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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