

## **Operating Reserve Requirements**

### **Introduction**

Operating Reserve Requirement is the minimum reserve requirement for controlling the frequency of the system as well as the power flow in the interconnectors to meet performance Standard.

Operating Reserve is the capacity above the firm demand which provide for regulation of load forecasting error, non-firm generations (wind and solar generations), and equipment forced and scheduled outages. It consists of regulating reserve contingency reserve and replacement reserve from the generators which are operated as spinning reserve and Non-spinning reserve as well as agreeable load reduction

### **Objective**

The standard set out the criteria for each country to secure operating reserve to control frequency and power flow in the interconnection transmission system and secure the inter connection against single contingency and restore system to the normal condition within speech time

### **Definition**

Regulating Reserve – Spinning Reserve Immediately response to Automatic Generation Control (AGC) to meet Control Performance Standard (CPS)

Contingency Reserve – An amount of Spinning and Non-Spinning Reserve Sufficient to reduce Area Control Error (ACE) to meet performance requirements within [15] minutes

Automatic Generation Control (AGC) – The ability of generating unit to response to signals from Energy Management System Control computer to provide Control Area balancing, Frequency bias and time error correction.

Area Control Error (ACE) – The Instantaneous difference between net actual generation and demand including scheduled interchange taking into account the effects of frequency bias and correction for meter error

### **Requirement**

#### **R 1. Regulating Reserve**

R 1.1 the Control Center shall sufficient spinning reserve which consisting of primary control reserve and secondary control reserve responsive to Automatic Generation

Control (AGC). The minimum amount required is to regulate the system necessary to meet Control Performance Standard (CPS1, CPS2)

R 1.2 the Control Center should calculate regulating reserve as the sum of the 10 minutes ramping ability of the generators either on AGC control and non-synchronized units but be able to synchronized and loaded to a capacity within 10 minutes. Then subtract the algebraic sum of the expected 10 minutes forecasted load change, the expected 10 minutes variation due to Non-firm generation and ACE requirement to meet CPS1 the equation for calculating Regulating Reserve Compliance (Rc) are

$$R_c = A_c - R_m$$

$$R_m = L_v + S_v - f(ACE)$$

$A_c$  : the Available Regulating Reserve is the combined ramp rate of all the generator in the next 10 minutes.

$R_m$  : Minimum Regulating Reserve Requirement in the next 10 minutes.

$L_v$  : Anticipated changes in the load forecast in the next 10 minutes

$S_v$  : Anticipated changes in the interchange scheduled

$f(ACE)$  : A function of ACE requirement to meet CPS The regulating reserve compliance shall not be less than zero without

## R 2. Contingency Reserve

R 2.1 the system operator shall provide spinning and non-spinning reserve sufficient area control error to meet single contingency outage equivalent to outage of the biggest generation in the system and the operator should be able to restore the frequency to normal within 15 minutes after the incident.

R 2.2 Contingency Reserve is equal to the sum of the ramping MW Capability of AGC and Non-Spinning reserve capable to generate within 10 minutes plus interruptible load and interruptible exports.

R 2.3 System Operator should calculate contingency reserve compliance every 10 minutes by the formulas:

$$R_d = T_r - R_r$$

$$T_r = S_r - N_r$$

$$R_r = R_m + S_c$$

Tr : Total Contingency Reserve available which is the sum of increase capability of generator in 10 minutes

Sr : Spinning Reserve available in 10 minutes

Nr : Non-Spinning Reserve capable to Synchronize generate in 10 minutes

Sc : Most Severe Single contingency which is equal to the biggest generator in the system [100 MW]

Reserve Compliance for disturbance (Rd) should not be less than zero without contingency plan.

Bi is the Frequency Bias Setting of each control area (country)

Bs is the Frequency Bias Setting of the inter connected area

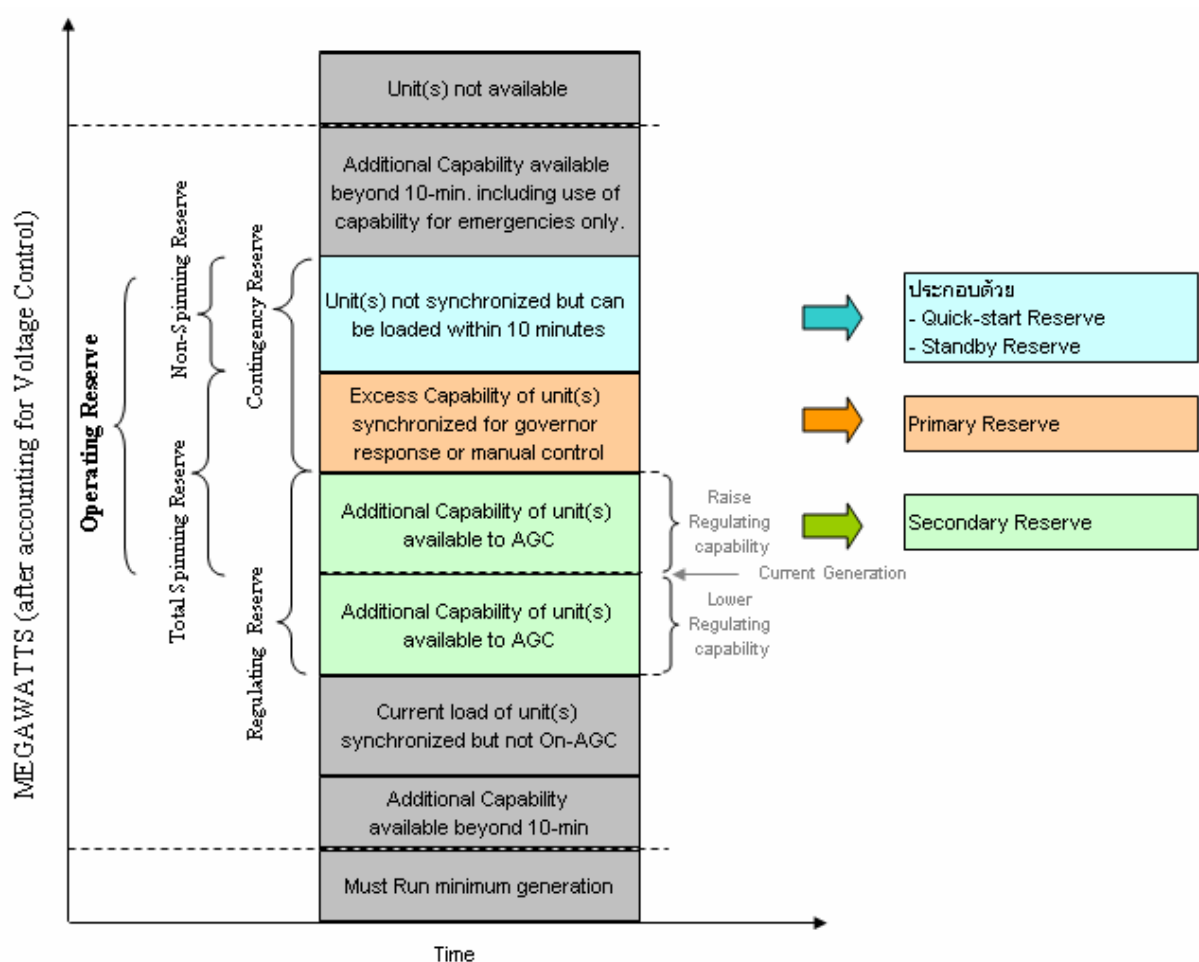


Figure1 Plant MW Capability Diagram Definition of Terms

## Standard

### S.1 regulating reserve

S. 1. 1 The control center shall provide sufficient regulating reserve to control the average 12 months frequency deviation to be within specific value by the equation

$$AVG_{period} \left[ \left( \frac{ACE_i}{-10B_i} \right)_1 * \Delta F_1 \right] \leq \epsilon_1^2 \text{ or } \frac{AVG_{period} \left[ \left( \frac{ACE_i}{-10B_i} \right)_1 * \Delta F_1 \right]}{\epsilon_1^2} \leq 1$$

The equation for ACE is:

$$ACE = (NI_A - NI_S) - 10B (F_A - F_S) - I_{ME}$$

Where

- $NI_A$  is the algebraic sum of actual flows on all tie lines.
- $NI_S$  is the algebraic sum of scheduled flows on all tie lines.
- $B$  is the frequency Bias Setting (MW/0.1 Hz) for the balancing Authority. The constant factor 10 converts the frequency setting to MW/Hz.
- $F_A$  is the actual frequency.
- $F_S$  is the scheduled frequency.  $F_S$  is normally 50 Hz but may be offset to effect manual time error corrections.
- $I_{ME}$  is the meter error correction factor typically estimated from the difference between the integrated hourly average of the net tie line flows ( $NI_A$ ) and the hourly net interchange demand measurement (megawatt-hour). This term should normally be very small or zero.

$$AVG_{10\text{-minute}} (ACE_i) \leq L_{10}$$

Where:

$$L_{10} = 1.65 \epsilon_{10} \sqrt{(-10B_i)(-10B_s)}$$

## S.2 Disturbance Control Performance

S.2.1 The control center shall provide contingency reserve to cover severe single contingency which account for the biggest generator in the system. The control center shall restore the system and bring the system up to normal within 5 minutes.

S.2.2 The control center shall prepare the contingency report for the incident of 80% of severe single contingency loss

### S.2.3 Replacement Reserve

The control center shall start up a generator within [60] minutes to cover the second contingency that may occur. The size of the generator is large enough to put the contingency reserve back to normal.

## Measures

The control center shall achieve 100% of the minimum requirement for CPS1, CPS2 and DCS

### M 1 Control Performance Standard1 (CPS1)

$$CPS_1 = (2 - CF) \pm 100\%$$

$$CF = \frac{CF_{12-month}}{(\epsilon_1)^2}$$

$$CF_{clock-minute} = \left[ \frac{ACE}{-10B} \right]_{clock-minute} * \Delta F_{clock-minute}$$

Where

ACE used for calculation should be periodicity sampling at least (15) times per minute to represent clock-minute average of ACE. The value E1 is the allowed frequency deviation which will be determined among interconnected countries.

### M 2 Control Performance Standard2 (CPS2)

$$CPS2 = \left[ \frac{1 - VIOLATIONS_{month}}{(Total\ Period_{month} - Unavailable\ Period_{month})} \right] * 100$$

Where

Violations month are a count of number of periods that ACE clock-ten minutes exceed L10

ACE clock-ten-minutes is the sum of valid ACE samplings within a clock-ten-minutes period divided by the number of valid samplings

L10 is the number divided from target frequency bound

### M 3 Disturbance Control Performance (R)

Ri is the measure of percentage of recovery after loss of large generation (80% of the biggest unit) compared to the pre-disturbance or normal condition.

Using Formula

$$R = \frac{MW_{Loss} - \max(0, ACE_A - ACE_M)}{MW_{Loss}} * 100\%$$

Where

$ACE_A$  is the area control error before the disturbance and is equal to zero if

$$ACE_A > 0$$

$ACE_M$  is the area control error measure at 15 minutes after the disturbance

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## Appendix

1. **Control Performance Standard1 (CPS1)** is the result of the calculation from the formula with measured variables consisting of Frequency Bias, average clock-minute of ACE and Frequency error

$$\boxed{CPS1 = (2 - CF) * 100\%} \quad (1)$$

where

$$\boxed{CF = \frac{CF_{12-month}}{(\epsilon_1)^2}} \quad (2)$$

$\epsilon_1^2$  = is the constant relating to the allowance frequency deviation agreed among the countries

(Target frequency bound)

Compliance Factor (CF) is delivered as a clock – minute average ACE divide by -10 times frequency bias setting times the clock-minute average frequency error

$$CF_{clock-minute} = \left[ \frac{ACE}{-10B} \right]_{clock-minute} * \Delta F_{clock-minute}$$

where

$$\left( \frac{ACE}{-10B} \right)_{clock-minute} = \frac{\left( \frac{\sum ACE_{sampling\ cycles\ in\ clock-minute}}{n_{sampling\ cycles\ in\ clock-minute}} \right)}{-10B}$$

and

$$\Delta F_{clock-minute} = \frac{\sum \Delta F_{sampling\ cycles\ in\ clock-minute}}{n_{sampling\ cycles\ in\ clock-minute}}$$

$B$  is the System Frequency Bias (MW/0.1 Hz)

Clock-Hourly Compliance Factor are calculated from clock-min. minute Compliance Factor

$$CF_{clock-hour} = \frac{\sum CF_{clock-minute}}{n_{clock-minute \text{ samples in hour}}}$$

$$CF_{month} = \frac{\sum_{hours-in-day} [(CF_{clock-hour}) (n_{one-minute \text{ samples in clock-hour averages}})]}{\sum_{hours-in-day} [n_{one-minute \text{ samples in clock-hour averages}}]}$$

$$CF_{12-month} = \frac{\sum_{i=1}^{12} [(CF_{month-i}) (n_{(one-minute \text{ samples in month})-i})]}{\sum_{i=1}^{12} [n_{(one-minute \text{ samples in month})-i}]}$$

## 2. Control Performance Standard2 (CPS2)

CPS2 is designed to bound ACE ten-minute average and at the same time limit excessive unscheduled power flows that could result from large ACEs

$$\boxed{AVG_{10-minute} (ACE_i) \leq L_{10}} \quad (3)$$

where  $L_{10} = 1.65 \epsilon_{10} \sqrt{(-10B_i)(-10B_s)}$

$\epsilon_{10}$  in Hz is the target RMS of ten-minute average frequency error from scheduled based on selected historical period of interconnection frequency performance

1.65 is a constant used to convert the frequency target to 90% probability.

$B_i$  in (negative) MW per tenth Hz, is the frequency bias of each system.

$B_s$  in (negative) MW per tenth Hz, is the sum of the frequency bias settings of the interconnected system.

## 3. Disturbance Control Standard (DCS)

DCS is the measure of Percentage recovery ( $R_i$ ) for the loss of generation

if  $ACE_A < 0$

$$R_i = \frac{MW_{Loss} - \max(0, ACE_A - ACE_M)}{MW_{Loss}} * 100\%$$

if  $ACE_A \geq 0$

$$R_i = \frac{MW_{Loss} - \max(0, -ACE_M)}{MW_{Loss}} * 100\%$$

Where

$MW_{Loss}$  is the MW size of the disturbance as measured at the beginning of the event. It is the size of the resource or demand loss, not the ACE deflection,

$ACE_A$  is the pre-disturbance ACE,

$ACE_M$  is the value of ACE representing the point of greatest recovery from the disturbance measured within the fifteen minutes following the start of the disturbance event A  
BA or RSG may, at their discretion, set ( $ACE_M = ACE_{15 \text{ min}}$ )

The measure of percentage recovery must be recorded for any disturbance greater than or equal to 80% of the magnitude of the biggest generate in the system. If the percentage recovery is less than 100% the Contingency Reserve shall be adjusted by the amount equal to the average percentage of power that should recover the system back to normal within 15 minutes.

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