

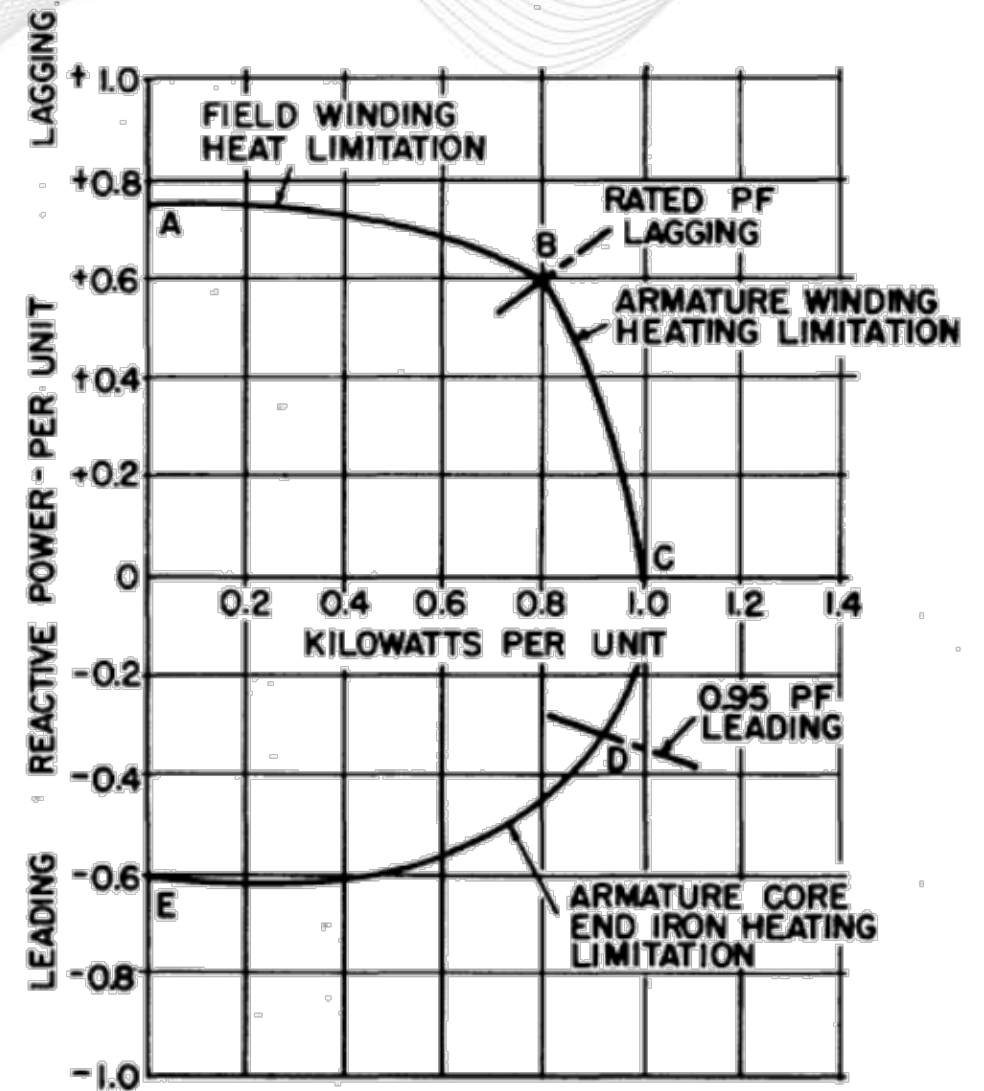
Reactive & Reserves for Energy Storage Resources

Scott Benner

Reactive

- Apparent Power (MVA) = $\sqrt{\text{Active (MW)}^2 + \text{Reactive (MVAr)}^2}$
- 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

- 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



- 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

- [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 $\leq 10\text{m}$
 - Non-Synchronized Reserves Quick-start, $\leq 10\text{m}$
- Secondary Reserves Energized $10\text{m} \leq 30\text{m}$

And after deployment, sustain for 30 minutes

- *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**

- *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](#))

- 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**