Cross-Region Accommodation

Nomenclature：

|  |  |  |  |
| --- | --- | --- | --- |
| indices and sets | | | |
| *T*(*t*) | set (index) of periods | *Ga* | set of generation units in area *a* |
| *A*(*a*) | set (index) of areas | *~~W~~~~a~~* | ~~set of wind farms in area~~ *~~a~~* |
| *Lk* | set of tie-lines of type *k* | *~~V~~~~a~~* | ~~set of PV stations in area~~ *~~a~~* |
| *l*(*a*,*b*) | index of tie-lines connected area *a*,*b* |  |  |
| *TD*(*td*) | set (index) of days for tie-line |  |  |
|  |  |  |  |
| parameters: | | | |
| *Da*(*t*) | demand of area *a* at *t* | *RPta* | positive spinning reserve of area *a* |
| *MUg* | minimum up time of unit *g* | *RNta* | negative spinning reserve of area *a* |
| *MDg* | minimum down time of unit *g* | *~~C~~~~w~~*~~(~~*~~t~~*~~)~~ | ~~credible capacity of wind farm~~ *~~w~~* |
| *Pgmax* | maximum output of unit *g* | *~~C~~~~v~~*~~(~~*~~t~~*~~)~~ | ~~credible capacity of PV station~~ *~~v~~* |
| *Pgmin* | minimum output of unit *g* | *Pwa\**(*t*) | theory output of wind power at *t* |
| *RUg* | ramp up limit of unit *g* | *Pva\**(*t*) | theory output of PV in area *a* at *t* |
| *RDg* | ramp down limit of unit *g* | *Flo*(*t*) | fixed power flow of line *l* |
| *xg0* | initial status of unit *g* at *t*=0 | *Flmax* | maximum power flow of line *l* |
| *Pg0* | initial output of unit *g* at *t*=0 | *Eltd* | exchange energy of line *l* in day *td* |
| *UPg0* | length of time unit *g* has to be on at |  |  |
|  | the beginning |  |  |
| *DWg0* | length of time unit *g* has to be off at |  |  |
|  | the beginning |  |  |
|  |  |  |  |
| variables: | | | |
| *Pwa*(*t*) | output of wind farm *w* at *t* | *~~RP~~~~g~~*~~(~~*~~t~~*~~)~~ | ~~positive reserve of unit~~ *~~g~~* |
| *Pva*(*t*) | output of PV station *v* at *t* | *~~RN~~~~g~~*~~(~~*~~t~~*~~)~~ | ~~negative reserve of unit~~ *~~g~~* |
| *Pg*(*t*) | output of unit *g* at *t* | *~~RP~~~~ab~~*~~(~~*~~t~~*~~)~~ | ~~positive reserve supported through~~ |
| *Fl*(*t*) | outgoing power flow of line *l* |  | ~~tie-line~~ *~~l~~*~~(~~*~~a~~*~~,~~*~~b~~*~~)~~ |
| *xg*(*t*) | status of unit *g*, 1-up, 0-down | *~~RN~~~~ab~~*~~(~~*~~t~~*~~)~~ | ~~negative reserve supported through~~ |
| *yg*(t) | startup indicator, 1-start up, 0-else |  | ~~tie-line~~ *~~l~~*~~(~~*~~a~~*~~,~~*~~b~~*~~)~~ |
| *zg*(t) | shutdown indicator |  |  |
|  |  |  |  |

Model:

Objectives:



Constraints:

1. Thermal units

Binary variable logic constraint:



Output limit：



Minimum up/down time:



Ramping up/down limit:



1. Wind generation and PV

Output limit:



1. Tie-line

Type I (fixed power flow):



Type II (transmission limit):



Type III (fixed exchange energy per day):



1. System constraints

Power balance:



Spinning reserve capacity：

1) model 1









2) model 2





1. Consensus

Tie line power flow



Augmented Lagrangian Relaxation (reserve model 1)

Lagrangian Function：



Lower level problem：



Upper level problem：



Update multiples：



Augmented Lagrangian Relaxation (reserve model 2)

Lagrangian Function：

Lower level problem：

Upper level problem：

Update multiples：