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Maximization of Wind Energy Utilization and Flicker Propagation Mitigation Using SC and STATCOM

S.Mahdi Kazemi-Razi[1], Mojtaba Mirsalim[1], Hossein Askarian-Abyaneh[1], Hamed Nafisi[1], Mousa Marzband[2]
[1]Department of Electrical Engineering, Amirkabir University of Technology, Tehran, Iran.
[2]Department of Mathematics, Physics and Electrical Engineering, Northumbria University, Newcastle, United Kingdom.

***Abstract*—This paper proposes a novel approach to maximize utilization of wind energy by using a combination of flexible AC transmission system (FACTS) devices, shunt capacitor (SC) and static synchronous compensator (STATCOM). The stochastic nature of wind power is considered through a set of scenarios. After running the real market, the proposed model must be applied by the independent system operator (ISO) to determine the parameters such as the value of the real reserve of each generator. The control procedure of the proposed model is easier and more accelerated due to using SC. Moreover, the proposed method improves the voltage flicker mitigation and power quality parameters due to using STATCOM. The proposed method is applied to IEEE RTS. It is shown that the proposed model affects the total flexibility of the energy system compared to the system without SC and STATCOM in order to enhance effective wind energy utilization.**

***Index Terms*--FACTS devices, PCC point, voltage flicker, wind energy utilization.**

NOMENCLATURE

1. Indices

s	Index of scenarios, 1 to N_s.
r	Index of wind power units, 1 to N_r.
l	Index of loads, 1 to N_l.
i	Index of conventional units, 1 to N_i.
n / m	Index of buses.

2. Sets

ξ	Set of loads.
ϱ	Set wind units.
π_n	Set of buses adjacent to *n*th bus.
ζ	Set of conventional units.

3. Parameters

L_l^Q	Reactive load by *l*th load.
P_i^{fix}	Power production by *i*th conventional unit.
$\underline{Q}_i$ / $\overline{Q}_i$	Min/Max reactive power production of *i*th unit.
R_i^D / R_i^U	Min/Max active reserve by *i*th unit.
T_s	Probability of *s*th scenario.
L_l^P	Active load by *l*th load.
$Z_{nm_{loss}}$	Importance factor of loss in objective function.
$\overline{S}_{nm}$	Capacity of line from bus *n* to bus *m*.
Q_i^D / Q_i^U	Min/Max reactive reserve by *i*th unit.
$Z_{r_{wind}}$	Importance factor of wind spillage in objective function.
$Z_{l_{shedd}}$	Importance factor of load shedding in objective function.
W_{rs}	Output power of *r*th wind farm in *s*th scenario.
W_r^{fix}	Output power of *r*th wind farm as a result of market.
$\underline{V_n}$ / $\overline{V}_n$	Lower and upper bound of voltage magnitude.
X_{trans}	Reactance of transformer of wind power unit.
X_{net}	Reactance of equivalent thevenin circuit of utility grid that is seen by STATCOM.
B_{cap}	Susceptance of shunt capacitor C_{stat} at location of STATCOM.
R_{stat}	Resistance of STATCOM structure.
L_{stat}	Inductance of STATCOM structure.
C_{stat}	Capacitance of STATCOM structure.
ω_e	Operational frequency at the location of STATCOM.
v_{dc} / i_{dc}	DC voltage/current of STATCOM.
v_1 / v_2	Voltage levels of transformer.

4. Decision Variables

V_n^0	Voltage magnitude at *n*th bus in first level.
θ_n^0	Voltage angle at *n*th bus in first level.
Q_i^0	Reactive power of *i*th unit as a result of market in first level.
$W_{rs_{wind}}$	Wind power spillage of *r*th wind power in *s*th scenario.
$L_{ls_{shedd}}$	Unserved *l*th active load in *s*th scenario.
r_{is}	Deployed active reserve of *i*th unit in *s*th scenario.
q_{is}	Deployed reactive reserve of *i*th unit in *s*th scenario.
v_{ns}	Voltage magnitude at *n*th bus in *s*th scenario.
θ_{ns}	Voltage angle at *n*th bus in *s*th scenario.