Central California Clean Energy Transmission Project

Preliminary Draft Report

Section 3.1.1

PG&E Greater Fresno Area Load Serving Capability Study
Objectives
The Reliability Study selects the alternatives, which can meet the NERC/WECC/CAISO Reliability Standards, and, can meet all PG&E Project Objectives outlined in the Study Plan (Attachment ##, Section ##). The Reliability Study on PG&E’s transmission system consists of three parts:

1. Load Serving Capability to the Fresno and Yosemite Area
2. Transmission Capacity for Supporting Helms Pumping Operation
3. Import Capability from southern California

The results of PG&E’s Reliability Study will be coordinated with the results of SCE’s Reliability Study to serve loads in its Big Creek area (Appendix IV). The alternatives thus selected will be further evaluated in the CAISO’s Economic Study (Appendix V).

This report covers the first part of PG&E’s reliability Study to:

1. Evaluate the transmission upgrades in the Greater Fresno Area that would be needed to meet the NERC/WECC reliability planning criteria with a planning horizon of 20 years after the expected project operation date of 2013 (20-year planning horizon)
2. Determine the alternatives that merit further evaluation in the subsequent Reliability Studies on Transmission Capacity for Supporting Helms Pumping Operation (see Attachment ##) and on Import Capability from southern California (see Attachment ##).

Assumptions and Methodology
This part of the reliability evaluation starts from the 2014 Summer Peak base case and 2014 summer partial-peak base case. (Please see Section 3 in the Study Plan included as Appendix xxx for more details.) The loads in the Greater Fresno Area were increased to represent 2033 (20 years after the expected project operation date of 2013) Summer Peak and Summer Partial Peak Conditions. (See Attachment 1 of Appendix 1 for Fresno and Yosemite Area load forecast and generation dispatch). The system was then evaluated for potential thermal overload and voltage stability problems for NERC Categories A (all facilities in service), B (Single Contingency or N-1) and C (Multiple Contingency or N-2) conditions.

Each of the fourteen proposed alternatives (outlined in Section 2.5 of the Study Plan) was evaluated and system reinforcements were added as needed to develop the conceptual plan-of-service for the 20-year planning horizon. The resulting system was then further investigated to determine if system performance can meet NERC/WECC/CAISO Reliability Criteria. The alternatives that do not meet standards by themselves will not be considered further as stand alone alternatives. However, they may be studied in combination with a different alternative, as needed.
Conclusions

Alternatives Need Further Analysis
The following Table 1 summarizes the transient stability analysis results and V-Q analysis results. Table 2 summarizes the post-transient power flow study results which identify the additional upgrades that would be needed to serve the Greater Fresno area loads for the 20-year planning horizon. Table summarizes the PV analysis. Base on the analysis, these alternatives were recommended to be studied further in the PG&E’s Reliability Studies on Transmission Capacity for Supporting Helms Pumping Operation (see Appendix II) and on Import Capability from southern California (see Appendix III):

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Transient Stability Analysis 2033 Summer Peak (See Attachment 4)</th>
<th>V-Q Analysis 2033 Summer Partial-peak (See Attachment 3)</th>
<th>Average Hydro</th>
<th>Drought Year Hydro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative 2: Build Midway-E2 500kV DCTL</td>
<td>• Stable and damped</td>
<td>• Meet NERC/WECC voltage criteria</td>
<td>• Meet NERC/WECC voltage criteria</td>
<td>• Drop loads for a 230 kV DCTL outage.</td>
</tr>
<tr>
<td>Alternative 2a: Build Midway-E2 500kV DCTL with S2 loop-in</td>
<td>• Stable and damped</td>
<td>• Meet NERC/WECC voltage criteria</td>
<td>• Drop loads for a 230 kV DCTL outage.</td>
<td></td>
</tr>
<tr>
<td>Alternative 2b: Build Midway – E2 500kV DCTL, S2 and S3 Loop-in, and Whirlwind – S3 500 kV SCTL</td>
<td>• Stable and damped</td>
<td>• Meet NERC/WECC voltage criteria</td>
<td>• Drop loads for a 230 kV DCTL outage.</td>
<td></td>
</tr>
<tr>
<td>Alternative 2c: Build Midway-E2 500kV DCTL with S2 loop-in. Upgrade Midway-Whirlwind 500kV line</td>
<td>• Stable and damped</td>
<td>• Meet NERC/WECC voltage criteria</td>
<td>• Drop loads for a 230 kV DCTL outage.</td>
<td></td>
</tr>
<tr>
<td>Alternative 2d: Build Midway – Gregg 500kV DCTL</td>
<td>• Stable and damped</td>
<td>• Meet NERC/WECC voltage criteria</td>
<td>• Drop loads for a 230 kV DCTL outage.</td>
<td></td>
</tr>
</tbody>
</table>
Table 1 (continue)
Summary of Transient Stability Analysis and V-Q Analysis for Alternatives Recommended to be studied further

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Transient Stability Analysis</th>
<th>V-Q Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2033 Summer Peak (See Attachment 4)</td>
<td>2033 Summer Partial-peak (See Attachment 3)</td>
</tr>
<tr>
<td><strong>Average Hydro</strong></td>
<td><strong>Drought Year Hydro</strong></td>
<td><strong>Average Hydro</strong></td>
</tr>
<tr>
<td>Alternative 3: Build Midway – E2 500kV SCTL with S2 Loop-in</td>
<td>• Stable and damped</td>
<td>• Meet NERC/WECC voltage criteria</td>
</tr>
<tr>
<td>Alternative 4: Build Whirlwind – E2 500kV DCTL with S2 Loop-in</td>
<td>• Stable and damped</td>
<td>• Meet NERC/WECC voltage criteria</td>
</tr>
<tr>
<td>Alternative 6: Build Fresno – Big Creek 230kV Tie</td>
<td>• Need to install 400 MVAR SVC at Gregg 230kV bus to protect the system from system instability.</td>
<td>• Meet NERC/WECC voltage criteria</td>
</tr>
<tr>
<td>Alternative 7: Build Midway – McCall – E2 230 kV DCTL</td>
<td>• Need to install 400 MVAR SVC at Gregg 230kV bus to protect the system from system instability.</td>
<td>• Meet NERC/WECC voltage criteria</td>
</tr>
<tr>
<td>Alternative 8: Build Gates – Gregg 230kV DCTL</td>
<td>• Need to install 400 MVAR SVC at Gregg 230kV bus to protect the system from system instability.</td>
<td>• Drop loads for a 230 kV DCTL outage.  • Increase dispatch of Fresno area peaking generation to 50%.</td>
</tr>
<tr>
<td>Alternative 10: New Generation (400MW at Borden + 600MW at McCall)</td>
<td>• Stable and damped</td>
<td>• Drop loads for a 230 kV DCTL outage.  • Drop loads for a 230 kV DCTL outage.</td>
</tr>
</tbody>
</table>
**Table 2**
Summary of Post-transient Power Flow Analysis for
Alternatives Recommended to be studied further

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Upgrades Needed for Normal and Single Contingency (Category “A” &amp;“B” Contingency)</th>
<th>Upgrades Needed for Double Contingencies (Category “C” Contingency)</th>
</tr>
</thead>
</table>
Table 2 (continue)
Summary of Post-transient Power Flow Analysis for Alternatives Recommended to be studied further

|-------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------|
| Alternative 3: Build Midway – E2 500kV SCTL with S2 Loop-in | 1. Warnerville – Wilson 230kV line  
  2. Panoche – Helm 230kV line  
  3. Helm – McCall 230kV line  
  4. Panoche – McMullin 230kV line  
  5. McMullin – Kearney 230kV line  
  6. Kearney – Herndon 230kV line  
  7. Herndon – Woodward 115kV line  
  8. Ring-bus arrangement at Henrietta 230kV Substation  
  9. Static Voltage Device (SVD) at Gregg (2x75MVAR) and McCall (4x75MVAR) | 1. McCall – Henrietta 230kV line  
  2. Wilson – Oro Loma 115kV line  
  3. Oro Loma – El Nido 115kV line  
  4. Borden – Gregg 230kV line  
  5. Special Protection Scheme to drop local loads for the loss of E2-Gregg 230kV DCTL. |
| Alternative 4: Build Whirlwind – E2 500kV DCTL with S2 Loop-in | 1. Warnerville – Wilson 230kV line  
  2. Panoche – Helm 230kV line  
  3. Helm – McCall 230kV line  
  4. Panoche – McMullin 230kV line  
  5. McMullin – Kearney 230kV line  
  6. Herndon – Woodward 115kV line  
  7. Ring-bus arrangement at Henrietta 230kV Substation  
  8. Static Voltage Device (SVD) at Gregg (2x75MVAR) and McCall (4x75MVAR) | 1. Kearney – Herndon 230kV line  
  2. McCall – Henrietta 230kV line  
  3. Wilson – Le Grand 115kV line  
  4. Oro Loma – El Nido 115kV line  
  5. Borden – Gregg 230kV line  
  6. Special Protection Scheme to drop local loads for the loss of E2-Gregg 230kV DCTL. |
| Alternative 6: Build Fresno – Big Creek 230kV Tie | 1. Panoche – Helm 230kV line  
  2. Helm – McCall 230kV line  
  3. Panoche – McMullin 230kV line  
  4. McMullin – Kearney 230kV line  
  5. Kearney – Herndon 230kV line  
  6. Warnerville – Wilson 230kV line  
  7. Melone – Wilson 230kV line  
  8. Wilson – Storey 230kV line  
  9. Gates – Henrietta 230kV line  
  10. McCall - Henrietta 230kV line  
  12. El Nido - Oro Loma section of the Wilson B – Oro Loma 115kV line  
  13. LeGrand - Chowchilla 115kV line  
  14. Ring-bus arrangement at Henrietta 230kV Substation  
  15. Static Voltage Device (SVD) at Gregg (4x75MVAR) and McCall (4x75MVAR) | 1. Borden – Gregg 230kV line  
  2. Bellota – Cottle B section of the Bellota – Wilson 230kV line  
  3. Storey – Borden 230kV line section of the Gregg – Wilson 230kV line  
  4. Wilson A – Le Grand 115kV line  
  5. Le Grand Jct. – El Nido section of the Wilson B – Oro Loma 115kV line  
  6. Panoche – Oro Loma 115kV line  
  7. Special Protection Scheme to drop local loads for the loss of E2-Gregg 230kV DCTL. |
### Table 2 (continue)
Summary of Post-transient Power Flow Analysis for Alternatives Recommended to be studied further

|-------------|--------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| **Alternative 7:** Build Midway – McCall – E2 230 kV DCTL | 1. Warnerville – Wilson 230kV line  
2. Panoche – Helm 230kV line  
3. Helm – McCall 230kV line  
4. Panoche – McMullin 230kV line  
5. McMullin - Kearney 230kV line  
6. Borden – Gregg 230kV line  
7. McCall 230/115 kV transformer bank #1  
8. McCall – Sanger #3 115 kV line  
9. Ring-bus arrangement at Henrietta 230kV Substation  
10. Static Voltage Device (SVD) at Gregg (4x75MVAR) and McCall (4x75MVAR) | 1. Kearney – Herndon 230kV line  
2. McCall – Henrietta 230kV line  
3. Wilson – Oro Loma 115kV line  
4. Panoche – Oro Loma 115kV line  
5. Special Protection Scheme to drop local loads for the loss of E2-Gregg 230kV DCTL. |
| **Alternative 8:** Build Gates - Gregg – E2 230kV DCTL | 1. Warnerville – Wilson 230kV line  
2. Panoche – Helm 230kV line  
3. Helm – McCall 230kV line  
4. Panoche – McMullin 230kV line  
5. Borden – Gregg 230kV line  
6. Herndon – Woodward 115kV line  
7. Ring-bus arrangement at Henrietta 230kV Substation  
8. Static Voltage Device (SVD) at Gregg (4x75MVAR) and McCall (4x75MVAR) | 1. McCall – Henrietta 230kV line  
2. McMullin – Kearney 230kV line  
3. Wilson B – Le Grand 115kV line  
4. El Nido – Oro Loma section of the Wilson B – Oro Loma 115kV line  
5. Panoche – Oro Loma 115kV line  
6. Le Grand – Chowchilla 115kV line |
| **Alternative 10:** New Generation (400MW at Borden + 600MW at McCall) | 1. Warnerville – Wilson 230kV line  
2. Panoche – McMullin 230kV line  
3. McMullin - Kearney 230kV line  
4. Kearney – Herndon 230kV line  
5. McCall 230/115kV transformer bank #1  
6. McCall – Sanger #3 115 kV line  
7. Herndon – Woodward 115kV line  
8. Ring-bus arrangement at Henrietta 230kV Substation  
9. Static Voltage Device (SVD) at Gregg (2x75MVAR) and McCall (2x75MVAR)  
10. Other transmission facilities identified in generation interconnection studies. | 1. Wilson A– Le Grand 115kV line  
2. Wilson B – Le Grand Jct. 115kV line  
3. Le Grand Jct. – El Nido 115kV line  
4. Panoche – Oro Loma 115kV line  
5. Oro Loma – El Nido 115kV line |
Table 3
Summary of PV Analysis for
Alternatives Recommended to be studied further

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Worst Contingency (Category “C” contingency)</th>
<th>P_{collapse} (MW)</th>
<th>V_{collapse} (kV)</th>
<th>Real Power Margin (MW)</th>
<th>Load Serving Capability (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alt-2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alt-2a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Alt-2b</td>
<td></td>
<td></td>
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<tr>
<td>Alt-2c</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Alt-2d</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Alt-3</td>
<td></td>
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<td>Alt-4</td>
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<td>Alt-6</td>
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<td></td>
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<tr>
<td>Alt-7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alt-8 (new)</td>
<td>3640</td>
<td>218</td>
<td>91</td>
<td>3549</td>
<td></td>
</tr>
<tr>
<td>Alt-10 (new)</td>
<td>3400</td>
<td>207</td>
<td>85</td>
<td>3315 !!!</td>
<td></td>
</tr>
</tbody>
</table>

**Alternative 2**: Build Midway – E2 500kV DCTL (See Figure 7 and 8 in the Study Plan)

Transient stability study shows Alternative 2 would meet WECC transient disturbance performance standards. See appendix I, Attachment 4. V-Q and P-V analyses show that this alternative would meet NERC/WECC voltage criteria under the 2033 summer partial-peak conditions studied. See Appendix 1, Attachment 3 and 5.

Post-transient power flow study results show that Alternative 2 would require additional upgrades in order to serve the Greater Fresno area loads for the 20-year planning horizon. See Appendix I, Attachment 2.

**Alternative 2a**: Build Midway – E2 500kV DCTL with S2 Loop-in (See Figure 9 and 10 in the Study Plan)

**Alternative 2b**: Build Midway – E2 500kV DCTL, S2 and S3 Loop-in, and Whirlwind – S3 500 kV SCTL (Figure 11 and 12 in the Study Plan)

**Alternative 2c**: Build Midway – E2 500kV DCTL with S2 Loop-in and upgrade the existing Midway – Whirlwind 500 kV line (See Figure 13 and 14 in the Study Plan)
This alternative is same as Alternative 2a, except also upgrading the existing Midway – Whirlwind 500 kV line. The system performance and upgrades needed would be the same as that for Alternative 2a.

**Alternative 2d**: Build Midway – Gregg 500kV DCTL (See Figure 15 and 16 in the Study Plan)

**Alternative 3**: Build Midway – E2 500kV SCTL with S2 Loop-in (See Figure 17 and 18 in the Study Plan)

**Alternative 4**: Build Whirlwind – E2 500kV DCTL with S2 Loop-in (See Figure 19 and 20 in the Study Plan)

**Alternative 6**: Build Fresno – Big Creek 230 kV Tie (see Figure xx and xx in the Study Plan)

**Alternative 7**: Build Midway - McCall –E2 230 kV DCTL (see Figure xx and xx in the Study Plan)

**Alternative 8**: Build Gates - Gregg 230kV DCTL (see figure 27 and 28 in the study plan)

**Alternative 10**: New Generation (a 600 MW of combined cycle plant at McCall and a 400MW of solar farm at Bolden)
Alternatives Considered but Eliminated from Further Analysis

Table 4 summarizes the transient stability analysis and V-Q analysis results. Table 5 summarizes the PV analysis. Based on the analysis, these alternatives were recommended to be eliminated from further analysis. Based on the analysis despite additional transmission reinforcement these alternatives do not meet the NERC/WECC/CAISO Reliability Standards, or can result in potential voltage collapse leading to wide spread blackouts.

Table 4
Summary of Transient Stability Analysis and V-Q Analysis for Alternatives Recommended to Be Eliminated

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Transient Stability Analysis 2033 Summer Peak (See Attachment 4)</th>
<th>V-Q Analysis 2033 Summer Partial-peak (See Attachment 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Hydro Drought Year Hydro</td>
<td></td>
</tr>
<tr>
<td>Alternative 1: Upgrading the existing transmission system without building new transmission lines</td>
<td>* Need to install 400 MVAR SVC at Gregg 230kV bus to protect the system from system instability.</td>
<td>* Reactive margin deficiency and high voltage collapse points at McCall, Henrietta, and Wilson for a DCTL outage. * Not meet NERC/WECC voltage criteria</td>
</tr>
<tr>
<td>Alternative 5: Build Midway - E2 230kV DCTL</td>
<td>* Need to install 400 MVAR SVC at Gregg 230kV bus to protect the system from system instability.</td>
<td>* Drop loads for a 230kV DCTL outage. * Not meet NERC/WECC voltage criteria</td>
</tr>
</tbody>
</table>
**Table 5**
Summary of PV Analysis for Alternatives Recommended to Be Eliminated

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Worst Double Contingency (Category “C”)</th>
<th>P(_\text{collapse}) (MW)</th>
<th>V(_\text{collapse}) (kV)</th>
<th>Real Power Margin (MW)</th>
<th>Load Serving Capability (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alt-1 (new)</td>
<td>3440</td>
<td>220</td>
<td>86</td>
<td>3354</td>
<td></td>
</tr>
<tr>
<td>Alt-5 (new)</td>
<td>3655</td>
<td>217</td>
<td>91</td>
<td>3564</td>
<td></td>
</tr>
<tr>
<td>Alt-9 (new)</td>
<td>3430</td>
<td>207</td>
<td>86</td>
<td>3344</td>
<td></td>
</tr>
</tbody>
</table>

**Alternative 1**: Upgrade the existing transmission system without building new transmission lines (see Figure 5 and 6 in the Study Plan)

Alternative 1 is eliminated because even after mitigating the potential thermal overloads identified (see Appendix I, Attachment 2 Table 1), by upgrading the impacted transmission facilities and adding the maximum voltage support without introducing over-voltage, system performance cannot meet the requirements for Standard I.D.WECC-S2\(^1\). V-Q analysis shows reactive margin deficiency at McCall and Henrietta and Wilson for a Category “C” contingency (see Appendix I, Attachment 3 Figure A3-Alt1M-1 through A3-Alt1M-3.) P-V analysis also shows that this alternative cannot serve the area for a 20-year planning horizon (see the above Table 5).

**Alternative 5**: Build Midway – E2 230kV DCTL (see Figure 21 and 22 in the Study Plan)

Alternative 5 is eliminated because even after mitigating the thermal overloads identified (see Appendix I, Attachment 2, Table 1) by upgrading the impacted transmission lines and adding the voltage support needed, system performance would still not be acceptable. The voltage at McCall 230kV bus voltage could collapse at 217 kV for the loss of Helm-McCall and Henrietta-McCall 230kV DCTL that is higher than the WECC voltage criteria of 10% voltage deviation (207 kV) for a Category “C” contingency (See Appendix 1, Attachment 3, Figures A3-Atl5M-3.)

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\(^1\) See [http://www.wecc.biz/documents/library/procedures/CriteriaMaster.pdf](http://www.wecc.biz/documents/library/procedures/CriteriaMaster.pdf). WECC Standard I.D.WECC-S2 states, “For load areas, post-transient voltage stability is required for the area modeled at a minimum of 105% of the reference load level for system normal conditions (Category A) and for single contingencies (Category B). For multiple contingencies (Category C), post-transient voltage stability is required with the area modeled at a minimum of 102.5% of the reference load level. For this standard, the reference load level is the maximum established planned load limit for the area under study.”
Increase in the existing Fresno Area peaking generation from the historical level of 13% to 50% of installed capacity would not lower the voltage collapse point that is too high and not acceptable (See Appendix 1, Attachment 3, Figures A3-Atl5M-4). The P-V analysis confirms the potentially high voltage collapse point making this alternative unacceptable.

Under drought year conditions, the system would still have reactive margin deficiency at McCall and Henrietta even after building a new E2 – Pine Flat 230 kV DCTL and upgrading the Pine Flat - McCall 230 kV DCTL. Alternative 5 with the additional upgrades would still not meet the NERC/WECC voltage criteria.

**Alternative 9: Build Raisin City Switching Station**

The decision to eliminate Alternative 9 is still under review by the CAISO.