Panhandle Renewable Energy Zone (PREZ) Study – Scenario 1 Preliminary Results

ERCOT System Planning

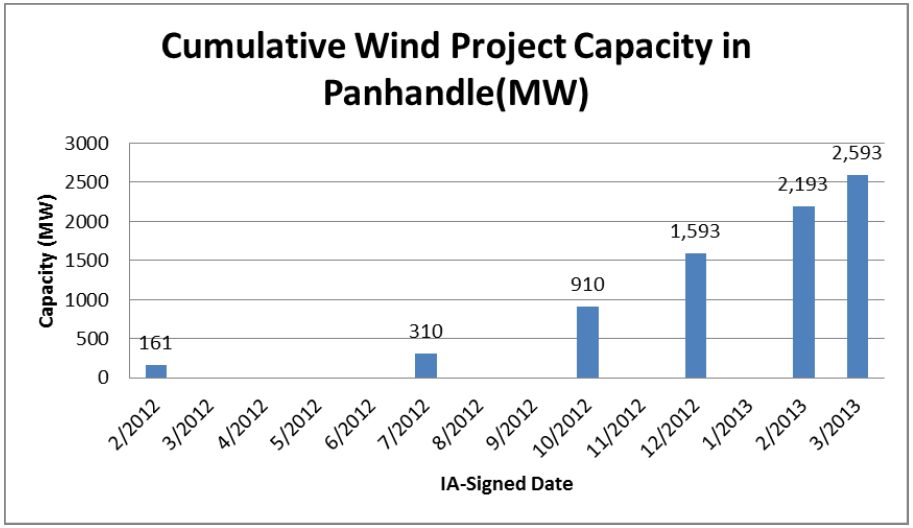
06-25-2013 ERCO Regional Planning Group (RPG) Meeting

Outlines

- Needs and Purpose of PREZ study
- Study Approach
- Preliminary Results – Scenario 1 (5 GW wind in Panhandle)
- Observation and Discussion

Needs of Panhandle Study

- 2012 Long Term System Assessment
  - Indicated significant expansion of wind resources in the Panhandle under a range of future outcomes.
  - If the northwestern-most portion of the Panhandle CREZ system becomes over-subscribed, voltage stability limits will constrain wind power delivery to the rest of the ERCOT system.
- The approved CREZ projects will be in-service by 2013

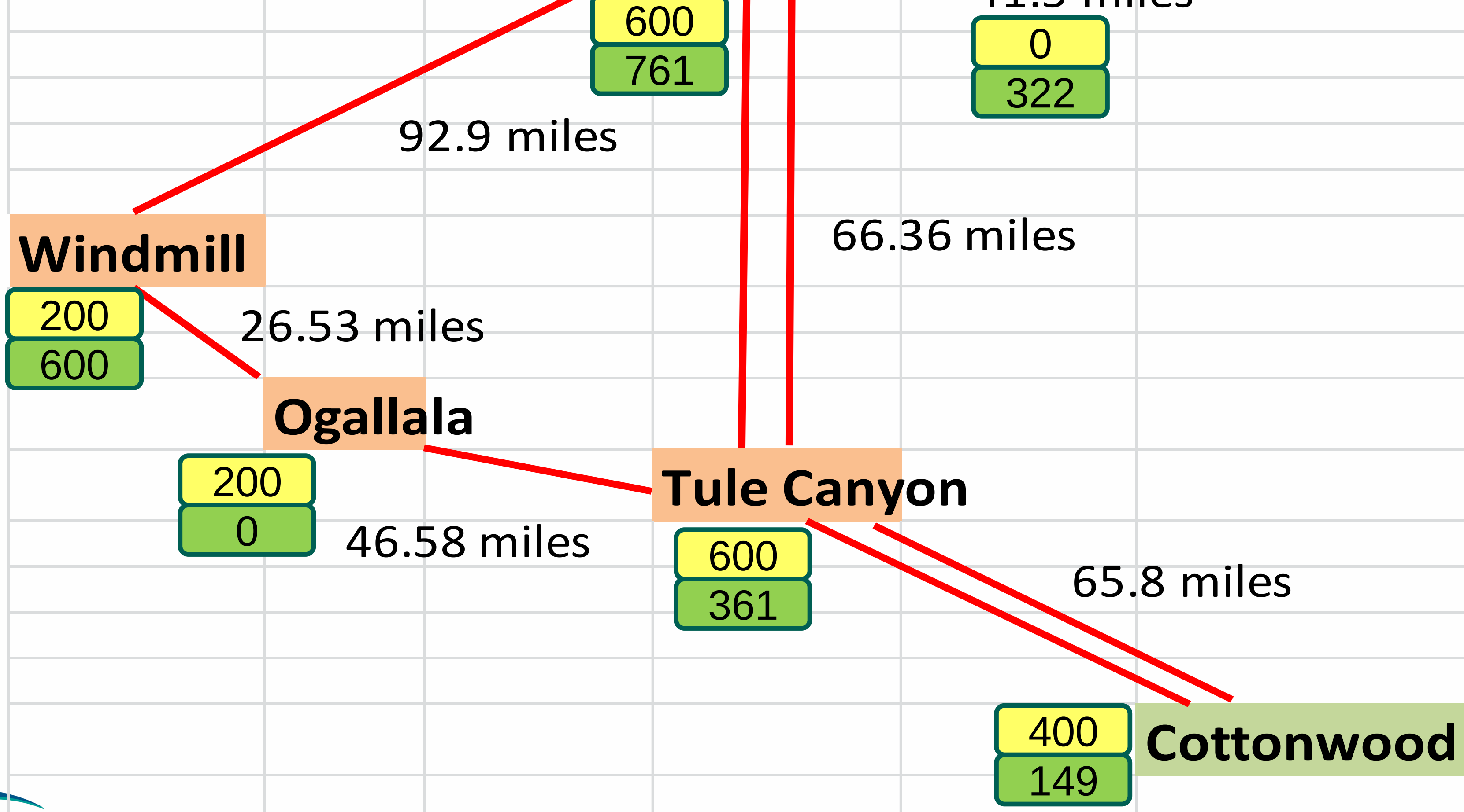


All projects except one with 200 MW are proposed to be in service by 2015.

Initial Build (2400 MW)	IA (2593 MW)	FIS-Complete (2450 MW)	FIS Study (5409 MW)

Panhandle GINR Overview

Updated by March 8th, 2013



Purpose of PREZ Study

- Generation projects will exceed the existing CREZ design capacity (based on the CREZ Reactive Study "Initial Build" recommendations) in the Panhandle area.
- To identify system constraints and improvements required to accommodate future wind generation projects.
- To provide a roadmap for both ERCOT and TSPs to accommodate additional generation resources in the study area.
  - List of potential system improvement projects.
  - Triggers for when those projects will be recommended.

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Study Approach – Scenario 1

- Reliability Analysis:
  - Steady State and Dynamic Stability Analysis
  - Contingency
    - Steady State: NERC B, C and ERCOT double circuit
    - Stability:
      - 3 phase fault normal clearing (NERC B, C and double circuit)
      - single-line-to-ground fault delay clearing (NERC C)

- Economic Analysis:
  - 2017 UPLAN case from 2012 Five-Year Transmission Plan
  - Contingency: NERC B + ERCOT Double Circuit

Study Case: Scenario 1

- SSWG 2016 HWLL(high wind low load) case
  - Wind output dispatch: 8,946 MW (10,785 MW installed capacity)
  - Load: 36.5 GW
- Panhandle Generation Capacity in the scenario 1
  - Scenario 1: IA-Signed + FIS Complete (as of March 08, 2013, based on study scope)
    - Add 5,043 MW of Panhandle wind at 95% output
    - Wind penetration: 37.6% (13.7GW wind output / 36.5 GW load)

Panhandle Station	Scenario 1	Initial Build CREZ
TOTAL	5,043 MW	2,400 MW
Windmill/Ogallala	1,800 MW	400 MW

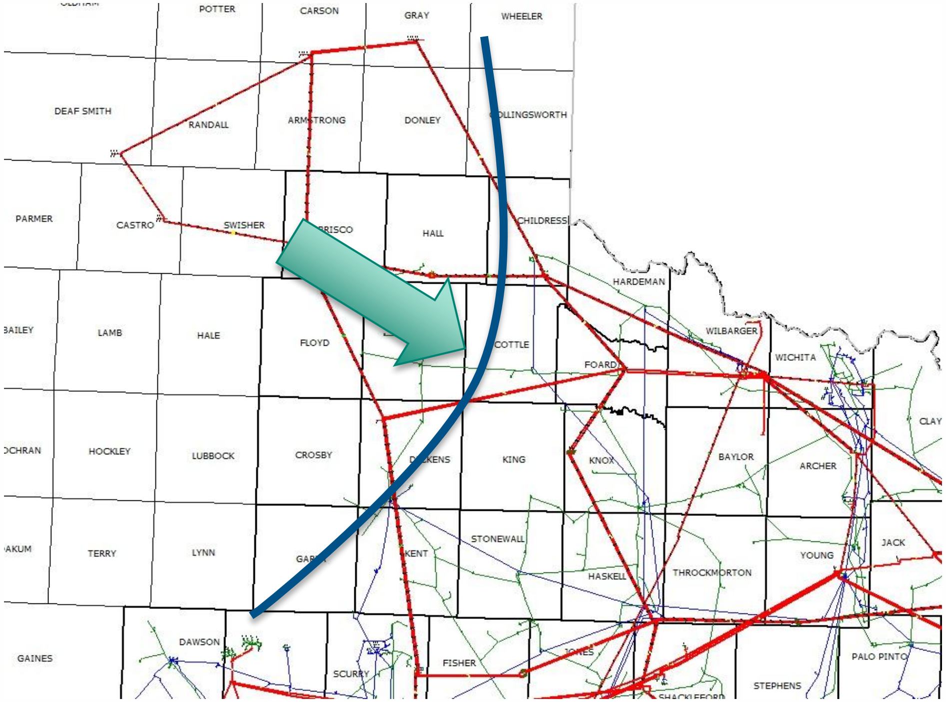
Study Criteria

- Reliability Criteria (ERCOT SOL methodology*)
  - Steady State:
    - Thermal:
      - 100% rate A for base case
      - 100% rate B for contingency analysis
      - 0.95 to 1.05 pu for base case
      - 0.9 to 1.05 pu for contingency analysis
  - Transient stability:
    - Post disturbance voltage within the range from 0.9 to 1.05 pu
    - Post disturbance frequency within the range from 59.4 Hz to 60.4 Hz
- Economic Criteria
  - Thermal: 100% rate A for base case, 100% rate B for contingency analysis

* Available at http://planning.ercot.com/procedures/irtcm/

Study Assumptions

- Panhandle wind project model is based on signed interconnection agreement or full interconnection study report
  - Size, location, turbine type, dynamic model, voltage/frequency ride through capability
- Panhandle Interface



Panhandle Grid Characteristic

- Far away from load centers, long distance transfer
  - Require sufficient reactive support
  - Highly compensated area with switch shunt, SVC
- Dominated by power electronic devices (wind, SVC)
  - Limited short circuit current contribution
  - Low short circuit ratio (inversely proportional to connected wind capacity)

Preliminary Results

- Without upgrades,
  - No thermal constraint in Panhandle.
  - Stability constraint will limit the Panhandle export to 2.6 GW.

- Upgrades are tested and identified based on the following,
  - Adequate reactive support for Panhandle area
  - Improve the system strength (short circuit ratio) for stable response for power electronic controllers (wind farms and SVC)
  - Reduce the transient overvoltage after disturbance

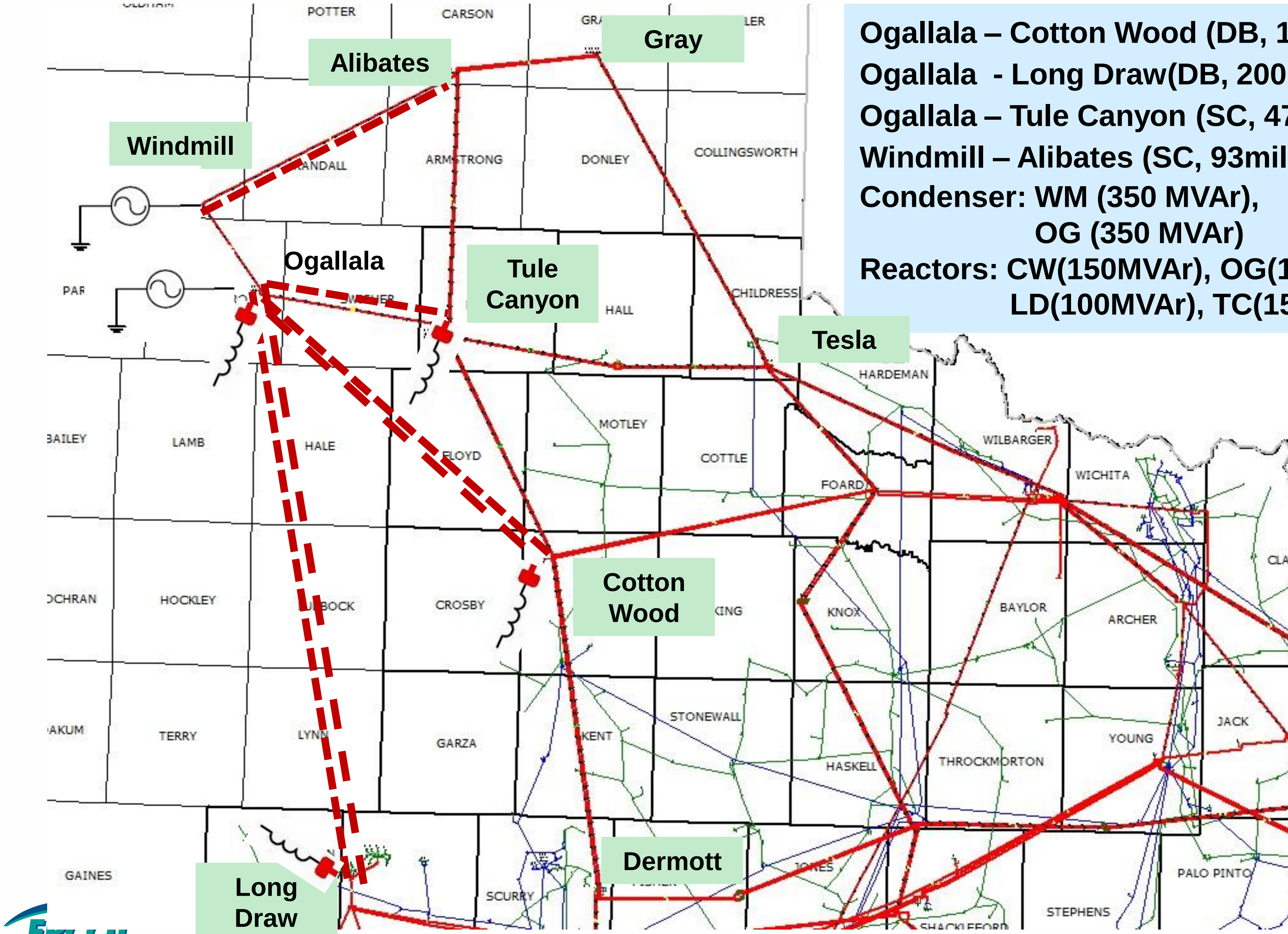
Tested Upgrade Options

Ind.	System Upgrades	Comments
1	**OG – CW(SC)** + OG – TC(SC)	limited transfer in PV study
2	Option 1 + **Phase Shifter Transformer** between GR and TS	limited transfer in PV study
3	Option 1 + Phase Shifters between TC and CW	limited transfer in PV study
4	OG-CW(SC) + OG-WM(SC)	limited transfer in PV study
5	Option 1 + OG - LD(SC)	Dynamic instability
6	Option 1 + **SVC** at Alibates (+300, -100)	Dynamic instability
7	Option 1 + 750 MVar **Capacitors**	Dynamic instability
8	Option 1 + **765 kV** OG-Willow Creek (DB)	Need huge amount of reactors
9	Option 1 + **500 kV** OG-LD (DB)	PV good, to be tested in dynamic
10	Option 1 + 350 MVAr **sync condenser**	Dynamic instability
11	Option 1 + 700 MVAr condenser(GR+AL)	Dynamic instability
12	Option 1 + 700 MVAr condenser(WM+OG)	Dynamic instability
13	Option 5 + 350 MVAr condenser	Dynamic instability
14	Option 5 +700MVAr condenser(GR+AL)	Dynamic instability
15	Option 5 + 700 MVAr condenser(WM+OG)	Acceptable
16	OG-CW(DB)+OG-LD(DB)+OG-TC(SC)+WM-AL(SC)	Acceptable
17	OG-LD(DB)+OG-TC(SC)+WM-AL(SC)+OG-WM(SC)	Acceptable

Tested Upgrade Options – Observation

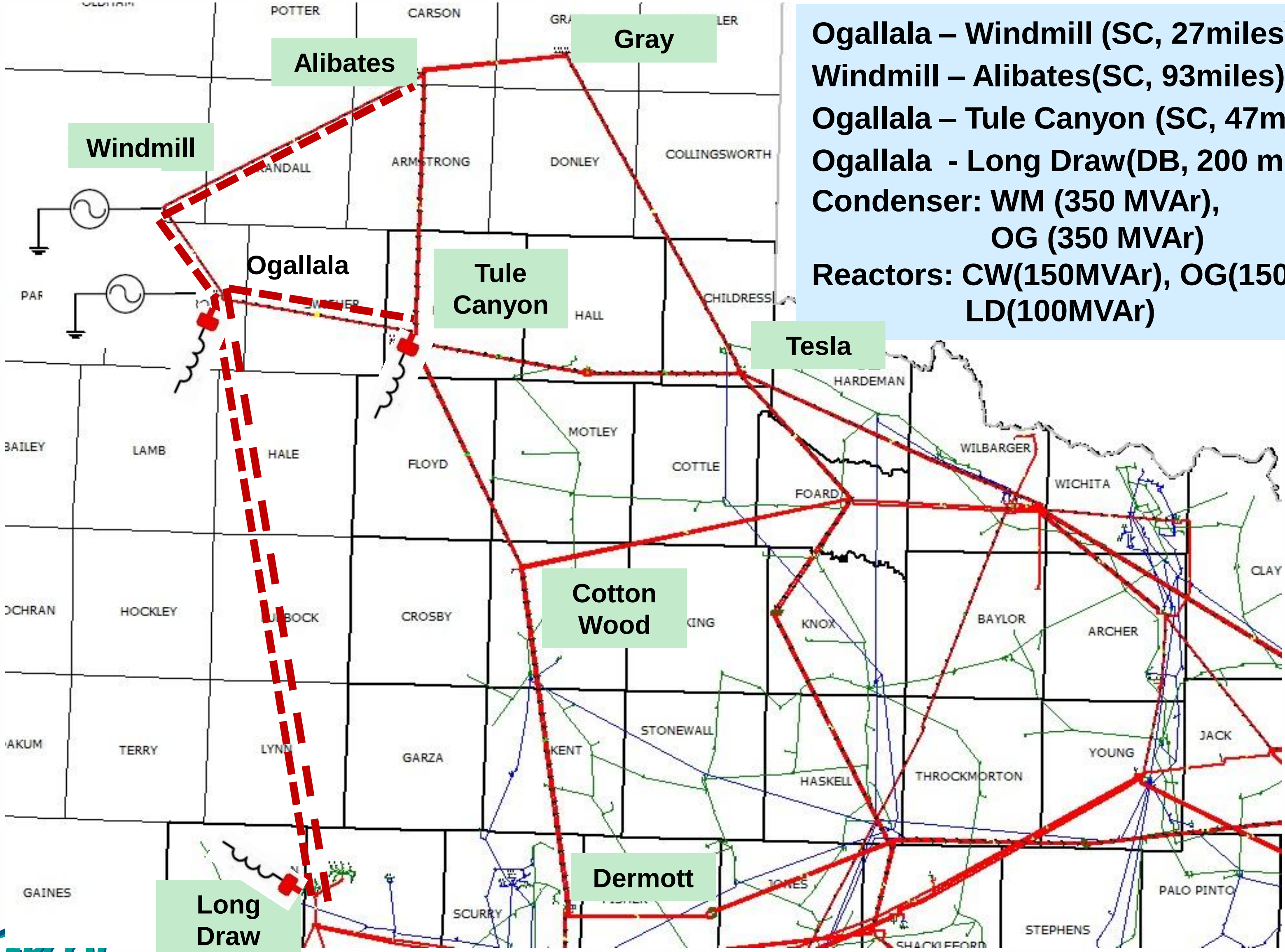
- Static switch shunt:
  - will further compensate the system and lead to higher critical voltage for voltage collapse.
  - Not effective to improve the dynamic stability
- 765 kV:
  - Significant line charging under no/low loading will require large amount of reactors
- Phase shifter transformer:
  - Add additional impedance to the system, not effective to increase the transfer capability
- SVC:
  - Provide good dynamic reactive support
  - Not effective to enhance the system strength
- Sync Condenser:
  - Provide sufficient dynamic reactive support
  - Improve the system strength
- Other Options: Variable Frequency Transformer (VFT), STATCOM, HVDC, 500 kV

Proposed System Upgrade Option A:



Ogallala – Cotton Wood (DB, 100miles)
Ogallala - Long Draw(DB, 200 miles)
Ogallala – Tule Canyon (SC, 47miles)
Windmill – Alibates (SC, 93miles)
Condenser: WM (350 MVAr), OG (350 MVAr)
Reactors: CW(150MVAr), OG(150MVAr), LD(100MVAr), TC(150MVAr)

Proposed System Upgrade Option B:



Ogallala – Windmill (SC, 27miles)
Windmill – Alibates(SC, 93miles)
Ogallala – Tule Canyon (SC, 47miles)
Ogallala - Long Draw(DB, 200 miles)
Condenser: WM (350 MVAr), OG (350 MVAr)
Reactors: CW(150MVAr), OG(150MVAr), LD(100MVAr)

System Upgrade Options – Scenario 1

Upgrade Option	Equivalent Short Circuit Ratio in Panhandle	Max. Wind Trip (MW)
A	1.52*	973**
B	1.51	973

$$* \text{ ESCR} = \frac{\sum(SCMVA\ at\ bus_i * \text{Wind capacity (MW)connect to } bus_i)}{Total\ Wind\ Capcity\ (MW)\ connect\ to\ Panhandle}$$

**Wind farms tripped by overvoltage protection relay based on the settings of wind project's voltage ride through capability.

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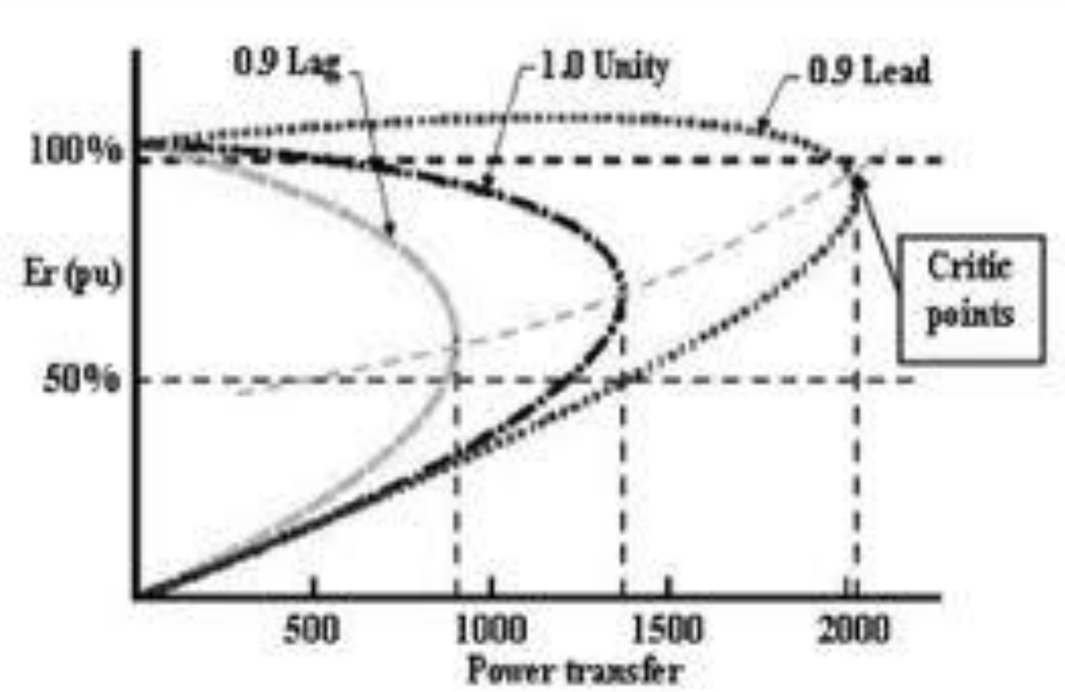
Study Observation – Voltage Stability

- Voltage collapse can occur at higher critical voltage
  - At more leading power factors the maximum power is higher (leading power factor is obtained by shunt compensation). The critical voltage is also higher, which is a very important aspect of voltage stability. **(Caron Taylor, 1994, Power System Voltage Stability)**

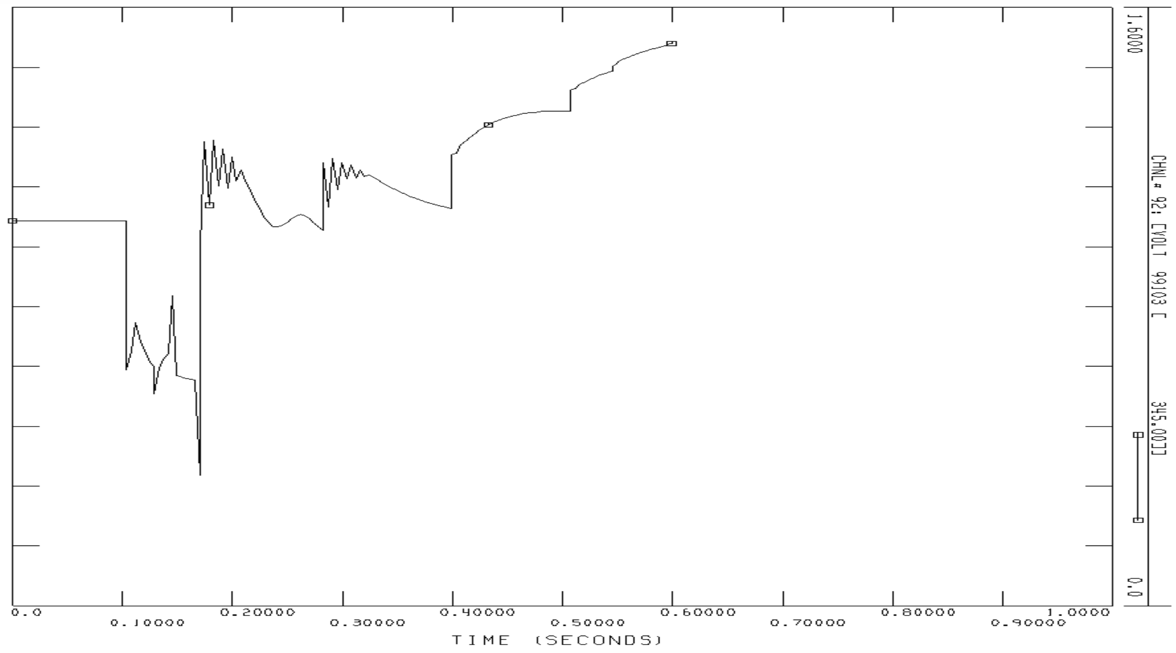


Study Observation – Short Circuit Ratio (SCR)

- The short circuit capacity measures the system voltage strength. A low short circuit capacity means the network is weak. **(Caron Taylor, 1994, Power System Voltage Stability)**
- Power electronic devices (wind turbine, SVC) provide limited short circuit capacity.
- SCR = $\frac{System\ Short\ Circuit\ Capacity\ (MVA)}{Connected\ Wind\ Capacity\ (MW)}$
- Wind turbines may not work properly for the area with SCR less than 1.5
- Without upgrades, SCR at Panhandle can be close to 1.0 with 5 GW wind capacity.
- Measures to improve SCR
  - Synchronous condenser
  - Transmission lines

Study Observation – Voltage Ride Through

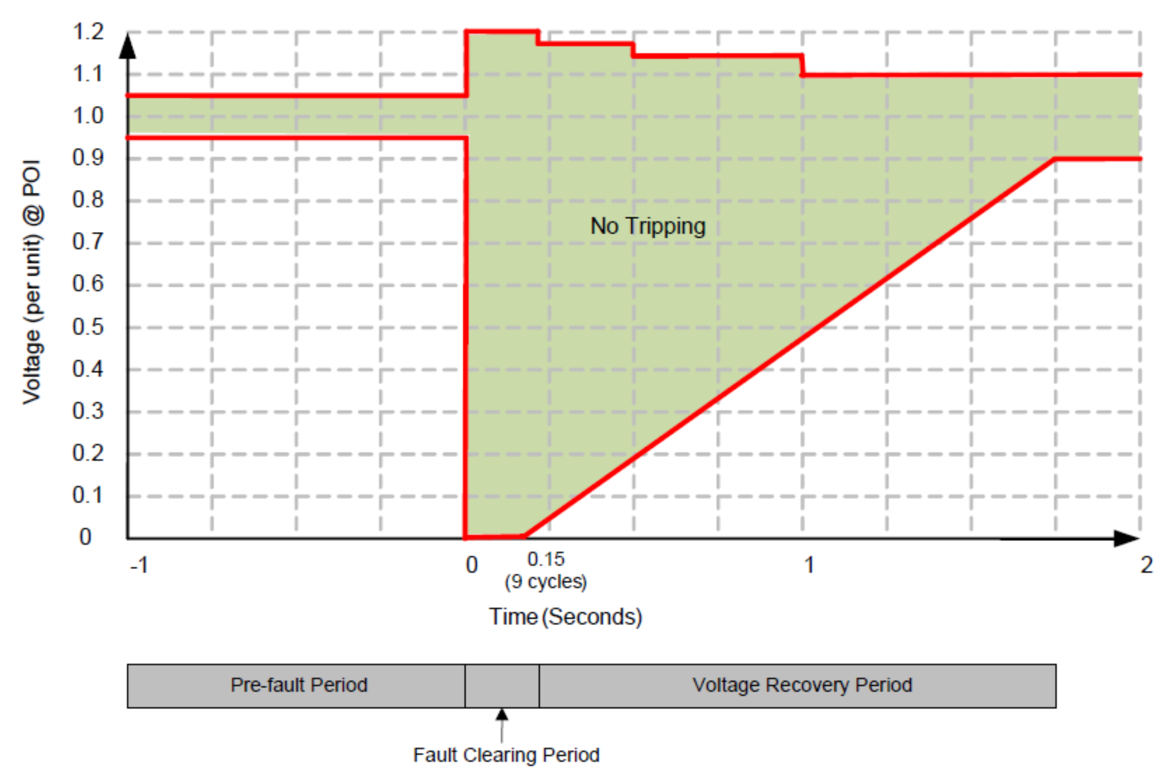
- Weak network conditions can cause transient overvoltage
- Based on the modeled wind farms in the study, 973 MW wind capacity tripped due to transient overvoltage.
  – More capacity can be tripped that can even lead to high voltage collapse in the entire Panhandle area if wind farms are equipped with less voltage ride through capability.



Panhandle 345kV Bus Voltage Response

Proposed High Voltage Ride Through (HVRT)

- Add HVRT base on PRC-024 (Adopted by the NERC Board of Trustees on May 9, 2013)



- No change to the low voltage ride through requirement in Operating Guide 2.9.1

Economic Analysis – Scenario 1

- Without upgrades,
  - No thermal constraint in Panhandle. (case 1)
  - Stability constraint will limit the Panhandle export to 2.6 GW. (case 2)

Case	Panhandle Export Limit	% of congestion *	Production Cost Saving ($M)**
1	5 GW	0%	–
2	2.6 GW (stability constraint)	41%	79

* = (total hours with congestion in Panhandle)/(total hours in 2017,8760 hrs)
** using case 1 as reference for cost saving calculation

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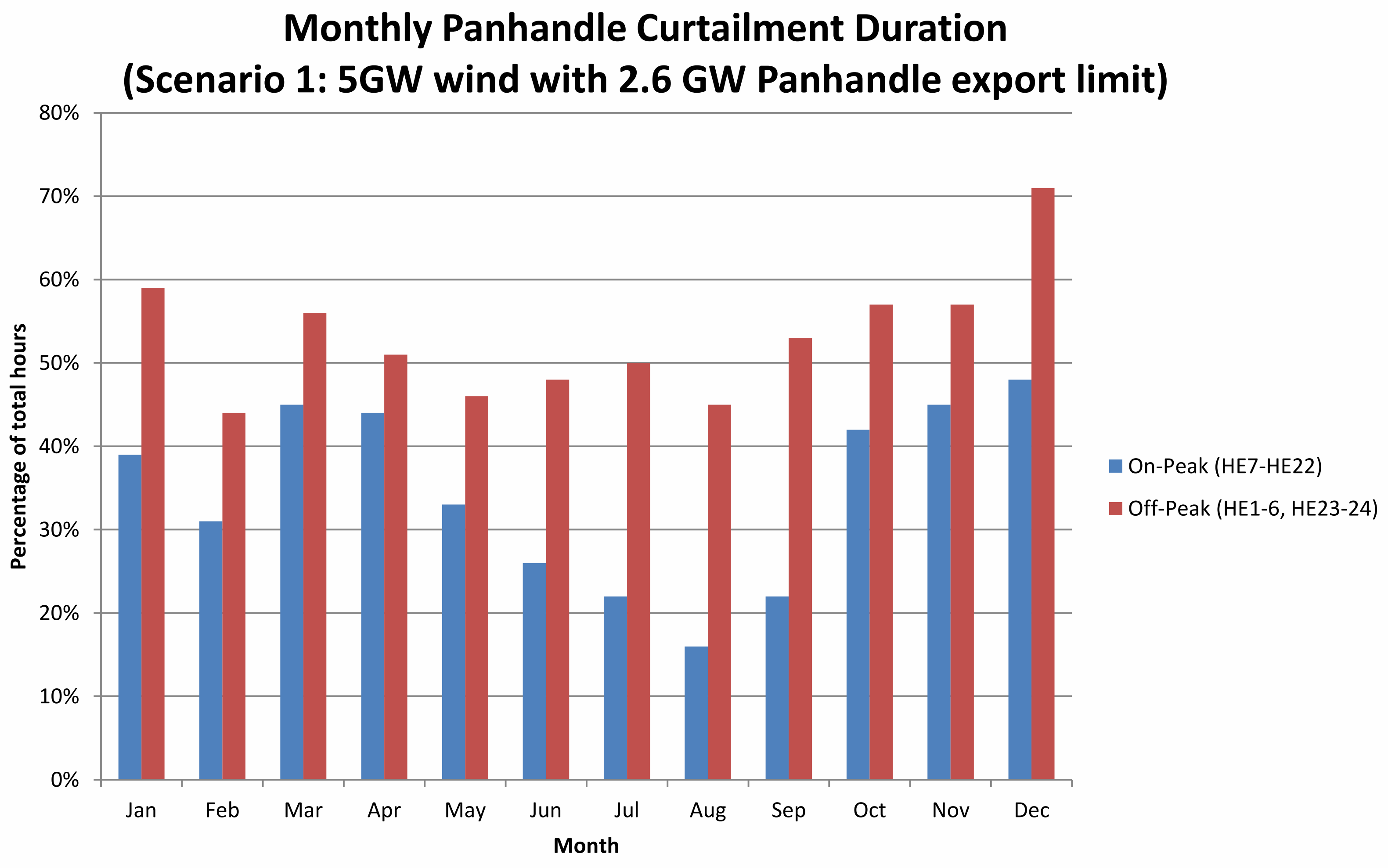
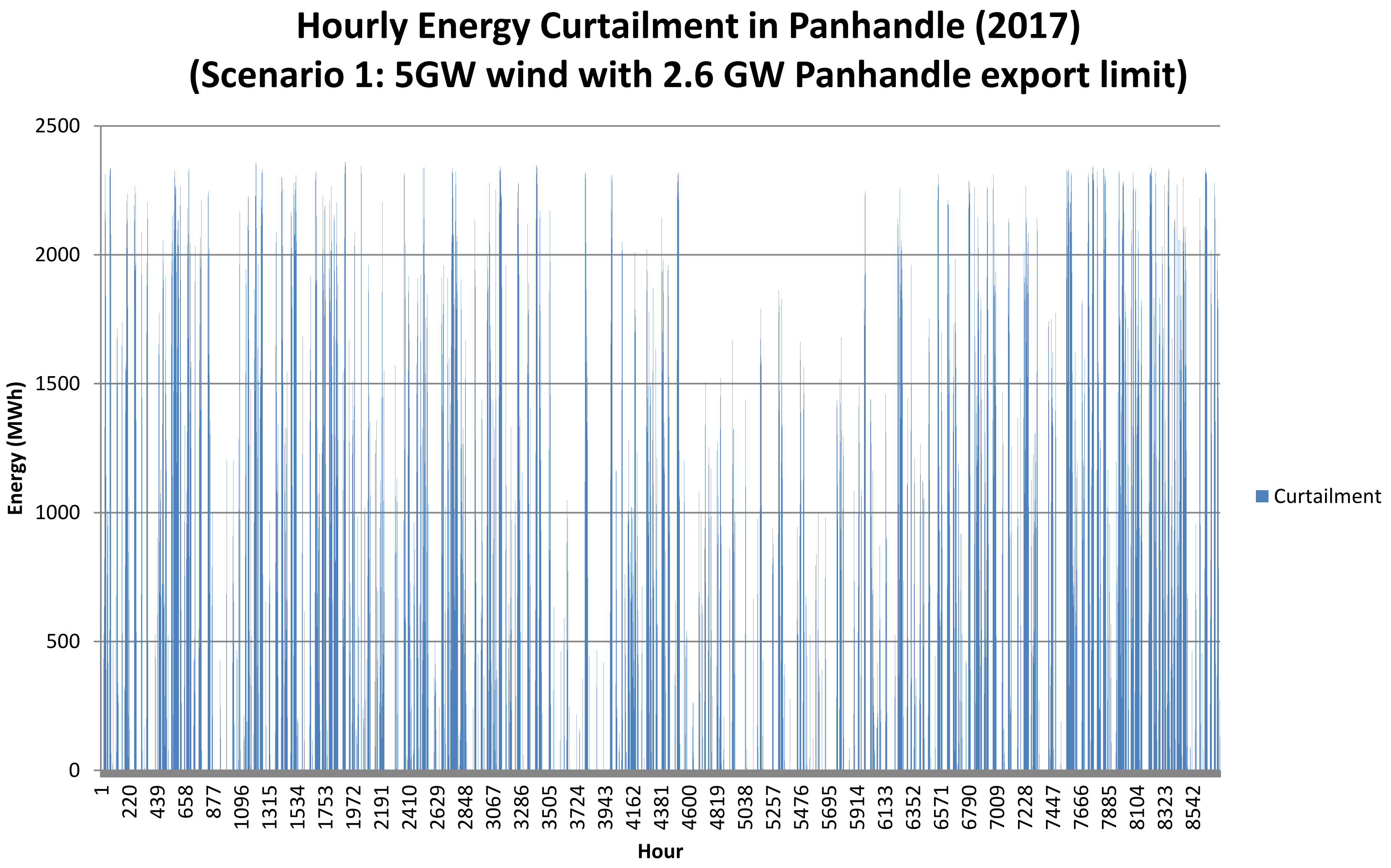
Curtailment Duration Overview (2017)



Curtailment Energy Overview (2017)



Next Step: Scenario 2

- SSWG 2016 HWLL(high wind low load) case
  - Wind output dispatch: 8,946 MW (10,785 MW installed capacity)
  - Load: 36.5 GW
- Panhandle Generation Capacity in the scenario 2
  - Scenario 2: Scenario 1 (IA-Signed + FIS Complete) + additional wind projects under FIS (as of March 08, 2013, based on study scope)
    - Add 7,845 MW of Panhandle wind at 95% output
    - Wind penetration: >40% (16.4GW wind output)

Panhandle Station	Scenario 1	Initial Build CREZ
TOTAL	7,845 MW	2,400 MW
Windmill/Ogallala	3,200 MW	400 MW

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