WIND ENERGY TRANSMISSION TEXAS, LLC
WETT

345kV Bearkat Area Transmission Improvement Project

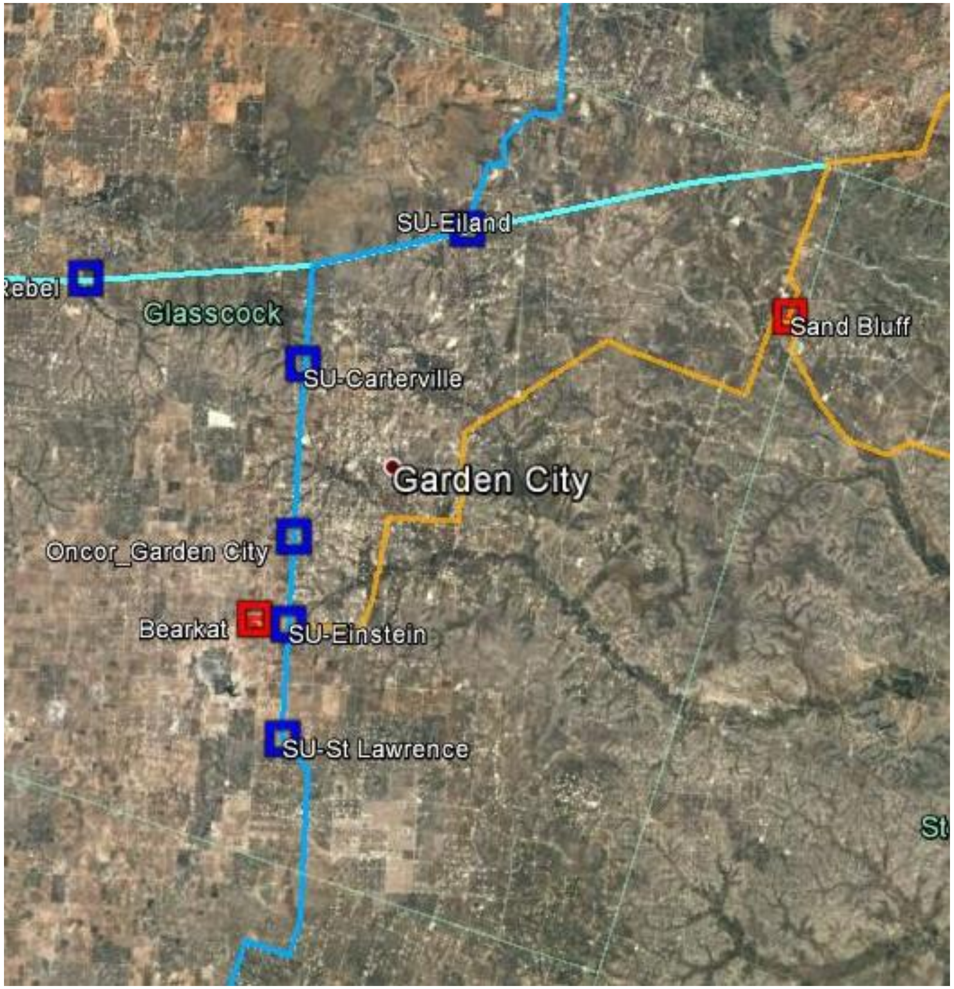
August 22nd, 2017.
ERCOT Regional Planning Group

Agenda:

- Study Background
- Study Objective & Methodology
- Transmission Option Development
- Dynamic Assessment
- Economic Assessment
- Conclusion & Final Recommendation
- Appendix – Transmission Options

Study Background

- WETT's 345kV Bearkat station is located in Glasscock County.
- Bearkat Station has only two transmission outlets
  - 345kV Sand Bluff
  - 345/138kV Einstein
- Existing wind generation
  - Rattlesnake (207 MW)
- WGR meeting Section 6.9 requirements of ERCOT Planning Guide
  - Bearkat Wind Phase 1(196.65MW) (COD: Q3 2017)
  - Bearkat Wind Phase 2(162.15MW) (COD: Q2 2018)
- There are ~800 MW of WGR at various stages of the interconnection process with interest in connecting to the **345kV Bearkat station alone** (in addition to the section 6.9 generations)

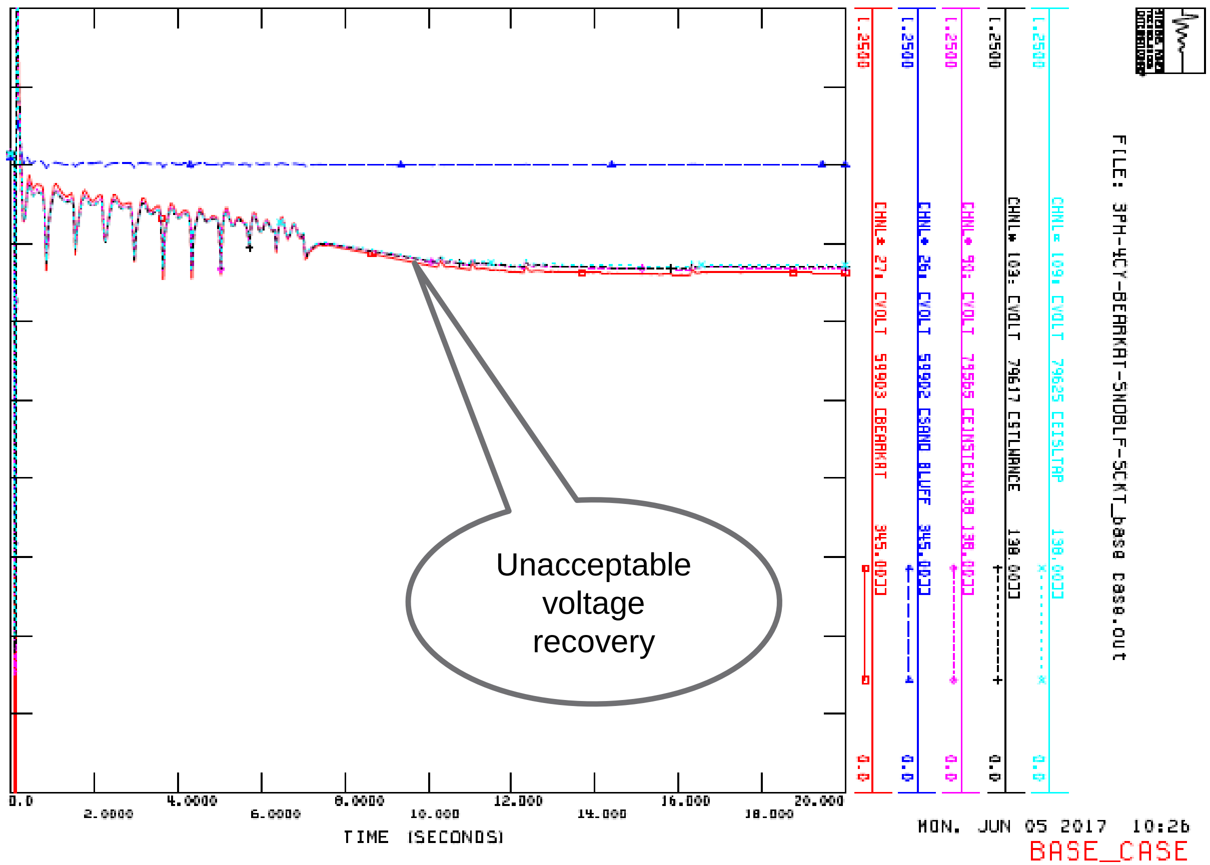


~ 1365 MW of generation that needs to be planned for at 345kV Bearkat station

Study Background

- Stability assessment portion of the Bearkat Wind Full Interconnection Study (FIS) (dated January 30, 2017) has been indicative of instability issues following the loss of Bearkat – Sand Bluff 345kV line:
- This will limit the ability of the Bearkat station to accommodate planned generation resources.
- Per ERCOT Planning Guide Section 5.4.5 (6) (recently approved PGRR54), WETT, in collaboration with the IE, has studied various solution options to mitigate the instability issues observed in FIS.
  - Changes to the proposed Generation Resource were observed not feasible to resolve the instability issues
  - Need for interim - Remedial Action Scheme (RAS):
    - WETT is developing and will propose RAS that would limit Bearkat Wind generation to avoid the violations observed in the FIS
  - Need for transmission improvements as the Exit Strategy from RAS
- WETT has also observed other system issues during the steady state assessment of the Bearkat Wind generation FIS (dated April 20, 2017):
  - Non-convergence solutions and/or thermal overloads following select N-1-1 events (P6 event) involving loss of Bearkat – Sand Bluff line
  - Further limit the transmission deliverability of low cost wind generation resources connecting to and/or planned to connect to Bearkat station
  - WETT recognizes the need for supplemental economic justification associated with the same

Study Background



Voltage Response – Loss of Bearkat to Sand Bluff 345kV line (NERC TPL P1 Condition)

Study Objective & Methodology

Study Objective

To identify the most cost-effective transmission addition and/or upgrade to address the instability (and thermal) violations observed following addition of proposed generation interconnections at Bearkat station while keeping an eye at the long-term needs of the Study Region:

Study methodology

1. Development of transmission options to further increase the Bearkat station generation limit.
   - Initial screening performed to identify the options suited for further detailed dynamic and supplementary economic assessment
2. Dynamic assessment to identify generation limits at Bearkat station associated with each shortlisted option.
3. Preliminary economic assessment to evaluate the impact of relieving potential congestion at the Bearkat station on the production cost savings for increasing levels of generation at Bearkat station (Phase 1 of economic assessment)
4. Supplementary Economic assessment to evaluate the performance of shortlisted options with additional WGR capacity at the Bearkat station (above those meeting Section 6.9 requirements) to align with the stability limits obtained from the stability assessment. (Phase 2 of economic assessment)

Transmission Options Development

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Transmission options were considered keeping in mind following performance criteria:

- Primary:
  - Effectively mitigate the instability issues observed following addition of financially committed generation at Bearkat Station.
  - Reduce dependency on the existing 345kV Bearkat – Sand Bluff line to export power generated at Bearkat Station
  - Cost-effectiveness of the over-all solution while keeping in mind the long-term needs of the region.

- Additional Benefits to the wider region (if applicable):
  - Ability to serve as an additional 345kV source to the load intensive 138kV system in Stanton/Midland.
  - Ability and flexibility to accommodate additional generation at Bearkat for the foreseeable future.

Transmission Options Development

Combinations of following were considered:

- 345kV and 138kV connections to the existing grid,
- Addition of dynamic VAR support equipment
- Combination of above

Initial Screening results:

- Options that did not involve at least one (1) new 345kV path resulted in instability.
- Options that involved a 138kV connection were observed to result in thermal constraints, and congestion on the 138kV system after the loss of the 345kV Bearkat to Sand Bluff line for increasing generation levels.
    - Not a long term solution for the needs of the region
- The dynamic VAR support options, while providing voltage support, are not expected to provide benefits in terms of mitigating the thermal constraints in the study region.
- The transmission options deemed feasible for further assessment were those that involved a new 345kV generation outlet path in the study region.

Transmission Options Development

Eight (8) Final Transmission Options Selected for Detailed evaluation

Option #	Description
1	Add new 345kV Coulomb station (2 breaker ring-bus)
	Add a new 138kV bay for break-and-a-half configuration plus breaker at 138kV Driver
	Add a new 345/138kV Auto (750 MVA) at Coulomb station
	Add a new 345kV bay for break-and-a-half configuration plus breaker at 345kV at Bearkat
	Add a new 345kV line (double circuit capable) from the Bearkat station to the 345kV Coulomb station
2	Tap 345kV Longshore -Midessa line and add a new 345kV Crespin station (3 breaker ring-bus), 24 miles from Longshore
	Add a new 345kV bay for break-and-a-half configuration plus breaker at 345kV at Bearkat
	Add a new 345kV line (double circuit capable) from the Bearkat station to the new 345kV Crespin station
3	Add a new 345kV bay for break-and-a-half configuration plus breaker at 345kV Longshore
	Add a new 345kV bay for break-and-a-half configuration plus breaker at 345kV at Bearkat
	Add a new 345kV line (double circuit capable) from the Bearkat station to the 345kV Longshore station
4	Tap 345kV Grelton - Odessa line and add a new 345kV Crespin station (3 breaker ring-bus), 18 miles from Grelton
	Add a new 345kV line (double circuit capable) from the Bearkat station to the 345kV Crespin station
	Add a new 345kV bay for break-and-a-half configuration plus breaker at 345kV at Bearkat
5	Add a new 345kV bay for break-and-a-half configuration plus breaker at 345kV Grelton station
	Add a new 345kV line (double circuit capable) from the Bearkat station to the 345kV Grelton station
	Add a new 345kV bay for break-and-a-half configuration plus breaker at 345kV at Bearkat
6	Add new 345kV Coulomb station (3 breaker ring-bus)
	Add a new 138kV bay for break-and-a-half configuration plus breaker at 138kV Driver
	Add a new 345/138kV Auto (750 MVA) at Coulomb station
	Add a new 345kV line (double circuit capable) from the Bearkat station to the 345kV Coulomb station
	Tap 345kV Grelton - Odessa line and add a new 345kV Crespin station (3 breaker ring-bus), 20 miles from Odessa
	Add a new 345kV bay for break-and-a-half configuration plus breaker at 345kV at Bearkat
	Add a new 345kV line (double circuit capable) from the Coulomb station to the new 345kV Crespin station
7	Add a new 345kV bay for break-and-a-half configuration plus breaker at 345kV Divide
	Add a new 345kV bay for break-and-a-half configuration plus breaker at 345kV at Bearkat
	Add a new 345kV line (double circuit capable) from the Bearkat station to the 345kV Divide station
8	Add a new 345kV bay for break-and-a-half configuration plus breaker at 345kV Odessa
	Add a new 345kV line (double circuit capable) from the Bearkat station to the 345kV Odessa station
	Add a new 345kV bay for break-and-a-half configuration plus breaker at 345kV at Bearkat

Dynamic Assessment

- **Scenarios:**
  1. *Base* transient stability assessment to evaluate all eight (8) select options from a transient voltage and angle stability standpoint.
  2. *Sensitivity* analysis with increased generation at Bearkat station to assess the potential of the proposed options in terms of accommodating future generation additions at Bearkat station
- **Assumptions:**
  - DWG 2020HWLL dynamic dataset as the base dataset
  - All generation meeting Section 6.9 requirements of the ERCOT planning guide close to Glasscock county not already included in the ERCOT posted dataset were incrementally modelled
    - Wind dispatch at 85%
    - Solar dispatch at 47%
  - Financially committed generation at Bearkat (567 MW) was dispatched at 100%
  - Applicable NERC planning events spanning across P1-P7 categories studied
- **Stability Criteria:**
  - P1 events: voltage shall recover to 0.90 p.u. within five seconds after clearing the fault.
  - P2-P7 events: voltage shall recover to 0.90 p.u. within 10 seconds after clearing the fault.
  - Damping ratio more than 3%
  - Loss of source should not exceed the ERCOT Responsive Reserve Service

Dynamic Assessment - Results

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Transmission Option #	Generation connected at Bearkat Station	
	Financially committed generation (MW)	Incremental Generation limit (MW)
1	570	326
2	570	730
3	570	730
4	570	730
5	570	680
6	570	730
7	570	660
8	570	670

Dynamic Assessment Based Generation Limits at Bearkat Station

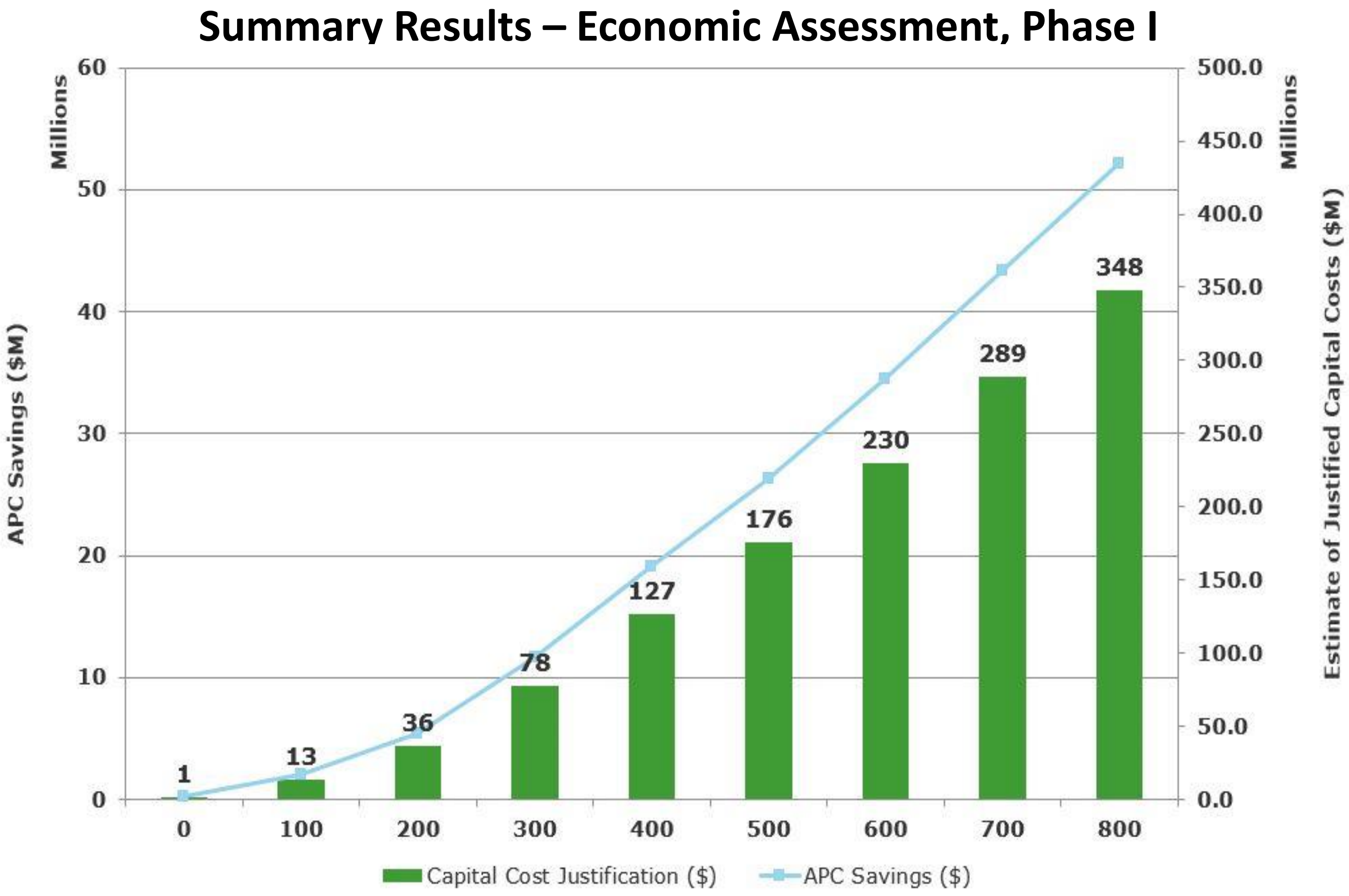
Economic Assessment Objectives:

- **Phase I:**
    - Identify the total APC savings with all constraints due to the Bearkat – Sand Bluff 345kV contingency in the study region are eliminated
    - Estimate the total APC savings for increasing levels of generation at Bearkat station with all constraints eliminated
- **Phase II:**
    - APC savings calculation for each of 8 transmission options to evaluate the relative performance of each option

Modelling Assumptions:

- 2021 study year
- All generation meeting Section 6.9 requirements of ERCOT PG included
- DC Ties modeling, Load forecast, wind and solar profiles and other relevant economic modeling assumptions aligned with ERCOT 2016 RTP assumptions
- Bid price of $0/MWh for renewable generation units
- EIA Annual Energy Outlook prices for 2021 utilized
- Far West Texas transmission project was still under ERCOT independent review at the time of development of the economic cases for this project.
    - Not included in the assessment

Economic Assessment – Results



Phase I results establish the argument for looking at a robust long-term solution to address the Bearkat area constraints – near exponential economic benefits to be derived by increasing transmission deliverability

Economic Assessment – Results

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Option #	Total Generation at Bearkat Station Meeting ERCOT Section 6.9 (MW)	Additional Generation at Bearkat Station (MW)	Stable (Yes/No)	Annual Production Cost Savings ($M)	Cost ($M)
[1]	[2]	[3]	[4]	[5]	[6]
1	570	300	Yes	10.1	54.95
		700	No	NA	
2	570	400	Yes	19.3	55.61
		700	Yes	43.7	
3	570	400	Yes	19.3	58.06
		700	Yes	43.7	
4	570	400	Yes	19.3	69.87
		700	Yes	43.8	
5	570	400	Yes	19.4	80.54
		700	No	NA	
6	570	400	Yes	19.1	93.47
		700	Yes	43.5	
7	570	400	Yes	19.3	102.15
		700	No	NA	
8	570	400	Yes	19.2	106.5
		700	No	NA	

Summary Results – Economic Assessment, Phase II

Economic Assessment – Key Observations

- Benefits are observed to increase exponentially with the future generation expected at Bearkat station.
- Options #2, #3, #4 and #6 provide comparable performance in terms of the stability limit at the Bearkat station and economic performance.
  - Options #2 and #3 are relatively limited in their ability to provide support to the load-growth needs of the 138kV system in the Study Region.
    - Stations with the highest projected load-growth are concentrated in the north-west section of the 138kV system.
  - The cost estimate of Option #2 and #3 is more than that of Option #4, if all these three options are modified to include a 345-kV source to underlying 138kV System.
- Options #4 and #6 meet all the key performance criteria, however, cost estimate for Option #4 is considerably less than cost estimate for Option#6.

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Conclusion & Final Recommendation

- **Based on the results of the analysis performed, WETT recommends Option #4 as the most cost-effective transmission solution to meet the needs of the Study Region:**
  - Option #4 is observed to mitigate all the stability concerns observed in the Study Region for the 570 MW of financially committed generation connecting at the Bearkat station.
    - Exit strategy for the proposal RAS for Bearkat Wind generation
  - Keeping in mind the extensive amount of generation interconnections expected at the Bearkat station, Option #4 provides the ability to reliably integrate an additional 730 MW of generation at the Bearkat station without any stability concerns.
  - Option #4 was also observed to present no thermal constraints for the conditions evaluated in terms of accommodating the financially committed generation (570 MW) plus the additional 730 MW.
  - The proposed 345kV Crespin station is adjacent to Sharyland’s 138kV Blue Acres station, providing Option #4 the flexibility of serving as an additional 345kV source for the fast-growing load in the Stanton-Midland region at a lower cost compared to other options.
    - In particular, Option #4 fares better in terms of support to the underlying 138kV system in comparison to Options #2 and #3
  - The capital cost estimate for Option #4 is estimated to be $ 69.87M and WETT estimates the project to be in service by the end of 2021.

Appendix– Transmission Options

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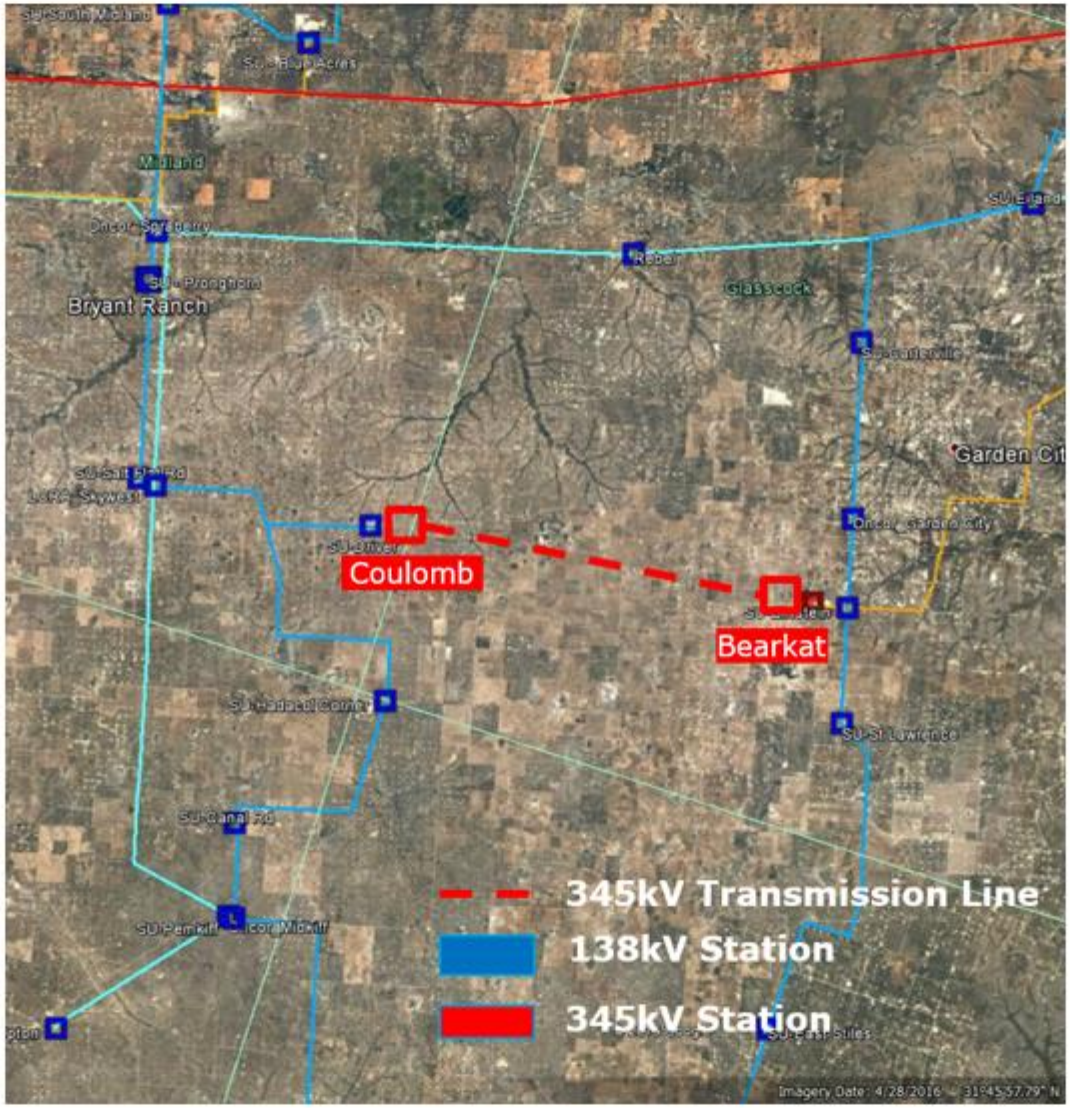
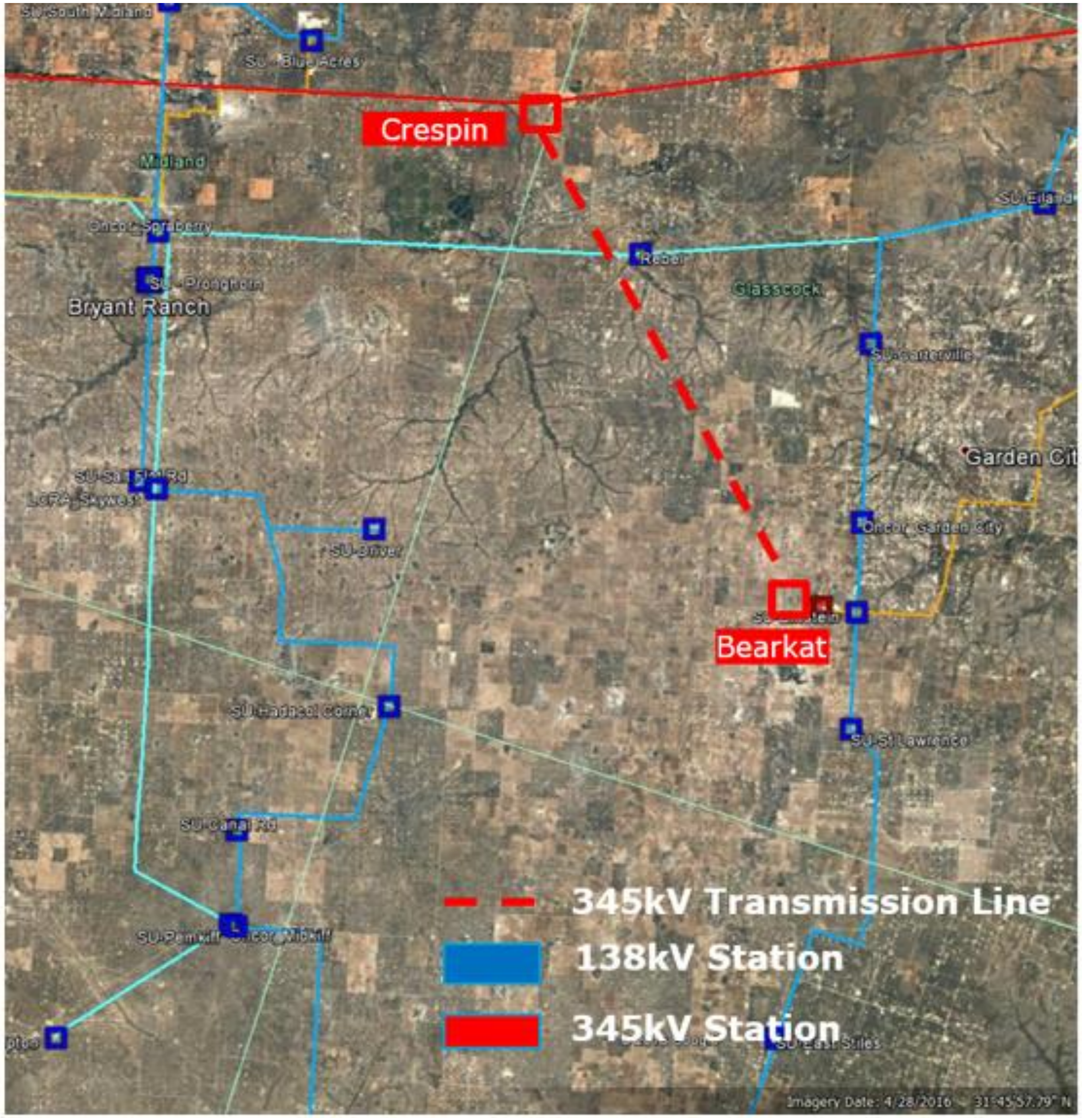


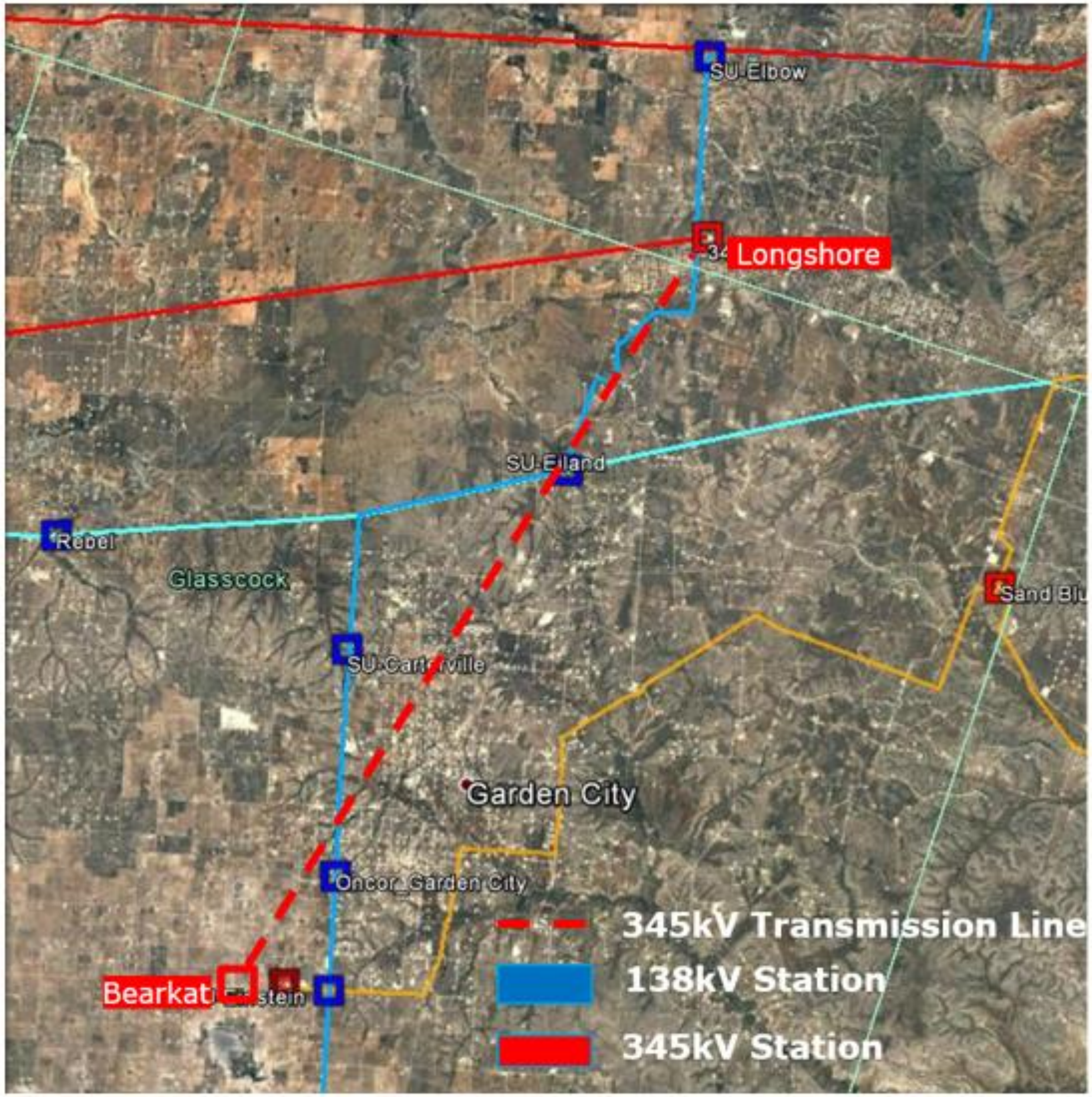
Option 1

Appendix– Transmission Options



Option 2

Appendix– Transmission Options



Option 3

Appendix– Transmission Options

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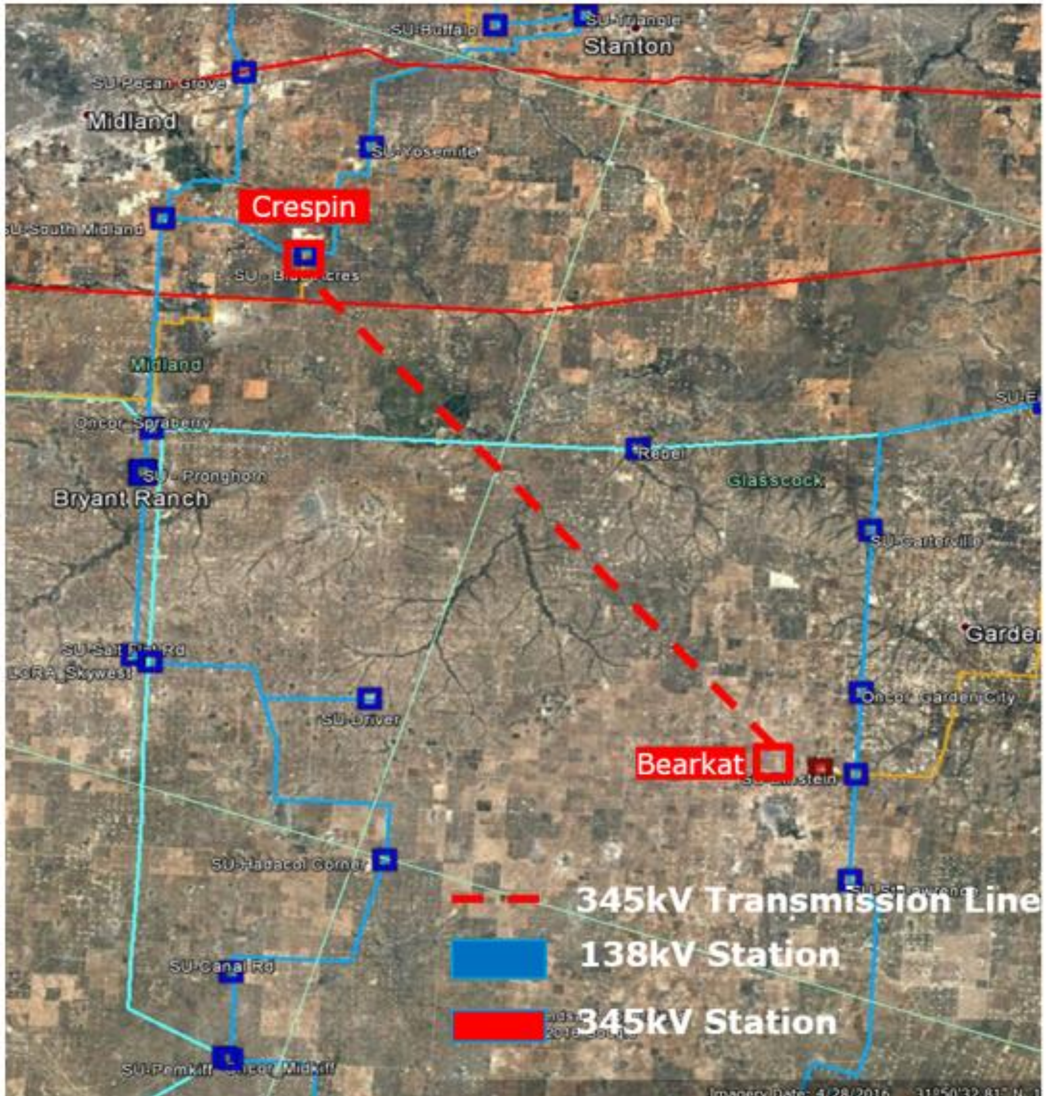

Option 4

Appendix– Transmission Options

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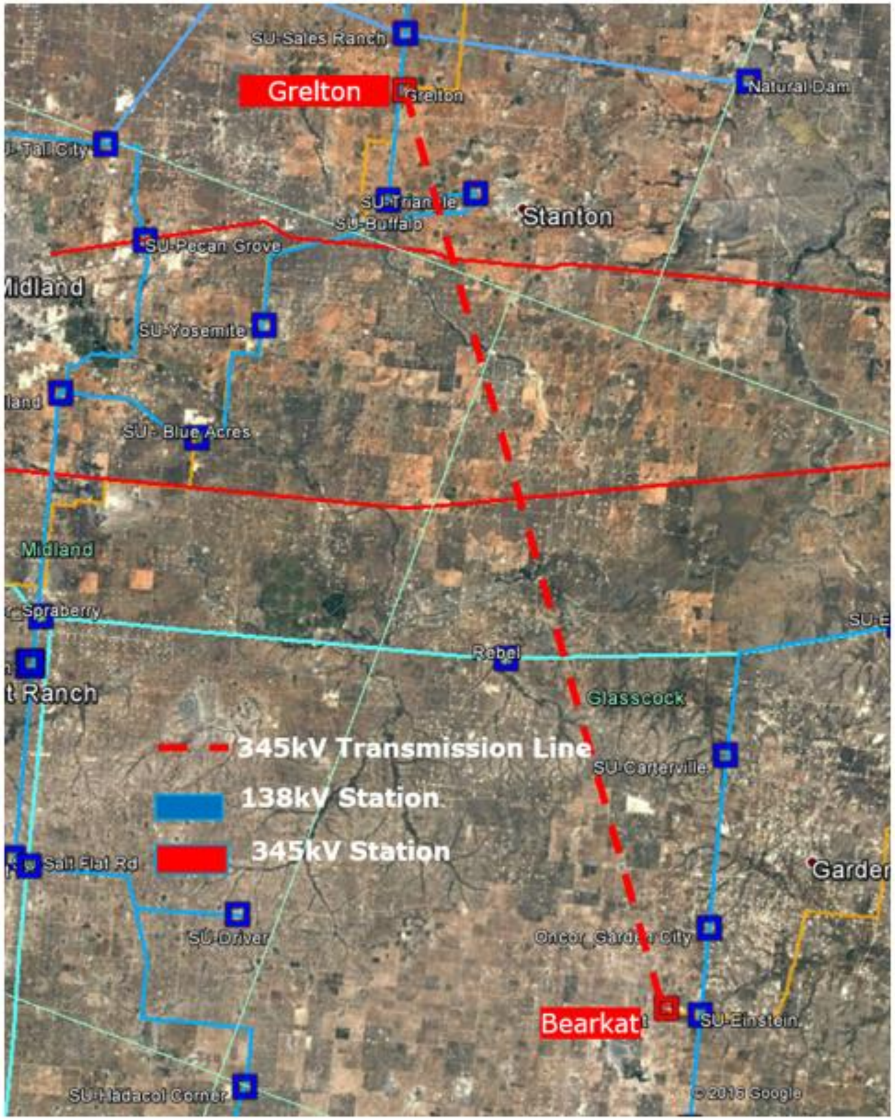

Option 5

Appendix– Transmission Options

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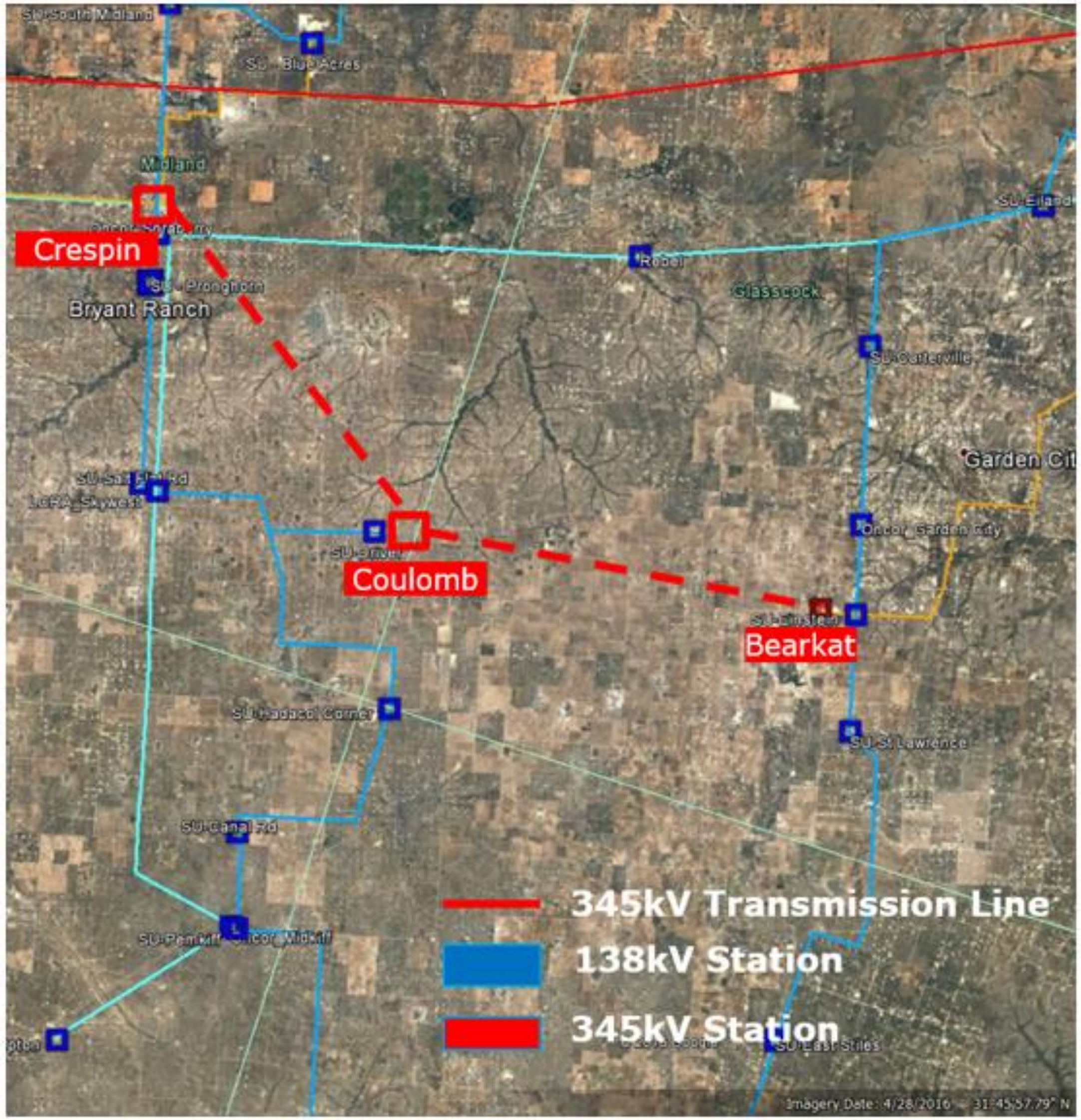
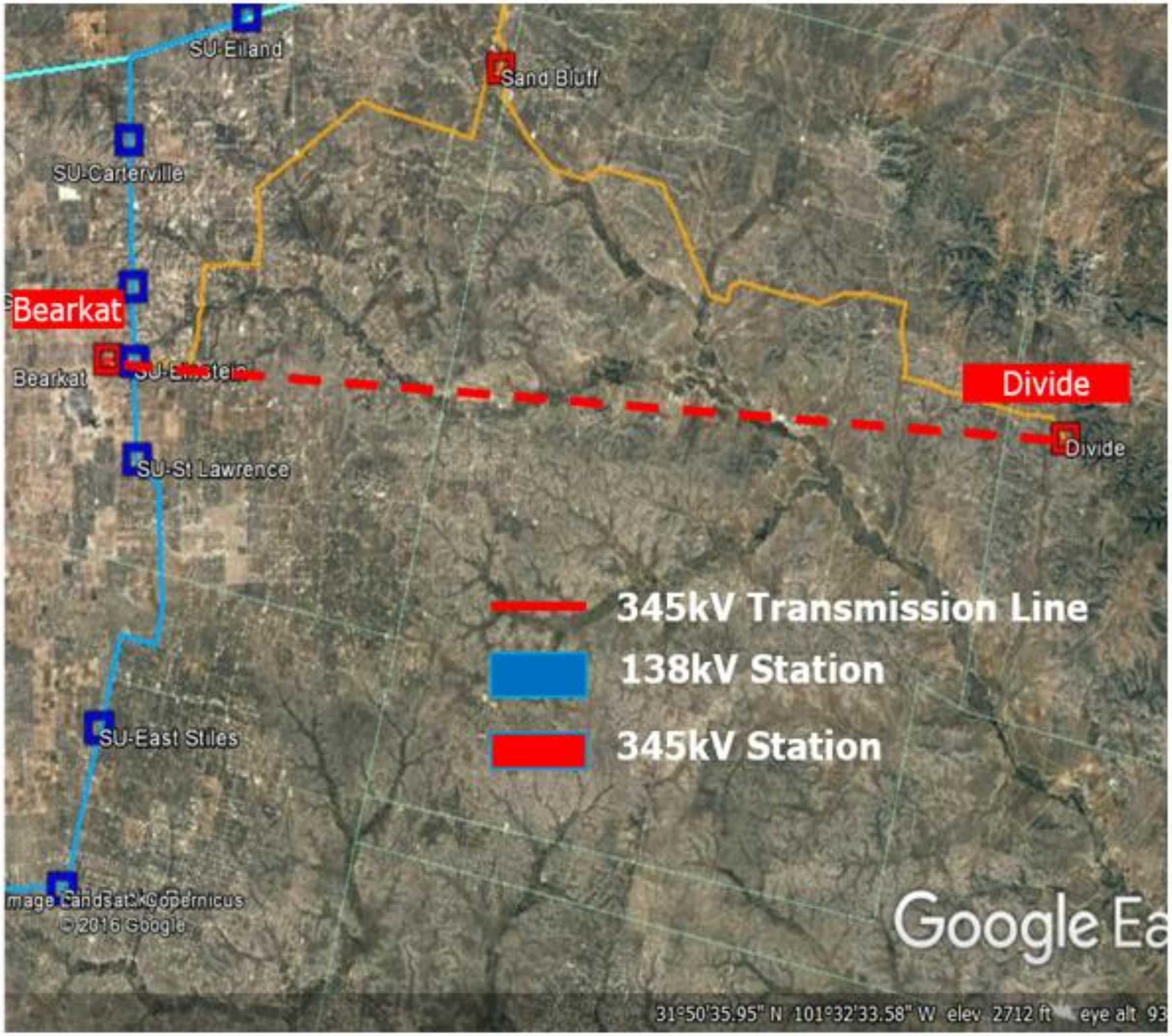


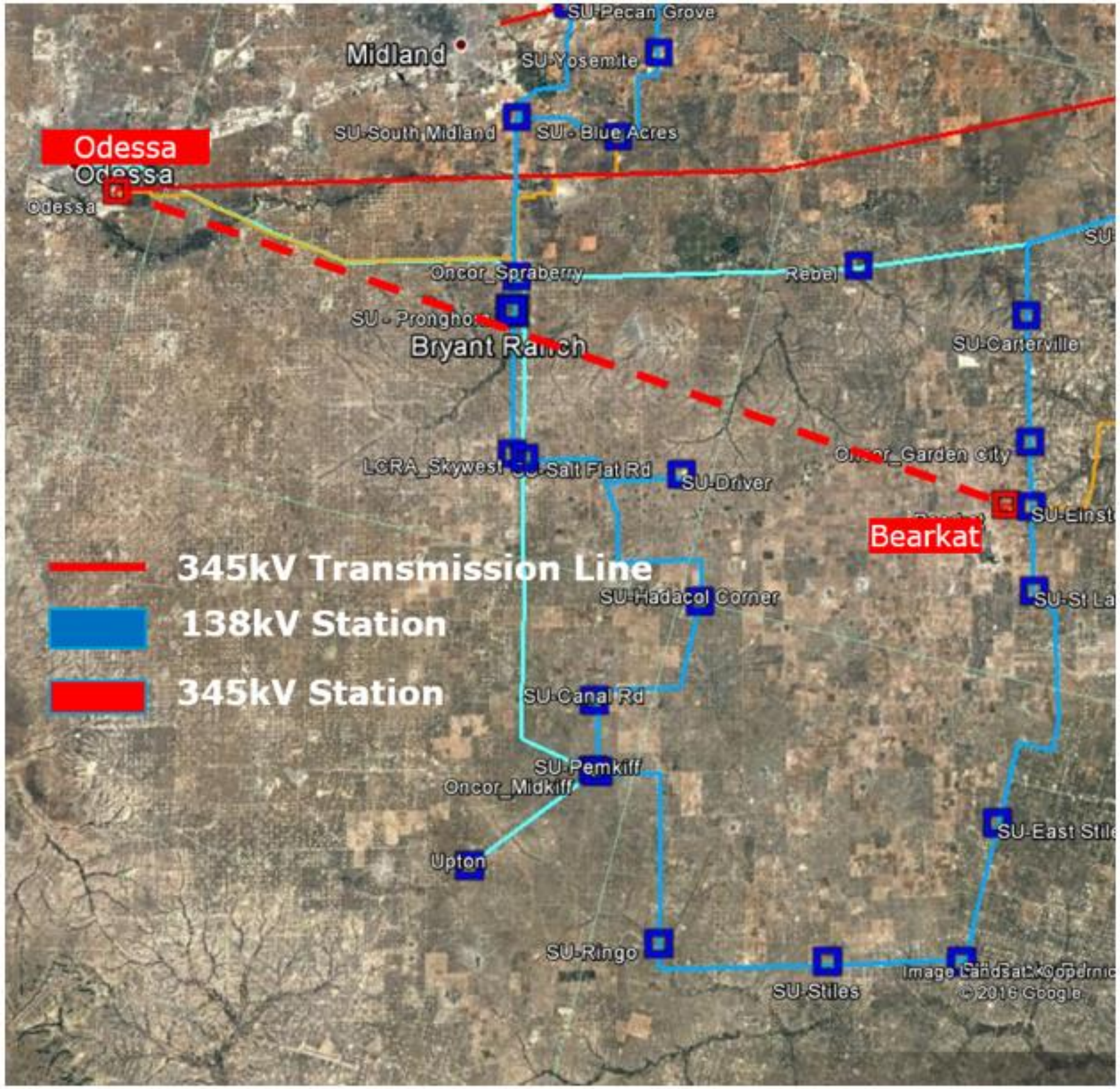
Option 6

Appendix– Transmission Options



Option 7

Appendix– Transmission Options



Option 8

Cost Estimates – Transmission Options

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	Description	Cost/Unit	Units	Total ($M)
Option 1	345kV two-breaker, ring bus configuration	9.25	1.00	9.25
	Add a 138kV bay for break-and-a-half configuration plus breaker	2.15	1.00	2.15
	Cost per mile for 345kV single circuit on double circuit capable towers	1.80	18.22	32.80
	2-winding autotransformer, at least 750 MVA	6.00	1.00	6.00
	Add a 345kV bay for break-and-a-half configuration plus breaker	4.75	1.00	4.75
	Total			**54.95**
Option 2	345kV three-breaker, ring bus configuration	9.75	1.00	9.75
	Cost per mile for 345kV single circuit on double circuit capable towers	1.80	22.84	41.11
	Add a 345kV bay for break-and-a-half configuration plus breaker	4.75	1.00	4.75
	Total			**55.61**
Option 3	Add a 345kV bay for break-and-a-half configuration plus breaker	4.75	2.00	9.50
	Cost per mile for 345kV single circuit on double circuit capable towers	1.80	26.98	48.56
	Total			**58.06**
Option 4	345kV three-breaker, ring bus configuration	9.75	1.00	9.75
	Cost per mile for 345kV single circuit on double circuit capable towers	1.80	30.76	55.37
	Add a new bay at Bearkat to accommodate new Bearkat – Crespin Line	4.75	1.00	4.75
	Total			**69.87**
Option 5	Add a 345kV bay for break-and-a-half configuration plus breaker	4.75	2.00	9.50
	Cost per mile for 345kV single circuit on double circuit capable towers	1.80	39.47	71.04
	Total			**80.54**
Option 6	345kV three-breaker, ring bus configuration	9.75	2.00	19.50
	Add a 138kV bay for break-and-a-half configuration plus breaker	2.15	1.00	2.15
	Cost per mile for 345kV single circuit on double circuit capable towers	1.80	33.93	61.07
	2-winding autotransformer, at least 750 MVA	6.00	1.00	6.00
	Add a 345kV bay for break-and-a-half configuration plus breaker	4.75	1.00	4.75
	Total			**93.47**
Option 7	Add a 345kV bay for break-and-a-half configuration plus breaker	4.75	2.00	9.50
	Cost per mile for 345kV single circuit on double circuit capable towers	1.80	51.47	92.65
	Total			**102.15**
Option 8	Add a 345kV bay for break-and-a-half configuration plus breaker	4.75	2.00	9.50
	Cost per mile for 345kV single circuit on double circuit capable towers	1.80	53.89	97.00
	Total			**106.50**

Planning Level Cost Estimates

Cost Estimates – 345/138kV Transmission Options

	Description	Cost/Unit	Units	Total ($M)
Option 2	345kV three-breaker, ring bus configuration	9.75	2.00	19.50
	Add a 138kV bay for break-and-a-half configuration plus breaker	2.15	1.00	2.15
	Cost per mile for 138kV single circuit on double circuit capable towers	1.20	5.00	6.00
	Cost per mile for 345kV single circuit on double circuit capable towers	1.80	22.84	41.11
	Add a 345kV bay for break-and-a-half configuration plus breaker	4.75	1.00	4.75
	2-winding autotransformer, at least 750 MVA	6.00	1.00	6.00
	Total			**79.51**
Option 3	345kV three-breaker, ring bus configuration	9.75	1.00	9.75
	Add a 138kV bay for break-and-a-half configuration plus breaker	2.15	1.00	2.15
	Add a 345kV bay for break-and-a-half configuration plus breaker	4.75	2.00	9.50
	Cost per mile for 138kV single circuit on double circuit capable towers	1.20	5.00	6.00
	Cost per mile for 345kV single circuit on double circuit capable towers	1.80	26.98	48.56
	2-winding autotransformer, at least 750 MVA	6.00	1.00	6.00
	Total			**81.96**
Option 4	345kV three-breaker, ring bus configuration	9.75	1.00	9.75
	Add a 138kV bay for break-and-a-half configuration plus breaker	2.15	1.00	2.15
	Cost per mile for 345kV single circuit on double circuit capable towers	1.80	30.76	55.37
	Add a 345kV bay for break-and-a-half configuration plus breaker	4.75	1.00	4.75
	2-winding autotransformer, at least 750 MVA	6.00	1.00	6.00
	Total			**78.02**

Planning Level Cost Estimates for most-cost effective options to include 345 kV source to 138kV system