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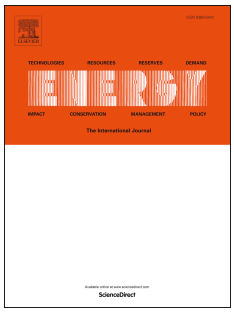

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Multiobjective economic-environmental power dispatch with stochastic wind-solar-small hydro power

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Abstract: Economic-environmental power dispatch is one of the most popular bi-objective non-linear optimization problems in power system. Classical economic power dispatch problem is formulated with only thermal generators often ignoring security constraints of the network. But importance of reduction in emission is paramount from environmental sustainability perspective and hence penetration of more and more renewable sources into the electrical grid is encouraged. However, most common forms of renewable sources are intermittent and uncertain. This paper proposes multiobjective economic emission power dispatch problem formulation and solution incorporating stochastic wind, solar and small-hydro (run-of-river) power. Weibull, lognormal and Gumbel probability density functions are used to calculate available wind, solar and small-hydro power respectively. Some conventional generators of the standard IEEE 30-bus system are replaced with renewable power sources for study purpose. Network security constraints such as transmission line capacities and bus voltage limits are also taken into consideration alongwith constraints on generator capabilities and prohibited operating zones for the thermal units. Decomposition based multiobjective evolutionary algorithm and summation based multiobjective differential evolution algorithm are applied to the problem under study. An advanced constraint handling technique, superiority of feasible solutions, is integrated with both the multiobjective algorithms to comply with system constraints. The simulation results of both the algorithms are summarized, analyzed and compared in this study.

Keywords: Economic-environmental dispatch · Wind power generator · Solar photovoltaic · Small-hydro power unit · Uncertainty modelling · Multiobjective evolutionary algorithms

Nomenclature

Abbreviations

EED	economic-environmental dispatch
MOEA/D	multiobjective evolutionary algorithm based on decomposition
SMODE	summation based multiobjective differential evolution
SF	superiority of feasible solutions
TG	thermal power generator
WG	wind generator
PV	photovoltaic
SPH	a solar PV and a small-hydro (run-of-river) power unit
ISO	independent system operator
PDF	probability density function
POZ	prohibited operating zone

Symbol

P_{TGi}	power output from the i-th thermal generator
P_{ws}	scheduled power from the wind power plant
P_{ss}	scheduled power from the solar PV plant
P_{ssh}	scheduled power from the combined solar PV and small-hydro unit
P_{wav}	actual available power from the wind power plant
P_{sav}	actual available power from the solar PV plant
P_{shav}	actual available power from the combined solar PV and small-hydro unit
g_w	direct cost coefficient for the wind power
h_s	direct cost coefficient for the solar PV power
m_h	direct cost coefficient for the small-hydro unit power
K_{Rw}	reserve cost coefficient for overestimation of wind power
K_{Pw}	penalty cost coefficient for underestimation of wind power
K_{Rs}	reserve cost coefficient for over-estimation of solar power
K_{Ps}	penalty cost coefficient for under-estimation of solar power
K_{Rsh}	reserve cost coefficient for combined solar and hydro system
K_{Psh}	penalty cost coefficient for combined solar and hydro system
G_s	solar irradiance in $\mathrm{W/m^2}$
Q_w	river flow rate in m^3/s
$f_v(v)$	probability of wind speed v
$f_G(G_s)$	probability of solar irradiance G_s
$f_Q(Q_w)$	probability of river flow rate Q_w
p_{wr}	rated output power of a wind turbine
P_{sr}	rated output power of the solar PV plant
P_{hr}	rated output power of the small-hydro unit
α, β	Weibull PDF scale and shape parameters respectively
μ, σ	lognormal PDF mean and standard deviation respectively
λ, γ	Gumbel PDF location and scale parameters respectively
P_{loss}	real power loss in the network
VD	cumulative voltage deviation of load buses in the network