Managing Transmission Line Ratings

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PRESENTED BY
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Agenda

- What are Line Ratings?
- Static vs Dynamic Line Ratings
- Potential Benefits
- What is Missing?

What are Line Ratings?

Transfer capabilities are largely defined by two factors: the physical capacity of individual lines and network topology.*

Physical capacity of individual overhead lines:

- Primarily defined by the maximum operating temperature to:
  - Maintain minimum electrical clearances (line sagging etc).
  - Limit annealing of conductor aluminum.
  - Limit aging of connectors/hardware.
- Increased power flow warms the line (resistive heating)
- Ambient conditions also impact line temperature.

Dynamic Line Rating and Adoptive Line Ratings are technology options for enhanced and flexible application of the transfer capability of individual overhead lines.

Network Topology

- Key factor defining the distribution of power flows—i.e., how much flows on individual lines.
- Technology options include PARs, FACTS devices, and Topology Control.

* Note that the actual operating limits are more often defined by contingencies, rather than the ratings of a single line.

Static vs Dynamic Line Ratings

Today's practice is largely based on Static Line Ratings (SLR).

Maximum operating temperature for a given line is pre-determined.

- Uses conservative assumptions, such as low wind, higher temperature, high solar irradiance etc., to accommodate most conditions.
- It is similar to setting the speed limit for highways based on a snowy road conditions.

Dynamic Line Rating (DLR) adjusts this limit based on ambient conditions.

- Thermal ratings use real time measurements at the line location (along line corridor).
  - Line temperature.
  - Line sagging.
  - Ambient conditions (temperature, humidity, solar irradiance, wind, precipitation etc.).
- Accumulation of real time data can be used for future calibration.
- High wind leads to higher cooling and allows for increased flow.
  - High degree of overlap between wind production and DLR-induced allowable flow increase has been observed.
  - European studies indicate DLR contributes to approximately 15% reduction in wind curtailments.

Static vs Dynamic Line Ratings

There are commonalities between SLR and DLR…….

- Both use conservative assumptions.
- The maximum allowable temperature is likely the same.

And there are difference between SLR and DLR.

- DLR requires line specific data (real time measurements).
- SLR that applies uniform weather conditions to all lines is generally lower than DLR that applies line specific conditions.
  - DOE/ONCOR study indicates DLR to be 5 to 25% higher than SLR.
- DLR is variable and therefore requires a forecast for operations planning.

Potential Benefits

Various studies indicate significant benefit potentials at relatively low cost.

Benefits are in the *tens to hundreds of million dollars*:

- Similar range to the operational benefits of RTO-/ISO-operated regional markets.
  - PJM estimates benefits of $100 million a year for nodal vs TLR, and $100 million a year reduced needs of Grid services.
- Reduces congestion.
  - DOE/ONCOR Study estimates 10% increase in ratings could eliminate most congestion.
  - Entergy confirms an average of 10+% increase in line capacity (DLR applied primarily in off-peak periods).
  - U.S.-wide annual congestion cost is estimated to be nearly $6 billion.
- Helps with renewable integration.
  - European studies indicate DLR's contribution to reduced wind curtailment (~15%).
  - Quick implementation helps with the fast clean energy transition pace.
  - Relatively lower cost investments helps cash stranded utilities that need to invest to accommodate load growth (which could be triggered even further by electrification etc).
- Complements new investments.
  - Enhance underlying system to take full advantage of new investment potential
  - Remedy during construction (or maintenance) outages.
  - Bridge the gap until permanent solution can be achieved.
- Others (system awareness, redundancy and resiliency etc).

What is Missing?

Are the technologies by themselves understood?

- DLR (and other operational technologies) are relatively new.
  - Enabled through recent technology breakthrough in electronics, communications, computational power, etc.

Are the incentives aligned?

- Congestion costs are passed through to end-consumers.
  - Limited benefits for transmission operators/owners to adopt these technology options.
- Industry rewards maintaining reliability more than improving operational efficiency.
  - Changing operations to improve efficiency can be seen as risk taking.
- Transmission owners who earn sufficient returns on investments may prefer larger investments.
  - These technology options are actually complementary to new investments.
- Should there be a benefit-sharing mechanism?
  - UK or Australian system may provide hints.

https://www.brattle.com/news-and-knowledge/publications/improving-transmission-operation-with-advanced-technologies-a-review-of-deployment-experience-and-analysis-of-incentives

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