Reactive & Reserves for Energy Storage Resources

Scott Benner

Reactive

What is Reactive?

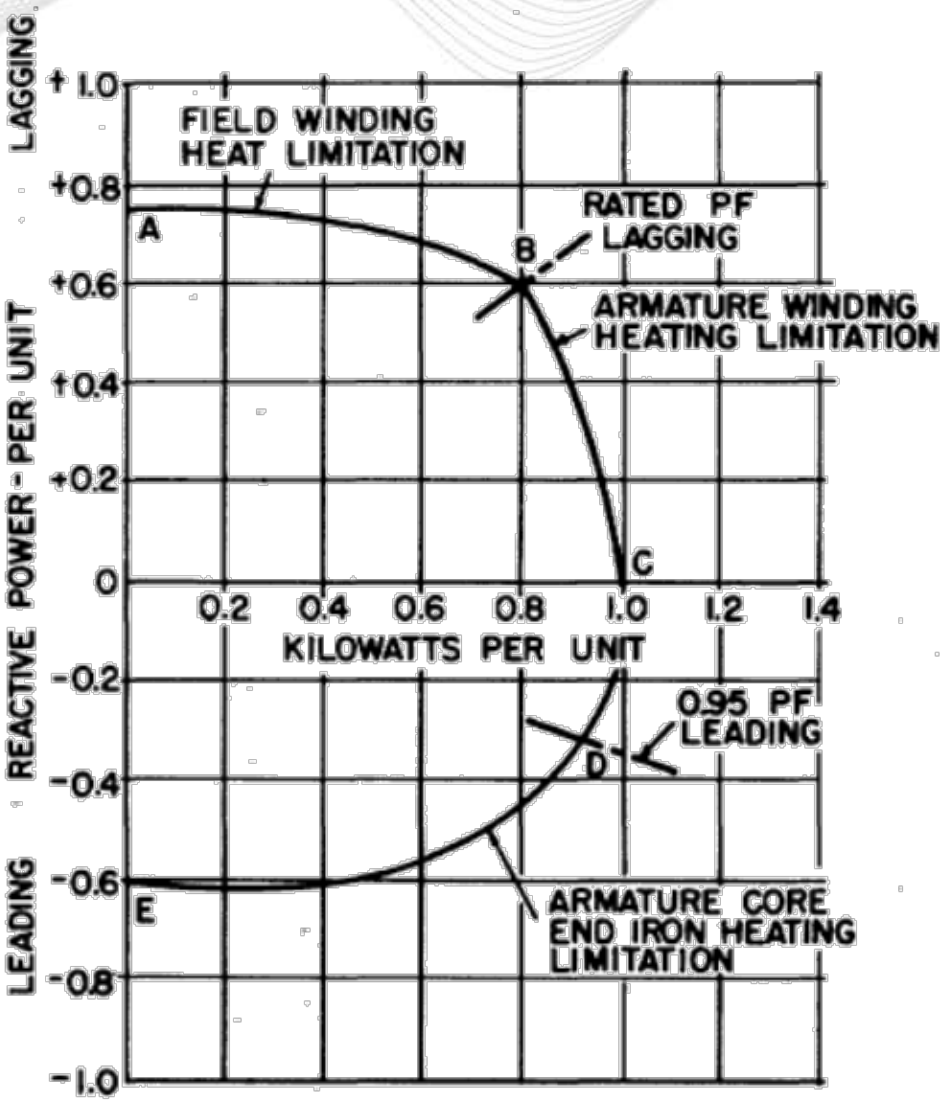
- Apparent Power (MVA) = √ Active (MW) ^{2} + Reactive (MVAr) ^{2}
- Power Factor = Active / Apparent ~= 1.0
- Voltage Schedule (Manual 3) sets bounds on GSU bus voltage

- Providing reactive energy for voltage control means adjusting the power factor by “lagging” or “leading” (pos. or neg. MVAr)
  - Motor load, transformers, lines typically consume reactive
  - Capacitors, generators typically create reactive
- *Reactive Reserve* = calculated remaining reactive capability

What is the D-Curve?

- Traditional Generators
  - Excitation of the rotor
- Batteries & DC-equipment
  - Power Converter (Inverter)

- Thermal limits create a D-shape
- Used in PJM EMS to calculate voltage, reactive reserve & alarms



Automatic Voltage Control (AVR)

- Generators required to provide up to 0.95 power factor per ISA
- Generators are expected to automatically control voltage at their point of interconnection (GSU bus)
  - Affects modelling of voltage stability
  - PJM requires AVR outage reporting in eDART (Manual 14d)
- Individual generators 20 MVA or larger, or plants 75 MVA or larger, are required to conduct reactive testing (M14d Att. E)
  - Eligible resources required to submit D-Curve to eDART

Reactive Supply

- PJM OATT Schedule 2 "Reactive Supply and Voltage Control from Generation or Other Sources Service"
  - Costs (monthly revenue requirements) are filed in **individualized rate cases** to FERC, administered by PJM
  - Allocated to network service customers (load, etc.)

- PJM Training on Reactive Supply
- **ESR: Already eligible to apply to FERC for reactive supply**

- Given the D-Curve shape, a resource may have to drastically reduce MW output to provide MVAr
- If PJM re-dispatched the resource in real-time to provide voltage support, it loses the opportunity to inject MW @ LMP @ 1.0 PF
- Traditional resources receive a make-whole
  - Operating Reserves Accounting (see Manual 28 § 5)

- **ESR: Already eligible to be made whole for reactive services**
  - **Requires energy offer, D-curve, reactive limits**

Reserves

Now it gets complicated….

Operating Reserves = Primary + Secondary

- Primary Reserves
  - Synchronized Reserves — Synchronized ≤ 10m
  - Non-Synchronized Reserves — Quick-start, ≤ 10m
- Secondary Reserves — Energized 10m ≤ 30m

And after deployment, sustain for 30 minutes

Primary Reserves

- *Contingency reserves* cover the loss of supply (generation)
  - **Synchronized Reserves** are resources synchronized to the grid
    - Online or condensing generation, curtailable demand response
    - Pumping pumped storage is not normally curtailable in 10m
  - **Non-synchronized reserves** are offline resources that can start in under 10 min

- **ESR: could be either depending on modelling**
  - **Eligible by exception**

Reserves Market & Compensation

- *SR Tier 1 Market Estimate*: Estimated response available within 10 minutes above dispatch set-point
  - Requires energy offer, be online, ramp-rate
  - SR T1 resources are not paid for estimated reserves
  - **ESR: not eligible unless by request**
- *SR Tier 2 Offer:* Self- or pool-scheduled response available within 10 minutes, as assigned by market (potential re-dispatch)
  - Requires energy offer, SR offer, online or condensing-capable
  - SR T2 resources are compensated by SRMCP + LOC + EUC
  - **ESR: eligible, but no SR offer requirement** (Manual 11 § 4.2.1)

Synchronized Reserve Event & Compensation

- Deployment of reserves is a *contingency event*
- SR Tier 2 assigned resources are required to increase output by at least the assigned MW within 10m and sustain for up to 30m
- **Anyone who responds is compensated** (Manual 28 § 6.1)
  - SR T2 resources are already compensated by SR market
  - Other resources are paid a Sync. Energy premium of $50/MWh
  - Response above the SR T2 assignment is compensated at SR T1 premium
- **ESR: Already eligible for response premium**
  - **Requires RT telemetry, response above regulation assignment**