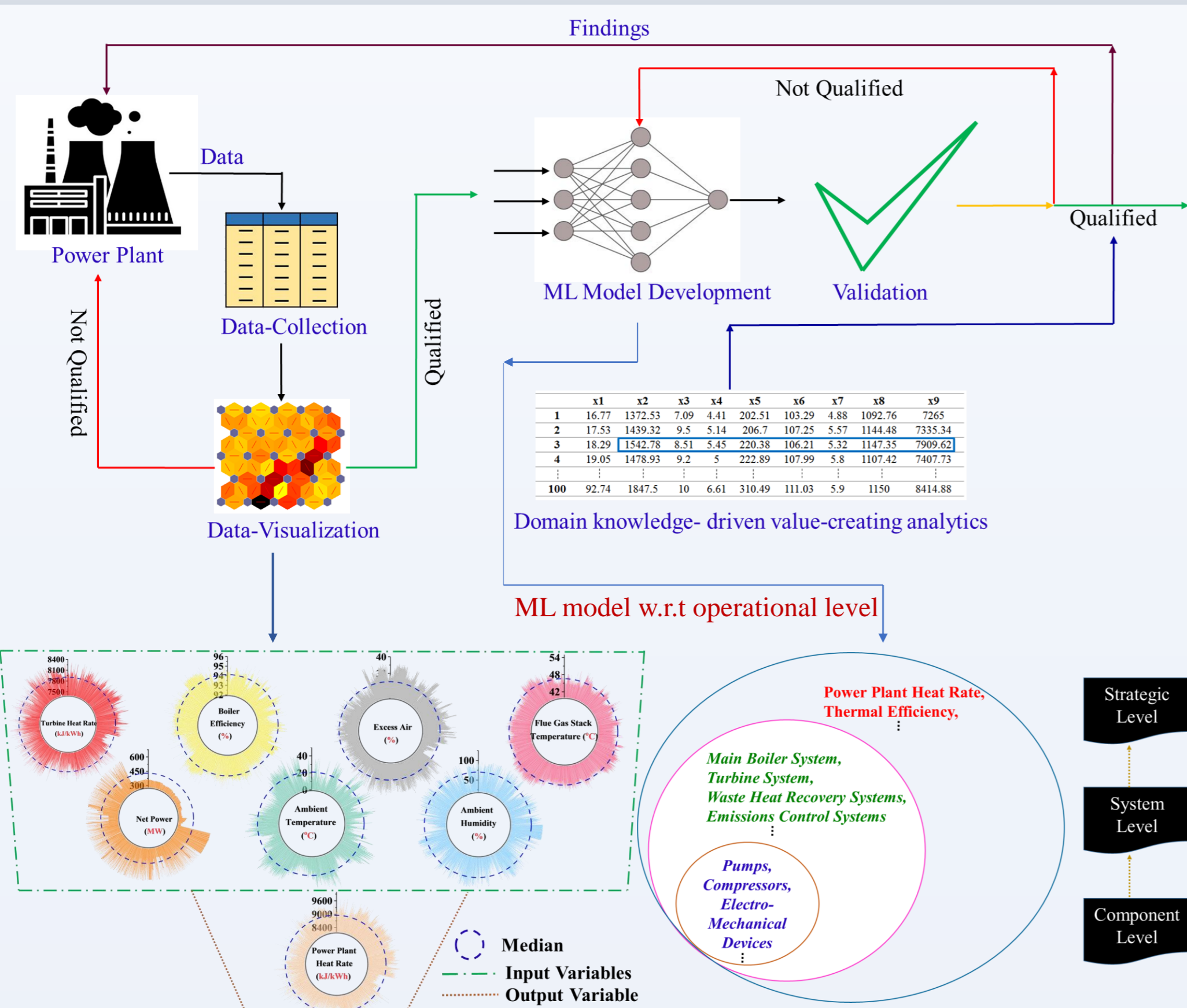
- Large industrial complexes store heaps of valuable operational data that is severely under-utilized to enhance their operational excellence
- Data is the fuel to maintain smart operation of complex industrial processes which are controlled on hyperdimensional input space
- The operation of large industrial complexes is categorized into component, system and strategic level and the performance indicators are either of quantitative or qualitative nature
- The choice of machine learning (ML) model is critical and should be relevant to the nature of problem (quantitative or qualitative)
- A systematic and generic methodology demonstrating the step-wise procedure for reliable implementation of machine learning based analytics is lacking
- Supporting energy efficient operations is critical to contribute to net-zero from the electrical power generation sector which is dominated by fossil fuels for emerging economies (coal causes 40% of global CO₂ emissions [1])



Objective

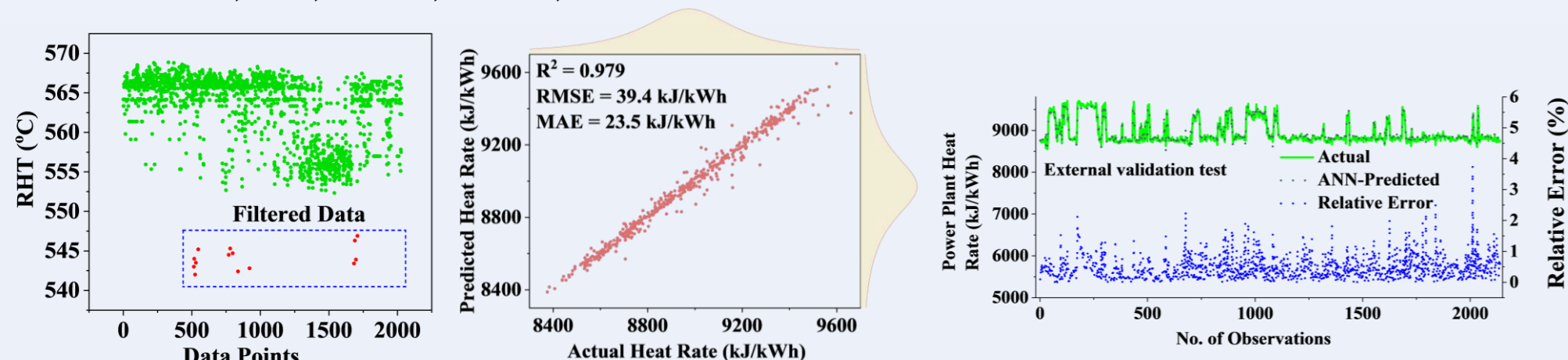
- To exploit the true potential of machine learning algorithms for the operational excellence of large-scale industrial complexes including power generation systems
- To contribute to net-zero goal from the energy sector by machine learning

Methodology



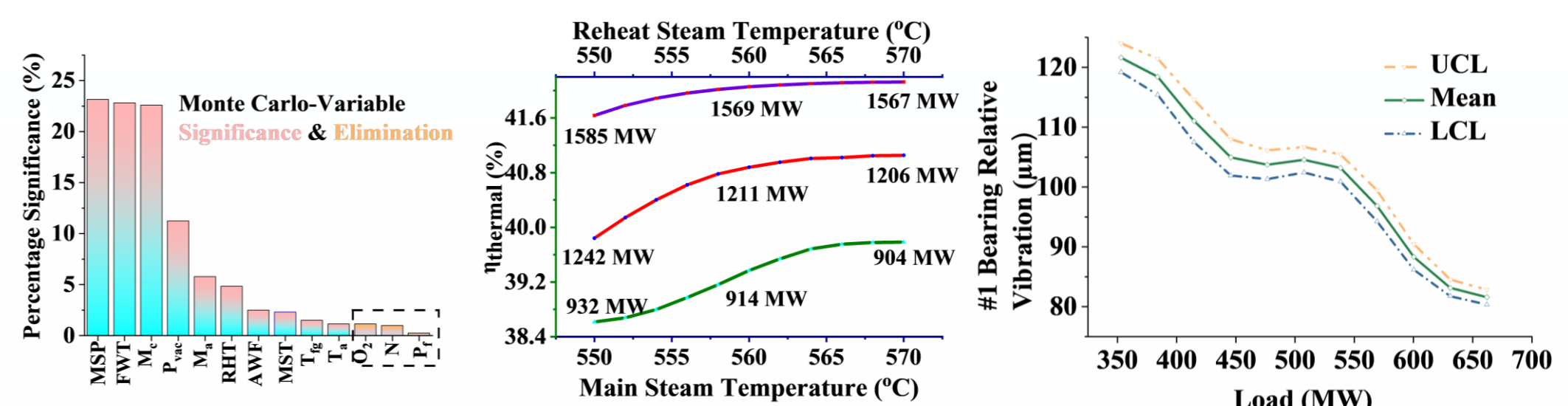
Results

- Deployment of extensive data-cleaning and various pre-processing techniques to enhance data quality
- Development of problem-specific (qualitative or quantitative nature) ML models, i.e., ANN, SVM, ELM

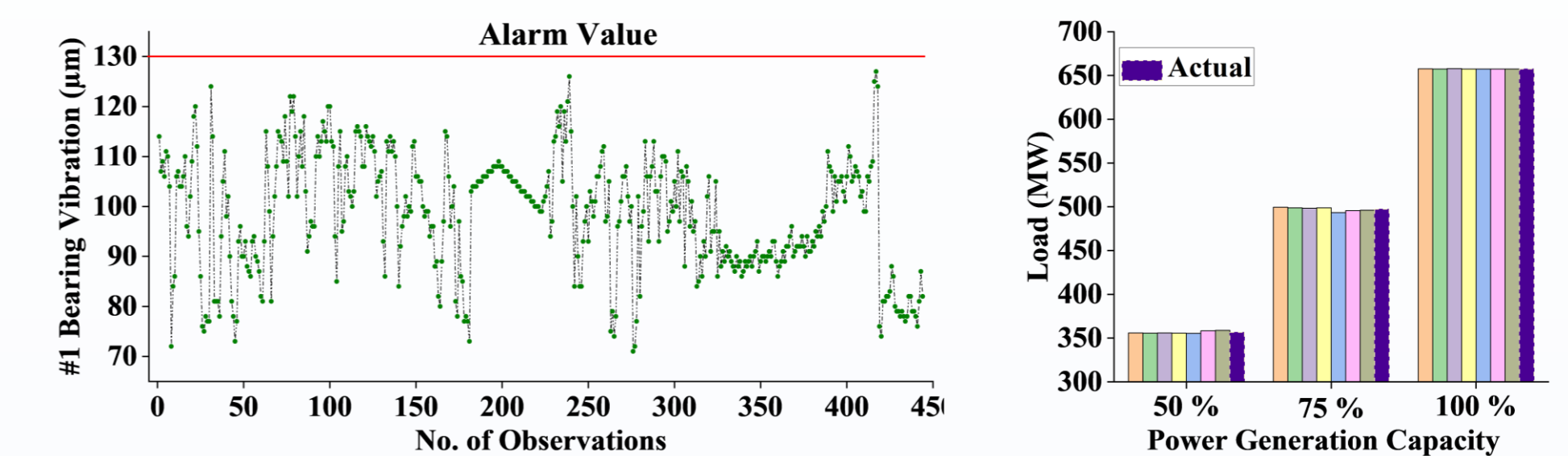


Results

Variables significance analysis and parametric study corresponding to different operational nature problem (component – strategic)

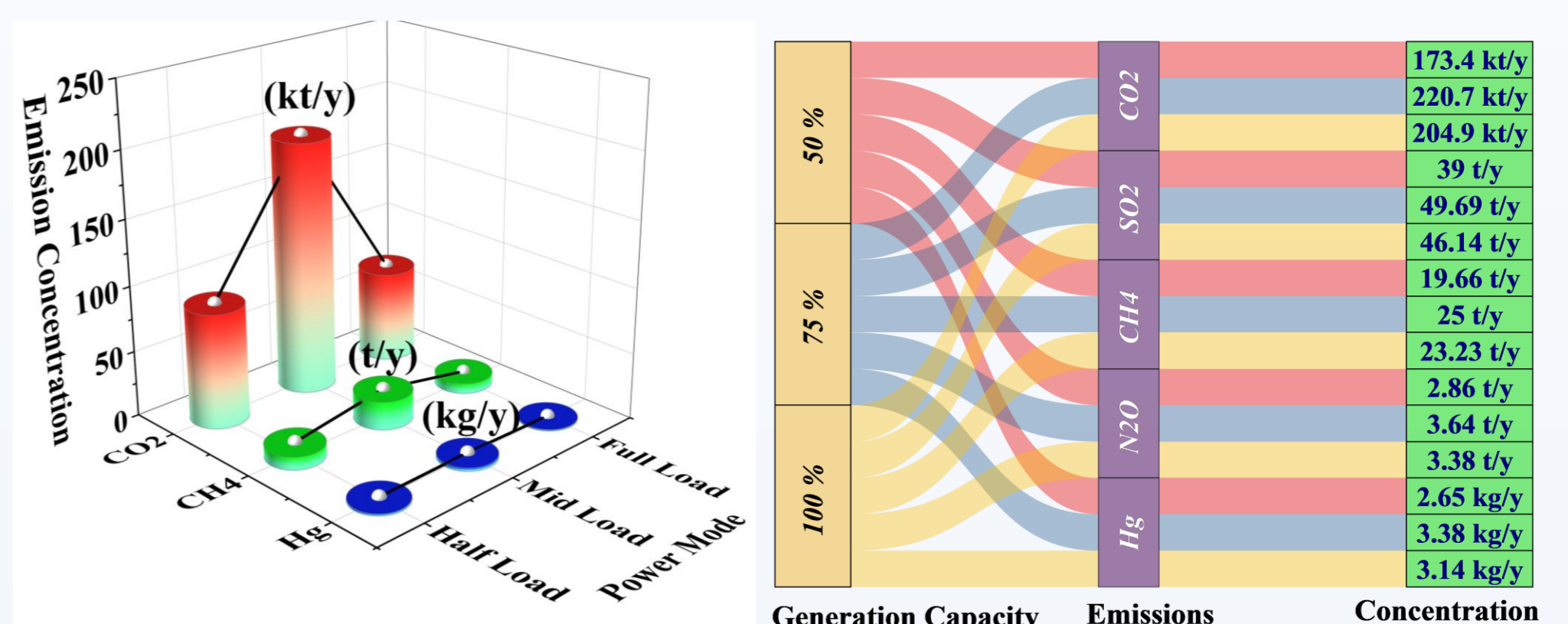


Validation of simulated results of different operational nature problem (component – strategic) on the power plant operation



Energy efficiency enhancement and emissions reduction as the result of ML-driven operational excellence for the power generation [2,3]

| Generation Capacity | State | \dot{m}_f (t/h) | Thermal Efficiency (%) | Heat Rate (kJ/kWh) |
|---------------------|--------|-------------------|------------------------|--------------------|
| 50% | BAU | 138 | 39.41 | 9135 |
| | RSM-SV | 134 | 40.70 | 8846 |
| 75% | BAU | 195 | 38.97 | 9239 |
| | RSM-SV | 183 | 41.60 | 8653 |
| 100% | BAU | 241 | 41.89 | 8594 |
| | RSM-SV | 235 | 42.83 | 8406 |



Conclusions & Future work

- ML models like ANN, SVM and ELM are trained under rigorous hyper-parameters tuning for modelling the operational performance parameters corresponding to component, system and strategic level of a 660 MW supercritical coal power plant
- Variables significance analysis and extensive parametric study are conducted, and the results are supported by the domain knowledge of the power plant
- The ML model-simulated findings are validated on the real-operation of the power plant and significant savings in fuel consumption, improvement in energy efficiency and significant reduction in emissions (210.2 kt/y) are achieved [2,3]
- The energy efficiency improvement and emissions reduction potential using machine learning enabled modelling and optimization of fossil-based global energy assets (coal, gas and oil), and quantifying the performance enhancement under uncertainty

References

- [1] IEA, 2021, "An Energy Sector Roadmap to Carbon Neutrality in China; <https://www.iea.org/reports/an-energy-sector-roadmap-to-carbon-neutrality-in-china>.
- [2] Ashraf, W. M., Uddin, G. M., Arafat, S. M., Krzywanski, J., and Xiaonan, W., 2021, "Strategic-level performance enhancement of a 660 MWe supercritical power plant and emissions reduction by AI approach," Energy Conversion and Management, 250, p. 114913
- [3] Ashraf, W. M., Uddin, G. M., Ahmad, H. A., Jamil, M. A., Tariq, R., Shahzad, M. W., and Dua, V., 2022, "Artificial intelligence enabled efficient power generation and emissions reduction underpinning net-zero goal from the coal-based power plants," Energy Conversion and Management, 268, p. 116025.

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