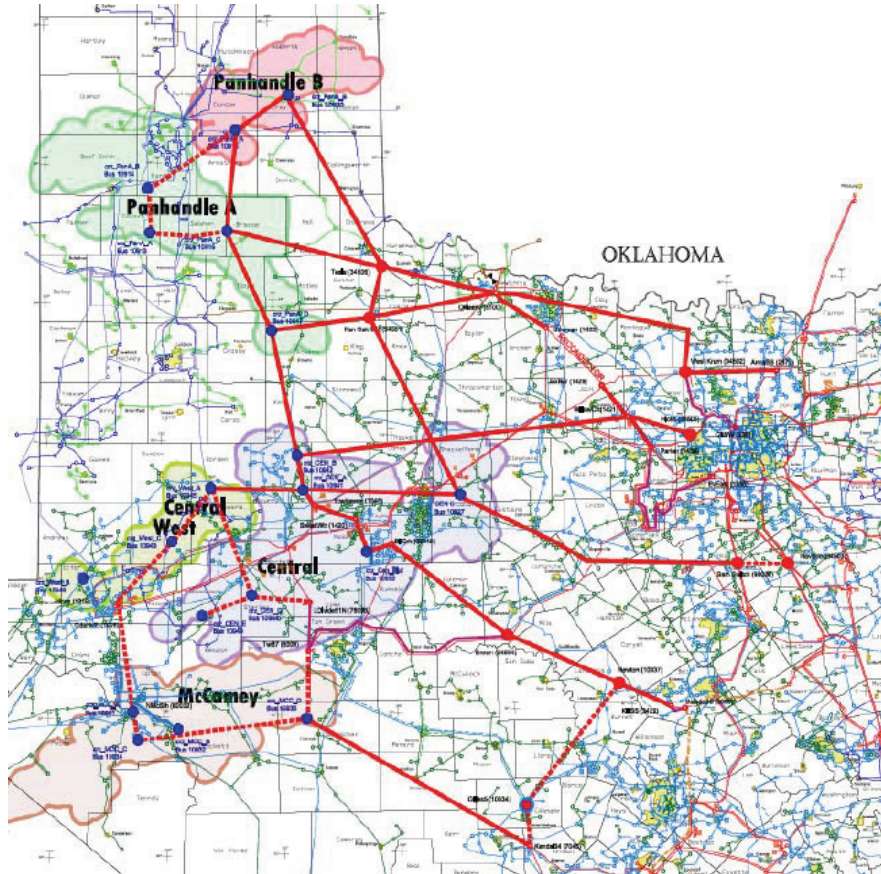


CREZ Reactive Requirements Analysis Presentation Developed by ABB

ERCOT RPG Meeting
November 13, 2009

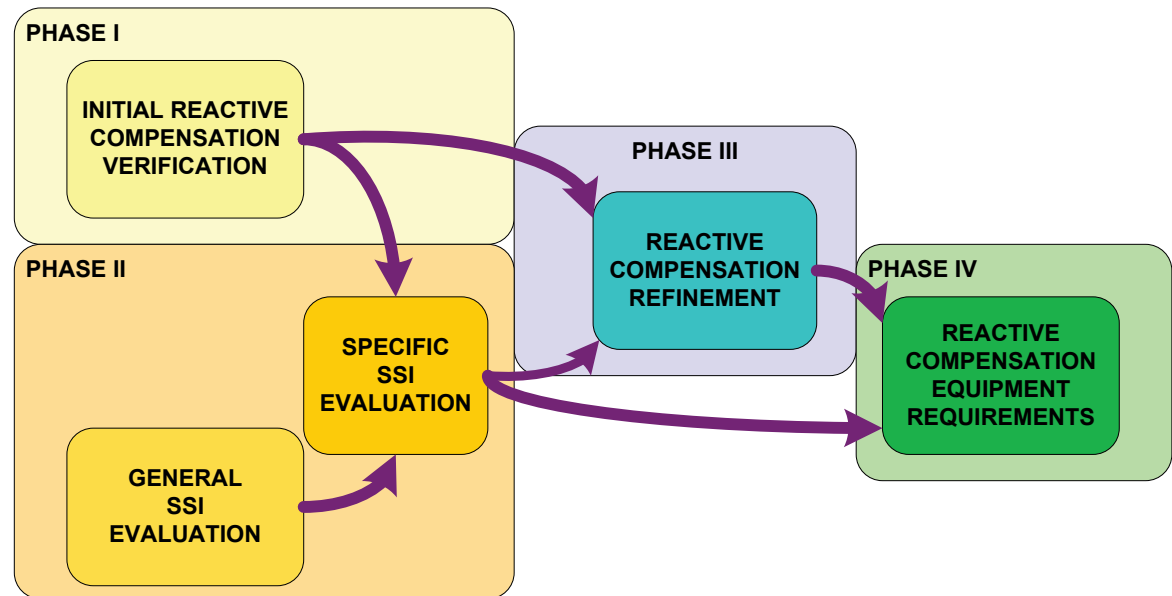
Project Overview



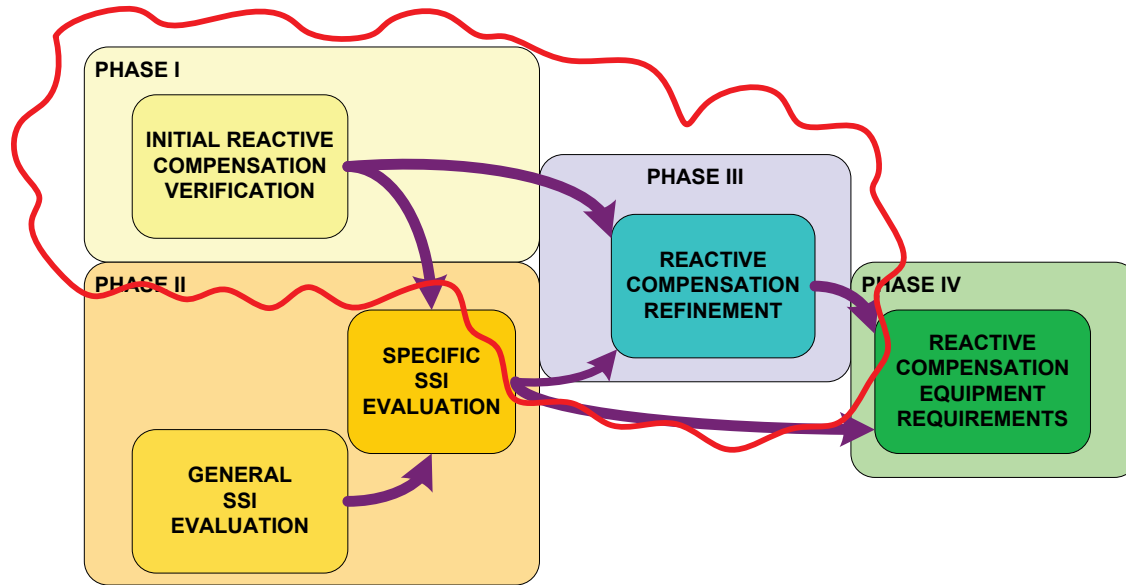
- ERCOT identified three work areas
 - Determine design specifications of CREZ series compensation
 - Provide location, size and response of shunt compensation
 - Evaluate potential impacts of sub-synchronous interactions with ERCOT equipment.
- ERCOT specified 17 scope items

Proposal Overview

- Address work areas in four phases
 - I – Initial reactive compensation verification
 - II – Sub-synchronous Interaction (SSI) evaluation
 - III – Reactive compensation refinement
 - IV – Finalize and compile equipment requirements



Phase I and III: Reactive Compensation Requirements



- Phase I
 - Initial confirmation of series compensation levels
 - Initial determination of shunt compensation levels
- Phase III
 - Refinement of series and shunt levels with consideration of SSI issues and impacts

Phase I and III: Reactive Compensation Requirements Steady-State Analyses

COMPREHENSIVE CONTINGENCY ANALYSES

- ✓ COMPLIANCE WITH THERMAL CRITERIA
- ✓ CONVERGENCE
- ✓ COMPLIANCE WITH VOLTAGE CRITERIA

THERMAL VIOLATIONS

Perform OPF & Conventional

- Identify possible solutions
 - Wind farm curtailment (30 min ?)
 - Series comp rating changes
 - Compensation levels or topology
- Minimize total series compensation costs

Results will be tuned using dynamic analysis

NON-CONVERGENCE & VOLTAGE VIOLATIONS

OPF

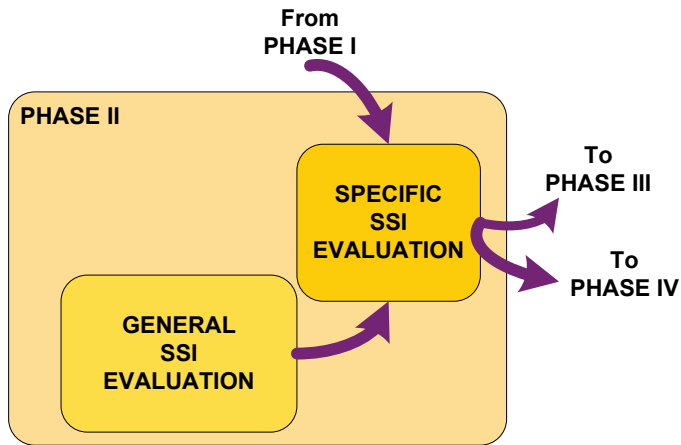
- Characterize reactive deficiency
 - change series compensation
 - curtail wind
 - add shunt compensation

Conventional Powerflow

- QV Curves
 - highlight needs for SVC, STATCOM, etc.
- PV Curves
 - Confirm adequate margin for voltage stability

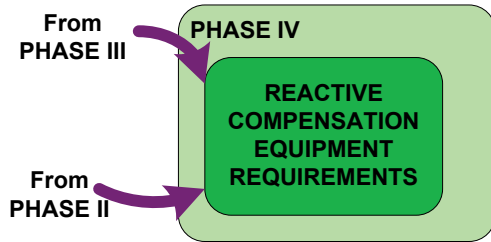
- For shunt compensation, determine split between
 - Mechanically switched capacitors (MSC)
 - Dynamic compensation (SVC, STATCOM, etc.)
 - Steady-state voltage stability
 - Flicker control/Avoiding excessive switching of MSCs

Phase II – Sub-Synchronous Interaction Evaluation



- General SSI issues related to series capacitors used with WTGs
 - Performed in parallel to Phase I
 - Evaluate WTG technology interactions with series caps
 - Information used for evaluation of Phase I results and allows first-cut SSI evaluation of future installations
- Specific SSI issues for Phase I compensation strategy
 - Specific evaluation of WTG technologies with compensation plan from Phase I
 - Evaluate SSR of existing thermal units
 - Evaluate SSI between existing thermal units and active shunt compensation

Phase IV – Equipment Requirements



- Utilize previous results or perform additional calculations (as needed) to determine
 - Steady-State Requirements
 - Fundamental Frequency Short-Circuit Requirements
 - Transient Stability Requirements
 - Equipment Cost Estimates and Performance

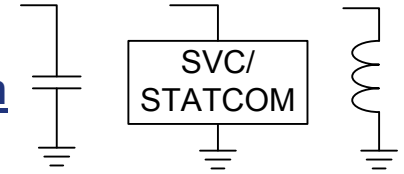
Phase IV – Equipment Requirements

Series Compensation



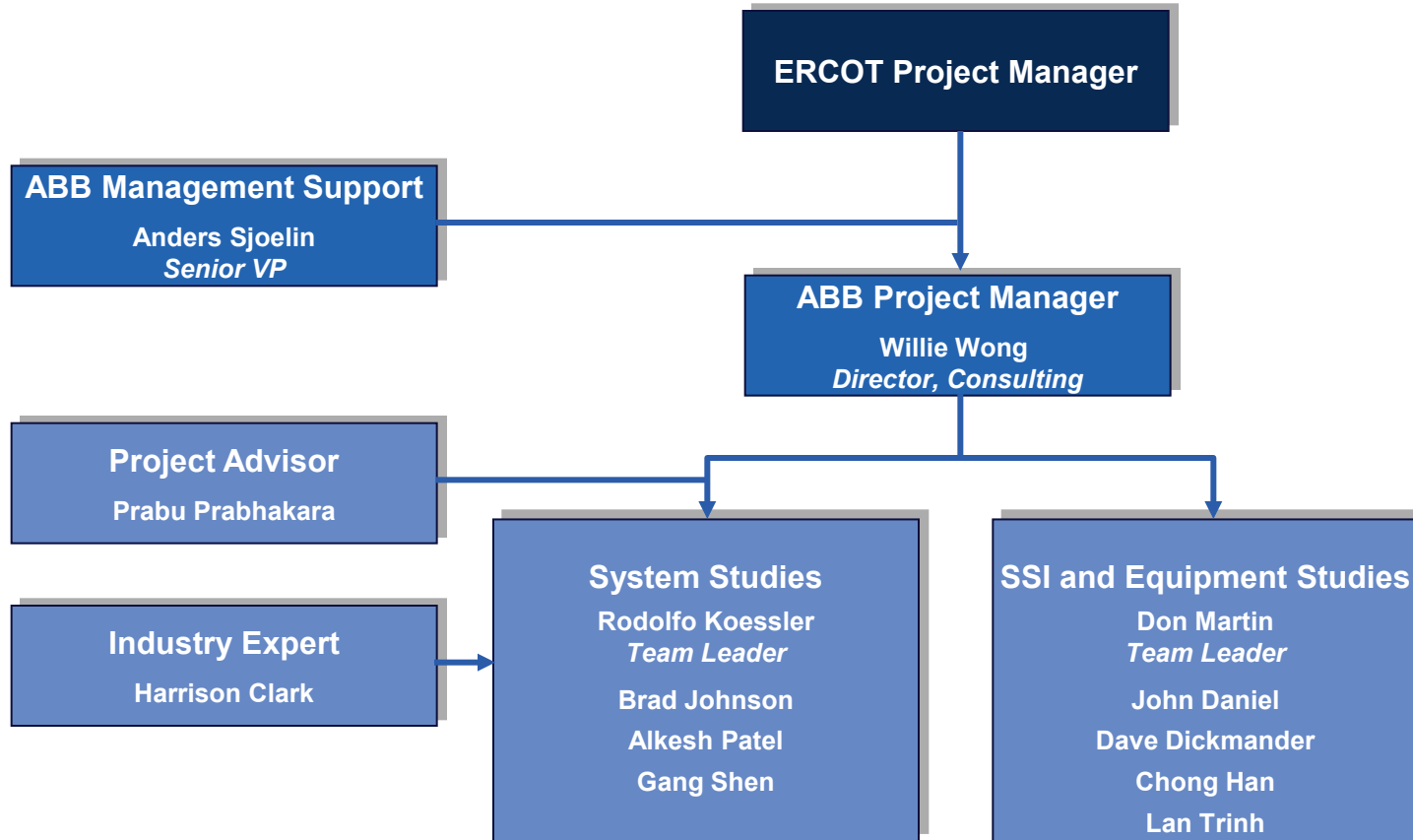
- Series compensation levels for optimum power transfer
- Continuous rating
- 30-minute rating
- Peak transient currents
- Fault current levels
- Optimal locations and capacitor segment size
- Line-voltage profiles
- Estimated cost of conventional series capacitors
- Estimated cost of SSI mitigation
 - TCSC
 - By-pass filters
- Typical reliability/availability
- Typical O&M requirements

Shunt Compensation



- Size, location and estimated costs of
 - Fixed and variable line-reactors
 - Shunt capacitor banks
 - SVCs/STATCOMS
 - Synchronous condensers
- Dynamic reactive power requirements
- Dynamic voltage profiles
- Typical reliability / availability
- Typical O&M requirements
- Need for balancing phase voltages

Project Team





ERCOT CREZ Reactive Study

Questions?