Utilization of Adaptive Transmission Rates in Dispatch

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Overview

• Adaptive Transmission Rates (ATR) concept
• ATR Proof-of-Concept (POC) implementation
• Some ATR results
Formulation

• Post-contingency thermal transmission constraints are based on transient Emergency Ratings of lines and transformers:

\[
\text{Post contingency flow} \leq \text{Emergency Rate}
\]

• Emergency Rate is typically a static parameter and equals to Long-Term Emergency (LTE, 4 hours) or Short-Term Emergency (STE, 15 min) rate

\[ STE \geq LTE \]

→ Which rate to use?

• Adaptive Transmission Rate (ATR) concept intends to adaptively select Emergency Ratings by accounting for the post-contingency dispatch and pre-contingency conductor loading
Transient Emergency Rate

\[ \text{Rate} = \text{Function of (Weather, Time, Load)} \]

- Cooling conditions: “Dynamic ratings”
- Post-contingency time frame for which a rate is defined
- Pre-contingency temperature (current) of conductor

ATR
Definition of Emergency Transient Rate

IEEE 738-1993 standard: “The transient thermal rating is that final current that yields the maximum allowable conductor temperature ($t_{MAX}$) in a specified time ($T$) after a step change in electrical current from some initial current ($I_0$).”

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**Rate**(time) characteristic

- **Rate**(time) is a physical characteristic and can be developed for each line by using the same methods as for calculation of **STE** and **LTE**

- Any point on a curve can be used as an Emergency rate

![Graph](image)

- Curve corresponds to DRAKE conductor, IEEE standard 738-1993

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How initial load impacts \textit{Rate}?

- The lower the initial load is, the higher is \textit{Rate} value
  \[ I^a_0 < I^b_0 \rightarrow Rate^a > Rate^b \]

- Typical assumption for pre-contingency loading of a conductor is 75\% of \textit{NORM} rate

- Real time loading often is less than 75\% and that opens an opportunity to recalculate \textit{Rate} according to actual loading of conductor
Change in *Rate(Time)* characteristic

*Rate(Time)* adjustment per pre-contingency load by standard IEEE technique

- Initial load = 40% *Norm*
- Variation of *Rate* depending on initial load
- Initial load = 75% *Norm*

Variation of *STE* rate for overhead conductor

- Pre-contingency load of a conductor, % of *Norm*
- 115 KV
- 345 KV

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How to Get ATR?

• **ATR** is obtained as the solution of the following equation

\[ \text{Rate}(\text{time}) = \text{LTE} + \text{RC}(\text{time}) \]

• Conservative reduction of **ATR** range: \[ \text{LTE} \leq \text{ATR} \leq \text{STE} \]

**Diagram:**
- Physical **Rate(time)** characteristic of a line
- Ramping Capability (RC) on a line post-contingency
- “Safe zone”: any value in this range can be safely used as an emergency rate
Ramping Capability: $RC(\text{time})$

- $RC$ is the change in MW flow in a line of interest over time as a result of economic dispatch after contingency
- Accurate calculation of $RC$ requires to model post-contingency dispatch
- Use the same dispatch procedure and input data which are used for Real-Time dispatch
- $RC$ is calculated for each critical contingency causing loading above $LTE$ on the line of interest
- For critical contingency, calculate $RC(t)$ as the MW flow change in the line of interest by SCED for different look-ahead time intervals 15, 30, 45 and 60 minutes
ATR results

• $RC$ is different for each critical contingency

• The same line can have several ATR values correlated to specific contingencies

• There is no need to enforce the most conservative ATR value for all critical contingencies as it is used in traditional dispatch
ATR benefits

• Increased utilization of power system transfer capabilities without deterioration of system reliability

• Reduction of electricity production cost. ATR allows enforcing transmission constraints in dispatch at the maximal but safe load level

<table>
<thead>
<tr>
<th>Process</th>
<th>Applicability of ATR</th>
</tr>
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<tbody>
<tr>
<td>Real Time Operation</td>
<td>Yes, most efficient</td>
</tr>
<tr>
<td>Day Ahead Market</td>
<td>Yes</td>
</tr>
<tr>
<td>Planning</td>
<td>No</td>
</tr>
</tbody>
</table>
Use of ATR in dispatch

- ATR to be used instead of Static rates in post-contingency transmission constraints
- Operator advisory mode (RT)
- Automatic (Day-Ahead)

Temperature sensitive "Dynamic rates" or Static rates

Contingency Analysis

ATR calculation

Enforced transmission constraints

Units Dispatch Software
ATR and Dynamic ratings correlation

\[ \text{Emergency Rating} = f(\text{Weather}, \text{Time}, \text{Load}) \]

- ATR and Dynamic ratings complement each other
- They could be considered independently
- The best way is to consider them simultaneously
ATR Proof-of-Concept (POC) implementation
Motivation

- Joint R&D effort between ISO-NE and Alstom Grid to improve efficiency of market and system operations
- ATR POC is a standalone application which can use real-time EMS and Market data
- Gather more experience with technology and feedback from Operators
AIMMS based project and includes two components:

- **ATR Scheduling Pricing and Dispatch (SPD)**
  - Reuse the production RT SPD code to reduce the maintenance effort (there is no duplicated efforts to port the changes in future RT SPD code)
  - Add New control flow and data processing logic for ATR

- **ATR Simultaneously Feasibility Test (SFT)**
  - An application that is developed based on the e-terraplatform Contingency Analysis application
  - Provide post-contingency topology and post-contingency Flow

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ATR POC - Data flow chart

Input data

- RTNET
- RTCA results
- RT Market case
- Static line ratings

ATR tool

Results: Recommended ATR values

Impact of initial loading on ATR is not considered in ATR POC
From RTCA results, select critical contingencies and lines for ATR estimation (overloaded above LTE post-contingency)

Loop for critical contingencies

Apply contingency and save the case as new base case

Estimate RC for lines of interest by running SPD for look-ahead time of 15, 30, 45, and 60 min

Estimate ATR for lines of interest

Display results: Line, ATR, critical contingency, Time
ATR POC - Configuration

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ATR POC - Results

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ATR values for Real-Time binding constraints
Statistics for March-June, 2011

ATR value

ATR time

Average increase in capacity over LTE is 27%
ATR values for Real-Time constraints

Statistics for March-June, 2011

Average increase in capacity over LTE is 19%
Enforcing constraints. RT case, June 2011.

- The same line is thermally overloaded by six contingencies resulting in six transmission constraints
- ATR value is individual to a specific contingency
- Each constraint can be enforced at individual ATR value

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<thead>
<tr>
<th>Contingency</th>
<th>Limit to enforce, % of LTE</th>
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<tbody>
<tr>
<td>1</td>
<td>137%</td>
</tr>
<tr>
<td>2</td>
<td>137%</td>
</tr>
<tr>
<td>3</td>
<td>137%</td>
</tr>
<tr>
<td>4</td>
<td>137%</td>
</tr>
<tr>
<td>5</td>
<td>130%</td>
</tr>
<tr>
<td>6</td>
<td>132%</td>
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What is next?

- Continue to use ATR POC to obtain more statistics and experience with the new technology
- Gain more feedback from Control Room to optimize technology
- Implementation in Production tool
Thank you

Questions