Targeted 765kV ITC-AEP Project - LOLE Study Report

Objective
As part of the "ITC-AEP 765kV Targeted Study", system reliability enhancements were evaluated using Loss of Load Expectation (LOLE) for planning years of 2016 and 2021.

Background
LOLE is the measure of an area's inability to meet it's load given the probability of random generation forced outages and limited tie line support from neighboring systems. A less than 1 day in 10 years (or 0.1d/yr) LOLE target is often the criteria in which areas or zones are evaluated.

Input Data & Software Model
The LOLE model was constructed form the same PROMOD PowerBase dataset that was used for the production cost simulations of the ITC-AEP 765kV project. The data used in the LOLE analysis is a smaller subset of the data used in the PROMOD analysis, which includes:

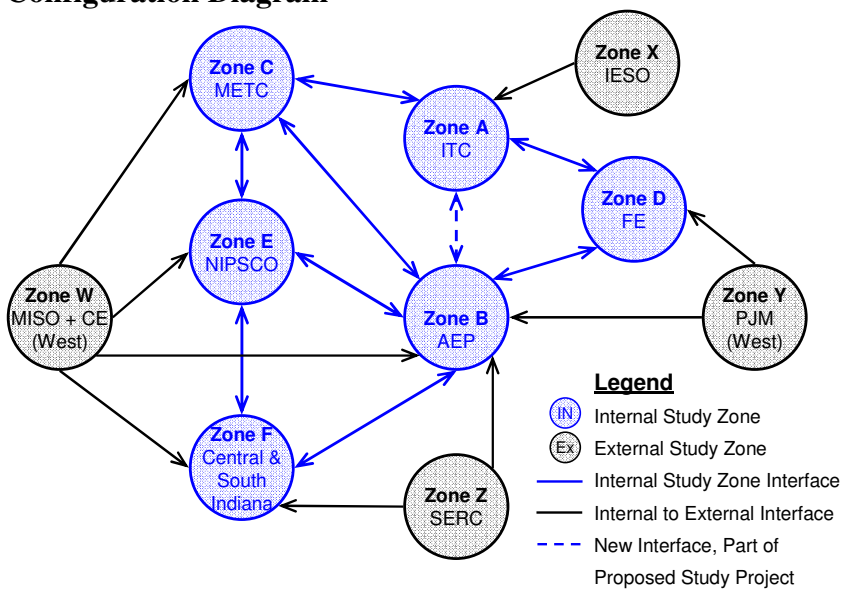
- Load Data
    - Peak and Hourly Load Profiles
    - Interruptible Load Values
- Generator Unit Data
    - Output Capacities
    - Forced Outage Rates
    - In-Service & Out-of-Service Dates
    - Planned Maintenance Data
- Does NOT include:
    - Production Cost
    - Emissions Data

The LOLE software program MARS was used to assess the reliability enhancements of this targeted project. MARS is a Multi-Area Reliability Simulation Program from the General Electric Company which utilizes a sequential Monte Carlo simulation to calculate indices.

Zones & Study System
LOLE models like MARS operate with an equalized transportation style model as oppose to using a fully detailed transmission model. Therefore a collection of zones and interfaces are used to capture the capabilities and limitations of the transmission system.

For this analysis the zones which were evaluated and LOLE's calculated consisted of the electrical area systems surrounding the purposed transmission project. The following diagram shows system configuration for this LOLE study.

Study System Configuration Diagram



Zone Summary & Isolated LOLE Values

For the study years of 2016 and 2021 each zones was initially evaluated on a stand-alone island basis, where each zone was isolated from the other study zones it would otherwise normally be interconnected to. The stand-alone zone evaluation included calculating the isolated LOLE values for each study zone and then determining what internal zonal capacity adjustments would bring the isolated zone to the 1 day in 10 years target LOLE criteria. Zones with higher than the targeted criteria LOLE would require positive capacity adjustments to reach the target and likewise zones with lower LOLE could lose capacity before hitting the criteria. The following table shows the results of the isolated LOLE evaluation as well as data summaries for each zone.

Study Year: 2016		Zone Data Summary				Isolated (Stand-Alone)	
Zone	Name	Peak Load Month	Peak Load (MW)	Interruptible Load (MW)	Capacity at Time of Peak (MW)	LOLE (days/yr)	0.1 days/year Adjusted Capacity
Zone-A	ITC	July	13,124	489	13,239	5.411	2,567
Zone-B	AEP	July	33,304	729	39,729	0.073	-244
Zone-C	METC	July	11,622	265	15,927	0.003	-1,585
Zone-D	FE	August	14,573	71	14,821	8.878	2,688
Zone-E	NIPSCO	July	3,932	292	3,697	27.700	1,275
Zone-F	CENT&SOUTH-IN	July	21,587	731	22,102	8.241	3,042

Study Year: 2021		Zone Data Summary				Isolated (Stand-Alone)	
Zone	Name	Peak Load Month	Peak Load (MW)	Interruptible Load (MW)	Capacity at Time of Peak (MW)	LOLE (days/yr)	0.1 days/year Adjusted Capacity
Zone-A	ITC	July	13,608	529	13,239	8.746	3,075
Zone-B	AEP	July	35,996	729	41,089	0.505	1,480
Zone-C	METC	July	12,324	305	16,504	0.005	-1,428
Zone-D	FE	August	14,955	111	15,974	3.468	1,924
Zone-E	NIPSCO	July	4,161	312	3,697	46.061	1,492
Zone-F	CENT&SOUTH-IN	July	23,006	867	23,828	5.194	2,860

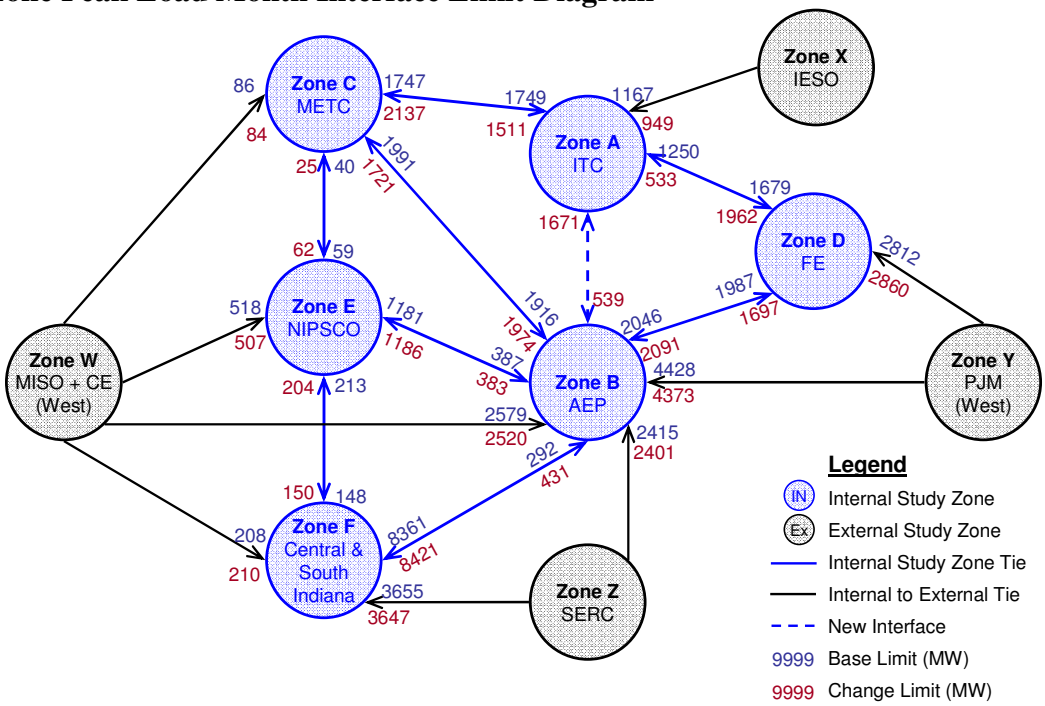
Interface Limits & Interconnected LOLE Analysis

To evaluate the purposed project an interconnected LOLE analysis was performed. The LOLE reliability improvements of the project are realized through changes in interface limits between models with and without the purposed project in them.

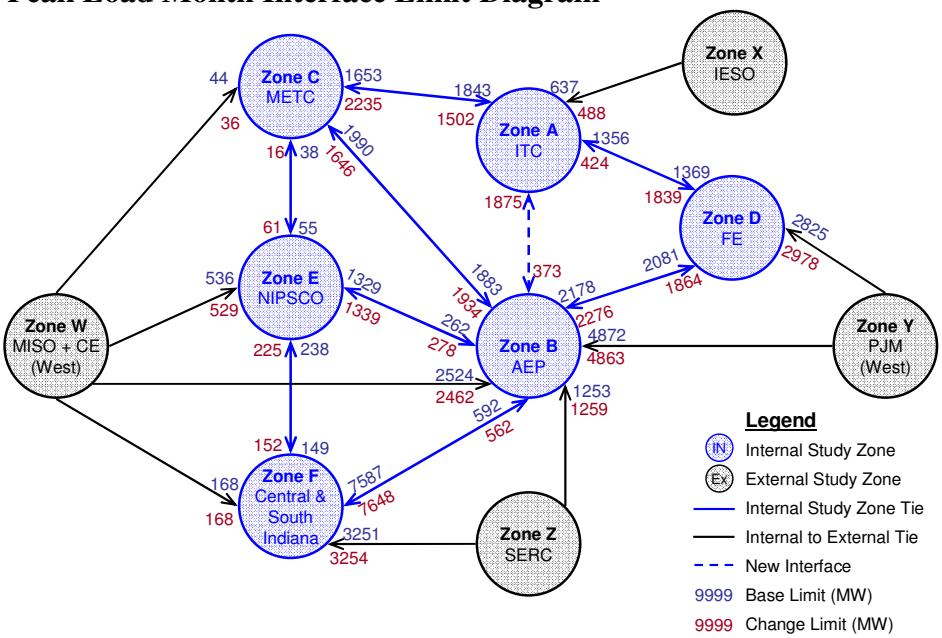
Using PROMOD, zone to zone interface limits where calculated using individual simulations for each internal study zone, with and without the purposed project and for each study year (2016 & 2021). The interface limits where calculated by increasing penalty factors that are assigned to the zone's generators whose import capability was being evaluated. In each simulation the transmission ties between the study zones were monitored and grouped to form interfaces whose hourly flow was recorded.

Since MARS utilizes monthly interface limits between zones the 8760 hourly interface flow values from PROMOD were condensed to 365 daily flow values which occurred at the time of the zone's peak load hour. These values were then averaged over the months they occurred and used in the MARS model. The following two diagrams show what the monthly interface limits were at time of zone's peak load month for each study year and what they were without (base) and with (change) the project. (Note: the peak load month for all internal zones is July expect for Zone D which is August)

<u>2016</u> Zone Peak Load Month Interface Limit Diagram



2021 Zone Peak Load Month Interface Limit Diagram



Interconnected LOLE Analysis Results

The next two tables show the study results from the interconnected LOLE analysis with and without the proposed project interface limits for both of the 2016 and 2021 study years. This also includes LOLE values without utilizing interruptible load.

Study Year: 2016		Base Case (no project)		Change Case (with project)	
Zone	Name	LOLE (days/yr)	LOLE(1) (days/yr)	LOLE (days/yr)	LOLE(1) (days/yr)
Zone-A	ITC	0.024	0.067	0.010	0.029
Zone-B	AEP	0.000	0.001	0.000	0.001
Zone-C	METC	0.000	0.000	0.000	0.000
Zone-D	FE	0.000	0.002	0.000	0.002
Zone-E	NIPSCO	0.003	0.019	0.003	0.020
Zone-F	CENT&SOUTH-IN	0.000	0.003	0.000	0.002
(1)Without utilizing Interruptible Load					

Study Year: 2021		Base Case (no project)		Change Case (with project)	
Zone	Name	LOLE (days/yr)	LOLE(1) (days/yr)	LOLE (days/yr)	LOLE(1) (days/yr)
Zone-A	ITC	0.062	0.179	0.020	0.068
Zone-B	AEP	0.001	0.006	0.001	0.006
Zone-C	METC	0.000	0.001	0.000	0.001
Zone-D	FE	0.002	0.011	0.002	0.011
Zone-E	NIPSCO	0.003	0.032	0.003	0.033
Zone-F	CENT&SOUTH-IN	0.002	0.011	0.002	0.011
(1)Without utilizing Interruptible Load					

ITC & METC Deferred Installed Capacity

With the purposed transmission project the Michigan ITC and METC zone may realize potential deferred installed capacity requirements to maintain a less than 1 day and 10 years loss of load criteria. To evaluate this potential the ITC and METC zones were driven to the 0.1 days/year LOLE with the resulting capacity adjustments differences measured between the results with and without the project in for both study years. The following table shows the results for potentially deferred capacity for the study years of 2016 and 2021.

Measured Potential for Deferred Installed Capacity			
Zone	**Name**	**2016**	**2021**
Zone-A	ITC	287	397
Zone-C	METC	80	190
Total	**Michigan**	**367 MW**	**587 MW**

Summary of Targeted 765kV ITC-AEP Project LOLE Study Findings

With the purposed ITC–AEP 765kV transmission project there are reliability improvements in the form of reduced Loss of Load Expectation (LOLE) for the study years of 2016 and 2021. There is also the potential for deferred installed capacity required to maintain a less than 1 day in 10 years loss of load expectation.