Condition monitoring platform for proactive and reactive operation and maintenance (O&M) with enhanced data analytic functionalities

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We are here!
Highlights of the PV Technology Laboratory

- Participation/coordination of over 60 national/international research projects
- Research funding of 18 MEuros over the past 10 years
- Comprises of 30 researchers
- Over 250 research publications
- Research quality/awards at international conferences
Indoor/outdoor testing
Official testing site for over 40 different manufacturers:

- Honeywell
- Q CELLS
- Conercon Energy Solutions
- tsmc solar
- SunTechnics
- oerlikon
- REC Solar
- SCHOTT Solar
- SolarWorld
Introduction

• Key factor for future PV uptake is to reduce Levelized Cost of Electricity (LCoE)
• Increasing performance and reducing operating costs (advanced monitoring)

Condition monitoring platform

- Data quality and sanity
- System health state
- Failure detection and classification
- Added Value Services: Performance loss quantification, Degradation rate estimation
Background & Objective

**Specific Objective:** Development of an innovative condition monitoring platform for proactive and reactive O&M with enhanced data analytic functionalities

Advanced baseline condition monitoring solution to ensure operational quality and optimise energy production

**Partners:** GI and UCY  
**Project:** Innovative Performance Monitoring System for Improved Reliability and Optimized Levelized Cost of Electricity  
**IPERMON** [Solar-ERA.net project]  
**Budget:** €400,000  
**Duration:** 36 Months  
**Weblink:** http://www.pvtechnology.ucy.ac.cy/projects/ipermon/
State-of-the-art

- Visual inspection is the simplest method to detect visible failures
- The most popular technique for failure diagnosis is image analysis
- Methods based on advanced data analysis of electrical parameters are becoming increasingly popular
Performance monitoring and data analytics

• Change from Descriptive analytics to Diagnostic/Predictive Analytics
Intelligent data analytic features
Intelligent data analytic features

Data quality and sanity
Intelligent data analytic features

System health state
Intelligent data analytic features

Failure detection and classification
Intelligent data analytic features

Added Values Services:
Performance loss quantification
Degradation rate estimation
Platform functionalities – Data quality routines (DQRs)

- Identify missing and erroneous data
- Estimate system availability and sensor deviations
- Correct data through data imputation techniques (LOCF and linear interpolation)
Platform functionalities – PV system model prediction

- Parametric and machine learning simulation models
Platform functionalities – Degradation Rate

• Statistical and comparative techniques for trend extraction and estimation of the degradation rate
Platform functionalities – System Health State

• Comparative assessment between measured and predicted daily PV performance
• Classification of the relative error in ranked categories
Platform functionalities – Failure detection

- Comparative assessment between measured and predicted measurements against set threshold levels (TL)
- Statistical outlier detection rules

![Graph showing power vs. irradiance with normal and fault conditions, and a false alarm.]

![Graph showing power vs. time with AE, measured, and predicted data with TL threshold.]
Platform functionalities – Failure classification

- Unsupervised procedures (voltage/current/power ratio and fuzzy logic rules)
- Supervised procedures (k-NN, SVM, Decision and Regression Trees)
- Failure patterns

Current and voltage indicators

Bypass diode pattern
Online Platform
Future...

- Digital Performance Architectures (Digital Twin Concepts)

  - Physical systems
  - IoT
  - Interoperability
  - Virtual system
  - Cloud
  - Added services
    - Grid control
    - Performance analysis
    - Forecasting
Summary

• PV performance measurements and analytical techniques are required to ensure optimal lifetime performance and to reduce LCoE.
• Performance monitoring platforms consist of the:
  • Sensor network
  • Data acquisition (DAQ) device
  • Visualizations portal – Descriptive analysis
• Required accuracy and complexity depends on the PV system size and user objectives.
• Future grid modernisation is the driver for advanced performance architectures.
Acknowledgement

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Together we do more for PV and Smart Grids

Team
- 3 countries
- Over 100 Expert Researchers, Trainers
- One stop shop (cells to modules to Grid)
- Training, Testing, Research
Photovoltaics Lifetime Output Improvement: Advanced Monitoring, Failure Detection and Classification and Energy Forecasting

Guest Editors
Prof. George E. Georghiou, Dr. George Makrides, Dr. Marios Theristis

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Thank you for your attention

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