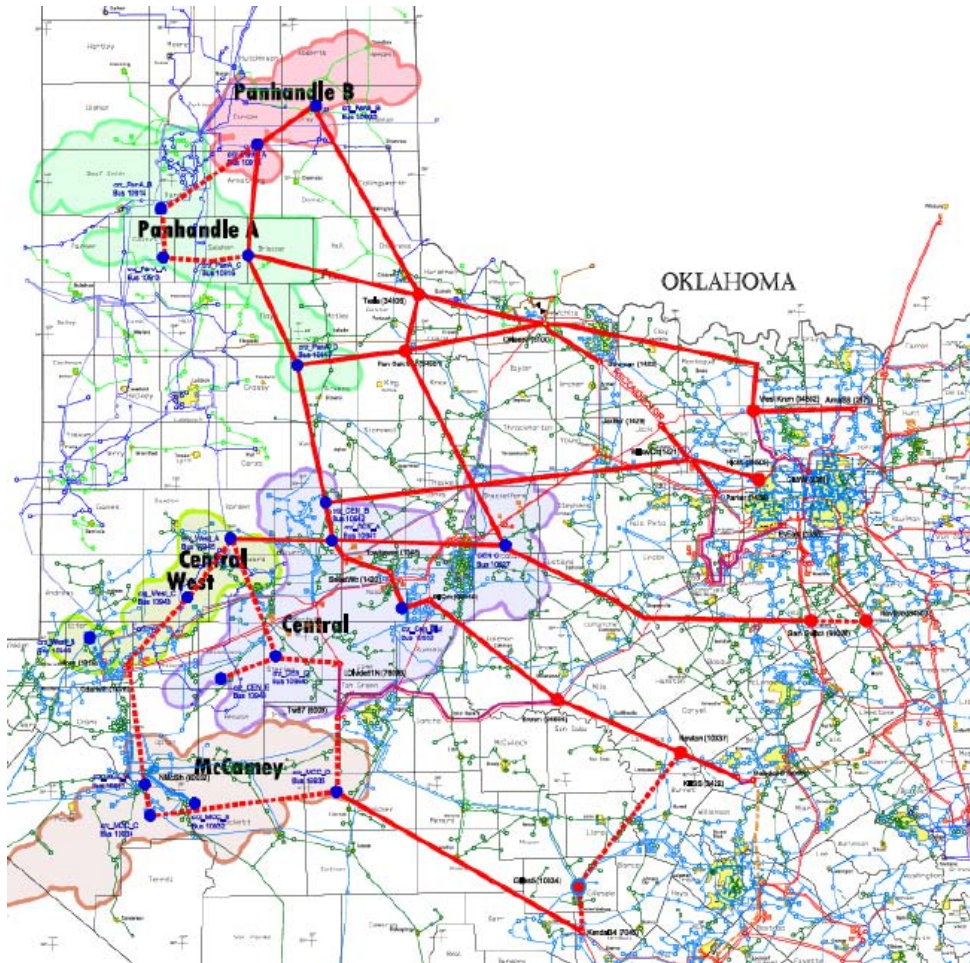


Willie Wong / John Daniel, Grid Systems Consulting / Austin, Texas, March 11, 2010

ERCOT CREZ Reactive Study

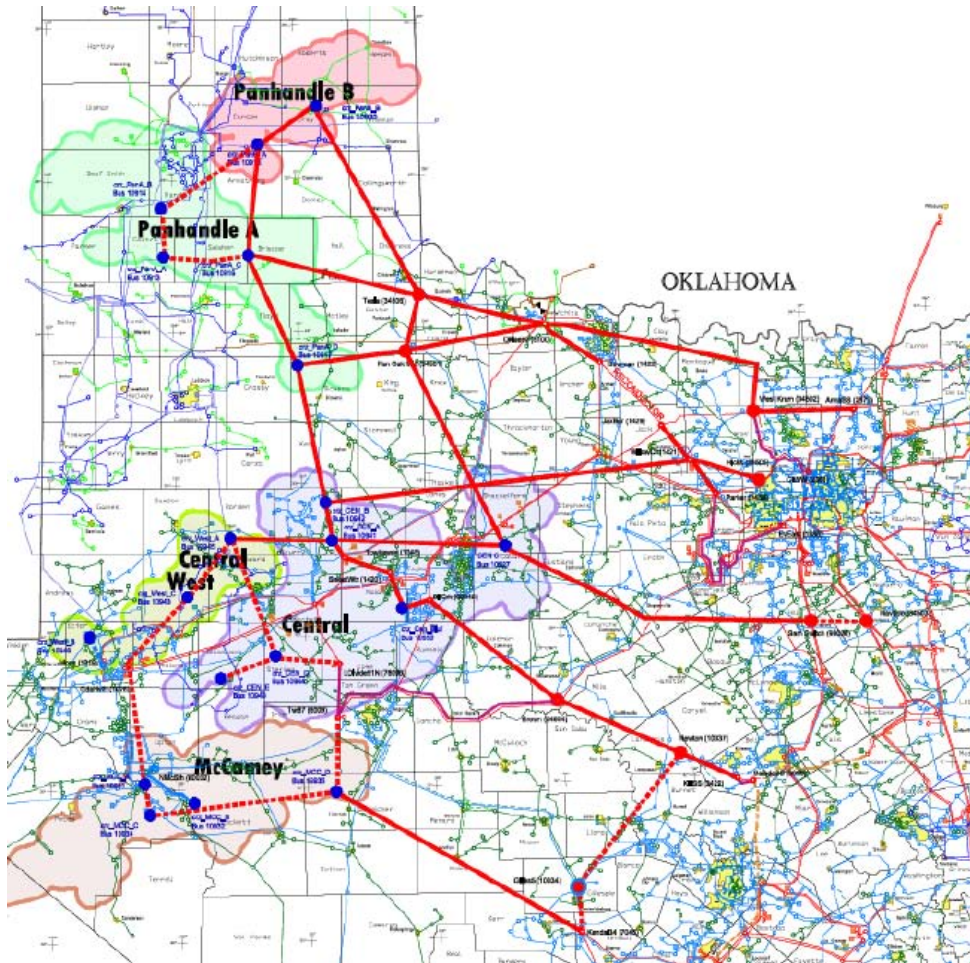
ERCOT ROS Meeting

ERCOT CREZ Reactive Study Overview



- A large-scale, complex study to determine the reactive compensation needs for the CREZ transmission to bring wind energy from West Texas to the eastern load centers.
- Both shunt and series reactive compensation needs are being considered
- Ambitious goals and schedule
- Excellent support being received from ERCOT and the TSPs

ERCOT CREZ Reactive Study Overview



Four (4) basic study categories

- 1) Reactive Compensation Requirements – series and shunt compensation
- 2) Subsynchronous Interactions (SSI) between wind generation and reactive compensation
- 3) SSI between thermal generation reactive compensation
- 4) Equipment Specifications

ERCOT CREZ Reactive Study

1) Reactive Compensation Requirements

- **Purpose:** Determine shunt and series reactive compensation needs for optimal economics and power transmission

- **Critical Results to Date:**

Steady-State analysis of a Maximum Export scenario shows

- A minimum of about 800 Mvar additional shunt compensation around Riley is required to meet voltage stability requirements following critical contingencies (typically double circuit outages).
- Increases in series compensation are not cost-effective in reducing those requirements, but a substation at Clear Crossing would help.
- Reductions in series compensation levels lead to large increases in additional shunt compensation requirements and in the number of critical contingencies.
- System stress is dependent on wind generation assumptions. An additional scenario, with similar wind generation levels, but stressing the southern part of CREZ, is being investigated.

ERCOT CREZ Reactive Study

1) Reactive Compensation Requirements

- **Work in Progress:**

- Completion of steady-state analyses of maximum export scenarios with development of overall compensation strategy.
- Study of minimum export and peak load scenarios, which are likely to provide insight on inductive compensation requirements.
- Setup of dynamic model, with existing and future wind generation, and load dynamics.

- **Future Work:**

- Dynamic Studies. Development of a series and shunt compensation strategy that will meet both steady-state and dynamic needs.

- **Challenges:**

- Complexity of study (multiple scenarios, series vs. shunt compensation, passive vs. active, etc.)
- Enormous amounts of data
- Additional scope being identified as study progresses

ERCOT CREZ Reactive Study

2) Subsynchronous Interactions with Wind Farms

- **Purpose:** identify issues related to SSI between wind farms and series compensation
- **Critical Results to Date:**
 - Evaluations for WTGs on worst case *radial* system
 - Simulations have shown self-excitation for series compensated radial systems with low resistance
 - Self-excitation is theoretically possible for three types of WTGs
 - DFIG types have severe SSI control interaction with series compensated radial systems
 - Bypass filter damped out the self-excitation but did not fully eliminate SSI control interaction for DFIG WTGs in simulations on radial system
 - Thyristor controlled series capacitors eliminated all SSI and self-excitation for radial system

ERCOT CREZ Reactive Study

2) Subsynchronous Interactions with Wind Farms

- **Work in Progress:**
 - Developing the full CREZ system in PSCAD to evaluate SSI on full network
- **Future Work:**
 - Simulations of all four types of WTGs on the full system to more fully evaluate SSI potential
 - Simulations of Bypass Filters or Thyristor Controlled Series Capacitors for locations where SSI mitigation needed
- **Challenges:**
 - Industry only beginning to fully appreciate and understand the phenomena involved

ERCOT CREZ Reactive Study

3) SSI with Thermal Generation

- **Purpose:** identify issues related to SSI between thermal generation and reactive compensation
- **Critical Results to Date:**
 - Preliminary subsynchronous resonance (SSR) evaluations completed for four (4) of six (6) thermal plants identified – Comanche Peak, Tradinghouse Creek, Willow Creek, Oklaunion
 - First three units have initial indications** of SSR with as little as four (4) lines out of service
 - Oklaunion has initial indications** of SSR with as little as two (2) lines out of service
 - Evaluations of mechanical torsional modes at Oklaunion and Willow Creek highlights concern for some but not all torsional modes

** - *not necessarily a problem*

ERCOT CREZ Reactive Study

3) SSI with Thermal Generation

- **Work in Progress:**
 - Verifying torsional modes of concern for Tradinghouse Creek
 - Obtaining torsional data for Comanche Peak
- **Future Work:**
 - Refine SSR evaluations for four completed units
 - Perform SSR evaluations for Hays and Odessa-Ector
 - Perform Subsynchronous Interaction evaluations for active shunt compensation (e.g. SVC) and nearby thermal units (requires completion of reactive compensation requirements)
- **Challenges:**
 - Difficult to obtain machine torsional data. Plant owners, TSPs and ERCOT have been very helpful in approaching manufacturers.

ERCOT CREZ Reactive Study

4) Equipment Specifications

- **Purpose:** Identify steady-state and dynamic requirements for the reactive equipment including any requirements related to SSI mitigation
- **Critical Results to Date:**
 - The steady-state requirements have been documented in the reactive power study
 - A report discussing line voltage profiles for series compensation has been delivered
 - The potential impact of SSI has been identified and potential solutions evaluated
- **Work in Progress:**
 - The study for the dynamic requirements is underway
 - Study of SSI impact on the full system has been started

ERCOT CREZ Reactive Study

4) Equipment Specifications

- **Future Work:**

- Complete evaluation for shunt capacitors and reactors requirements
- Complete evaluation and specifications for series capacitors
- Perform evaluation and specifications for SVC, Statcoms and synchronous condensers.

- **Challenges:**

- Obtaining all data and study results in a timely manner to finalize an optimum solution

ERCOT CREZ Reactive Study Conclusions

- The study is large scale and complex with ambitious goals and schedule.
- Involves a large number of stake holders that provide many good but often diverse ideas and opinions.
- Extensive amounts of data are needed and must be correlated. It can be challenging to obtain in a timely manner.
- Study results are rapidly increasing our understanding of reactive needs and their impact on the system and equipment
- Data issues have caused some delays in the study schedule.
- A major concern is that the data and criteria used to draw conclusions are acceptable to all stakeholders.

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