DER Models

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1 Without Storage

1.1 Disaggregation

$$\max \quad \sum_{t\in T}\left(P_t^{DA}x_{it}+\mathbb{E}\left[P_t^{RT}(\xi)y_{it}^{+}(\xi)-P_t^{PN}y_{it}^{-}(\xi)\right]\right) \tag{1a}$$

$$\text{s.t.} \quad R_{it}(\xi)-x_{it}=y_{it}^{+}(\xi)-y_{it}^{-}(\xi) \quad \forall t\in T \tag{1b}$$

$$R_{it}(\xi)\geq y_{it}^{+}(\xi) \quad \forall t\in T \tag{1c}$$

$$y_{it}^{+}(\xi)\leq Mz_{it}(\xi), \quad y_{it}^{-}(\xi)\leq M(1-z_{it}(\xi)) \quad \forall t\in T \tag{1d}$$

$$x_{it}^{DA}\geq 0, y_{it}^{+}(\xi)\geq 0, y_{it}^{-}(\xi)\geq 0, z_{it}(\xi)\in\{0,1\} \quad \forall t\in T \tag{1e}$$

1.2 Aggregation

$$\max \quad \sum_{t\in T}\left(P_t^{DA}\alpha_t+\mathbb{E}\left[P_t^{RT}(\xi)\beta_t^{+}(\xi)-P_t^{PN}\beta_t^{-}(\xi)\right]\right) \tag{2a}$$

$$\text{s.t.} \quad \sum_{i\in I}R_{it}(\xi)-\alpha_t=\beta_t^{+}(\xi)-\beta_t^{-}(\xi) \quad \forall t\in T \tag{2b}$$

$$\sum_{i\in I}R_{it}(\xi)\geq \beta_t^{+}(\xi) \quad \forall t\in T \tag{2c}$$

$$\beta_t^{+}(\xi)\leq Mz_t(\xi), \quad \beta_t^{-}(\xi)\leq M(1-z_t(\xi)) \quad \forall t\in T \tag{2d}$$

$$\alpha_t^{DA}\geq 0, \beta_t^{+}(\xi)\geq 0, \beta_t^{-}(\xi)\geq 0, z_t(\xi)\in\{0,1\} \quad \forall t\in T \tag{2e}$$

1.3 Settlement

$$\max \quad \sum_{t\in T}\left(P_t^{DA}\alpha_t+\mathbb{E}\left[P_t^{RT}(\xi)\beta_t^{+}(\xi)-P_t^{PN}\beta_t^{-}(\xi)\right]\right) \tag{3a}$$

$$\text{s.t.} \quad \sum_{i\in I}R_{it}(\xi)-\alpha_t^{DA}=\beta_t^{+}(\xi)-\beta_t^{-}(\xi) \quad \forall t\in T \tag{3b}$$

$$\sum_{i\in I}R_{it}(\xi)\geq \beta_t^{+}(\xi) \quad \forall t\in T \tag{3c}$$

$$\beta_t^{+}(\xi)\leq Mz_t(\xi), \quad \beta_t^{-}(\xi)\leq M(1-z_t(\xi)) \quad \forall t\in T \tag{3d}$$

$$\alpha_t=\sum_{i\in I}x_{it}(\xi), \quad \beta_t^{+}(\xi)=\sum_{i\in I}e_{it}^{+}(\xi), \quad \beta_t^{-}(\xi)=\sum_{i\in I}e_{it}^{-}(\xi) \quad \forall t\in T \tag{3e}$$

$$R_{it}(\xi)-x_{it}(\xi)=y_{it}^{+}(\xi)-y_{it}^{-}(\xi) \quad \forall t\in T \tag{3f}$$

$$R_{it}(\xi)\geq y_{it}^{+}(\xi) \quad \forall t\in T \tag{3g}$$

$$y_{it}^{+}(\xi)\leq Mz_{it}(\xi), \quad y_{it}^{-}(\xi)\leq M(1-z_{it}(\xi)) \quad \forall t\in T \tag{3h}$$

$$\sum_{j\in I,j\neq i}d_{ijt}(\xi)\leq y_{it}^{+}(\xi), \quad \sum_{j\in I,j\neq i}d_{jit}(\xi)\leq y_{it}^{-}(\xi) \quad \forall t\in T \tag{3i}$$

$$d_{iit}(\xi)=0 \quad \forall t\in T \tag{3j}$$

$$e_{it}^{+}(\xi)=y_{it}^{+}(\xi)-\sum_{j\in I,j\neq i}d_{ijt}(\xi) \quad \forall t\in T \tag{3k}$$

$$e_{it}^{-}(\xi)=y_{it}^{-}(\xi)-\sum_{j\in I,j\neq i}d_{jit}(\xi) \quad \forall t\in T \tag{3l}$$

2 With Storage

2.1 Disaggregation

$$\max \quad \sum_{t\in T}\left(P_t^{DA}x_{it}+\mathbb{E}\left[P_t^{RT}(\xi)y_{it}^{+}(\xi)-P_t^{PN}y_{it}^{-}(\xi)\right]\right) \tag{4a}$$

$$\text{s.t.} \quad R_{it}(\xi)-x_{it}=y_{it}^{+}(\xi)-y_{it}^{-}(\xi)+z_{it}^{C}(\xi)-z_{it}^{D}(\xi) \quad \forall i,t \tag{4b}$$

$$R_{it}(\xi)\geq y_{it}^{+}(\xi) \quad \forall i,t \tag{4c}$$

$$z_{i,t+1}(\xi)=z_{it}(\xi)+z_{it}^{C}(\xi)-z_{it}^{D}(\xi) \quad \forall i,t \tag{4d}$$

$$z_{it}^{D}(\xi)\leq z_{it}(\xi) \quad \forall i,t \tag{4e}$$

$$z_{it}^{C}(\xi)\leq K_i-z_{it}(\xi) \quad \forall i,t \tag{4f}$$

$$0\leq z_{it}(\xi)\leq K_i \quad \forall i,t \tag{4g}$$

$$y_{it}^{+}(\xi)\leq M_1\rho_{it}(\xi), \quad y_{it}^{-}(\xi)\leq M_1(1-\rho_{it}(\xi)) \quad \forall i,t \tag{4h}$$

$$y_{it}^{-}(\xi)\leq M_1\delta_{it}(\xi), \quad z_{it}^{C}(\xi)\leq M_1(1-\delta_{it}(\xi)) \quad \forall i,t \tag{4i}$$

$$z_{it}^{C}(\xi)\leq M_1\zeta_{it}(\xi), \quad z_{it}^{D}(\xi)\leq M_1(1-\zeta_{it}(\xi)) \quad \forall i,t \tag{4j}$$

2.2 Aggregation

$$\max \quad \sum_{t\in T}\left(P_t^{DA}\alpha_t+\mathbb{E}\left[P_t^{RT}(\xi)\beta_t^{+}(\xi)-P_t^{PN}\beta_t^{-}(\xi)\right]\right) \tag{5a}$$

$$\text{s.t.} \quad \sum_{i\in I}R_{it}(\xi)-\alpha_t=\beta_t^{+}(\xi)-\beta_t^{-}(\xi)+\gamma_t^{C}(\xi)-\gamma_t^{D}(\xi) \quad \forall t \tag{5b}$$

$$\sum_{i\in I}R_{it}(\xi)\geq\beta_t^{+}(\xi) \quad \forall t \tag{5c}$$

$$\gamma_t^{D}(\xi)\leq\gamma_t(\xi) \quad \forall t \tag{5d}$$

$$\gamma_t^{C}(\xi)\leq\sum_{i\in I}K_i-\gamma_t(\xi) \quad \forall t \tag{5e}$$

$$0\leq\gamma_t(\xi)\leq\sum_{i\in I}K_i \quad \forall t \tag{5f}$$

$$\gamma_{t+1}(\xi)=\gamma_t(\xi)+\gamma_t^{C}(\xi)-\gamma_t^{D}(\xi) \quad \forall t \tag{5g}$$

$$\beta_t^{+}(\xi)\leq M_2\mu_t(\xi), \quad \beta_t^{-}(\xi)\leq M_2(1-\mu_t(\xi))\forall t \tag{5h}$$

$$\beta_t^{-}(\xi)\leq M_2\eta_t(\xi), \quad \gamma_t^{C}(\xi)\leq M_2(1-\eta_t(\xi))\forall t \tag{5i}$$

$$\gamma_t^{C}(\xi)\leq M_2\lambda_t(\xi), \quad \gamma_t^{D}(\xi)\leq M_2(1-\lambda_t(\xi)) \quad \forall t \tag{5j}$$

2.3 Settlement