Renewable and Sustainable Energy Reviews 52 (2015) 256–264

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Renewable energy resources short-term scheduling and dynamic network reconfiguration for sustainable energy consumption

G. Gutiérrez-Alcaraz [a,*], E. Galván [a], N. González-Cabrera [a], M.S. Javadi [b]

[a] Department of Electrical Engineering, Instituto Tecnológico de Morelia, Morelia, Michoacán, México
[b] Department of Electrical Engineering, Shiraz Branch, Islamic Azad University, Shiraz, Iran

ARTICLE INFO

Article history:
Received 11 November 2014
Received in revised form
19 May 2015
Accepted 26 July 2015
Available online 13 August 2015

Keywords:
Distributed generation
Electricity market
Network reconfiguration
Renewable energy resources

ABSTRACT

This paper proposes a two-phase approach for optimal short-term operational scheduling with intermittent renewable energy resources (RES) in an active distribution system. The first phase determines the amounts of purchased power from the market and the unit status of distributed generation (DG) and feeds the data into the second phase, a real-time scheduling coordination with hourly network reconfiguration. The two-phase proposed approach is applied to a case study of a sixteen-bus test system that uses synthetic data from renewable power generators and forecasts local user demands with a sampling time of five minutes.

Contents

1. Introduction

Increased demand, insufficient supply, and ineffective production practices are major obstacles in older generation systems that are attempting to incorporate more sustainable management practices. Today, the world's energy system comes from conventional energy such as oil, gas and coal, which together supply around 80% of our primary energy. Conventional energy contains mostly carbon which is the leading cause of global warming [1]. Only around 0.5% of primary energy comes from renewable energy resources (RES) such as wind, solar and geothermal [2]. While the RES share is still relatively small, its growth has accelerated in recent years. The share of RES is predicted to contribute approximately 30% to 80% in 2100 [3]. The transition to clean and sustainable generation, transmission and uses of energy typically

* Corresponding author at: Department of Electrical and Electronic Engineering, Instituto Tecnológico de Morelia, Morelia, Mich., México. Tel/Fax: +52 4433121570 x 1511.

E-mail address: ggutier@itmorelia.edu.mx (G. Gutiérrez-Alcaraz).

http://dx.doi.org/10.1016/j.rser.2015.07.105
1364-0321/

Nomenclature

$\alpha_i, \beta_i, \gamma_i$	Coefficients of the production cost function
P_{it}	Active power generation of unit i at time t
ρ_t^{DA}	Day-ahead electricity market price for time t
$P_{s,t}^{DA}$	Net power purchased from the market in time t
PW_{it}	Active power generation of wind turbine i at time t
PS_{it}	Active power generation of PV i at time t
N_{rs}	Total number of branches included in the spanning tree
N_n	Total number of nodes
N_g	Total number of generating units
N_b	Total number of branches
N_T	Set of all substation transformers
N_W	Total number of wind generation installations
N_{PV}	Total number of photovoltaic aggregated installations
Pd_k	Active load at node k
Qd_k	Reactive load at node k
Pg_k	Active power injected at node k
Qg_k	Reactive power injected at node k
K_{out}	Set of feeders receiving power from transformer p
S_{pk}	Power flowing from transformer p to feeder k
S_p^{Max}	Rating of transformer p
S_j	Loading of feeder j
S_j^{Max}	Rating of feeder j
V_k	Voltage magnitude at node k
V_k^{Min}	Minimum voltage magnitudes at node k
V_k^{Max}	Maximum voltage magnitudes at node k
p	Order of non-seasonal auto-regression
d	Number of regular differencing
q	Order of non-seasonal *MA*
P	Order of seasonal auto-regression
D	Number of seasonal differencing
Q	Order of seasonal MA
B	Seasonal differencing operator
s	Length of season (periodicity)
φ	*AR* operator of order p
Φ	Seasonal AR parameter of order P
Z_t	Observed value at time point t
θ	MA operator of order q,
Θ	Seasonal *MA* parameter of order Q
a_t	White noise component of the stochastic model
σ^2	Variance
$error_{test}$	Error test
$\hat{D}_{t-i}$	Value forecasted of period t
$D_{real,t-i}$	Real value measured
T	Total number of periods
K	Total number of transformers
$F_{ci}(P_i)$	Production cost function of unit i
I_{it}	Commitment state of unit i at time t
SU_{it}	Startup cost of unit i at time t
SD_{it}	Shutdown cost of unit i at time t
$R_{S,it}$	Spinning reserve of unit i at time t
$R_{S,t}$	System spinning reserve at time t
$R_{O,it}$	Operating reserve of unit i at time t
$R_{O,t}$	System operating reserve at time t
R_{it}	Reserve of unit i at time t
P_i^{Min}	Minimum active power generation of unit i
P_i^{Max}	Maximum active power generation of unit i
RU_i	Ramp-up rate limit of unit i
RD_i	Ramp-down rate limit of unit i
T_i^{on}	Minimum down time of unit i
T_i^{off}	Minimum up time of unit i
$x_{i(t-1)}^{on}$	ON time of unit i at time t
$x_{i(t-1)}^{off}$	OFF time of unit i at time t

involves a large number of social, economic, environmental, technical and political factors [4]. The urgent need to reduce greenhouse gas emissions (GHG) involves integrating non-conventional energy supply sources, i.e. wind and solar [5]. The Photovoltaic (PV) system is promising source of electricity generation for energy resource saving and CO_2 emission reduction [6]. Wind RES ranks second in terms of installed capacity and is experiencing rapid growth [3]. However, integration of photovoltaic (PV) systems and wind turbines (WTs) into the distribution systems is a major challenge to system operators and planners due to the high uncertainty and variability in the characteristics of PVs and WTs [7–9].

According to the U.S. Energy Information Administration (EIA) though electrical consumption has slowed in the last years it is expected to increase by 28% from 2011 to 2040. Also, there are projections that by 2040 15% of coal fired power generation will be retired, an estimated decline of up to 100,000 MW of generation [10]. Projections expect that a percentage of the loss in generation capacity will be covered by the slight increase in natural gas generation [11]. Thus, coupled with mandating renewable portfolio standards and other environmental policies lead directly to value creation along the value chain of the adopted RES as well as to indirect effects which are achieved in other sectors [12]. The deployment of such strategies will also change the geopolitics of energy by allowing oil-rich nations to transition to the production of sustainable energy with high penetration in renewable resources as analyzed in [13]. In the United States, the federal government is advocating PV installation as part of its push for energy self-sufficiency by cities [14]. However, the stochastic nature of variable RES is complicated. In [4] developed methodology can tackle uncertainties expressed as interval values and dynamics of capacity-expansion issues. Enhancing hydro-storage and wind power generation modules of the developed power management systems enable an in-depth analysis of renewable energy development strategies and sustainable transition pathways. A combined use of wind- and hydro-storage power generation facilities arranged to form a multi-level storage can compensate the stochastic fluctuations of power over diverse time scales. In this context, the access-oriented storage functions as a shock absorber to shield fuel cells and electrolysis from the fast fluctuations in wind power and load [15,16] Stochastically models the uncertainties of wind power, photovoltaic (PV) power, and load by using autoregressive moving average (ARMA). [17] reports a probabilistic ranking of different renewable technologies by using Multi-criteria Analysis. Load shifting strategies are proposed to provide efficiency and flexibility to reduce the mismatch between the renewable generation and heating ventilation and air conditioning loads in a hybrid power system. The integration of intermittent RES as a market is based upon the economical operation of the electric system, coordinating renewable and thermal generation, or the introduction of micro-grids and smart grids [18]. Smart grid implementation improves a system through seamless integration of RES, thus improving power quality using automated controls, modern communications networks, and energy management techniques that optimize demand, energy and network accessibility [19–21]. A methodology for energy resource short-term scheduling in smart grids, considering intensive penetration of DG and load curtailment opportunities enabled by demand response programs is reported in [22]. The short-term scheduling, undertaken five minutes ahead,