Wind Turbine Digital Twins Training Course

Professional Development Training Course Outline

Category	Renewable Energy	**Duration**	5 Days
Base Fee	$1,500 USD	**Delivery Mode**	Online / On-site Hybrid

Course Introduction

Wind Turbine Digital Twins Training Course provides a practical, future-focused foundation in Digital Twin technology, artificial intelligence (AI), machine learning (ML), Industrial Internet of Things (IIoT), predictive maintenance, condition monitoring, and renewable-energy asset optimization. Digital Twins are increasingly being applied to wind-energy operations to connect real-time sensor data, simulation models, analytics, and maintenance decision-making. Recent research highlights the growing convergence of physics-based modeling, data-driven AI, SCADA analytics, IoT, prognostics, and predictive maintenance for wind-turbine lifecycle management. The course therefore focuses on how a virtual representation of a turbine can support real-time monitoring, fault diagnosis, remaining useful life (RUL) estimation, performance optimization, risk assessment, and intelligent O&M strategies.

Participants will explore the complete physical-to-digital-to-physical lifecycle, from turbine sensors and SCADA data through data engineering, virtual modeling, AI analytics, simulation, visualization, and maintenance decisions. The training incorporates contemporary applications such as hybrid physics–AI Digital Twins, edge/cloud computing, anomaly detection, structural health monitoring, probabilistic prognostics, and prescriptive maintenance. Current research also demonstrates applications spanning drivetrain condition monitoring, offshore turbine maintenance optimization, and multi-scale digital twins combining real-time control with long-term prognostics. Through practical exercises and case studies, learners develop an understanding of how Digital Twins can contribute to higher reliability, reduced unplanned downtime, improved asset availability, data-driven decision-making, and sustainable wind-farm operations.

Programme Curriculum

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Course Duration

5 days

Course Objectives

By the end of the course, participants will be able to:

1. Explain Digital Twin architectures and their role in modern wind-energy asset management.
2. Design IIoT and sensor-data architectures for real-time turbine monitoring.
3. Analyze SCADA, vibration, acoustic, environmental, and operational data.
4. Develop physics-based and data-driven turbine models.
5. Apply AI and machine learning to turbine condition monitoring.
6. Implement anomaly detection and fault-diagnosis concepts.
7. Understand predictive maintenance and prognostics workflows.
8. Apply Remaining Useful Life (RUL) estimation to critical turbine components.
9. Evaluate hybrid physics–AI Digital Twin approaches.
10. Explore edge computing, cloud platforms, and real-time data pipelines.
11. Use Digital Twins for performance optimization and maintenance planning.
12. Assess cybersecurity, interoperability, data quality, model validation, and uncertainty.
13. Develop an integrated roadmap toward prescriptive and autonomous Digital Twin-enabled O&M.

Target Audience

1. Wind-farm engineers and asset managers
2. Renewable-energy operations and maintenance professionals
3. Mechanical, electrical, and control engineers
4. Data scientists and AI/ML engineers
5. Reliability and predictive-maintenance specialists
6. Digital-transformation and Industry 4.0 professionals
7. Researchers, academics, and postgraduate engineering students

8. Energy-sector managers and technology decision-makers

Course Modules

Module 1 — Digital Twin Foundations for Wind Energy

- Digital Twin concepts, terminology, lifecycle, and value proposition
- **Physical–virtual synchronization** and cyber-physical systems
- Wind-turbine architecture
- Digital Thread, asset lifecycle management, and **Industry 4.0**
- Digital Twin maturity
- **Case Study:** Build a conceptual Digital Twin architecture for a utility-scale wind turbine, mapping physical assets to virtual models, sensor streams, analytics, and maintenance decisions.

Module 2 — Wind Turbine Data, Sensors, SCADA & IIoT

- **SCADA data engineering** and time-series data fundamentals
- Sensors for temperature, vibration, pressure, strain, speed, and power
- IoT/IIoT connectivity and real-time telemetry
- Data quality, synchronization, missing data, and anomaly handling
- Edge, cloud, and high-performance data architectures
- **Case Study:** Develop a data-flow model connecting turbine sensors and SCADA systems to an analytics layer for real-time condition monitoring.

Module 3 — Physics-Based & Hybrid Digital Twin Modeling

- First-principles modeling of wind-turbine components
- **Structural, mechanical, thermal, and aerodynamic modeling**
- Finite Element Analysis (FEA) and multi-physics simulation concepts
- Reduced-order and surrogate models for faster computation
- **Hybrid physics–AI Digital Twin** development
- **Case Study:** Compare a computationally intensive physics model with a surrogate model for a floating-wind application and examine how AI-enhanced surrogate modeling can support real-time predictive maintenance.

Module 4 — AI, Machine Learning & Anomaly Detection

- Supervised and unsupervised **machine learning for wind turbines**
- Time-series forecasting and deep-learning concepts
- Anomaly detection and health-state classification
- Fault detection, feature engineering, and model evaluation
- Explainable AI and trustworthy analytics
- **Case Study:** Design an ML-based workflow that identifies abnormal turbine behavior from historical operational data and feeds the results into a Digital Twin for diagnostic support.

Module 5 — Predictive Maintenance, Prognostics & RUL

- **Condition-Based Maintenance (CBM)** and predictive maintenance
- Fault diagnosis and root-cause analysis
- Degradation modeling and **Remaining Useful Life (RUL)**
- Prognostics and Health Management (PHM)
- Maintenance prioritization using risk and reliability indicators

- **Case Study:** Develop a conceptual RUL workflow for a wind-turbine drivetrain, using condition indicators to transition from reactive maintenance toward predictive maintenance

Module 6 — Offshore Wind, Structural Health & Risk-Based Twins

- Offshore and floating wind Digital Twin challenges
- Structural Health Monitoring (SHM)
- Corrosion, fatigue, loads, and environmental uncertainty
- Probabilistic Digital Twins and reliability assessment
- **Risk-informed maintenance optimization**
- **Case Study:** Examine an offshore Digital Twin that combines real-time environmental and operational data with probabilistic failure prediction and maintenance-cost estimation to support risk-informed decisions.

Module 7 — Real-Time Optimization, Control & Prescriptive Twins

- Real-time Digital Twin synchronization
- **Performance optimization and Model Predictive Control (MPC)**
- Scenario simulation and what-if analysis
- Prescriptive maintenance and decision support
- Closed-loop and emerging autonomous Digital Twin concepts
- **Case Study:** Analyze a multi-scale wind-energy Digital Twin integrating real-time control and long-term prognostics.

Module 8 — Digital Twin Deployment, Governance & Future Roadmap

- Cloud/edge deployment and scalable Digital Twin architectures
- **Interoperability, cybersecurity, data governance, and standards**
- Model validation, uncertainty quantification, and lifecycle management
- Business value, ROI, O&M transformation, and deployment readiness
- Roadmap toward **AI-native, federated, prescriptive, and autonomous Twins**
- **Case Study:** Create a Digital Twin maturity roadmap for a wind-farm operator, progressing from basic digital monitoring to diagnostic, prognostic, prescriptive, and autonomous maintenance capabilities.

Training Methodology

- Interactive lectures and presentations.
- Group discussions and brainstorming sessions.
- Hands-on exercises using real-world datasets.
- Role-playing and scenario-based simulations.
- Analysis of case studies to bridge theory and practice.
- Peer-to-peer learning and networking.
- Expert-led Q&A sessions.
- Continuous feedback and personalized guidance.

Register as a group from 3 participants for a Discount

Send us an email: info@fineskilltrainingcenter.org or call *+254769199797*

Certification

Upon successful completion of this training, participants will be issued with a globally- recognized certificate.

Tailor-Made Course

We also offer tailor-made courses based on your needs.

Key Notes

a. The participant must be conversant with English.

b. Upon completion of training the participant will be issued with an Authorized Training Certificate

c. Course duration is flexible and the contents can be modified to fit any number of days.

d. The course fee includes facilitation training materials, 2 coffee breaks, buffet lunch and A Certificate upon successful completion of Training.

e. One-year post-training support Consultation and Coaching provided after the course.

f. Payment should be done at least a week before commence of the training, to Fineskill Training Center account, as indicated in the invoice so as to enable us prepare better for you.

Upcoming Scheduled Sessions

Start Date	End Date	Location	Price
21 Sep 2026	25 Sep 2026	Online	$1,000
21 Sep 2026	25 Sep 2026	Physical	$1,500
21 Sep 2026	25 Sep 2026	Physical	$0
21 Sep 2026	25 Sep 2026	Physical	$0
21 Sep 2026	25 Sep 2026	Physical	$0
21 Sep 2026	25 Sep 2026	Physical	$0
21 Sep 2026	25 Sep 2026	Physical	$0
21 Sep 2026	25 Sep 2026	Physical	$0

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