OPF Strategies and Tips

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Potential OPF Challenges

• Unenforceable Transmission Constraints
• Unenforceable Area Constraints due to insufficient generation reserves
• Too much power transfer in LP causes power flow solution to diverge
Analysis of Unenforceable Constraints

• Example: PJM Case
• Initial solution has 16 unenforceable constraints
• Of these many seem to be caused by radial
  - Change Limit Monitoring Settings to “Ignore Radial Lines and Buses”
    • Radial Bus is connected to the system by only one transmission line
    • Radial Line is a line connected to a radial bus.
  - Choosing this eliminates the unenforceable constraints

Unenforceable Constraints

• Check unenforceable lines for VERY large MVar flows
  – Add Columns for Max MW and Max MVar on LP OPF, Lines and Transformers
• LTC tap ratios
• Phase-shifters in series with an overloaded branch
Reset the Tap Settings

- Set all transformers on tap control to have a ratio of 1.00
- Set all phase-shifters to be controlled by the OPF solution
  - Phase Shifters have three control options
    - None – leave at a fixed angle
    - Power Flow – Allow the power flow solution to dispatch according to the setpoints of the controller
    - OPF – Allow the OPF’s linear program to “dispatch” the transformer for a more global optimization
  - Use caution with Phase Shifter MW limits when using OPF control – large ranges may cause OPF to dispatch to an unstable point

Unenforceable Constraints Left

- This results in a reduced list of 17 unenforceable constraints
A Closer Look

- Look more closely at the majority of the remaining unenforceable constraints
  - Continues to show a large number of under radial elements which should probably just be ignored
- A handful of elements require greater study
  - Breakdown and just start drawing a oneline diagram to represent this part of the system
  - You will start to see what the problem is

Example: Internal Shawvill

Four of the stepup transformers experience high loadings. I choose to just ignore these limits.

The lines from 426-228 and 423 - 426 also experience high loadings because the generators are all at their low limits and can not back down far enough to remove these problems.

To fix this, I have turned off generators at buses 431 and 424
Example: Internal MERCK

4217-4216 line has a large impedance of 0.15 compared to the lines 4214-4217, 4214-4215, 4216-4215 which have impedances of 0.0002

This means that 4216-4217 will NEVER have any flow on it. Thus the line 4214-4217 is essentially radial.

After these changes we remove all unenforceable Constraints

- Still some very high cost constraints remain
- BIRDBORO – Pine LNE = 772.8 $/MVAhr
Birdboro – Pine LNE

- Yellow Region forms a “load pocket” for two large loads
  - 85.3 MW
  - 193.7 MW
- The 69 kV lines feeding this region have high loadings

Contour of Prices around Birdboro – Pine Lne

- Load Pocket
- These prices could be reasonable.
Unenforceable Constraints

Summary

- Look for radial systems and “load pockets”
- Look for generators or phase-shifters which can relieve problems
  - Give the OPF more controls to FIX the problems
- Look for constraints which don’t make sense
  - Radial lines serving load
  - Radial transformers/lines leaving generators
- Use your judgment to setup a reasonable case
- Realize that some unenforceable constraints are inevitable at first

Insufficient Reserves

- In this example, Area 28 (JCP&L) does not have enough AGCable generation
- Message Log: “Insufficient controls to enforce area … constraint”
Insufficient Reserves: Tips

- Examine Generator records or Area field “Gen MW AGC Range Up”
- To resolve
  - Commit more generation
  - Make more generation AGCable
  - Increase imports, or make Area part of a Super Area
  - Decrease load, or make load dispatchable

Too Much Power Transfer

- The linear program (LP) iterates with the non-linear power flow to achieve convergence of the entire solution
- If an AC OPF is performed over a very large area, the LP may dispatch generators in a manner that exceeds voltage stability margins
- May occur more frequently in WECC cases
Too Much Power Transfer

• Example: A Northern and a Southern section of the eastern interconnection in one Super Area
  – North: includes eastern PJM, AEP, First Energy
  – South: includes TVA, Southern Company, Entergy
• Assume generation much less expensive in the south, so OPF will try to increase the transfer from south to north
• OPF may exceed stability margin of power flow

Too Much Power Transfer

• Message Log

Message Log

Insufficient controls to enforce line 61090 TO 62130 CXT T2 MVA constraint
1. Unenforceable Generator MW Limits
   Unable to enforce generator 18137 (N3 BRN) #1 MW Limit

Simulation: LP OFF Finished with Error = Power Flow Did Not Converge in 9.22 Seconds

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Too Much Power Transfer: Tips

- Tighten MW Limits on generators with unrealistic limits (e.g. Max MW = 9999)
- Place less of the system on OPF control
- Use interface limits
- Break a large area (or super area) into two or more smaller areas; use OPF dispatchable transactions between the smaller areas
- Manually move generation in the direction of the LP transfer, resolve power flow, restart OPF
- Use DC Power Flow

OPF Dispatchable Transactions

- Example: Break MMWG super area into Northern and Southern super areas
- Add a new transaction between a Northern area (e.g. AEP) and a Southern area (e.g. TVA)
- Set MW limits on the new transaction
- If OPF and power flow solve, try increasing the limits of the transaction – stop when the power flow will not converge
OPF Dispatchable Transactions

South-North transaction limited to 500 MW beyond base case transfer

OPF determines optimal transaction. If transaction is non-binding at the solution, then areas are acting as a single super area.

Manually Move Generation

- Solve a “Single Outer Loop” of the OPF
- Look at OPF controls following the failure
- Move generation in direction of transfer (e.g. 10% of the transfer)
- Attempt to resolve the OPF
  - Often additional transmission constraints will become binding before the full transfer is made
  - OPF will know to move in a different direction
Manually Move Generation: Spreadsheet

- Use a spreadsheet to step the transfer
- Set GenMW = Orig. Value + (Value – Orig. Value)* PercentMove

1. Send OPF controls to the spreadsheet
2. Paste Gen Records back into Simulator, solve power flow, and restart LP OPF