A Corrective Approach to Security Constrained Unit Commitment and Dispatch

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Presentation Outline

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About CES

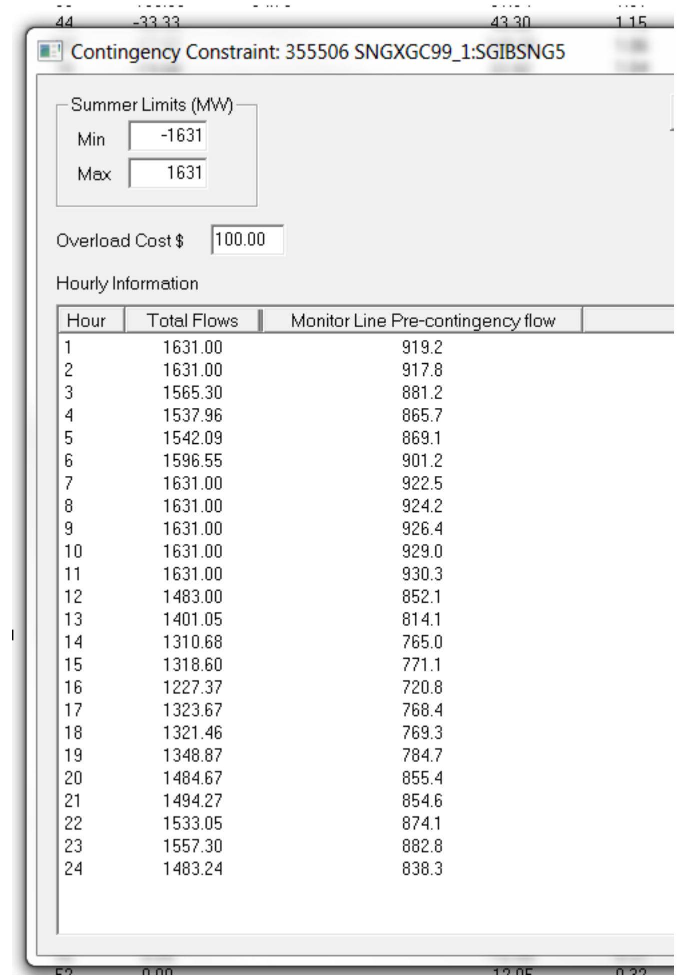
- Cambridge Energy Solutions is a software company with a mission to develop software tools for participants in deregulated electric power markets.
- CES-US provides information and tools to assist market participants in analyzing the electricity markets on a locational basis, forecast and value transmission congestion, and to understand the fundamental drivers of short- and long-term prices.
- CES-US staff are experts on market structures in the US, system operation and related information technology

Corrective versus Passive SCUC and SCD

- In this presentation we propose a deviation from the standard “passive” SCUC and SCD, where the system operator can use available resources post contingency to resolve constraint limits violation. The standard SCUC and SCD approaches limit the pre-contingency power flows so that the post contingency flows do not exceed long term emergency limits before taking any corrective action by ISO. In the proposed approach, available post contingency corrective actions are included in the optimization using emergency ratings (ER), while the 15 minutes emergency ratings (ER15) are used for associated constraints before corrective actions. This approach increases both the electric power system and market efficiency by increasing the transmission system capacity available to the market, but might require higher level of operating reserve requirements (and potentially tradeoff between higher reserves cost and lower congestion cost) and increase the use of flexible resources in the market.
- Some ISOs currently have ad hoc procedures that address and solve targeted constraints through the use of special protection systems (SPSs) or other actions. This approach is a generalization of these ad hoc procedures in a competitive market with higher value for flexible resources and demand.

Pre- and Post- Contingency Power Flows

- Typically, pre-contingency power flows are much lower than post contingency flows.
- This means that the transmission system is operated conservatively and potentially have high congestion costs for very low probability events.


Contingency Constraint: 355506 SNGXGC99_1:SGIBSNG5

Summer Limits (MW)

Min -1631

Max 1631

Overload Cost $ 100.00

Hourly Information

Hour	Total Flows	Monitor Line Pre-contingency flow
1	1631.00	919.2
2	1631.00	917.8
3	1565.30	881.2
4	1537.96	865.7
5	1542.09	869.1
6	1596.55	901.2
7	1631.00	922.5
8	1631.00	924.2
9	1631.00	926.4
10	1631.00	929.0
11	1631.00	930.3
12	1483.00	852.1
13	1401.05	814.1
14	1310.68	765.0
15	1318.60	771.1
16	1227.37	720.8
17	1323.67	768.4
18	1321.46	769.3
19	1348.87	784.7
20	1484.67	855.4
21	1494.27	854.6
22	1533.05	874.1
23	1557.30	882.8
24	1483.24	838.3

Possible Post-Contingency Corrective Actions

- Increase/decrease generation from online units (redispatch)
- Turn on a Gas Turbine (within 10 minutes)
- Trip a generation unit offline (requires activation of generation reserves)
- Reduce price responsive demand (PRD)

The order of these corrective actions depends on the economics, offers/bids of generation and demand

Possible Post-Contingency Corrective Actions

- Open a line, transformer or a circuit breaker
- Switch on/off series (or shunt) capacitors or reactors, and other voltage control devices (SVCs)
- Change PAR settings, transformer taps, etc..
- Turn on fast start combined cycle units (that takes more than 15 minutes, but less than few hours)

The ISO must have the ability to control all these elements remotely, and monitor the status in real time.

The order depends on the effectiveness and risks associated with these corrective actions

Modifying Current Problem Formulation and Solution in DAM and RT Markets (SCUC and SCD)

- There are alternative approaches to solving the corrective SCUC in Day Ahead Markets, and corrective intra-day SCUC and SCD in Real Time markets.
- In both markets modify existing software to:
  - continuously evaluate all contingencies and identify any potential corrective actions associated with critical or potentially limiting contingencies
  - Run the market clearing software (DAM and RT) taking into consideration the limiting contingencies and available corrective actions using one of the following three options:

Modifying Current Problem Formulation and Solution

- Pre Processing (before running the MIP or SCD)
  - Identify a list of post-contingency transmission constraints, with a list of corrective actions, if resources available and corrective actions can resolve congestion post contingency, then remove these constraints from the active list of constraints for that day.
  - Simple pre-processing analysis without major changes in existing DAM or RT market software.
  - May not capture all potential corrective actions

Modifying Current Problem Formulation and Solution

- Add in the MIP and SCD
  - Modify contingency constraints to include corrective actions (CA) (lines to open, units to trip, PRD to dump)
  - For example: Monitor line A for loss of Contingency C
    - Now
      - Post contingency flows on A flo C < ER
    - Proposed
      - Post contingency flows on A flo C < ER15, and
      - Post contingency flows on A flo C + CA < ER

Modifying Current Problem Formulation and Solution

- Post Processing (After running the first MIP or SCD)
  - Only for those binding constraints, check if there are
    - resources available and can relieve the congestion in case of that contingency,
    - and taking these corrective actions do not cause additional congestion or issues.
  - Remove those constraint from the active list, remove corrective controls from active list (add to reserves), rerun the optimization.
  - Might require more than one iteration before the final results.

DAYZER Simulation Runs for ERCOT

- Run a simulation of the operation of the ERCOT market in 2014 for two scenarios, with all constraints, pre-contingency flows limited using limit A (Normal Ratings) but in:
  - Scenario 1, with post-contingency power flows limited using limit B (Emergency Ratings)
  - Scenario 2, with post-contingency power flows limited using limit C (Emergency 15 Min. Ratings). On average, an increase of around 5% in ratings (in other markets these are the same, and they have “dump” ratings)
- This limited analysis assumes there are feasible corrective actions for all contingency constraints
- The estimated savings in this limited analysis
  - congestion cost: around 12 %
  - load payment: around 0.15%,
  - **production cost: < 0.02% (Very small impact, most congestion is marginal)**

Reliability and Risks!

- There are risks associated with possibilities that any one of expected corrective actions cannot be deployed (GT is available but did not start, Price Responsive Demand did not respond, etc..) which might require some uneconomic load shedding in some instances.
- Can be addressed through a requirement of redundant corrective actions or other methods (e.g. derate effective response)
- If the power flows can be secured post contingency, then the solution is feasible and the issue is the timing of corrective actions (to do those pre or post contingency) and the response rate, and effective response of these controls (which is more critical post-contingency).

Summary and Further Research

- This approach increases the operational efficiency and, if implemented conservatively, without increasing the risk of uneconomic load curtailments
- Smart Grid requires smart ISO software and procedures that allow the ISO to effectively use all resources and grid controls to optimize the operation of the markets
- Further research is needed on efficient implementation and to capture impact on reserve requirements, reactive power and dynamic stability issues and on corrective actions response and success rates.