Southwest Power Pool

DISIS PROCESS OVERVIEW

DISIS DEFINITION

- **Definitive Interconnection System Impact Study (DISIS)** – engineering study that evaluates the impact of the proposed interconnection on the safety and reliability of the Transmission System and, if applicable, an Affected System. The study shall identify and detail the system impacts that would result if the Generating Facility were interconnected without project modifications or system modifications, or that may be caused by the withdrawal or addition of an Interconnection Request, or to study potential impacts, including but not limited to those identified in the Scoping Meeting as described in the Generator Interconnection Procedures.

SECTIONS

- Pre-Study
- Study Overview
- Powerflow Models and Assumptions
- Stability and Short Circuit Models
- Scope of Analysis
- Deliverables
- Appendix

PRE-STUDY

APPLICATION REQUIREMENTS

GI Study Agreement Appendix 3

Completed Attachments A, B, C

Cash Study Deposit

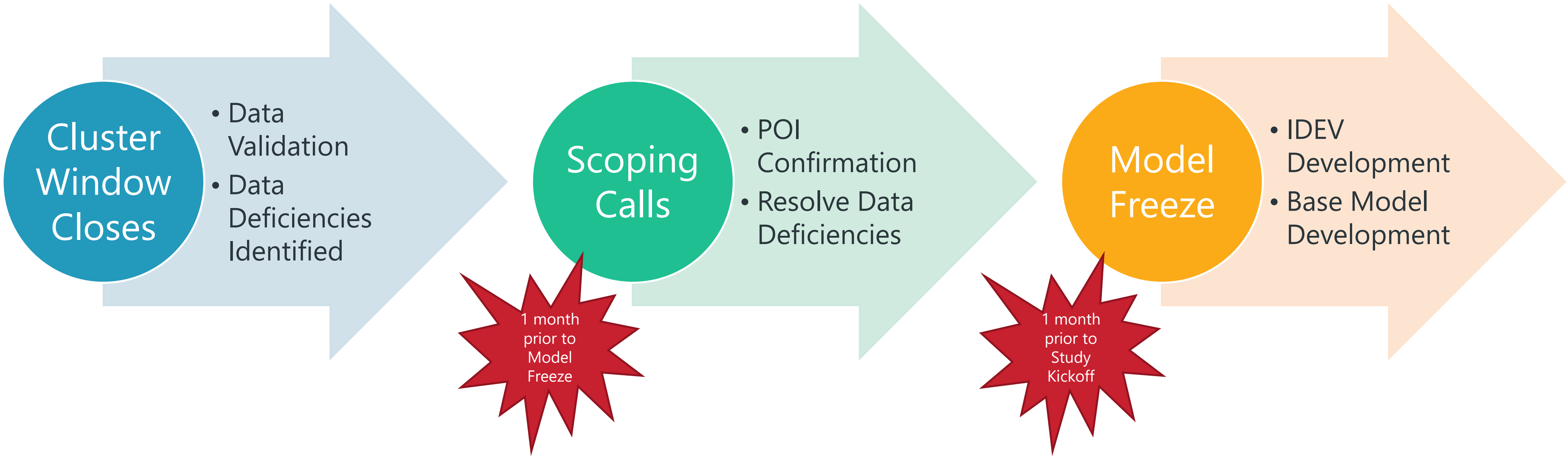
Cash, Letter of Credit, or Surety Bond Securities

Site Control

APPLICATION GUIDELINES

- Reference SPP Tariff Attachment V, Generator Interconnection Procedure, Section 8 for full requirements.
- Eleven month open window followed by one month review period.
- Upon receipt and validation of all requirements per Section 8.2 of the GIP, SPP will notify customer of the GI study queue number and assignment to the DISIS queue cluster.

PRE-STUDY TIMELINE



STUDY OVERVIEW

DISIS 3-PHASE STUDY PROCESS OVERVIEW

1. **DISIS 3-Phase Study Kickoff**
2. **Phase 1: Powerflow Analysis** (60 calendar days)
3. **Approve and Post P1 Report**
4. **Decision Point 1** (15 business days)
5. **Phase 2: Powerflow and Stability Analyses** (120 calendar days)
6. **Approve and Post P2 Reports**
7. **Decision Point 2** (15 business days)
8. **Facilities Study** (15 day cure + 45 calendar days)
9. **Next DISIS Study Queue**

THE DEFINITIVE INTERCONNECTION SYSTEM IMPACT STUDY (DISIS)

DISIS Phase One will consist of:

- **Powerflow analysis and calculation of the short-circuit ratio.**

DISIS Phase Two will consist of:

- **Powerflow analysis (modeling, constraints, and solutions)**, taking into account the impact on the powerflow analysis of any requests withdrawn after the DISIS Phase One.
- **Short circuit analysis, stability analysis and Short Circuit Ratio Critical Clearing Time (SCRCCT) screening**

DISIS Facilities Study will consist of:

- **Facilities Study** to specify and estimate the cost of the equipment, engineering, procurement and construction work needed to implement the conclusions of the DISIS and electrically connect the Generating Facility to the Transmission System

DECISION POINT REQUIREMENTS

Decision Point 1 after Phase 1

- Completed election form
- Section 4.4.1 permitted changes
- Continued site control of generating facility
- Continued site control of 50% of gen tie line or financial security in lieu of site control
- Financial Security Two

Decision Point 2 after Phase 2

- Completed election form
- Section 4.4.1 permitted changes
- Continued site control of generating facility
- Continued site control of 75% of gen tie line or financial security in lieu of site control
- Site control of 100% of any new substations required at POI
- Development milestone
- Financial Security Three

MODIFICATION TYPES

POI Changes

- After a request's application is submitted, customer-requested POI changes are considered a Material Modification. If a POI is deemed infeasible by the respective TO, SPP may identify an alternate POI; in the case SPP identifies an alternate POI, the customer shall update the application to the alternate POI or will be deemed an invalid request.

Decision Point Changes

- Customer-requested changes explicitly allowed during DP1 in Attachment V Section 4.4.1 will be applied in the request's DISIS Phase 2.
- Customer-requested changes explicitly allowed during DP2 in Attachment V Section 4.4.1 will be applied in the request's DISIS restudies.

Post-GIA Changes

- Once the request's GIA is effective and before any portion of the request is in commercial operation, the Modification Request Impact Study section of the GI Manual should be referenced.

POWERFLOW MODELS & ASSUMPTIONS

POWERFLOW MODEL ASSUMPTIONS

Base Models

- The SPP Integrated Transmission Plan (ITP) powerflow models serve as the starting point for all interconnection studies requiring steady-state powerflow analysis. These models include:
  - AG1 models (Example: 2022)
    - Year 2 Summer Peak (Example: 24SP)
    - Year 5 Summer Peak (Example: 27SP)
    - Year 5 Winter Peak (Example: 27WP)
    - Year 5 Light Load (Example: 27L)

Base Genlist

- Genlist from previous cluster

MODEL ASSUMPTIONS

Higher-Queued Projects

- Previous cluster withdrawals removed
- Previous cluster upgrades included
- Upgrades which were 100% allocated to withdrawn requests removed

Affected Systems (Reference Relative Queue Priority)

- No AFS requests included in Phase 1
- Remove unnecessary upgrades from previous studies
- Remove previous study AFS withdrawals

PHASE 1 SIMPLIFIED MODELS

Assumptions

- Gen-tie less than 20 miles modeled as:

Gen-tie Rate A	Gen-tie Rate B	Gen-tie Lead Length	Gen-tie Resistance	Gen-tie Inductive Reactance	Gen-tie Capacitive Reactance	Gen-tie Units
0	0	0.5	0	0.0001	0	Ohms/PU

- Gen-tie length greater than 20 miles modeled at actual length
- Reactive devices are not included
- Pmax for DISIS requests in powerflow are modeled at requested service amount.
  - Hybrid requests are modeled at full capacity and dispatched per hybrid dispatch table in the DISIS Manual (section 4.2.1.1.1).
- Collector system is modeled at zero impedance for powerflow.

BASE CASE UPGRADES

Upgrades with an Approved Notification to Construct (NTC)

Base case upgrades that are part of the current SPP Transmission Expansion Plan that have an approved NTC are added to the base case models

Upgrades that are In Construction

Base case upgrades in construction stages are assumed to be in service and are added to the models if they are not already included in the model

POTENTIAL UPGRADES

Potential Upgrades without a Notification to Construct (NTC)

- Any potential upgrades that do not have a NTC and are not explicitly listed within the report will not be included in the base case

Prior-Queued Interconnection Requests and their Associated Upgrades

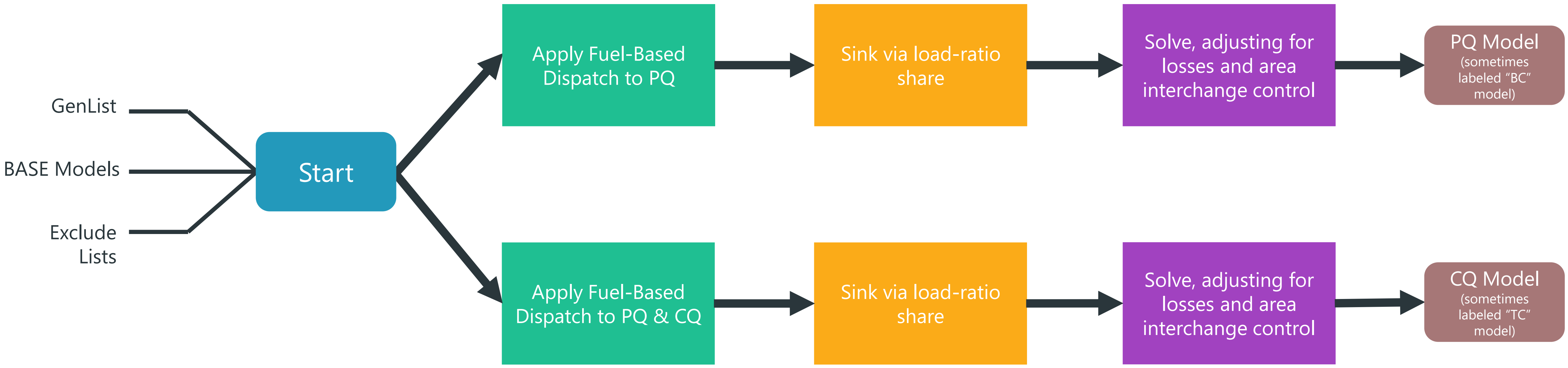
- Prior-queued interconnection requests and their associated upgrades are added to the base case models

CONTINGENT UPGRADES

Contingent upgrades are not yet in-service

- These are facilities that have been assigned to higher-queued interconnection customers
  - They <u>are included in the models</u> for the study and are <u>assumed to be in service</u>
  - This list may not be all-inclusive such as ITP or Transmission Service upgrades.
  - If a current-queue request is determined to need a contingent upgrade as a solution, the contingent upgrade would be assigned to the request in the report but would have zero cost allocation (at this time); however, costs may later be assigned to current-queue DISIS interconnection customers if higher-queued customers terminate their generator interconnection agreement or withdraw from the interconnection queue.

POWERFLOW MODEL DEVELOPMENT PROCESS



MODEL REVIEW

ACTION REQUIRED

Customers are responsible for reviewing the draft models for their project to determine if there are any modeling errors. Errors identified after the model review/comment period will not be incorporated during the current analysis phase. The following should be reviewed for accuracy:

1. Point of Interconnection (POI)
2. Gen-tie line
3. Main Power Transformer (MPT)
4. Generator Step-Up (GSU) Transformer
5. Generator
6. Connection Voltage
7. ERIS/NRIS MW Service
8. GenList

STABILITY AND SHORT CIRCUIT MODELS

DYNAMIC STABILITY MODEL SET

Base Models

- The SPP Model Development Advisory Group (MDSG) dynamic stability models serve as the starting point for all interconnection studies requiring dynamic analysis. These models include:
  - MDAG models (Example: 2021)
    - Year 5 Summer Peak (Example: 26SP)
    - Year 5 Winter Peak (Example: 26WP)

Base Genlist

- Genlist from previous cluster

SHORT CIRCUIT MODEL SET

Base Models

- The SPP Model Development Advisory Group (MDAG) dynamic stability models serve as the starting point for all interconnection studies requiring dynamic analysis. These models include:
  - MDAG models (Example: 2021)
    - Year 5 Summer Peak (Example: 26SP)

SCOPE OF ANALYSIS

THE DEFINITIVE INTERCONNECTION SYSTEM IMPACT STUDY (DISIS)

DISIS Phase One will consist of:

- **Steady-State Contingency (Powerflow) analysis**
  - Non-converged, steady-state thermal, and steady-state voltage analysis to determine the impact of the current-queue requests on system powerflow or voltages.
  - Mitigation Identification
  - Cost Allocation
- **Calculation of the short-circuit ratio for each request**
  - To determine the relative size of the generation/inverter-based resource to the system short-circuit capacity for the Year 5 Summer Peak case

THE DEFINITIVE INTERCONNECTION SYSTEM IMPACT STUDY (DISIS)

DISIS Phase Two will consist of:

- **Steady-State Contingency (Powerflow) analysis**
- **Stability Analysis**
- **Reactive Compensation Analysis**
- **Short Circuit Fault Current Calculation**
- **Short Circuit Ratio and Critical Clearing Time (SCRCCT) Screening**

POWERFLOW CONTINGENCY ANALYSIS AND MITIGATION IDENTIFICATION

Contingency Analysis

- Will be conducted using TARA for all cases developed utilizing the applicable input files (mon/con/sub)
- Study results will be analyzed based on SPP constraint identification criteria as outlined in:
  - Business Practice 7250
  - Tariff Attachment V, Section 4.2.2
  - the DISIS Manual

Mitigation Identification

- The most cost effective solutions will be determined for constraints that require mitigations pertaining to:
  - Non-convergence
  - Thermal violations
  - Voltage violations

DISIS SCOPE OF ACTIVITIES

For purposes of determining necessary Interconnection Facilities and Network Upgrades,

The DISIS shall consider the level of Interconnection Service requested by the Interconnection Customer,

Unless otherwise required to study the full Generating Facility Capacity due to safety or reliability concerns.

Each phase of the Definitive Interconnection System Impact Study will provide

A list of facilities that are required as a result of the Interconnection Request

A non-binding good faith estimate of cost responsibility and a non-binding good faith estimated time to construct.

POWERFLOW COST ALLOCATION

Cost allocation will be performed consistent with:

- SPP OATT Attachment V, Section 4.2.2
- DISIS Manual Section 4.5
- SPP Business Practice 7250
  - Additional calculation will be performed as applicable to account for the sum of all MW impacts from projects with a TDF of 5% or greater

Network upgrades for wind requests will be cost allocated using the Year 5 Light Load model

Network upgrades for solar requests will be cost allocated using the Year 5 Summer Peak model

THERMAL OVERLOADS

Thermal overloads are identified when the flow across a monitored element exceeds either its normal (Rate A) rating under system intact (n-0) conditions or its emergency (Rate B) rating under contingency (n-n) conditions.

ERIS

- Upgrades required to mitigate the constraints identified in the ERIS scenarios will be assigned to every current-queue request meeting any of the following criteria:
  - 3% TDF on contingent elements that resulted in a non-converged solution
  - 3% TDF for system intact conditions (n-0)
  - 20% TDF upon outage-based conditions (n-n)
  - At least 5% TDF impact where the constraint is identified under contingency conditions where the sum of all the current-queue requests having a TDF impact on the constrained element of at least 5% equals at least 20% of the constrained element's emergency rating **(Cumulative Criteria)**

NRIS

- Upgrades required to mitigate constraints identified in the NR scenarios will be assigned to every NRIS current-queue request meeting any of the following criteria:
  - 3% TDF for system intact conditions (n-0)
  - 3% TDF upon outage-base conditions (n-n)

VOLTAGE VIOLATIONS

After all non-converged contingency and thermal overload mitigations are determined, any remaining voltage violations are checked to determine applicability to the current queue.

SPP voltage criteria is applicable to all SPP facilities 69 kV and greater in the absence of more stringent criteria.

Per Unit (PU) voltages must change by at least 2% from the PQ models to the CQ models to be assigned to the current cluster.

For constraints meeting this criteria, requests having at least 3% PTDF on the contingent element monitored in the direction of system intact MW flow causing voltage constraints will be assigned responsibility for mitigating the voltage issue(s).

CONSTRAINT IDENTIFICATION

Service Type	Constraint	Type	TDF %
ERIS/NRIS	System Intact / N-n	Voltage	3
ERIS	System Intact / Non-Converge	Thermal	3
ERIS	N-n	Thermal	20
NRIS	System Intact / Non-Converge	Thermal	3
NRIS	n-n	Thermal	3

TRANSIENT STABILITY ANALYSIS

Transient Stability Analysis evaluates:

- System stability in response to fault events
- Compliance of Current-Queued Requests and Prior-Queued Requests with FERC Order 661-A
- Adherence to the SPP Disturbance Performance Requirements
- Post event voltage recovery within the SPP voltage criteria
- Adherence to NERC reliability standards and requirements
- Adherence to Transmission Owner Stability Evaluation Criteria which has been filed with FERC

REACTIVE COMPENSATION ANALYSIS

Determines the amount of shunt reactive compensation that will be required to offset the charging current of each request

Performed on only the Year 5 Summer Peak Stability Analysis power flow case

SHORT CIRCUIT ANALYSIS

Phase 1

- Short-circuit ratio is calculated and included in DISIS Phase 1 report
- $SCR_{POI} = \frac{SCMVA_{POI}}{MW_{VER}}$

Phase 2

- Three-phase fault currents for each bus are calculated
- Assumes all upgrades identified in the powerflow analysis are in-service unless otherwise noted

SCRCCT

- Short-circuit ratio and critical clearing time screening is also included in Phase 2
- Evaluates SCR, WSCR, and CSCR using EPRI GSAT Tool (<6.0 is deemed weak)
- Critical Clearing Time < 0.15s is too low

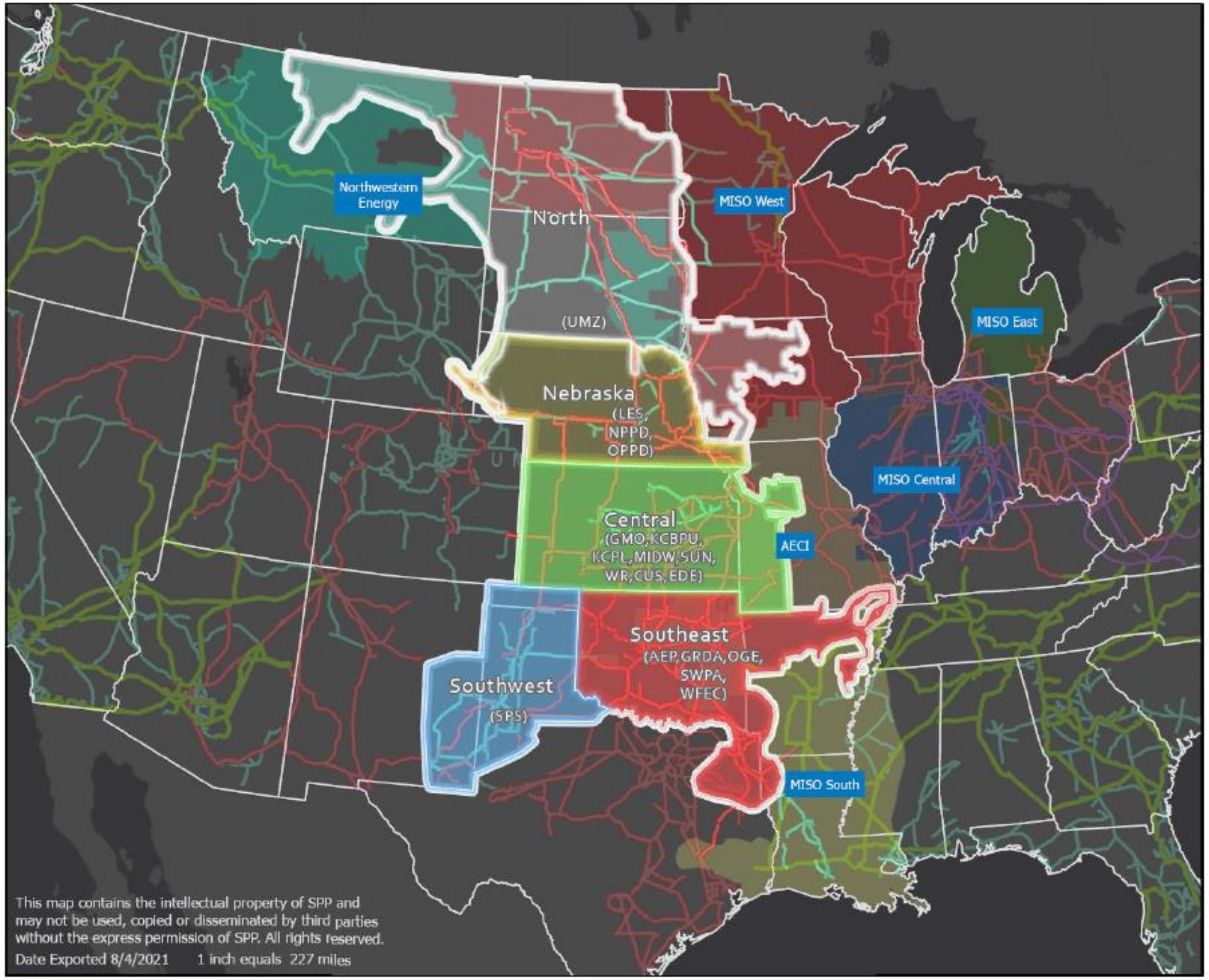
DELIVERABLES

DELIVERABLES

ACTION REQUIRED **Draft Models for IC/TO review/comment**	Notification email will be sent and models will be posted on GlobalScape (See Appendix for access requirements)
Final Models	Notification email will be sent and models will be posted on GlobalScape
ACTION REQUIRED **Draft Report for IC/TO review/comment**	Notification email will be sent and report will be posted at: https://opsportal.spp.org/Studies/GenList?yearTypeId=199
Final Report	Notification email will be sent and report will be posted at: https://opsportal.spp.org/Studies/GenList?yearTypeId=199

APPENDIX

SPP REGIONS



1 NORTH
9 Nebraska
15 Eastern South Dakota
16 Western North Dakota
17 Western South Dakota
18 Eastern North Dakota

2 NEBRASKA
9 Nebraska

3 CENTRAL
3 Spearville
4 Northwest Kansas
8 North Oklahoma/South Central Kansas
9 Nebraska
12 Northwest Arkansas
13 Northeast Kansas/Northwest Missouri

4 SOUTHEAST
1 Woodward
7 Southwestern Oklahoma
8 North Oklahoma/South Central Kansas
10 Southeast Oklahoma/Northeast Texas
12 Northwest Arkansas
14 South Central Oklahoma

5 SOUTHWEST
2 Hitchland
6 South Texas Panhandle/New Mexico

FUEL BASED DISPATCH (FBD) TABLE FOR STEADY-STATE ERIS HVER SCENARIO (TRANSFER ANALYSIS SOURCE PERSPECTIVE)

Fuel Type	In-Group									Out-Group								
	Summer Peak			Winter Peak			Light Load			Summer Peak			Winter Peak			Light Load		
	L / NL	PQ	CQ	L / NL	PQ	CQ	L / NL	PQ	CQ	L / NL	PQ	CQ	L / NL	PQ	CQ	L / NL	PQ	CQ
HVER Scenario																		
Combined Cycle	NC	0%	0%	NC	0%	0%	NC	0%	0%	NC	NC / 0%	0%	NC	NC / 0%	0%	NC	NC / 0%	0%
Combustion Turbine	NC	0%	0%	NC	0%	0%	NC	0%	0%	NC	NC / 0%	0%	NC	NC / 0%	0%	NC	NC / 0%	0%
Diesel Engine	NC	0%	0%	NC	0%	0%	NC	0%	0%	NC	NC / 0%	0%	NC	NC / 0%	0%	NC	NC / 0%	0%
Hydro	NC	50%	50%	NC	50%	50%	NC	50%	100%	NC	NC / 0%	0%	NC	NC / 0%	0%	NC	NC / 0%	0%
Nuclear	NC	100%	100%	NC	100%	100%	NC	100%	100%	NC	NC / 0%	0%	NC	NC / 0%	0%	NC	NC / 0%	0%
Storage	NC (Summer Peak AVG)	0%	100%	NC (Winter Peak AVG)	0%	100%	NC	0%	0%	NC (Summer Peak AVG)	NC / 0%	0%	NC (Winter Peak AVG)	NC / 0%	0%	NC	NC / 0%	0%
Coal	NC	0%	0%	NC	0%	0%	NC	0%	0%	NC	NC / 0%	0%	NC	NC / 0%	0%	NC	NC / 0%	0%
Oil	NC	0%	0%	NC	0%	0%	NC	0%	0%	NC	NC / 0%	0%	NC	NC / 0%	0%	NC	NC / 0%	0%
Waste Heat	NC	0%	0%	NC	0%	0%	NC	0%	0%	NC	NC / 0%	0%	NC	NC / 0%	0%	NC	NC / 0%	0%
Wind	NC (Summer Peak AVG)	40%	100%	NC (Winter Peak AVG)	45%	100%	100% LTFTS	75%	100%	NC (Summer Peak AVG)	NC / 0%	20%	NC (Winter Peak AVG)	NC / 0%	20%	100% LTFTS	NC / 0%	60%
Solar	NC (Summer Peak AVG)	40%	100%	NC (Winter Peak AVG)	10%	100%	0%	0%	0%	NC (Summer Peak AVG)	NC / 0%	40%	NC (Winter Peak AVG)	NC / 0%	10%	0%	NC / 0%	0%
Hybrid	See Hybrid Example																	

L = ITP Legacy Request (pre-dates SPP GI Queue)

NL = ITP Non-Legacy Request (have been studied in a GI process and are in the ITP models)

PQ = Prior-Queued Requests under active study

CQ = Current-Queue Requests under active study

NC = No Change in dispatch from BASE model (see notes below)

N/A = Not Applicable for this scenario

LTFTS = Long-Term Firm Transmission Service

Percentages are based on the requested interconnection service amount in megawatts.

NOTE: Per the base sinking methodology, L or NL requests are included in the sink definition minus in-group high variable energy resources

NOTE: PQ and NL generators which are co-located with a CQ request (electrically equivlent) are dispatched at the same percentage of a CQ request (in-group only)

FUEL BASED DISPATCH (FBD) TABLE FOR STEADY-STATE ERIS LVER SCENARIO (TRANSFER ANALYSIS SOURCE PERSPECTIVE)

Fuel Type	In-Group									Out-Group								
	Summer Peak			Winter Peak			Light Load			Summer Peak			Winter Peak			Light Load		
	L / NL	PQ	CQ	L / NL	PQ	CQ	L / NL	PQ	CQ	L / NL	PQ	CQ	L / NL	PQ	CQ	L / NL	PQ	CQ
LVER Scenario																		
Combined Cycle	NC	100%	100%	NC	100%	100%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Combustion Turbine	NC	100%	100%	NC	100%	100%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Diesel Engine	NC	100%	100%	NC	100%	100%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hydro	NC	50%	50%	NC	50%	50%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nuclear	NC	100%	100%	NC	100%	100%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Storage	NC (Summer Peak AVG)	100%	100%	NC (Winter Peak AVG)	100%	100%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Coal	NC	100%	100%	NC	100%	100%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Oil	NC	100%	100%	NC	100%	100%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Waste Heat	NC	100%	100%	NC	100%	100%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Wind	NC (Summer Peak AVG)	20%	20%	NC (Winter Peak AVG)	20%	20%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Solar	NC (Summer Peak AVG)	40%	40%	NC (Winter Peak AVG)	10%	10%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hybrid	See Hybrid Example																	

L = ITP Legacy Request (pre-dates SPP GI Queue)

NL = ITP Non-Legacy Request (have been studied in a GI process and are in the ITP models)

PQ = Prior-Queued Requests under active study

CQ = Current-Queue Requests under active study

NC = No Change in dispatch from BASE model (see notes below)

N/A = Not Applicable for this scenario

LTFTS = Long-Term Firm Transmission Service

Percentages are based on the requested interconnection service amount in megawatts.

NOTE: Per the base sinking methodology, L or NL requests are included in the sink definition minus in-group high variable energy resources

NOTE: PQ and NL generators which are co-located with a CQ request (electrically equivlent) are dispatched at the same percentage of a CQ request (in-group only)

FUEL BASED DISPATCH (FBD) TABLE FOR STEADY-STATE NRIS SCENARIO (TRANSFER ANALYSIS SOURCE PERSPECTIVE)

Fuel Type	In-Group									Out-Group								
	Summer Peak			Winter Peak			Light Load			Summer Peak			Winter Peak			Light Load		
	L / NL	PQ	CQ	L / NL	PQ	CQ	L / NL	PQ	CQ	L / NL	PQ	CQ	L / NL	PQ	CQ	L / NL	PQ	CQ
NR Scenario																		
Combined Cycle	NC	100%	100%	NC	100%	100%	NC	0%	0%	N/A	N/A	N/A	N/A	N/A	N/A	NC	NC / 0%	0%
Combustion Turbine	NC	100%	100%	NC	100%	100%	NC	0%	0%	N/A	N/A	N/A	N/A	N/A	N/A	NC	NC / 0%	0%
Diesel Engine	NC	100%	100%	NC	100%	100%	NC	0%	0%	N/A	N/A	N/A	N/A	N/A	N/A	NC	NC / 0%	0%
Hydro	NC	50%	50%	NC	50%	50%	NC	50%	100%	N/A	N/A	N/A	N/A	N/A	N/A	NC	NC / 0%	0%
Nuclear	NC (Summer Peak AVG)	100%	100%	NC (Winter Peak AVG)	100%	100%	NC	100%	100%	N/A	N/A	N/A	N/A	N/A	N/A	NC	NC / 0%	0%
Storage	NC	100%	100%	NC	100%	100%	NC	0%	0%	N/A	N/A	N/A	N/A	N/A	N/A	NC	NC / 0%	0%
Coal	NC	100%	100%	NC	100%	100%	NC	0%	0%	N/A	N/A	N/A	N/A	N/A	N/A	NC	NC / 0%	0%
Oil	NC	100%	100%	NC	100%	100%	NC	0%	0%	N/A	N/A	N/A	N/A	N/A	N/A	NC	NC / 0%	0%
Waste Heat	NC	100%	100%	NC	100%	100%	NC	0%	0%	N/A	N/A	N/A	N/A	N/A	N/A	NC	NC / 0%	0%
Wind	NC (Summer Peak AVG)	20%	100%	NC (Winter Peak AVG)	20%	100%	100% LTFTS	60%	100%	N/A	N/A	N/A	N/A	N/A	N/A	100% LTFTS	NC / 0%	60%
Solar	NC (Summer Peak AVG)	40%	100%	NC (Winter Peak AVG)	10%	100%	0%	0%	0%	N/A	N/A	N/A	N/A	N/A	N/A	0%	NC / 0%	0%
Hybrid	See Hybrid Example																	

L = ITP Legacy Request (pre-dates SPP GI Queue)
NL = ITP Non-Legacy Request (have been studied in a GI process and are in the ITP models)
PQ = Prior-Queued Requests under active study
CQ = Current-Queue Requests under active study
NC = No Change in dispatch from BASE model (see notes below)
N/A = Not Applicable for this scenario
LTFTS = Long-Term Firm Transmission Service
Percentages are based on the requested interconnection service amount in megawatts.
NOTE: Per the base sinking methodology, L or NL requests are included in the sink definition minus in-group high variable energy resources
NOTE: PQ and NL generators which are co-located with a CQ request (electrically equivlent) are dispatched at the same percentage of a CQ request (in-group only)

FUEL BASED DISPATCH (FBD) TABLE FOR STABILITY SCENARIO (TRANSFER ANALYSIS SOURCE PERSPECTIVE)

Fuel Type	In-Group						Out-Group					
	Summer Peak			Winter Peak			Summer Peak			Winter Peak		
	L	NL / PQ	CQ	L	NL / PQ	CQ	L	NL / PQ	CQ	L	NL / PQ	CQ
Combined Cycle	NC	100%	100%	NC	100%	100%	NC	NC	0%	NC	NC	0%
Combustion Turbine	NC	100%	100%	NC	100%	100%	NC	NC	0%	NC	NC	0%
Diesel Engine	NC	100%	100%	NC	100%	100%	NC	NC	0%	NC	NC	0%
Hydro	NC	50%	50%	NC	50%	50%	NC	NC	0%	NC	NC	0%
Nuclear	NC	100%	100%	NC	100%	100%	NC	NC	0%	NC	NC	0%
Storage	NC	100%	100%	NC	100%	100%	NC	NC	0%	NC	NC	0%
Coal	NC	100%	100%	NC	100%	100%	NC	NC	0%	NC	NC	0%
Oil	NC	100%	100%	NC	100%	100%	NC	NC	0%	NC	NC	0%
Waste Heat	NC	100%	100%	NC	100%	100%	NC	NC	0%	NC	NC	0%
Wind	NC	40%	100%	NC	45%	100%	NC	NC	20%	NC	NC	20%
Solar	NC	40%	100%	NC	10%	100%	NC	NC	40%	NC	NC	10%
Hybrid	See Hybrid Example											

L = MDAG Legacy Request (pre-dates SPP GI Queue)

NL = MDAG Non-Legacy Request (have been studied in a GI process and are in the MDAG models)

PQ = Prior-Queued Requests under active study

CQ = Current-Queue Requests under active study

NC = No Change in dispatch from MDAG model (see notes below)

Percentages are based on the requested interconnection service amount in megawatts.

NOTE: Per the base sinking methodology, L or NL requests are included in the sink definition minus in-group high variable energy resources

NOTE: PQ and NL generators which are co-located with a CQ request (electrically equivalent) are dispatched at the same percentage of a CQ request (in-group only)

NOTE: Non-Legacy MDAG generators are firm and non-firm Variable Energy Resources (e.g. Solar and Wind) not dispatched in the MDAG model consistent with the SPP Model Development Procedure Manual.

Non Variable Energy Resources are assumed to have been considered for dispatch as needed in the MDAG model consistent with the SPP Model Development Procedure Manual; these resources will follow the Fuel Based Dispatch Table for Stability on a limited case-by-case basis.

PRIOR-QUEUED HYBRID EXAMPLE (HVER MODEL)

Hybrid Request #	Hybrid Request Capacity	Type	Installed Capacity (MW)	Summer Peak	Winter Peak	Light Load
1	**100MW**	Solar	50	40%*50MW= 20MW	10%*50MW= 5MW	0%*50MW= 0MW
		Wind	100	40%*100MW= 40MW	45%* 100MW= 45MW	75%* 100MW= 75MW
		Total	**150**	**60MW**	**50MW**	**75MW**
2	**190MW**	Storage	100	0%*100MW= 0MW	0%*100MW= 0MW	0%*100MW= 0MW
		Wind	200	40%*200MW= 80MW	45%*200MW= 90MW	75%*200MW= 150MW
		Total	**300**	**80MW**	**90MW**	**150MW**

If requested Hybrid capacity is exceeded by calculated values, dispatch will be scaled down on a pro rata basis (of calculated values) to honor requested capacity

Example assumes hybrid is in-group, but not at a current study gen's electrically equivalent POI

STUDY HYBRID EXAMPLE (HVER MODEL)

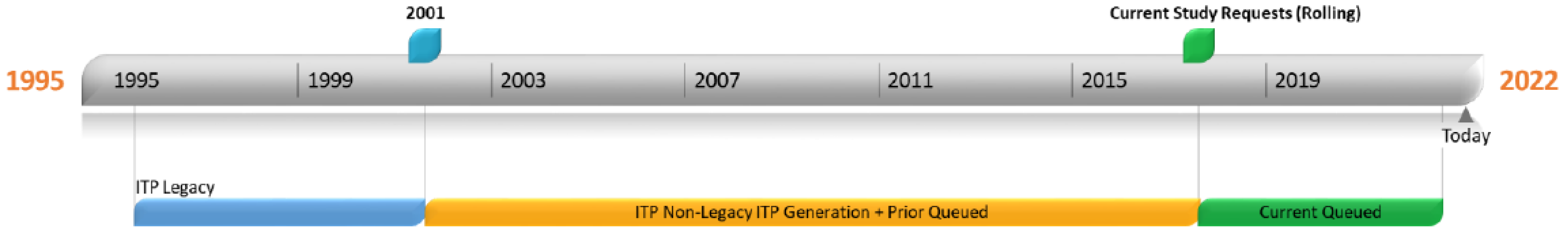
Hybrid Request #	Hybrid Request Capacity	Type	Installed Capacity (MW)	Summer Peak	Winter Peak	Light Load
1	**100MW**	Solar	50	100%*50MW= 50MW→33MW	100%*50MW= 50MW→33MW	0%*50MW= 0MW
		Wind	100	100%* 100MW= 100MW→67MW	100%* 100MW= 100MW→67MW	100%* 100MW= 100MW
		Total	**150**	**150MW→100MW**	**150MW→100MW**	**100MW**
2	**190MW**	Storage	100	100%*100MW= 100MW→63MW	100%*100MW= 100MW→63MW	0%*100MW= 0MW→0MW
		Wind	200	100%*200MW= 200MW→127MW	100%*200MW= 200MW→127MW	100%*200MW= 200MW→190MW
		Total	**300**	**300MW→190MW**	**300MW→190MW**	**200MW→190MW**

If requested Hybrid capacity is exceeded by calculated values, dispatch will be scaled down on a pro rata basis (of calculated values) to honor requested capacity
Example assumes hybrid is in-group

GENERATOR CATEGORY DEFINITIONS

The following generator categories are referred to throughout this presentation

- ITP legacy: generators pre-dating SPP's GI queue
- ITP non-legacy: generators that have been studied in a GI process and are in the ITP models
- PQ: prior-queued requests under active study
- CQ: current-queue requests under active study



GENLIST "CATEGORY" COLUMN AND ITS USAGE

- The Category column in the GenList is an indicator of how the request will be treated for FBD
  - "CQ": current-queued request
  - "PQ": prior-queued request
  - "ITP": non-legacy ITP generator

WHAT IS A BASE MODEL?

- As noted earlier, a BASE model contains PQ and CQ requests modeled as off-line
- Mitigations associated with PQ requests from earlier DISIS studies are also incorporated
- BASE models are built off of SPP's AGG models, which are built off of ITP models
- 4 BASE models are built for a DISIS study
  - Year 2 Summer Peak
  - Year 5 Summer Peak, Winter Peak, Light Load

USAGE OF BASE MODELS IN DISIS

- BASE models are not used for analysis and do not factor into mitigation identification or cost allocation
- FBD is applied on top of the BASE models to create the PQ and CQ models for each group
- In a DISIS study, nearly all of the model development time goes into building the BASE models; the creation of PQ and CQ models is automated and runs in minutes
  - Ensuring correct modeling of PQ and CQ requests is critical

PQ MODEL PURPOSE

- A PQ model (sometimes labeled “BC” model in DISIS) contains both PQ and CQ requests, but only the PQ requests are dispatched
  - The CQ requests are off-line
- The purpose of a PQ model is to serve as a reference point in the study
  - A PQ model is the “before”; the corresponding CQ model is the “after”

APPLICATION OF FBD

- In a PQ model, FBD is applied **only to the PQ requests**
  - CQ requests remain off-line
  - ITP legacy (pre-2001) and non-legacy (post-2001) generators remain at their ITP/BASE dispatch
  - There is one exception to this: **electrically-equivalent ITP non-legacy or PQ generators** (discussed in detail in the next section, although it applies to PQ models as well)
- The GenList contains the group number and fuel type of each PQ request and is used to apply the FBD percentages

CQ MODEL PURPOSE

- A CQ model (sometimes labeled "TC" model in DISIS) contains both PQ and CQ requests, with both PQ and CQ requests according to their FBD amounts
- The purpose of a CQ model is to determine the impacts of CQ requests, relative to the PQ models
  - A PQ model is the "before"; the corresponding CQ model is the "after"

APPLICATION OF FBD

- In a CQ model, FBD is applied **to both PQ and CQ requests**
  - The PQ requests are dispatched following the procedure described in the previous section
  - ITP legacy (pre-2001) and non-legacy (post-2001) generators remain at their ITP/BASE dispatch
  - There is one exception to this: electrically-equivalent ITP non-legacy or PQ generators (discussed in detail later)
- The GenList contains the group number and fuel type of each CQ request and is used to apply the FBD percentages

ELECTRICAL EQUIVALENCE

- If a CQ request is "co-located" with a PQ request or an ITP non-legacy generator, the PQ/ITP generator is deemed "electrically equivalent" and **dispatched at the percentage level of a CQ request**
  - This only occurs for in-group models; this exception does not apply to an out-of-group generator electrically equivalent to an out-of-group CQ request
  - This does, however, apply to both PQ and CQ models
- "Co-located" is a multi-faceted definition
  - At the same substation and nominal KV level; OR
  - On the same branch or collection of in-series two-terminal branches; OR
  - On radial branches

GROUP CHANGES DUE TO ELECTRICAL EQUIVALENCE

- A CQ request near a group seam may be electrically equivalent to a PQ or ITP non-legacy unit in a different group
- When this happens, the group of the CQ request is changed to the group of the electrically equivalent generator

SINKING

- For every new MW added to the system by dispatching PQ and CQ requests, a MW must be subtracted from the sink to maintain power balance between generation and load
- At this point of the process, the models have been **dispatched** but the dispatched generation has not been **sunk**

PURPOSE OF THE SINKING STEP

- DISIS clusters are large relative to SPP's peak load
  - DISIS-2017-002: 19.8 GW
  - DISIS-2018-001: 9.2 GW
  - DISIS-2018-002/2019-001: 13.5 GW
  - DISIS-2020-001: 16.9 GW
- Queued generation cannot be added to the models without that new generation being sunk to maintain power balance between generation and load

DEFINITION OF THE SINK

- Any unit in the SPP footprint not subject to FBD is part of the sink, meaning its power output can be reduced to make room for the dispatched PQ and CQ generation
  - ITP non-legacy
  - ITP legacy
- Units labeled as must run as identified in the ITP Base Reliability and economic dispatch methodologies, including but not limited to hydroelectric, cogeneration facilities, landfill gas and nuclear units, are **excluded from the sink**

LOAD RATIO SHARE CALCULATION

- The total MW imbalance in the SPP footprint caused by dispatching the PQ and CQ requests is sunk across the entire SPP footprint
- The amount of power sunk to any given transmission owner control area is determined based on a **load ratio share** (LRS)

$$Control\ Area\ LRS = \frac{Control\ Area\ Load}{SPP\ Total\ Load}$$

$$Control\ Area\ MW\ to\ sink = Control\ Area\ LRS\ \times Total\ SPP\ MW\ Imbalance$$

GENERATOR LIMITS AND AREA "FOOTROOM"

- Any non-excluded generator in an area participates in sinking and is eligible to sink as low as its Pmin will allow
  - Generator limits are strictly enforced

$$Amount\ to\ sink\ generator = Sinking\ MW\ Assigned\ to\ Area * \frac{Generator\ Pg}{Area\ Footroom}$$

- If an area does not have enough "footroom" to sink the assigned number of MW, the sink generators in that area are set to Pmin and the LRS weights are recomputed

LIGHT LOAD CASES

- In light load seasonal models, the amount to be sunk into each SPP area is a function of both the sinking area, as well as the source area (the area where the generation was added)
- The amount of sinking assigned to SPP sink area *A* is equal to the sum over all SPP source areas, *B*:

$$Amount\ of\ sinking\ assigened\ to\ area\ A = \sum Change\ in\ area\ B\ Pg\ * LRS\ of\ area\ A\ with\ respect\ to\ area\ B$$

- The LRS of area *A* with respect to area *B* is 0 if A = B

$$LRS\ of\ A\ with\ respect\ to\ area\ B = \frac{Load\ of\ Area\ A}{SPP\ Total\ Load\ - Load\ of\ Area\ B}$$

EXPANDING THE SINK

- If the iterative load ratio share sinking fails to sink the full amount of generation (i.e., all generators in the sink hit Pmin), the sink may be expanded in the following priority order:
  - Out-of-group CQ requests
  - In-group PQ requests (excluding electrically equivalent PQ requests)
  - In-group, electrically equivalent PQ requests
- Expansion of the sink has not been required in a DISIS study since the introduction of FBD

SINKING OUTSIDE SPP

- The DISIS process may include dispatching generation outside SPP
  - Example: higher-queued MISO requests
- For non-SPP regions (both ERIS and NRIS scenarios), a proportional, uniform scaling across all sink units in each region is used to offset the regional imbalance
- If insufficient generation is available in sink system, the sink is expanded (as defined earlier) until the imbalance is corrected

SOLUTION PARAMETERS AND MODEL ADJUSTMENTS

- PQ and CQ models are solved with the following options
  - Switched shunt adjustment
  - Transformer tap adjustment
  - DC line tap adjustment
  - Area interchange control (ties and loads)
- Models are solved such that the net export of power from SPP (and neighboring regions) remains the same, within a tolerance
  - Individual area interchanges inside of SPP may change due to the FBD and sinking process
- Sink generation may be further adjusted to compensate for losses

AREA INTERCHANGE CONTROL

- When establishing a base case and TC case to perform (N-0 or N-1):
  - The appropriate interchanges between SPP and other areas will be done with area interchange enabled for tie lines and loads.
  - This ensures that area interchanges external to SPP are correct and that loads shared between SPP and Externals are accounted for properly.
  - Generation will be re-dispatched in SPP to obtain the desired interchanges with areas external to SPP.
  - The area-slack bus will adjust its output for the change in losses resulting from this re-dispatch.
  - Generation at the area-slack bus will be validated to within the operating limits of that generator.
- For contingency analysis, area interchange will be disabled.
  - The contingency analysis will use a system wide default dispatch definition to adjust system generation for consequential changes in generation, load, or losses as a result of the contingency.

OTHER NOTES

- Both ERIS-only and NRIS requests are dispatched in ER models
- Only NRIS requests are dispatched in the NR models
- LVER models are only created from the BASE models if the current queue contains one or more conventional requests

SHORT CIRCUIT RATIO

$$SCR = \frac{Ssc}{MW}$$

Maximum Available Short Circuit Power (MVA) before connection of the resource

Power Rating (MW) of resource to be connected

- Measures the strength (voltage stiffness) at a point (bus) in the power system
- Measured at the POI of a resource to be connected
- Low SCR indicates weakness and additional analysis may be required

SHORT CIRCUIT RATIO

$$CSCR = \frac{CSCMVA}{MW_n}$$

Composite Short Circuit Ratio

$$WSCR = \frac{\sum_i^N SCMVA * MW_i}{\sum_i^N MW_i}$$

Weighted Short Circuit Ratio

- A large concentration of wind plants connected in the vicinity of a transmission node can result in low grid strength
- Ratio calculation becomes more complicated
- Composite and Weighted SCR better measure of Ratio

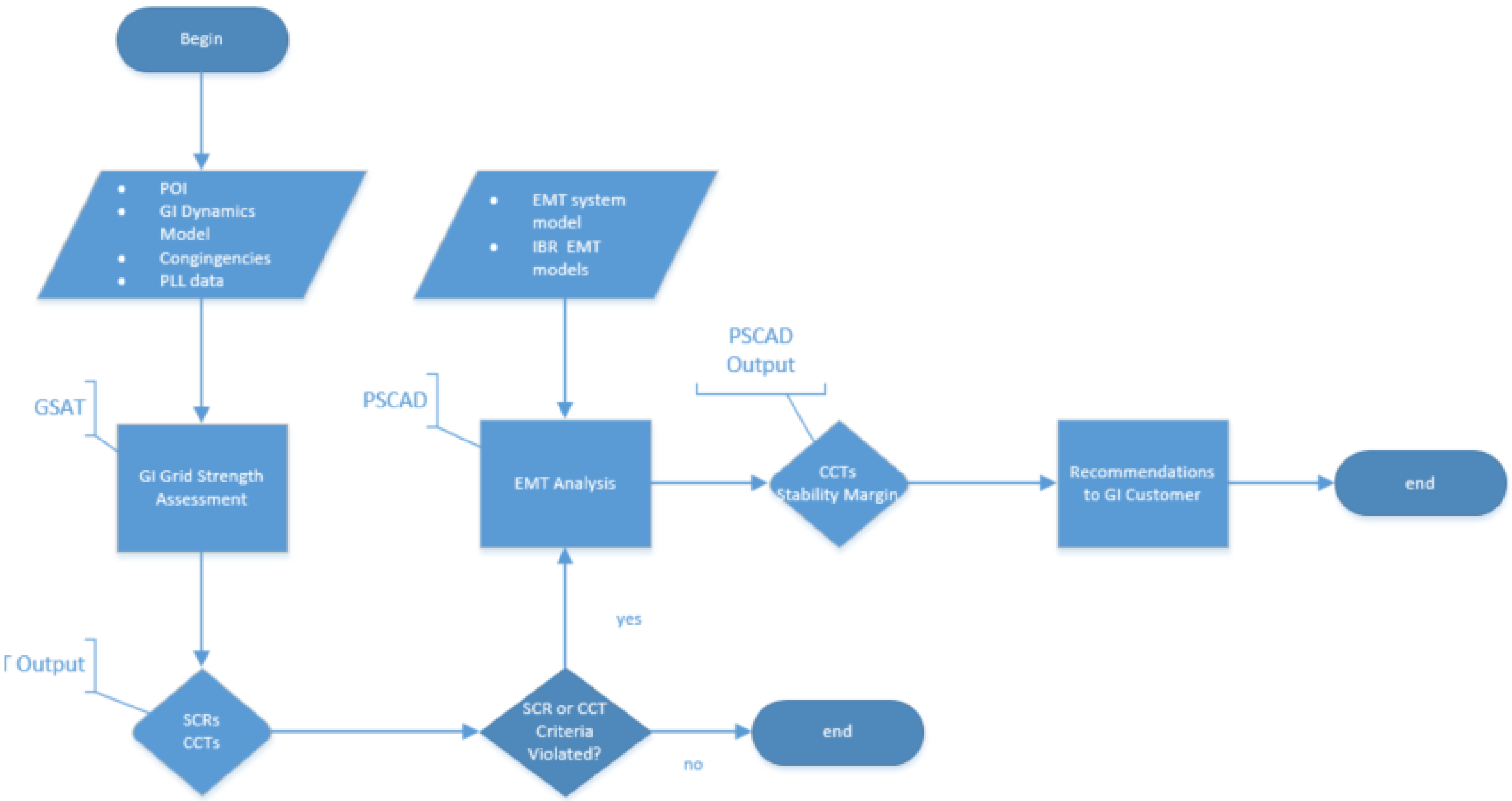
EPRI GSAT TOOL

- Grid Strength Assessment Tool - Benefits
  - Fast screening of hundreds of buses based on short circuit current
  - Provides insights into possible interactions among electrically nearby generating plants
  - Provides insights into possible controller interactions and instabilities for converter resources interconnected at low short circuit locations
- Developed in 2018 under project P173.03
- Evaluates SCR, WSCR, and CSCR

CRITICAL CLEARING TIME

- **Critical Clearing Time (CCT)** - the maximum time a fault near the POI of the inverter plant is allowed to remain on the system such that inverter plant remains stable
- GSAT CCT metric can help identify IBRs with **possible** oscillatory instability
- The possibility of inverter instability is governed by,
    - Short circuit current
    - Controller gains
    - MW power output
    - Fault clearing time

GI Inverter Based Resource (IBR) Studies



SCRCCT SCREENING PROCESS

SCRCCT SCREENING THRESHOLDS

- **SCR, WSCR, CSCR = 6.0**
  - If SCR < 6, bus or bus group is deemed weak (not good)
- **CCT =0.15s**
  - If CCT < 0.15s, clearing time is too low (not good)
- **Generally, if at least one of the above conditions is true, further study is required***
- **Some Examples:**

SCR	CCT (s)	WSCR	Further Study Required?*
5.2	0.8	7.7	yes
6.6	1.2	4.1	yes
8.8	1.0	na	no
23.0	0.025	17.0	Yes
6.1	0.16	na	Maybe

* Further study may include positive sequence dynamics analysis and / or EMT analysis

GIR DATA

1. FERC order 845 uncouples the generating capability from the GIR Amount
2. Bus name/numbers and tap distances preferred, POI coordinates are relied upon for validation
3. Two-winding transformers modeled. Maximum Nameplate and positive sequence impedance used
4. Generator Nameplate kVa & output MW used during validation, SPP assumes 0.95 power factor

1

b. Maximum electrical output of the proposed new Generating Facility or the amount of increase in the generating capacity of an Existing Generating Facility;

Maximum summer electrical output or increase of ____ megawatts at _____ degrees C

Maximum winter electrical output or increase of ____ megawatts at _____ degrees C

h. Requested capacity (in MW) of Interconnection Service (if lower than the Generating Facility Capacity);

2

Designation of Point of Interconnection and configuration to be studied.

(Name or description of substation or transmission line and voltage):

____

Geographic coordinates of the proposed Point of Interconnection:

Latitude: ___ degrees, ___ minutes, ___ seconds (North)

Longitude: ___ degrees, ___ minutes, ___ seconds (West)

3

GENERATOR STEP-UP TRANSFORMER DATA RATINGS
(for a single generator in a group of generators)

Capacity ________/ Self-cooled/ Maximum Nameplate ________kVA

Voltage Ratio (Generator Side/System side/Tertiary) ________/________/________kV

Winding Connections (Low V/High V/Tertiary V (Delta or Wye)) ________/________/________

Fixed Taps Available ________________________

Present Tap Setting ________________________

Impedance: Positive Z1 (on self-cooled kVA rating)________% ________X/R

Impedance: Zero Z0 (on self-cooled kVA rating)________% ________X/R

MAIN GENERATOR STEP-UP TRANSFORMER DATA RATINGS
(for a single generator or the step-up from collector system to POI voltage)

Capacity
Self-cooled/Maximum Nameplate

________/________kVA

Voltage Ratio (Generator Side/System side/Tertiary) ________/________/________kV

Winding Connections (Low V/High V/Tertiary V (Delta or Wye)) ________/________/________

Fixed Taps Available ________________________

Present Tap Setting ________________________

Impedance: Positive Z1 (on self-cooled kVA rating)________% ________X/R

Impedance: Zero Z0 (on self-cooled kVA rating)________% ________X/R

4

UNIT RATINGS
(for a single generator in a group of generators)

Nameplate kVA ________ °F ________ Voltage ________
Prime Mover type ________________
Power Factor: Lead ________ Lag ________
Speed (RPM) ________ Connection (e.g. Wye) ________
Short Circuit Ratio ________ Frequency, Hertz ________
Stator Amperes at Rated kVA ________ Field Volts ________
Max Turbine Power Output Capability: Summer MW ________ °F ______
Winter MW ________ °F ______

POWERFLOW MODEL BUILD

- Collector system layout modeled as designed in one-line
  - i.e. multiple MPTs, GSUs, shared facilities, etc.
  - Reactive devices and load are not generally included
- ∑Pmax = Requested Interconnection Service Amount
  - Hybrid requests are modeled at full capacity

GSU:
Max Nameplate * # of units
Z1% & X/R

Collector:
0 impedance

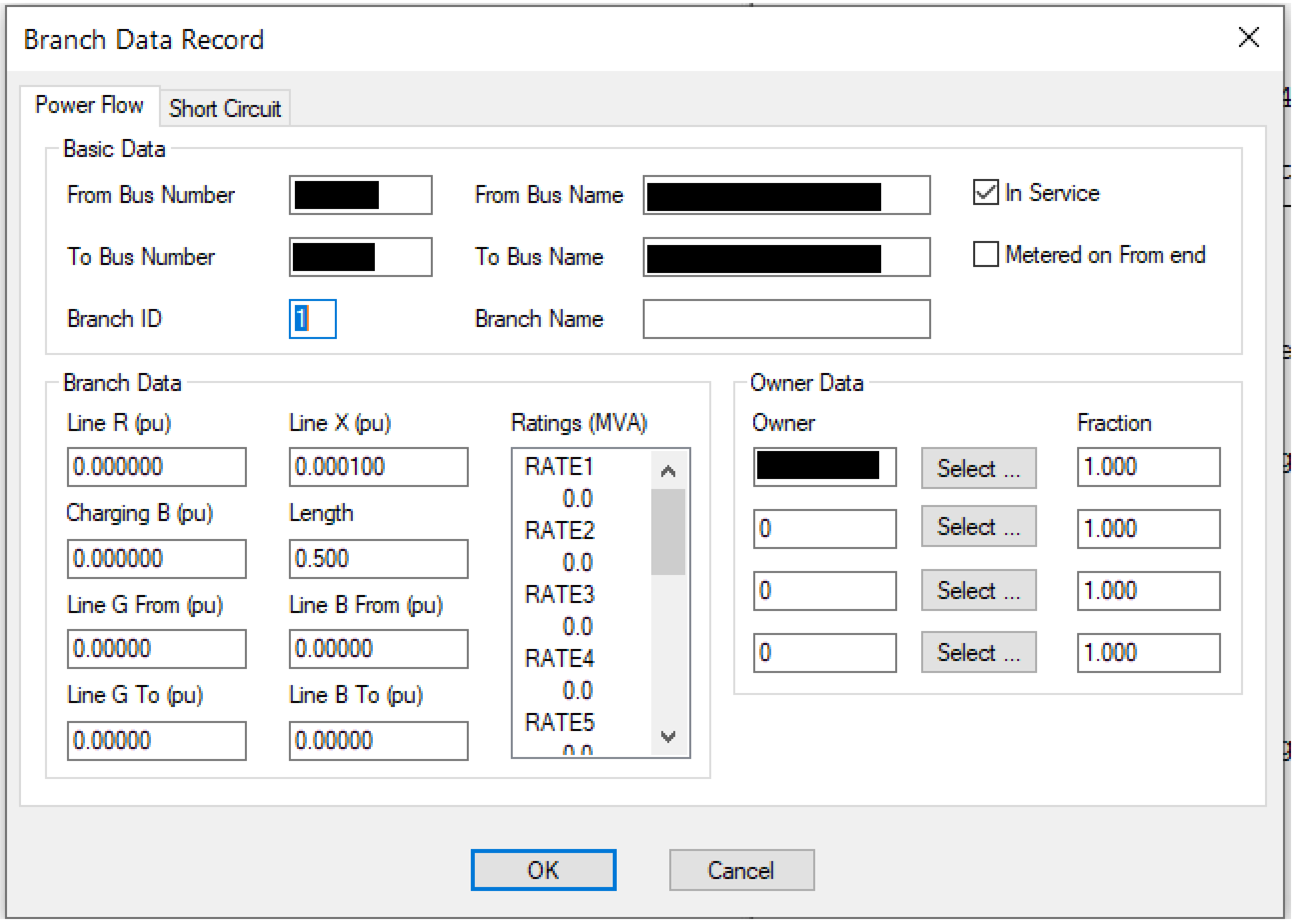
MPT:
Max Nameplate
Z1% & X/R

Gen-Tie:
R, X, B , & Length
(if >20 mi)

Machine:
Pmax = GIR amount
0.95 pf

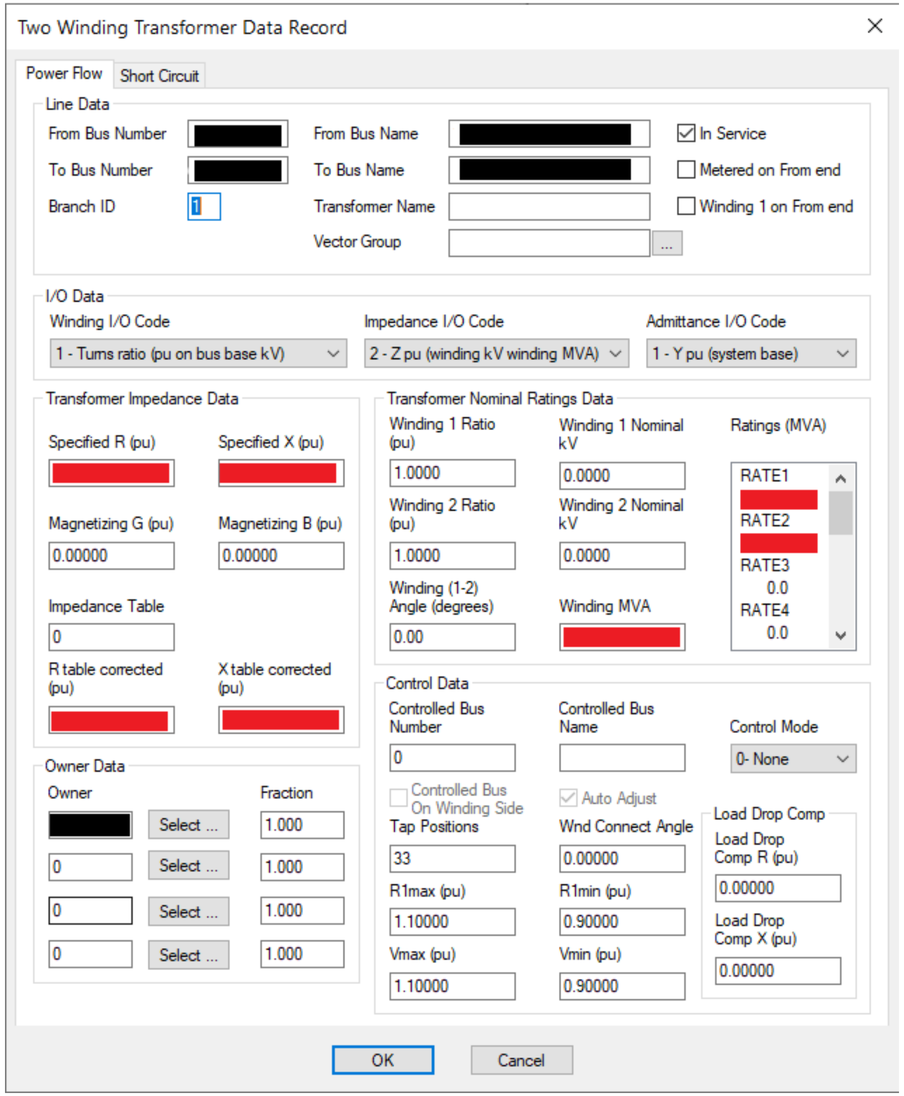
BRANCH REVIEW

- Gen-Tie < 20 miles, as shown
- Gen-tie > 20 miles, explicitly modeled (when provided)
- Collector branch, as shown
- Projects sharing Gen-Ties/facilities will be modeled as such



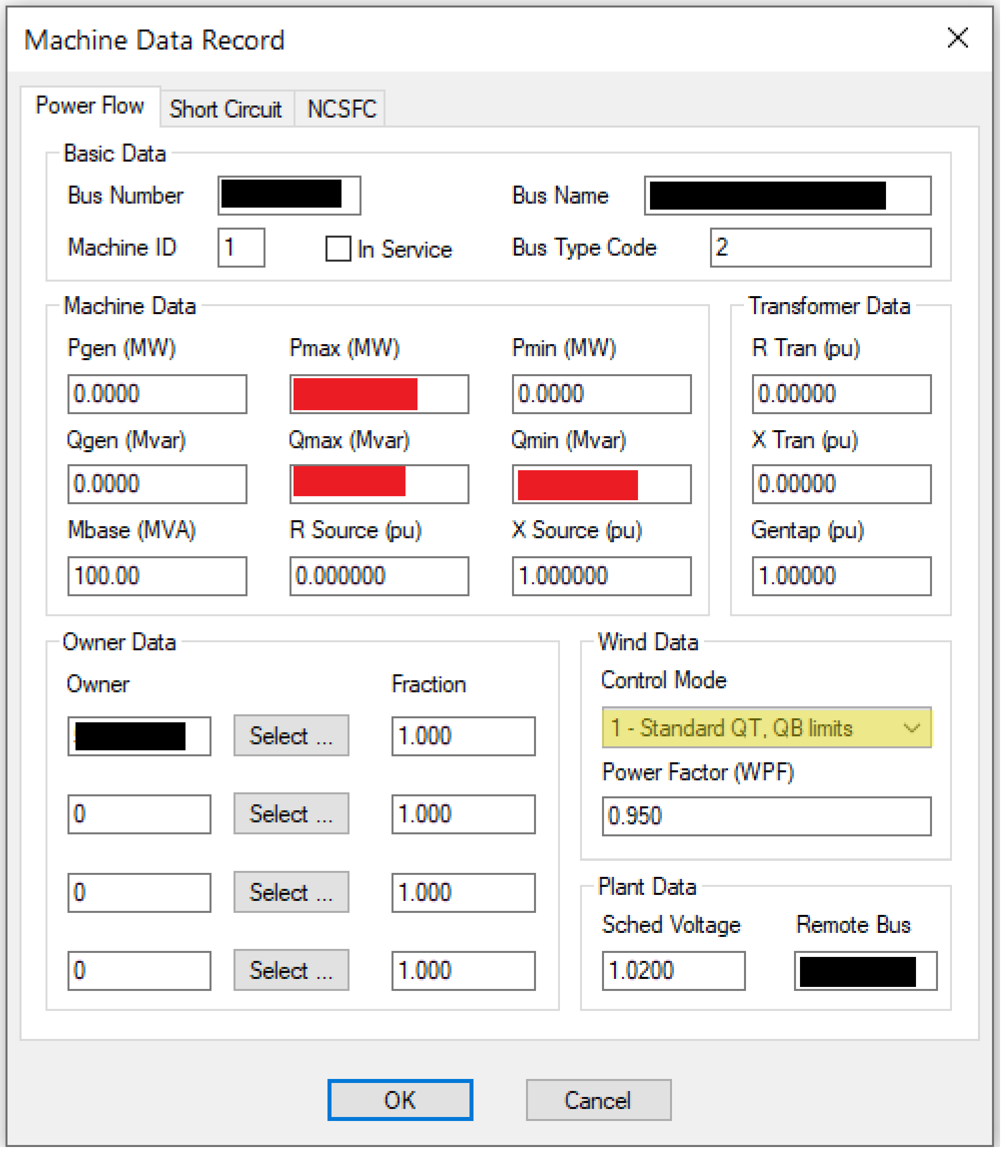
TRANSFORMER REVIEW

- Positive sequence impedance (X/R & Z%)
- MPT
  - Rate 1 & 2 = Maximum Nameplate (MVA)
  - Winding MVA = Maximum Nameplate * 0.6
- GSU
  - Rate 1 & 2 = Maximum Nameplate (MVA) * # of units
  - Winding MVA = Rating



MACHINE REVIEW

- Total Pmax = Requested Interconnection Service Amount
  - Hybrid requests are modeled at full capacity
- 0.95 pf assumed
- Control Mode
  - Conventional – 0
  - Renewables – 2
- Default Remote Bus



MODEL NAMING CONVENTION

Service Type	Dispatch Scenario	Year 2	Year 5	PQ Models	CQ Models	Total
ERIS	HVER	- Summer, 5 groups	- Summer, 5 groups - Winter, 5 groups - Light Load, 5 groups	20	20	40
	LVER	- Summer, SPP Region	- Summer, SPP Region - Winter, SPP Region	3	3	6
NRIS	NR	- Summer, SPP Region	- Summer, SPP Region - Winter, SPP Region - Light Load, 5 groups	8	8	16
Total				31	31	62

DIS	21	1	BC	00	ALL	-	24	SP
DISIS	Study Year	Cluster	Case	Group	Service Type		Year	Season

Case	
BC	Base Case (PQ Models)
TC	Transfer Case (CQ Models)

Group	
00	All groups
01	01 North
02	02 Nebraska
03	03 Central
04	04 Southeast
05	05 Southwest

Service Type	
ALL	ERIS (HVER & LVER)
NR	NRIS

Year	
24	Year 2 from ITP
27	Year 5 from ITP

Season	
SP	Summer Peak
WP	Winter Peak
L	Light Load

GLOBALSCAPE ACCESS

- ***Via the SPP Request Management System (RMS)**, using the "Initiate a System Access Action" **Request Template**, "Access" **Request Type** "Globalscape File Sharing" **Subtype 1, "**Add User" **Subtype 2** and "SPPDocushare / Engineering / TCR Models" **Subtype 3**.*

- For GlobalScape access, you will need a NDA. Here is the link to the confidentiality agreements SPP Confidentiality Agreement Based on your job function, please complete either a competitive (CD) or non-competitive (NCD) NDA and attach it to the RMS ticket and SPP Legal will process.

- Please note, NDAs are executed on the individual level, therefore, if there are multiple parties that need access to the CEII data, we will need an NDA for each person.

- Please attach your completed NDA with your request. Attachments can be added in RMS by clicking the paper clip on the top of the screen by the Request #, or by clicking Attachments in the menu to the right.

REFERENCES

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  - https://spp.org/documents/64300/spp%20oatt%20business%20practices.pdf
- SPP GI Queue
  - https://opsportal.spp.org/Studies/GIActive
- SPP Open Access Transmission Tariff Attachment V
  - https://opsportal.spp.org/documents/studies/SPP%20Tariff%20Attachment%20V%20Generator%20Interconnection%20Procedures.pdf
- Study Results and Report Postings
  - https://opsportal.spp.org/Studies/Gen
- GI Study Cluster Weekly Status
  - https://opsportal.spp.org/documents/studies/sppgistudyupdate_weekly.pdf
- GI Finances (Requirements, Risks, and Refunds)
  - https://opsportal.spp.org/documents/studies/GIFinances.pdf
- GI Business Guide and Practice
  - https://opsportal.spp.org/documents/studies/GuidelinesAndBusinessPracticesForGIP.pdf
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  - https://www.spp.org/documents/68856/spp%20planning%20criteria%20v4.0.pdf