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Using Expected Generation for Derates for Variable Units

GADS Wind Training Module 22

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RELIABILITY | ACCOUNTABILITY

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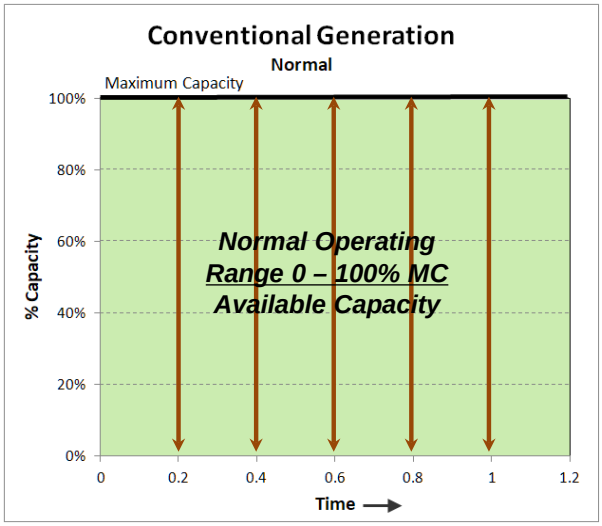
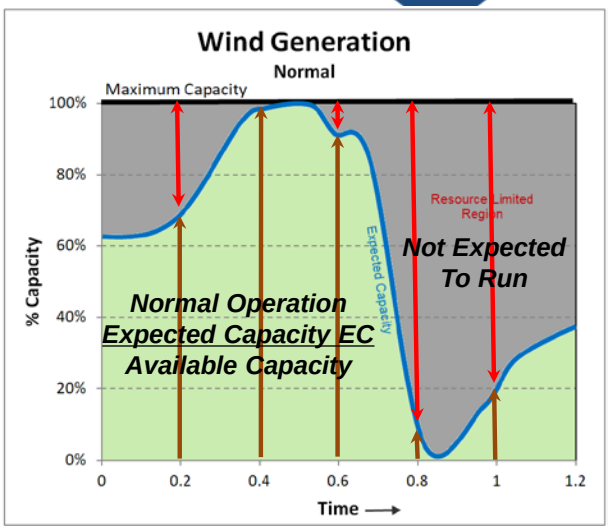
Normal Operation



- Normal operation – 0-100% MC
- Any cause preventing 100% MC is a derate, outage or reserve shutdown
- In most cases Maximum, dependable and expected capacity are the same



- Normal operation – 100% EC
- Cannot operate > EC
- Difference between EC and MC is Resource Limited and not expected to run
- Any operation < 100% EC is an outage, derate or reserve shutdown

Note: Expected Capacity (EC) = Capacity based on available fuel supply (Wind / Solar)

Conventional generation normally operates between 0 and 100% maximum capacity (MC). Anything that prevents a conventional unit from reaching 100% MC is a derate, outage or reserve shutdown (RS).

A variable resource unit (Wind or Solar) operates at 100% expected capacity (EC) all the time. It is not a range like 0-100% MC as seen in conventional plants. The area between EC and MC is resource limited and the unit is not expected to operate at higher than expected. Expected capacity is based on the fuel supply (wind / solar) corrected for ambient conditions

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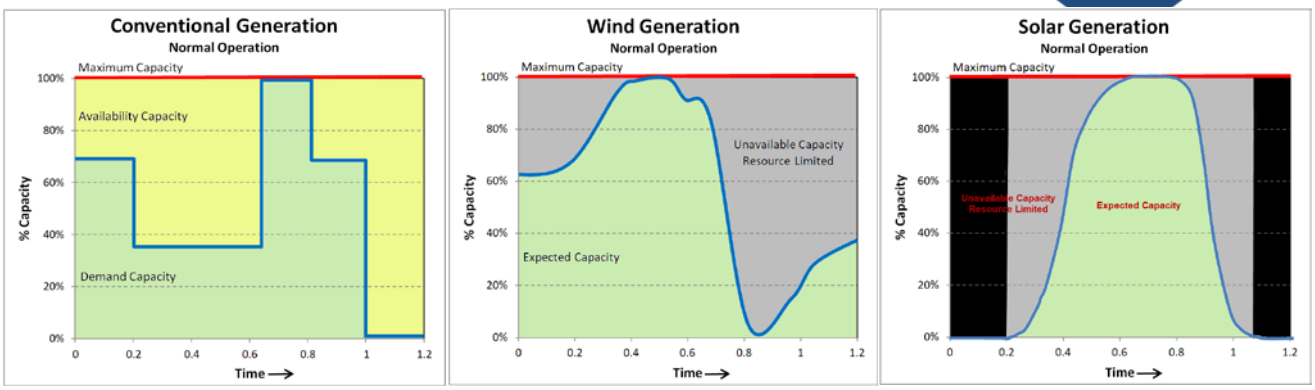
Variable Resource Units



Characteristic	Conventional	Wind	Solar
Maximum Capacity	Available	Capable	Capable
Generate	Demand Capacity	Expected Capacity	Expected Capacity
Generation	Steady	Variable – 24/7	Variable – Clouds, Night
Fuel	Contract	Free	Free
Predictability	High	Low	Moderate

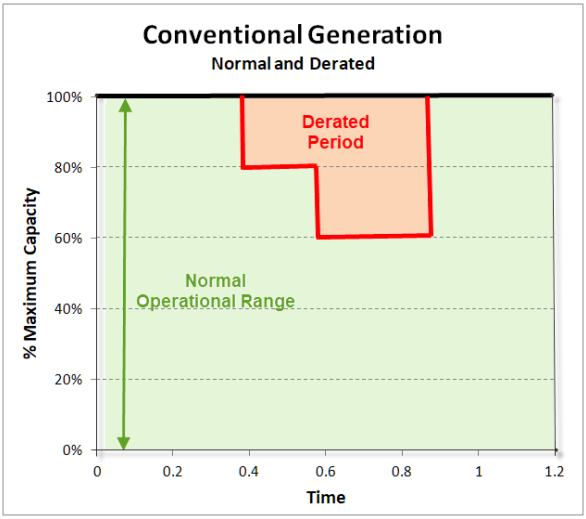
- Maximum Capacity – A conventional unit is always available to operate anywhere between 0 and 100% Maximum Capacity unless it is in derate, outage or unavailable. A variable unit is always capable of achieving Maximum Capacity but is limited to Expected Capacity due to the variable fuel supply.
- Generate – Conventional units generally work off of a system demand and produce steady state power during that period. Variable units always operate at Expected Capacity (unless in derate, outage or RS). There is no possibility of operating above expected capacity as there is no fuel. Resource limited
- Generation – Conventional units generate at a steady state based on demand. Variable unit generation changes over time. Wind varies minute to minute 24/7. Solar is more predictable as it varies with sun intensity.
- Fuel – Conventional units contract for their fuel. The fuel supply is predictable but has a dollar cost. Wind has free fuel but is difficult to predict delivery.
- Predictability – Conventional units have high confidence of meeting a demand. Wind has very low predictability especially over long periods. Solar is moderately predictable because sunrise and sunset or known. Cloud cover causes some unpredictability.

Variable Unit Operation

- Variable units are expected to generate at 100% of Expected Capacity (EC) which is based on resource and no equipment losses
- Because of the variability, Expected Generation (EG) is calculated for each unit and data interval (1-10 minutes). If capacity is required it is backed into for the data interval or time period of the study (note transition from EC to EG)
- Variable units cannot generate above EG as they are resource limited (RL)in that range. The RL can be calculated by subtracting expected generation from Maximum Generation (MG)
- EG is the generation limit based on the resource available for the time period being considered. Most newer SCADA system track EG per unit on a 10 minute or less interval
- EG varies minute to minute with wind being the most volatile
- EG can be averaged or summed over time for various reporting periods
- For the most part, variable units cannot meet a demand as this requires generating at a steady state between 0-100% MG
- Variable units can participate in day and hour ahead markets but usually at a level less than the predicted EG. Usually, these units have associated battery banks or related conventional plants to ensure steady state during the market period and avoid penalties

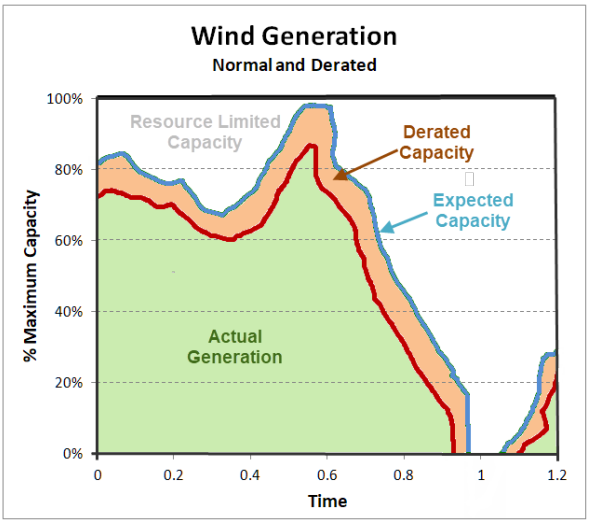
Conventional Derates

- Conventional units are expected to generate at a steady state between 0-100% of Maximum Capacity (MC)based on demand
- Any time a unit is not capable of 100% MC it is a derate or outage
- The % MC attributed to the derate times the hours of the derate equal the equivalent hour for the derate
- Calculations are made and summed each time the %MC derate changes



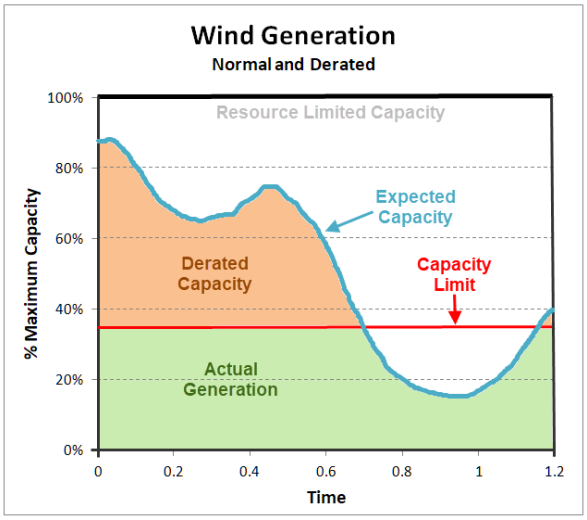
Variable Unit Constant Derate

- Variable unit derates can occur in many forms
- The most common form of derate is a constant derate seen through out the operation range
- Common causes:
  - Soiling of solar panels
  - Wind vane out of calibration
  - Wind pitch mechanism failing
  - Icing on blades
  - Blade alignment
  - Controller automatic derates
  - Temperature – high and low



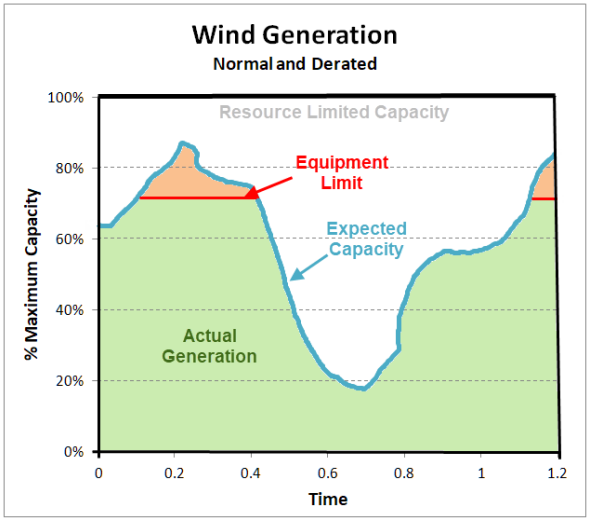
Variable Unit Capacity Limit

- Capacity limits or restrictions are usually orders from the System Operator
- The plant is limited to a <u>not to exceed</u> specified capacity
- Production less than the limit is OK
- When the EC is less than the limit there is no derated capacity
- Common Causes:
  - Limit due to Reserve Shutdown. Lack of demand or negative energy pricing. This is defined as ERSDTH in the wind data reporting instructions
  - Transmission constraints



Variable Unit Equipment Derate

- Equipment limitations
- There is no derate when the EC is below the equipment limit
- Common causes:
  - Failing gearbox – output limited to prevent failure before replacement
  - Sensor calibration – automatic derate from controller usually identified during start-up checks



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Summary

1. Generation is limited at any point in time by the variable unit's fuel supply. This is normal for the technology
2. Normal unit operation is always 100% of EC or EG
3. The unit cannot generate above 100% EC or EG because there is insufficient fuel which is not in the plant's control
4. Using MC inflates the equivalent hours, overstating the derate impact. MC includes a lot of resource limited capacity which is an area where the unit is not expected to run and not equipment related.
5. The trade off for free fuel is variability
6. Because of the variability, Expected generation is calculated for each unit and data interval (1-10 minutes). If capacity is required it is backed into for the data interval or time period of the study
7. Variable resource units normally work with generation where as conventional units normally work with capacity
8. Expected generation, for wind, is calculated using the unit power curve corrected for air density
9. Using EG truly defines the derate loss. MC would incorporate losses that were never achievable

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Example

- Actual calculations can use EC directly but this can be time consuming as EC is varying minute to minute
- Assuming only one derate, it is easier to use expected generation (EG) and actual generation (AG)
- The difference between EG and AG represents the actual generation loss due to the derate. Dividing the result by EG gives the percent loss or derate. Multiplying the percent derate times the derate period hours equals the equivalent hours

- Example:
  - Derate Period = 100 Hours
  - EG = 10,000 MWh
  - AG = 9,000 MWh
  - Equivalent Hours = (EG-AG)/EG x Derate Period
    = (10,000 MWh - 9,000 MWh)/10,000 MWh x 100 Hours
    = 10% x 100 Hours
    = 10 equivalent hours

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