Modeling the Stochastic Security-Constrained Unit Commitment Problem Considering Distribution Shift-Factors

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Contents

I. Introduction
II. Theoretical aspects
III. Proposed methodology
IV. Test Power Systems
V. Simulation Results
VI. Conclusions
VII. References
VIII. Questions
UNIT COMMITMENT

Purposes [1]:

• Determine the optimal hourly operation strategy for the generation units for a given horizon.

• Minimizing fuel and starting up and shutting down costs.
I. Introduction

UNIT COMMITMENT PROBLEM [2]-[4]

OBJECTIVE FUNCTION: Minimize total costs.

SYSTEM CONSTRAINTS
- Spinning Reserve margin.
- System Load Balance.
- Start-up cost.
- Shutdown cost.

BASICAL TECHNICAL CONSTRAINTS
- Power Generation Limits.
- Power Generation Ramp Constraints.
- Minimum Up-Time Generation Constraints.

NETWORK CONSTRAINTS
- Transmission Thermal Limits.
I. Introduction

SECURITY-CONSTRAINED UNIT COMMITMENT

- Transmission capacity.
- Possible contingencies.

STOCHASTIC UNIT COMMITMENT

- Load forecasting.
- Hydro energy availability.
- Fuel prices.
- Renewable energy.

Stochastic SCUC
II. Theoretical aspects

Many SCUC uses the classical DC-based formulation to model transmission power flow equations [1].

- Commitment status.
- Production Levels.
- Voltage bus angles ($\delta_i$).

\[
(p_{i,t,s} - Pd_{i,t,s}) - \sum_{ij \in L} f_{ij,t,s} = 0
\]

\[
f_{ij,t,s} = B_{ij} \times (\delta_i - \delta_j)
\]

\[
|f_{ij,t,s}| \leq F_{ij}^M
\]

\[
|\delta_{i,t,s}| \leq \frac{\pi}{2}
\]

\[\forall i \in B, \forall ij \in L, \forall t \in T, \forall s \in S\]

Where:

- $p_{i,t,s}$: Active power dispatched
- $Pd_{i,t,s}$: Load demand
- $f_{ij,t,s}$: Power Flow of Branch $ij$
- $B_{ij}$: Susceptance
- $\delta_{i,t,s}$: Voltage bus angles
III. Proposed Methodology

Distribution Shift-Factors:

- Gives the variation in flow of line $nm$ due to changes in the nodal injection at bus $n$.
- SF are a function of transmission susceptance's and the topology.
III. Proposed Methodology

Security Constrained Unit Commitment SF-based [4]:

- Stochastic mixed-integer problem (SMIP).
- Commitment Status.
- Production Levels.
- No voltage bus angle.

\[
\sum_{g \in G} p_{g,t,s} + \sum_{b \in B} ENS_{b,t,s} = \sum_{b \in B} p_{d,b,t,s}
\]

\[
\left| \sum_{b \in B} SF_{ij,b} \cdot (p_{b,t,s} - P_{d,b,t,s}) \right| \leq F_{ij}^M
\]

Where:

- \(SF_{ij,b}\): Linear shift-factor for transmission element
IV. Test Power Systems

We use two power systems:

1) IEEE-39 bus [2]
   • 10 generators
   • 46 branches

2) Pegase 89-bus
   • 12 generators
   • 210 branches

15 Synthetic scenarios
   • Same probability
V. Simulation Results

STOCHASTIC SCUC – IEEE 39 BUS

- 15 scenarios ($\omega_s = 1/15$).
- 24 hours.
- Reserve margin of 10%.
- Load shedding cost 500 $/MW.

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T = 24 Hours

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V. Simulation Results

STOCHASTIC SCUC RESULTS TRANSMISSION CAPACITY – PEGASE 89 BUS

- Including transmission network.
- 3,5,10,15 load scenarios.

SSCUC SF based is more compact and less computationally burdensome.
V. Simulation Results

STOCHASTIC SCUC RESULTS INCLUDING A LOWER TRANSMISSION CAPACITY – PEGASE 89 BUS

- We reduced transmission network capacity.
- Include load scenarios (3-5-10-15)
VI. Conclusions

This study introduced an efficient SCUC formulation based on shift-factors to cope with the stochastic UC problem. Simulation results showed a very significant reduction in problem size and simulation time achieved by the SF-based formulation in comparison with the classical formulation without compromising the solution's optimality.
VII. References


VIII. Questions
THANKS