Proactive Resilience Enhancement for Flexible Distribution Networks Containing Data Centers with Multiple Fault Phases Coupling

Ziyao Wang, Tao Yu, *Senior Member, IEEE*, Jimmy Chih-Hsien Peng, Senior Member, IEEE, Zhenning Pan, *Member, IEEE*, Wei Chen, *Member, IEEE*, Yufeng Wu

I. APPENDIX

A. Model Linearization

In this section, the expressions are transformed into mixed integer linear form with linearization technique. The absolute term in (2b) can be transformed into the following formulation.

$$\begin{cases} \left|d_i^{TL}\right| = d_{i,abs}^{TL} \\ d_{i,abs}^{TL} \geq d_i^{TL}, d_{i,abs}^{TL} \geq -d_i^{TL} \end{cases}, \forall i \in \Omega_N^{IDC} \tag{1}$$

The bilinear term in (7b) can be transformed into the following formulation.

$$-M\left(1-x_{ij}^{SOP}\right) \leq P_{i,PH}^{SOP} + P_{j,PH}^{SOP} \leq M\left(1-x_{ij}^{SOP}\right), \forall i \in \Omega_N^{IDC} \tag{2}$$

The bilinear term in (15) can be transformed into the following formulation.

$$\begin{cases} -M\left(1-\alpha_{i,PH,c}\right) \leq \Delta P_i^L \leq M\left(1-\alpha_{i,PH,c}\right) \\ -M\alpha_{i,PH,c} + P_i^L \leq \Delta P_i^L \leq M\alpha_{i,PH,c} + P_i^L \\ -M\left(1-\alpha_{i,PH,c}\right) \leq \Delta Q_i^L \leq M\left(1-\alpha_{i,PH,c}\right) \\ -M\alpha_{i,PH,c} + Q_i^L \leq \Delta Q_i^L \leq M\alpha_{i,PH,c} + Q_i^L \end{cases}, \forall i \in \Omega_N^{IDC} \tag{3}$$

B. Parameters

The parameters in the case study is presented in Table I. And the topology information of the case study can be found in `https://drive.google.com/file/d/11fHRoRfibhEdl4Y0CxcJ9gP9K0sxiNV5/view?usp=sharing`.

TABLE I
SUMMARY OF KEY PARAMETERS

Parameter	Value	Description
$\underline{V_i}$, $\overline{V_i}$	0.95 p.u., 1.05 p.u.	Lower and upper bound of the voltage
$\overline{S_{max}}$	8 MVA	Maximum line capacity
T_{DD}	0.46 h	Duration of the degradation phase
T_{RI}	0.23 h	Duration of the remote isolation phase
T_{SR}	0.22 h	Duration of the service restoration phase
p_c	1/10	Probability of each fault scenario
N_s	10	Total number of generated fault scenarios
S_{SOP}	20 MVA	Capacity of SOP
c^{Voll}	42 k$/MWh	Unit value of lost load in the area
c^{RCS}	0.79 k$	Annual investment cost of RCS
c^{SOP}	26.92 k$	Annual investment cost of SOP