

# Frequency Response & Frequency Responsive Reserve Measurement

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# 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

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- **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

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

# Arrest Frequency Decline

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- **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

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- **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)

# Restore FRR

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- 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

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- 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

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- 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

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- **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

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- **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**

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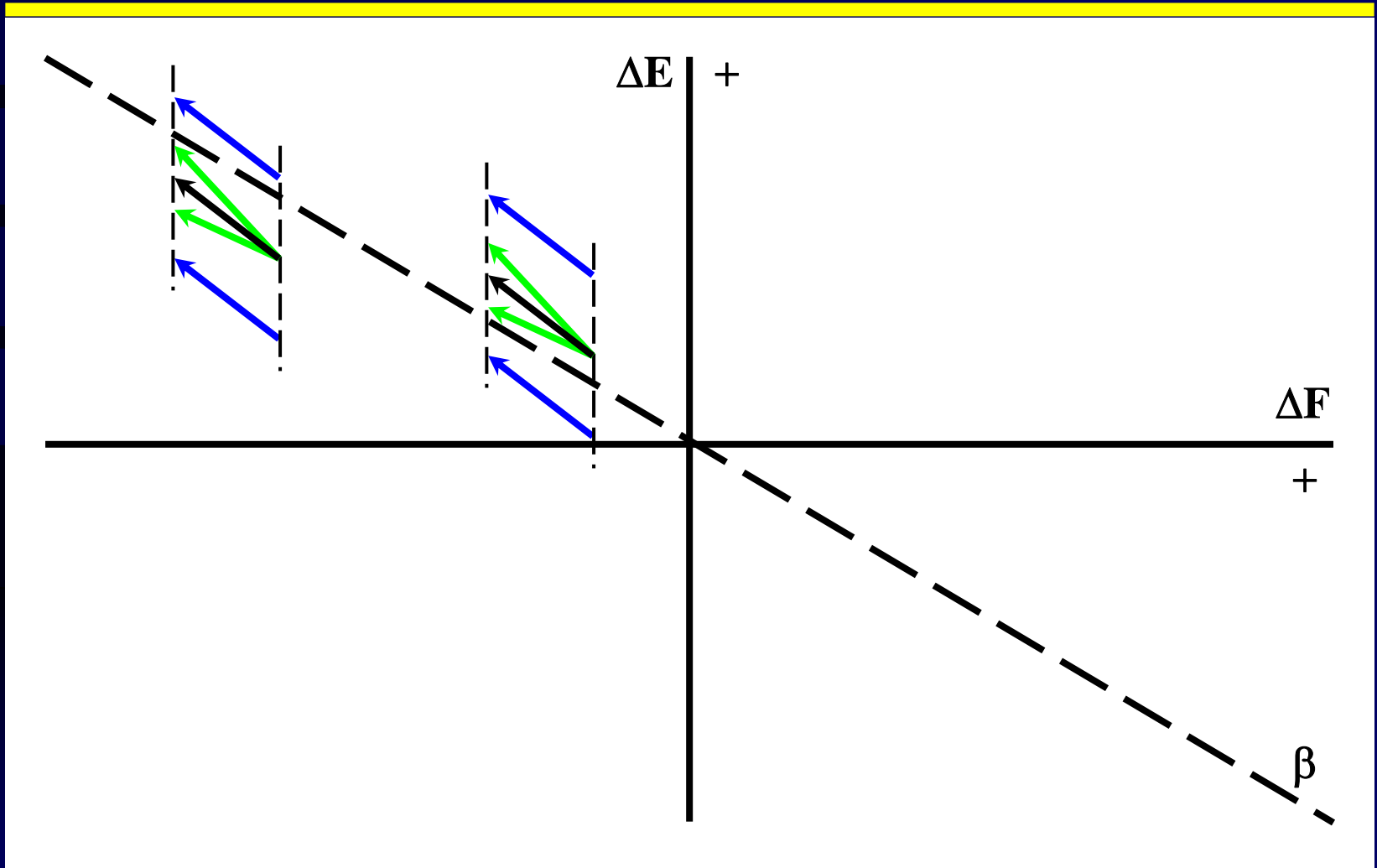
- **Measure CA & ASP performance**
- **Measurement must be performed without looking inside the CA / ASP**
- **Limits data to measurements at the CA / ASP boundary**
- **Prevents unscrupulous participants from implementing strategies such as Enron's "Get Shorty"**

# Measure FR & FRR

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- 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



# Good Solution Qualities

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- **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

# Questions

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