An AC-QP Optimal Power Flow Algorithm Considering Wind Forecast Uncertainty

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Outline

- Optimal Power Flow (OPF) Problem
- AC-QP Solution Method
- Stochastic AC-QP OPF Algorithm
- Test Case
- Conclusions

General OPF Problem

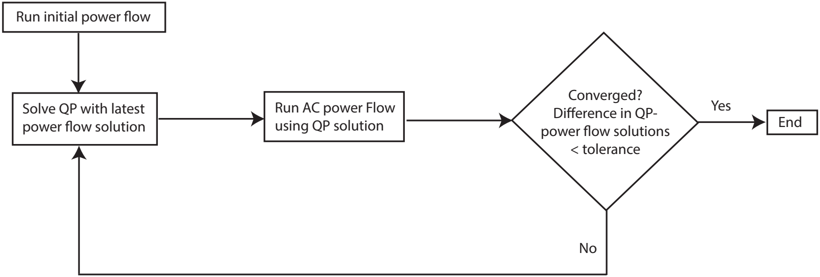
$\min C(P_g)$ ← (Quadratic) Cost of Conventional Generation

subject to

$g(x) \leq 0$ ← Operational Limits & Line Flow Limits

$h(x) = 0$ ← (AC) Power Flow Equations

AC-QP OPF Solution Method



[1] A. Wood, B. Wollenberg, and G. Sheble, *Power Generation, Operation and Control*, 2013.
[2] J. F. Marley, D. K. Molzahn, and I. A. Hiskens, to appear in *IEEE Transactions on Power Systems*, 2016.

Stochastic AC-QP OPF Algorithm

Modified the AC-QP OPF algorithm to provide an AC-feasible solution for a given set of wind scenarios

- Does not rely upon model approximations
- Maintains scalability with respect to the number of scenarios

Utilized a scenario based algorithm to accompany the solution with a-posteriori probabilistic guarantees [4]

[4] M. Campi, S. Garatti, and F. Ramponi, "Non-convex scenario optimization with application to system identification", CDC 2015.

OPF Problem with Wind Generation Uncertainty

Given a set of possible wind scenarios, $\mathcal{S}$:

$\min C(P_g)$ ← (Quadratic) Cost of Conventional Generation

subject to

$g(x) \leq 0$ ← Operational Limits & Line Flow Constraints

$h(x) = 0$ ← (AC) Power Flow Equations

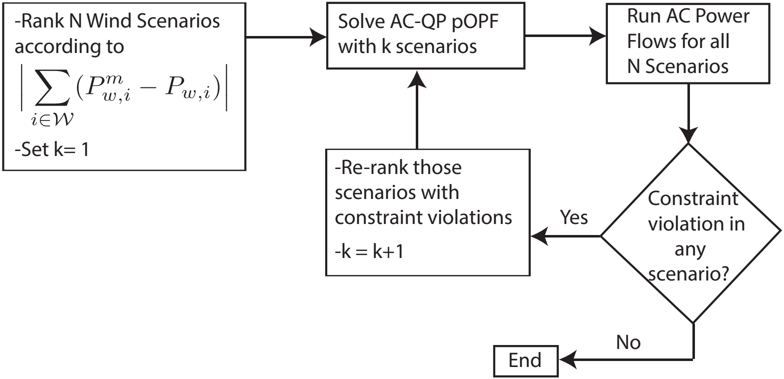
$\forall m \in \mathcal{S}$:

$g(x, x^m) \leq 0$ ← Operational Limits & Line Flow Constraints

$h(x, x^m) = 0$ ← (AC) Power Flow Equations

Introducing scenarios into the AC-QP OPF

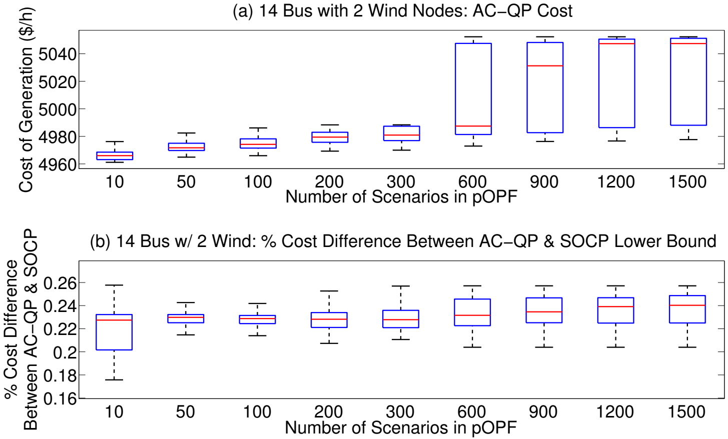
Given N scenarios, what is the minimum number that must be included in the OPF problem so that the solution is feasible for all N scenarios?



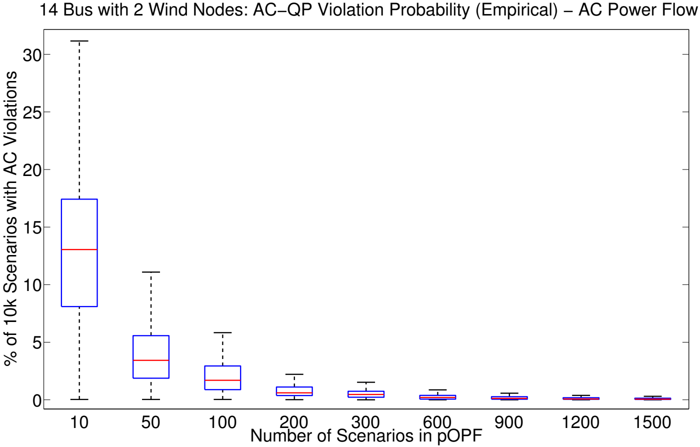
Test Case

- IEEE 14-bus network
- Two wind generators added at nodes 9 and 3
- 40 MW of available wind power is assumed at each node in the base case forecast (9.4% renewable penetration)

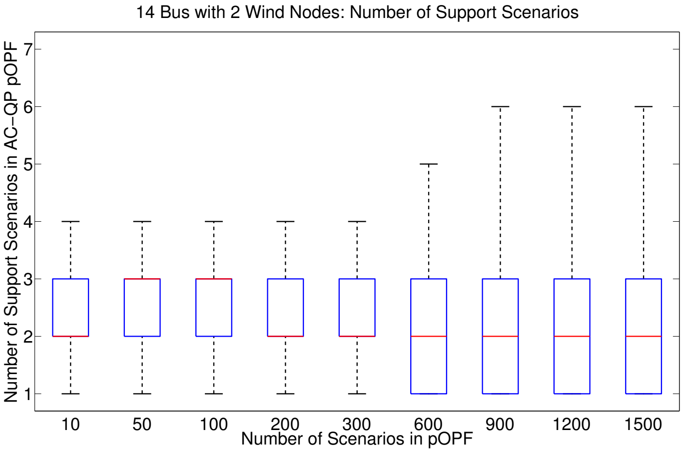
Results: Cost of Generation



Results: Empirical Probability of Violation



Results: Number of Support Scenarios



Conclusions

The AC-QP OPF method has been extended to include wind power uncertainty, through the addition of a finite number of wind scenarios. This modified AC-QP pOPF algorithm offers several advantages:

- It does not rely upon model approximations.
- It produces an AC feasible solution.
- It maintains scalability with respect to the number of scenarios to be optimized over, which is a limitation of convex relaxations.
- Finally, it provides a probabilistically robust solution with a-posteriori probabilistic violation guarantees.

Thank you, questions?

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