Solving Multi-Period SCOPF Using Sensitivities and Sequential Linear Approximation

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Introduction

Real-time operation of power systems with high renewable integration requires efficient solutions to the Multi-Period **Security-Constrained Optimal Power Flow (MP-SCOPF)** problem. We propose a **tractable Sequential Linear Approximation (SLA)** method that maintains accuracy while reducing computation time. The method uses **sensitivities** to linearize nonlinear constraints within an **adaptive trust region**. Tested on a 2746-bus Polish system, our approach significantly improves solution in terms of security violations and also speed compared to existing linear models when a good initial point is available.

SCOPF Reformulation

Sensitivities are derived using a standard relation:

$$S^{hw} = \frac{\partial h(x,w)}{\partial w} - \frac{\partial h(x,w)}{\partial x}\left[\frac{\partial g(x,w)}{\partial x}\right]^{-1}\frac{\partial g(x,w)}{\partial w}$$

Then we can linearize security constraints around initial operating point.

Voltage security constraint:

$$\Delta V_n = \sum_{z\in N} S^{VP}_{n,z}.\ \Delta P^{inj}_z + S^{VQ}_{n,z}.\ \Delta Q^{inj}_z$$

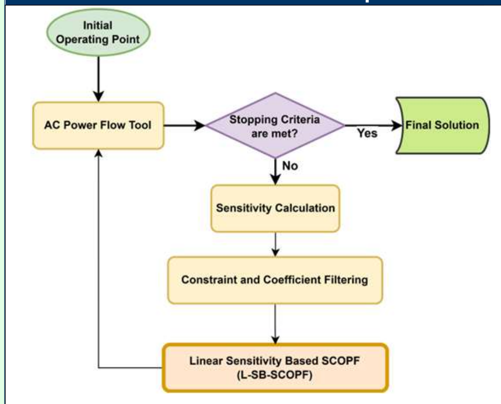
$$V^{\min}_n \le V^0_n + \Delta V_n \le V^{max}_n$$

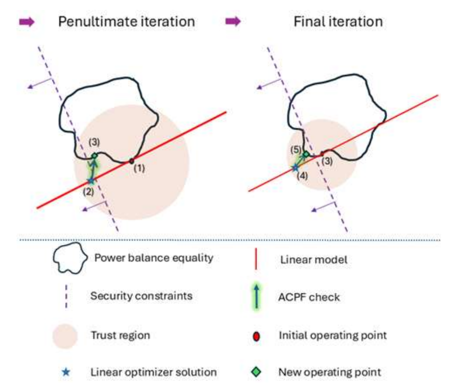
Thermal constraint on line:

$$\Delta I^2_l = \sum_{z\in N} S^{I^2P}_{l,z}.\ \Delta P^{inj}_z + S^{I^2Q}_{l,z}.\ \Delta Q^{inj}_z$$

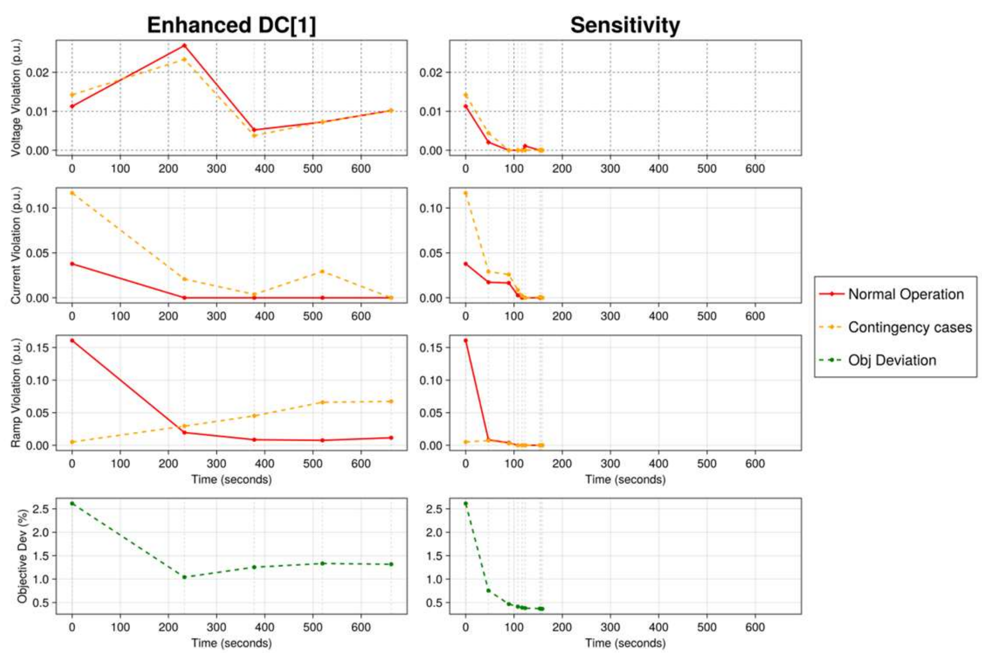
$$\left(I^0_l\right)^2 + \Delta I^2_l \le \left(I^{max}_l\right)^2$$

Sequential Linear Approximations





Results for 2746-bus Polish test system

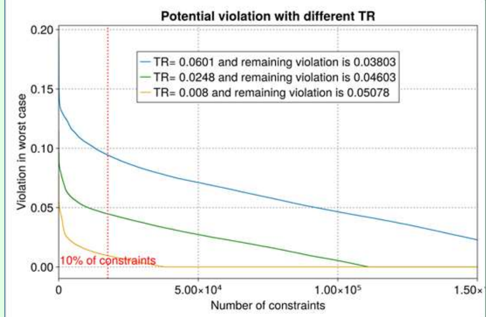


In this case study, the non-linear solution takes 1020 seconds.

Adaptive Trust Region

An **adaptive trust region** controls the step size for each SLA iteration:

- **Larger radius** → more constraints, slower solve, but faster violation removal
- **Smaller radius** → fewer constraints, faster solve, but more iterations needed



Conclusion

While nonlinear methods are too slow and DC models lack sufficient accuracy in contingencies, the proposed method achieves a **fast solution** by leveraging the initial operating point, with **comparable accuracy** to nonlinear models for **real-time redispatch.**

References

[1] Z. Yang, H. Zhong, A. Bose, T. Zheng, Q. Xia, and C. Kang, "A linearized OPF model with reactive power and voltage magnitude: A pathway to improve the MW-only DC OPF," IEEE Transactions on Power Systems, vol. 33, no. 2, pp. 1734–1745, 2017.

Acknowledgments

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