# Links Between the VG Forecast and the Unit Commitment Programs and Associated Algorithms - A Vendor Perspective

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# Unit Commitment Problem

- Determine the generator unit commitment status in a **period of time** so that the system cost can be minimized when the economic dispatch is performed to meet the system demand
- Typical constraints honored in the unit commitment
  - Minimum up and down time
  - Run up and down rate
  - Start up and shutdown cost
  - Ramp up and down rate
- Usually the unit commitment and economic dispatch are performed simultaneously (Mixed Integer Programming)

# Challenges from the Variable Generation Integration

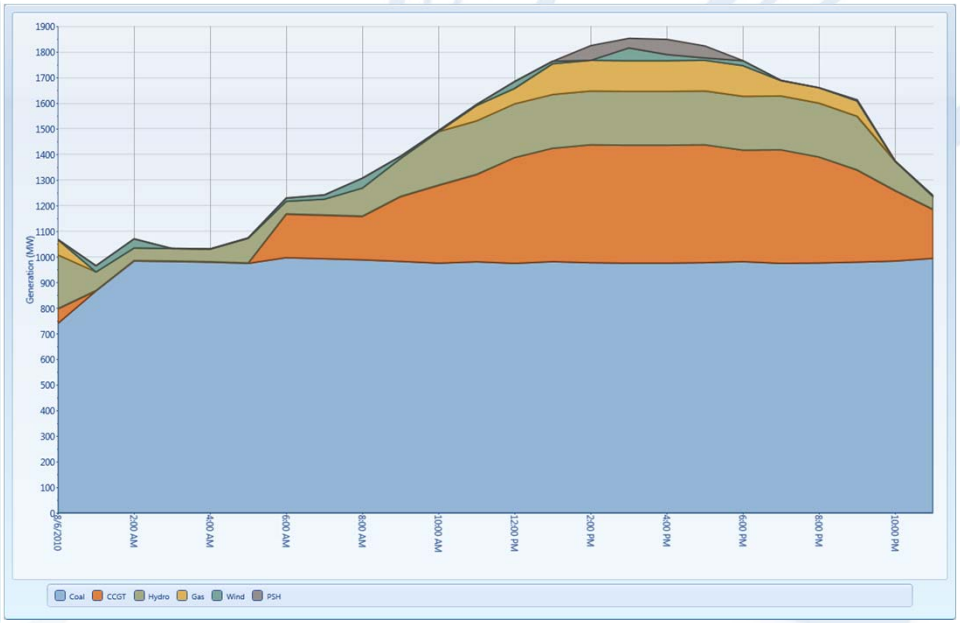
- Variable generation is not dispatchable
- Variable generation variability and forecast error
- Definition of variable generation perfect forecast?
  - Perfect forecast at what moment?
  - How far into the future will the perfect forecasts be?
- If the perfect forecast is too close to the dispatch interval, it will be too late to revise the commitment or de-commitment decisions or the commitment decision is too costly (expensive unit will be committed and dispatched).

# Impact of Variable Generation Forecast to the Unit Commitment

- How to measure the unit commitment (or a system) is ready to handle the variable generation uncertainty and variability?
  - How much ramp up and down capacity is on-line (or can be committed in the system)
- What will help a better (less costly) unit commitment?
  - Accurate moving trend of the variable generation forecast
  - The length of the accurate forecast into the future

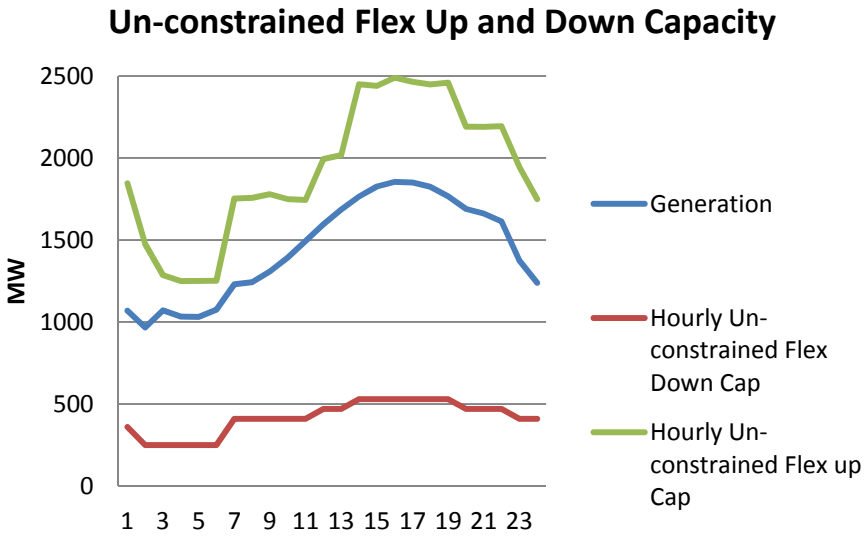
# Impact of Variable Generation Forecast to the Unit Commitment

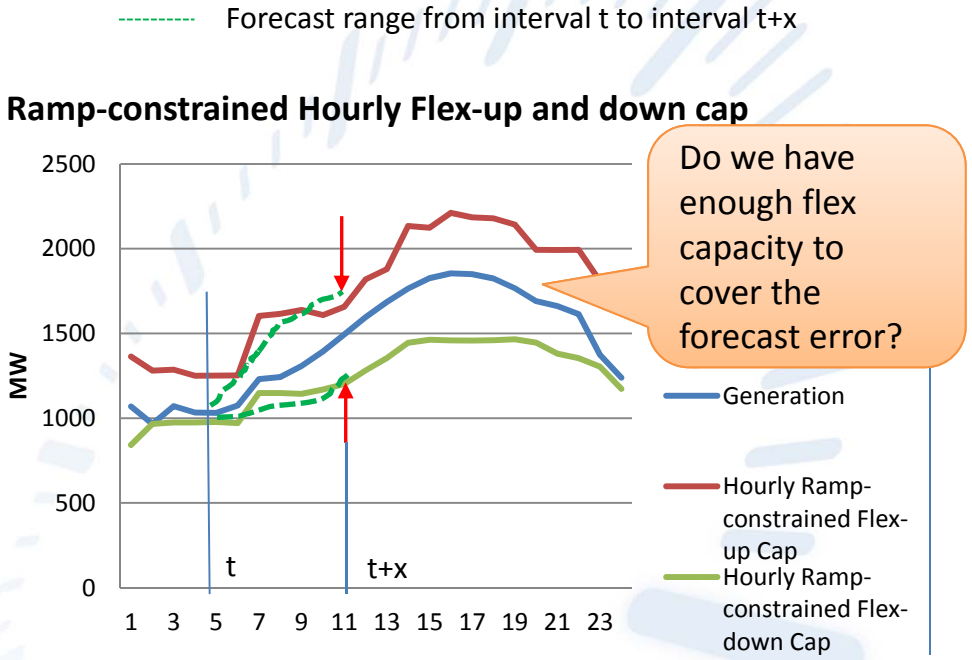
- Example of the Unit Commitment to cover the renewable generation uncertainty and variability

# Impact of Variable Generation Forecast to the Unit Commitment

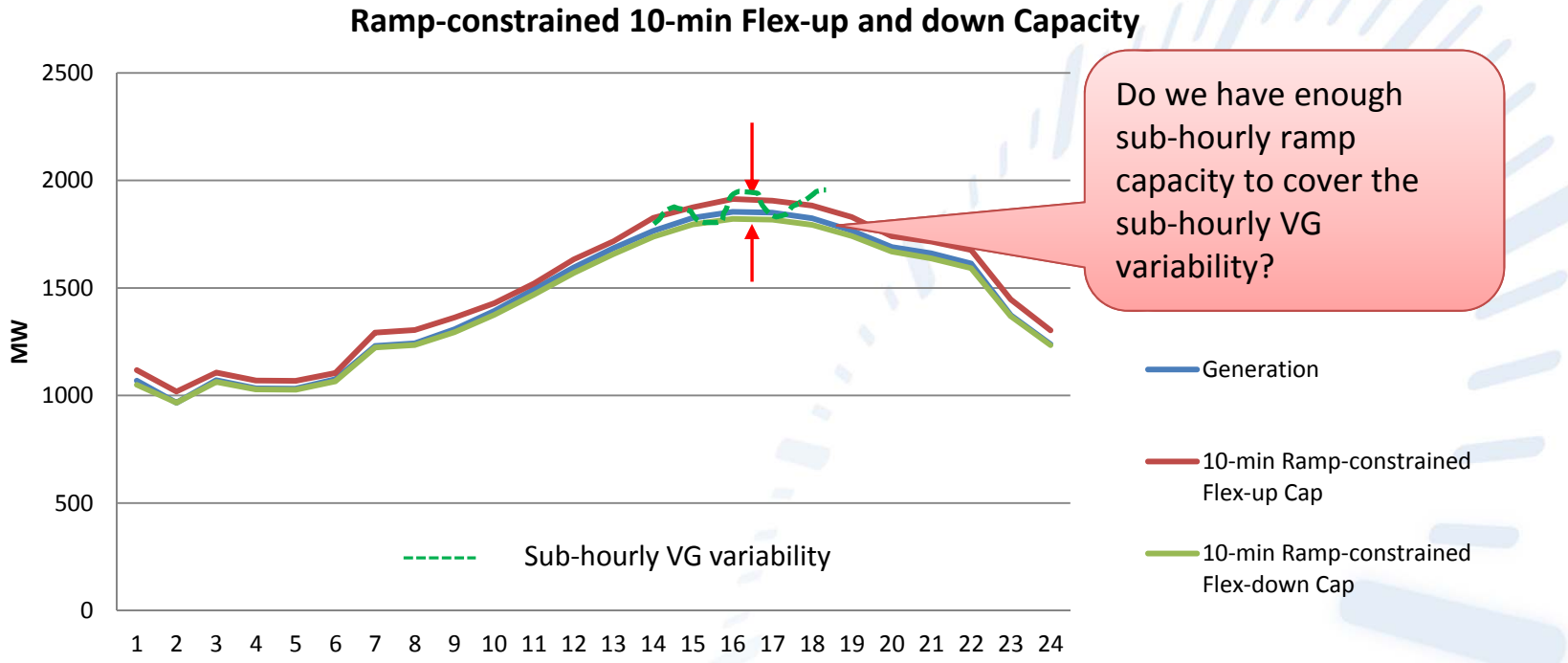
- Un-constrained and Ramp-constrained Flexibility Up and Down Capacity



# Impact of Variable Generation Forecast to the Unit Commitment

- 10-min Ramp-constrained Flexibility Up and Down Capacity.



# Observations

- If the perfect forecast comes in too late, it would not help too much.
- The range and the length into the future of the VG forecast moving trend will determine additional reserve requirements that will incur the additional cost in UC

# Illustration of Energy-AS-DCOPF Co-optimization by MIP

$$\text{Min} \sum_t \sum_k c_k^t g_k^t u_k^t + sc_k^t (u_k^t - u_k^{t-1}) + \sum_m ac_{m,k}^t as_{m,k}^t u_k^t$$

subject to

$$\sum_k g_k^t u_k^t = \sum_k l_k^t + \sum_j loss_j^t \quad \forall t \text{ (System Energy Balance)}$$

$$\sum_k as_{m,k}^t \geq as_m^{t,min} \quad \forall t, m \text{ (AS constraint for AS m)}$$

$$as_{m,k}^{t,min} u_k^t \leq as_{m,k}^t \leq as_{m,k}^{t,max} u_k^t \quad \forall t, k, m \text{ (Generation AS Capacity Limits)}$$

$$g_k^{t,MIN} u_k^t \leq g_k^t \pm \sum_m as_{m,k}^t \leq g_k^{t,MAX} u_k^t \quad \forall t, k \text{ (Generation and AS Capacity Limits)}$$

$$g_k^t - g_k^{t-1} + \sum_m as_{m,k}^t \leq ramp_k^{t,MAX} u_k^t \quad \forall t, k \text{ (Generation and AS Ramp Capacity Limits)}$$

$$\sum_t g_h^t \leq g_h^{\text{day/week/month/year\_max}} \quad \forall h \text{ (Daily/Weekly/Monthly/Yearly Energy Limits)}$$

$$\mathbf{f_j^t = \sum_k PTDF_{k,j}^s (g_k^t u_k^t - l_k^t)} \quad \mathbf{\forall t, k, s \text{ (}\textit{Linearized}\text{ power flow for violated line limit in NA)}}$$

$$\mathbf{f_j^{t,MIN} \leq f_j^t \leq f_{j,}^{t,MAX}} \quad \mathbf{\forall t \text{ (Flow limits for lines w/ limit violation in NA)}}$$

$$\mathbf{BG_b^{t,MIN} \leq \sum_j BGF_b^j f_j^t \leq BG_b^{t,MAX}} \quad \mathbf{\forall t \text{ (Interface limits for violated interfaces in NA)}}$$

Other Constraints : resource chronological constraints, resource constaints, etc.

# Questions and comments?

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