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LIST OF ABBREVIATIONS

Abbreviation

AGC	= automatic generation control
AS	= ancillary service
ASM	= ancillary services market
BWO	= black widow optimisation
CAGC	= cost of automatic generation control
CCE	= cost of carbon emission
CDR	= cost of demand response
CE	= carbon emissions
CECPS	= competitive electricity-carbon prices scheme
CECRPS	= competitive electricity-carbon-REC prices scheme
CEPS	= competitive electricity price scheme
CG	= cost of generation
CM	= carbon pricing mechanism
CMC	= co-optimised market clearing
CMC-DR	= co-optimised market clearing with demand response
CRE	= cost of renewable energy
CS	= consumer surplus
CSR	= cost of spinning reserve
DISCOs	= distribution companies
DR	= demand response
DSA	= double-sided auction
EM	= electricity market
ETS	= emission trading scheme
GENCOs	= generation companies

LIST OF ABBREVIATIONS (Continued)

GHG	= global greenhouse gas
GWO	= grey wolf optimisation
ISO	= independent system operator
KKT	= Karush-Kuhn-Tucker
LMP	= locational marginal price
LP	= linear programming
MBECPS	= market-based electricity-carbon prices scheme
MBECRPS	= market-based electricity-carbon-REC prices scheme
MBEPS	= market-based electricity price scheme
OPF	= optimal power flow
PS	= producer surplus
PSO	= particle swarm optimisation
QP	= quadratic programming
REC	= renewable energy certificate
RECR	= renewable energy certificate revenue
REM	= renewable energy market
RES	= renewable energy source
SMC	= sequential market clearing
SMC-DR	= sequential market clearing with demand response
SR	= spinning reserve
SSA	= single-sided auction
SW	= social welfare
TC	= total cost
TCC	= total cost to consumer (from spot price)
WOA	= whale optimisation algorithm

LIST OF ABBREVIATIONS (Continued)

Symbol

a_i , b_i and c_i	= the coefficients that depend on the GENCOs' willingness to sell behaviours
a_{li}	= the line l sensitivity factor to the active injection power at bus i
AGC_i	= the activated automatic generation control capacity at bus i (MW)
$AGCP_i$	= the automatic generator control price (\$ or THB/MWh)
B_{ij}	= the susceptance of the entry in the bus admittance matrix (Y bus)
$B_j(P_{D,j})$	= the consumers willing to buy at the price of the load bus j
c_1 and c_2	= the acceleration constants of PSO
$C_i(P_{G,i})$	= the suppliers willing to sell at the price of the generator bus i .
C_{tax}	= the carbon tax rate (\$ or THB/tonCO ₂)
$CAGC(P_{G,i})$	= the cost of automatic generation control at bus i (\$ or THB/h)
$CCE(P_{G,i})$	= the cost of carbon emission at bus i (\$ or THB/h)
$CDR(\delta_{i,j})$	= the cost of demand response for step i by demand response participant j (\$ or THB/h)
$CE(P_{G,i})$	= the carbon emission at bus i (ton/h)
$CG(P_{G,i})$	= the cost of generation at bus i (\$ or THB/h)
$CRE(P_{RE,r})$	= the cost of renewable energy at bus r (\$ or THB/h)
$CSR(P_{G,i})$	= the cost of spinning reserve at bus i (\$ or THB/h)
d_j , e_j and k_j	= the non-negative coefficients of the benefit function for the load at bus j from consumer bidding behaviour
EC_i^w	= the electricity cost with carbon emission cost spot pricing (\$/h)
EC_i^{wo}	= the electricity cost without carbon emission cost spot pricing (\$/h)
f_i , g_i , and h_i	= the coefficients that determine the shape of RE the quadratic curve
$g(x,u)$	= the equality constraint
G_{ij}	= the conductance of the entry in the bus admittance matrix (Y bus)
$h(x,u)$	= the inequality constraint
ITL_i	= the incremental transmission loss

LIST OF ABBREVIATIONS (Continued)

nl	= the number of transmission lines
NB	= the total number of buses in the power system
NC	= the total number of shunt reactors or capacitors
ND	= the total number of loads in the power system
NDR	= the total number of pricing steps in the demand response program
NG	= the total number of generating units in the power system
NP	= the number of particles in the population
NRE	= the number of renewable energy sources
NT	= the total number of transformers with controllable taps
$P_{D,j}$	= the active power demand at bus j
$P_{G,i}$	= the active power output of the generator at bus i (MW)
$P_{G,i}^{\min}$ and $P_{G,i}^{\max}$	= the minimum and maximum active power output limit for the generator bus i, respectively (MW)
P_{loss}	= the total active power loss in the transmission network (MW)
$P_{L,j}$	= the active power demand at bus j (MW)
$P_{RE,r}$	= the active renewable energy power output RE at bus r (MW)
$Q_{C,i}^{\max}$	= the minimum and maximum reactive power compensation limits for the shunt device, respectively (MVar)
$Q_{G,i}$	= the reactive power generation at bus i (MVar)
$Q_{G,i}^{\min}$ and $Q_{G,i}^{\max}$	= the minimum and maximum reactive power output limits for the generator bus i, $Q_{C,i}^{\min}$ respectively (MVar)
$Q_{L,j}$	= the reactive power load at bus j (MVar)
r_1 and r_2	= the random values of PSO
R_{total}	= the total revenue (\$ or THB/h)
$R_{i,j}$	= the price per unit of electricity reduction for step i by demand response participant j (\$/MWh)
$RECP$	= the renewable energy certificate price (\$ or THB/MWh)
$RECR(P_{RE,r})$	= the renewable energy certificate revenue (\$ or THB/h)
S_i	= the complex power at bus i

LIST OF ABBREVIATIONS (Continued)

SR_i	= the spinning reserve utilisation at bus i (MW)
SRP_i	= the spinning reserve price (\$ or THB/MWh)
SW	= the social welfare (\$ or THB/h)
SW_{eco}	= the economic social welfare (\$ or THB/h)
SW_{post}	= the post-transfer social welfare (\$ or THB/h)
T_i	= the tap setting limits for the transformer i (p.u.)
$T_i^{\min}$ and $T_i^{\max}$	= the minimum and maximum tap setting limits for the transformer, respectively (p.u.)
TC	= the total cost (\$ or THB/h)
TCC	= the total cost to consumer (\$ or THB/h)
u	= the dependent variable
$V_{G,i}$	= the voltage magnitude for the generator bus i
$V_{G,i}^{\min}$ and $V_{G,i}^{\max}$	= the minimum and maximum voltage magnitude limits for the generator bus i, respectively
w	= the inertia weight factor of PSO
x	= the control variable
$X_{C,i}$	= the reactance control setting of the shunt reactor i
X_{ij}	= the reactance of the transmission line between buses i and j
α_i , β_i and ω_i	= the coefficients of carbon emission at bus i
$\delta_{i,j}$	= the amount of load reduction achieved within step i by demand response participant j (MW)
$\delta_{i,j}^{\max}$	= the maximum allowable reduction in step i by demand response participant j (MW)
$\eta_{L,i}$	= the marginal transmission loss at bus i (\$/MWh)
$\eta_{QS,i}$	= the network quality of supply at bus i (\$/MWh)
λ	= the system marginal price (\$/MWh)
λ_{AGC}	= the automatic generation control marginal price (\$/MWh)
λ_{CG}	= the energy marginal price (\$/MWh)
λ_{CCE}	= the carbon emission marginal price (\$/MWh)

LIST OF ABBREVIATIONS (Continued)

λ_{SR}	= the spinning reserve marginal price (\$/MWh)
μ	= the penalty factor
μ_l	= the reduction in supply cost that results from an incremental relaxation of constraint l (\$/MWh)
θ_i and θ_j	= the phase angles at buses i and j , respectively
ρ_i	= the spot price at bus i (\$/MWh)
ρ_i^w	= the spot price with carbon emission cost at bus i (\$/MWh)
ρ_i^{wo}	= the spot price without carbon emission cost at bus i (\$/MWh)
$\%AGCR_i$	= the percentage of automatic generator control requirement
$\%SRR_i$	= the percentage of spinning reserve requirement