

Active Power Ramp Rates

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Equations (1) and (2) from [1] are used to estimate generator active power ramp up and ramp down rates, respectively, as functions of nameplate capacity.

$$\text{RAMP}_{\text{up}} = \begin{cases} u_{11} + nu_{12} & \text{if } n < 500 \text{ MW} \\ u_{21} + nu_{22} & \text{if } n \geq 500 \text{ MW} \end{cases} \quad (1)$$

$$u_{11} = 0.006038$$

$$u_{12} = -0.000003840$$

$$u_{21} = 0.004573$$

$$u_{22} = -0.0000009099$$

$$\text{RAMP}_{\text{down}} = \begin{cases} d_{11} + nd_{12} & \text{if } n < 500 \text{ MW} \\ d_{21} + nd_{22} & \text{if } n \geq 500 \text{ MW} \end{cases} \quad (2)$$

$$d_{11} = 0.006783$$

$$d_{12} = -0.000004314$$

$$d_{21} = 0.005138$$

$$d_{22} = -0.000001022$$

where n is the nameplate capacity of the generator.

For additional reference, Table 1 shows typical ramp rates for a variety of generator sizes and types.

Unit Type	Unit Size (MW)	Ramp Rate (MW/minute)	Reference
Oil/Steam	12	1	[2]
Oil/Steam	100	7	[2]
Oil/Steam	197	3	[2]
Oil/CT	20	3	[2]
Coal/Steam	76	2	[2]
Coal/Steam	155	3	[2]
Coal/3 Steam	350	4	[2]
Nuclear	400	20	[2]
Nuclear (PWR)	–	1 to 3 percent per minute	[4]
Gas CT (typical)	–	15 to 25	[3]
Gas CT (new GE)	510	50	[3]
Pumped Hydro	–	> 100	[5]

Table 1: Generator Ramp Rates by Size and Type

References

- [1] Federal Energy Regulatory Commission. RTO Unit Commitment Test System. *Staff Report*, July 2012.
- [2] C. Grigg, P. Wong, P. Albrecht, R. Allan, M. Bhavaraju, R. Billinton, Q. Chen, C. Fong, S. Haddad, S. Kuruganty, W. Li, R. Mukerji, D. Patton, N. Rau, D. Reppen, A. Schneider, M. Shahidehpour, and C. Singh. The ieee reliability test system-1996. a report prepared by the reliability test system task force of the application of probability methods subcommittee. *Power Systems, IEEE Transactions on*, 14(3):1010–1020, 1999.
- [3] Chris Meehan. General electric introduces gas turbine designed for renewables. *Clean Energy Authority*, 2011.
- [4] Laurent Pouret and William Nuttall. Can Nuclear Power be Flexible? Eprg0710, Judge Business School, University of Cambridge, March.
- [5] Matthew Shapiro. Pumped storage hydro: Benefits for eastern wyoming wind and transmission. *Presentation to the Wyoming Infrastructure Authority*, May 10 2011.