

Integrated Risk Assessment Approach – Refinement to Severity Risk Index

With the OC/PC approval of a risk assessment framework and concepts whitepaper¹ at the September 2010 meeting, RMWG applied the concepts and conducted sensitivity analyses to evaluate the impact of specific variables and coefficients on calculating a severity risk index. This helped establish importance of each variable in calculating the blended metric.

In the concepts document, the value of the severity is calculated based on impact of risk-significant events and the relative weightings, as shown below:

$$SRI_{\text{event}} = w_L * (MW_L) + w_T * (N_T) + w_G * (N_G) + w_D * (H_D) + w_E * (N_E) \quad (1)$$

Where:

SRI_{event}	=	severity risk index for specified event,
w_L	=	weighting of load loss,
MW_L	=	normalized MW of Load Loss in percent,
w_T	=	weighting of transmission lines lost,
N_T	=	normalized number of transmission lines lost in percent,
w_G	=	weighting of generators lost,
N_G	=	normalized number of generators lost in percent,
w_D	=	weighting of duration of event,
H_D	=	normalized duration of the event in percent,
w_E	=	weighting of equipment damage, and
N_E	=	normalized number of equipment damaged in percent

The RMWG recommends focusing transmission, generation and load losses (N_T , N_G , and MW_L) to develop severity risk curves initially; it enhanced load loss as a method of incorporating consequential damage, with the expectation that damaged equipment would impact the promptness of restoration. The following risk factors identified in the concepts document will be reviewed and updated periodically as a part of ongoing open improvement process.

¹[http://www.nerc.com/docs/pc/rmwg/Integrated Bulk Power System Risk Assessment Concepts Final.pdf](http://www.nerc.com/docs/pc/rmwg/Integrated_Bulk_Power_System_Risk_Assessment_Concepts_Final.pdf)

1. Equipment damage (N_E) – Due to infrequent occurrences, this factor will be considered later once more data becomes available.
2. Duration of transmission loss and generation loss – The duration of transmission facility loss and generation facility loss will be considered in the future since their reliability impact is relatively small compared with the facility loss itself.

However the RMWG believes the duration of load loss should be included in the Severity Risk Index (SRI) since it directly impacts end-user customers and may act as an indicator of consequential damage.

Therefore the refined SRI equation is

$$SRI_{event} = (RPL) * w_L * (MW_L) + w_T * (N_T) + w_G * (N_G) \quad (2)$$

Where:

SRI_{event}	=	severity risk index for specified event (assumed to span one day),
w_L	=	60%, weighting of load loss,
MW_L	=	normalized MW of Load Loss in percent,
w_T	=	30%, weighting of transmission lines lost,
N_T	=	normalized number of transmission lines lost in percent,
w_G	=	10%, weighting of generators lost,
N_G	=	normalized number of generators lost in percent,
RPL	=	load Restoration Promptness Level: $RPL = 1/3$, if restoration < 4 hours, $RPL = 2/2$, if $4 \leq$ restoration < 12 hours, $RPL = 3/3$, if restoration \geq 12 hours

The value of SRI_{event} will range from 0 to 1. The loss of load due to transmission-related events is weighted the highest (60%) since it directly indicates an inability to deliver load to delivery points per ALR.6.² The transmission outages are ranked second (30%), which reveals inability to meet ALR.1, ALR.2 and ALR.3 characteristics. Generation outages are placed third (10%) because the generation outages have less impact to the grid since operating reserves are allocated to preserve load and generation balance.

The normalized MW of Load Loss in percent, MW_L , is equal to the total MW loss divided by coincident daily peak load. The daily peak load is aggregated at NERC, interconnection or regional level.

² <http://www.nerc.com/docs/pc/Definition-of-ALR-approved-at-Dec-07-OC-PC-mtgs.pdf>.

The normalized number of transmission lines lost in percent, N_T , is equal to the number of AC transmission lines lost weighted by their average line MVA ratings, and the total of number of AC circuits at each voltage class obtained from TADS inventory report. The following average line MVA ratings are used to measure different impact in terms of voltage classes:

- 230 kV → 700 MVA
- 345 kV → 1,300 MVA
- 500 kV → 2,000 MVA
- 765 kV → 3,000 MVA

For example, if an event in the Eastern Interconnection resulted in the loss of 100 AC lines rated at 230 kV, 40 lines at 345 kV, 10 lines at 500 kV, and 3 lines at 765 kV, for this event:

$$N_T = (100*700 + 40*1,300 + 10*2,000 + 3*3,000) \text{ divided by } (2,708*700 + 1,078*1,300 + 344*2,000 + 33*3,000) = 151,000/4,084,000 = 0.03697$$

Where 2,708 is the total number of AC circuits at 230 kV in the Eastern Interconnection, 1,078 at 345 kV, and 344 at 500 kV and 33 at 765 kV.

The normalized number of generators lost in percent, N_G , is equal to the total MW loss divided by the total MW capacity reported in ESD (NERC's *Electricity Supply and Demand* database).

RMWG also recommended using the Six Sigma³ method as a screening tool for extreme events and the rolling average for smooth out short-term fluctuations and highlight longer-term trends. RMWG further recommends that Six Sigma screens and extreme weather events not be removed from the data set but identified and reviewed on a long term basis to establish broader historical trends.

There is no extreme significant event found from the 2008 and 2009 data using the Six Sigma method. Figure 1 provides the 2008/2009 NERC SRI curves based on the refined equation (2). Figure 2 includes historic benchmark events using the same refined SRI formula. The daily 2008 and 2009 generation and AC transmission line outages were obtained from GADS and TADS. The load loss and duration data were gathered from EOP-004 and OE-417 reports. For presentation purposes as shown in Figure 1 and 2, the SRI values were multiplied by 1,000 and called SRI_{index} , or the indexed SRI score's equation is

$$SRI_{index} = 1,000*SRI_{event} \quad (3)$$

³ The Six Sigma method is a screening tool and uses a set of statistical methods to identify the extreme events and minimize variability.

Figure 1 – NERC Severity Risk Index Curves by Year

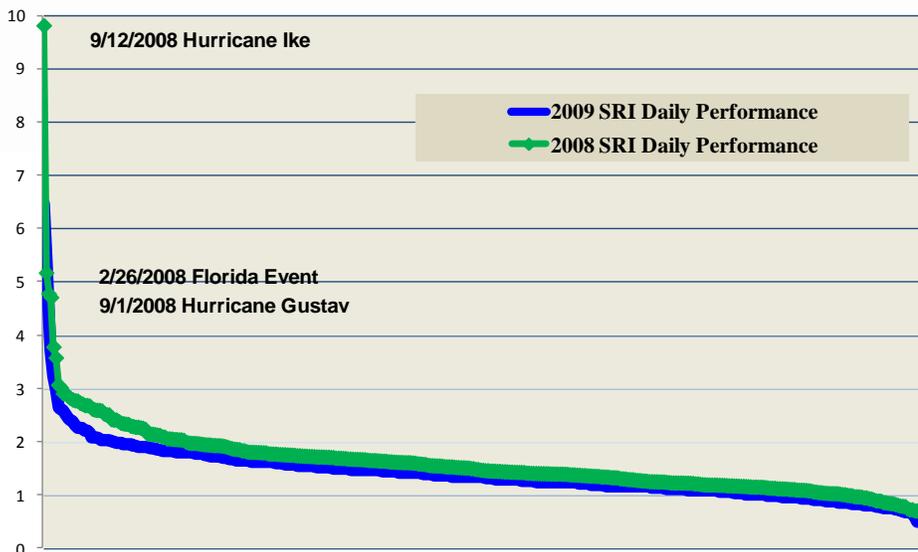
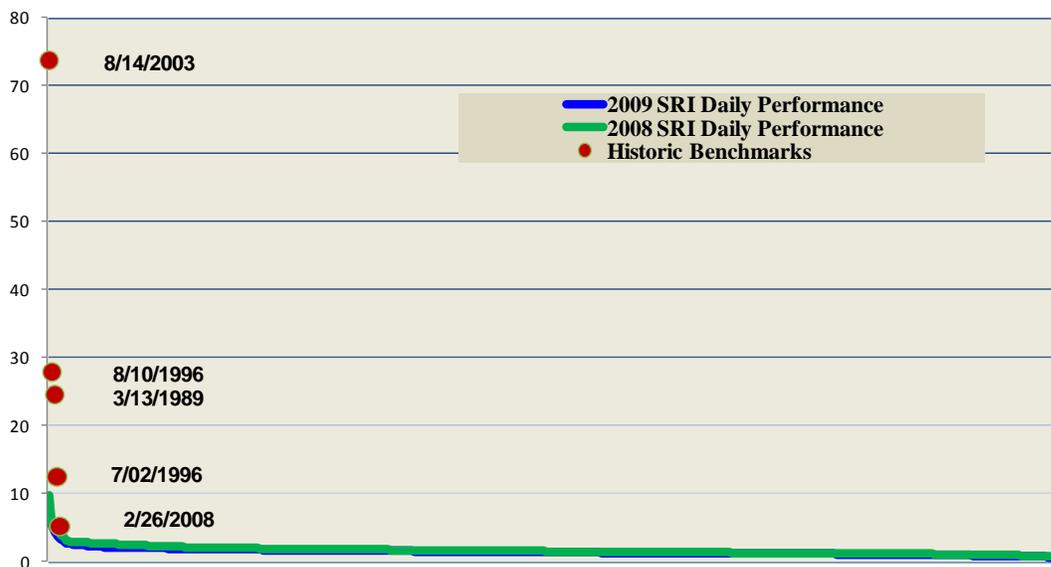


Figure 2 – NERC 2008 and 2009 Severity Risk Index versus Benchmark Days



The RMWG has adopted the open metric development process. By applying industry expertise and technical judgment, RMWG will embrace continuous improvement, conduct periodic review and model update on applicability and deliverability of the severity risk index calculation. Other factors that impact severity of a particular event to be considered in the future, include whether equipment operated as designed and resulted in loss of load from a reliability perspective (intentional and controlled load-shedding); further RMWG will explore developing mechanisms for enabling ongoing refinement to include the historic and simulated events for future severity risk calculations.