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Operational Control of the Power Grid through AI in the advent of Wildfire

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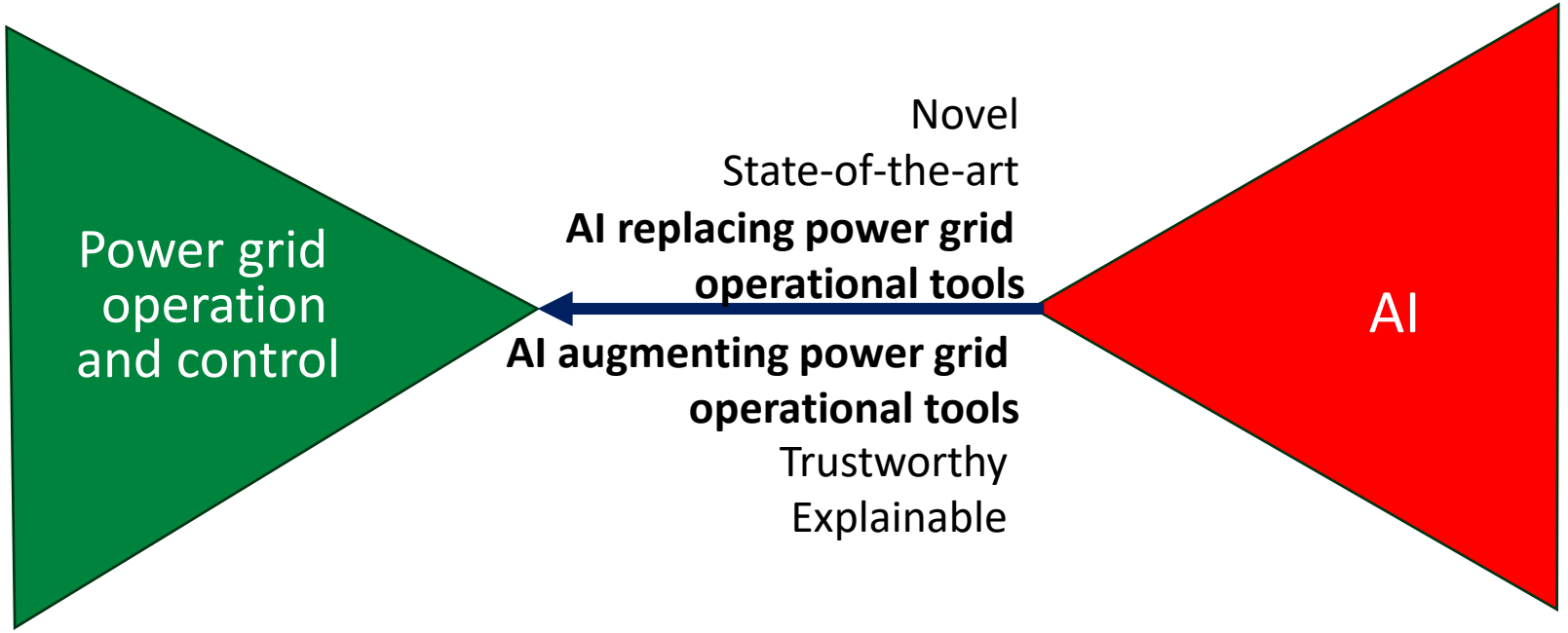
Panel Session in the Asian and Australasian Electricity Infrastructure WG of IPSC
(under EDPG of PES) for the 2024 IEEE PES General Meeting

Operation and Control of Future Grid



How do we augment/replace existing power grid operations with SOTA AI tools in the advent of wildfire?

Peripheral Tools

Risk mapping

Forecasting

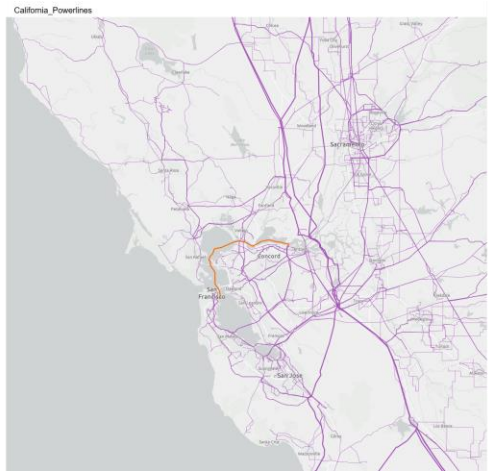
Situational Awareness

Power grid scheduling

Traditional Tools

AI Tools

Using LLMs for Risk Mapping



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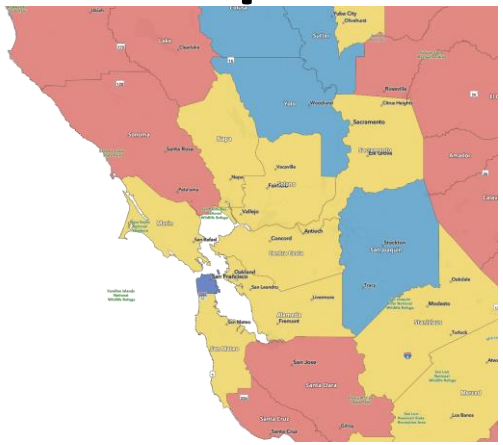
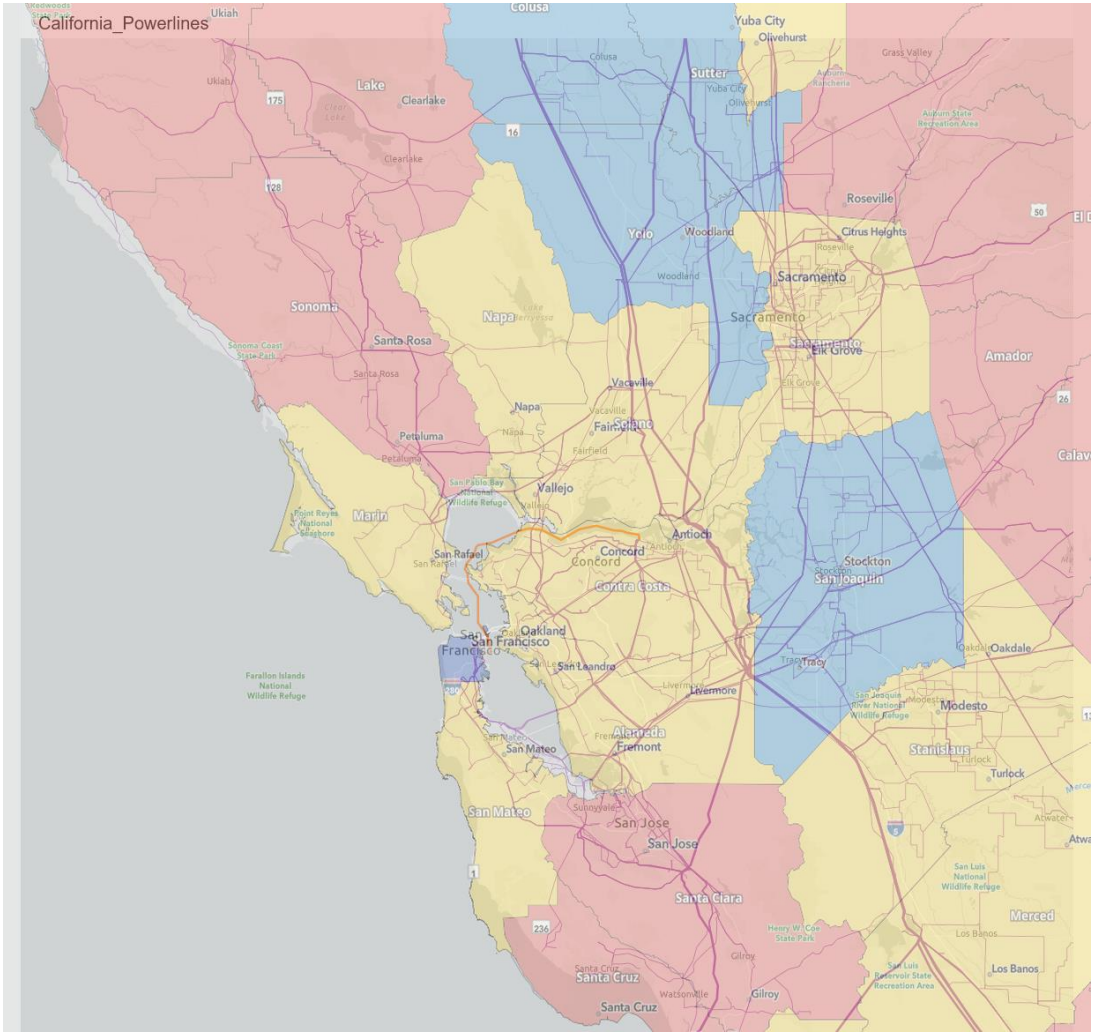


LLM Query



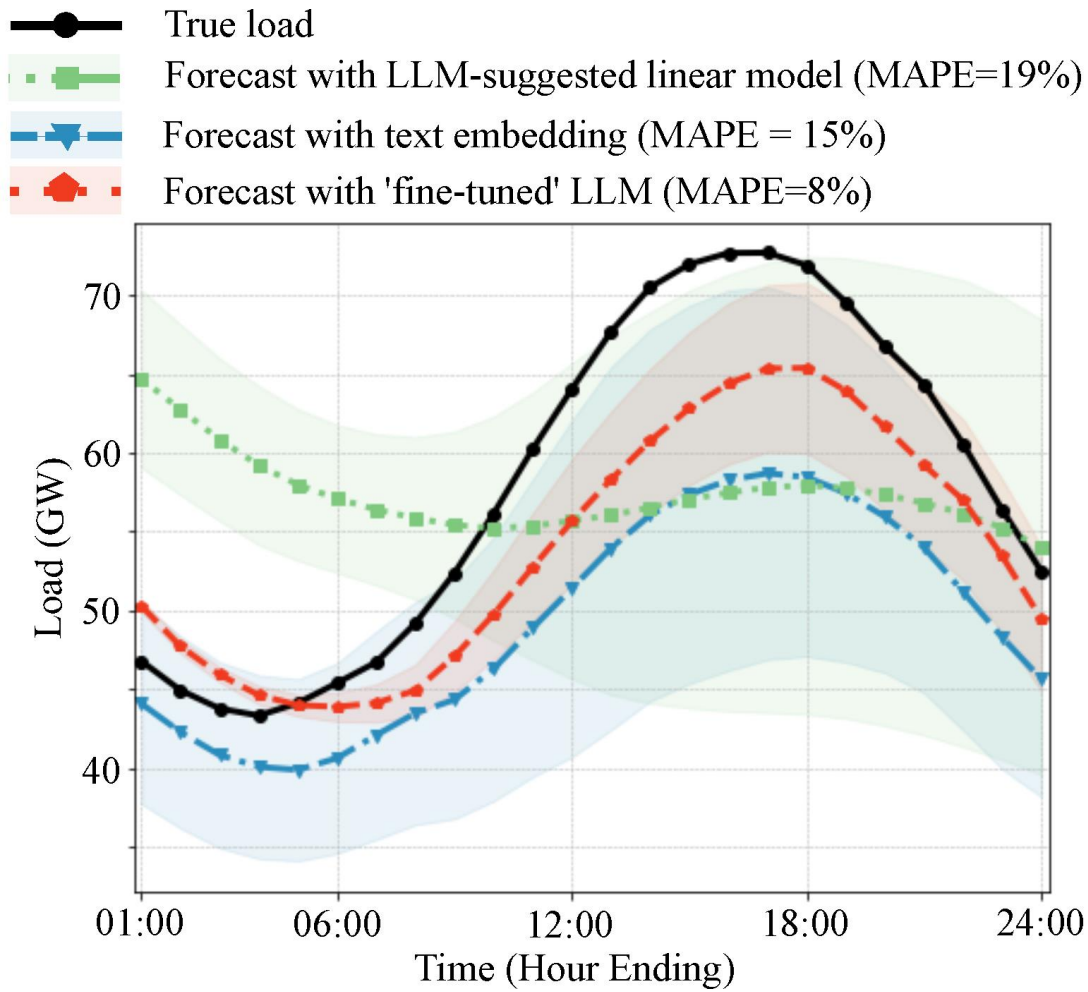
https://hazards.fema.gov/nri/map#
https://atlas.eia.gov/apps/895faaf79d744f2ab3b72f8bd5778e68/explore

Majumder, S., Dong, L., Doudi, F., Cai, Y., Tian, C., Kalathil, D., Ding, K., Thatte, A.A., Li, N. and Xie, L., 2024. Exploring the capabilities and limitations of large language models in the electric energy sector. *Joule*, *8*(6), pp.1544-1549.

Using AI-tools for load forecasting

Input Data:
1. Historic Temperature, Load
2. Temperature of the target day

Three ways to do the forecast:
1. Direct prompt with task description: Usually leads to linear regression model.
2. Text embedding:
a) Convert numbers into text in a specific way. “0”->”A”, “1”->”B”, …
3. Fine-tuning: Fine-tune the GPT with historical data.



https://www.ercot.com/gridinfo/load/load_hist

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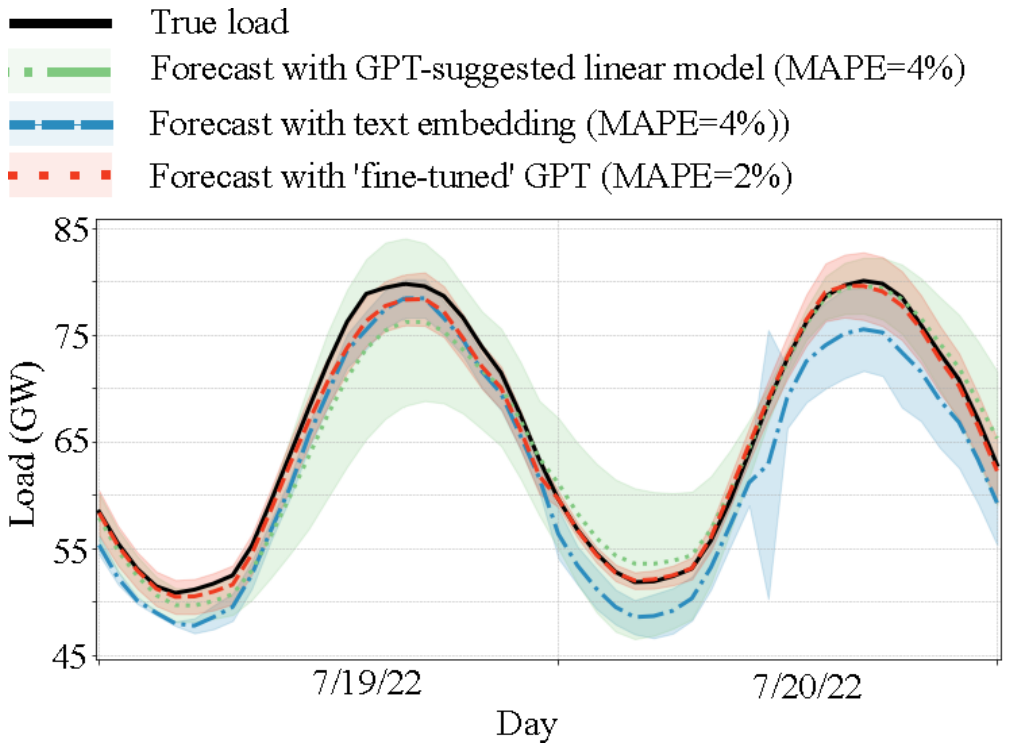
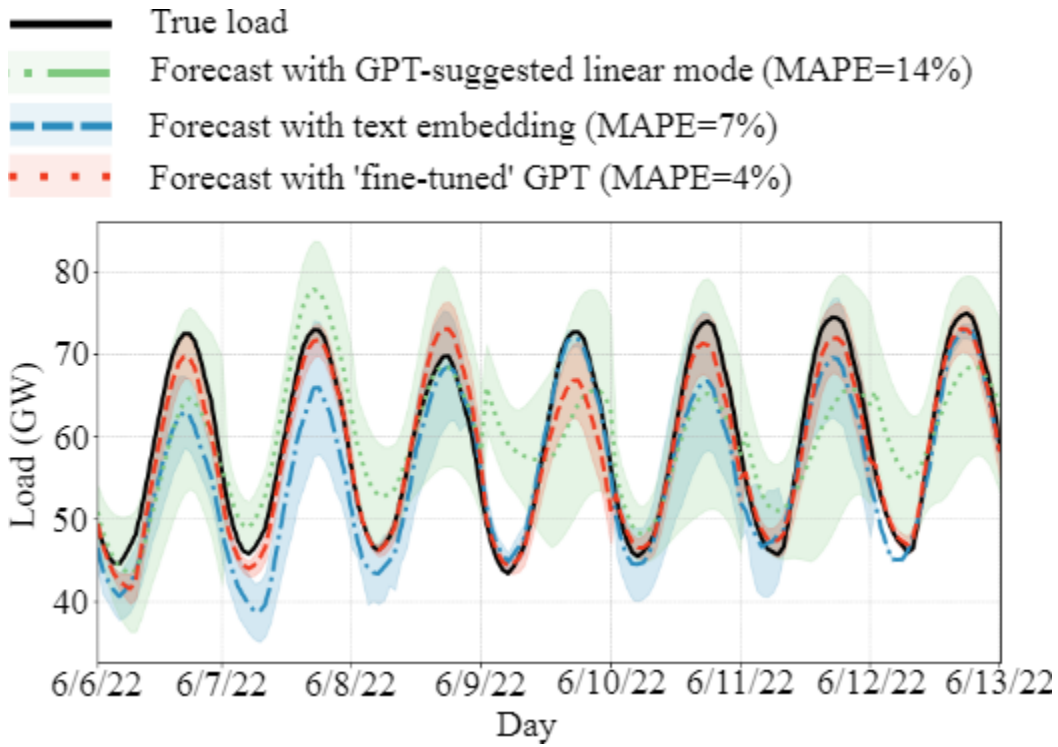
Using AI-tools for load forecasting

Peak summer months in Texas



Weakly load forecasting



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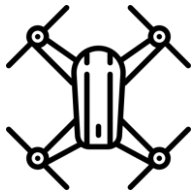
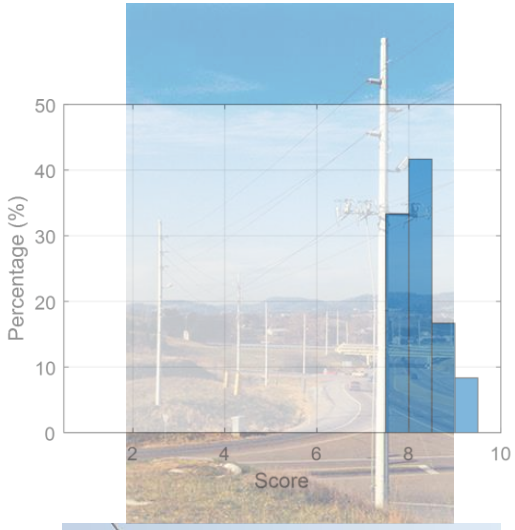
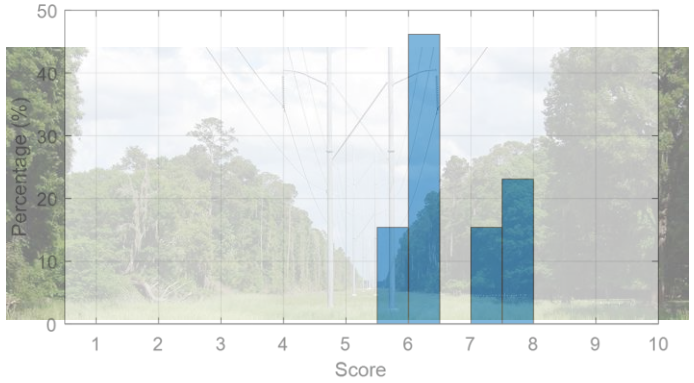
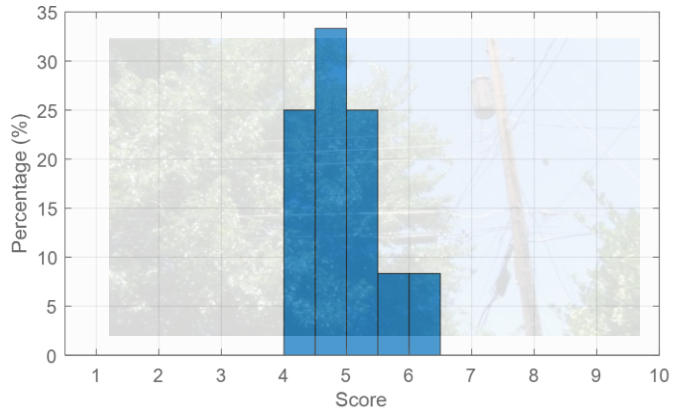
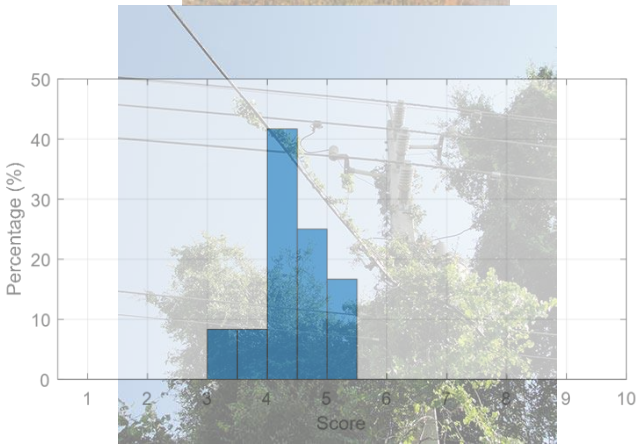
Using LLMs for Situational Awareness

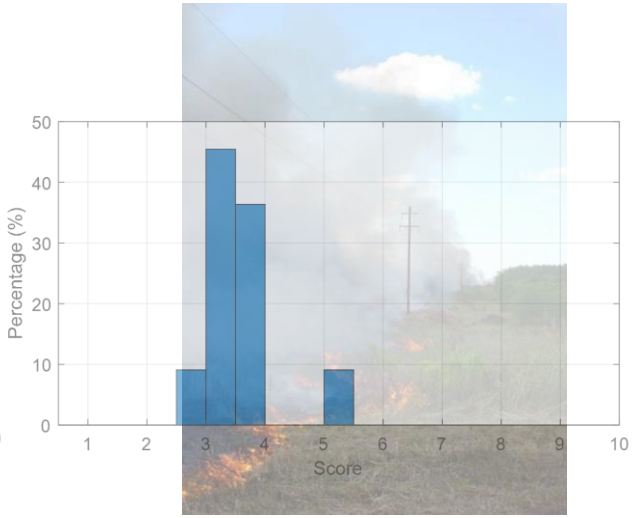


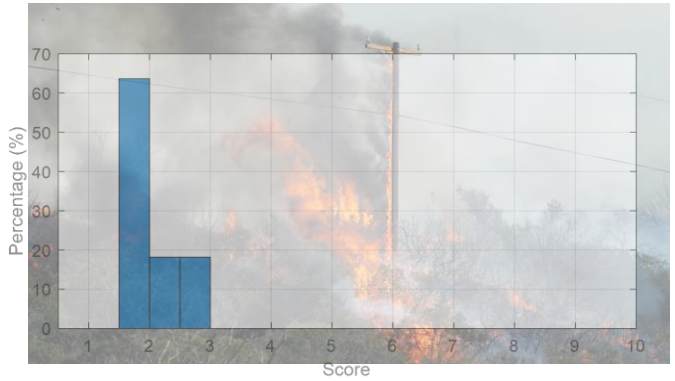












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https://www.hunter-ed.com/prescribedburn/studyGuide/Smoke-Powerlines/203025_169533/
https://www.theatlantic.com/technology/archive/2018/05/power-lines-are-burning-the-west/561212/
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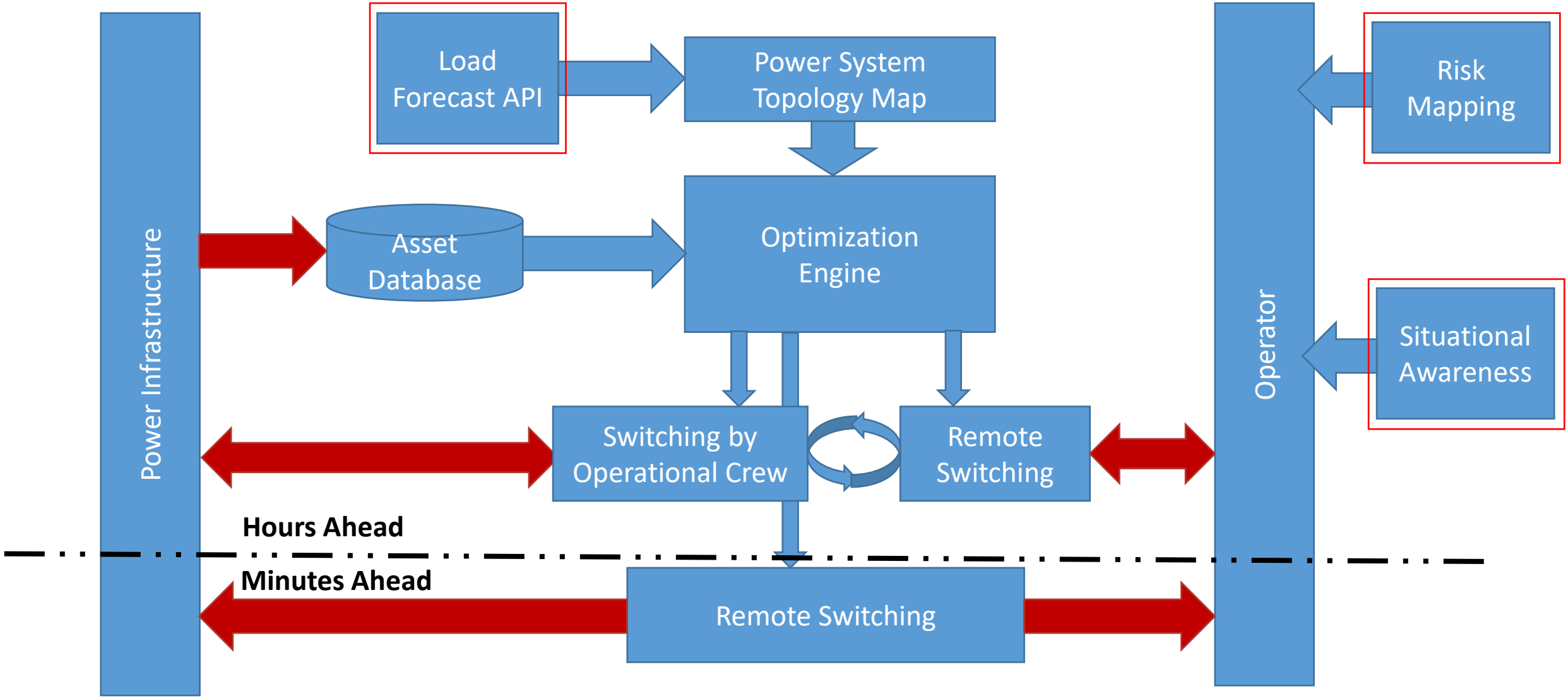
Give an aggregated safety score for this picture. Instruction: First, allocate a risk score between 0-10 for each of the following factors with 0 being the high risk and 10 being the low risk. If you are unsure about a particular aspect, give it a score of 5. My aggregated score will be the average of all individual scores. Factors: Vegetation Overgrowth, Live Wires, Structural Integrity, Falling Objects, Access Issues, Fire, and Smoke Inhalation.

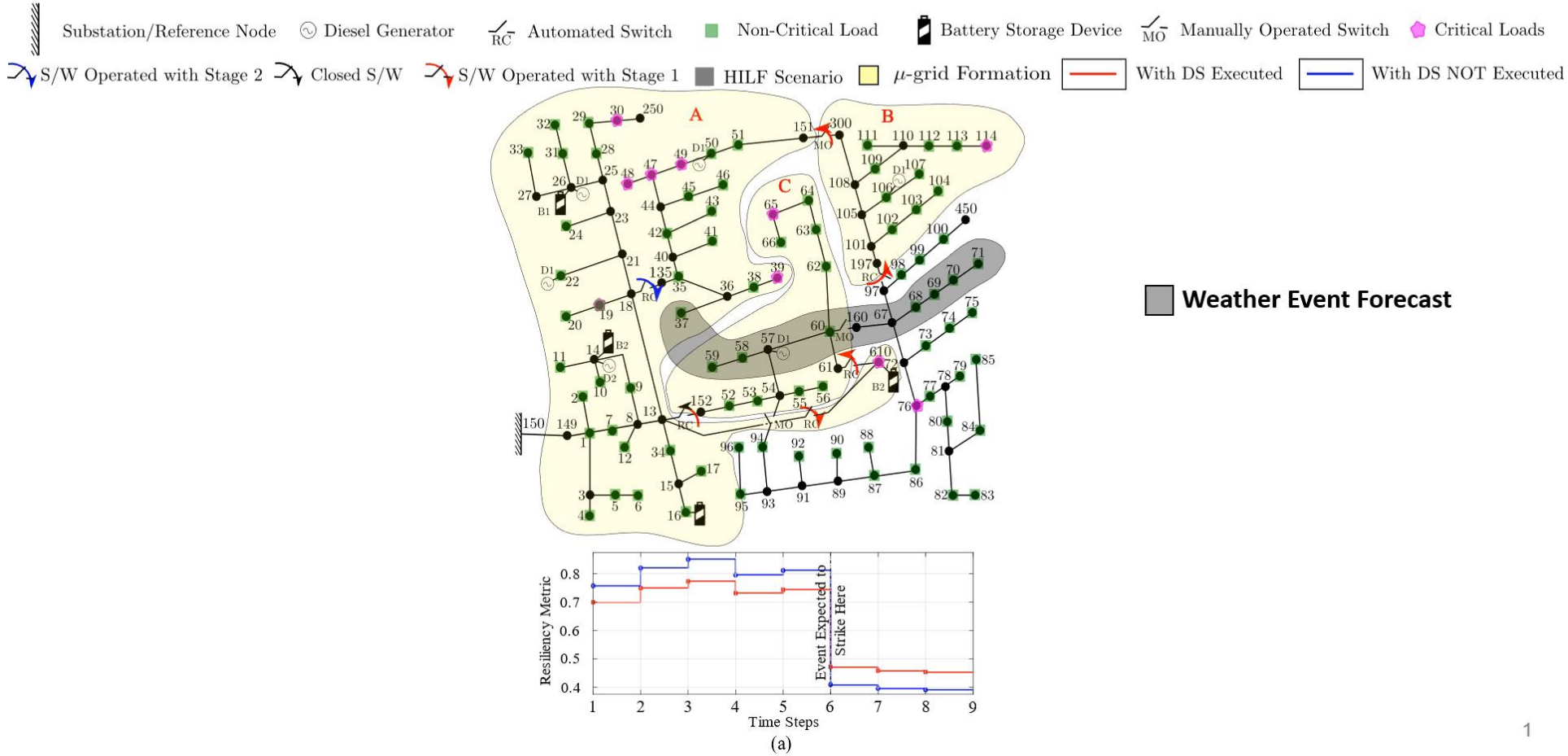
Traditional two stage proactive control



Majumder, S., Kandaperumal, G., Pandey, S., Srivastava, A.K. and Koplin, C., 2022. Pre-event two-stage proactive control for enhanced distribution system resiliency. *IEEE Access*, *10*, pp.83281-83296.

Traditional Proactive control: Demo

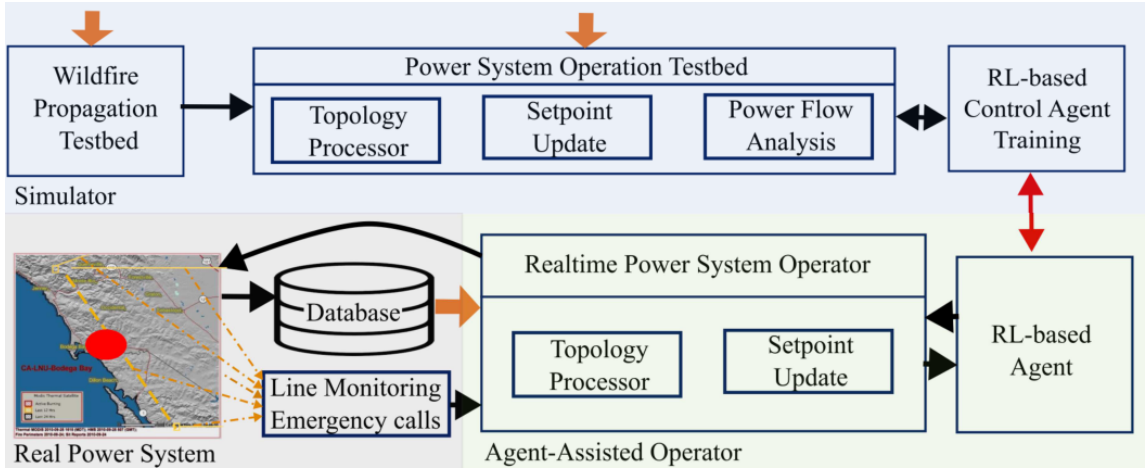
Decision Support Demonstration with IEEE 123 Node System

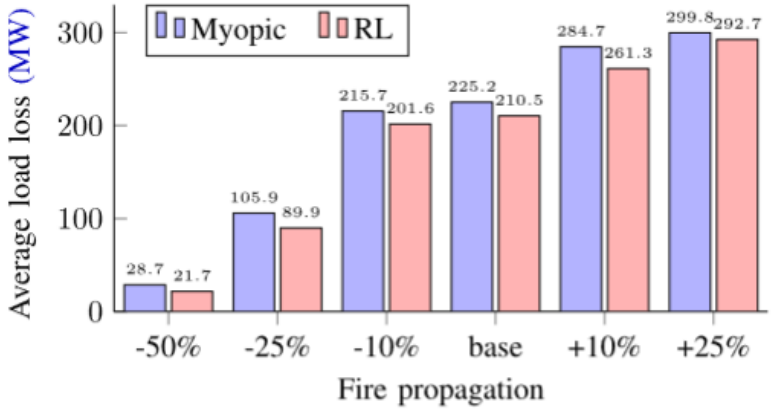


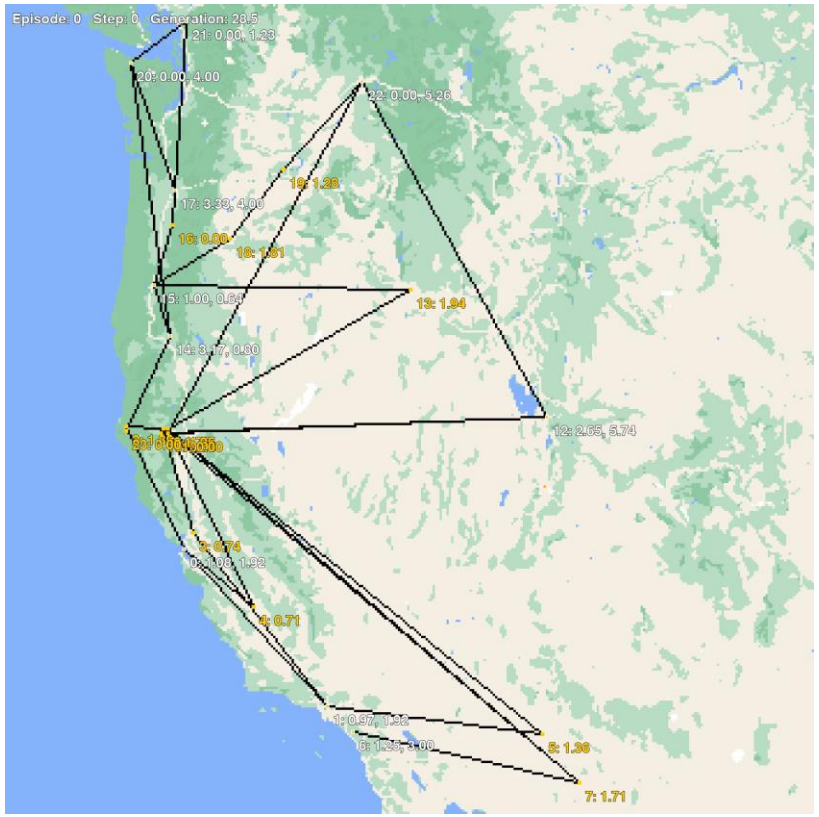
Weather Event Forecast

Majumder, S., Kandaperumal, G., Pandey, S., Srivastava, A.K. and Koplin, C., 2022. Pre-event two-stage proactive control for enhanced distribution system resiliency. *IEEE Access*, *10*, pp.83281-83296.

AI-based Proactive control







Kadir, S.U., Majumder, S., Srivastava, A.K., Chhokra, A.D., Neema, H., Dubey, A. and Laszka, A., 2023. Reinforcement-Learning-Based Proactive Control for Enabling Power Grid Resilience to Wildfire. IEEE Transactions on Industrial Informatics, 20(1), pp.795-805.

Summary

- AI tools demonstrate strong capability in assisting the power engineers during wildfire
- AI tools can remain at the periphery, or replace traditional control tools
- However, it is the ‘trust’ that prevents us from using AI tools

How do we remain conscious about limitations of AI tools; but use it judiciously in power grid decision-making?

Thank you!

Many thanks to my collaborators, mentors and funding agencies!