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Impacts of Hydrological Dimensionality Reduction in Stochastic Energy Modeling of Interconnected Power Systems

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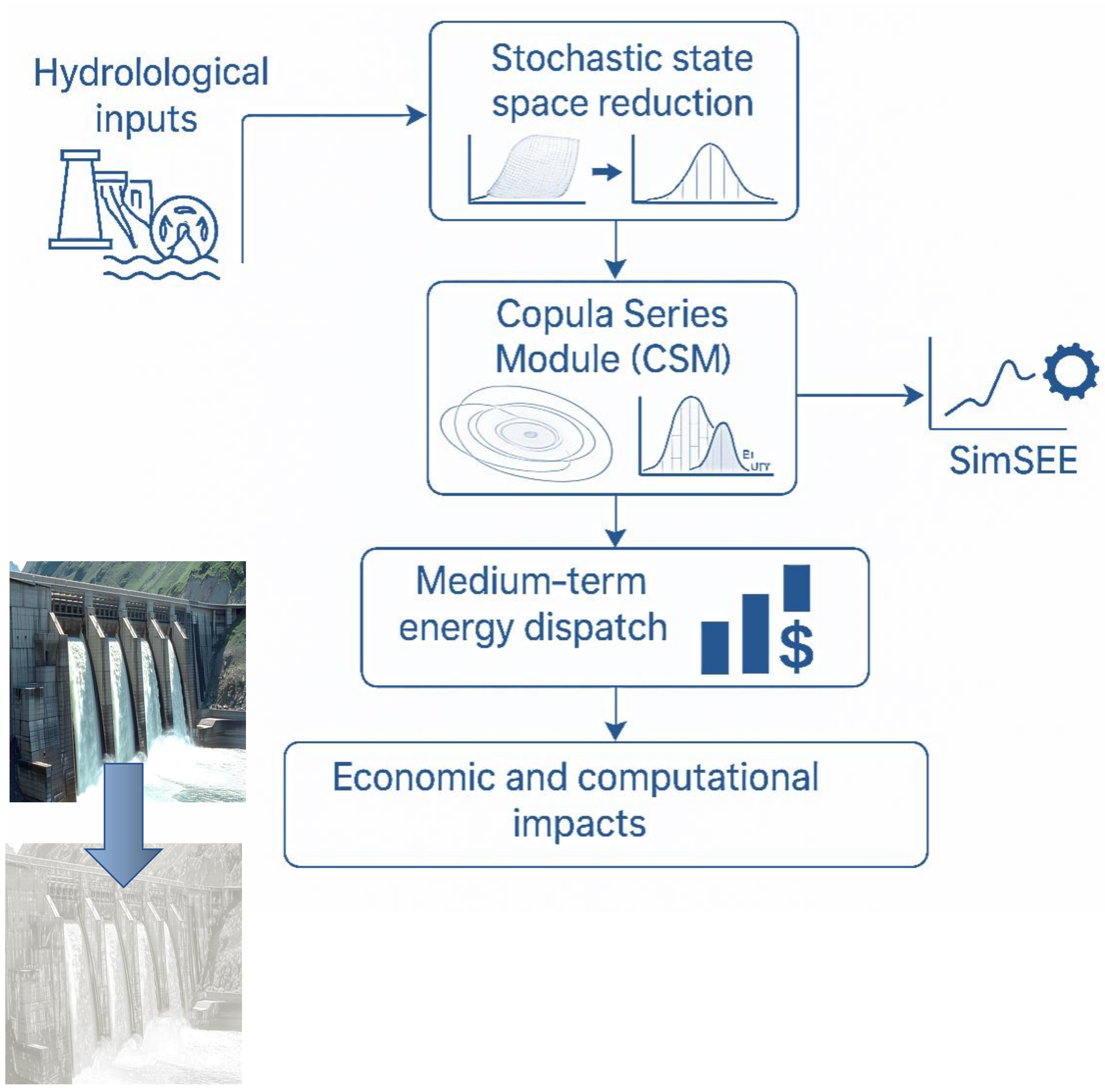
INTRODUCTION & AIM

- Hydrological inflows critically influence dispatch and economic performance in stochastic power-system modeling.
- To enhance computational efficiency without compromising realism, this study applies the CEGH method (Correlations in Gaussian Space with Histogram) to generate reduced yet representative hydrological states [1], assessing their impact on medium-term dispatch and system operation.

METHOD

- Workflow: Synthetic inflows → Case matrix → Simulation → Economic & flexibility analysis.



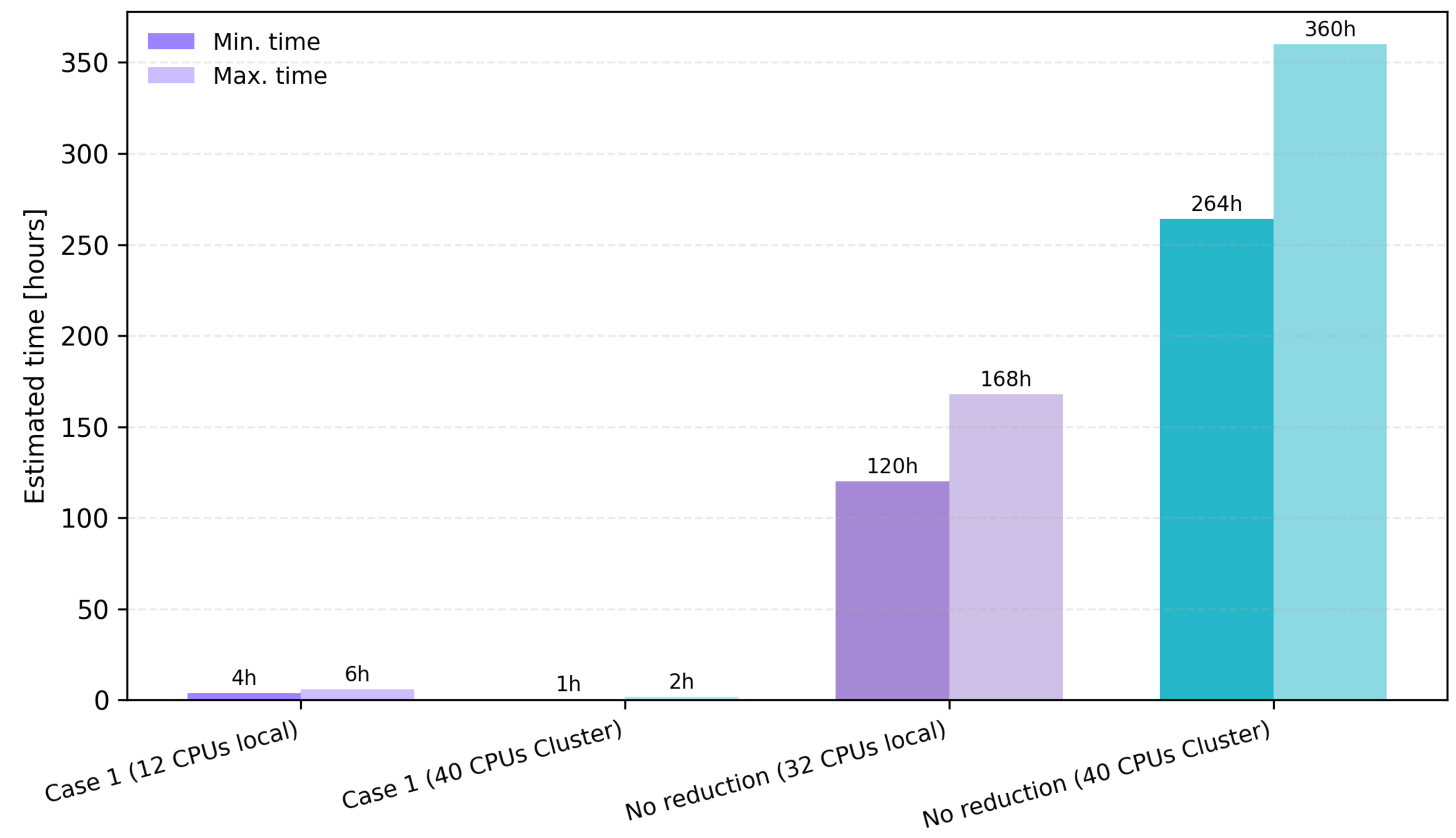
CONCLUSIONS

- Operational robustness: Reduced-state configurations sustain dispatch stability and maintain cost deviations within 4–15 %, ensuring consistency across hydrological regimes.
- Computational performance: Modeling time decreases from ≈ 122 h (full-state) to 2–6 h.
- Scalability and applicability: The proposed framework strengthens stochastic hydro-VRE coordination, offering a reproducible pathway for efficient, data-driven energy planning in interconnected systems.

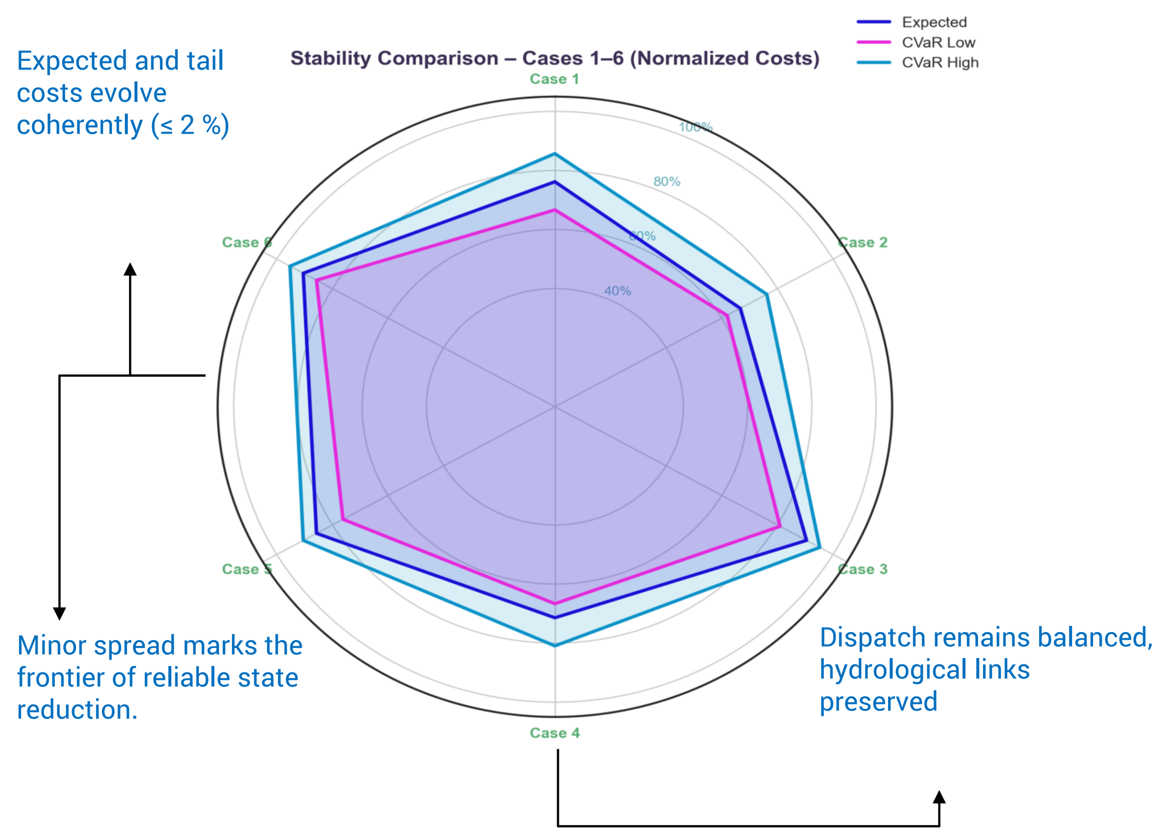
RESULTS & DISCUSSION

- State-space reduction cuts runtime from days to hours, preserving cost efficiency and stability.

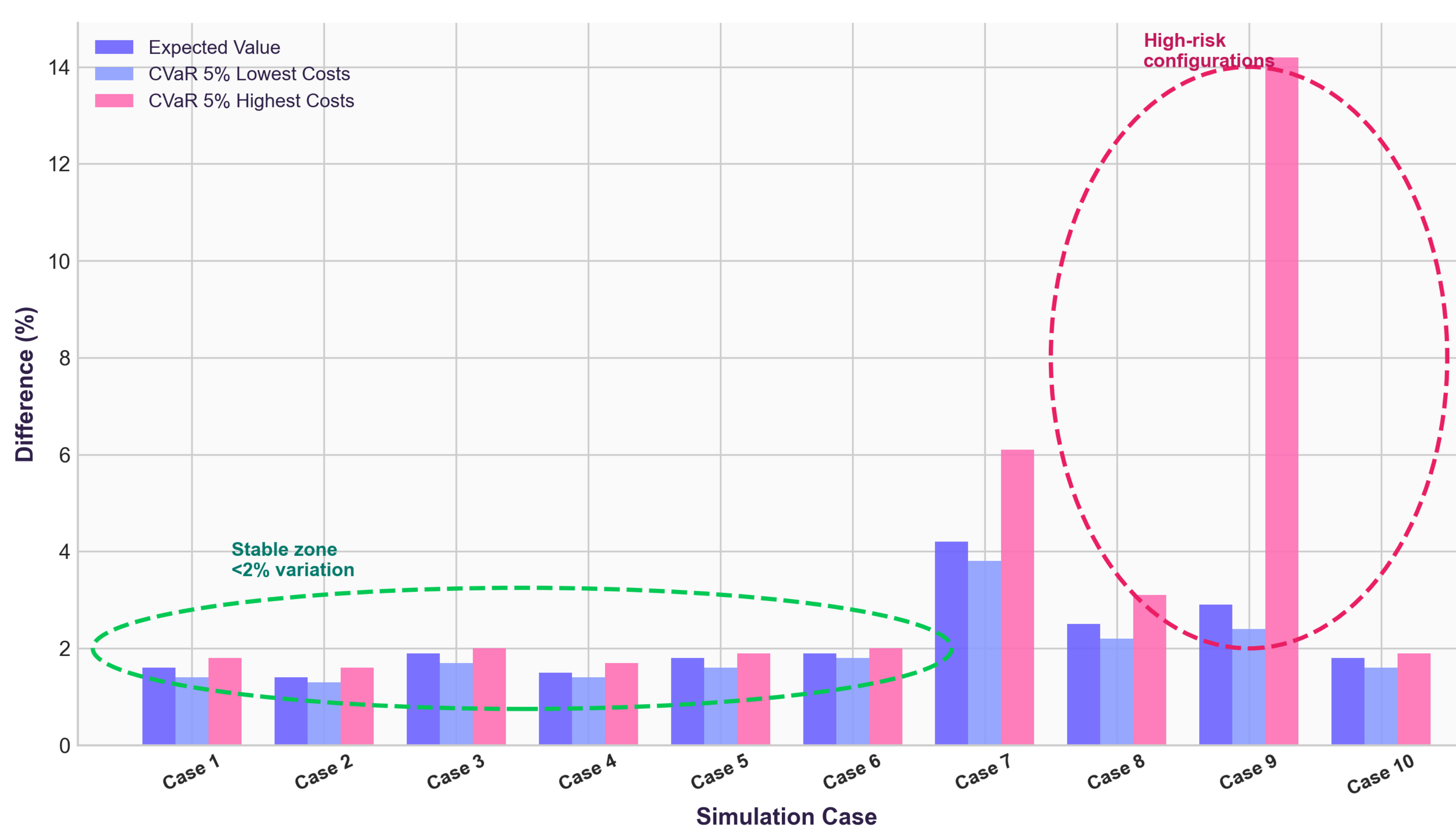
Comparison of Computational Time per Case



- Stable regime (cases 1–6): < 2 % deviation → consistent dispatch & hydrological coherence.
- Correlation onset (case 7): ≈ 3× volatility rise → onset of inflow decorrelation.
- Asymmetric exposure (case 8): CVaR ≈ 1.4 × → partial hydro synchrony loss.
- Amplification phase (case 9): CVaR ≈ 14 % → nonlinear cost escalation.
- Re-stabilization (case 10): minor spread → numerical weighting artefact.



Cost Indicator Variation under State-Space Reduction



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[1] Casaravilla G, Chaer R, and Alfaro P, “SimSEE Simulation of Electric Power Systems.” Accessed: Aug. 09, 2025. [Online]. Available: https://simsee.org/index_en.html