

# Accelerated-Decomposition SCUC-CNR With ML-Based Warm Starts and Parallel Contingency Screening

## NOMENCLATURE

<i>Indices</i>	
$c$	Line contingency index
$g$	Generator index
$k$	Transmission element (line or transformer) index
$n$	Bus index
$N(g)$	Bus location of generator $g$
$t$	Time period index

## MATHEMATICAL FORMULATION

### A. Master Unit Commitment (MUC)

The Master Unit Commitment determines the base-case generator commitment and dispatch while satisfying operational constraints.

#### 1) Objective Function:

$$\min \sum_t \sum_g (c_g P_{g,t} + c_g^{NL} u_{g,t} + c_g^{SU} v_{g,t}) \quad (1)$$

where  $P_{g,t}$  is the generation output of unit  $g$  at time  $t$ ,  $u_{g,t}$  is the unit commitment status,  $v_{g,t}$  is the startup variable,  $c_g$  is the generation cost coefficient,  $c_g^{NL}$  is the no-load cost, and  $c_g^{SU}$  is the startup cost.

#### 2) Generation Limits:

$$P_g^{min} u_{g,t} \leq P_{g,t} \quad (2)$$

$$P_{g,t} + r_{g,t} \leq P_g^{max} u_{g,t} \quad (3)$$

#### 3) Reserve Constraint:

$$0 \leq r_{g,t} \leq R_g^{10} u_{g,t} \quad (4)$$

#### 4) Ramp Rate Constraints:

$$P_{g,t} - P_{g,t-1} \leq R_g^{hr} u_{g,t-1} + R_g^{SU} v_{g,t} \quad (5)$$

$$P_{g,t-1} - P_{g,t} \leq R_g^{hr} u_{g,t} + R_g^{SD} (v_{g,t} - u_{g,t} + u_{g,t-1}) \quad (6)$$

#### 5) DC Power Flow:

$$P_{k,t} = b_k (\theta_{n,t} - \theta_{m,t}) \quad (7)$$

#### 6) Line Flow Limits:

$$-P_k^{max} \leq P_{k,t} \leq P_k^{max} \quad (8)$$

#### 7) Power Balance:

$$\sum_{g \in g(n)} P_{g,t} + \sum_{k \in \delta^+(n)} P_{k,t} - \sum_{k \in \delta^-(n)} P_{k,t} = d_{n,t} \quad (9)$$

### B. Critical Sub-Problem Screener (CSPS)

Critical contingencies are identified using Line Outage Distribution Factors (LODF).

$$P_{k,c,t} = P_{k,t}^{MUC} + LODF_{k,c} P_{c,t}^{MUC} \quad (10)$$

A contingency is critical if

$$|P_{k,c,t}| > P_k^{emax} \quad (11)$$

### C. Post-Contingency Feasibility Check (PCFC)

The PCFC verifies system feasibility after a contingency using generation redispatch.

*Objective:*

$$\min s_1 \quad (12)$$

where  $s_1$  is the infeasibility slack variable.

*Generator Limits:*

$$P_g^{min} u_{g,t}^{MUC} \leq P_{g,c,t} \quad (13)$$

$$P_{g,c,t} \leq P_g^{max} u_{g,t}^{MUC} \quad (14)$$

*Post-Contingency Power Flow:*

$$P_{k,c,t} = b_k (\theta_{n,c,t} - \theta_{m,c,t}) \quad (15)$$

*Outaged Line:*

$$P_{c,c,t} = 0 \quad (16)$$

*Emergency Limits:*

$$-P_k^{emax} \leq P_{k,c,t} \leq P_k^{emax} \quad (17)$$

*Power Balance:*

$$\sum_{g \in g(n)} P_{g,c,t} + \sum_{k \in \delta^+(n)} P_{k,c,t} - \sum_{k \in \delta^-(n)} P_{k,c,t} = d_{n,t} \quad (18)$$

### D. Network-Reconfigured Post-Contingency Feasibility Check

If the PCFC is infeasible, corrective network reconfiguration is applied by switching a transmission element.

$$P_{j,c,t} = 0 \quad (19)$$

where  $j$  denotes the intentionally switched transmission line.

Big-M Method::

$$P_{k,c,t} - b_k (\theta_{n,c,t} - \theta_{m,c,t}) + (1 - z_{c,t}^k) M \geq 0 \quad (20)$$

$$P_{k,c,t} - b_k (\theta_{n,c,t} - \theta_{m,c,t}) - (1 - z_{c,t}^k) M \leq 0 \quad (21)$$

$$-P_k^{emax} z_{c,t}^k \leq P_{k,c,t} \leq z_{c,t}^k P_k^{emax} \quad (22)$$

$$\sum_k (1 - z_{c,t}^k) \leq Z_{max} \quad (23)$$

### I. FLOWCHART

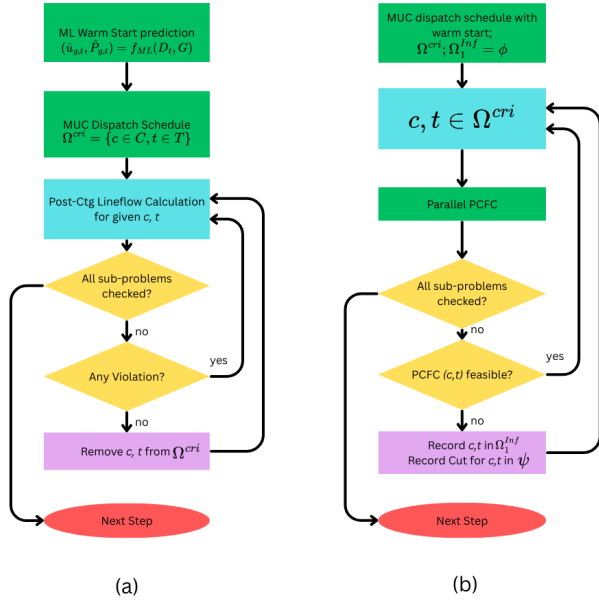


Fig. 1: Flowchart: (a) Critical sub-problem screener (b) Post-contingency feasibility check.

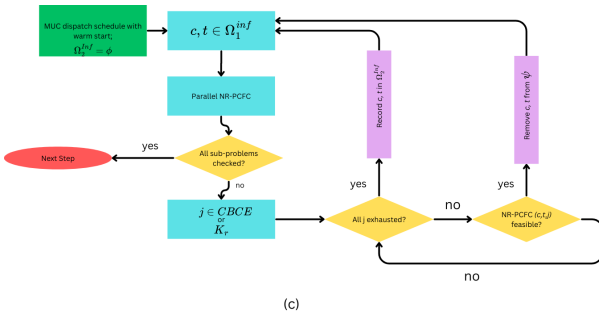


Fig. 2: Network-reconfigured post-contingency feasibility check.