Agentic Agents for Autonomous Microgrids

Driving the Next Generation of Grid Resilience

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Source: Microgrid Archives - Schneider Electric Solar America

CHALLENGE

A Shifting Energy Landscape

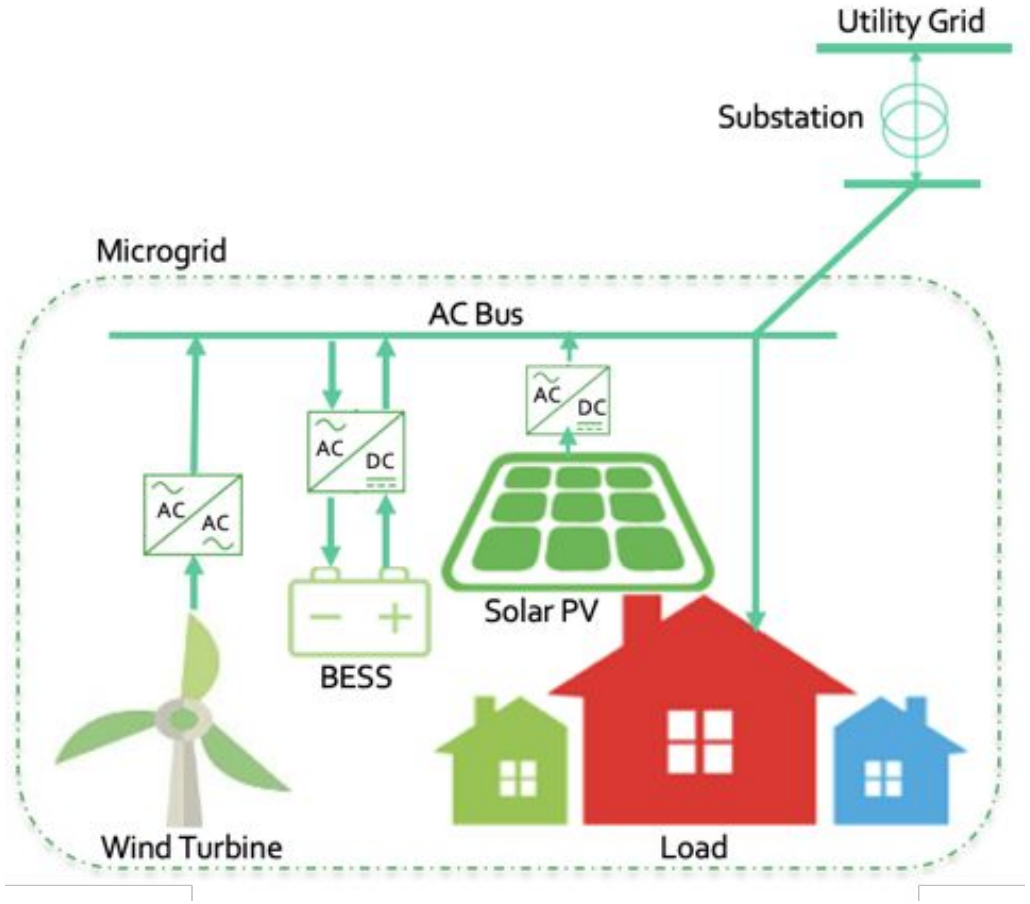
- **Decentralization**
  - **Global shift** from centralized fossil-fuel grids to distributed renewable systems, accelerating post-2022
- **Intermittency Crisis**
  - Solar & wind **volatility** creates real-time imbalances. Grid operators face unprecedented **complexity**.
- **Microgrid Imperative**
  - Localized **resilience** is essential — but demands self-correcting, software-defined **control** at scale.



rce: Gemini Image Generator

COST BARRIER

Existing Traditional Controls are Expensive



- ~ $300k → ~50% of Total Microgrid setup
- Vendor Lock-in and rigid built controller units
- No contextual reasoning - reactive logice



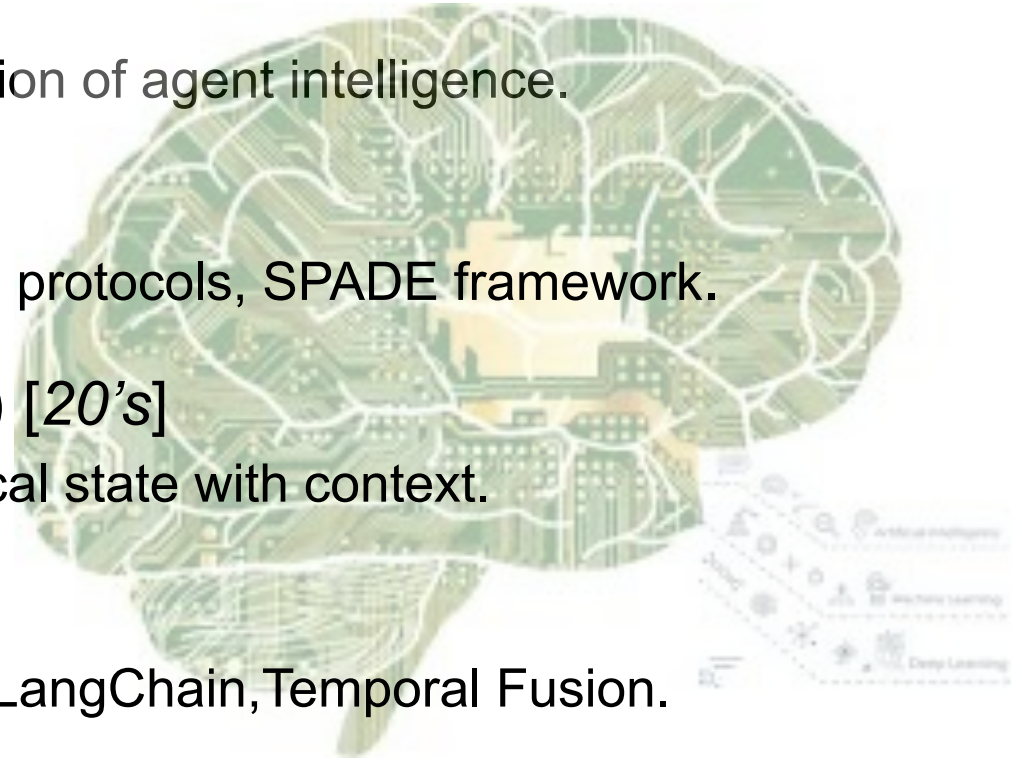
Source: Russelectric: Siemens Business - Energy Controller

Software-defined AI agents can eliminate the custom hardware layer reducing cost by 60%.

EVOLUTION

Paradigm Shift: Road to Cognitive Power Systems

- **Complex Adaptive Systems (CAS)** [*Late 90's*]
  - Self-organizing entities without central control - foundation of agent intelligence.
- **Multi-Agent Systems (MAS)** [*Early 00's*]
  - Distributed agents perceive, infer & act via coordination protocols, SPADE framework.
- **Agentic Retrieval-Augmented Generation (RAG)** [*20's*]
  - LLM reasoning + embedded retrieval. Bridging numerical state with context.
- **Cognitive AI (RAG)** [*24's*]
  - LLM tool-use + neuro-symbolic verification. GridMind, LangChain,Temporal Fusion.



3DMICROGRID

energynautics
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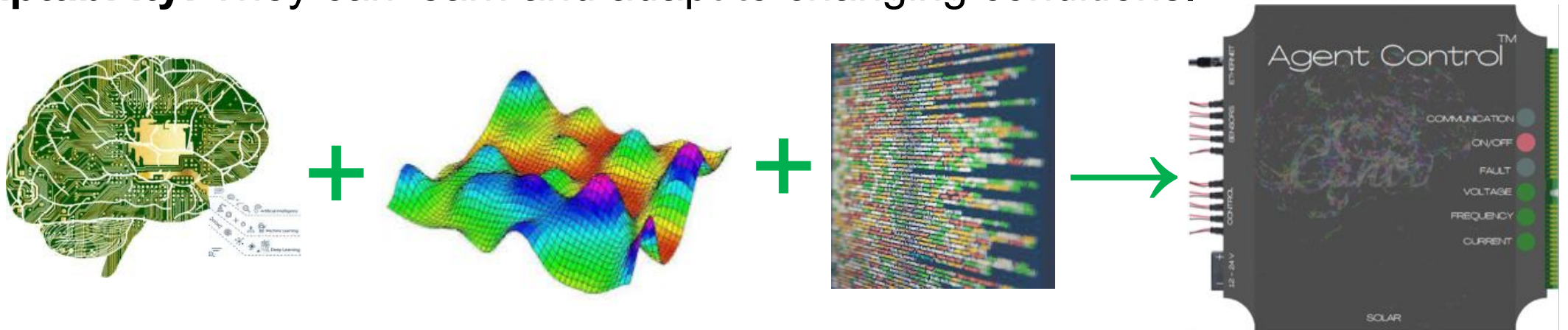
AI CONTROL

The Core Innovation: AI Agents for Microgrids

What are AI Agents? Autonomous software entities that perceive their environment, make decisions, and act to achieve specific goals.

Why Agents for Microgrids?

- **Decentralized Control:** Mirrors the distributed nature of microgrids.
- **Autonomy:** Each agent manages its own component (e.g., Solar, Wind, Storage ..).
- **Coordination:** Agents communicate and negotiate to achieve system-wide goals.
- **Adaptability:** They can learn and adapt to changing conditions.

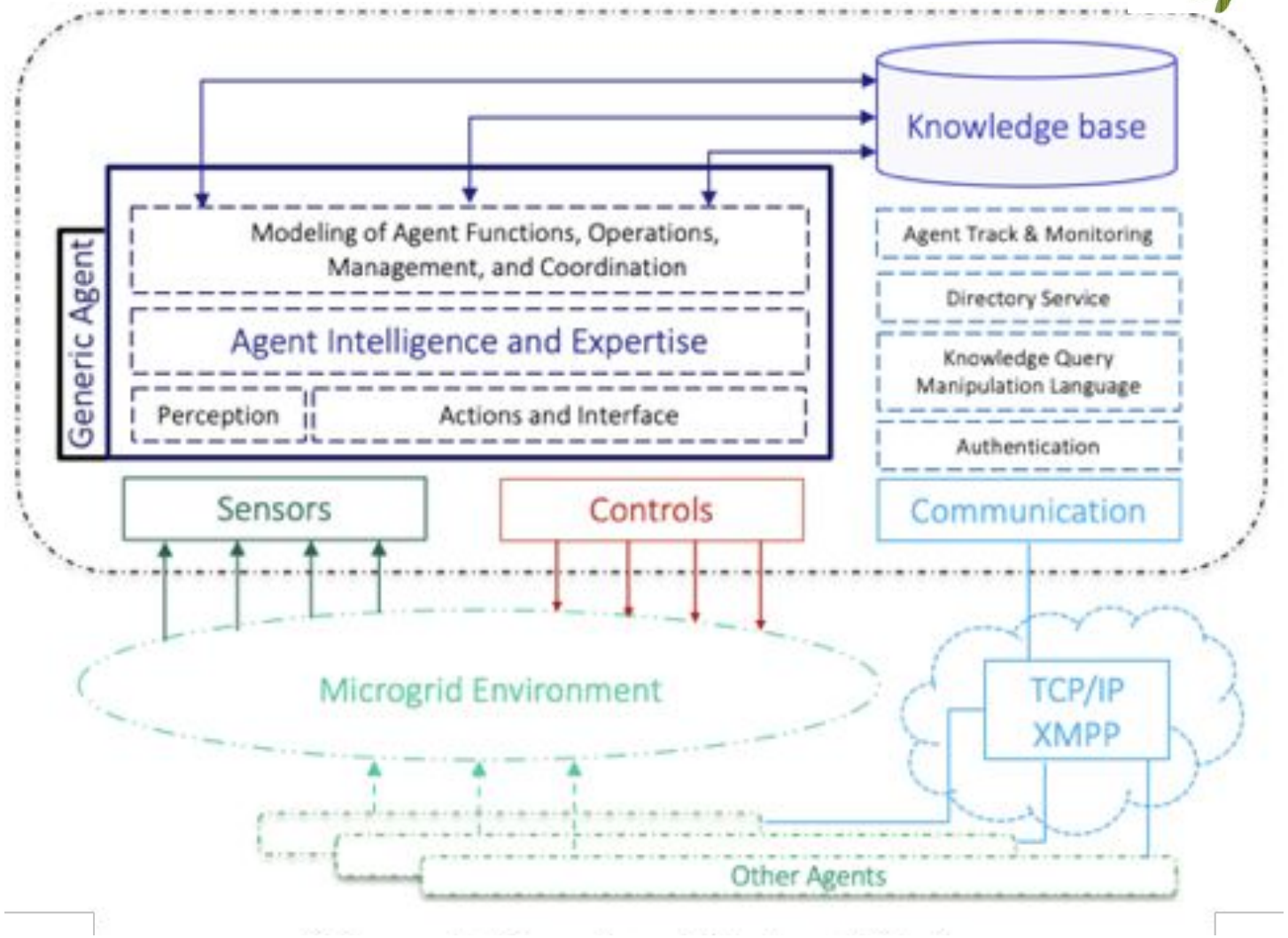


ARCHITECTURE

Agent Implementation: SPADE Framework



- **Foundation:** Built on SPADE (Smart Python Agent Development Environment) + Packages.
- **Component Agents:** Solar, Wind, Load, & Storage agents manage physical assets.
- **Control Agent:** The central coordinator, making high-level decisions.

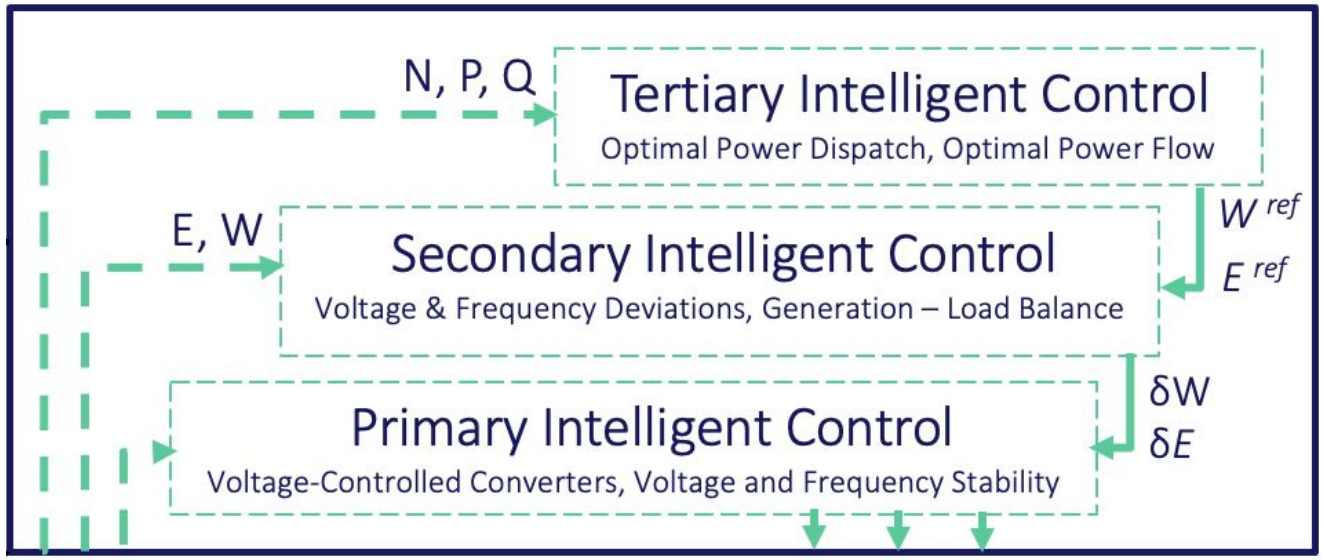


INTELLIGENCE

The Intelligent Engine: AI-Powered Decision Making

- **Forecasting (Proactive Decisions):**
  Using LSTM for predicting load profiles and Gradient Boosting/Random Forest for forecasting solar and wind generation
- **Control & Optimization (Reactive Decisions)**
  Using Deep Reinforcement Learning (TD3, SAC, DDPG), agents learn control policies to minimize costs while maintaining stability..

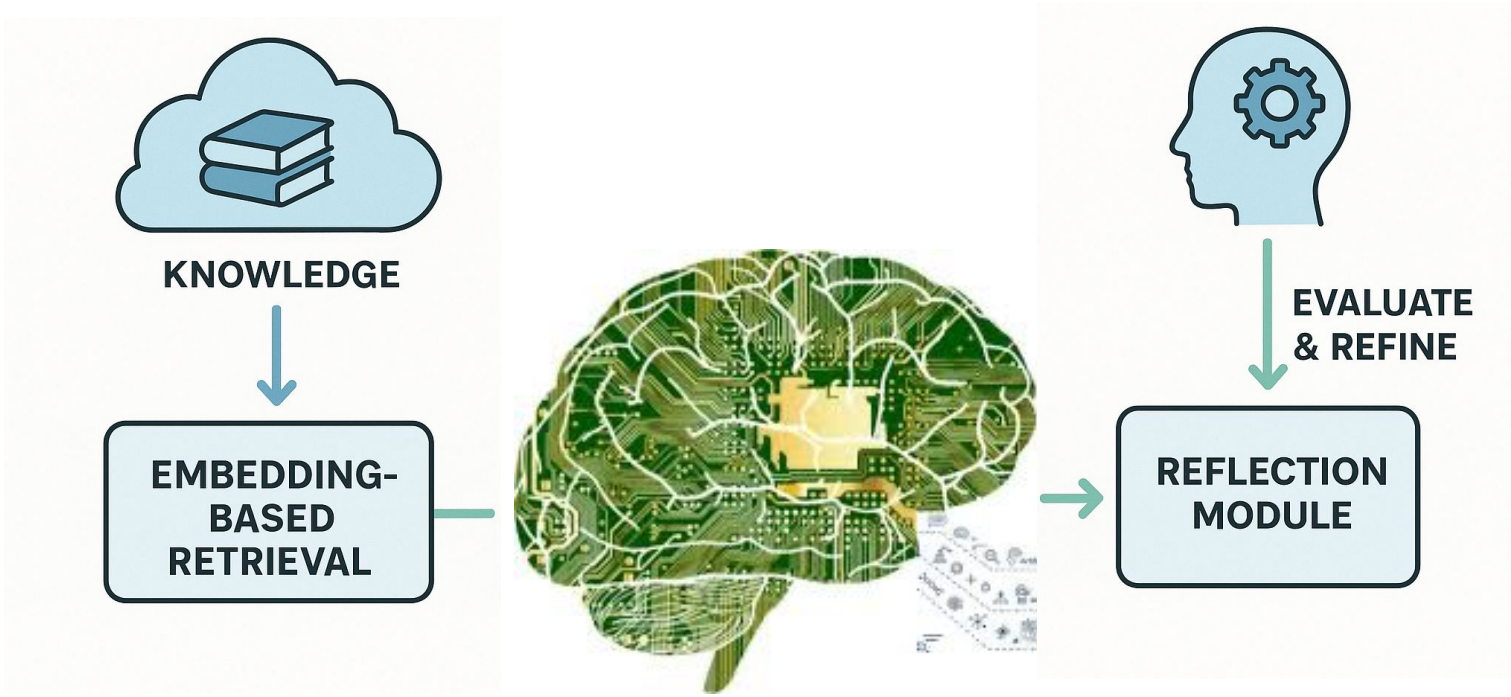




COGNITIVE

Generative AI Agents for Cognitive Microgrids

Embedding-based retrieval enables agents to access knowledge & reflection modules allow them to evaluate, refine their performance, leading to cognitive microgrid agents.



GOOGLE ADK

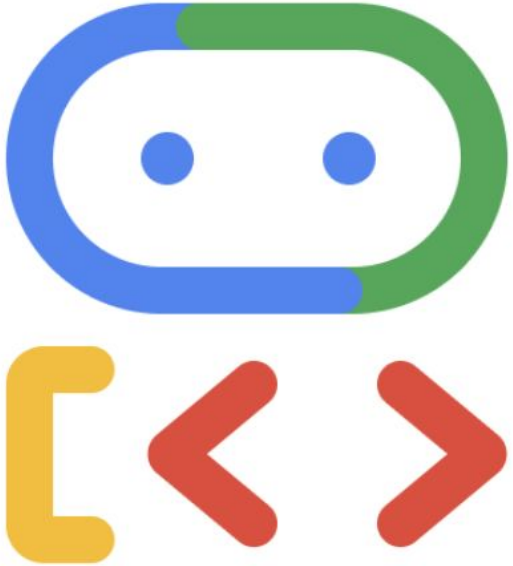
Industry Standard Agent Development Kit

Built-In Tool Use: No custom wrappers. Pass tools, ADK handles calling and parsing.

Lifecycle Hooks: on_agent_start, on_tool_end, on_model_end. Organized and clear audit trails and monitoring.

Plugin Architecture: Add logging or custom behavior once, runs everywhere.

Local Testing: In Memory Runner lets you test agents without Docker or API calls.



COMPARISON

Google ADK vs SPADE

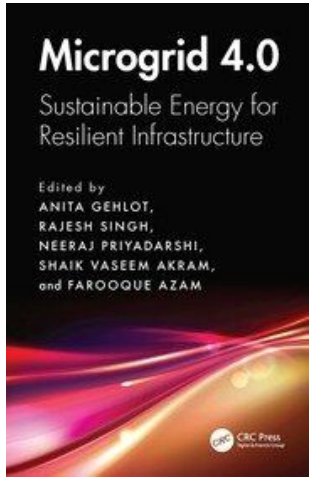
Feature	Google ADK	SPADE
LLM Integration	Built-in prompting, tool calling, reasoning.	Not designed for LLMs. Requires custom infrastructure.
Agent Communication	HTTPS/REST Simplicity	XMPP/ACL Sophisticated formal protocols.
Monitoring	Built-in tracing, logs, and token usage.	XMPP logs hard to parse and limited visibility.
Time to First Agent	Days: If you know Python and prompting.	Weeks: Learn XMPP, ACL, finite-state design.
Production Readiness	LLM-based agents (Google support)	Smaller Traditional multi-agent communities.
Security	Supports mTLS (Python libraries).	Strong built-in mTLS and authentication protocols.

Conclusion

- Multi-agent architecture provides robust, decentralized control.
- Combining LSTM/DRL with Agentic RAG contextual intelligence addresses performance and economic barriers
- LLM frameworks unlock capabilities impossible with prior-generation models
- Shifting regulatory landscape calls for software-defined, cost-efficient solutions
- Cognitive Microgrids will make energy grids smarter, resilient, and sustainable.

Agentic AI Implementation
Link on GitHub

SPADE Implementation
Link on GitHub



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AGENTS FOR MICROGRIDS
Thank you!
MAXIMIZE RENEWABLE BENEFITS