AI Strategy for Energy Managers

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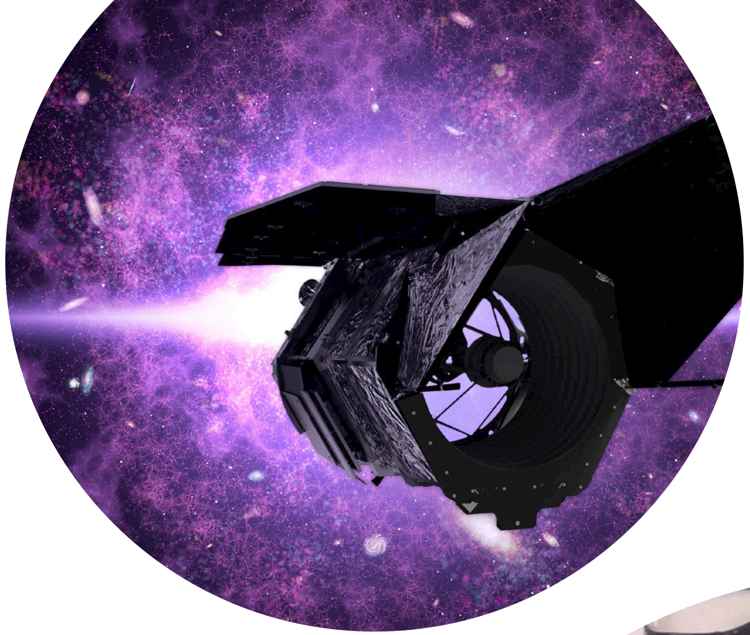
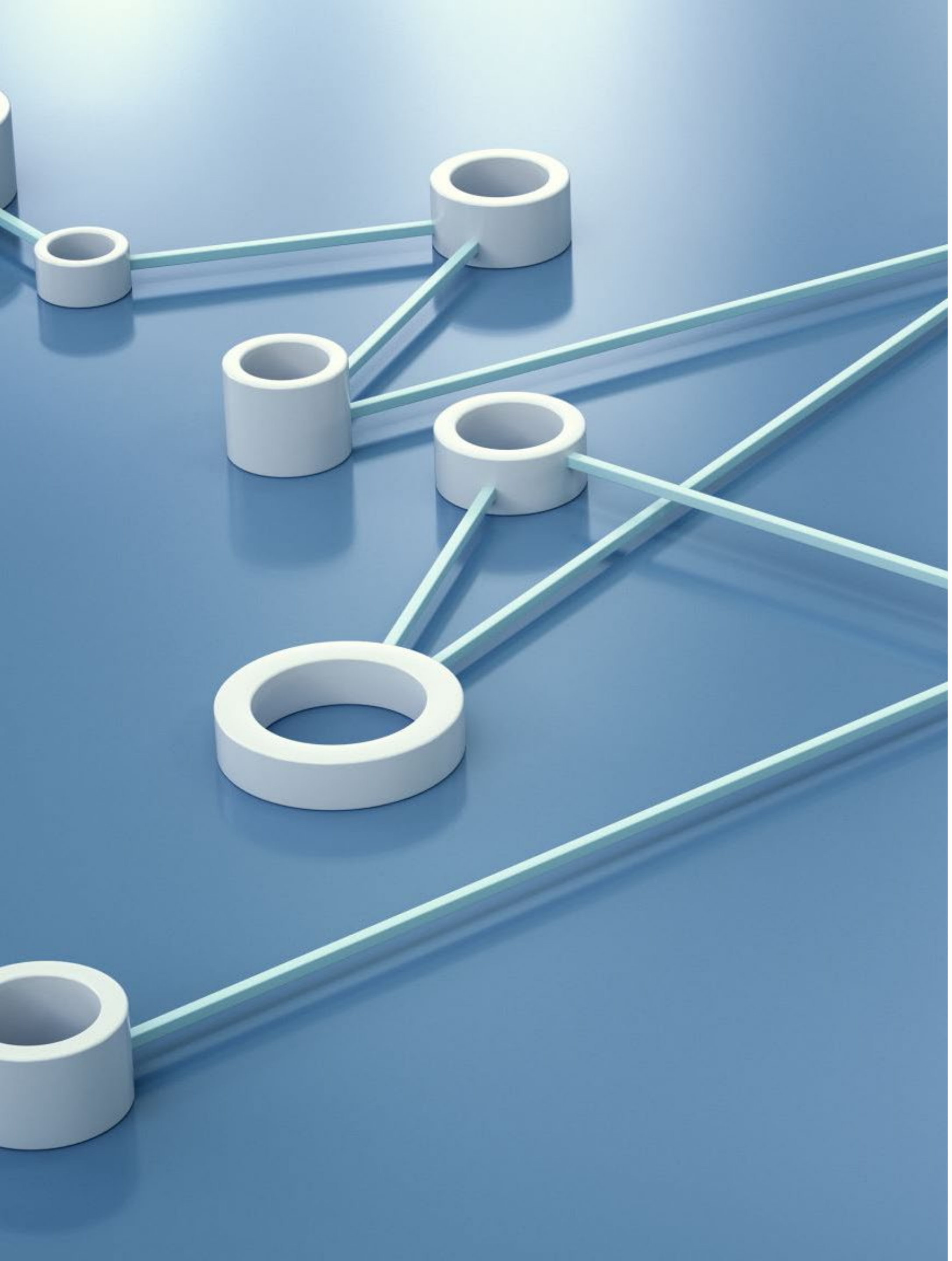
About Me

- Systems Software Engineer
    - AI for spacecraft telemetry data analysis
    - NASA GSCF AI Center of Excellence
    - NASA LaRC Autonomy Incubator (2018-2022)

- AI Education and Outreach
    - Introduction to AI using Python workshops





Why are we here?

- This presentation provides **energy managers** with an actionable roadmap for integrating **AI**, establishing it as the essential intelligence layer needed to manage the modern grid's complexity and **distributed energy resources**. The goal is to maximize **high-ROI applications** like Predictive Maintenance and advanced forecasting, while simultaneously addressing critical risks related to **cybersecurity, ethical bias**, and necessary **workforce transformation**

Outline

- Part 1:Introduction & The AI Mandate
- Part 2: AI for Operational Efficiency & Cost Reduction
- Part 3: AI Implications, Risk Management, and Ethics
- Part 4: Strategic AI, Transforming the Grid and Workforce
- Part 5: Conclusion and Call to Action

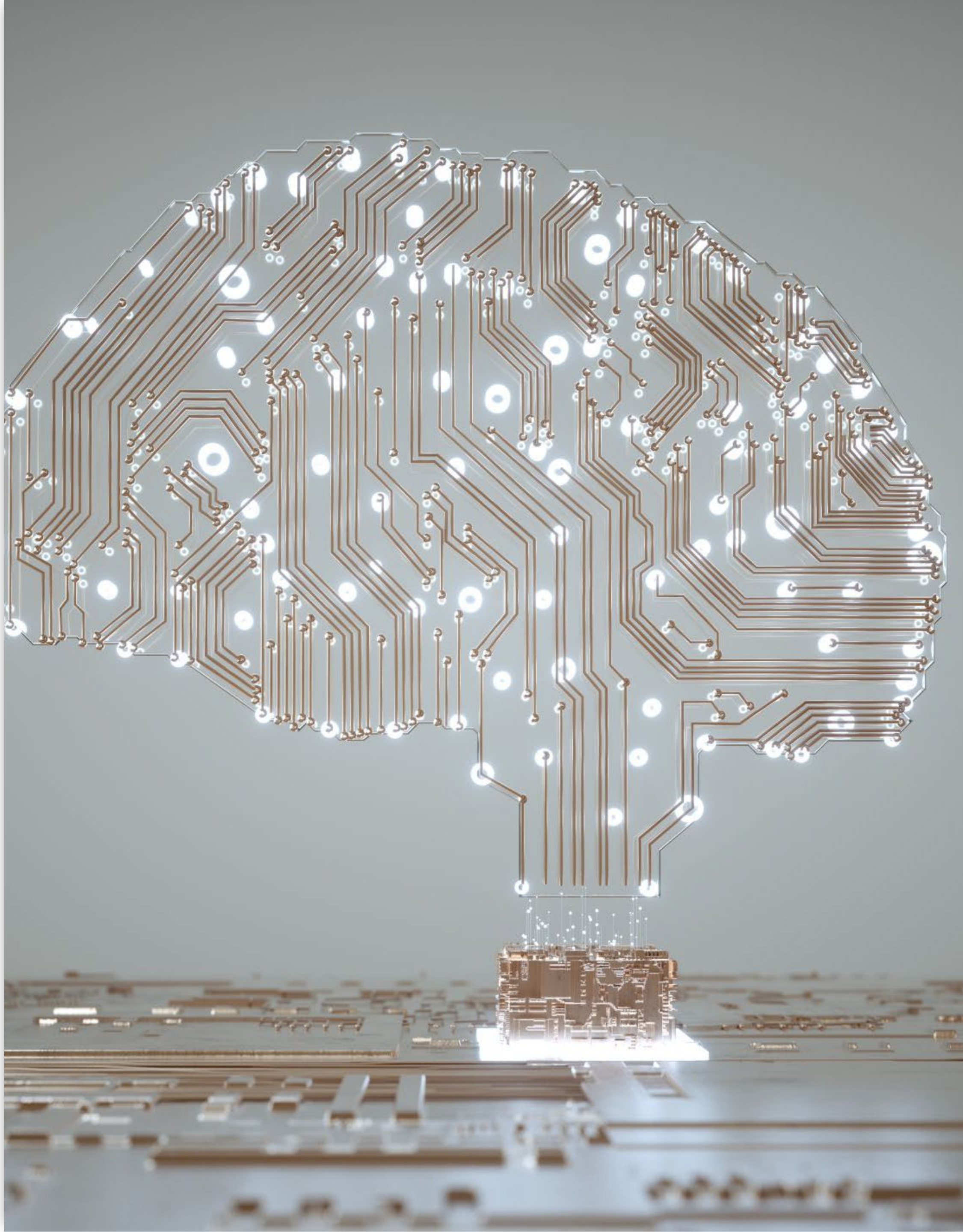
Part 1:
Introduction and the AI Mandate

The Evolving Energy Landscape

- The grid is moving beyond a simple one-way power flow. There are four critical pressures
  I. **Aging Infrastructure**: decades old equipment must be maintained against load and volatility
  II. **Mass Electrification**: Managing sharp, unpredicted demand spikes from new consumer adoption (EVs, AI usage, electric heating and cooling, etc.)
  III. **Distributed Energy Resources (DERs)**: Integrating solar, wind, and storage into a stable two-way system
  IV. **Net-Zero Pressure**: Achieving deep decarbonization while maintaining affordability and reliability

The AI Imperative

- AI is no longer a strategic option, it’s the required intelligence layer to manage the operational complexity of the modern energy ecosystem
    - Human Scale is Maxed Out: Traditional software and human operators cannot process the volume and velocity of data generated by millions of connected assets (smart meters, sensors, DERs)
    - Predictive Power: AI shifts operations from reactiveness (fixing failures) to proactiveness (preventing failures and anticipating demand)



Focus on Actionable Strategy

- This session will move beyond theory and focus on practical strategy for energy managers

Focus Area	Key Deliverable
Practical Applications	Identifying high-ROI use cases: Predictive Maintenance, Forecasting, Demand Optimization
Risk and Mitigation	Understanding the real-world implications of AI: Cybersecurity, data privacy, and ethical bias
Strategic Next Steps	Building an AI roadmap, scaling solutions, and transforming your team for the future

Part 2: AI for Operational Efficiency and Cost Reduction

Where intelligence creates ROI

Preventative Maintenance

- Shift from reactive repair to proactive health
- AI analyzes high-volume sensor data (vibration, temperature, oil quality, acoustics) to detect anomalies that signal imminent failure

Traditional Maintenance	AI-Driven Predictive Maintenance
Fix it when it breaks (Reactive)	AI-Driven Predictive Maintenance (Proactive)
High unscheduled downtime	Minimum unscheduled downtime
High cost of energy repairs	Optimized maintenance scheduling

- Key action: Deploying AI on high-value, aging assets (e.g., transformers, turbines) is the fastest path to ROI.

Initial case studies predict up to a 40% potential reduction in maintenance costs

Load and Renewable Forecasting

- Intermittent nature of renewables (solar, wind) with fluctuating energy prices require superior forecasting. AI can fuse multiple data streams to achieve 95%+ accuracy including
  - Weather Data (hyper-local forecasts)
  - Market Signals (real time pricing)
  - Asset Performance (historical output and degradation)
  - Usage Patterns (Granular consumer demand)
- The results for managers
  - Optimized energy trading : buying/selling power at the ideal moment
  - Storage Synchronization: Timing battery energy storage system (BESS) charge/discharge cycles more precisely
  - Grid Stability: Better balance supply for traditional and renewable sources

Demand Side Optimization

- AI powered systems (
building management systems, industrial process controls, etc.) use live data to make real time adjustments going beyond simple time of day automation

Application	Role of AI	Value Proposition
Facility HVAC	Adjusts cooling based on *predicted* occupancy, not just schedule.	Maintains comfort while minimizing peak demand penalty costs.
Industrial Processes	Analyzes production schedule vs. real-time energy price signals.	**Automated Load Shedding:** Temporarily pauses non-critical loads when price spikes exceed a set threshold.
Data Centers	Deep learning algorithms optimize cooling loops and fan speeds.	Google reported cutting cooling energy by 40% in data centers using AI.

AI Delivers on The Triple Bottom Line

Value Pillar	Enabled By AI Application	Managerial Inpact
Cost	Predictive Maintenance, Optimized Trading	Reduced Operational Expenses, Lower Capital Costs
Reliability	Accurate Forecasting, Autonomous Control	Less Downtime, Greater System Resilience
Sustainability	Demand Management, DER Synchronization	Accelerated Decarbonization Goals

Part 3: AI Implications Risk Management, and Ethics

Cybersecurity and Data Integrity

- AI introduces new risks due to increased data volume and connectivity
- **Attack Vector:**
  - Automated systems are single points of failure. If an adversary compromises a predictive maintenance algorithm or an autonomous control system, the potential for widespread grid disruption is high.
  - ***Managerial Action***: Implement rigorous security protocols around data ingestion and model deployment (MLOps).
- **Data Privacy (C&I Focus):** Energy consumption data is sensitive business intelligence (BI) for industrial clients.
  - ***Managerial Action:*** Ensure all AI models comply with data anonymization and locality regulations.
- **Integrity Risk:** Models are vulnerable to "data poisoning" or manipulation, leading to bad predictions (e.g., intentionally wrong load forecasting).

Bias, Equity, and the Black Box

AI models learn from historic data which may reflect past systemic issues

Bias risk: If training data disproportionately represents affluent areas or specific energy users, AI-driven resource allocation (like smart grid routing or new technology rollouts) can unfairly disadvantage other communities

Lack of Transparency: Many sophisticated models are "black boxes," making it hard to audit *why* a decision was made (e.g., why a specific customer was curtailed during a peak event)

Solution: Explainable AI (XAI): Energy managers must demand XAI capabilities from vendors. This ensures that the reasoning behind critical decisions (e.g., asset retirement, price adjustments) is clear, auditable, and ethically sound

The Environmental Cost of AI

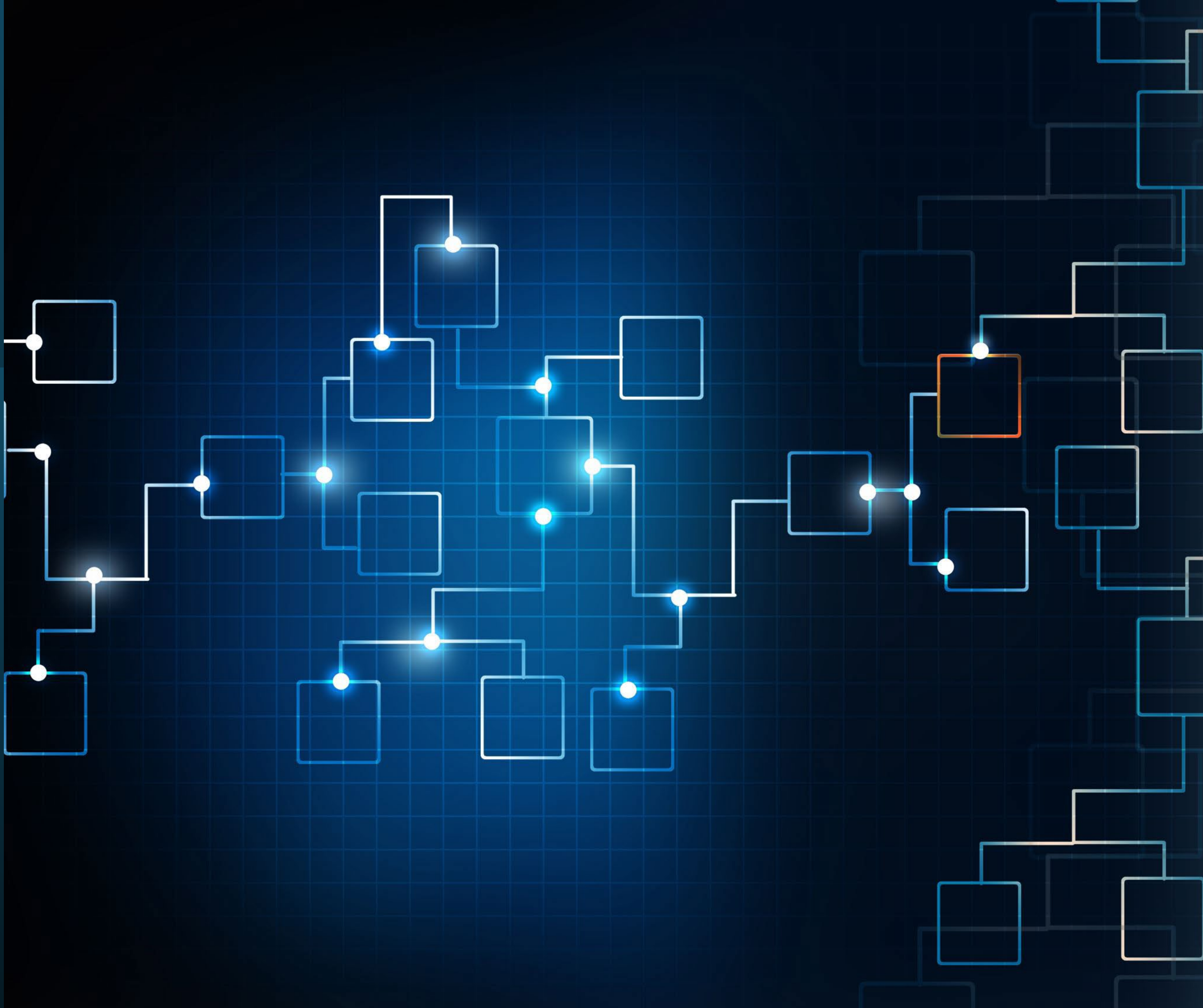
- AI solves energy problems but is also a massive energy consumer

- **The Data Center Load**: Training large-scale AI models (like Generative AI) requires immense computational power, putting increasing pressure on the electric grid and local water supplies (for cooling)
- **New Load Driver**: The rapid global expansion of AI data centers is a new, substantial source of load growth that must be planned for
- **The Manager's Responsibilities:**
    - Prioritize AI solutions that are optimized for **inference efficiency** (running the model efficiently) over training size.
    - Demand that your organization's AI infrastructure relies on **renewable-powered data centers** and sustainable cooling.

You Must Manage the Risk Before Scaling the Technology

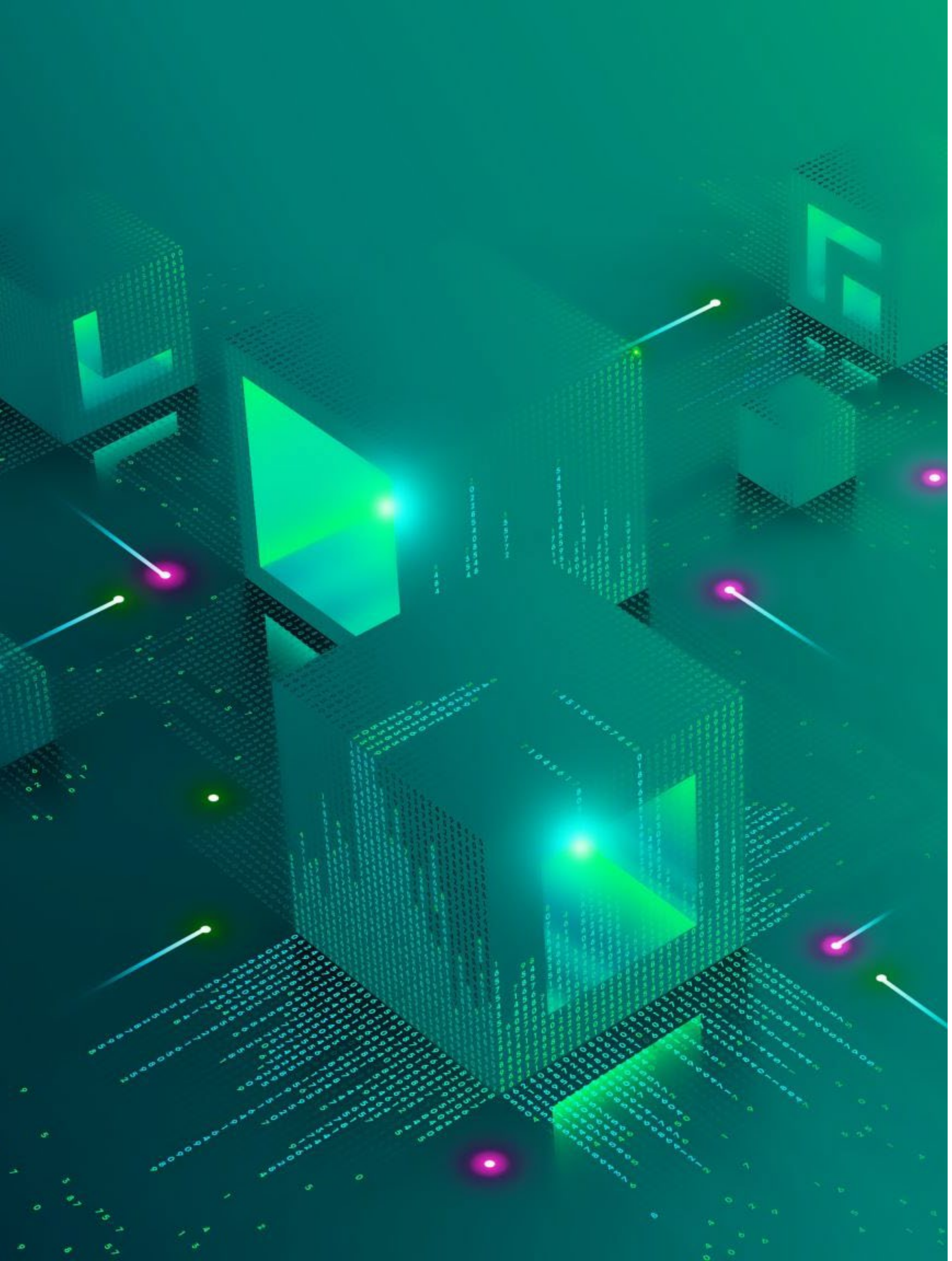
Risk Area	Mitigation Strategy
Cybersecurity	Mandatory security reviews (Pen-Testing) of all AI models before deployment
Bias/ Equity	Implement **Explainable AI** tools and conduct mandatory audits of training data for representativeness
Environmental	Prioritize models designed for power efficiency and deployment in green infrastructure.

Part 4: Strategic AI, Transforming the Grid and Workforce



Digital Twins and the Autonomous Grid

- **Digital Twins:** Virtual, high-fidelity replicas of physical energy systems (power plants, substations, distribution networks).
  - Allows managers to run unlimited, risk-free simulations (e.g., extreme weather events, high DER penetration) to optimize control strategies before deployment
- **Autonomous Operation:** The final goal is a **self-healing grid**. AI moves beyond *predicting* a fault to *autonomously* isolating the problem, rerouting power, and rebalancing the system in milliseconds
  - This level of resilience is impossible with human intervention alone.



Orchestrating the Distributed Energy Revolution

- Distributed Energy Resources (DERs) are volatile but flexible. AI is the tool that makes them reliable
    - **Coordination:** AI manages thousands of assets (rooftop solar, residential batteries, EV charging) as a single, large **Virtual Power Plant (VPP)**
    - **Dynamic Response:** The system uses AI to rapidly dispatch or absorb energy from these devices in response to grid needs (e.g., telling a fleet of EVs to pause charging for 10 minutes to avoid a blackout)
    - **Managerial Impact:** DER integration shifts energy managers from simply *consuming* power to actively *managing* a complex, distributed supply and demand network

Workforce Transformation: Evolving Skillsets

- AI will automate manual, repetitive tasks (data logging, routine inspections), but it elevates the human role to oversight and strategy

Old Skill Focus	New Skill Focus
Manual Monitoring & Inspection	**AI Model Oversight** & Anomaly Investigation
Spreadsheet-based Forecasting	**Data Governance** & Machine Learning Operations (MLOps)
Reactive Troubleshooting	**Human-in-the-Loop** Decision-Making & Strategy

- Action: Energy organizations must establish formal reskilling and training programs focused on data literacy and AI model interaction

Module 4 Takeaway: Platform vs Point Solution

- Think Ecosystem, not just efficiency
    - AI in energy is not a feature you plug in; it's the **central operating platform** for future resilience, asset management, and DER integration
    - Every major decision point on the modern grid could eventually be augmented or executed by AI

Part 5 : Conclusion and Call to Action

The Energy Manager's Three Immediate Actions

- Pilot Program Selection
  - Choose a single, high-impact area with clear, measurable data (e.g., Predictive Maintenance on one critical transformer bank, or optimizing HVAC for one C&I building)
  - Establish clear success metrics ($ saved, downtime reduced)
- Establish Data Governance
  - Define data collection standards, storage protocols, and security requirements *today*. AI is useless without clean, accessible data
- Vendor Vetting
  - When evaluating AI solutions, demand evidence of **XAI (Explainability)** and model training on **diverse, unbiased data** relevant to your specific assets and customers

Thank you / Final Q&A !

- **The challenge is not whether AI *can* optimize the grid, but whether we can strategically and ethically lead its deployment**

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