X SICEL 2021

Transición energética en la 4ta revolución industrial

Universidad Tecnológica de Pereira

UNIVERSIDAD NACIONAL DE COLOMBIA

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

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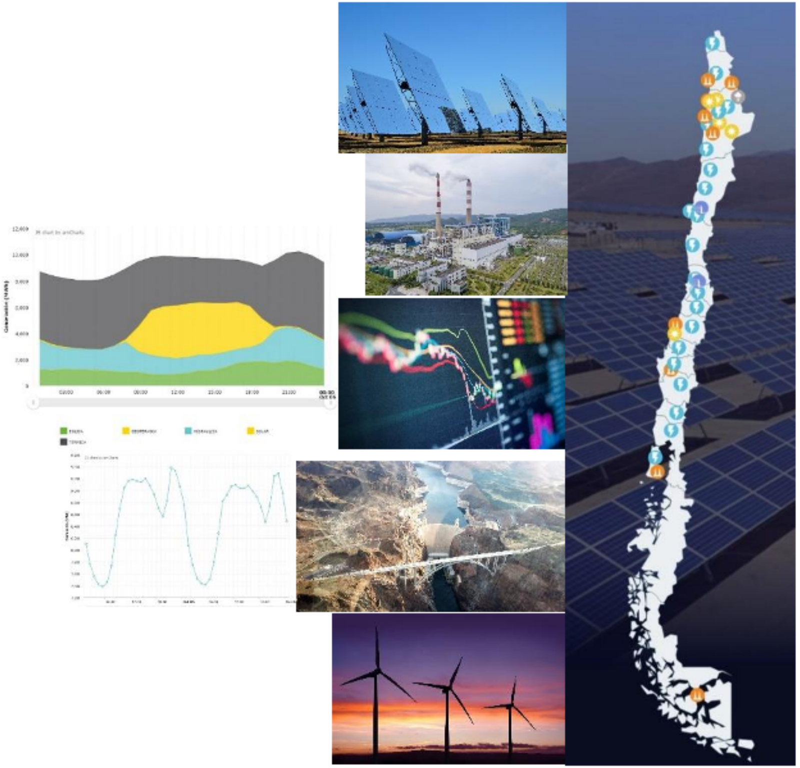
I. Introduction

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

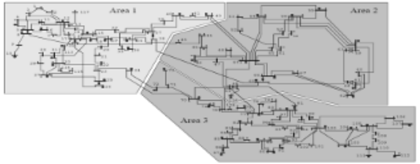
UNIT COMMITMENT PROBLEM [2]-[4]

MILP o MILQ

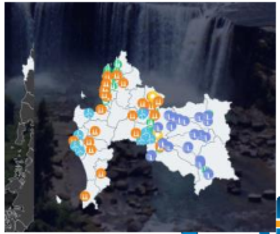
OBJECTIVE FUNCION: Minimize total costs.

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 Constrains.
- Minimum Down-Time Generation Constraints.



NETWORK CONSTRAINS
- Transmission Thermal Limits.



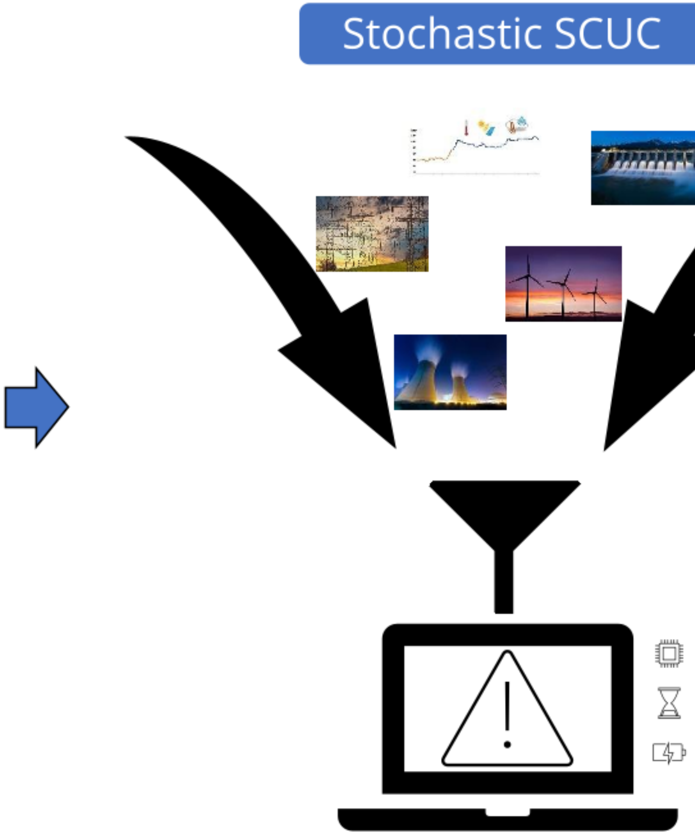
I. Introduction

SECURITY-CONSTRAINED UNIT COMMITMENT

- Transmission capacity.
- Possible contingencies.

STOCHASTIC UNIT COMMITMENT

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



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 (δ_i).

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

$$f_{ij,t,s} = B_{ij} * (\delta_i - \delta_j)$$

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

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

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

Where:

$p_{i,t,s}$: Active power dispatched

$Pd_{i,t,s}$: Load demand

$f_{ij,t,s}$: Power Flow of Branch ij

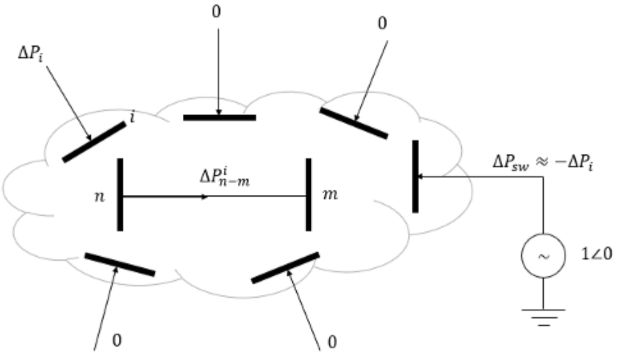
B_{ij}: Susceptance

$\delta_{i,t,s}$: Voltage bus angles

III. Proposed Methodology

Distribution Shift-Factors:

- Gives the variation in flow of line nm due to changes in the 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.

$$\sum_{g\in G} p_{g,t,s} + \sum_{b\in B} ENS_{b,t,s} = \sum_{b\in B} Pd_{b,t,s}$$

$$\left|\sum_{b\in B} SF_{ij,b} * (p_{b,t,s} - Pd_{b,t,s})\right| \leq F_{ij}^{M}$$

Where:

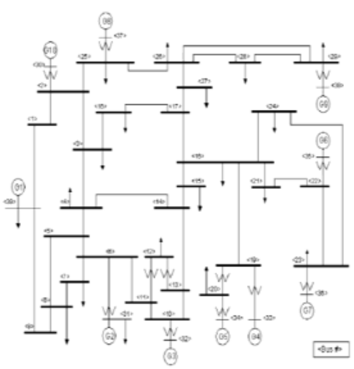
$SF_{ij,b}$: Linear shift-factor for transmission element

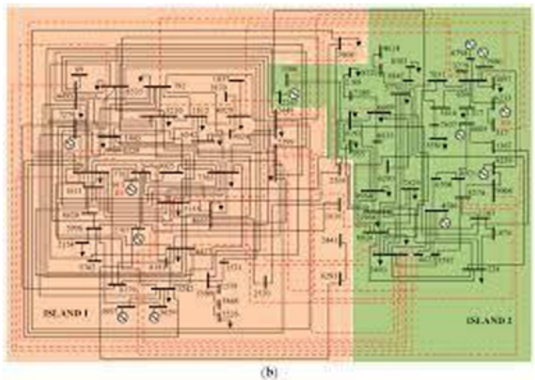
IV. Test Power Systems

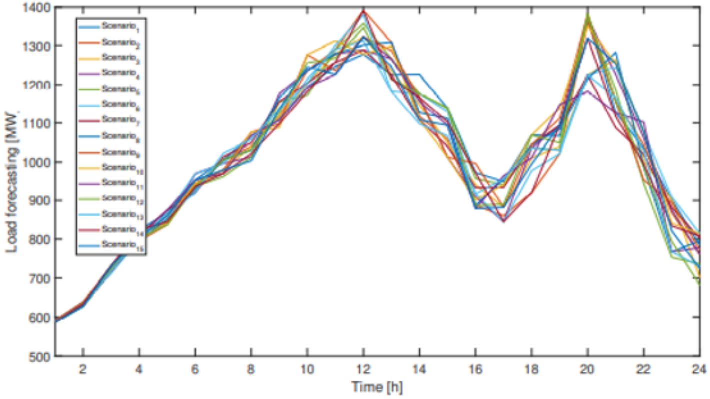
We use two power systems:

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.

Intel Core i5 5200 (2.2Ghz) – 8Gb of RAM

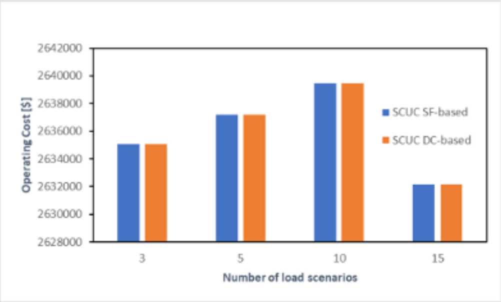
Unit	*t1*	*t2*	*t3*	*t4*	*t5*	*t6*	*t7*	*t8*	*t9*	*t10*	*t11*	*t12*	*t13*	*t14*	*t15*	*t16*	*t17*	*t18*	*t19*	*t20*	*t21*	*t22*	*t23*	*t24*
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
5	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
6	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	1	1	1	0	0	0
7	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	1	1	0	0
8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

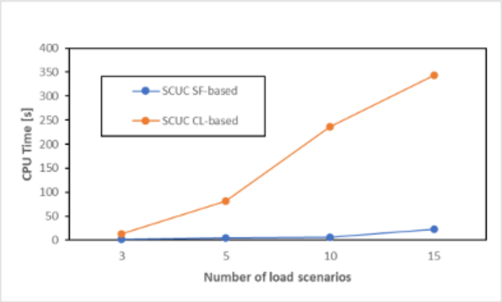
T= 24 Hours	SSCUC SF-based	SSCUC Clasical
Scenarios	15	15
Operational Cost [$]	502,072.96	502,072.96
Start up Cost [$]	5,980.00	5,980.00
Variables	36360	50400
Constraints	51030	126270
Solver Time [s]	47.96	168.9

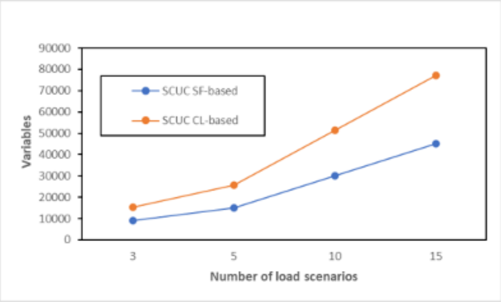
V. Simulation Results

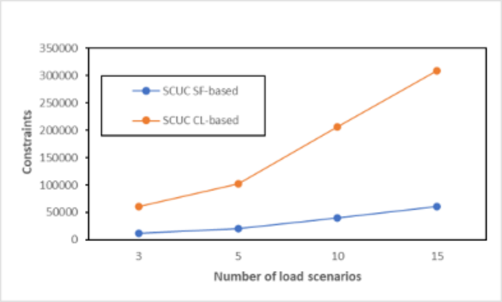
STOCHASTIC SCUC RESULTS TRANSMISSION CAPACITY – PEGASE 89 BUS

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







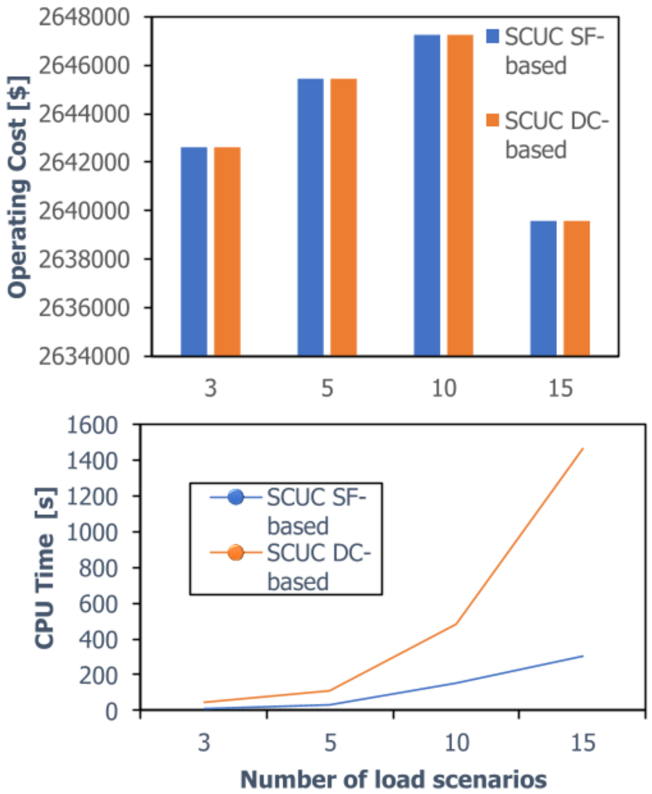


SSCUC SF based is more compact and less computationally burdensome.

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.

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VIII. Questions

THANKS