Modeling, Control, and Diagnosis of PEM Fuel Cell Systems with Techno-Economic Analysis

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This agenda ensures a balanced mix of theoretical knowledge and practical skills, providing participants with a thorough understanding of PEM Fuel Cell systems, their control, diagnosis, and economic assessment

Target Audience: Academics | Industry Professionals | Engineers in Renewable Energy, Control, Automation | master's and PhD Students in Control, Electrical, Mechanical Engineering

Total Duration: ~6 hours (including breaks)

🔹 **Session 1: Fundamentals of PEM Fuel Cells (9 :00-9:45)**

- **Overview of Fuel Cell Technologies**: Introduction to various fuel cell types and their applications.
- **Working Principle of PEMFC**: Detailed explanation of the proton exchange mechanism.
- **Key Components and Their Roles**: Membrane Electrode Assembly (MEA), bipolar plates, gas diffusion layers.
- **Performance Metrics**: Efficiency, voltage-current characteristics, power density.
- **Operational Challenges**: Issues like water management, thermal management, and degradation mechanisms

🔹 **Session 2: Control Strategies for PEMFC Using MATLAB/Simulink (9 :45: 10:45)**

- **Modeling PEMFC in MATLAB/Simulink**: Building dynamic models using Simscape and Simulink.
- **Control Objectives**: Voltage regulation, load following, efficiency optimization.
- **Implementing Advanced Control Strategies**: PID, fuzzy logic, and model predictive control techniques.
- **Simulation and Analysis of Performance**: Evaluating control strategies under various operating conditions

☕ **Coffee Break (15 min)**

🔹 **Session 3: Fault Diagnosis and Prognostics in PEM Fuel Cells (60 min)**

- **Common Faults & Degradation Mechanisms**: Membrane drying, flooding, catalyst degradation.
- **Fault Detection Methods**: Analytical redundancy, data-driven approaches, and model-based techniques.

- **Prognostics and Health Management**: Estimating remaining useful life and implementing predictive maintenance.
- **Case Studies**: Real-world examples of fault diagnosis in PEMFC systems

🍽️ **Lunch Break (90 min)**

🔹 **Session 4: Techno-Economic Analysis Using HOMER & RETScreen (13 :30-14:30)**

- **Introduction to HOMER and RETScreen**: Overview of software capabilities and applications
- **Evaluating Feasibility of Fuel Cell Systems**: Assessing technical and economic viability.
- **Case Study: Hybrid System Design with PEMFC (HOMER)**: Designing and optimizing a hybrid renewable system
- **Energy Efficiency and Financial Analysis (RETScreen)**: Performing cost-benefit analysis and environmental impact assessment

🔹 **Session 5: Hands-On Simulation Exercises (14 :30-16 :00-)**

Participants will engage in practical exercises using MATLAB/Simulink, HOMER, and RETScreen:

- **MATLAB/Simulink**: Simulating PEMFC control strategies and fault scenarios.
- **HOMER**: Optimizing fuel cell integration in hybrid energy systems.
- **RETScreen**: Conducting performance, cost analysis, and environmental impact assessments.

🔹 **Session 6: Q&A, Wrap-Up, and Future Directions (16 :00-16 :30)**

- **Key Takeaways**: Summarizing essential concepts and learnings
- **Future Trends in PEMFC Technology**: Emerging research areas and industrial applications.
- **Open Discussion**: Addressing participant questions and exploring collaborative opportunities

✅ **Deliverables for Participants :**

- **Workshop Slides**: Comprehensive presentation covering all sessions
- **Simulation Models**: MATLAB/Simulink files for PEMFC modeling and control
- **Software Project Files**: HOMER and RETScreen project examples
- **Reading Materials**: Relevant research papers and articles for further study