ENERGY

Lubbock Power & Light (LP&L) ERCOT Integration Study
ERCOT Regional Planning Group (RPG)

Prepared by PWR Solutions – A DNV GL Company
November 20, 2015
Agenda

- LP&L System Overview & Background
- LP&L – ERCOT Integration Approach
- LP&L System Evaluation, Transition Roadmap & Upgrades
- Integration Option Development & Screening Assessment
- Shortlisted Option Analyses
  - Steady State Assessment
  - Long-term Load Deliverability Assessment
  - System Strength Assessment
  - Sub-Synchronous Resonance (SSR) Risk Evaluation
  - Budgetary Cost Estimates
- Identification of Preferred Options
**Agenda**

- Additional Analyses for Preferred Options
  - N-1-1 Analysis
  - Panhandle Generation Sensitivity
  - Dynamic Analysis
  - Economic Assessment
- Cost-Benefit Assessment – Preferred Options
- Recommendations
- Q&A
LP&L System Overview & Background

• LP&L has served as the city’s municipal provider since 1916 when the City of Lubbock established LP&L to manage the electric power of the city.

• LP&L generates and distributes electricity to more than 103,000 customers.

• LP&L operates within certificated areas established by the Public Utility Commission located within the Lubbock city limits.

• In 2010, LP&L purchased the majority of Xcel Energy’s distribution assets located within the Lubbock city limits making it the primary provider of electric service in the city.

• LP&L is associated with the West Texas Municipal Power Agency (WTMPA). Member cities that include Lubbock, Brownfield, Floydada and Tulia.

• City of Lubbock requested PUCT to direct ERCOT to evaluate LP&L integration into ERCOT (Texas Grid) via a detailed study

  • http://www.lpandl.com/energy-services/2019/

• On September 24, 2015, PUCT instructed ERCOT to study the impact of integrating LP&L into the ERCOT grid

• LP&L engaged PWR Solutions to perform an independent evaluation of LP&L integration to ERCOT – PWR analysis expected to inform the ERCOT study
ERCOT Integration Approach

Guiding Principle: Identify most cost-effective solution to reliably integrate LP&L system into ERCOT ........

- LP&L System Performance & Adequacy Assessment
- Identification of source/sink locations on ERCOT/LP&L - Integration Option Development
- Steady state Screening Assessment - Option screening & fine-tuning
- Detailed Analysis - Steady State - System Strength - SSR - Long-term load serving capability - Cost Estimates
- Preferred Options - N-1-1 Analysis - PH Gen Sensitivity - Dynamic Assessment - Economic Assessment

........ While evaluating the long-term impact/benefit of each solution on both systems when treated as ONE.
LP&L System Overview, Transition Roadmap & Upgrades

- Based on initial discussions with PUCT, LP&L anticipates a potential ERCOT integration timeline between 2019-2021

- 2021 chosen as the study year for the reliability & economic studies performed
  - No material difference in the ERCOT transmission topology in the vicinity of LP&L system between 2019 & 2021 – no change in selected options expected between 2019 & 2021
  - LP&L peak system load expected to be higher for 2021 – integration option selected should be designed to account for the higher load in case of slippage in the integration schedule
  - Study year of 2021 accounts for certain LP&L generation unit retirements – thereby presenting a more conservative scenario from a planning perspective

- Based on data provided by LP&L, 2021 load levels on the LP&L system expected to be between 466MW to 593.5MW – all fed off of 69kV transmission system per current design
  - Business as Usual (BAU) load forecast: 466MW
  - High Growth load forecast: 593.5MW
  - Future LP&L load: 200MW (“Additional LP&L Load”)

- LP&L indicated that most of the existing 69kV stations and transmission lines are expected to be insulated for 115kV by the time of ERCOT integration
**LP&L System Overview, Transition Roadmap & Upgrades**

- **LP&L Transition Roadmap & Upgrades Assessment**
  - Comparative analysis performed for the LP&L system for two (2) potential scenarios
    - **Scenario #1**: LP&L system continues to operate at 69kV at time of ERCOT integration and beyond
    - **Scenario #2**: LP&L system is configured to have a 115kV outer loop surrounding a 69kV inner loop
      - Take advantage of the planned capital improvements to convert 69kV facilities to 115kV
      - Limit the load being served from the 69kV system to 200 MW or lesser from a reliability perspective
      - LP&L’s planned transmission upgrades can be utilized to design a 115kV loop surrounding the 69kV footprint
        - Reconfiguration will lead to ~300MW of load being served from 115kV system
        - Inner 69kV loop and outer 115kV loop fed by 345kV sources from ERCOT
      - More robust LP&L internal system to fully leverage the benefit of the ERCOT integration
**LP&L System Overview, Transition Roadmap & Upgrades**

- **LP&L Transition Roadmap & Upgrades Assessment**
  - Analysis focused on performance of the LP&L system for both scenarios under multiple contingency events
    - NERC category P1 and P7 (ERCOT_1)
    - NERC category P3 (G-1+N-1)
    - NERC category P6 (N-1-1)
    - A-1+N-1 events (if applicable) – 345/115kV transformers assumed to be applicable for A-1 events
  - Business as Usual (BAU) load growth forecast utilized for conducting comparative analysis
    - High load growth scenario expected to yield higher loadings
  - Key findings of this comparative analysis utilized to identify which scenario is likely to better serve the LP&L system from a reliability perspective
LP&L System Overview, Transition Roadmap & Upgrades

- Numerous NERC TPL-001-4/ERCOT criteria reliability violations observed under Scenario #1
- Scenario #2 observed to address most of the issues affecting reliability of the LP&L system
  - LP&L system modeled per Scenario #2 for conducting the ERCOT integration study
  - Much more cost-effective solution in comparison to LP&L’s original plan of new 230kV loop

<table>
<thead>
<tr>
<th>Metric</th>
<th>LP&amp;L Remains at 69KV (Scenario #1)</th>
<th>LP&amp;L Transitions to Scenario #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Loadings &gt;90% of Rate B under P1, P7, and P3 (G-1+N-1) Conditions</td>
<td>Majority of lines in LP&amp;L</td>
<td>None for BAU Load Forecast; Minimal for BAU Load + Future LP&amp;L Load</td>
</tr>
<tr>
<td>Thermal Overloads &gt;90% of Rate B under A-1+N-1 Conditions</td>
<td>Not Applicable</td>
<td>Only related to 345/115kV Transformers; Can be addressed by resizing or using two (2) transformers at each station</td>
</tr>
<tr>
<td>Thermal Overloads under P6 (N-1-1) Conditions</td>
<td>Multiple overloads in violation of ERCOT N-1-1 criteria - power flow convergence issues</td>
<td>Only three (3) overloads observed – No violation of ERCOT N-1-1 criteria</td>
</tr>
<tr>
<td>Low-voltage violations under P6 (N-1-1) Conditions</td>
<td>Widespread low-voltage violations observed on the LP&amp;L system</td>
<td>Only three (3) stations observed to depict low-voltage issues</td>
</tr>
</tbody>
</table>

Comparative Analysis – Summary
Robust LP&L System Design Imperative for Cost-effective & Successful ERCOT Integration
LP&L System Overview, Transition Roadmap & Upgrades

Proposed LP&L System Upgrades & Configuration
Integration Option Development & Screening Assessment

- A minimum of 3 sources to LP&L from ERCOT evaluated across all integration options
  - Two (2) source integration options not deemed a reliable integration plan for LP&L
    - N-1-1 conditions expected to result in loss of 2 source options
    - Loss of load expected to be in excess of ERCOT criteria (300 MW) – LP&L load expected to be close to 466 MW
  - Double circuit 345kV lines also considered to circumvent the N-1-1 issue
    - Potential concerns around the A-1+N-1 conditions still resulting in loss of both sources
    - At best, the two (2) source options will result in LP&L being fed radially from a single source
    - Anywhere from 466 MW – 593 MW worth of LP&L load being fed radially from a single source – unacceptable from a reliability standpoint

- Currently LP&L is connected to the rest of the SPP system via four (4) 230kV connections
Integration Option Development & Screening Assessment

- Identification of a list of potential stations on the LP&L system which could serve as POIs with ERCOT
  - Ability to accommodate 345kV interconnections from ERCOT including line terminations and step-down transformers
  - Ability to acquire right of way (ROW) for 345kV lines in vicinity of the station
  - Ability of existing 69kV equipment to be operated at 115kV
  - Ability of the station to be upgraded incrementally if required
  - Potential for land acquisition at the station in case upgrades are required
  - Anticipated load growth in the LP&L system
    - E.g. higher load growth anticipated in the West/North-west region
  - Detailed questionnaire provided to LP&L to acquire additional data associated with these stations

- Three (3) stations are ultimately shortlisted for interconnection with ERCOT
  - Existing Wadsworth Sub, planned North Sub and new 345/115kV sub station south of Oliver Sub
    - Wadsworth – East Interconnection, North Sub – North/West Interconnection & New sub south of Oliver – South Interconnection
Integration Option Development & Screening Assessment

- Sixteen (16) 345kV stations identified as candidates on the ERCOT system as potential interconnection points for LP&L integration
- Preferred stations derived from the candidate stations based on the following
  - Geographical proximity to LP&L stations
  - System strength at the particular station
  - Potentially redundant options i.e. one between Windmill & Ogallala

**Preferred ERCOT Stations**

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<tr>
<th>Group</th>
<th>ERCOT Station Name</th>
<th>Shortlisted</th>
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<tbody>
<tr>
<td>1</td>
<td>WINDMILL</td>
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<tr>
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<td></td>
<td>TULE CANYON</td>
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<td>WHITE RIVER</td>
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<td></td>
<td>ABERNATHY</td>
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<tr>
<td>2</td>
<td>COTTONWOOD</td>
<td>Y</td>
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<td></td>
<td>DERMOTT</td>
<td>Y</td>
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<td></td>
<td>SCURRY COUNTY</td>
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<tr>
<td>3</td>
<td>GRASSLAND EXTENSION</td>
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<tr>
<td></td>
<td>FARADAY</td>
<td>N</td>
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<tr>
<td></td>
<td>LONGDRAW</td>
<td>N</td>
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<td></td>
<td>GRELTON</td>
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<td>4</td>
<td>ODESSA</td>
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<tr>
<td></td>
<td>FALCON SEABOARD</td>
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<tr>
<td></td>
<td>MORGAN CREEK</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>TONKAWAS</td>
<td>N</td>
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</table>

**Note:**
- GRASSLAND EXTENSION is not planned to be an actual/physical substation
- All references to this represent termination location of Sharyland’s 345kV line in Grassland region from hereon
- Per Sharyland July 2014 RPG submittal, this line can be extended to connect to the LP&L system as a potential Southern source

**Sixteen (16) Candidate Stations - ERCOT**
Location of Candidate ERCOT Stations vis-à-vis LP&L (Preferred Stations in Green)
Integration Option Development & Screening Assessment

- 115kV interconnections to ERCOT with the 345/115kV transformations being performed at the ERCOT station locations also considered to evaluate a cost-competitive option in comparison to 345kV interconnections
  - N-1-1 and A-1+N-1 conditions lead to LP&L system being fed from one 115kV line
  - Not enough capacity to reliably serve LP&L load in the long term
  - Low voltage issues for the LP&L system especially for the longer distance 115kV lines
  - No major reliability benefits to ERCOT system with the 115kV connections
  - System strength benefits to be significantly reduced
  - Voltage stability benefits for Panhandle region non-existent

- 345kV interconnections to LP&L with 345/115kV transformations at the LP&L POIs the preferred approach
  - All relevant and non-redundant combinations across Groups 1-3 utilized to develop LP&L integration options
  - Total of **36 interconnection options** included for the screening assessment
Integration Option Development & Screening Assessment

Integration Option – Illustrative Example #1 Integration Option – Illustrative Example #2

Options with and without a connection from Group 1 to Abernathy considered
Integration Option Development & Screening Assessment

- **Screening Assessment – Salient Features**
  - Evaluation of all 36 interconnection options from a normal operation standpoint
  - Further eliminate any redundant options
  - A-1+N-1 assessment for all 36 interconnection options (given the normal operation flows, the A-1 condition was deemed to be more critical than a G-1 internal to LP&L)
  - Evaluate need for additional 345/115kV autos to comprise option definition
  - Evaluate need to consider 4 source options along with 3 source options
  - Panhandle zero wind sensitivity to evaluate reliance of Panhandle interconnections on wind generation
  - 15% Panhandle wind assumed in the base assessment

- **Twenty Two (22) options shortlisted for detailed study**

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## ERCOT POIs Prior to Screening Study

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<th>Group</th>
<th>ERCOT Station Name</th>
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<tbody>
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<td>1</td>
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<td></td>
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<td>DERMOTT</td>
</tr>
<tr>
<td></td>
<td>SCURRY COUNTY</td>
</tr>
<tr>
<td>3</td>
<td>GRASSLAND EXTENSION</td>
</tr>
<tr>
<td></td>
<td>GRELTON</td>
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<tr>
<td></td>
<td>FALCON SEABOARD</td>
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</tbody>
</table>

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## ERCOT POIs After Screening Study

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<tr>
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<td>COTTONWOOD</td>
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<td></td>
<td>DERMOTT</td>
</tr>
<tr>
<td>3</td>
<td>GRASSLAND EXTENSION</td>
</tr>
</tbody>
</table>

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Integration Option Development & Screening Assessment

Option #34
- Length: 33 miles
- Output: 90 MW

Option #35
- Length: 96 miles
- Output: 84 MW

Option #36
- Length: 93 miles
- Output: 86 MW
Steady State Assessment – Interconnection Options

- As mentioned previously, 22 options are included for the steady state study
- ERCOT Steady State Working Group (SSWG) 16DSB 2021 Summer Peak case utilized for developing the study model
  - All generation resources meeting Section 6.9 requirements of ERCOT planning guide incrementally modeled in the case
  - Wind generation resources in Panhandle/West region dispatched at 15%
  - Antelope gas generation units kept offline for the screening study
    - Sensitivity around Antelope (Elk) generation unit dispatch studied for preferred options
- LP&L system per Scenario #2 with 115kV outer loop and 69kV inner loop
  - Load in LP&L system modeled as per “high load growth” forecast (~593MW)
- ERCOT and LP&L systems interconnected via the 22 options finalized for study
  - Impedances for 345kV lines interconnecting LP&L and ERCOT modeled to be consistent with existing CREZ lines
  - Impedances for the 345/115kV and 115/69kV transformers modeled based on typical design level data provided by vendors
Steady State Assessment – Interconnection Options

- Load-generation balance in the study cases maintained by scaling loads in the non-study zones based on “diversity factor” analysis
  - West/Far West/North regions in ERCOT identified to be a part of the “study zone”
  - Coast/East/North Central/South/South Central regions are in the “non-study” zone
Steady State Assessment – Interconnection Options

- Steady state analysis involved evaluation of thermal overloads and potential voltage issues under A-1+N-1 and G-1+N-1 conditions, if any
- Methodology A-1+N-1: Loss of a 345/115kV auto transformer followed by:
  - Loss of another line/transformer (including P1 & P7 (ERCOT 1) events)
  - Loss of a single generator (per ERCOT planning guide)
    - Single generator outage within ERCOT system near Lubbock was considered
- Methodology G-1+N-1: Loss of single largest generation unit within LP&L system (78MW unit at McKenzie station) followed by:
  - Loss of another line/transformer (including ERCOT_1 (P7) and N-1 events (P1))
- Performance Criteria
  - Rate B for thermal overloads
    - Loading levels above 85% of Rate B were identified in order to provide 15% margin
    - Margin included to account for operations and future load growth
  - 0.9-1.05 pu for voltage range and 0.07 pu for voltage deviation
  - Non-consequential load loss not acceptable
### Steady State Assessment – Interconnection Options

<table>
<thead>
<tr>
<th>Option</th>
<th>A-1+N-1</th>
<th>G-1+N-1</th>
<th>Num of Unsolved Contingencies</th>
<th>Num. of Sources into LP&amp;L</th>
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<tbody>
<tr>
<td></td>
<td>Num Of 115kV Loadings &gt; 85%</td>
<td>Num Of 69kV Loadings &gt; 85%</td>
<td>Num Of 115kV Loadings &gt; 85%</td>
<td>Num Of 69kV Loadings &gt; 85%</td>
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</table>

#### Option Performance Evaluation – A-1+N-1/G-1+N-1 Analysis

* Indicates options with partial 345kV loops around LP&L
Long-Term Load Deliverability Assessment

- The following assessments were performed to evaluate long-term load deliverability of the shortlisted sixteen (16) interconnection options (based on results of the steady state assessment)
  - Available Transfer Capability (ATC)
    - Identify potential future thermal limitation (>100% of Rate B)
  - PV analysis
    - Identify potential future voltage stability limitation (voltage collapse)

- Long Term Load Deliverability Performance Criteria
  - Option expected to support long term LP&L load growth i.e. minimum threshold of 700 MW
  - MW/$M metric also utilized to gauge the relative cost-effectiveness of various options

- G-1+N-1/A-1+N-1 scenarios were analysed for Long-term Load Deliverability
  - Most limiting transfer levels were considered for evaluating options from a thermal and voltage security standpoint
  - LP&L facilities in planning stage not considered as potential constraints for future load serving scenario
    - Scope to size the facility appropriately based on the results of the assessment
Long-Term Load Deliverability Assessment

Load Deliverability Assessment, Shortlisted Options, Thermal Standpoint
For the purpose of WSCR computation, a total of **4302.2 MW** of WGR capacity included on the Panhandle transmission system

- All WGRs included for assessment meet Section 6.9 requirements of ERCOT Planning Guide
- Note that WGR capacity only included for WSCR calculation
- Short-circuit contribution of WGRs not included while computing $S_{SCMVA}$ at each station
- Fault current contribution from the synchronous condensers modeled to be 1050A at 345kV
# System Strength Assessment – ERCOT Perspective

## WSCR Assessment - Shortlisted Options

(With Sensitivity Around Elk Generation)

<table>
<thead>
<tr>
<th>Description</th>
<th>WSCR with LP&amp;L Generation in Service &amp; Elk Units Offline</th>
<th>WSCR with LP&amp;L Generation &amp; Elk 1 In-service</th>
<th>WSCR with LP&amp;L Generation &amp; Elk 1, 2, 3 In-service</th>
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<td>1.47</td>
<td>1.56</td>
<td>1.64</td>
</tr>
</tbody>
</table>
System Strength Assessment – ERCOT Perspective

WSCR Evaluation – Key Observations

- Base case without LP&L shows a WSCR value of 1.35
- WSCR values increase after integration with LP&L irrespective of the integration option
  - New 345kV lines proposed as a part of LP&L integration lead to increase in $S_{SCMVA}$ at ERCOT Panhandle stations
  - Generation in Lubbock also leads to marginal increase in $S_{SCMVA}$
  - WSCR shows higher increment over the base case whenever there is a line connecting Ogallala and Abernathy
  - Presence of 345kV loops around LP&L is also observed to increase WSCR values (e.g. Option#3A)
  - Connection from Dermott instead of Cotton Wood offers no benefit in terms of WSCR

- **In summary, integration of LP&L observed to provide clear benefit to the ERCOT Panhandle transmission system from a system strength standpoint**

- Elk sensitivity expected to have the same relative impact across all options
System Strength Assessment – ERCOT Perspective

WSCR Evaluation – Benefit Quantification

- Increase in WSCR due to LP&L integration is expected to reduce the amount of synchronous condensers required to meet a specific WSCR target
  - As discussed previously, with ~4300MW of WGRs in the Panhandle, the base case WSCR is 1.35
  - With LP&L integrated, the WSCR for the same WGR capacity is 1.55 (best performing option)
  - Estimated that if LP&L was not integrated, there would be need for 390MVAR of additional synchronous condensers to increase the WSCR from 1.35 to 1.55
    - SCs located at 3 stations (Windmill, Ogallala and Gray) for the purpose of this estimation
    - If SCs are at 2 stations (e.g. Windmill/Ogallala or Windmill/Gray), around 380MVAR of capacity is required to realize same WSCR benefit
  - Thus LP&L integration provides WSCR benefit equivalent to ~390MVAR of synchronous condensers (~$80M) with the 4300MW of WGR capacity
    - Sensitivity around LP&L generation off-line also performed
    - Sensitivity around LP&L generation off-line indicates no significant reduction in the SC benefits
WSCR Benefits – Summary

LP&L integration continues to provide the same WSCR benefit (equivalent to ~390MVAR of SCs) even if the Panhandle WGR capacity increases to ~6500MW

Synchronous Condenser Benefits - Summary
System Strength Assessment – LP&L Perspective

- Involves assessment of benefit provided to LP&L by each interconnection option from a system strength standpoint
- Defined a “System Strength Metric” (SSM) for each option
  - SSM expected to be indicative of how strongly a particular option integrates ERCOT and LP&L from an LP&L perspective
- SSM calculation accounts for the following:
  - Short-circuit MVA at each 345kV station serving as POI for the LP&L system
    - 345kV North, Wadsworth, New Oliver, Holly, New McDonald stations
  - Power flow (in MW) into each LP&L POI from the ERCOT system
- Analytical expression for SSM

\[
SSM = \left( \sum_{i=1}^{N} S_{SCMV Ai} \times P_{MWi} \right) / \left( \sum_{i=1}^{N} P_{MWi} \right)^2
\]

Where,

\( S_{SCMV Ai} = \text{Short-circuit MVA at } i^{th} \text{ LP&L POI} \)

\( P_{MWi} = \text{Total MW capacity being injected into the } i_{th} \text{ LP&L POI} \)
### System Strength Assessment – LP&L Perspective

**SSM Analysis - Shortlisted Options**  
*(with Sensitivity Around Elk Generation)*

<table>
<thead>
<tr>
<th>Option#</th>
<th>SSM_No_Elk</th>
<th>SSM_With_Elk1</th>
<th>SSM_With_Elk1, 2, 3</th>
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<td>3A</td>
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<td>3B</td>
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<td>17</td>
<td>8.14</td>
<td>8.85</td>
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<tr>
<td>18</td>
<td>8.25</td>
<td>8.94</td>
<td>9.62</td>
</tr>
</tbody>
</table>
SSR Risk Evaluation – ERCOT Perspective

- Benefit of each interconnection option in reducing SSR risk for generation resources in the vicinity of LP&L region also evaluated
  - Lowest “N-X” outage count required to establish a radial connection between each ERCOT station and nearest series compensated lines is determined for the base case
  - Determined whether the lowest “N-X” count for a particular ERCOT station increases after implementing an LP&L integration option
  - If the lowest “N-X” count for a particular station is observed to increase, the option is marked to benefit that station from an SSR standpoint

### Stations Included for SSR Assessment

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gray</td>
</tr>
<tr>
<td>Raihead</td>
</tr>
<tr>
<td>Alibates</td>
</tr>
<tr>
<td>AJ Swope</td>
</tr>
<tr>
<td>Windmill</td>
</tr>
<tr>
<td>Ogallala</td>
</tr>
<tr>
<td>Tule Canyon</td>
</tr>
<tr>
<td>White River</td>
</tr>
<tr>
<td>Abernathy</td>
</tr>
<tr>
<td>Cotton Wood</td>
</tr>
<tr>
<td>Long Draw</td>
</tr>
</tbody>
</table>

**ERCOT Stations for SSR Benefit Evaluation**
### SSR Risk Evaluation – ERCOT Perspective

- All interconnection options that involve a connection from Ogallala to Abernathy provide a benefit to all Panhandle options from an SSR standpoint

<table>
<thead>
<tr>
<th>Option #</th>
<th>No of Stations Benefited</th>
<th>Names of Stations Benefited</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>AB, CW, LD</td>
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<tr>
<td>2</td>
<td>11</td>
<td>GR, RH, ALI, AJ, WM, OG, TC, WR, CW, AB, LD</td>
</tr>
<tr>
<td>3A</td>
<td>11</td>
<td>GR, RH, ALI, AJ, WM, OG, TC, WR, CW, AB, LD</td>
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<td>3B</td>
<td>2</td>
<td>AB, LD</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>AB, CW, LD</td>
</tr>
<tr>
<td>8A</td>
<td>11</td>
<td>GR, RH, ALI, AJ, WM, OG, TC, WR, CW, AB, LD</td>
</tr>
<tr>
<td>8B</td>
<td>3</td>
<td>AB, CW, LD</td>
</tr>
<tr>
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<td>4</td>
<td>AB, CW, WR, LD</td>
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<td>AB, CW, WR, LD</td>
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<td>18</td>
<td>11</td>
<td>GR, RH, ALI, AJ, WM, OG, TC, WR, CW, AB, LD</td>
</tr>
</tbody>
</table>
SSR Risk Evaluation – LP&L Perspective

- SSR screening assessment for the three (3) LP&L generation facilities (McKenzie/Brandon/Holly) performed
  - Three (3) series compensated lines in ERCOT included for SSR screening
    - 345kV Tule Canyon – Tesla
    - 345kV Dermott – Clear Crossing
    - 345kV Edith Clarke – Clear Crossing
  - For each LP&L generation facility, lowest “N-X” outage count required to establish radial connection to the aforementioned lines in ERCOT is determined
    - “N-X” computation performed for all sixteen (16) integration options
  - Requires N-8 or greater concurrent outages to result in the LP&L generation facilities to be radially connected to series compensation across all options
  - Potential for SSR risk (if any) expected to be addressed via procedural mitigation in the form of outage coordination
    - Based on latest language in ERCOT SSR Workshop & NPRR562
  - SSR risk for LP&L generation facilities may have to be evaluated further via detailed screening/EMT simulations for the recommended options
### LP&L Generation – SSR Risk Evaluation

<table>
<thead>
<tr>
<th>Option #</th>
<th>Holly</th>
<th>McKenzie</th>
<th>Brandon</th>
</tr>
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<tr>
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<td>N-10</td>
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<tr>
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<tr>
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<td>N-8</td>
<td>N-9</td>
<td>N-10</td>
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<tr>
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<tr>
<td>18</td>
<td>N-8</td>
<td>N-11</td>
<td>N-12</td>
</tr>
</tbody>
</table>

### LP&L Generation – SSR Risk Assessment Summary
Budgetary Cost Estimates – Basis Assumptions

- 345kV transmission line estimates based on ERCOT rural average cost estimates ($1.95M/mile)
- New 345kV stations assumed to be 6-breaker ring bus and ERCOT average cost estimates utilized @ $15.94M
- New 115kV stations assumed to be 6-breaker ring bus @ $9.05M
- ERCOT average cost estimates for 345/138kV autos utilized for the 345/115kV autos (rating < 700 MVA)
- Land acquisition costs for new 345/115kV stations included ($500K)
- Cost estimates for new 115kV lines obtained from LP&L ($1.6M/mile)
- Existing LP&L station expansion costs not included – expected to be minimal in terms of ERCOT integration per discussion with LP&L
Budgetary Cost Estimates

Total Capital Cost Estimates - LP&P Integration Options

Budgetary Cost Estimates - Shortlisted Options
Identification of Preferred Options

- Sixteen (16) integration options observed to result in acceptable steady state performance based on conditions studied
  - NERC TPL-001-4 & ERCOT Planning Criteria standpoint
- Following factors utilized to further assess the relative merits of each of the sixteen (16) options
  - Long term load serving capability for LP&L system
  - System Strength benefits to LP&L & ERCOT
  - SSR impacts to both LP&L & ERCOT
  - Cost estimates & cost-effectiveness
- Options 3A and 8A identified as top performing options based on the metrics outlined above
  - Options 3B and 8B subsets of Options 3A and 8A respectively – **Minimum set of transmission facilities required to integrate LP&L into ERCOT**
  - 345kV Ogallala – Abernathy line incremental addition to Options 3B/8B to transition to 3A/8A respectively i.e. phased approach
- Options 3A, 3B, 8A and 8B identified as preferred options
Identification of Preferred Options

Option #3A

Option #8A

Option #3B

Option #8B
None of the contingencies lead to divergent power flow solutions.

Post-contingency overloads:
- Some are greater than 115% of rate B of the conductor rating.
- None are greater than 150% of Rate A of the conductor rating.

Amount of load shed required to address overloads is <300MW.

To that effect, per the highlighted portion of the flowchart, only load shed mitigation plans need to be developed, if any.
### Additional Analysis Preferred Options - N-1-1 Assessment

<table>
<thead>
<tr>
<th>Option</th>
<th>Num Of Xformers Violations</th>
<th>Num Of Violations Of Proposed Lines</th>
<th>Num Of Violations Of Existing Lines</th>
<th>Length of Existing 115kV Lines Overloaded (miles)</th>
<th>Length of Existing 69kV Lines Overloaded (miles)</th>
<th>Length of Proposed 115kV Lines Overloaded (miles)</th>
<th>Max Load Shed 115kV (MW)</th>
<th>Max Load Shed 69kV (MW)</th>
<th>Num of unsolved contingencies</th>
<th>Num of Sources into LP&amp;L</th>
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</thead>
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<tr>
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<td>3.1</td>
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<td>16</td>
<td>0</td>
<td>3</td>
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<td>Option #8A</td>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>3.1</td>
<td>0</td>
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<td>16</td>
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<td>Option #8B</td>
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<td>16</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Preferred Option Performance– N-1-1 Analysis (P6 Events)

- None of the contingencies lead to divergent power flow solutions
  - Load shed levels are limited to 16 MW to mitigate the 69kV overloads
- All preferred options meet ERCOT/NERC TPL-001-4 criteria from reliability standpoint
Additional Analysis Preferred Options – Panhandle Generation Sensitivity

- All Antelope generation (Elk 1, Elk 2 and Elk 3) were dispatched at full output during sensitivity studies
  - Elk 1: 359 MW
  - Elk 2: 197 MW
  - Elk 3: 197 MW

- A-1+N-1 & G-1+N-1 assessments were performed as a part of the sensitivity studies
  - Mckenzie unit (78MW) was still considered as the most severe G-1 outage within LP&L facilities

- With Elk units dispatched at full output, none of LP&L existing facilities were observed to be loaded above 85% for all four (4) preferred options
  - 345kV partial loop around LP&L observed to effectively distribute power under these conditions

- Panhandle generation including Antelope generation expected to have better deliverability to ERCOT system in the presence of the partial loop
**Additional Analysis Preferred Options – Dynamic Assessment**

- ERCOT Dynamic Working Group (DWG) Future Year 2021 Flat Start Dataset utilized for the dynamic analysis
- LP&L system was added to the ERCOT dataset
  - Separate dynamic dataset for each of the four (4) preferred options
  - LP&L system load was modelled to represent high load growth scenario (~ 593 MW)
- Dynamic data associated with LP&L system generation was taken from SPP models
  - Data includes models for generator, excitation system and governor system
- ‘CLOD model’ was utilized to model the dynamic nature of LP&L system loads
  - Customer type (residential, commercial etc) at each substation was provided by LP&L
  - Typical parameters were assumed for load mix (i.e. % of large motors, % small motors etc)
- All generation resources meeting section 6.9 requirements of ERCOT planning guide incrementally modeled in the case
  - Antelope gas generation units kept offline for the dynamic analysis
  - Wind generation resources in the vicinity of Lubbock dispatched at 20%
**Additional Analysis Preferred Options – Dynamic Assessment**

- Following incremental updates made to the dynamic datasets in line with ERCOT Panhandle Transfer Capability Assessment dated September 2015
  - Addition of 2\textsuperscript{nd} circuit on the Panhandle loop
  - Addition of 150 MVA of synchronous condensers at Sharyland’s 345 kV Alibates and Tule Canyon stations
- P1-P7 category events developed in accordance with NERC transmission planning standard TPL-001-4 and ERCOT Planning Guide
  - 3-Phase fault based events studied for worst case scenario
  - G-1 conditions around loss of LP&L Holly & Mackenzie units evaluated for P3 events
  - Outage of 345 kV/115 kV transformers at North, Wadsworth and New Oliver stations included as part of first contingency for A-1+N-1 events
  - P1 and P7 events are included as part of second contingency for both G-1+N-1 & A-1+N-1 events
  - Per discussion with LP&L, no non-redundant protection schemes by the time of ERCOT integration on their facilities – P5 events not applicable
- ERCOT Planning Guide & NERC TPL-001-4 performance criteria/guidelines were utilized to assess the dynamic performance of the preferred options
Dynamic Analysis for Preferred Options

Dynamic Simulation Results

- The study area was observed to be stable for all simulated events across all options studied
  - The rotor angle stability of the LP&L system and ERCOT system was maintained
  - The transient voltage recovery response of the study area was acceptable and in-line with ERCOT Planning Guide for P1-P7 events studied
  - No voltage collapse or system wide instability issues were observed
  - No incremental generation trips were observed other than the units that were tripped as part of the dynamic event
    - Only exception is breaker failure at North/McKenzie station – CCT for McKenzie generation will need to be updated as part of ERCOT integration

<table>
<thead>
<tr>
<th></th>
<th>P1/P2 Events</th>
<th>P3 Events</th>
<th>P4 Events</th>
<th>P6 Events</th>
<th>P7 events</th>
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</thead>
<tbody>
<tr>
<td><strong>Option#3-a</strong></td>
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<td>Stable*</td>
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<td>Stable*</td>
<td>Stable</td>
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</tr>
</tbody>
</table>
Additional Analysis Preferred Options – Economic Assessment

- Hourly production-cost based economic analysis performed for the preferred options
- Key objective of the economic analysis to quantify the relative annual production cost savings associated with the preferred options
  - Specific focus on quantifying benefit of LP&L on Panhandle wind deliverability
    - Panhandle wind deliverability benefited in terms of two aspects by virtue of LP&L integration
    - LP&L load “local load” for Panhandle by virtue of the integration
    - WSCR/Voltage stability benefits further increase Panhandle export capability
- Study Scenario
  - Base Case – No LP&L Integration, 2\textsuperscript{nd} circuit on Panhandle loop & SCs (and their impact) included
  - Change Cases – Base Case + LP&L Load + LP&L Integration Option
- Future generation unit additions limited to those meeting Section 6.9 requirements of ERCOT Planning Guide
### Economic Modeling Assumptions Summary, 2021

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td><strong>Installed Capacity, Thermal/Hydro/Nuclear/Solar</strong></td>
<td>65,248.24</td>
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<tr>
<td><strong>Switchable Capacity, MW</strong></td>
<td>3,667.00</td>
</tr>
<tr>
<td><strong>Available Mothballed Capacity, MW</strong></td>
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<tr>
<td><strong>Capacity from Private Use Networks</strong></td>
<td>4,561.52</td>
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<tr>
<td><strong>Non-Coastal Wind, Peak Average Capacity Contribution (12%)</strong></td>
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<tr>
<td><strong>Coastal Wind, Peak Average Capacity Contribution (56%)</strong></td>
<td>940.24</td>
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<tr>
<td><strong>RMR Capacity to be under Contract</strong></td>
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<tr>
<td><strong>Total Capacity, MW</strong></td>
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<tr>
<td><strong>Firm Peak Load, MW</strong></td>
<td>72,180.00</td>
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</table>

**Reserve Margin** 14%
## Panhandle Transmission Interface
(Source: Panhandle Transfer Capability Analysis, ERCOT, September 2015)

### Panhandle Export Limits – Study Scenarios, Economic Assessment

<table>
<thead>
<tr>
<th>Option#</th>
<th>Voltage Stability Limit</th>
<th>System Strength Limit</th>
<th>Minimum of WSCR &amp; VS Limit (MW)</th>
<th>Maximum Operational Limit (90% of limit) (MW)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Planning Studies (MW)</td>
<td>WSCR with 4302MW</td>
<td>Generation Capacity in MW for WSCR = 1.5</td>
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<tr>
<td>Base Case</td>
<td>4044</td>
<td>1.35</td>
<td>3872</td>
<td>3872</td>
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<tr>
<td>3A</td>
<td>&gt;4500</td>
<td>1.55</td>
<td>4474</td>
<td>4474</td>
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<tr>
<td>3B</td>
<td>&gt;4500</td>
<td>1.45</td>
<td>4152</td>
<td>4152</td>
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<tr>
<td>8A</td>
<td>&gt;4500</td>
<td>1.54</td>
<td>4431</td>
<td>4431</td>
</tr>
<tr>
<td>8B</td>
<td>&gt;4500</td>
<td>1.44</td>
<td>4130</td>
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</tbody>
</table>
Significant Reduction in Panhandle Export Constraints for Scenarios 3 and 8
Additional Analysis Preferred Options – Economic Assessment

- **Relative production cost savings** utilized to evaluate potential economic benefits provided by each option
- Options 3A and 8A exhibit comparable performance from a production cost savings standpoint
- Option 8B depicts ~$5M/year APC savings in comparison to Option 3B albeit at a higher capital cost
- Economics of 345kV Ogallala – Abernathy segment are observed to be better justified in Option 3 when compared to Option 8
  - APC/Capital Cost of 9.55% for Ogallala-Abernathy line in Option 3 & 4.43% in Option 8
  - ERCOT economic criteria requirement is 15% or more

<table>
<thead>
<tr>
<th>Description</th>
<th>Option 3A</th>
<th>Option 3B</th>
<th>Option 8A</th>
<th>Option 8B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative APC Savings ($M)</td>
<td>9.55</td>
<td>0.00</td>
<td>9.25</td>
<td>4.82</td>
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<tr>
<td>APC Savings Ogallala - Abernathy line ($M)</td>
<td>9.55</td>
<td></td>
<td></td>
<td>4.44</td>
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</table>
Cost-Benefit Assessment – Preferred Options

- Cost-Benefit (C/B) assessment performed to quantify benefits accrued by LP&L integration options
  - Primarily accounts for known and quantifiable benefits – avoided costs in terms of transmission upgrades that will be eliminated by LP&L integration
  - Any other benefits afforded by LP&L i.e. two (2) 50 MVA generation units expected to be retired in the future that can potentially serve as Synchronous Condensers
  - Other benefits such as SSR and APC savings not directly accounted for in the C/B assessment
  - C/B assessment limited to capital cost impacts on the integration options

<table>
<thead>
<tr>
<th>Cost Description</th>
<th>Option 3A</th>
<th>Option 3B</th>
<th>Option 8A</th>
<th>Option 8B</th>
</tr>
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<tbody>
<tr>
<td>Gross Capital Cost of Integration Options ($M)</td>
<td>$429.00</td>
<td>$330.00</td>
<td>$476.00</td>
<td>$376.00</td>
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<tr>
<td>SC Cost Replaced by LP&amp;L Integration ($M)</td>
<td>$83.20</td>
<td>$51.40</td>
<td>$83.20</td>
<td>$51.40</td>
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<tr>
<td>100 MVA SC ERCOT Cost ($M)</td>
<td>$21.33</td>
<td>$21.33</td>
<td>$21.33</td>
<td>$21.33</td>
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<tr>
<td>LP&amp;L Cost of re-furbishing two (2) 50 MVA generation units as SCs ($M)</td>
<td>$12.00</td>
<td>$12.00</td>
<td>$12.00</td>
<td>$12.00</td>
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<tr>
<td>Net Benefit - Refurbished SCs ($M)</td>
<td>$9.33</td>
<td>$9.33</td>
<td>$9.33</td>
<td>$9.33</td>
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<tr>
<td>Net Cost of Integration Options ($M)</td>
<td>$336.47</td>
<td>$269.27</td>
<td>$383.47</td>
<td>$315.27</td>
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</table>
Recommendations

- Based on analysis and results presented, following recommendations for LP&L Integration to ERCOT
  - Option 3B – 1st Recommended Option with potential to phase in Ogallala – Abernathy line in the future (Option 3A)
    - Ogallala – Abernathy line justification expected to be based on ERCOT reliability/economic criteria
  - Option 8B – 2nd Recommended Option with potential to phase in Ogallala – Abernathy line in the future (Option 8A)
    - Ogallala – Abernathy line justification expected to be based on ERCOT reliability/economic criteria
- Final report to be submitted to ERCOT for RPG stakeholder review and comments
Thank You

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LP&L Integration Options – One-Line Schematics
Three (3) Sources to LP&L

Option#1:
- **A** = 345kV line from Abernathy to LP&L North Sub
- **B** = 345kV line from Cotton Wood to LP&L Wadsworth
- **C** = Extend 345kV Grassland extension to New Oliver
- **D** = Existing 345kV line
- Two (2) 345/115kV Transformers at each LP&L POI
- Two (2) 115kV lines from New Oliver to existing Oliver and Chalker
Three (3) Sources to LP&L

- **Option#2:**
  - **A** = 345kV line from Ogallala to Abernathy
  - **B** = 345kV line from Abernathy to LP&L North Sub
  - **C** = 345kV line from Cotton Wood to LP&L Wadsworth
  - **D** = Extend 345kV Grassland extension to New Oliver
  - **E** = Existing 345kV line
  - Two (2) 345/115kV Transformers at each LP&L POI
  - Two (2) 115kV lines from New Oliver to existing Oliver and Chalker

**Option#2**
Three (3) Sources to LP&L

Option#3A (Preferred):

- **A** = 345kV line from Abernathy to LP&L North Sub
- **B** = 345kV line from Abernathy to LP&L Wadsworth
- **C** = Extend 345kV Grassland extension to New Oliver
- **D** = Existing 345kV line
- **E** = 345kV line LP&L Wadsworth to New Oliver
- **F** = 345kV line from Ogallala – Abernathy
  - Add a 2nd circuit on the existing Abernathy – White River line
  - Two (2) 345/115kV Transformers at each LP&L POI
  - Two (2) 115kV lines from New Oliver to existing Oliver and Chalker
Evaluation of Modified Options #3 and #8

Option#3B (Preferred):
- **A** = 345kV line from Abernathy to LP&L North Sub
- **B** = 345kV line from Abernathy to LP&L Wadsworth
- **C** = Extend 345kV Grassland extension to New Oliver
- **D** = Existing 345kV line
- **E** = 345kV line LP&L Wadsworth to New Oliver

Add a 2nd circuit on the existing Abernathy – White River line
- Two (2) 345/115kV Transformers at each LP&L POI
- Two (2) 115kV lines from New Oliver to existing Oliver and Chalker
Three (3) Sources to LP&L

Option#4:
- **A** = 345kV line from Ogallala to Abernathy
- **B** = 345kV line from Abernathy to LP&L North Sub
- **C** = 345kV line from Abernathy to LP&L Wadsworth
- **D** = Extend 345kV Grassland extension to New Oliver
- **E** = Existing 345kV line

Two (2) 345/115kV Transformers at each LP&L POI
Two (2) 115kV lines from New Oliver to existing Oliver and Chalker
Three (3) Sources to LP&L

- **Option#5:**
  - **A** = 345kV line from Abernathy to LP&L North Sub
  - **B** = 345kV line from Dermott to LP&L Wadsworth
  - **C** = Extend 345kV Grassland extension to New Oliver
  - **D** = Existing 345kV line
  - Two (2) 345/115kV Transformers at each LP&L POI
  - Two (2) 115kV lines from New Oliver to existing Oliver and Chalker
Three (3) Sources to LP&L

Option#6:

• **A** = 345kV line from Ogallala to Abernathy
• **B** = 345kV line from Abernathy to LP&L North Sub
• **C** = 345kV line from Dermott to LP&L Wadsworth
• **D** = Extend 345kV Grassland extension to New Oliver
• **E** = Existing 345kV line

• Two (2) 345/115kV Transformers at each LP&L POI
• Two (2) 115kV lines from New Oliver to existing Oliver and Chalker
### Three (3) Sources to LP&L

- **Option#7:**
  - **A =** 345kV line from Ogallala to Abernathy
  - **B =** 345kV line from Abernathy to LP&L North Sub
  - **C =** 345kV line from Cotton Wood to LP&L Wadsworth
  - **D =** Extend 345kV Grassland extension to New Oliver
  - **E =** 345kV line LP&L North to LP&L Wadsworth
  - **F =** Existing 345kV line
  - Two (2) 345/115kV Transformers at each LP&L POI
  - Two (2) 115kV lines from New Oliver to existing Oliver and Chalker
Option #3

Option #8A (Preferred):

- **A** = 345kV line from Abernathy to LP&L North Sub
- **B** = 345kV line from Cotton Wood to LP&L Wadsworth
- **C** = Extend 345kV Grassland extension to New Oliver
- **D** = 345kV line LP&L North to New Oliver
- **E** = Existing 345kV line
- **F** = 345kV line from Ogallala to Abernathy

Two (2) 345/115kV Transformers at each LP&L POI

Two (2) 115kV lines from New Oliver to existing Oliver and Chalker
Three (3) Sources to LP&L

- **Option#8B (Preferred):**
- **A** = 345kV line from Abernathy to LP&L North Sub
- **B** = 345kV line from Cotton Wood to LP&L Wadsworth
- **C** = Extend 345kV Grassland extension to New Oliver
- **D** = 345kV line LP&L North to New Oliver
- **E** = Existing 345kV line
- Two (2) 345/115kV Transformers at each LP&L POI
- Two (2) 115kV lines from New Oliver to existing Oliver and Chalker

**Option#8B**
Three (3) Sources to LP&L

Option#9:

- **A** = 345kV line from Ogallala to Abernathy
- **B** = 345kV line from Abernathy to LP&L North Sub
- **C** = 345kV line from Cotton Wood to LP&L Wadsworth
- **D** = Extend 345kV Grassland extension to New Oliver
- **E** = 345kV line LP&L Wadsworth to New Oliver
- **F** = Existing 345kV line

Two (2) 345/115kV Transformers at each LP&L POI

Two (2) 115kV lines from New Oliver to existing Oliver and Chalker
Option#10:

- **A** = 345kV line from Abernathy to LP&L North
- **B** = 345kV line from Abernathy to New McDonald
  - Lines A and B share same tower up to North
- **C** = 345kV line from Cotton Wood to LP&L Wadsworth
- **D** = Extend 345kV Grassland extension to New Oliver
- **E** = Existing 345kV line
  - Add a 2nd circuit on the existing White River - Abernathy
  - Two 345/115kV Transformers at New Oliver and Wadsworth
  - Two (2) 115kV lines from New Oliver to existing Oliver and South East
Option#11:

- **A** = 345kV line from Ogallala to Abernathy
- **B** = 345kV line from Abernathy to LP&L North
- **C** = 345kV line from Abernathy to New McDonald
- **D** = 345kV line from Cotton Wood to LP&L Wadsworth
- **E** = Extend 345kV Grassland extension to New Oliver
- **F** = Existing 345kV line

One 345/115kV Transformer at each LP&L POI

Two (2) 115kV lines from New Oliver to existing Oliver and South East

Two (2) 115kV lines from New McDonald to existing McDonald and Chalker
**Four (4) Sources to LP&L**

- **Option#12:**
  - **A** = 345kV line from Abernathy to LP&L North
  - **B** = 345kV line from Abernathy to LP&L Wadsworth
  - **C** = 345kV line from Cotton Wood to LP&L Holly
  - **D** = Extend 345kV Grassland extension to New Oliver
  - **E** = Existing 345kV line
    - Add a 2nd circuit on the existing White River - Abernathy
    - Two (2) 345/115kV Transformer at Wadsworth and New Oliver
    - Two (2) 115kV lines from New Oliver to existing Oliver and Chalker
Option#13

- **Option#13**:  
  - **A** = 345kV line from Ogallala to Abernathy  
  - **B** = 345kV line from Abernathy to LP&L North  
  - **C** = 345kV line from Abernathy to LP&L Wadsworth  
  - **D** = 345kV line from Cotton Wood to LP&L Holly  
  - **E** = Extend 345kV Grassland extension to New Oliver  
  - **F** = Existing 345kV line  
    - One (1) 345/115kV at each LP&L POI  
    - Two (2) 115kV lines from New Oliver to existing Oliver and Chalker
Four (4) Sources to LP&L

Option#14:

- **A** = 345kV line from Ogallala to Abernathy
- **B** = 345kV line from Abernathy to LP&L North
- **C** = 345kV line from Abernathy to New McDonald
- **D** = 345kV line from Cotton Wood to LP&L Wadsworth
- **E** = 345kV line from Cotton Wood to New Oliver

- **Lines D and E share same tower up to Wadsworth**
- **F** = Extend 345kV Grassland extension to New Oliver
- **G** = Existing 345kV line
  - One 345/115kV Transformer at each LP&L POI
  - Two 115kV lines from New Oliver to Oliver and S_East
  - Two 115kV lines from New McD to LPL McD and Chalker
Four (4) Sources to LP&L

Option#15:
- **A** = 345kV line from Ogallala to Abernathy
- **B** = 345kV line from Abernathy to LP&L North
- **C** = 345kV line from Abernathy to New McDonald
- **D** = 345kV line from Cotton Wood to LP&L Wadsworth
- **E** = 345kV line from Cotton Wood to New Oliver
- **Lines D and E share same tower up to Wadsworth**
- **F** = Extend 345kV Grassland extension to New Oliver
- **G** = Existing 345kV line
  - Two 345/115kV Transformers at New Oliver
  - Two 115kV lines from New Oliver to Oliver and S_East
  - Two 115kV lines from New McD to LPL McD and Chalker
Four (4) Sources to LP&L

Option#16:

- **A** = 345kV line from Abernathy to LP&L North
- **B** = 345kV line from Abernathy to New McDonald
  - **Lines A and B share same tower up to North**
- **C** = 345kV line from Cotton Wood to LP&L Wadsworth
- **D** = 345kV line from Cotton Wood to New Oliver
  - **Lines C and D share same tower up to Wadsworth**
- **E** = Extend 345kV Grassland extension to New Oliver
- **F** = Existing 345kV line
  - Add a 2nd circuit on existing White River to Abernathy
- Two 345/115kV Xfmr at New Oliver and Wadsworth
Four (4) Sources to LP&L

- **Option#17:**
  - **A** = 345kV line from Abernathy to LP&L North
  - **B** = 345kV line from Abernathy to New McDonald
  - **Lines A and B share same tower up to LP&L North**
  - **C** = 345kV line from Dermott to LP&L Wadsworth
  - **D** = Extend 345kV Grassland extension to New Oliver
  - **E** = Existing 345kV line
  - Add a 2nd circuit on existing White River - Abernathy
  - Two 345/115kV Xfmrs at New Oliver and Wadsworth
  - Two (2) 115kV lines from New Oliver to existing Oliver and South East
  - Two (2) 115kV lines from New McDonald to existing McDonald and Chalker
Four (4) Sources to LP&L

Option#18:
- **A** = 345kV line from Ogallala to Abernathy
- **B** = 345kV line from Abernathy to LP&L North
- **C** = 345kV line from Abernathy to New McDonald
- **D** = 345kV line from Dermott to LP&L Wadsworth
- **E** = Extend 345kV Grassland extension to New Oliver
- **F** = Existing 345kV line
  - One 345/115kV Transformer at each LP&L POI
  - Two (2) 115kV lines from New Oliver to existing Oliver and South East
  - Two (2) 115kV lines from New McDonald to existing McDonald and Chalker
Four (4) Sources to LP&L

**Option#19:**

- **A** = 345kV line from Abernathy to LP&L North
- **B** = 345kV line from Abernathy to LP&L Wadsworth
- **C** = 345kV line from Dermott to LP&L Holly
- **D** = Extend 345kV Grassland extension to New Oliver
- **E** = Existing 345kV line
  - Add a 2nd circuit on existing White River - Abernathy
  - Two (2) 345/115kV Transformer at Wadsworth and New Oliver
  - Two (2) 115kV lines from New Oliver to existing Oliver and Chalker
Four (4) Sources to LP&L

Option#20:

A = 345kV line from Ogallala to Abernathy
B = 345kV line from Abernathy to LP&L North
C = 345kV line from Abernathy to LP&L Wadsworth
D = 345kV line from Dermott to LP&L Holly
E = Extend 345kV Grassland extension to New Oliver
F = Existing 345kV line

One (1) 345/115kV at each LP&L POI
Two (2) 115kV lines from New Oliver to existing Oliver and Chalker