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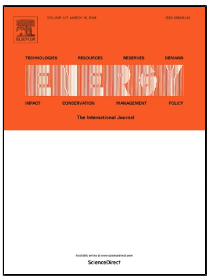

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ON THE USE OF DYNAMIC RELIABILITY FOR AN ACCURATE MODELLING OF RENEWABLE POWER PLANTS

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ABSTRACT

Renewable energies are a key element of the modern sustainable development. They play a key role in contributing to the reduction of the impact of fossil sources and to the energy supply in remote areas where the electrical grid cannot be reached.

Due to the intermittent nature of the primary renewable resource, the feasibility assessment, the performance evaluation and the lifecycle management of a renewable power plant are very complex activities. In order to achieve a more accurate system modelling, improve the productivity prediction and better plan the lifecycle management activities, the modelling of a renewable plant may consider not only the physical process of energy transformation, but also the stochastic variability of the primary resource and the degradation mechanisms that affect the aging of the plant components resulting, eventually, in the failure of the system.

This paper presents a modelling approach which integrates both the deterministic and the stochastic nature of renewable power plants using a novel methodology inspired from reliability engineering: the Stochastic Hybrid Fault Tree Automaton. The main steps for the design of a renewable power plant are discussed and implemented to estimate the energy production of a real photovoltaic power plant by means of a Monte Carlo simulation process. The proposed approach, modelling the failure behavior of the system, helps also with the evaluation of other key performance indicators like the power plant and the service availability.

Keywords: Renewable Energy, Stochastic Hybrid Automaton, Availability, Photovoltaic Power Plant, Service Availability

Nomenclature

Generic Acronyms

GHI	Global horizontal irradiation
IPER	Italian Producer Electrical Regulation
DFT	Dynamic Fault Tree
KPI	Key Performance Indicator
RDFT	Repairable Dynamic Fault Tree
SHyFTA	Stochastic Hybrid Fault Tree Automaton

Photovoltaic Power Plant

ACB	Alternate current circuit breaker
ACD	Alternate current disconnector
ACS	Alternate current section
BAT	Battery
DCB	Differential circuit breaker
DCD	Direct current disconnector
DCS	Direct current section
GCC	Grid connect coupling section
GPR	Grid protection
INV	Inverter
PVM	Photovoltaic module section
PVG	Photovoltaic generator
PVS	Photovoltaic string
SDP	Surge protection (AC section)
SPD	Surge protection (DC section)
SPR	String protection
STB	String box
TRA	Transformer
TRK	Tracker

SHyFTA Parameters

β	Shape factor (Weibull function)
γ	Scale parameter (Weibull function)
λ	Failure rate
μ	Repair rate