Training Course on Data Analytics for Electrical Grids

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 specialized training course provides a comprehensive deep dive into leveraging data science, machine learning, and statistical methods to extract actionable insights from the vast and complex datasets generated by modern electrical power systems. Participants will learn how to analyze data from smart meters, SCADA systems, Phasor Measurement Units (PMUs), renewable energy sources, and grid sensors to enhance grid efficiency, reliability, resilience, and sustainability. The curriculum emphasizes practical application, covering essential techniques such as time-series analysis, anomaly detection, predictive analytics, and visualization of grid performance. Training Course on Data Analytics for Electrical Grids is essential for power system engineers, data scientists, and energy professionals seeking to harness the power of big data to drive intelligent decision-making and optimize the operations of traditional and smart grids.

The program focuses on real-world challenges and industry best practices, exploring trending topics like predictive maintenance for grid assets, load forecasting for demand response, fault analysis and root cause identification, cybersecurity using data analytics, and the integration of distributed energy resources (DERs). Through hands-on exercises and case studies, attendees will gain proficiency in data ingestion, cleaning, feature engineering, model development, and results interpretation using industry-standard tools and programming languages (e.g., Python, R). By the end of this course, participants will possess the expertise to apply robust data analytics methodologies to electrical grid data, enabling proactive maintenance, optimized resource allocation, improved operational control, and the acceleration of smart grid initiatives. This training is indispensable for professionals aiming to transform raw data into strategic intelligence for the evolving energy landscape.

Programme Curriculum

Training Course on Data Analytics for Electrical Grids

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Course Objectives

1. Understand the sources and types of data available in modern electrical grids.
2. Apply advanced data preprocessing techniques for cleaning and preparing grid data.
3. Perform exploratory data analysis (EDA) to uncover patterns and trends in power system data.
4. Implement time-series forecasting models for electricity load and renewable generation.
5. Develop anomaly detection algorithms to identify faults and abnormal conditions in grid operations.
6. Utilize predictive analytics for equipment maintenance and remaining useful life (RUL) estimation.
7. Apply machine learning for grid optimization tasks such as demand response and energy management.
8. Analyze power quality issues and identify root causes using data analytics.
9. Leverage data to enhance grid resilience through fault location and restoration analytics.
10. Understand cybersecurity analytics for power systems to detect and mitigate threats.
11. Perform spatial data analysis for geographical grid planning and DER integration.
12. Design effective data visualizations and dashboards for grid operators and analysts.
13. Apply statistical inference and hypothesis testing to grid operational data.

Organizational Benefits

1. Optimized grid operations, leading to reduced energy losses and improved efficiency.
2. Reduced maintenance costs through proactive, data-driven fault detection and prediction.
3. Enhanced grid reliability and stability by identifying and addressing anomalies faster.
4. Improved integration of renewable energy sources, maximizing their value.
5. Faster fault detection and isolation, leading to quicker service restoration.
6. Better capacity planning and demand response management, balancing supply and demand.
7. Increased cybersecurity posture for critical power infrastructure.
8. Development of new data-driven services and business models.
9. More accurate financial forecasting based on improved energy predictions.
10. Strategic decision-making informed by deep insights from grid data.

Target Participants

- Power System Engineers
- Grid Operators and Dispatchers
- Data Scientists working in the Energy Sector
- Smart Grid Researchers and Developers
- Utility IT/OT Professionals
- Energy Analysts
- Consultants in the Power and Utilities Industry

Course Outline

Module 1: Introduction to Data in Electrical Grids

- **Modern Grid Data Sources:** SCADA, AMI (Smart Meters), PMUs, Weather, GIS, Sensor Networks.
- **Characteristics of Grid Data:** Volume, Velocity, Variety, Veracity (the 4 V's).
- **Data Lifecycle in Utilities:** Acquisition, Storage, Processing, Analysis, Visualization.
- **Role of Data Analytics:** From descriptive to prescriptive analytics.
- **Case Study:** Mapping data flows in a typical utility's operations center.

Module 2: Data Preprocessing and Cleaning for Grid Data

- **Handling Missing Values:** Imputation techniques (mean, median, mode, interpolation).
- **Outlier Detection and Treatment:** Statistical methods, Z-score, IQR, Isolation Forest.
- **Data Normalization and Scaling:** Min-Max, Z-score scaling for ML models.
- **Feature Engineering:** Creating new, meaningful features from raw data (e.g., temporal, statistical).
- **Case Study:** Cleaning and preparing a smart meter dataset for load forecasting, including handling missing readings and outliers.

Module 3: Exploratory Data Analysis (EDA) for Power Systems

- **Statistical Summaries:** Mean, median, standard deviation, quartiles.
- **Data Visualization Techniques:** Histograms, scatter plots, box plots, line plots for time series.
- **Correlation Analysis:** Identifying relationships between grid variables.
- **Pattern Recognition:** Identifying recurring trends and anomalies visually.

- **Case Study:** Performing EDA on PMU data to understand voltage and current phase relationships during normal operation.

Module 4: Time-Series Analysis and Forecasting

- **Time-Series Components:** Trend, Seasonality, Cyclicity, Residuals.
- **Classical Time-Series Models:** ARIMA, SARIMA, Exponential Smoothing.
- **Machine Learning for Time-Series:** Regression models (Random Forest, Gradient Boosting).
- **Deep Learning for Time-Series:** LSTMs, GRUs for long-term dependencies.
- **Case Study:** Forecasting day-ahead electricity load for a city using a combination of historical data and weather forecasts.

Module 5: Power Load and Demand Response Analytics

- **Load Profiling and Segmentation:** Identifying different customer behaviors.
- **Demand Response Program Evaluation:** Quantifying energy savings and peak reduction.
- **Non-Intrusive Load Monitoring (NILM):** Decomposing total load into individual appliance usage.
- **Forecasting Peak Demand:** Predicting critical periods for grid stress.
- **Case Study:** Using smart meter data to identify customer segments suitable for a demand response program.

Module 6: Renewable Energy Generation Forecasting and Integration

- **Solar Power Forecasting:** Using irradiance data, cloud cover.
- **Wind Power Forecasting:** Using wind speed, direction, turbine characteristics.
- **Probabilistic Forecasting:** Quantifying uncertainty in renewable generation.
- **Impact of Renewables on Grid Stability:** Using data to manage intermittency.
- **Case Study:** Developing a machine learning model to predict 24-hour ahead output of a solar farm.

Module 7: Anomaly Detection for Grid Operations and Assets

- **Statistical Anomaly Detection:** Z-score, control charts.
- **Clustering-based Anomaly Detection:** DBSCAN, K-Means for outliers.
- **Machine Learning Anomaly Detection:** Isolation Forest, One-Class SVM, Autoencoders.
- **Applications:** Fault detection, sensor errors, cybersecurity threats.
- **Case Study:** Detecting unusual power quality events in a feeder using unsupervised anomaly detection.

Module 8: Predictive Maintenance for Electrical Grid Assets

- **Asset Health Monitoring:** Collecting data from transformers, circuit breakers, generators.
- **Feature Engineering for Degradation:** Extracting health indicators (e.g., DGA for transformers).
- **Classification for Fault Prediction:** Predicting component failure.
- **Regression for Remaining Useful Life (RUL):** Estimating asset lifespan.
- **Case Study:** Building a model to predict the likelihood of a transformer failure based on its operational data.

Module 9: Power Quality Analytics

- **Power Quality Phenomena:** Sags, swells, harmonics, transients.

- **Data Sources for PQ Analysis:** Waveform recorders, power quality meters.
- **Signal Processing Techniques:** FFT for harmonic analysis, wavelet transforms for transients.
- **Automated Classification of PQ Events:** Using ML for event categorization.
- **Case Study:** Analyzing high-resolution waveform data to identify and classify voltage sag events.

Module 10: Grid Resilience and Fault Analysis

- **Fault Location Analytics:** Using PMU data and line parameters.
- **Outage Management Systems (OMS) Data Analytics:** Optimizing restoration.
- **Root Cause Analysis (RCA):** Data-driven identification of fault origins.
- **Post-Mortem Analysis:** Learning from past incidents to prevent future ones.
- **Case Study:** Using smart meter outage data to pinpoint fault locations in a distribution network.

Module 11: Cybersecurity Analytics for Power Systems (OT/IT Convergence)

- **Cybersecurity Threats to Grids:** Ransomware, unauthorized access, denial of service.
- **Data Sources:** Network logs, firewall logs, SCADA system logs.
- **Anomaly Detection for Intrusions:** Identifying suspicious network traffic or control commands.
- **Threat Intelligence Integration:** Using external data sources.
- **Case Study:** Analyzing SCADA network traffic logs to detect potential cyberattack patterns.

Module 12: Spatial Data Analytics for Grid Planning

- **Geographic Information Systems (GIS) Data Integration:** Network topology, asset locations.
- **Spatial Clustering:** Identifying geographical patterns in grid performance or customer demand.
- **Optimal DER Siting:** Using spatial analysis to identify best locations for solar/wind farms.
- **Network Visualization:** Interactive maps for grid operators.
- **Case Study:** Performing spatial analysis to identify areas with high potential for rooftop solar adoption.

Module 13: Data Visualization and Dashboarding for Grid Operators

- **Principles of Effective Visualization:** Clarity, accuracy, impact.
- **Tools for Grid Dashboards:** Tableau, Power BI, D3.js, custom Python dashboards.
- **Real-Time Data Visualization:** Monitoring critical grid parameters.
- **Interactive Dashboards:** Enabling drill-down and root cause exploration.
- **Case Study:** Designing an interactive dashboard for a grid control center showing real-time load, generation, and fault status.

Module 14: AI/ML Deployment and MLOps in Utilities

- **Model Deployment Strategies:** Edge computing, cloud-based inference.
- **Monitoring Model Performance:** Drift detection, retraining strategies.
- **MLOps Principles:** Automation of ML lifecycle (CI/CD for models).
- **Data Governance and Security:** Ensuring data integrity and privacy.
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Upcoming Scheduled Sessions

Start Date	End Date	Location	Price
21 Sep 2026	02 Oct 2026	Online	$2,000
21 Sep 2026	02 Oct 2026	Physical	$3,000
21 Sep 2026	02 Oct 2026	Physical	$0
21 Sep 2026	02 Oct 2026	Physical	$0
21 Sep 2026	02 Oct 2026	Physical	$0
21 Sep 2026	02 Oct 2026	Physical	$0
21 Sep 2026	02 Oct 2026	Physical	$0
21 Sep 2026	02 Oct 2026	Physical	$0

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