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| TVA<br><br>**TRO Standard Processes and Procedures** | **TITLE**<br>**Transmission Reliability Margin (TRM)** | **TRO-RC-SPP-10.245**<br>**Rev. 0002**<br>**Page 1 of 10**<br><br>Effective Date 01-01-2010 |

Prepared by: Nathan Schweighart

Reviewed by: ____________________ 12/22/09
FOR Nathan Schweighart, Manager, Reliability Engineering — Date

Approved by: ____________________ 12/22/09
Stuart L. Goza, Manager, Transmission System Services — Date

**Revision Log**

| Revision or Change Number | Effective Date | Affected Page Numbers | Description of Revision/Change |
|---|---|---|---|
| 0000 | 05/01/2008 | | Initial issue. |
| 0001 | 06/15/2009 | All | Corrected misstatement (or typo) in non-firm availability, added MW reduction as an option for TRM, and added statement of clarity regarding the ability of TRM to account for unexpected system conditions. |
| 0002 | 01/01/2010 | | Added the CRSG component of TRM. |

## Table of Contents

## 1.0 PURPOSE

Transmission Reliability Margin (TRM) is comprised of two components. One Component is based upon the uncertainty in the transmission system and the second component is based upon the requirements of the generation Contingency Reserve Sharing Group (CRSG) agreement. The inherent uncertainty in the assumed system conditions used to compute Available Transfer Capability (ATC) can result in unreliable transmission system operations. To ensure reliable operation of the transmission system under a broad range of system conditions, a portion of the computed ATC will be set aside as TRM. This capability will provide the operating flexibility required to ensure reliable operations and will minimize the need to curtail transmission service. TRM will also be used to deliver the power obligations as identified in the CRSG agreement.

## 2.0 SCOPE

This document describes the methodology by which the TRM values are determined.

## 3.0 PROCESS

### 3.1 Uncertainty Calculation

Because the impact of power transfers on a transmission network is not constrained to the path it is reserved on, TVA does not define TRM by transmission paths. Instead, TRM is applied against the facility ratings of network components and is measured as a percentage or MW reduction of those ratings. This allows the application of TRM on every flowgate or monitored element in TVA, instead of only being applied to the limiting elements of transfer paths. Network facility derating allows for more consistent application of TRM across different transmission paths.

The TRM will account for the following components of transmission system uncertainty:

- Aggregate load forecast error
- Load distribution error
- Forecast uncertainty in transmission system topology
- Allowances for parallel path (loop flow) impacts
- Allowances for simultaneous path interactions
- Variations in generation dispatch
- Variations in facility loadings due to balancing of generation within a Balancing Authority area
- Short-term system operator response (Operating Reserve actions not exceeding a 59-minute window

## 3.1 Uncertainty Calculation (continued)

An assessment of the impacts that the uncertainty components have on the transmission system was made in order to determine the amount of TRM that is sufficient to maintain reliable system operations.

### 3.1.1 Aggregate Load Forecast

The inability to precisely predict a future load level and the subsequent loadings experienced on transmission system elements requires a reasonable quantity of transfer capability to remain uncommitted in the form of TRM.

The effect the aggregate load forecast error has on transmission capacity is determined using PTI MUST. An increase in load is simulated and the change in capability on lines preloaded to 50 percent or greater is measured.

The existing load forecast error can be separated into time horizons. The further the horizon from present day, the more error in the load forecast. The current calculated load forecast errors are the following (ShortTerm_LoadForecastError_010208.xls, Monthly and Annual Pk Variances.xls):

Short Term Daily: 2 percent error

Monthly: 5.7 percent error

Therefore, the effect of the Aggregate Load Forecast Error on transmission line loading is the following:

| Time Period | Percent Effect on Capability |
|---|---|
| Same day and real-time | 2% error => 1% Effect |
| Day-ahead and pre-schedule | 2% error => 1% Effect |
| Beyond day-ahead and pre-schedule to 18 months | 5.7% error => 3% Effect |

### 3.1.2 Load Distribution Error

The distribution of load can vary the loading on the transmission system facilities. This is closely related to the load forecast error. Since the load distribution error is closely correlated to the load forecast error, any uncertainty that would occur because of load distribution error would already be accounted for by the load forecast error component.

### 3.1.3 Forecast Uncertainty in Transmission System Topology

A reasonable allowance for the impact of facility outages that may occur day-to-day should be accounted for in TRM. Although TVA accounts for outages in the short-term horizon, all transmission configurations cannot be analyzed. Therefore, a certain amount of uncertainty will exist because of variances in system topology. An average effect of transmission outages on line capabilities was determined using a PTI MUST study. In the study, each transmission line was outaged as a single contingency. If the post contingency loading was greater than 80 percent and the Line Outage Distribution Factor (LODF) for that contingency was greater than zero, then the effect the contingency had on that transmission line was used in the calculation. For example, if a contingency caused the loading on the Bull Run Volunteer 500-kV Transmission Line to go from 82 percent to 93 percent, then that effect was taken into account to compute the average because the post contingency loading was greater than 80 percent and the LODF is nonzero. An average effect on transmission line capability was calculated from those studied contingencies. Based on the study, the average is 2.8 percent (AverageEffectofTranOutage_010208.xls).

Based on the study, a 3 percent uncertainty factor would sufficiently account for the forecast uncertainty in transmission system topology.

### 3.1.4 Allowances for Parallel Path (Loop Flow) Impacts

All network elements are subject to parallel path flows. These parallel path flows are the result of transmission service transactions that are not explicitly scheduled on the transmission system of TVA's Transmission Provider. Since these transfers are not scheduled on TVA's system, TVA cannot account for the impact of these third-party transactions. A reasonable quantity of uncommitted transmission capacity such as TRM will ensure that the reliability of the Interconnection is preserved when loop flows occur.

A study of loop flows on TVA's transmission system revealed that on average TVA historically observes loop flows of approximately 850 MW. In order to determine the effect these loop flows have on transmission line loading, a North to South and West to East transfers were modeled across TVA.

This study determined that the average change in line capability due to loop flows across TVA is 1.5 percent (LoopFlowEffect_010208.xls).

### 3.1.5 Allowances for Simultaneous Path Interactions

In the short-term horizon, TVA uses an Available Flowgate Capability (AFC) process in which transactions are accounted for using a flow based method. Each impact from a prior request is subtracted from the Total Flowgate Capacity (TFC) on each affected flowgate. Because of this, there is no need to account for simultaneous path interactions during the short-term planning horizon. Therefore, TVA does not include any amount of uncertainty for the simultaneous path interactions for its TRM calculations in the short-term horizon.

### 3.1.6 Variations in Generation Dispatch

The impact of variations in generation dispatch on transmission line capability depends mostly on the proximity of the lines to the generators being dispatched. A transmission line in close proximity to a generator may have very small loading when the generator is not being dispatched and a large loading when it is being dispatched. Therefore, the net change in transmission line capacity is large. But in the context of transfer capabilities, it is only necessary to determine the effect of variations in generation dispatch on lines that could be limiting elements to the transfer. Accounting for the change in transmission line capacity for lines that are pre-loaded to 50 percent (excluding Generator Step-Up transformers) will determine the effect of variations in generation dispatch on lines that are more likely limits to the transfer. This will also help exclude lines that are close to offline generation in the case. The inclusion of these lines would exaggerate the results because of the large changes in line loading when the offline generation is dispatched.

For this study, two different dispatches were created. One is a normal spring case and the other is a drought condition spring case with low hydro generation. The study determined that the average change in transmission capability for the lines pre-loaded above 50 percent for two significantly different dispatches on the TVA transmission system is 3.0 percent (DispatchEffect.xls).

### 3.1.7 Variations in Facility Loadings Due to Balancing of Generation within a Balancing Authority Area

System load is a dynamic quantity. Generation increases and decreases in response to these load variations. The variation in generation and load levels can inject uncertainty in the transmission network. TVA's TRM methodology takes into account errors in generation dispatch and load forecasting. Since TVA includes these errors in the TRM calculation, any uncertainty caused by loadings due to the balancing of generation and load are already captured.

### 3.1.8 Short-Term System Operator Response (Operating Reserve Actions Not Exceeding a 59-Minute Window)

In compliance with NERC Standard EOP-001-0, TVA has bilateral agreements in place with neighboring utilities for short-term energy emergency assistance. Under these agreements, either party may declare an energy emergency. When this occurs, the opposite party shall provide emergency assistance to the extent possible without jeopardizing its own power system stability or power supply obligations. An energy emergency, as described in these agreements, is a temporary condition in which a load serving entity is unable or in imminent danger of not being able to meet its firm load commitments. More information on these agreements can be found in the SPP ESO-BA-SOP-10.314.

In order to maintain transmission capability to meet these emergency energy obligations, a study is done to determine the maximum effect of a generator unit outage on TVA's transmission system. This type of study is known as a generation inrush study.

Studies show that the average effect of generation inrush on TVA-owned flowgates is 2 percent. (Average Gen GSF.xls)

### 3.2 Uncertainty Component Values

| **Current TRM** | **Percent Capacity Effect** |
|---|---|
| **Same day and real-time** | |
| Aggregate load forecast error impact | 1.0 |
| Forecast uncertainty in topology | 3.0 |
| Loop flow impact | 1.5 |
| Variations in Generation Dispatch | 3.0 |
| Operator Response | 2.0 |
| **TRM Needed** | **3%** |
| | |
| **Day-ahead and pre-schedule** | |
| Aggregate load forecast error impact | 1.0 |
| Forecast uncertainty in topology | 3.0 |
| Loop flow impact | 1.5 |
| Variations in Generation Dispatch | 3.0 |
| Operator Response | 2.0 |
| **TRM Needed** | **3%** |
| | |
| **Beyond day-ahead and pre-schedule to 18 months** | |
| Aggregate load forecast error impact | 3.0 |
| Forecast uncertainty in topology | 3.0 |
| Loop flow impact | 1.5 |
| Variations in Generation Dispatch | 3.0 |
| Operator Response | 2.0 |
| **TRM Needed** | **3%** |

Each TVA-owned flowgate in the AFC process will have the TRM applied to it, based on the largest component of uncertainty during that time horizon for the flowgate. The above uncertainties are used as the default for all applicable flowgates. For example, in same day and real-time, 3 percent is the largest TRM requirement from the TRM components of uncertainty; therefore, 3 percent is used for that horizon. If it becomes known for a specific flowgate that a certain component of uncertainty has become greater for a specific time period, the TRM for that flowgate can be reevaluated and applied to the flowgate. For example, if the loop flow impact on a certain flowgate becomes much larger than previously expected for a certain flowgate, the TRM on that flowgate can be changed to reflect the new uncertainty component expectation.

### 3.3 Reserve Sharing Component Values

The reserve sharing component values are determined within the CRSG deliverability study. These numbers are based upon the system conditions such as load forecast and largest installed generation and therefore can change during the year.

#### 3.3.1 Converting the Reserve Sharing Component of TRM to a Flowgate TRM Amount

The reserve sharing component of the TRM is set as a path-based amount. In order to account for the TRM in our AFC process, it is required to convert the TRM to a flowgate based number. This conversion will be conducted every time after the reserve sharing TRM amounts are recalculated. The reserve sharing component of TRM will also have to be calculated for any flowgate added to the transfer capability calculation process. The equation to convert a path-based TRM number to a flowgate TRM number is the following:

### 3.3.1 Converting the Reserve Sharing Component of TRM to a Flowgate TRM Amount (continued)

$$TRM_{flowgate} = TDF_{path} \times TRM_{path}$$

### 3.3.2 Converting the TRM Set Aside on a Flowgat on an Amount Set Aside on a Path

TRM is presently applied against the facility ratings of network components and is measured as percentage or MW reduction of those ratings. In order to post the amount of TRM on specific paths, the margin must be converted to a path number. This is done using the following equation.

$$TRM_{path} = \frac{TRM_{flowgate}}{TDF_{path}}$$

Since the TDF for that path on that flowgate will change, the TRM for the path will also change as the model topology and generation dispatch changes.

### 3.4 Availability of TRM to the Market on a Non-Firm Basis

TVA does not make TRM available on a non-firm basis. This is due to the uncertainty still present in the non-firm transfer capability calculations.

## 4.0 ROLES AND RESPONSIBILITIES

Reliability Engineering

Reliability Engineering is responsible for evaluating and determining the quantity of the TRM uncertainty components. Reliability Engineering will recalculate TRM values as changing conditions warrant and will review the values every quarter.

Transmission Provider

Transmission Providers are responsible for applying the TRM values provided when calculating AFC and ATC.

## 5.0 RECORDS

### 5.1 QA Records

None

### 5.2 Non-QA Records

None

## 6.0 DEFINITIONS

**AFC - Available Flowgate Capability** - The flow capability remaining on a flowgate for further commercial activity over and above already committed uses.

**ATC - Available Transfer Capability** - The measure of the transfer capability remaining in the physical transmission network for further commercial activity above already committed uses.

**LODF - Line Outage Distribution Factor** - The percent of pre-outage flow on a contingent element that will flow on a monitored element post-outage.

**TFC - Total Flowgate Capability** - The facility rating of a flowgate.

**TRM - Transmission Reliability Margin** - The amount of transfer capability on the transmission system necessary to provide a reasonable level of assurance that the interconnected transmission network will be secure under a broad range of uncertainties in system conditions.

**CRSG - Generation Contingency Reserve Sharing Group** - A group whose members consist of two or more Balancing Authorities that collectively maintain, allocate, and supply operating reserves required for each Balancing Authority's use in recovering from contingencies within the group.