AI for Transmission Operations and Planning

Early Learnings and Direction of R&D at EPRI

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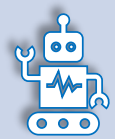
ESIG Fall Workshop, 2025
Philadelphia, PA

State of the AI in Energy Industry - Summary

Need for Automation		The need for automation (and AI)		AI for Process Automation / AI for Decision Making
Developing Use Cases		Good ideas but generally low level of maturity and adoption.		Difficult to set value use case ideas to prioritize
Solutions, Platforms and Technology		Platforms, cloud HPC solutions		Software technology providers, startups, developing solutions.

Embedding AI in EPRI R&D

INSIGHTS COMPLEMENT OUR EXPERTISE

INTEGRATING INTO EPRI SOFTWARE SOLUTIONS

SUPPORTING ADOPTION BY MEMBERS

Energy Sector AI Use Case Repository (coming soon)

Operators and Planners Need to Solve Problems

To do this, they:

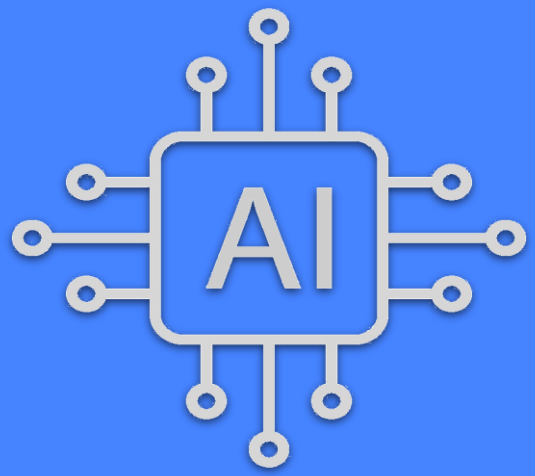
- **Make sense** of models, alarms, trends, guidelines, reports, etc.
- **Make decisions** based on forecasts, simulations, risk
- **Take actions** by writing reports, dispatching, investing, etc.

The challenge:

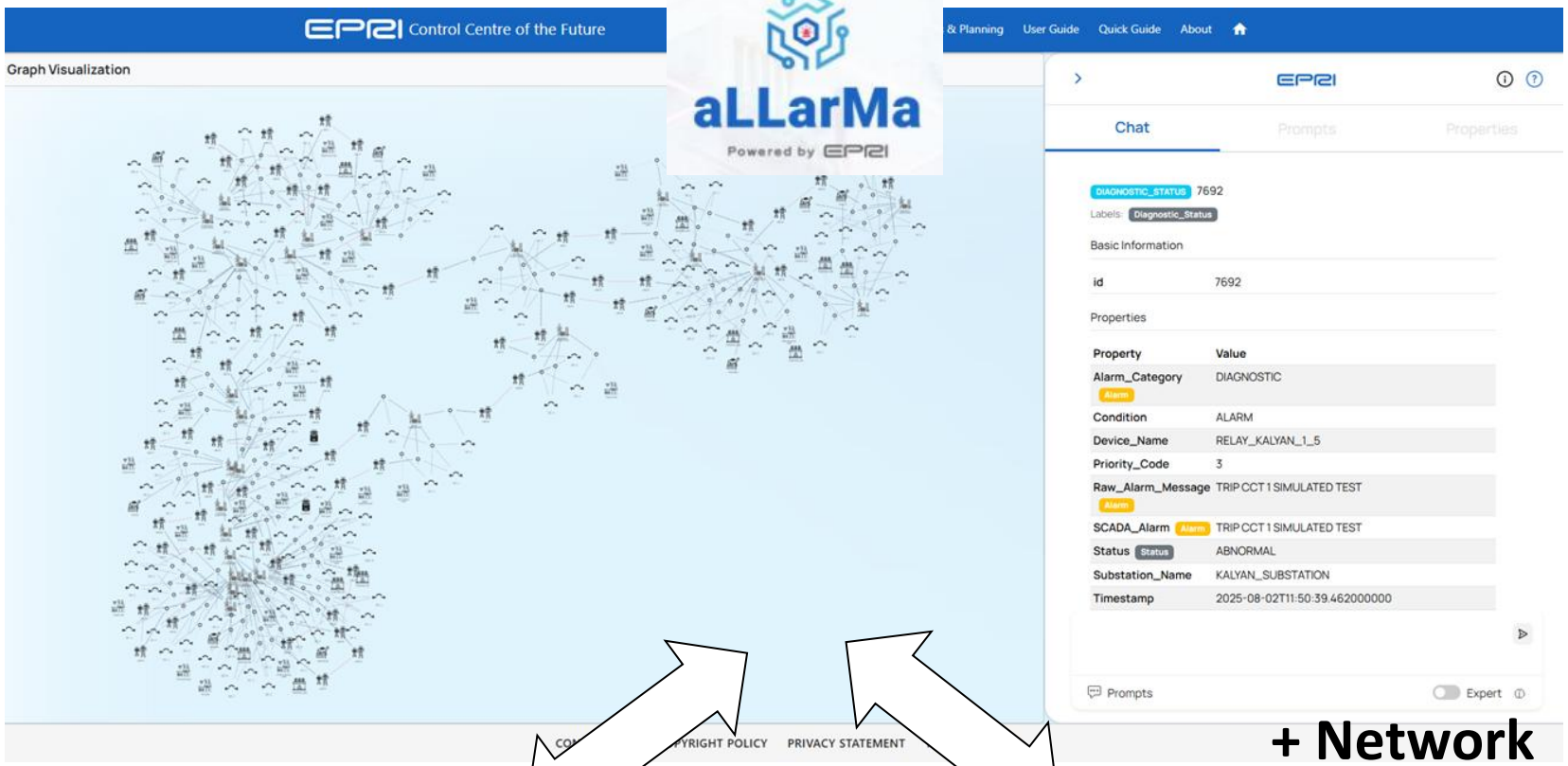
- **More data** to manage and scenarios to consider
- **Less experience** in dealing with new conditions
- **Greater complexity** with higher pace of change

AI as a solution:

- **Engineering process automation** – make sense of data, automate reports, etc.
- **Decision-making automation** – simulate large amounts of data



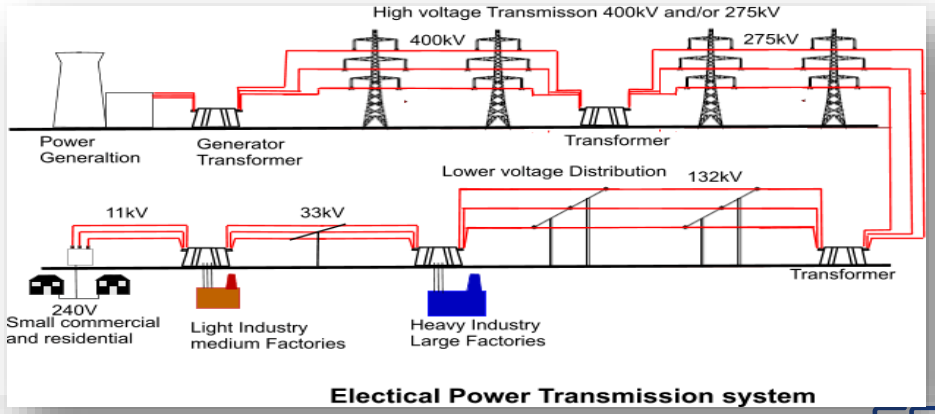
Safely use LLMs with Alarm and Operational Data



Alarm Data

EventTimeStamp	SCADA_Category	TOC	AOR	Priority_Code	Substation	DeviceType	Device	event_message
01/05/2017 00:00	MH	TMS	TOCMSDOC	3	Substation1317	STN	STA_SERVICE	Substation1317 STN STA_SERVICE AC SERV VOLTAGE NORMAL CHG-DET
01/05/2017 00:00	ML	TMS	TOCPB	4	Substation1265	BLKCAR	STUTR_PR1_UPLC	Substation1265 BLKCAR STUTR_PR1_UPLC CARRIER LEVEL LOW CHG-DET
01/05/2017 00:00	MH	TMS	TOCPB	3	Substation1459	BLKCAR	Device285	Substation1459 BLKCAR Device285 CARRIER LEVEL LOW CHG-DET
01/05/2017 00:00	MH	TMS	TOCPB	3	Substation1459	BLKCAR	Device285	Substation1459 BLKCAR Device285 SIGNAL RECEIVED NORMAL CHG-DET
01/05/2017 00:00	MH	TMS	TOCGR	3	Substation275	FIBOPT	LABAR_X_311L	Substation275 FIBOPT Device4576 PRI #2 OPTIC/CH NORMAL CHG-DET
01/05/2017 00:00	MH	TMS	TOCBM	3	Substation749	RELAY	L37_P2_SEL411L	Substation749 RELAY L37_P2_SEL411L RELAY FAILURE NORMAL CHG-DET
01/05/2017 00:00	MH	TMS	TOCBM	3	Substation256	RELAY	L532_SEL421313	Substation256 RELAY L532_SEL421313 SYSTEM NORMAL CHG-DET
01/05/2017 00:00	MH	TMS	TOCPA	3	Substation113	RELAY	L513_SEL411_P2	Substation113 RELAY L513_SEL411_P2 RELAY FAILURE NORMAL CHG-DET
01/05/2017 00:00	MH	TMS	TOCPA	3	Substation460	RELAY	L461	Substation460 RELAY L461 BKUP SYSTEM FAIL NORMAL CHG-DET
01/05/2017 00:00	ML	TMS	TOCED	4	Substation232	BLKCAR	Device689	Substation232 BLKCAR Device689 SIGNAL RECEIVED NORMAL CHG-DET
01/05/2017 00:00	MH	TMS	TOCGR	3	Substation1322	RELAY	Device1492	Substation1322 RELAY Device1492 #1 PRIMARY RELAY NORMAL CHG-DET

+ Network



EPRI AI Grid Planning Assistant: Objectives in, Solutions Out

<u>Objectives:</u>
Description of what you want

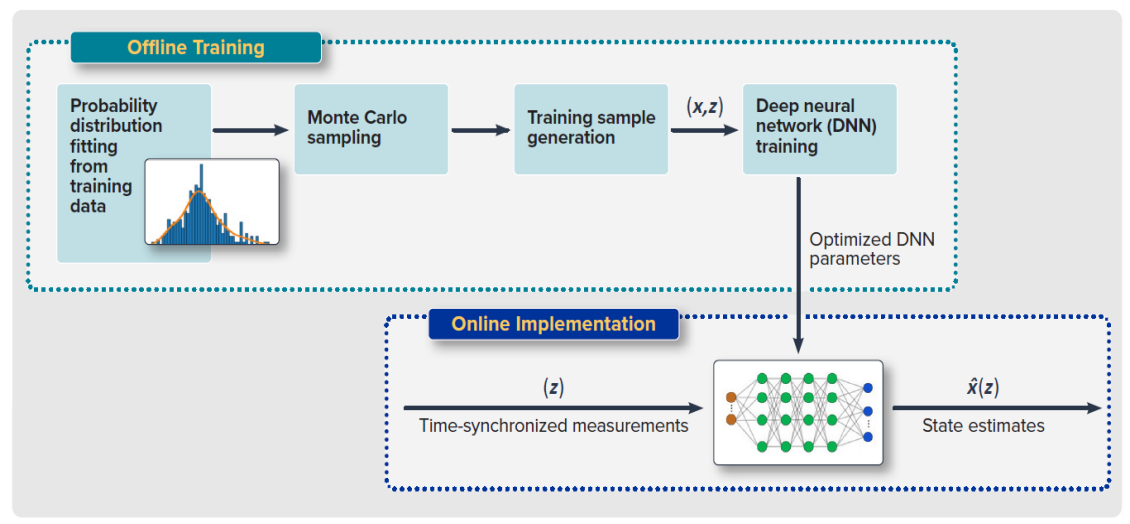
EPRI AI Planning Assistant

<u>Solutions:</u>
Data, Charts
Reports
Conclusions
Solutions

- Engineering concepts, equations, standards
- Local documents, guides, reports
- Grid Models, forecasts, restrictions
- Tools
- Memory

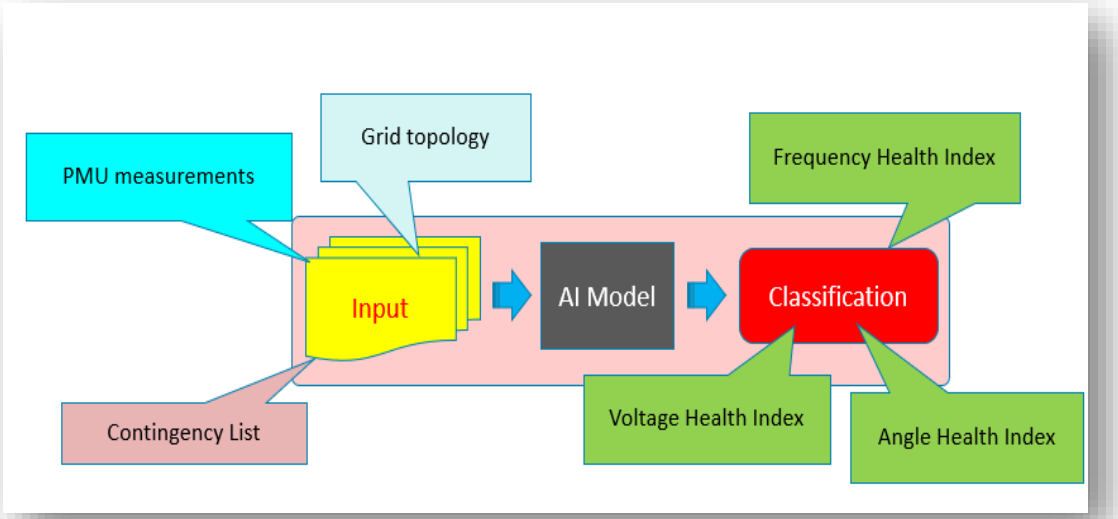
Machine Learning / AI Using Synchrophasor Measurements

ML & PMU Based State Estimation



- Network model independent
- Deep neural network based
- Full system observability with limited number of PMUs
- AI Model Training: EMS state estimation snapshots

ML & PMU Based Security Assessment



- Network model independent
- Graph neural network based
- Health indices prediction: Voltage, frequency, and angle stability
- AI Model Training: Dynamic simulations

AI-ccelerating Production Cost Modeling Competition

Why it Matters:

Production cost modeling is vital for power system planning, but it's computationally demanding.

The AI Advantage:

AI can dramatically speed up production cost modeling by reducing computational load potentially without sacrificing accuracy, especially in long-term planning.

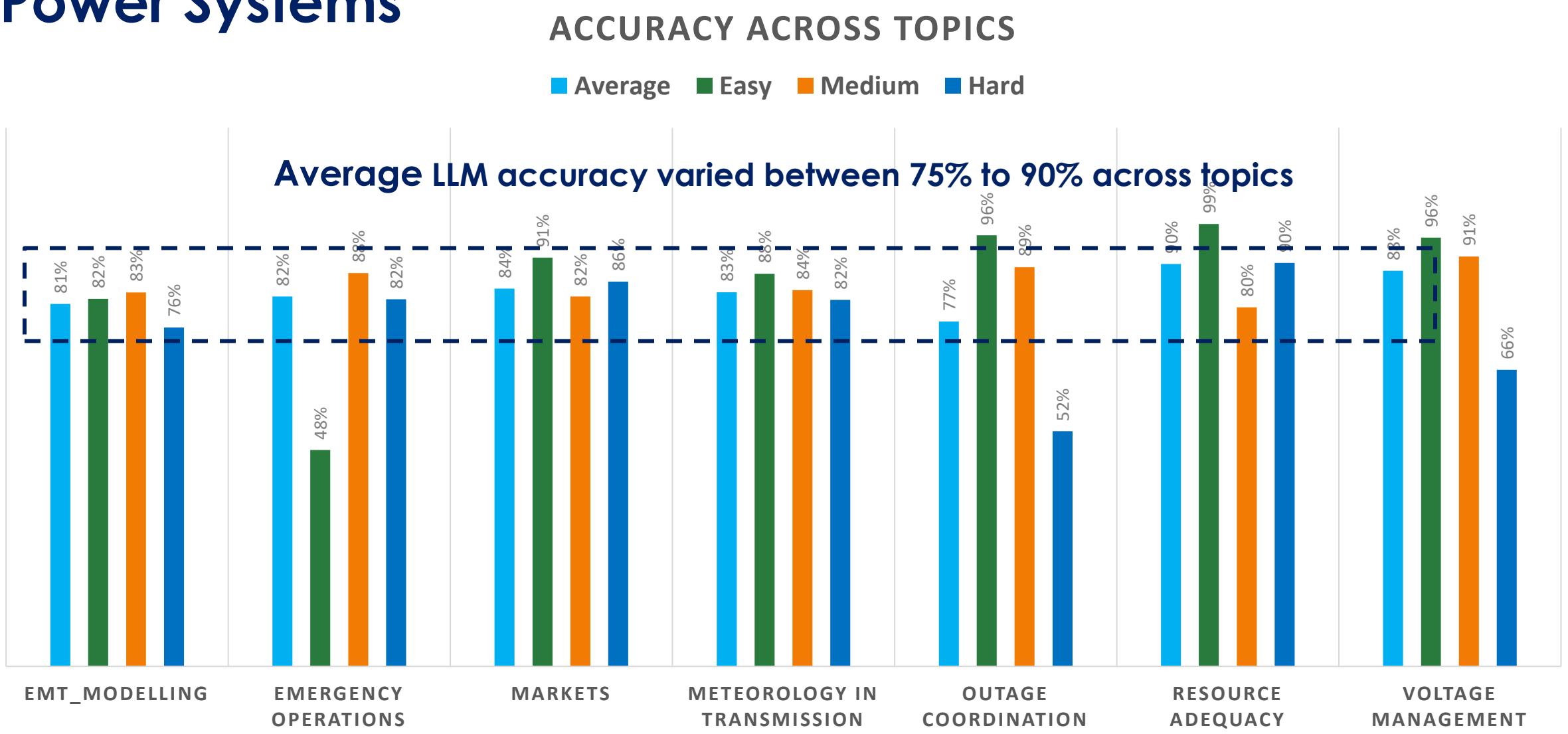
Competition Goal:

- Develop AI models that accelerate production cost modeling
- Real-world scenarios from the Irish Power System
- Submit AI agents for evaluation
- In-depth analysis of results post-launch

Scan to access competition website

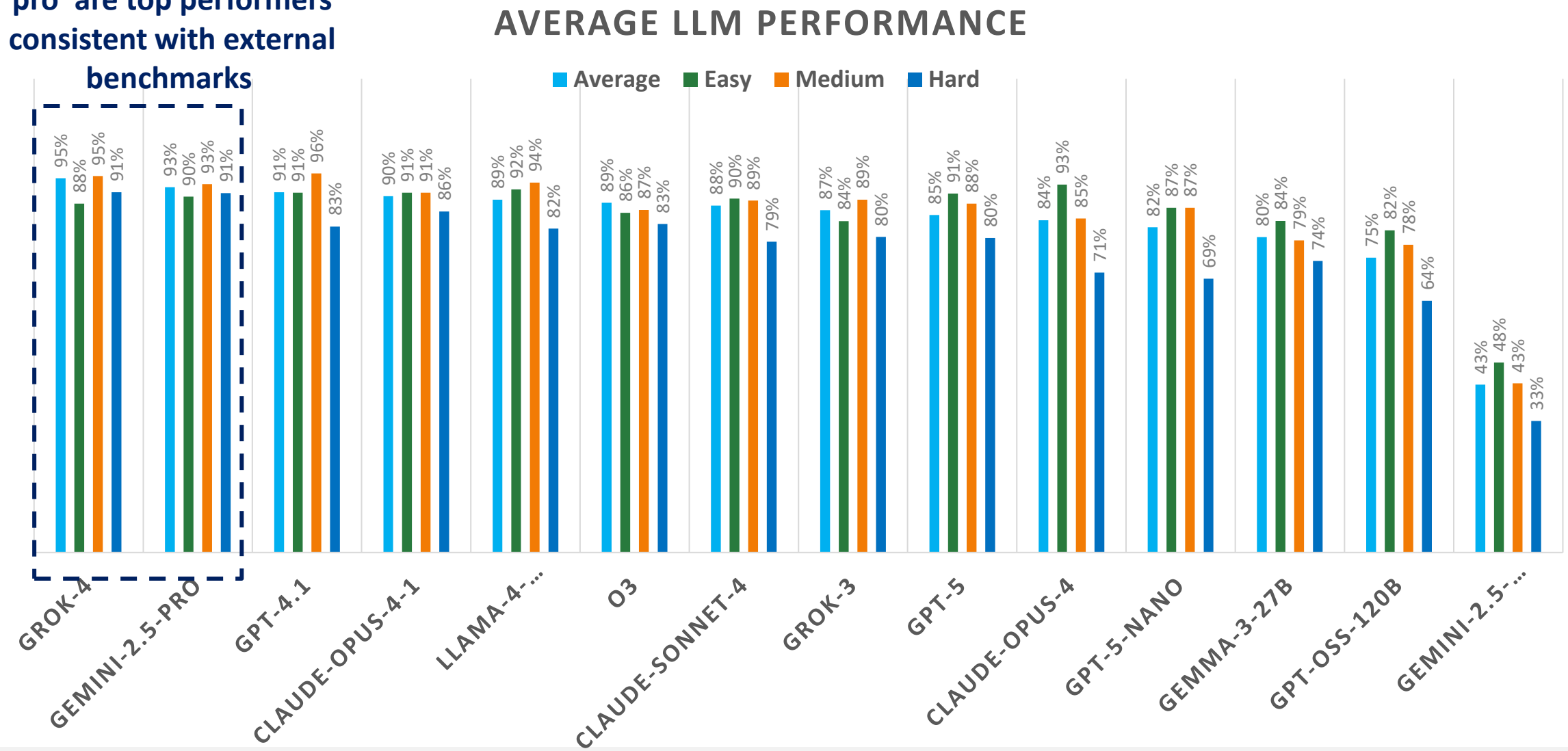
🚀 **Competition Launch: November 3rd**

Benchmarking Large Language Models for Knowledge of Power Systems

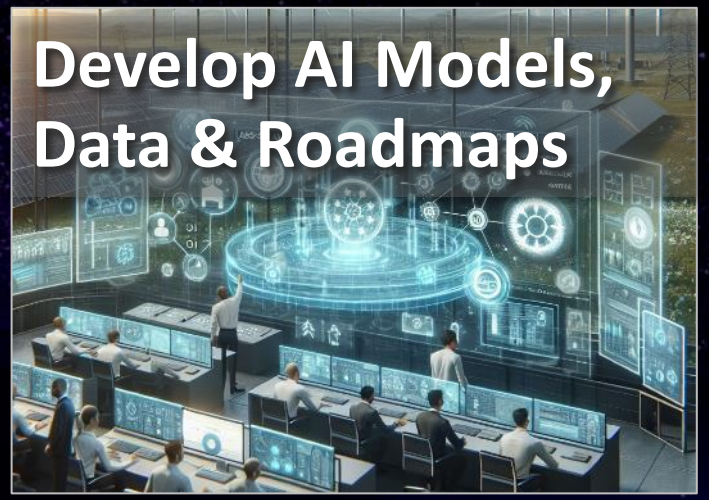


Preliminary Results

‘Grok-4’ and ‘Gemini-2.5-pro’ are top performers consistent with external benchmarks



Open Power AI Consortium – Key Objectives

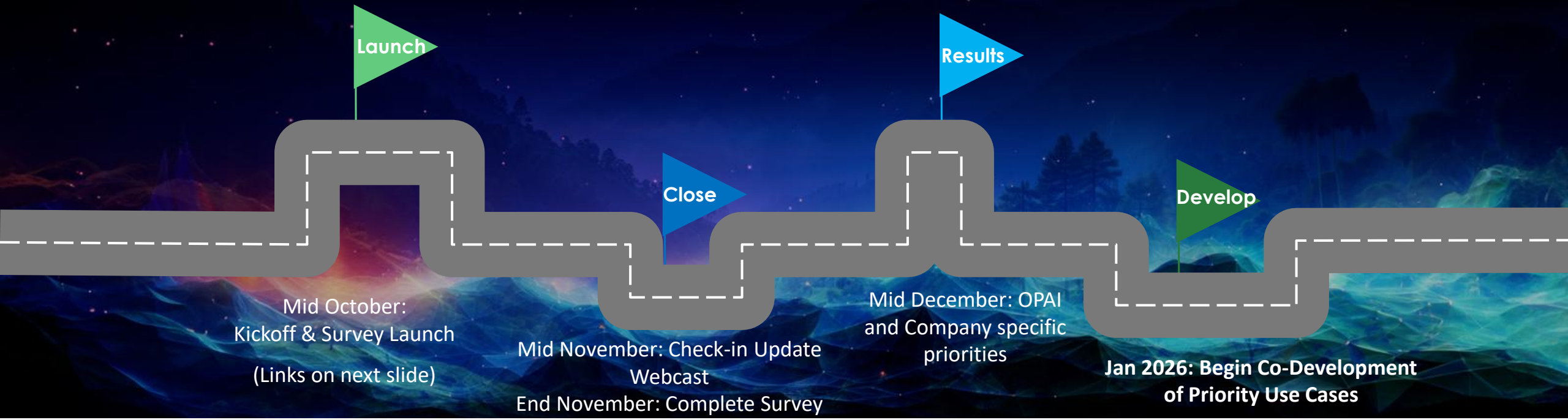


Create an ecosystem for stakeholders to identify, develop, validate and deploy AI solutions to transform the electric sector

Images created with Copilot

OPAI Use Cases Workstream – Survey Launch

- Collated 260 use case titles and descriptions across the energy sector
- Need utilities to complete one of two surveys:
  - Utilities: **To grade the use case for priority and describe demos**
  - Tech Providers: **To match their technology to the use case and describe demos**



OPAI Use Case Survey

Energy Utility Survey

Same Use Case – Different Response

4. Advanced Metering Infrastructure (AMI) Data Validation

AI validates smart meter data by detecting anomalies, missing values, or implausible readings. Models compare real-time data against historical patterns and neighboring meters. Errors are flagged and corrected or imputed before billing or analysis. This ensures accurate consumption records and strengthens customer trust.

	Limited	Minimal	Moderate	Signifcant	Extensive
Impact - Company or Customer Cost Saving	○	○	○	○	○
Impact - Reliability of Resilience	○	○	○	○	○
Impact - Safety or Security	○	○	○	○	○
Implementation Complexity	○	○	○	○	○
Data Availability	○	○	○	○	○
Risk of Misoperation	○	○	○	○	○

Do you have an existing project for this use case in your company?....if so please describe

https://www.surveymonkey.com/r/OPAI-Use-Cases-Utilities

Technology Provider Survey

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TRL 1: Basic principles observed and reported	TRL 2: Technology concept formulated	TRL 3: Proof of concept	TRL 4: Laboratory validation	TRL 5: Relevant environment validation	TRL 6: Demonstration in relevant environment	TRL 7: Prototype demonstration in operational environment	TRL 8: System completed and qualified	TRL 9: Actual system proven in operational environment
○	○	○	○	○	○	○	○	○

Is your entity working with an energy utility on a demo of your technology for this use case? If so please elaborate

https://www.surveymonkey.com/r/OPAI-USe-Cases-Tech-Providers

OPAI Use Case Survey Links

Energy Utility Survey

https://www.surveymonkey.com/r/OPAI-Use-Cases-Utilities

Click or Scan

Technology Provider Survey

https://www.surveymonkey.com/r/OPAI-USe-Cases-Tech-Providers

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