Generation Performance Monitor and the Degree of Generation Performance White Paper

PJM Interconnection

Date June 30, 2020

For Public Use

PJM © 2020

This page is intentionally left blank

Table of Contents

Background

The Generator Performance Monitor (GPM) logic was developed as an operational reliability tool to improve Unit Dispatch System (UDS) solutions. Its objective is to track how close generators are responding to the UDS energy dispatch signals. It performs the following functions.

- Real time monitoring and evaluating a unit's actual performance
- Near real-time predicting unit's performance, i.e. achievable ramp rate

GPM was introduced into the dispatch algorithm in late 2003 in the UDS application, the precursor to RT SCED. The GPM logic is applied in the current Security Constrained Economic Dispatch engines (SCED) for calculating power balance, constraint control, and synchronized reserves (Tier 1 and Tier 2). GPM is not used to adjust the dispatch signal (also known as the economic basepoint) sent to generators.

GPM Model

Inputs to the GPM model include generator status (Economic, Must-Run), run-time limitations (Minimum Run Time and Maximum Run Time), regulation status, historic and current generator outputs and generator dispatch MW. It produces an output referred to as Degree of Generator Performance (DGP). Two DGP values are calculated: Interval DGP (IDGP) and Achievable DGP (ADGP).

First, the Interval DGP (IDGP) is calculated to measure the responsiveness of a generator to energy dispatch instructions in terms of its actual generation MW output. The formula for the calculation of IDGP is shown below.

$$IDGP_t = \frac{(AUgen_t - AUgen_{t-1})}{(Ugen_t - AUgen_{t-1})}$$

- $AUgen_t$: Actual unit output for interval *t*
- $Ugen_t$: SCED dispatch signal for interval *t*

IDGP will be a value between zero and one. If IDGP equals zero the unit is not following SCED dispatch. If IDGP equals one the unit is following SCED dispatch perfectly.

$$0 \leq IDGP \leq 1$$

The calculation of IDGP occurs every five minutes for on-line units or upon RTSCED case approval.

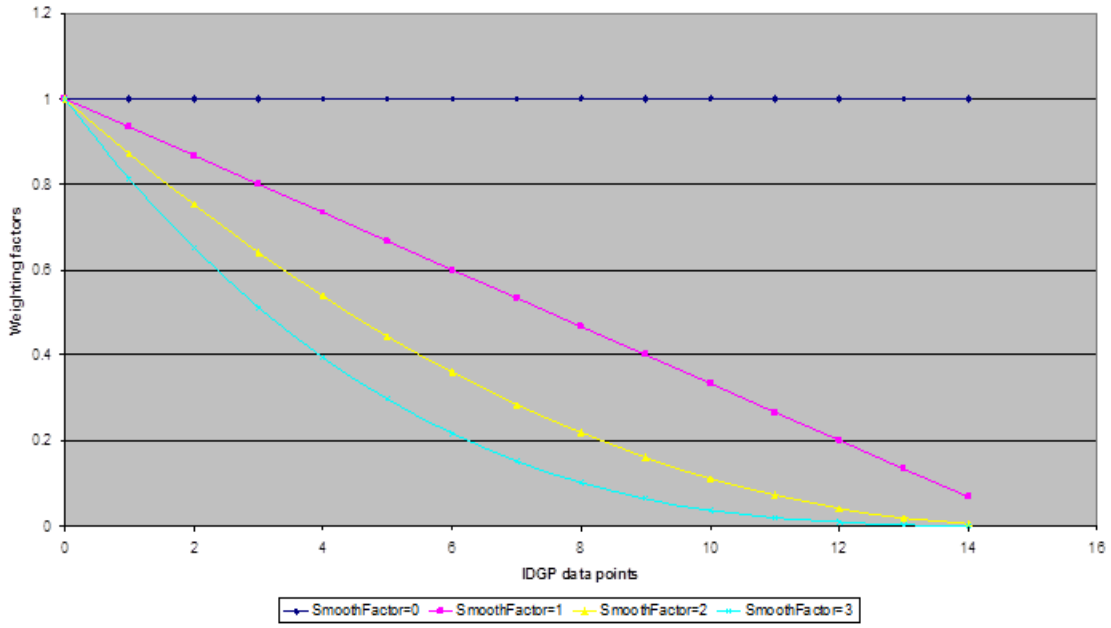
Second, the Achievable DGP (ADGP) is calculated using the historical IDGPs to project the responsiveness of a generator to dispatch instructions for the next SCED look-ahead interval. The algorithm uses the generator's response in the last ten SCED intervals, calculated per the IDGP logic, to predict the expected future performance of the generator.

- Weights most recent performance higher
- Upon generator startup, ADGP will be set to one
- Unit operated below Economic Minimum will have ADGP set to one until unit is above Economic Minimum

The ADGP algorithm uses an exponential smoothing approach to determine a unit's ADGP

- Exponential weighting factors:

$$EWF_{t-i} = \left(1 - \frac{i}{N}\right)^{\alpha}, i = 0,1,\ldots, N-1$$



The formula for calculating Achievable DGP (ADGP) is shown below:

$$ADGP_t = \left(\frac{\sum_{i=0}^{N-1} EWF_{t-i} \times IDGP_{t-i}}{\sum_{i=0}^{N-1} EWF_{t-i}} \right)$$

ADGP will be a value between zero and one.

$$0 \leq \text{ADGP} \leq 1$$

If ADGP equals zero the unit is not expected to move in response to its economic basepoint. If ADGP equals one then the unit is expected to move in response to its economic basepoint according to its bid-in ramp rate. ADGP is calculated every five minutes for on-line units or upon RTSCED case approval.

A floor is applied to the ADGP when the value is below a certain threshold. The current floor is 0.75. If the ADGP is zero, it remains at zero but 0.75 is used to calculate the unit's achievable ramp rate.

DGP for Energy Calculations

ADGP is applied in the current Security Constrained Economic Dispatch engines (SCED) for calculating power balance, constraint control, and synchronous reserves (Tier 1 and Tier 2). It is used in the market-clearing engine (MCE) to adjust a unit's bid-in ramp rate.

$$Achievable\_Ramp\_Rate = ADGP \times Bid\text{-}in\_Ramp\_Rate$$

This adjustment affects energy prices but it does not reduce the dispatch signal (economic basepoint) sent to the unit. DGP is applied to steam and combined cycle units.

For example,

SE MW = 100 MW

Eco Max = 200 MW

Ramp Rate = 5 MW/min

ADGP = 0.75

To meet power balance, RTSCED will assume that the unit can only provide 37.5 MW in 10 minutes (5 MW/min x 10 minutes x 0.75). The MW, used for pricing only, will be 137.5 MW.

If the RTSCED calculates an LMP higher than the unit's offer, the unit will be ramped up by 50 MW (5 MW/min x 10 minutes). The dispatch signal will be equal to 150 MW.

DGP for Synchronized Reserve (SR) Calculations

The use of ADGP was expanded to calculate a resource's maximum capacity of Tier 1 or Tier2 MW. The cleared Tier1 or Tier2 MW could be less than this value. This change was implemented in the June 2014 timeframe. ADGP is used to adjust a resource's synchronized reserve ramp rate. Typically, synchronized reserve ramp rate is used to estimate a unit's maximum synchronized reserve capability unless its value is less than the energy ramp rate, then energy ramp rate will be used. The ADGP floor is not applied in the reserve capability calculation.

For example,

Energy Ramp Rate = 5 MW/min

SR Ramp Rate = 7 MW/min

ADGP = 0.80

ADGP is applied to SR ramp rate to cap either Tier 1 or Tier 2 capacity.

SR Capacity <= ADGP * bid in spin ramp rate*10 minutes

However, when backing down a resource to provide Tier 2, only energy ramp rate is considered. The ramp rate is used for energy ramping down (for Tier2) is 0.80 * bid-in energy ramp rate.

The SR Capacity for the resource is 56 MW (0.80*7 MW/min*10 minutes). This is the maximum amount of SR the unit is able to provide and is based on the spin ramp rate adjusted by ADGP.

The calculated value of its reserve assignment is 40 MW (0.80*5MW/min*10 minutes). In calculating the actual reserve assignment, the energy ramp rate is used which is adjusted by ADGP. In this example, the unit is assigned 40 MW of SR.