Frequency Response & Frequency Responsive Reserve Measurement

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January 12, 2006
LFC & Operations Planning

- Load Frequency Control (LFC)
  - Frequency Management
  - Tie-Line Power Flow Management
  - Automatic Generation Control (AGC)
  - Economic Dispatch (ED)
  - Interchange Management
  - Time-Error Management

- Expand to include the resource planning necessary to perform these functions
Current Reserve Practices

- Operating Reserve – Spinning
  - Frequency Responsive Reserve (FRR)
  - Regulating Reserve (RR)
  - Contingency Reserve – Spinning

- Operating Reserve – Non-Spinning
  - Contingency Reserve – Non-Spinning

- Replacement Reserve (Generic)
How Reserve Is Used

- Arrest Frequency Decline
- Restore Scheduled Frequency
- Restore Frequency Responsive Reserve (FRR)
- Restore Contingency Reserve (CR)
Arrest Frequency Decline

- Frequency Response (FR) & FRR arrests the frequency decline
  - With insufficient Frequency Response, frequency declines below reliable limits before load & generation can rebalance
  - With insufficient FRR, load & generation cannot rebalance
  - Either insufficiency results in failure of the interconnection in seconds
Restore Scheduled Frequency

- Restore frequency with RR & CR
  - Restoring scheduled frequency returns the Frequency Responsive Reserve to those not participating in the recovery
    - If a CA is 4% of the interconnection and recovers on its own, then 96% of the original FRR is restored by the recovery
  - Reserve sharing groups & control area mergers have changed this restoration benchmark. (CaISO, ERCOT)
New operating practices require the implementation of new benchmarks to replace the old benchmark of restoring scheduled frequency.

- Requires the specification of FRR as a separate reserve category.
- Requires the measurement of FR & FRR.
Restore Contingency Reserve

- Restore CR completing the recovery process and assuring next recovery
  - Question? – Should firm load be interrupted to maintain reserve, or should reserve be reduced to serve firm load?
  - Answer
    - Interrupt firm load to maintain FRR
    - Economically reduce CR to serve firm load
New Reserve Practices

- FRR sufficient to arrest the largest contingency and expected normal frequency error concurrently
- RR sufficient to replace local FRR used during normal operations
- CR sufficient to restore share of total FRR used during operating disturbances
Minimum FRR

- Determine minimum FR & FRR for interconnection security
  - This minimum should allow for the joint probability of both normal control error and contingency imbalances

- Allocate the minimum FR & FRR among CAs on the interconnection
  - Allocate based on cause and effect relationships to support markets
Required Measurements

- CPS1 as currently implemented indicates the holding and correct dispatch of adequate RR and CR
- New measures are required for FRR
  - Continuous measure for FR & FRR for both the CA and Ancillary Service Provider (ASP) within the CA
Require Black Box Solution

- Measure CA & ASP performance
- Measurement must be performed without looking inside the CA / ASP
- Limits data to measurements at the CA / ASP boundary
- Prevents unscrupulous participants from implementing strategies such as Enron’s “Get Shorty”
Measure FR & FRR

- Two error types
  - Error at start of measurement interval
  - Error during measurement interval
- There is more error (noise) in the CA measurement problem
- Regression for all data points may provide a solution
FR Measurement

\[ \Delta F + \Delta E + \beta \]
Good Solution Qualities

- Technical Basis - Statistics
- Simple Algorithm – Implement easily
- Current Data - 1-minute CPS1 data
- Pass/Fail Limit - Easy to understand
- Continuous Proportional Result
  - How good is Pass or how bad is Fail
- Uncertainty Limits with Result
  - How accurate is the result