

Planning for Second Dry Year Operation Reliability Study

January 23, 2008

California ISO

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Executive Summary

The weather patterns in California can experience a number of dry years in succession. In a multi-year drought cycle, the water levels at major reservoirs can drop to less than half of its normal capacity or lower. This could lead to progressively lower hydro generation capacity as well as lower energy production that are available during peak and partial peak loading periods. To prepare for this operating condition, the CAISO assembled a team in July 2007 to study the potential impacts of low hydro generation scenarios and to make recommendations on how to mitigate the risks to grid reliability and ultimately to California customers.

This report identifies the impacts that drought conditions can have on the northern California power system based on 2008 summer 1-in-10 forecast peak load conditions. It further analyzes the risk of potential load losses due to either energy shortage and/or power grid constraints of overloads or voltage collapses. Finally, short and long term solutions are recommended.

A 1990 PG&E hydro generation report shows various hydro generation patterns for each of the hydro generators under dry, normal and wet hydro conditions and for peak, partial peak and off peak load levels. In an effort to expose all potential reliability problems, hydro generation levels were assumed to be generally lower than that expected for the partial peak load periods and loads were assumed to be higher than expected. Approximately 2500 MW hydro generation is assumed available in this study for the northern California system. With a maximum capacity of 9000+ MW, the northern California hydro generators would be expected to produce from 2900 MW during partial peak conditions to 4900 MW during peak load for dry hydro years. This compares to 4100 MW during partial peak and 5300 MW during peak load for normal hydro years.

With a low level hydro generation of 2500 MW, the northern California power grid would be stretched to and beyond its limits. Using 2008 summer base cases, studies have shown that normal overloads would occur on 12 transmission lines and 1 transformer. In addition, numerous contingency overloads were also identified. There would be little additional generation resources available to mitigate the congestion, which can occur when N-1 flow limits are violated. Studies have also shown potential voltage stability concerns in the event of single and/or double line contingencies. Additional studies are required to verify voltage stability problems.

To remove the normal overloads, it has been estimated that up to 1600 MW of load may be at risk of interruptions. The amount of load at risk to protect against single contingencies would be higher. This report describes a number of actions that could be taken to significantly reduce the amount of load that is at risk of being interrupted.

It is worth noting that the low hydro generation levels used are much lower than the levels used in normal planning studies such as Local Capacity Requirement and/or Transmission Expansion Planning and are lower than would be expected during a dry hydro year. However, multi-year droughts have occurred in the most recent two decades and most certainly can repeat themselves in the future. It is prudent that we formulate and implement this plan so minimize the risks identified and to safeguard the integrity of the California power grid. In addition to cost considerations, many of the fixes require long lead-time to implement. To address all of these issues, this plan separates the solutions into short term and long term fixes. Short-term fixes are to be implemented by summer

2008. Long-term fixes could take one, two more years or even longer depending on the complexity of each project. The bottom line is that we must do what we can to keep the risk of load loss at a minimum. Recommended solutions, both short term and longer term, are shown below, details are shown the Recommended Solutions section:

Table 1. Summary of Short Term and Long Term Solutions

| Required Project | Project Benefits | Target Date | Project Status | Lead Responsibility |
|---|---|--------------------|--|----------------------------|
| Emergency operating plans/procedures | To equip operating staff with tools and instructions to respond to real-time challenges. | March 2008 | To be implemented. | CAISO |
| Automated load shedding protections | To protect the transmission assets upon a contingency loss of a transmission element. | March 2008 | More study is required. | PG&E |
| Special Protection Schemes (UVLS) | Improves voltage collapse reliability margin. | May 2008 | PG&E is conducting feasibility study and is expected to provide the scope and cost of the project by Jan 2008 if feasible. | PG&E |
| Peaking generation and/or Demand Side Management in the Fresno, Stockton 115 kV and Sacramento areas. | To alleviate contingency and normal overloads. To reduce the risk of load interruptions. | June 2010 | Guidance from management is sought on how to proceed. | CAISO/LSEs |
| Dynamic Line Rating | Potentially increases transmission line ratings in real-time and possibly reduces congestion and improve reliability. | March 2008 | PG&E has installed Dynamic Rating devices at certain locations and is evaluating additional installations. | PG&E |
| Capacitor Additions | Improves Voltage Stability at McCall and Rio Oso areas. | May 2009 | More study is required. | PG&E/CAISO |
| Gates-McCall 230 kV line Reconductoring | Reduces line overloads. Improves Helms pumping window. Solves the normal overload problem. | 2010 to 2015 | PG&E will conduct feasibility analysis and provide project scope and cost if feasible. | PG&E |
| Table Mtn-Rio Oso 230 kV line reconductoring and raising towers | Reduces line overloads. Removes limitations on Hyatt/Thermalito generation outputs. | May 2009 | Project started in Oct 2007. Completion expected in early 2009. | PG&E |
| More line re-conductoring | To alleviate contingency and normal overloads | March 2009 | More study is required. | CAISO |
| Investing in new technologies, such as energy storage, real-time operating limits/control/protection | To maximize assets utilization, and to improve the load factor of intermittent energy source (wind) | 2011 | More study is required. | CAISO |
| Plan for and build new transmission/generation infrastructure | To solve additional reliability/congestion problems, such as state or west wide energy shortage due to drought and/or retirement of aging power plants. | 2011 to 2017 | More study is required. | CAISO |

Background

The weather pattern in California can experience a number of drought years in succession. Towards the end of the multi-year drought cycle, the water levels at major reservoirs can drop to less than half of its normal capacity or lower. This could lead to progressively lower hydro generation during peak and partial peak loading periods. This study attempts to identify any operating challenges under such conditions and make plans to mitigate adverse affects of lower hydro generation with a goal of maintaining reliable power supply to customers.

As of September 1, 2007, the California statewide reservoir water storage was about 85 percent of average. Real drought levels would be in the 70 - 75 percent of average storage range, which would take another drought year to get to that level. The worst-case scenario for reduction of generating capability is based on the worst case conditions found during the 1980's, which results in an approximate 50% reduction for total CAISO hydro generation during the latter months of the summer season. This leaves approximately 4,000 MW of hydro generation available to meet daily peak demands during August – September. These levels can be available for durations of only a few hours each day, leaving even lesser amounts of generating capabilities during other near-peak hours of the day. This level of reduction in generating capability is a very low probability, but it gives a frame of reference for what the worst-case scenario looks like.

Based on a preliminary analysis of the loads and resources balance for the summer 2008, there are a number of inputs such as a reduction in expected import levels that will result in reduced planning reserve margins (PRM) for 2008. The potential for loss of capacity due to adverse hydro conditions have the potential to overshadow all other impacts to the PRM for the summer 2008. If the extreme reduction of hydro capacity as described above were to occur (approximately 4,000 MW at time of peak) the PRM will likely decline to below the 15-17 percent target set in the Resource Adequacy program.

One other noteworthy potential impact could come from state and federal pumping operations, which could be restricted by judicial decree, administrative direction, or extreme runoff shortage, resulting in reduced load available for demand response.

Objective/Scope

The objective of this study is to assess the potential risk of a low hydro generation scenario on system reliability in northern California, and to propose mitigation measures in the form of short and longer-term solutions. To expose more risks, a lower than expected level of hydro generation is used in this study.

Specifically, this study has the following scope and objectives:

1. Develop base case assumptions on hydro generation.
2. Ascertain the impacts on the grid based on low levels of hydro availability, at local and zonal levels.
3. Estimate the amount of load at risk of not being served.
4. Identify potential solutions including short term and long term options, including:
 - a. Dynamic equipment ratings,
 - b. Special Protection Schemes (SPS), including UVLS.
 - c. Transmission line/transformer re-rates,
 - d. Transmission line reconductoring,
 - e. New reactive power devices (static or dynamic),
 - f. New transmission lines/transformers and/or new generators.
5. Identify areas of concern.

Baseline power flow, voltage stability and transient stability studies were performed for the PG&E system (Northern California) using one set of base cases. Sensitivity studies are required in order to account for the complexity of hydro generation patterns and load patterns during the summer months. However, these sensitivity studies may not be complete within the November timeline. A follow up study will be initiated in that case.

The focus of this study is on the two areas of northern California system (PG&E service areas): Central/North Valley and South Valley (two shaded areas on the map below). Southern California system and the surrounding areas could be included in the study in the future.

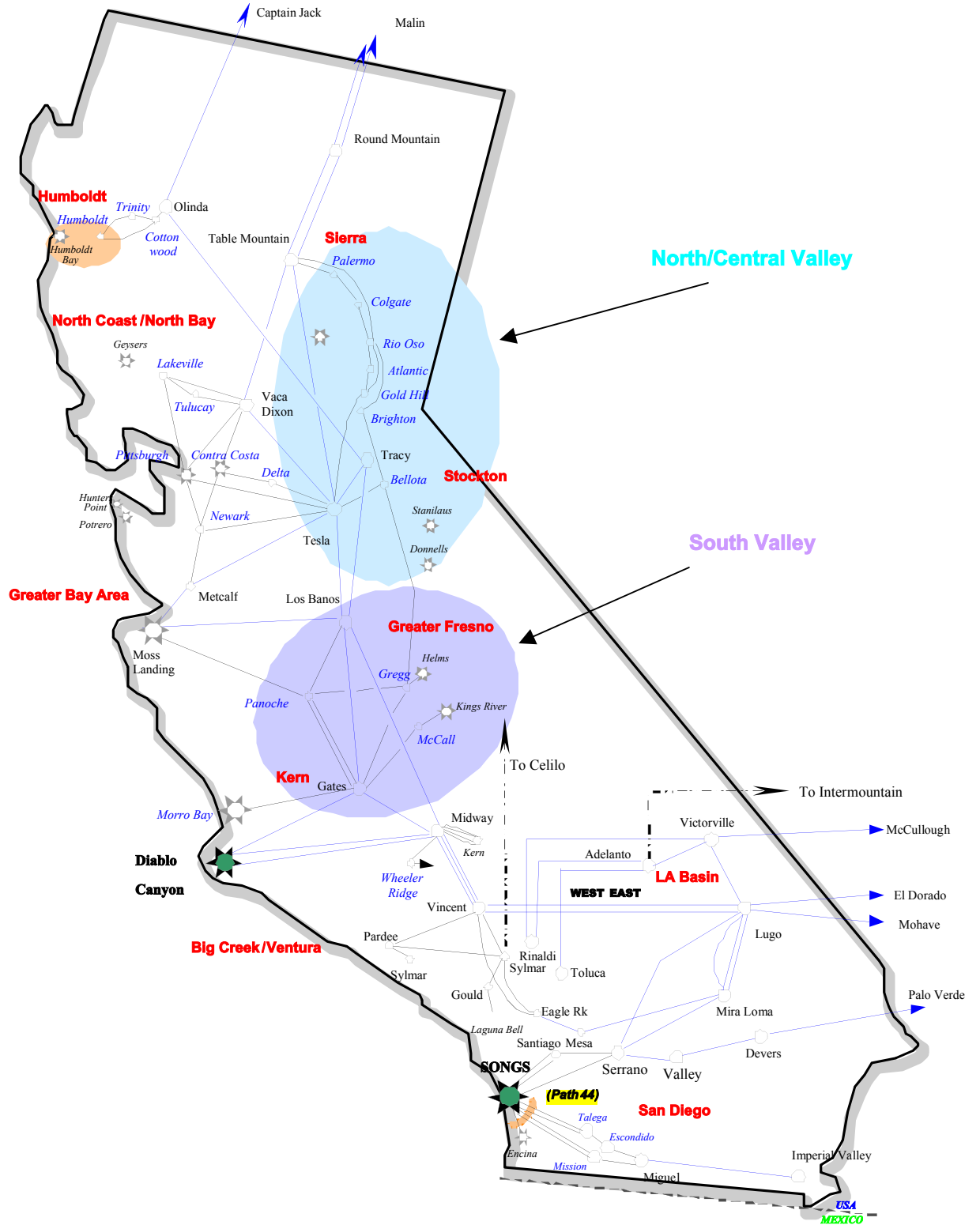


Figure 1. CAISO Grid Map: North/Central Valley and South Valley

Modeling (Base Case) Assumptions

1. Starting base cases

For this study, we focused on peak loading conditions of summer 2008. We start with the following three base cases that were used for the most recent LCR study:

- Case #1: 2008_1_5_pgssystem_v1.sav
- Case #2: 2008_1_10_cvalley_simult_v2.sav
- Case #3: 2008_1_10_valleysouth_simult_v1.sav

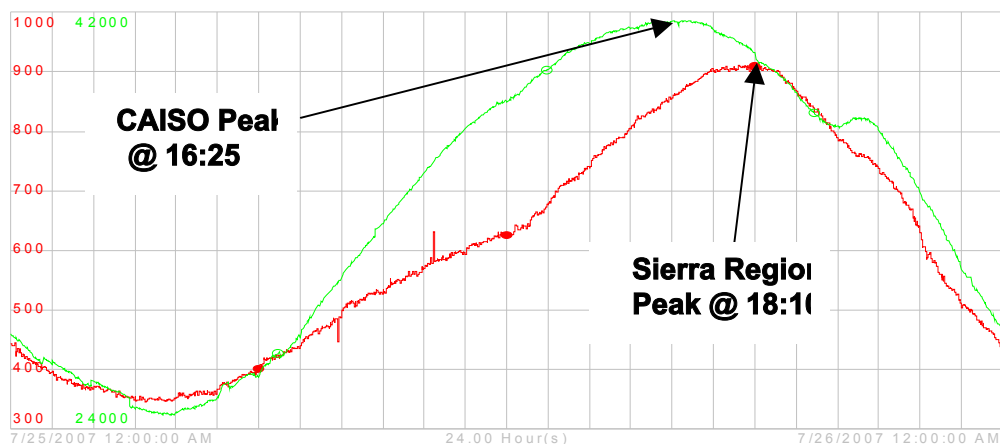
Case #1 is the 2008 summer peak planning base case with a 1 in 5 peak load forecast for all PG&E loads. Case #2 is the 2008 summer peak planning base case with a 1 in 10 load forecast for Central Valley system. Central Valley is the valley area north of Fresno and south of Table Mountain, including areas like Sierra, Sacramento (PG&E), Stockton and Stanislaus. Case #3 is the 2008 summer peak planning base case with a 1 in 10 load forecast for South Valley system. South Valley refers to the following areas of Fresno, Yosemite and Kern.

2. Hydro Generation Pattern:

The hydro generation pattern is based on the data from a PG&E hydro generation report. Hydro generation levels under different load conditions were reported, including system peak load, system partial peak and off peak loading conditions. Hydro generation levels under partial peak loading conditions were chosen to represent the Low Hydro conditions in this study. Two factors contributed to this selection:

1. In a drought year, hydro generation in the valley areas typically operates at high levels of output for a couple of hours to cover the system peak, but then drops drastically in the evening and morning periods.
2. Load in the north and south valleys typically peaks two to three hours later than the system peak. For example, the CAISO system peak typically peaks at 16:30 while PG&E's Sierra region can peak as late as 18:30. See Figure 2 for an illustration of this phenomenon.

Figure 2. CAISO vs Sierra Load Pattern



The generation assumptions in the study are a hybrid of Real Time measurements and historical drought year data. Hydro generation levels for each water shed during partial system peak in the 1990 PG&E Hydro Report were used as the target hydro generation levels. In an effort to reflect more recent hydro generation patterns, actual hydro generation levels for each of the hydro generators at certain time of a day in June 2007 were used such that the total output would match the partial peak levels in the 1990 PG&E report. It is worth noting that during summer 2007, there was adequate water supply that can power hydro generation and meet the capacity and energy requirements in northern California. The low hydro condition is modeled throughout Northern and Central California watersheds. Owners of the units along these watersheds include WAPA, CDWR, SMUD, and PG&E. Table 2 details the hydro generation pattern modeled for this study.

Table 2. Low Hydro Generation Pattern (MW) for Base Cases by Watershed

| Watershed | Capacity | North Valley Cases | South Valley Case |
|----------------------------|-----------------|---------------------------|--------------------------|
| CVP | 1,115 | 644 | 644 |
| McCloud-Pit | 763 | 184.5 | 184.5 |
| Cow-Battle Creek | 43 | 21.3 | 21.3 |
| Desabla | 25 | 12.1 | 12.1 |
| Feather River | 725 | 207.3 | 207.3 |
| Lake Oroville | 933 | 287.5 | 287.5 |
| North Yuba | 522 | 119.4 | 119.4 |
| South Yuba | 271 | 90.2 | 90.2 |
| American River (PG&E) | 272 | 35 | 35 |
| American River (SMUD) | 661 | 126.5 | 126.5 |
| American River (WAPA) | 178 | 53 | 53 |
| Mokelumne | 210 | 100 | 100 |
| Stanislaus (PG&E) | 200 | 37.5 | 37.5 |
| Stanislaus (WAPA) | 384 | 0 | 0 |
| Merced River | 100 | 20 | 20 |
| San Joaquin River | 222 | 16 | 29.5 |
| Kings River (except Helms) | 381 | 20 | NA |
| Kings River (With Helms) | 1593 | NA | 345.1 |
| Total (no Helms) | 7005 | 1974 | NA |
| Total (with Helms) | 8217 | NA | 395 |

3. Base Case Characteristics

All the base cases are tuned to reflect generation, load and path flows expected for a drought season. However, they are not meant to capture all possible conditions in a drought season. Instead, these base cases are for the purpose of a baseline analysis. Additional sensitivity studies may be necessary to analyze the impacts of other variations of generation, load and import levels. For this baseline study, a detailed summary of some of the key assumptions is shown in the following table.

Table 3. Base Case Characteristics

| Characteristic | North East | Central Valley | South Valley |
|---------------------------|-------------------|-----------------------|---------------------|
| COI (North to South) | 4,686 | 4,698 | 4,448 |
| Path 15 (South to North) | 3,586 | 4,052 | 2,951 |
| Path 26 (North to South) | 161 | -516 | 720 |
| Summit Tie (West to East) | 12 | 0 | 13 |
| Northern Cal Hydro (%) | 38% | 38% | 38% |
| Fresno Hydro (%) | 18.5% | 18.5% | 20% |
| Greater Fresno Load | 3,000 | 3,083 | 3,315 |
| Sacramento Load | 1,123 | 1,214 | 1,134 |
| Sierra Load | 1,333 | 1,469 | 1,338 |
| Bay Area Load | 8,580 | 8,310 | 7,867 |
| Stockton Load | 1,318 | 1,407 | 1,298 |
| Stanislaus Load | 268 | 287 | 264 |
| SMUD Load | 3,276 | 3,440 | 3,135 |
| TID Load | 422 | 427 | 413 |
| MID Load | 566 | 595 | 541 |

Note: All Area Load measurements are Load + Losses. All are in MW except for %.

Studies Performed

1. Power Flow Study

System normal, N-1 and common mode N-2 load flow studies were performed using the bases with generation levels shown in Table 3. A number of normal and contingency overloads were identified. The results are listed below.

Table 4. Normal Overload Results

| | Contingency | Overload | Rating | Loading | % |
|-----------------------|-------------|---|----------|----------|-------|
| North East | None | Table Mt-Palermo 230kV | 826 A | 1197 A | 145.0 |
| | None | Table Mt-Rio Oso 230kV | 826 A | 1033 A | 125.1 |
| | None | Stanislaus-Melones-Manteca #3 115kV | 281 A | 297 A | 105.8 |
| | None | Bogue-Rio Oso 115kV | 442 A | 458 A | 103.7 |
| | None | Tesla-Stagg 230kV | 826 A | 852 A | 103.2 |
| | None | Eight Mile-Tesla 230kV | 826 A | 842 A | 102.0 |
| Central Valley | None | Stanislaus-Melones-Manteca #3 115kV | 281 A | 334 A | 118.8 |
| | None | Tesla-Salado-Manteca 115kV | 281 A | 313 A | 111.2 |
| | None | Weber-Tesla 230kV | 1200 A | 1314 A | 109.6 |
| | None | Telsa 500/230kV Bank #2 | 1131 MVA | 1210 MVA | 107.0 |
| South Valley | None | Gates-McCall (Henrietta Tap-McCall) | 825 A | 987.7 A | 119.7 |
| | None | Panoche-Oro Loma 115kV (Panoche Jct-Hammonds) | 489 A | 525.3 A | 107.9 |
| | None | Panoche-Kearney 230kV (Panoche-McMullin) | 825 A | 838.7 A | 101.6 |

Table 5. Single Contingency (N-1) Results (Overload > 120%)

| | Contingency | Overload | Rating | Loading | % |
|-----------------------|-----------------------------|---------------------------------------|---------------|----------------|----------|
| North East | Table Mt-Rio Oso 230kV | Table Mt-Palermo 230kV | 976 A | 1601 A | 164.0 |
| | Table Mt-Palermo 230kV | Table Mt-Rio Oso 230kV | 976 A | 1451 A | 148.6 |
| | Stagg-Tesla 230kV | Tesla-Eight Mile 230kV | 976 A | 1434 A | 146.8 |
| | Placer-Gold Hill #2 115kV | Placer-Gold Hill #1 115kV | 417 A | 593 A | 142.2 |
| | Tesla-Eight Mile 230kV | Stagg-Tesla 230kV | 976 A | 1376 A | 141.0 |
| | Tesla-Manteca 115kV | Tesla-Salado-Manteca 115kV | 326 A | 417 A | 127.7 |
| | Bellota-Tesla 230kV | Tesla-Weber 230kV | 1200 A | 1477 A | 123.2 |
| | Table Mt 500/230kV Bank 1 | Hurley-Carmichael 230kV | 880 A | 1079 A | 122.6 |
| Central Valley | Tesla-Manteca 115kV | Tesla-Salado-Manteca 115kV | 326 A | 469 A | 143.7 |
| | Bellota-Tesla 230kV | Tesla-Weber 230kV | 1200 A | 1696 A | 141.3 |
| | Tesla-Tracy 115kV | Schulte-Lammers 115kV | 1125 A | 1407 A | 125.1 |
| | Stanislaus-Manteca #2 115kV | Stanislaus-Melones-Manteca #3 115kV | 326 A | 401 A | 122.8 |
| | Tesla-Tracy 115kV | Vierra-Tracy-Kasson 115kV | 884 A | 1068 A | 120.9 |
| South Valley | Gates-McCall 230kV | Helm-McCall 230kV | 850 A | 1148.6 A | 135.1 |
| | Helm-McCall 230kV | Gates-McCall 230kV (Henrietta-McCall) | 975 A | 1313.5 A | 134.7 |
| | Panoche-Helm 230kV | Gates-McCall 230kV (Henrietta-McCall) | 975 A | 1270.7 A | 130.3 |
| | Gates-Gregg 230kV | Gates-McCall 230kV (Henrietta-McCall) | 975 A | 1170.7 A | 120.1 |

Table 6. Double (N-2) Contingency Results (Overload > 130%)

| | Contingency | Overload | Rating | Loading | % |
|----------------|--|--|--------|----------|-------|
| North East | Table Mt-Rio Oso 230kV Palermo-Colgate 230kV | Pease-Rio Oso 115kV | 507 A | 747 A | 147.4 |
| | Gold Hill-Eight Mile 230kV Gold Hill-Lodi STIG 230kV | Table Mt-Palermo 230kV | 976 A | 1394 A | 142.8 |
| | Table Mt-Rio Oso 230kV Palermo-Colgate 230kV | Bogue-Rio Oso 115kV | 512 A | 693 A | 135.4 |
| | Table Mt-Rio Oso 230kV Table Mt-Palermo 230kV | Eight Mile-Tesla 230kV | 976 A | 1287 A | 131.9 |
| | Table Mt-Rio Oso 230kV Palermo-Colgate 230kV | Palermo-Bogue 115kV | 417 A | 546 A | 131.5 |
| Central Valley | Manteca-Vierra 115kV Tesla-Manteca 115kV | Tesla-Salado-Manteca 115kV | 326 A | 828 A | 253.8 |
| | Schulte-Lammers 115kV Tesla-Manteca 115kV | Vierra-Tracy-Kasson 115kV | 602 A | 1299 A | 215.6 |
| | Schulte-Lammers 115kV Tesla-Manteca 115kV | Tesla-Tracy 115kV | 974 A | 1915 A | 196.6 |
| | Manteca-Vierra 115kV Tesla-Manteca 115kV | Kasson-Louise 60kV | 385 A | 718 A | 186.5 |
| | Manteca-Vierra 115kV Tesla-Manteca 115kV | Kasson 115/60kV Bank | 91 MVA | 130 MVA | 142.8 |
| | Stanislaus-Manteca #2 115kV Stanislaus-Melones-Manteca #1 115kV | Stanislaus-Melones-Manteca #3 115kV | 326 A | 457 A | 140.2 |
| | Tesla-Manteca 115kV Tesla-Salado-Manteca 115kV | Schulte-Lammers 115kV | 1125 A | 1477 A | 131.3 |
| South Valley | Panoche-Kearney 230kV Panoche-Helm 230kV | Gates-McCall 230kV (Henrietta Tap-McCall) | 975 A | 1498 A | 153.6 |
| | Herndon-Kearney 230kV Gates-Gregg 230kV | Wilson-Oro Loma 115kV (Wilson-Le Grand Jct) | 398 A | 582 A | 146.2 |
| | Herndon-Kearney 230kV Gates-Gregg 230kV | Dairyland-Le Grand 115kV | 398 A | 554.6 A | 162.7 |
| | Herndon-Kearney 230kV Gates-Gregg 230kV | Wilson-Warnerville 230kV | 793 A | 1087.3 A | 137.1 |
| | Gregg-Herndon #1 & #2 230kV | Gregg-Ashlan 230kV (Gregg-Figarden Tap) | 850 A | 1160.4 A | 136.5 |

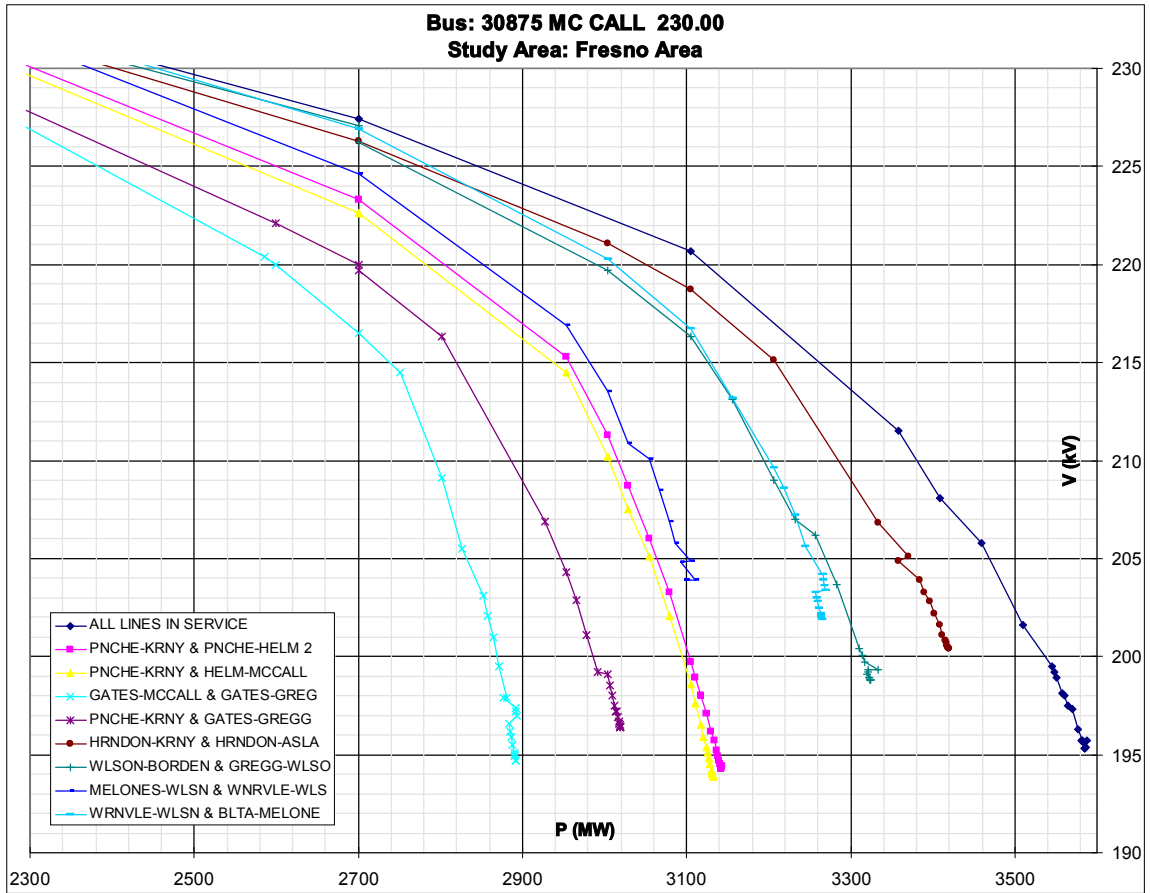
2. Voltage Stability Study

Voltage stability studies are being performed for the following select areas and/or load pockets.

- Woodland/Davis (complete, in a separate report, new UVLS implemented)
- Fresno (complete, in a separate report)
- Drum-Rio Oso 115 kV system
- Tesla-Bellota 115 kV system
- South of Palermo 230/115 kV system

Both PV and VQ studies were performed to assessment the voltage stability for two of the areas identified above. As an example, the following graph shows PV plots for the base line condition (All Line in Service) and various double contingencies at the McCall 230 kV bus.

Figure 3. PV Plots for Contingency P-V Results for 20% Fresno Hydro



The study for the Woodland/Davis area was completed. The short-term solution in the form of UVLS was implemented. Reactive support in the form of capacitors is being evaluated by PG&E. Although the hydro generation levels were not lowered to count for potential drought year operations for this area, we have no plan to re-study this area with new base case.

The study for the Fresno area is also complete. Study shows a double contingency loss of Gates-McCall/Gates-Gregg 230 kV lines can cause voltage collapse. To protect the system from this potential voltage collapse, PG&E and CAISO has agreed to install additional Under-voltage Load Shedding (UVLS) in the McCall area. To provide adequate reactive margin and to reduce the risk of UVLS tripping, longer-term solutions are required. CAISO is working with PG&E to add reactive sources in the McCall area, such as capacitor banks or an SVC.

Load at Risk Assessment (Zonal)

In addition to potential overload on transmission lines and/or transformers, another risk is whether we will have adequate energy supply during the shoulder peak loading periods. For this analysis, we tallied the load, generation and imports/exports used in the study for the whole PG&E system. The summary is shown below.

Table 7. Load and Resource Balance for 1-in-5 Year Peak Load Forecast (2008)

| PG&E Load, including losses (MW) | Generation (MW) | Imports (MW) |
|---|------------------------|---------------------|
| 22835 | 20498 (calculated) | 2337 |

In this load and resource balance, there is a net import 2337 MW to PG&E's system. This includes all the net tie-line flows between PG&E and all the interconnecting entities. A detailed summary of all the imports is shown below.

Table 8. Basecase PG&E Import Summary

| Tie Line | Flow (MW) |
|--------------------------|------------------|
| Path 26 | -161 |
| Path 66 | 4,424 |
| Path 24 | 9 |
| Path 25 | 68 |
| Total NP 26 Imports | 4,340 |
| Imports from TID | -72 |
| Imports from SMUD | -1,931 |
| PG&E Imports | 2,337 |

Note: PG&E Import includes NCPA loads

As shown in Table 7 and Table 8, we rely heavily on internal generation to meet the energy need of northern California. This assumes extremely high availability of all types of generation. Additional energy supply is assumed to come from Northwest US through COI. In reality the available generation in northern California could be much less due to planned and/or forced outages. Additional analysis would be required to ascertain the reasonable levels generation availability for the non-hydro generation in northern California.

Load at Risk Assessment (Local Areas)

If there is no additional generation available, firm load shedding could be required to protect equipment from damage. Anticipating the actual magnitude and location of load shedding is difficult and may vary. Factors such as simplicity of switching, response time, and load availability will contribute to the specific locations. Therefore it is nearly impossible to predict how much load shedding will be needed or how exactly load shedding will unfold in real-time.

Additionally, it is more likely that load shedding will be the result of a normal overload rather than a post-contingency emergency overload. The amount of the load at risk for a normal overload is typically less than the amount of the load at risk for an emergency overload; however a normal overload is more likely to occur. In order to estimate the range of load shedding required, we looked at both normal overload and contingency overload. Table 9 shows the estimated amount of load shedding required to alleviate normal and contingency overload.

In each case, normal (N-0) or contingency (N-1), two approaches were used to alleviate overload. First, load across the whole region was reduced uniformly. This approach, labeled as “non-specific” in Table 9, would likely provide the most amount of load shedding requirement. In the second approach, scenario #2 in Table 9, specific locations were chosen for load shedding. These locations provide the most relief to overload with the least amount of load shedding. A third scenario was also provided where dropping generation was available as an option.

North East Region

The worst normal overload is the Table Mt-Palermo 230kV line. The worst contingency for this region is the Table Mt-Rio Oso 230kV line overloading the Table Mt-Palermo 230kV line.

Assuming that load will be shed generally throughout the North East PG&E Region, approximately 1,700 MW of load must be shed to remove the overload. If the most effective locations are selected, the amount can be reduced to 1,000 MW of load. A third option available is to shed the most effective load and the most effective generation, further reducing the amount of load at risk to 800 MW. See Table 8 for the details of each scenario.

South Valley Region

The worst normal overload is the Gates-McCall 230kV line. The worst contingency for this region is the Gates-McCall 230kV line overloading the Helm-McCall 230kV line.

Assuming that load will be shed generally throughout the South Valley Region, approximately 585 MW of load must be shed to remove the overload. If the most effective locations are selected, the amount can be reduced to 268 MW of load. No generation backing is effective to mitigate the overload.

Table 9. Load at Risk (MW)

| | Location | N-0 Scenario | | | N-1 Scenario | | |
|--------------|----------------------------------|--------------|------|-----|--------------|-------|-----|
| | | 1 | 2 | 3 | 1 | 2 | 3 |
| North East | East Nicolaus 60kV | Non-Specific | 0 | 50 | Non-Specific | 53 | 53 |
| | Colgate 60kV | | 80 | 80 | | 80 | 80 |
| | West Sac, Davis, Woodland 115kV | | 427 | 427 | | 427 | 427 |
| | Gold Hill 115kV | | 0 | 0 | | 282 | 282 |
| | Atlantic 115kV & 60kV | | 230 | 0 | | 230 | 0 |
| | Hyatt & Thermalito Generation | 0 | 0 | 216 | 0 | 0 | 216 |
| | Caribou & Butt Valley Generation | 0 | 0 | 65 | 0 | 0 | 65 |
| | Total Load Shed | 1,200 | 737 | 557 | 1,700 | 1,072 | 842 |
| | Total Generation Shed | 0 | 0 | 281 | 0 | 0 | 281 |
| South Valley | McCall 115kV | Non-Specific | 51.5 | N/A | Non-Specific | 51.5 | N/A |
| | California 115kV | | 68.2 | | | 68.2 | |
| | Malaga 115kV | | 0 | | | 0 | |
| | Watoke 115kV | | 46.9 | | | 46.9 | |
| | West Fresno 115kV | | 40.2 | | | 81.9 | |
| | Sanger 115kV | | 0 | | | 19.7 | |
| | Las Pulgas 115kV | | 0 | | | 0 | |
| | Total Load Shed | 456 | 207 | | 585 | 268 | |

Recommended Solutions

To alleviate overloaded conditions and to minimize the risk to load, some of the short term and long term solutions were examined, including options such as automated load shedding schemes.

Short Terms Solutions:

These are the ones that need to and can be implemented prior to summer 2008 peak loading season. Short-term solutions include the following considerations:

- Emergency operating plans that outlines the steps for pre-contingency and post-contingency operations, up to and including load curtailments. These plans are needed because it may not be economical to build enough transmission infrastructures to solve all N-1 and N-2 overloads.
- Automated protection schemes that will safe guard the power grid against post-contingency voltage instability and/or severe overloads.
- Dynamic equipment ratings that maximize the safe operating thermal limits.
- Targeting locations where re-conductoring and/or raising towers can take place within the short-term time horizon.

Long Term Solutions:

These are the ones that need longer time to implement beyond summer 2008. Long-term solutions include the following considerations:

- Reconductoring of transmission lines and/or raising transmission line towers.
- Building new transmission infrastructure, such as new lines, transformers, and/or reactive devices.
- Investing in new technologies to maximize assets utilization, such as energy storage, operating limits/control and protection that are based on real-time information (synchro-phasor PMU)
- Working with generation developers and other state agencies that have generation mandates to encourage and possibly mandate in-state generation development. The urgency for this initiative comes from the looming risk of pending retirements of old, inefficient and environmentally unfriendly generators.

Both short term and long term solutions are summarized in Table 10.

Table 10. Summary of Short and Long Term Solutions

| Required Project | Project Benefits | Target Date | Project Status | Lead Responsibility |
|---|---|--------------------|--|----------------------------|
| Emergency operating plans/procedures | To equip operating staff with tools and instructions to respond to real-time challenges. | March 2008 | To be implemented. | CAISO |
| Automated load shedding protections | To protect the transmission assets upon a contingency loss of a transmission element. | March 2008 | More study is required. | PG&E |
| Special Protection Schemes (UVLS) | Improves voltage collapse reliability margin. | May 2008 | PG&E is conducting feasibility study and is expected to provide the scope and cost of the project by Jan 2008 if feasible. | PG&E |
| Peaking generation and/or Demand Side Management in the Fresno, Stockton 115 kV and Sacramento areas. | To alleviate contingency and normal overloads. To reduce the risk of load interruptions. | June 2010 | Guidance from management is sought on how to proceed. | CAISO/LSEs |
| Dynamic Line Rating | Potentially increases transmission line ratings in real-time and possibly reduces congestion and improve reliability. | March 2008 | PG&E has installed Dynamic Rating devices at certain locations and is evaluating additional installations. | PG&E |
| Capacitor Additions | Improves Voltage Stability at McCall and Rio Oso areas. | May 2009 | More study is required. | PG&E/CAISO |
| Gates-McCall 230 kV line Reconductoring | Reduces line overloads. Improves Helms pumping window. Solves the normal overload problem. | 2010 to 2015 | PG&E will conduct feasibility analysis and provide project scope and cost if feasible. | PG&E |
| Table Mtn-Rio Oso 230 kV line reconductoring and raising towers | Reduces line overloads. Removes limitations on Hyatt/Thermalito generation outputs. | May 2009 | Project started in Oct 2007. Completion expected in early 2009. | PG&E |
| More line re-conductoring | To alleviate contingency and normal overloads | March 2009 | More study is required. | CAISO |
| Investing in new technologies, such as energy storage, real-time operating limits/control/protection | To maximize assets utilization, and to improve the load factor of intermittent energy source (wind) | 2011 | More study is required. | CAISO |
| Plan for and build new transmission/generation infrastructure | To solve additional reliability/congestion problems, such as state or west wide energy shortage due to drought and/or retirement of aging power plants. | 2011 to 2017 | More study is required. | CAISO |

Action Plan

It is recommended that CAISO and PG&E will work together to take the following actions:

PG&E to:

1. Develop and implement the plan to modify the existing UVLS at McCall substation to key the tripping of additional load at California and West Fresno substations.
2. Develop and implement the plan to relocate capacitor banks to McCall or a location nearby that will meet N-2 reactive margin requirement.
3. Develop and implement the plan to relocate capacitor banks to the West Sac/Davis/Woodland area that will meet N-2 reactive margin requirement.
4. Investigate and select the technology that provides dynamic ampacity ratings.
5. Determine the long-term solution to alleviate the overload conditions on Gates-McCall-Gregg corridor that will be able to meet both load growth and to allow for three pump operations at Helms (1200 MW).

CAISO to:

1. Develop emergency operating procedures with PG&E.
2. Work with PG&E to implement the dynamic rating technology.
3. Determine potential sizes and locations for new generation in northern California
4. Study the potential impacts and the mitigation measures of drought conditions on southern California.
5. Study the potential impacts and mitigation measures of wide spread drought conditions in the whole WECC areas.

Updates:

12/14/2007

PG&E and CAISO continue to work together to implement the recommendations identified in this report. PG&E has provided valuable comments and suggestions to this report. Thanks to PG&E's comments, the recommended solutions in Table 10 were revised to have more realistic target dates.