Training Course on AI for Power System Optimization

Professional Development Training Course Outline

Category	Engineering	**Duration**	10 Days
Base Fee	$3,000 USD	**Delivery Mode**	Online / On-site Hybrid

Course Introduction

Introduction

This advanced training courseoffers a specialized deep dive into leveraging Artificial Intelligence (AI) and Machine Learning (ML) to enhance the efficiency, reliability, and sustainability of modern power systems. Participants will gain comprehensive knowledge of how cutting-edge AI techniques can address complex challenges in electricity generation, transmission, distribution, and consumption. Training Course on AI for Power System Optimization focuses on practical applications, including smart grid management, renewable energy integration, demand-side management, fault detection, and predictive maintenance within the dynamic power ecosystem. Attendees will acquire hands-on experience with leading AI frameworks and optimization tools, mastering crucial concepts such as reinforcement learning for grid control, deep learning for forecasting, and explainable AI for operational transparency. This course is essential for power system engineers and energy professionals seeking to innovate and transform the future of energy infrastructure through intelligent, data-driven solutions.

The program emphasizes practical implementation and industry best practices, exploring trending topics like digital twins for grid simulation, cyber-physical security using AI, distributed energy resource (DER) optimization, and the integration of AI models at the grid edge. Participants will delve into advanced algorithms for optimal power flow, unit commitment, energy trading, and real-time anomaly detection. By the end of this course, attendees will possess the expertise to design, implement, and deploy sophisticated AI solutions that drive operational efficiency, enhance grid resilience, reduce carbon footprint, and unlock new economic opportunities in the evolving energy landscape. This training is indispensable for professionals aiming to be at the forefront of the smart grid revolution and lead the transition to a more intelligent and sustainable power future.

Programme Curriculum

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Course Objectives

1. Understand core AI/ML concepts and their specific applications in power system optimization.
2. Apply supervised learning techniques for power load forecasting and renewable energy generation prediction.
3. Utilize unsupervised learning for anomaly detection in grid operations and equipment health.
4. Implement Reinforcement Learning (RL) algorithms for dynamic grid control and energy management.
5. Develop Deep Learning models for complex pattern recognition in power system data.
6. Optimize power flow and unit commitment problems using AI-driven approaches.
7. Design predictive maintenance solutions for transformers, generators, and other grid assets.
8. Leverage AI for smart grid resilience including fault location, isolation, and service restoration.
9. Integrate Distributed Energy Resources (DERs) and energy storage systems with AI for optimal dispatch.
10. Explore Explainable AI (XAI) techniques for understanding complex AI decisions in critical grid operations.
11. Implement AI for cybersecurity and intrusion detection in power system control networks.
12. Utilize digital twin technology with AI for real-time grid simulation and optimization.
13. Apply AI for energy market analysis and trading strategies.

Organizational Benefits

1. Significant improvements in grid operational efficiency and reliability.
2. Reduced energy losses and optimized power flow across the system.
3. Enhanced integration and management of renewable energy sources, increasing sustainability.
4. Lower maintenance costs through proactive, AI-driven predictive maintenance.
5. Improved resilience and faster restoration after grid disturbances and faults.
6. Development of intelligent demand-side management programs for energy savings.
7. New revenue streams from optimized energy trading and ancillary services.
8. Strengthened cybersecurity posture for critical power infrastructure.
9. Competitive advantage in the evolving smart grid and clean energy sectors.
10. Better utilization of data to make informed strategic and operational decisions.

Target Participants

- Power System Engineers
- Grid Operators and Dispatchers
- Energy Management System (EMS) Developers
- Renewable Energy Integration Specialists
- Smart Grid Researchers and Developers
- Data Scientists in the Energy Sector
- Control System Engineers in Utilities

Course Outline

Module 1: Introduction to AI in Power Systems

- **Fundamentals of Power Systems:** Generation, Transmission, Distribution, Consumption.
- **Challenges in Modern Power Systems:** Decarbonization, decentralization, digitalization.
- **Introduction to AI/ML Concepts:** Supervised, Unsupervised, Reinforcement Learning.
- **Why AI for Power System Optimization?** Benefits, opportunities, and limitations.
- **Case Study:** Identifying key optimization problems in a traditional large-scale power grid.

Module 2: Data Acquisition and Preprocessing for Power Systems

- **Sources of Power System Data:** SCADA, PMUs, Smart Meters, Weather Data, GIS.
- **Data Types and Formats:** Time-series data, network data, event logs.
- **Handling Missing Data and Outliers:** Imputation techniques, robust methods.
- **Feature Engineering for Power Systems:** Extracting relevant features from raw data.
- **Case Study:** Preprocessing real-world smart meter data for load forecasting.

Module 3: Power Load and Renewable Energy Forecasting

- **Short-Term, Medium-Term, Long-Term Forecasting:** Applications and methods.
- **Traditional Forecasting Methods:** ARIMA, Exponential Smoothing.
- **ML-based Forecasting:** Regression (Linear, SVR, Random Forest, GBDT).
- **Deep Learning for Forecasting:** LSTMs, GRUs, Transformers for time series.
- **Case Study:** Developing a deep learning model to forecast solar power generation from historical weather data.

Module 4: Anomaly Detection in Grid Operations

- **Types of Anomalies:** Outliers, contextual anomalies, collective anomalies.
- **Statistical Anomaly Detection:** Z-score, IQR, Gaussian Mixture Models.
- **ML-based Anomaly Detection:** Isolation Forest, One-Class SVM, Autoencoders.
- **Applications:** Equipment fault detection, cyberattack detection, sensor malfunction.
- **Case Study:** Identifying anomalous voltage patterns in a distribution feeder indicating equipment malfunction.

Module 5: Optimal Power Flow (OPF) with AI

- **Introduction to OPF:** Objective functions (cost, loss), constraints (voltage, current).
- **Traditional OPF Methods:** Newton-Raphson, Interior Point Method.
- **AI for OPF:** Surrogate models using ML, evolutionary algorithms (GA, PSO).
- **Reinforcement Learning for OPF:** Real-time dispatch decisions.
- **Case Study:** Using a trained ML model to predict optimal reactive power compensation settings.

Module 6: Unit Commitment and Economic Dispatch

- **UC and ED Problem Formulation:** Minimizing generation costs, meeting demand.
- **Classical Optimization Techniques:** Mixed-Integer Linear Programming (MILP).
- **AI for UC/ED:** Heuristic approaches, deep reinforcement learning for scheduling.
- **Handling Renewables and Storage in UC/ED:** Stochastic and robust optimization.
- **Case Study:** Optimizing the dispatch of conventional generators and battery storage units using an RL agent.

Module 7: Predictive Maintenance for Power System Assets

- **Condition Monitoring Data:** Vibration, temperature, oil analysis, partial discharge.
- **Feature Engineering for PdM:** Health indicators, degradation curves.
- **ML Models for PdM:** Classification for failure prediction, regression for Remaining Useful Life (RUL).
- **Benefits and ROI of AI-driven PdM:** Reducing downtime, extending asset life.
- **Case Study:** Predicting potential failure of a power transformer based on dissolved gas analysis (DGA) data using classification models.

Module 8: AI for Grid Resilience and Reliability

- **Fault Detection, Location, and Isolation:** Using sensor data and ML.
- **Service Restoration and Self-Healing Grids:** AI-driven optimization of switching actions.
- **Post-Fault Analysis:** Identifying root causes with ML.
- **AI for Blackstart and Resynchronization:** Planning and executing recovery.
- **Case Study:** Implementing an ML model to quickly identify fault locations on a distribution network.

Module 9: Distributed Energy Resource (DER) Optimization

- **Types of DERs:** Solar PV, Wind Turbines, Battery Energy Storage Systems (BESS), EVs.
- **Challenges of DER Integration:** Variability, intermittency, grid stability.
- **AI for DER Forecasting and Dispatch:** Optimal charging/discharging of BESS.
- **Peer-to-Peer Energy Trading with AI:** Market mechanisms.
- **Case Study:** Using RL to optimize the charging/discharging schedule of a community-level BESS for peak shaving.

Module 10: Digital Twin for Power System Optimization

- **Concept of Digital Twin:** Virtual replica of physical assets/systems.
- **Building a Power System Digital Twin:** Data integration, modeling, simulation.
- **AI within Digital Twins:** Real-time optimization, what-if analysis, predictive insights.
- **Applications:** Asset performance management, grid planning, operator training.
- **Case Study:** Developing a digital twin of a substation to predict equipment behavior under various conditions.

Module 11: AI for Cybersecurity in Power Systems

- **Cyber-Physical Security Threats:** Attack vectors unique to OT/ICS environments.
- **Anomaly Detection for Intrusion:** Identifying malicious activities in network traffic/SCADA data.
- **Attack Classification and Attribution:** Using ML to identify attack types.
- **Defensive AI:** AI for secure configurations, access control.
- **Case Study:** Applying unsupervised learning to detect unusual data patterns indicating a cyber intrusion in a SCADA system.

Module 12: Explainable AI (XAI) for Critical Power Applications

- **Importance of XAI in Power Systems:** Trust, accountability, regulatory compliance.
- **Local Explanations:** LIME, SHAP for understanding individual predictions (e.g., why load forecast was high).
- **Global Explanations:** Interpreting overall model behavior.
- **Challenges of XAI in Complex Models:** Deep neural networks.
- **Case Study:** Explaining the factors contributing to a specific grid instability prediction made by an AI model.

Module 13: Edge AI for Decentralized Power Systems

- **Edge Computing in Power Systems:** Benefits (latency, bandwidth, privacy).
- **Deploying AI Models at the Edge:** Microcontrollers, embedded systems, RTUs.
- **Model Optimization for Edge:** Quantization, pruning, efficient architectures.
- **Federated Learning for Distributed Grids:** Collaborative learning without data sharing.
- **Case Study:** Implementing a local ML model on an edge device in a distribution substation for real-time anomaly detection.

Module 14: AI for Energy Markets and Trading

- **Energy Market Structures:** Spot markets, futures, ancillary services.
- **Price Forecasting with AI:** Predicting electricity prices.
- **Bidding Strategy Optimization:** Using RL for market participation.
- **Risk Management with AI:** Assessing market volatility.
- Upcoming Scheduled Sessions

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Online	$2,000
23 Nov 2026	04 Dec 2026	Physical	$3,000

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$9,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$12,000

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