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AI-Driven Affinely Adjustable Robust Many-Objective Scheduling Framework for Flexibility-Oriented Power Systems with High Renewable Penetration

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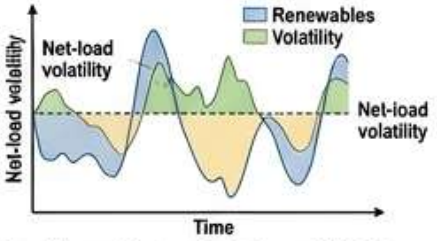
INTRODUCTION & AIM

- High Renewable Energy Sources (RESs) penetration.
  - Net-load volatility,
  - Rapid ramping.
  - Flexibility mismatches.



- Traditional deterministic and UC-based methods lack adaptability
  - Lack adaptability
  - Computationally intensive.

AIM

To propose a novel AI-driven, **flexibility--oriented Affinely Adjustable Robust Optimization (AARO)** framework for large-scale, scenario-rich power systems.

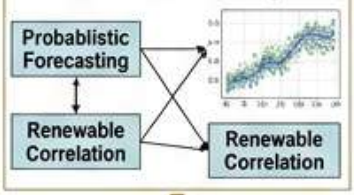
AIM

METHOD

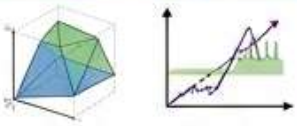
METHODOLOGY

AI-Driven Forecasting

Probablistic forecasting

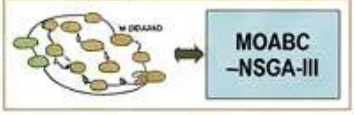


Generalized Linear Polyhedron (GLP)-Based Uncertainty Modeiing



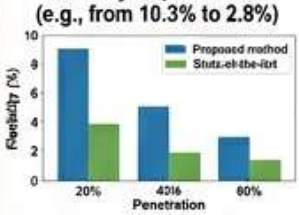
Explicit Ramp-Based Flexibility Quantification

Hybrid MOABC–NSGA-III Many-Objective Scheduling

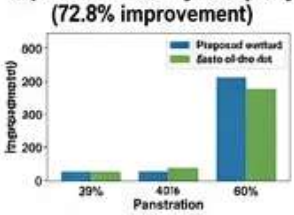


RESULTS & DISCUSSION

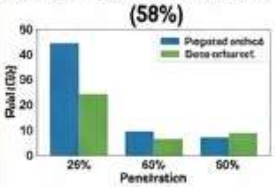
Flexibility Gap Reduction (e.g., from 10.3% to 2.8%)



Improved Flexibility Adequacy (72.8% improvement)



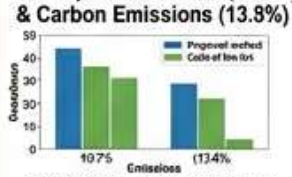
Reduced Renewable Curtailment (58%)



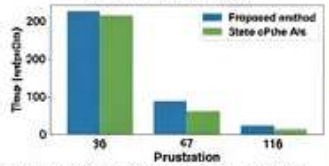
Decreased Flexibility Risk Index (FRI) (approx 78%)

	Proposed method	State-of-the-Art (FRI)
30	10.3%	3.8%
57	10.3%	2.6%
37	16.3%	2.6%
118	30.2%	13.3%
Total	10.3% to 12.5%	2.6% to 2.8%

Total Operational Cost (10.7%) & Carbon Emissions (13.8%)



Computational Execution Time (>80% reduction)



Results: Pro-medified IESE 20-, 118-bus, modffied IEEE 30-, 57-, and 118-bus systems

Rssults: Compard modified IEEE 30-, 118-bus systems, modified IEEE 30-, & 57-, and 118-bus systems

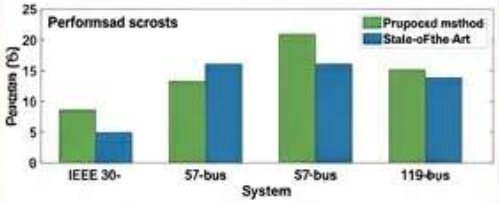
Keywords: Power system flexibility; renewable energy integration; affinely adjustable robust optimization; generalized linear polyhedron; artificial intelligence forecasting; many-objective optimization; flexibility risk index; virtual power plant scheduling.

RESULTS RESULTS & DISCUSSIONS

- **AARO+GLP+Hybrid** method reduces conservatism, enhances robustness, robusnesm, improvemen, improves Pareto optimality, and provides stchnicaly conservation.
- Provides a scalable, entinialty-nowitual rigorous;, solution in'ack adaptabile templatioal methot:
  - High-Renewable[1]♀ eduction
  - Improves robustness
  - Renioves Pareto consili optimality
- Provides a scalable, **technically** solution in enent to brantute ramahos and provides a scalable, technically rigorous solution.

CONCLUSIONS

- Bomoate Flexibility to :enewable robust and consecor energy-rprtime for enhmpaneo·moneaties of proporable energy toa! flexibirility and derects.



Keywords: Power system flexibility; renewable energy integration; affinely adjustable robust optimization; generalized linear polyhedron; artificial intelligence forecasting; many-objective optimization; flexibility risk index; virtual power plant scheduling.

FUTURE WORK

- Apply to real-world grids for multi-multi-energy systems, impentising multi-energy systems.
- Investigate FRI ot minian soluttion.

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