Development Plan for the
Phased Expansion of

Electric Power Transmission Facilities

in the

Tehachapi Wind Resource Area

Second Report

of the

Tehachapi Collaborative Study Group

Volume 4 of 5: Appendix 3

California Public Utilities Commission

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The report is printed in 5 volumes or electronic files:

Volume 1 contains the Second Report;

Volume 2 contains Study Plan #2 the basis for the Second Report (referred to in the Report as Appendix 1);

Volume 3 contains the PG&E Studies (referred to as Appendix 2);

Volume 4 contains the SCE Studies (referred to as Appendix 3);

Volume 5 contains the CAISO Studies and all remaining Appendices 5, 6 and 7.

Appendix 3

SCE Study Alternatives

SCE filed a report titled "Development Plan for the Phased Expansion of Transmission in the Tehachapi Wind Resource" (Report) on behalf of the TCSG in March 16, 2005 as directed by the Commission. The Report presented alternative transmission concepts for interconnecting and delivering Tehachapi wind generation to various load centers. The Report recommended that the study be continued in order to select the best alternative from the four candidate options and to further evaluate the potential for a new interconnect between SCE and PG&E in the Fresno area. This section provides SCE's modifications to these four alternatives plus the results of the SCE-PG&E Fresno area connection study.

It was assumed that a local Tehachapi Area 230 kV system would be developed to support the large amount of wind generation potential identified in the CEC Report. These facilities are common to all project alternatives and can only be developed once more information is made available as to exact wind generation locations and amounts. It is therefore impossible to properly develop the local area network at this point in time.

1. TRANSMISSION PLANS INTERCONNECTING WIND RESOURCES IN THE TEHACHAPI AREA TO THE GRID

The four alternatives that remained open from the original TCSG share the same Tehachapi local area wind collector facilities as discussed in Chapter 2, Section 2.2 of the March 16, 2005 TCSG Final Report and differed slightly in the facilities identified to be necessary to connect the wind resource areas to the main bulk power system. These four Tehachapi Interconnection facilities were summarized in Section 1 of Appendix A of the March 16, 2005 TCSG Final Report. SCE has conducted further review of these alternatives and has concluded that modifications are needed to these alternatives due to lack of available undeveloped land to support additional right-of-way requirements. As an example, SCE found it necessary to reroute Segment 2 of the Antelope Transmission Project (Phase 1) in the supplemental CPCN Application (A.04-12-008) filing submitted to the CPUC on September 2005. This reroute was needed to accommodate new housing projects developing adjacent to the existing Antelope-Vincent right-of-way. The following sections provide a detailed discussing of impacts to the four alternatives that were to be further reviewed.

1.1. Discussion of Modifications to Proposed Alternatives

1.1.1. Antelope-Substation #5 Transmission Section

The conceptual transmission plans identified in the March 16, 2005 TCSG Final Report were based on the assumption that only 300 MW of wind generation was to be located in the Cottonwood Creek area and connected to a proposed Cottonwind 230 kV Switching Station (a.k.a. Substation #5). All four alternatives included a reconductor of the existing Antelope-Magunden No.2 230 kV transmission line section between Antelope and the new switching station assuming the use of a Special Protection System (SPS) could be implemented and approved by the CAISO.

The use of an SPS was found to be unacceptable based on the study results obtained in a system impact study (SIS) performed for the 300 MW wind generation project. The SIS identified that the amount of monitoring points, number of outages, and the total amount of generation tripping required to maintain system reliability violated established CAISO Guidelines for implementing an SPS. Consequently, the recommended upgrade involves replacing an existing single circuit transmission line with a new double-circuit 230 kV transmission line. In addition, recent generation interconnections have been submitted which identify this substation as the point of interconnection. The total amount of wind generation proceeding through the CAISO interconnection process totals 1,110 MW. As a result, both existing single-circuit 230 kV transmission lines will need to be replaced with two double-circuit 230 kV transmission lines. It may be necessary to include additional transmission upgrades due to the large amount of generation interconnection requests in this area.

1.1.2. Antelope-Vincent Transmission Section

A detailed review of available land in the area was performed in support of the Antelope Transmission Project Segment 2 and 3 CPCN Supplemental Application. This detailed review concluded that only two 500 kV transmission facilities can be accommodated between Antelope and Vincent without significant impacts to existing residential owners or housing developments currently under construction. Alternative one shown below in Figure 3-1 included one 500 kV and two 230 kV transmission lines between Antelope and Vincent. Alternatives two and three shown below in Figure 3-2 and 3-3 respectively included two 500 kV and two 230 kV transmission lines between Antelope and Vincent. Alternative four included one 500 kV and three 230 kV transmission lines between Antelope and Vincent. In order to maximize capability between Antelope and Vincent, it is recommended that the conceptual transmission plan be modified to include an alternative with two 500 kV transmission lines.

1.1.3. Vincent-Rio Hondo/Mesa Transmission Section

SCE has been conducting studies in support of a new Mira Loma-Vincent 500 kV transmission line. The need for this new 500 kV line into the Mira Loma area was identified as part of the SCE CAISO Annual Expansion Program and is required to serve growing load demand in the Mira Loma area. This new line will provide an added benefit of supporting delivery of Tehachapi area wind generation to the SCE load center. Since last year's report, SCE has integrated this line with the Phase 2 of last year's TCSG Final Report, rebuild of the Antelope-Mesa 230 kV transmission line, in order to minimize the number of facilities and amount of new land disturbance that would otherwise result with building separate transmission projects.

In order to integrate the Vincent-Mira Loma 500 kV transmission line with the Antelope-Mesa Upgrades, the following upgrades are required:

- Rebuild the portion of the existing Antelope-Mesa 230 kV single circuit transmission line between Vincent and the southern boundary of the Angeles National Forest (City of Duarte) with single circuit 500 kV transmission line

- Replace a small section of the existing Vincent-Rio Hondo 230 kV transmission line outside of the Vincent Substation (approximately five miles) with single circuit 500 kV transmission (part of the Mira Loma-Vincent 500 kV transmission line project) to allow operation of this line at 500 kV

- Rebuild the portion of the existing Antelope-Mesa 230 kV single circuit transmission line between the City of Duarte and the Mesa Substation with double-circuit 500 kV transmission line

- Develop and permit a new Mesa 500 kV substation

Previous conceptual studies identified the utilization of the Rio Hondo substation as the 500 kV entry point to the Los Angeles Basin. Further review of this substation site has concluded that insufficient property is available to increase the underlying 230 kV capability needed to support a 500 kV substation. As a result, SCE is currently evaluating the Mesa substation for converting it to

500 kV. This substation site provides sufficient 230 kV transmission capacity to support a 500 kV substation. The substation site could provide for up to twelve 230 kV transmission lines, which serve the Los Angeles Basin, if necessary, without the need to construct new transmission on new right-of-way. In comparison, the Rio Hondo substation site allowed for only three 230 kV transmission lines to serve the Los Angeles Basin load center. Additional 230 kV transmission lines in new right-of-way would be necessary to support a Rio Hondo 500 kV substation site. These new 230 kV transmission lines would be extremely difficult, if not impossible, to construct given the land right-of-way restrictions that exist in the area (i.e. no available land). The new Mesa 500 kV substation will require three 500/230 kV transformers initially due to the large amount of load demand in the area.

1.1.4. Mesa-Chino Transmission Section

As part of the Mira Loma-Vincent 500 kV transmission line project, SCE had been evaluating requirements to bring the new 500 kV line all the way into the Mira Loma 500 kV Substation. With the integration of the Mira Loma-Vincent and Antelope-Mesa, SCE is now evaluating the utilization of an existing Mira Loma-Serrano 500 kV transmission line to avoid having to construct the new Mira Loma-Vincent 500 kV transmission line all the way into Mira Loma. This requirement is supported by preliminary study results, which have identified that outage of the new Mesa-Vincent 500 kV transmission line (part of the Antelope-Mesa Upgrade) results in rerouting a significant amount of power flow towards Mira Loma via Lugo through the step-down transformers at Mira Loma and finally through the underlying 230 kV network towards the Mesa area. As a result, the potential for a voltage collapse and thermal overloads were identified with high deliveries from the north (Path 26, Big Creek Corridor, Ventura area and the Tehachapi area) under loss of the new Mesa-Vincent 500 kV transmission line.

In order to provide continued reliable service to the Mesa local area loads, a second line to Mesa will be required. This line can be added by constructing the Mira Loma-Vincent 500 kV transmission line with double circuit 500 kV standard transmission design from the Mesa area to the Chino area (Mira Loma-Serrano right-of-way). The existing Mira Loma-Serrano 500 kV line can be “cut” and at the point where the new double circuit line joins the existing Mira Loma-Serrano 500 kV transmission line. Utilizing the Mira Loma section of the existing Mira Loma-Serrano 500 kV transmission line can then form the Mira Loma-Vincent 500 kV transmission line. The Mesa-Serrano 500 kV transmission line can be formed by adding a second circuit on the double-circuit 500 kV transmission line between the Mesa area and the Chino area and utilizing the Serrano section of the existing Mira Loma-Serrano 500 kV transmission line.

1.1.5. Second Mesa-Vincent Transmission Section

Depending on the overall increase of power deliveries to the south (i.e. SCE, SDG&E, LADWP, CFE, or Arizona utilities) and corresponding study results under loss of both the new Mesa-Vincent and Mira Loma-Vincent 500 kV transmission lines (same corridor through the Angeles National Forest and same tower from the City of Duarte to the Mesa substation), a second 500 kV transmission line from Vincent may be required in a separate right-of-way. Feasibility studies for the recent batch of interconnection requests will commence shortly (Study Agreement provided to customer), which will result in clarifying timing need for this additional upgrade. As a conceptual plan, SCE envisions utilizing the existing 500 kV transmission line section on the existing Vincent-Santa Clara 230 kV transmission line between Pardee and Vincent and operating it at 500 kV by sectionalizing line and terminating 230 kV section at the Pardee 230 kV bus and 500 kV section at the Pardee and Vincent 500 kV buses. The second 500 kV transmission line to Mesa can then be added by replacing a portion of the existing Pardee-Eagle Rock 230 kV transmission line (second smallest line south of Vincent) towards the Gould area and ultimately down to Mesa. This upgrade could also minimize the amount of loop flow from SCE to LADWP resulting from the addition of significant levels of Tehachapi wind generation.

1.2. Common Facilities in Alternatives (Not Modified)

1.1.1. 500 kV Transmission Line between Antelope and Pardee

This 500 kV transmission line is also referred to as Segment 1 of the Antelope Transmission Project (Phase 1). The CPCN Application (A.04-12-007) for this transmission line has been filed with the CPUC since December 9, 2004. The application is currently under review by the CPUC with approval anticipated before the end of the year.

1.1.2. 500 kV Transmission Line between Antelope and Vincent

This 500 kV transmission line is also referred to as Segment 2 of the Antelope Transmission Project (Phase 1). The CPCN Application (A.04-12-008) for this transmission line has been filed with the CPUC since December 9, 2004. A supplemental filing was made by SCE on September 2005 in order to augment environmental information. The application review has recently been initiated by the CPUC and as such SCE does not currently have an anticipated approval date.

1.1.3. Initial Transmission Facilities between Antelope and Tehachapi

A new 500 kV transmission line from Antelope to a new Tehachapi area substation site, two new Tehachapi area substations, and a 230 kV transmission line connecting the two new substations collectively are referred to as Segment 3 of the Antelope Transmission Project (Phase 1). The CPCN Application (A.04-12-008) for this transmission line has been filed with the CPUC since December 9, 2004. A supplemental filing was made by SCE on September 2005 in order to augment environmental information. The application review has recently been initiated by the CPUC and as such SCE does not currently have an anticipated approval date.

1.1.4. Second 500 kV Transmission Line between Antelope and Tehachapi

This 500 kV transmission line is similar to the 500 kV transmission line identified in Segment 3 of the Antelope Transmission Project but would utilize a separate right-of-way to provide sufficient separation thus avoiding conditions which could result in simultaneous loss of both transmission lines. Putting the second Antelope-Tehachapi 500 kV transmission line on the same right-of-way would limit the amount of Tehachapi area wind generation that can be supported to 1,400 MW due to CAISO Spinning Reserve requirements.

1.1.5. Additional Reactive Resources

Additional reactive resources may need to be added throughout the network in order to restore bus voltages to levels identified prior to adding and dispatching the Tehachapi area wind resources. With all the transmission upgrades needed to support the Tehachapi area and new Mira Loma-Vincent 500 kV transmission line, it is unclear exactly how much and where such reactive support should be located. Therefore, these resources where not included into this conceptual transmission plan. SCE will identify how much and where such reactive support should be installed as part of the detailed interconnection studies currently underway. If additional permitting is required, due to the need for substation expansion to support additional reactive resources, SCE will identify such requirements as part of the CPCN Applications to be submitted as required per CPUC Resolution E-3969.

1.3. Uncommon Facilities in Alternatives (Not Modified)

1.3.1. Third 500 kV Transmission Line between Antelope and Tehachapi

Alternative 2 included a third 500 kV transmission line between Antelope and Tehachapi. This line is similar to the 500 kV transmission line identified in Segment 3 of the Antelope Transmission Project Separation would only be required if the amount of generation tripping under loss of both 500 kV lines in the same right-of-way exceeds 1,400 MW. Without the benefit of detailed studies (power flow, post-transient voltage, and transient stability), the assumption can be made that this third line could potentially be placed in the same right-of-way as the second 500kV transmission line between Antelope and Tehachapi.

1.3.2. New 500 kV Transmission Line from Tehachapi to PG&E

SCE's Alternatives 1, 3, and 10 included a new 500 kV transmission line north of Tehachapi towards PG&E. For evaluation of the SCE network, Alternatives that involve a 500 kV transmission line to the north from Tehachapi were assumed to terminate at Midway. However, evaluation of the PG&E network considered terminating the transmission line further north due to anticipated potential transmission problems North of Midway Substation. Such an increase is likely to occur for two reasons:

1. The first involves transferring 2,000 MW more power on an already constrained path if Tehachapi area wind generation is to displace existing generation resources located in northern and central PG&E system.

2. The second is attributed to reduction in Path 15 transfer capability from 5,400 MW down to 4,100 MW if Tehachapi area wind generation is to displace existing generation resources located in the Midway area. Such reduction is necessary since the 5,400 MW rating can only be supported when the Midway area generation is dispatched as part of the Path 15 Remedial Action Scheme (RAS). Displacing this generation in order to accommodate the Tehachapi wind resource will result in reducing the support provided in the RAS, thus adversely impacting Path 15 transfer capability and will lead to increased congestion.

From an SCE perspective, conceptual study results are not anticipated to differ much regardless of where PG&E ultimately terminates the new 500 kV transmission line, or whether there would be a new PG&E 500 kV line, since study results from all parts of the systems will be overlaid to develop the integrated conceptual plans.

Figure 3.1.1
TCSG Alternative 1 Identified in the March 16, 2005 TCSG Final Report

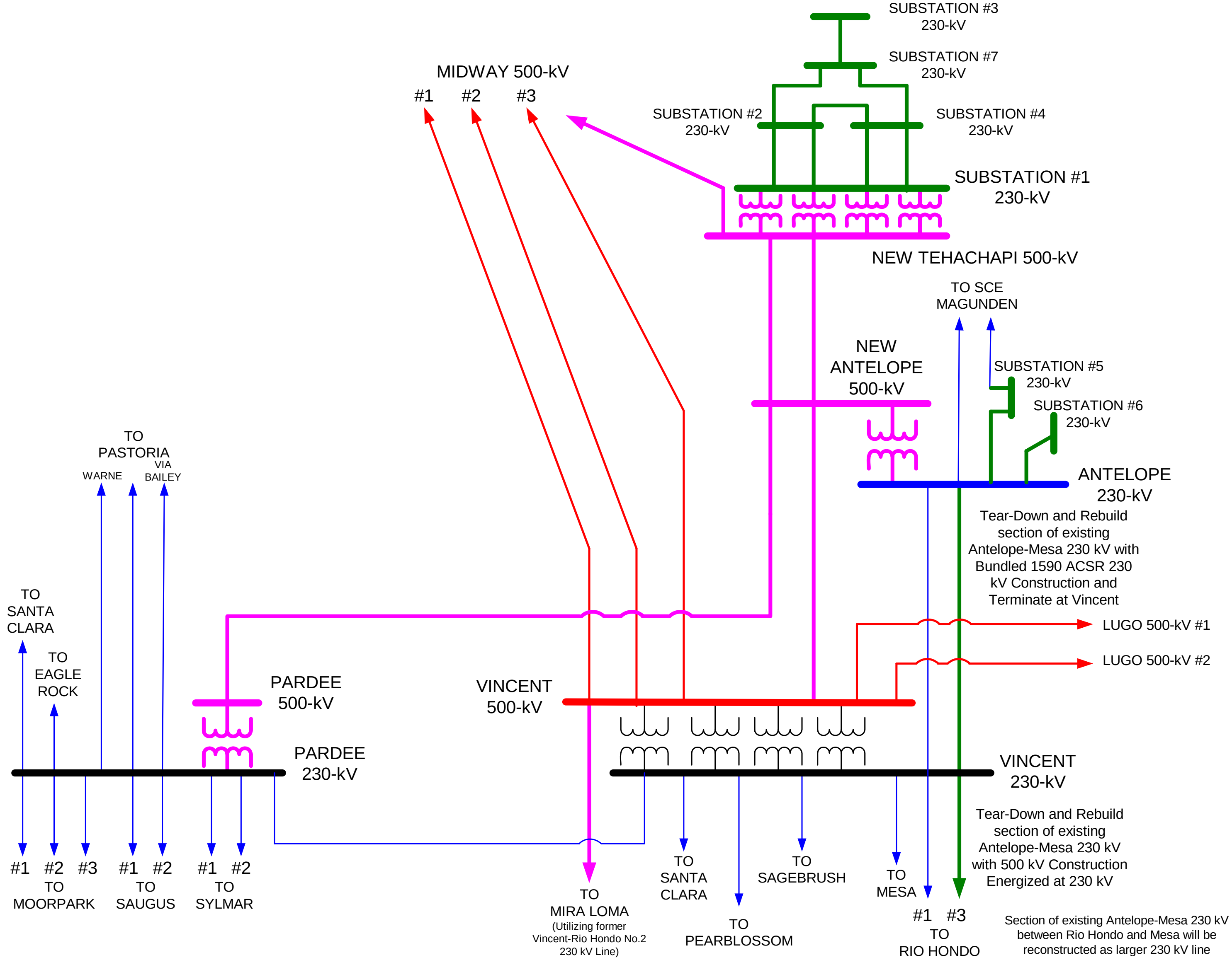


Figure 3.1.2
TCSG Alternative 2 Identified in the March 16, 2005 TCSG Final Report

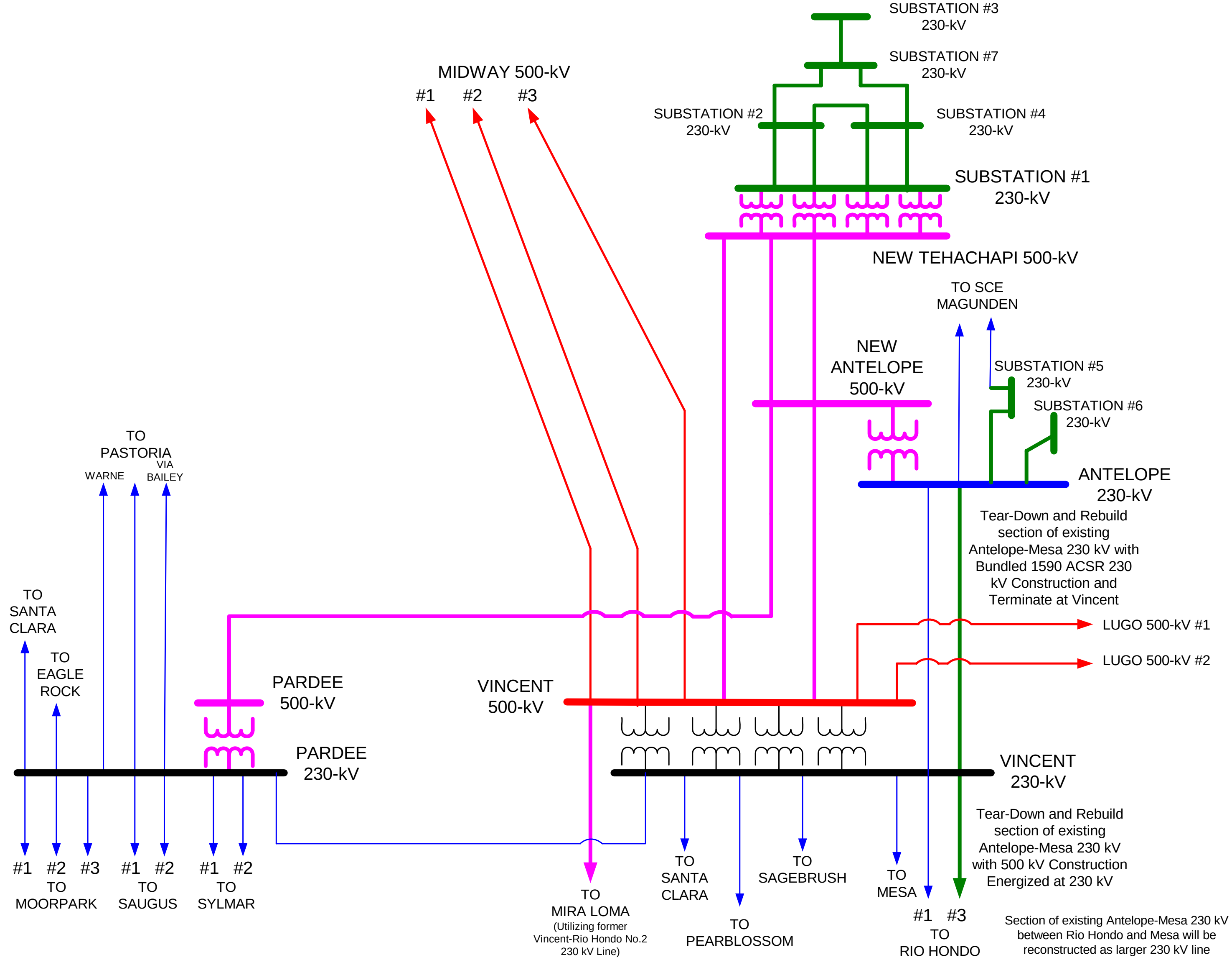


Figure 3.1.3
TCSG Alternative 3 Identified in the March 16, 2005 TCSG Final Report

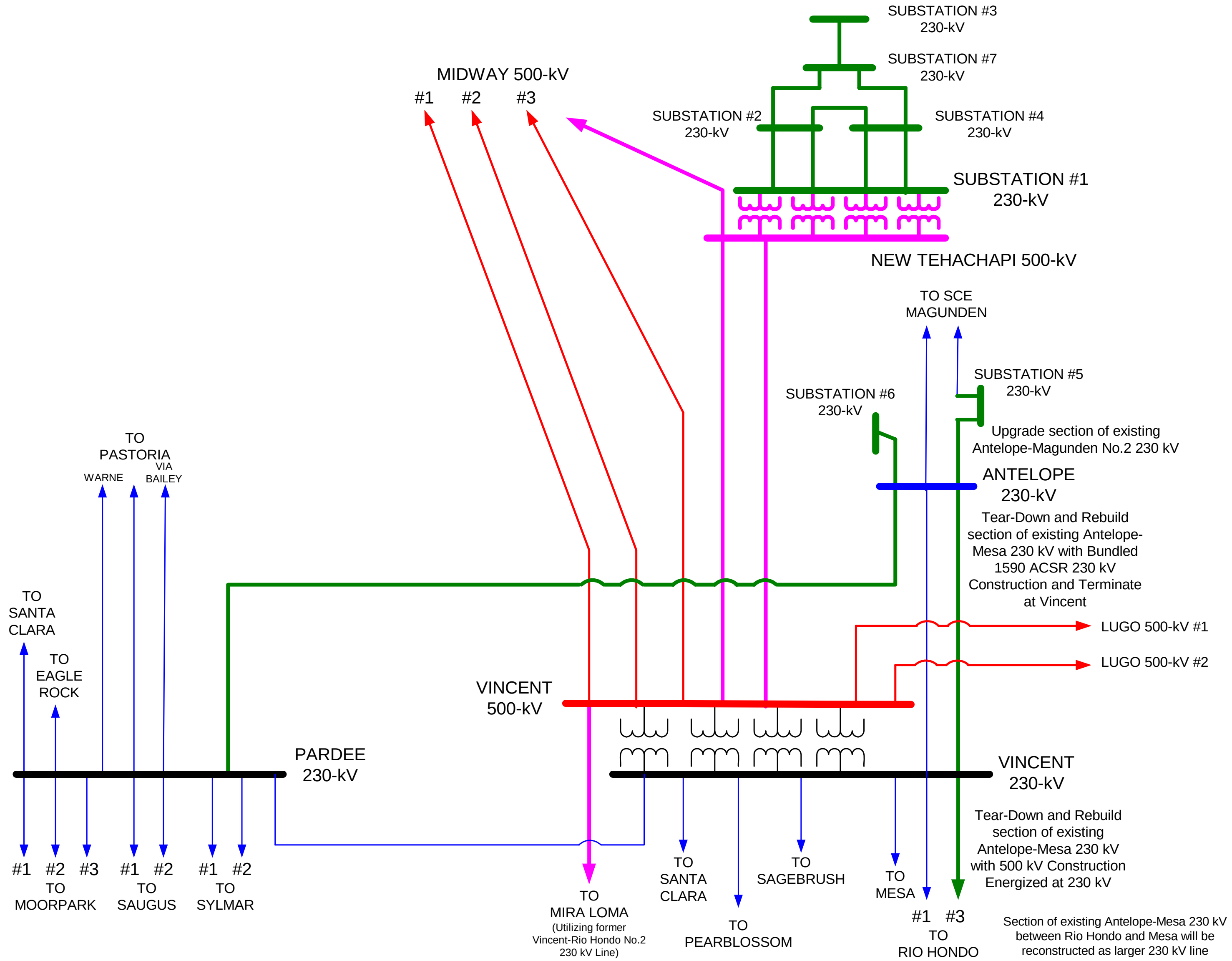


Figure 3.1.4
TCSG Alternative 10 Identified in the March 16, 2005 TCSG Final Report

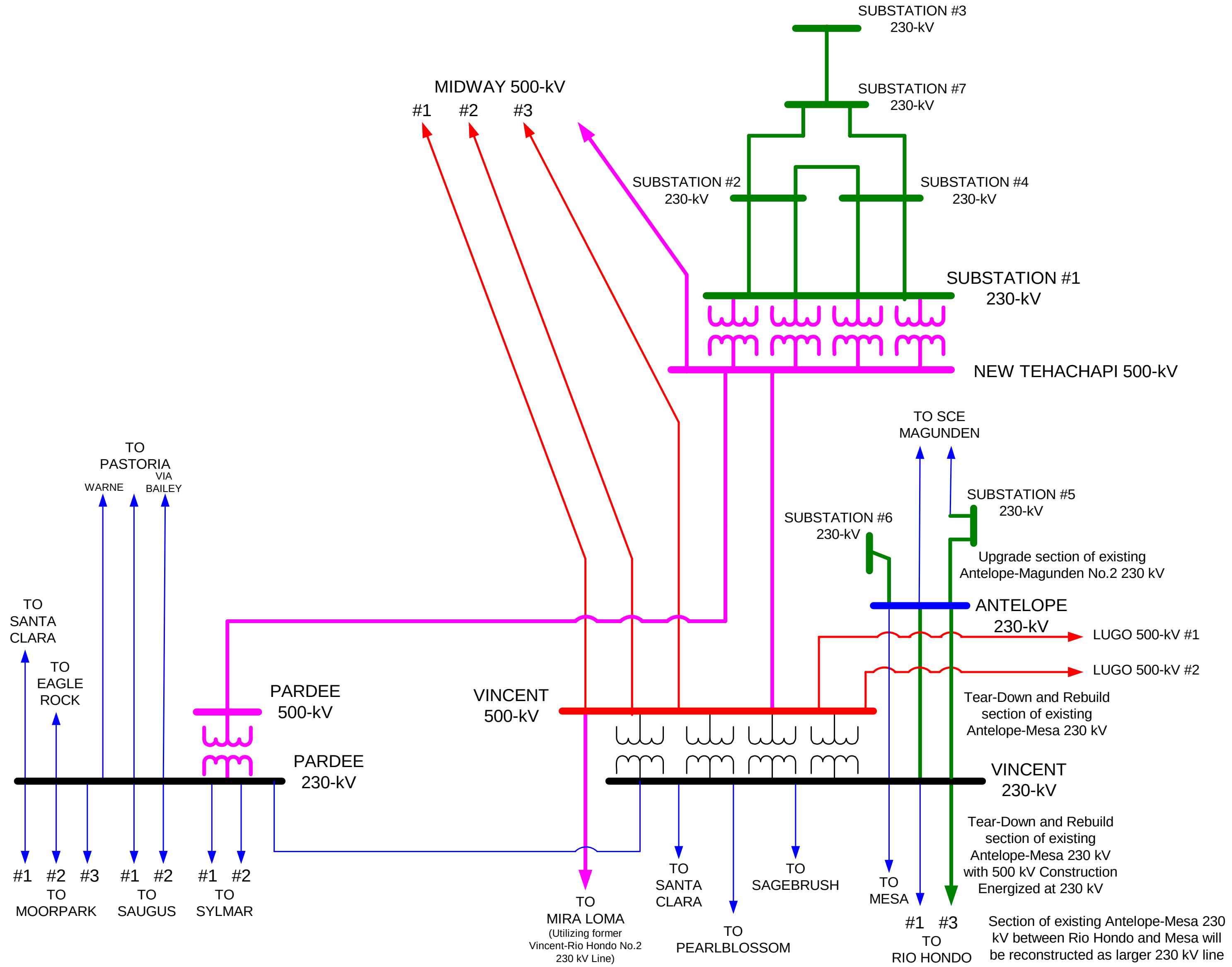
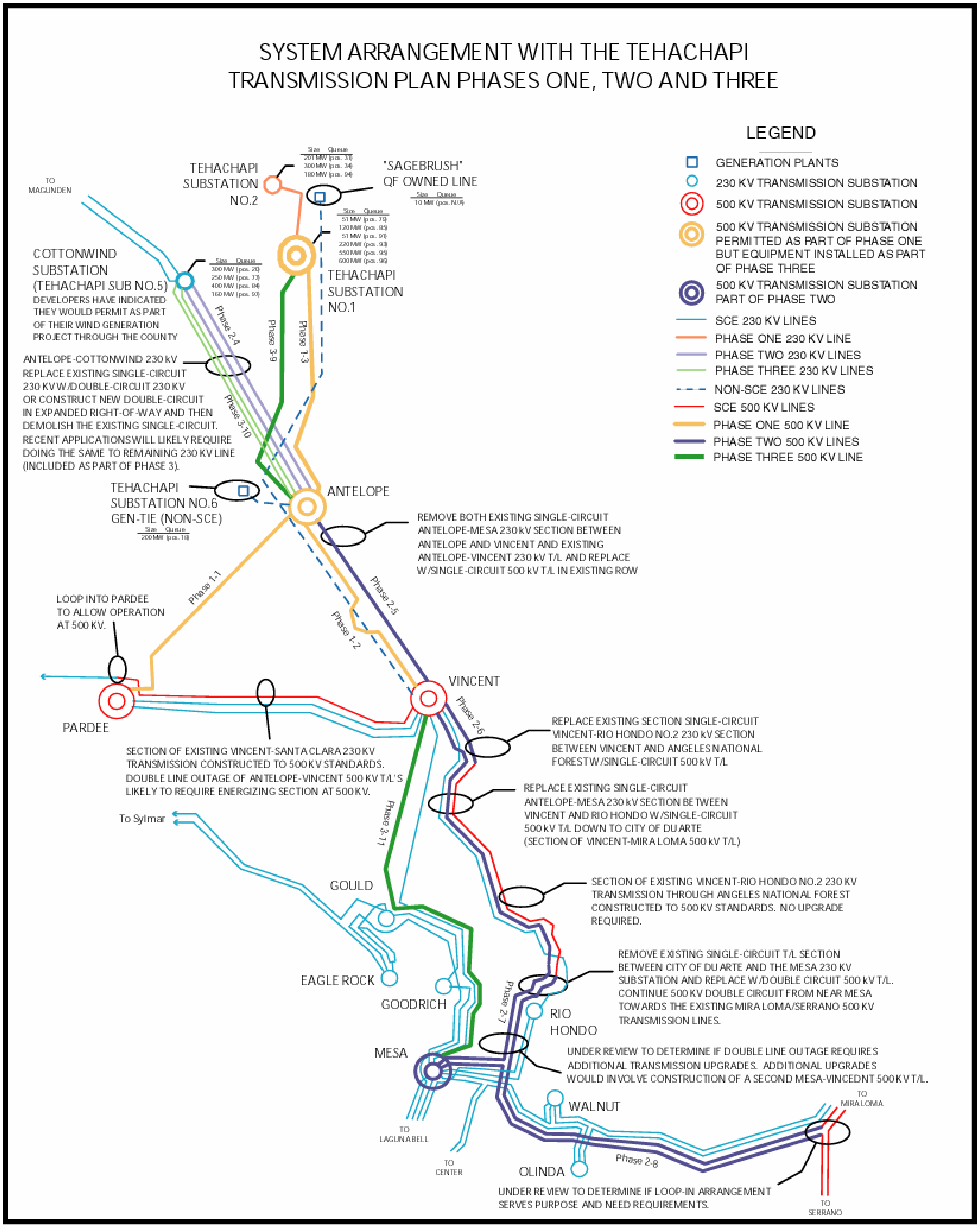


Figure 3.1.5
Revised Tehachapi Transmission Plan



2. GRID UPGRADES TO DELIVER TEHACHAPI WIND RESOURCES – STUDY RESULTS

SCE is in the process of performing Feasibility, System Impact, and Facilities Studies for a number of wind generation projects proceeding through the interconnection process. As a result, SCE did not revisit the previous conceptual power flow studies associated with the four alternatives remaining on the table. Instead, SCE utilized the study results from a limited number of Feasibility studies conducted to modify the previous transmission plans as presented above in Section 1.

With the modification included into the study case, SCE identified a few additional impacts that may need additional upgrades. The first is that increase power deliveries into the Cottonwind Substation (i.e. Substation #5) results in power flow "loop flow" up towards the SCE Magunden Substation and down the west leg of the corridor towards the Pastoria and Pardee Substations. The second is the potential for "loop flow" to impact three LADWP 230 kV transmission lines from Sylmar to Rinaldi.

2.1. Loop Flow on the Magunden-Pastoria-Pardee and Sylmar-Rinaldi Transmission Corridors

2.1.1. Loop Flow on the Magunden-Pastoria-Pardee Corridor

Depending on which generation resources are displaced, the amount of "loop-flow" increases loading on the three Magunden-Pastoria 230 kV transmission lines as well as the three transmission lines south of Pastoria. Two of the three transmission lines between Magunden and Pastoria are small conductored lines, which have a limited capability of 825 amps (approximately 325 MVA). The third line is a larger conductored line with a 1240 amp capability (approximately 490 MVA). As far as transmission south of Pastoria, two of these three lines are in the process of being reconductored with a trapezoidal ACSS conductor in order to increase capacity from 885 amps (approximately 350 MVA) up to 1,500 amps (approximately 600 MVA). The remaining line is conductored with 1240 amp capability (approximately 490 MVA) and is not being reconductored at this time. Reconductoring of the two smaller Magunden-Pastoria 230 kV and the Pastoria-Pardee-Warne 230 kV transmission lines may be required to support the large amount of generation interconnection at the Cottowind Substation. Such determination will be made as part of the detailed studies currently underway.

2.1.2. Loop Flow on Los Angeles Department of Water and Power (LADWP) Sylmar-Rinaldi Transmission Corridor

Imports from the north to the main Los Angeles Basin is delivered by a number of 500 and 230 kV transmission lines as well as through the Pacific DC Intertie. Since the network is an integrated network, schedules and actual flows may not coincide. This is due to the fact that there exist certain amounts of "loop-flow." In other words, power deliveries will follow the path of least resistance (impedance) from the source to the load.

The addition of significant amounts of Tehachapi wind generation results in increasing deliveries from the north to the Los Angeles Basin. This increase in deliveries from the north increases loadings on the following transmission lines:

- 500 kV transmission lines from Vincent to Lugo and ultimately down to Mira Loma
- 230 kV transmission lines from Pardee to Sylmar and from Pardee to Gould
- 230 kV transmission lines from Vincent to Rio Hondo and from Vincent to Mesa
- 230 kV transmission lines from Sylmar to Rinaldi (LADWP) due to loop flow
- 500 kV transmission line from Rinaldi to Victorville (LADWP) and ultimately to Lugo due to loop flow.

These increases in flow results in the potential to overload the 230 kV transmission lines between Sylmar and Rinaldi (LADWP). SCE does not know exact nature of transmission limitation, as LADWP did not actively participate in the collaborative study process. Consequently, mitigation requirements within the LADWP electrical system were not explored. However, SCE has identified the need for adding a second Vincent-Mesa
500 kV transmission line and operating transmission between Pardee and Vincent at 500 kV. SCE envisions utilizing the existing 500 kV transmission line section on the existing Vincent-Santa Clara 230 kV transmission line between Pardee and Vincent and operating it at 500 kV by sectionalizing line and terminating 230 kV section at the Pardee 230 kV bus and 500 kV section at the Pardee and Vincent 500 kV buses. The second 500 kV transmission line to Mesa can then be added by replacing a portion of the existing Pardee-Eagle Rock 230 kV transmission line (second smallest line south of Vincent) towards the Gould area and ultimately down to Mesa. It is expected that this upgrade would minimize the amount of loop flow through the Sylmar-Rinaldi 230 kV transmission lines.

2.2. Big Creek-Fresno Tie Evaluation

The CPUC and PG&E demonstrated interest in determining if this interconnection can supplement capability to move power from SCE to PG&E or possibly eliminate the need for transmission upgrades from PG&E to the Tehachapi area. The interconnection involves constructing a new 230 kV switching station at the crossing of the PG&E-owned and SCE-owned transmission lines. The existing SCE-owned Big Creek-Rector 230 kV and PG&E-owned Gregg-Helms 230 kV transmission lines are proposed to be looped into this new switching station as shown below in Figure 3.2.1. Power flow control devices such as phase-shifting transformers or unified power flow controllers (UPFC) will be required to "push" power from the SCE network to the PG&E network thereby appearing as additional load in the SCE Big Creek 230 kV corridor north of Magunden.

To evaluate the north of Magunden portion of the Big Creek Corridor, parametric studies covering 8,760 hourly load and generation conditions based on historical data were conducted. These studies were performed utilizing a simplified equivalent power flow case reflecting only the north of Magunden SCE facilities and the facilities from PG&E's Gregg Substation to the Helms Pump Storage Facilities. These facilities are all connected radial and can therefore be "cut-out" to examine local area problems. Complete WECC base cases were subsequently utilized to examine overall system performance and validate the local area problems identified in the parametric studies. Two methods were used in examining the local area. The fist method involved modeling a fixed power flow from the SCE network to the PG&E network throughout the entire calendar year while the second method involved modeling a fixed tap setting.

<u>Fixed Tap Setting Model</u>

This model reflects the use of traditional phase-shift transformers to connect the PG&E and SCE systems together. Several limitations exist with use of traditional phase-shift transformers that affect system operations. The limitations are summarized as follows:

- Phase-shift transformers have mechanical moving load taps that are used to adjust amount of flow through the transformer
- These load taps are generally set and adjusted on a seasonal basis
- Load taps are slow moving and thus do not respond well to system dynamics
- Load taps require frequent maintenance if they are constantly used.

- Phase-shift transformers increase reactive losses on the system adversely affecting system voltages

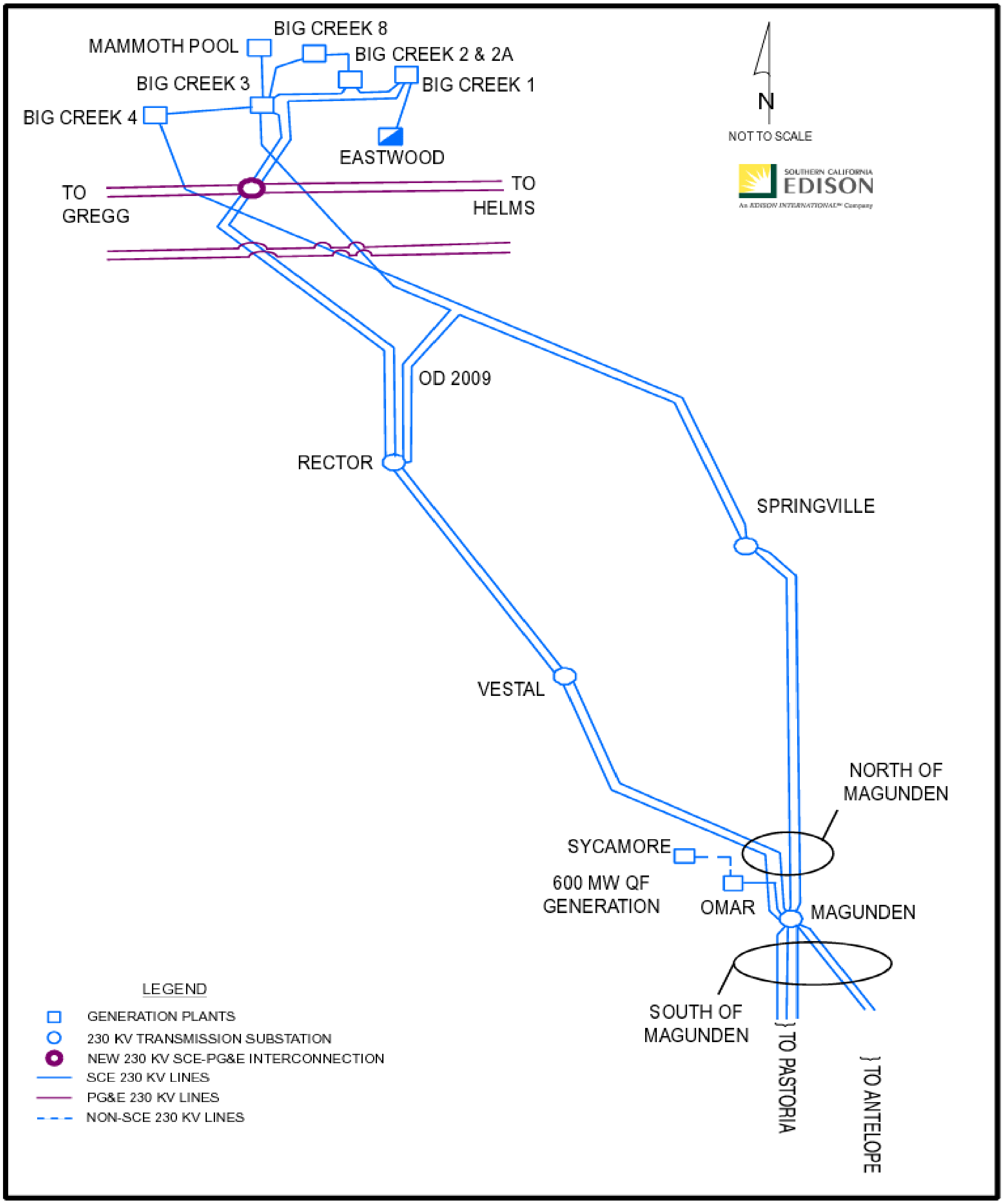
These limitations can subject the system to unintended performance. As a result, a robust transmission system is required to support a transformer phase-shifted system.

Fixed Power Flow Model

This model reflects the use of Flexible AC Transmission System (FACTS) technology to connect the PG&E and SCE systems together. Implementing a system tie with a FACTS device eliminates all of the limitations identified above. The benefits of utilizing a FACTS device are summarized as follows:

- Power electronics eliminate all mechanical moving parts
- The absence of mechanical moving parts allows for dynamic settings not possible with a phase-shift transformer
- FACTS devices respond well to system dynamics
- FACTS devices can be developed as to provide reactive resources improving system voltages

Figure 3.2.1
Big Creek-Fresno System Tie



2.2.1. Big Creek-Fresno Tie Study Results – Fixed Power Flow Model

2.2.1.1. Impacts to South of Magunden Line Flows

The addition of a new system tie between SCE and PG&E with a device to "push" fixed power from SCE to PG&E has the equivalent effect of increasing load in the San Joaquin Valley. This increase is graphically illustrated below in Figures R-1 through R-6. Figure R-1 illustrates the hourly South of Magunden line flows prior to adding the new system tie with adjusted San Joaquin Valley load to reflect 2014 forecast. Figures 3.2.2 through 3.2.5 illustrate the hourly South of Magunden line flows with the inclusion of a 300 MW, 500 MW, 1,000 MW, and 1,200 MW new system tie. Figure 3.2.7 provides the corresponding load duration curves for various system tie levels. SCE notes that adding a 300 MW system tie has the equivalent effect as 30 years of local load growth.

Figure 3.2.2
South of Magunden Flow Patterns Adjusted for 2014 Load

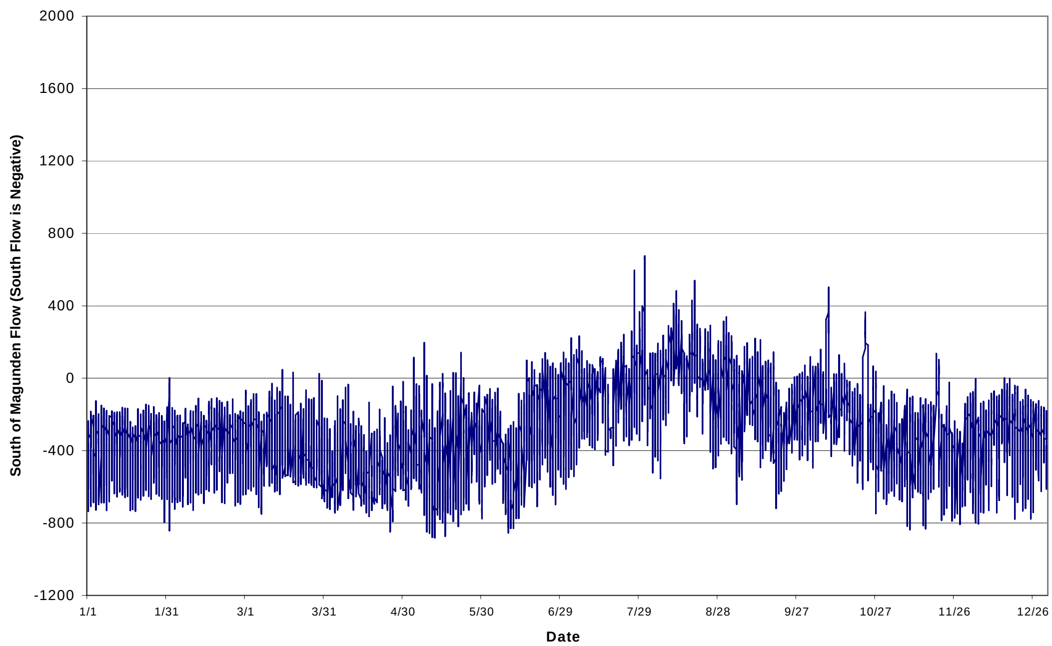


Figure 3.2.3
South of Magunden Flow Patterns with 300 MW System Tie

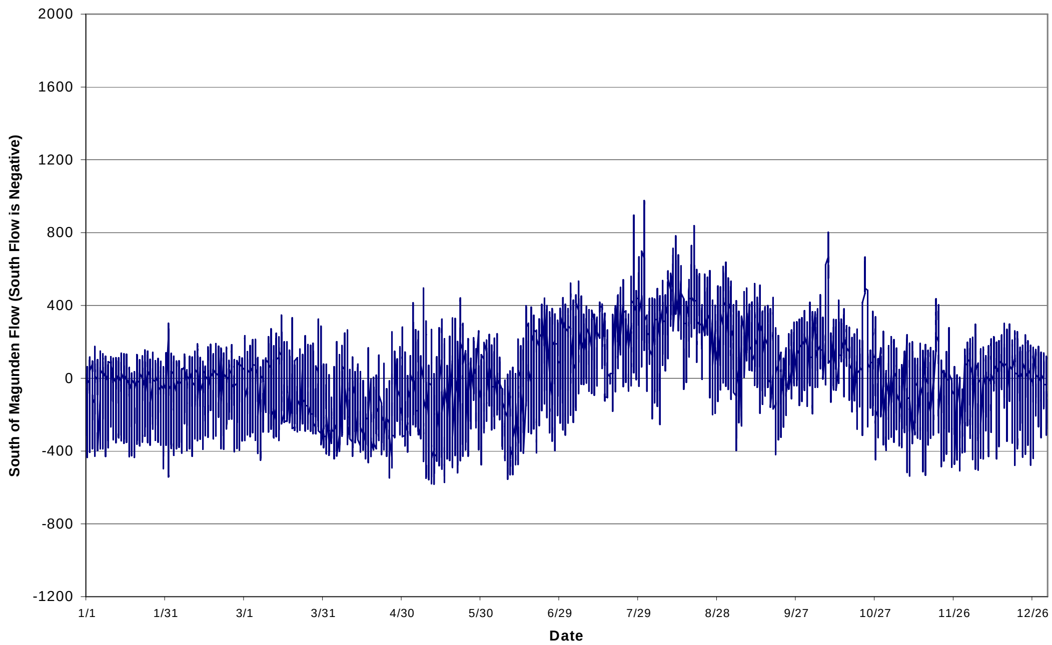


Figure 3.2.4
South of Magunden Flow Patterns with 500 MW System Tie

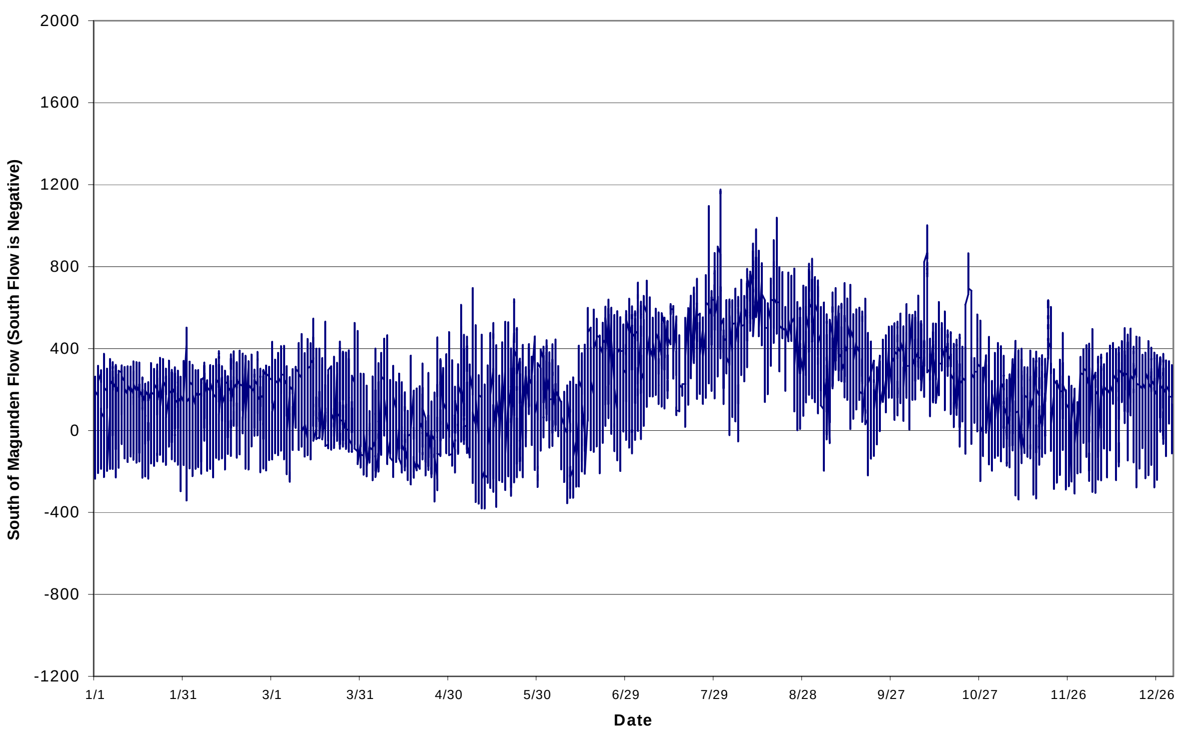


Figure 3.2.5
South of Magunden Flow Patterns with 1,000 MW System Tie

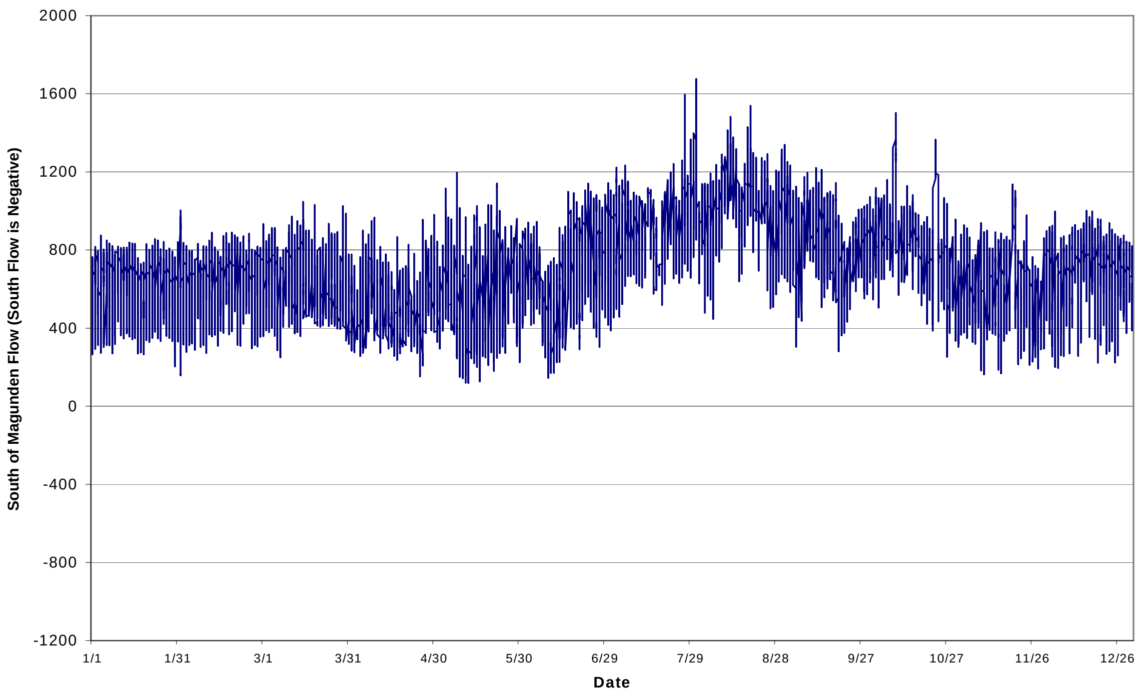


Figure 3.2.6
South of Magunden Flow Patterns with 1,200 MW System Tie

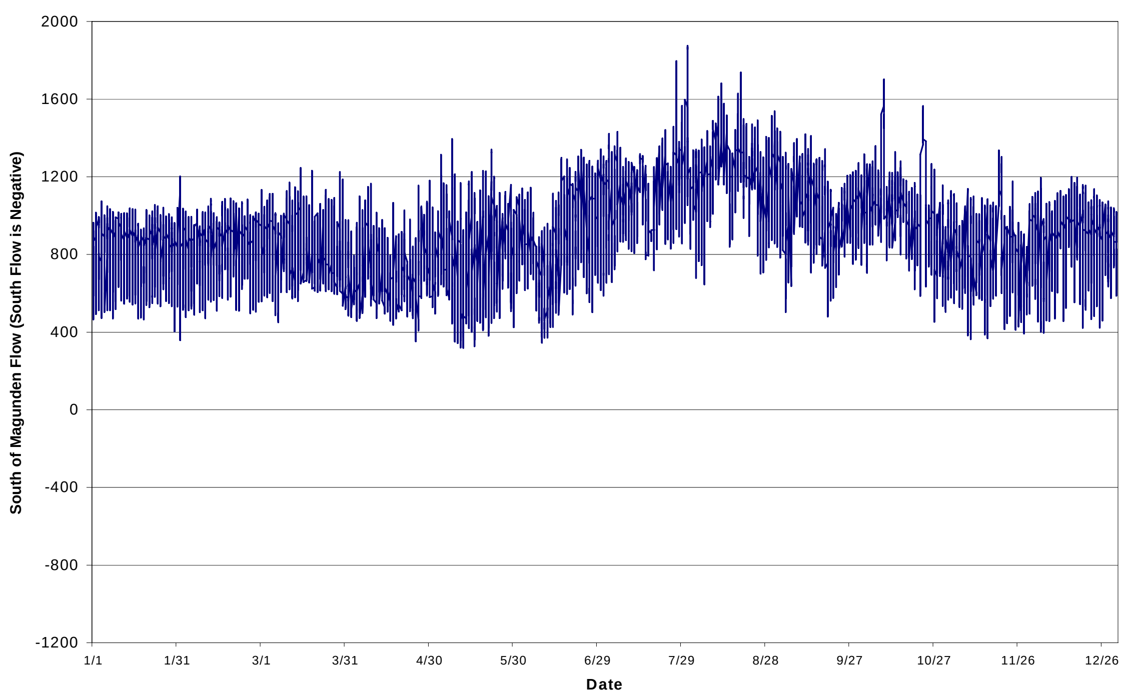
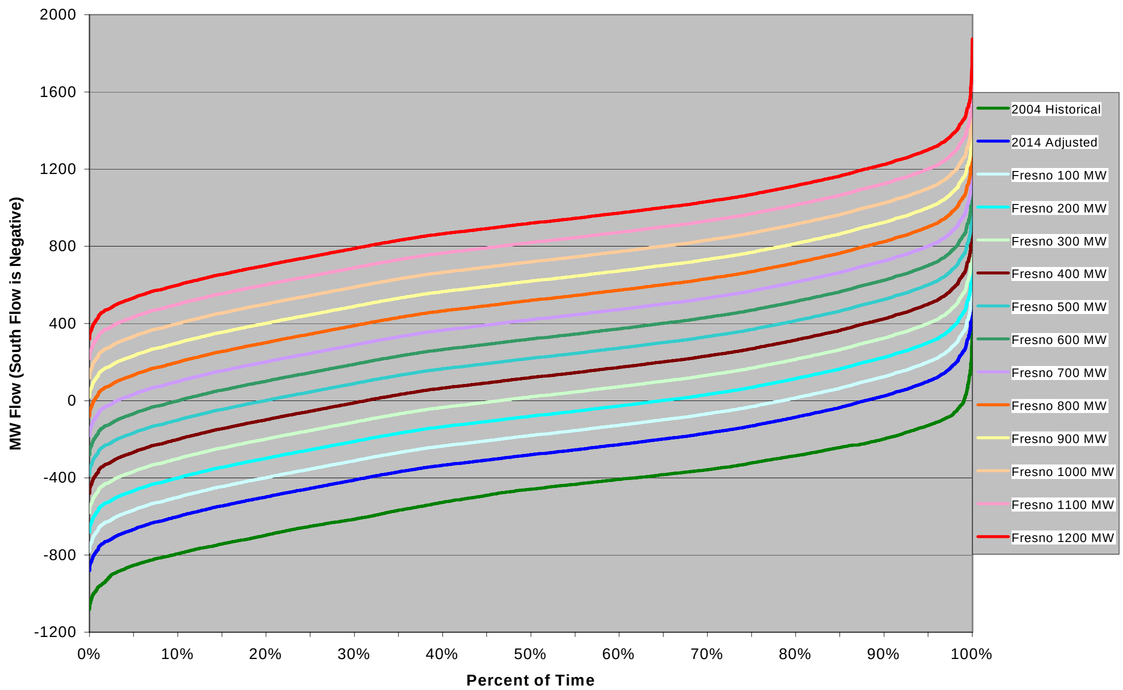


Figure 3.2.7
South of Magunden Flow Patterns with 1,200 MW System Tie

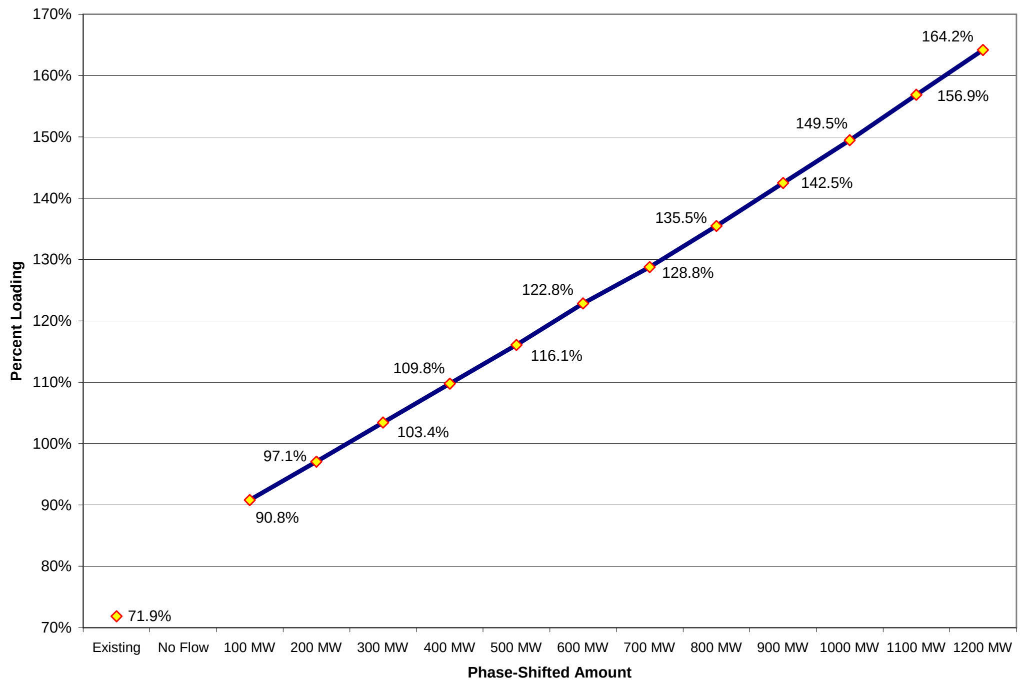


2.2.1.2. North of Magunden 230 kV Transmission Line Loadings Under Base Case Conditions

Four 230 kV transmission lines connect the Big Creek hydro complex, located in northern Fresno County, to the rest of the SCE network. Two of the four lines connect Big Creek to the SCE Rector 230 kV Substation, continue south towards the SCE Vestal 230 kV Substation and finally connect to the SCE Magunden 230 kV Substation. The other two lines connect Big Creek to the SCE Springville 230 kV Substation and continue south to the SCE Magunden 230 kV Substation.

The new system tie is proposed to connect to the two SCE 230 kV transmission lines heading towards the SCE Rector Substation, as shown above in Figure 3.2.1. Power flow study results indicate that additional system upgrades will be necessary to mitigate thermal overload problems identified with the addition of the new system tie represented as a fixed power flow model. Loading on the section of the existing Big Creek3-Rector 230 kV line between Big Creek 3 and the new system tie was found to exceed the maximum allowable thermal limits with all facilities in-service. Depending on the amount of power "pushed" from SCE to PG&E, thermal loading was identified to increase from 91% of the normal conductor limit up to 164% as shown below in Figure 3.2.8. To mitigate this overload, rebuild of a section of the existing Big Creek3-Rector 230 kV transmission line will be necessary to support a larger conductor.

Figure 3.2.8
Section of Existing Big Creek3-Rector 230 kV (BC to Fresno Tie)
Line Loading with All Facilities In-Service



Figures 3.2.9 through Figure 3.2.13 illustrate loading on the other transmission facilities in the Big Creek Corridor north of the SCE Magunden 230 kV Substation.

Figure 3.2.9
Section of Existing Big Creek1-Rector 230 kV (BC to Fresno Tie)
Line Loading with All Facilities In-Service

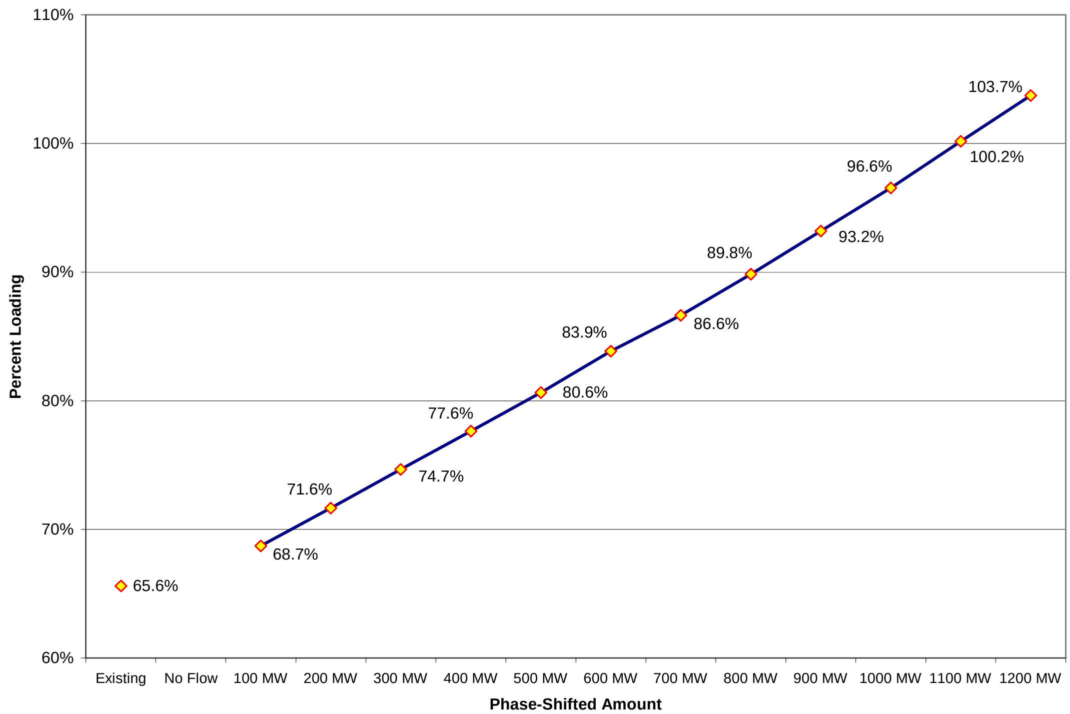


Figure 3.2.10
Section of Both Existing Big Creek-Rector 230 kV (Rector to Fresno Tie)
Line Loading with All Facilities In-Service

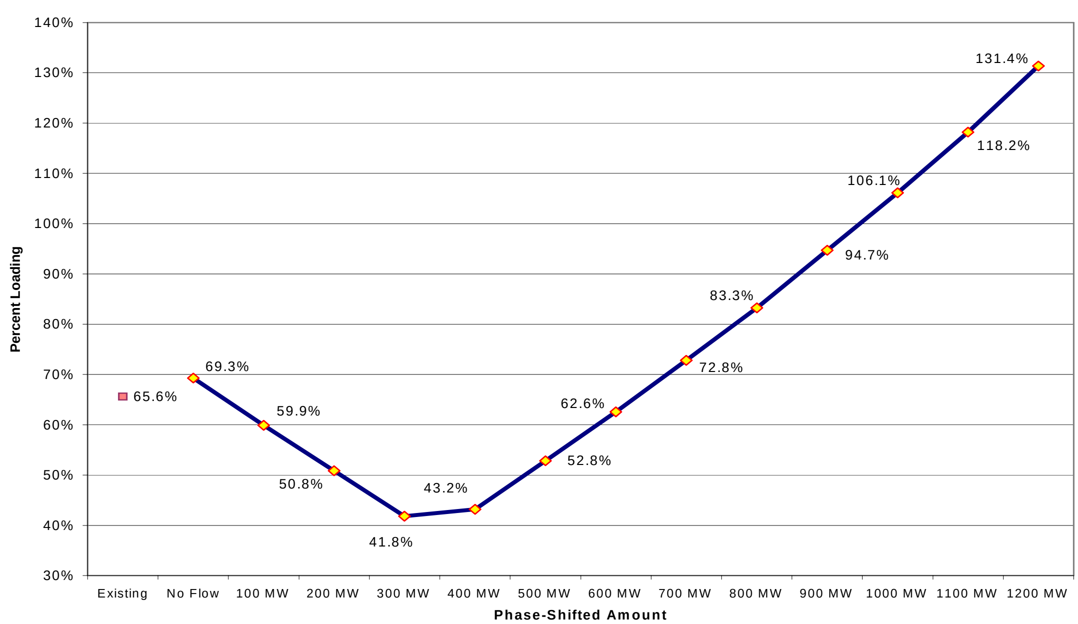


Figure 3.2.12
Both Existing Vestal-Rector 230 kV
Line Loading with All Facilities In-Service

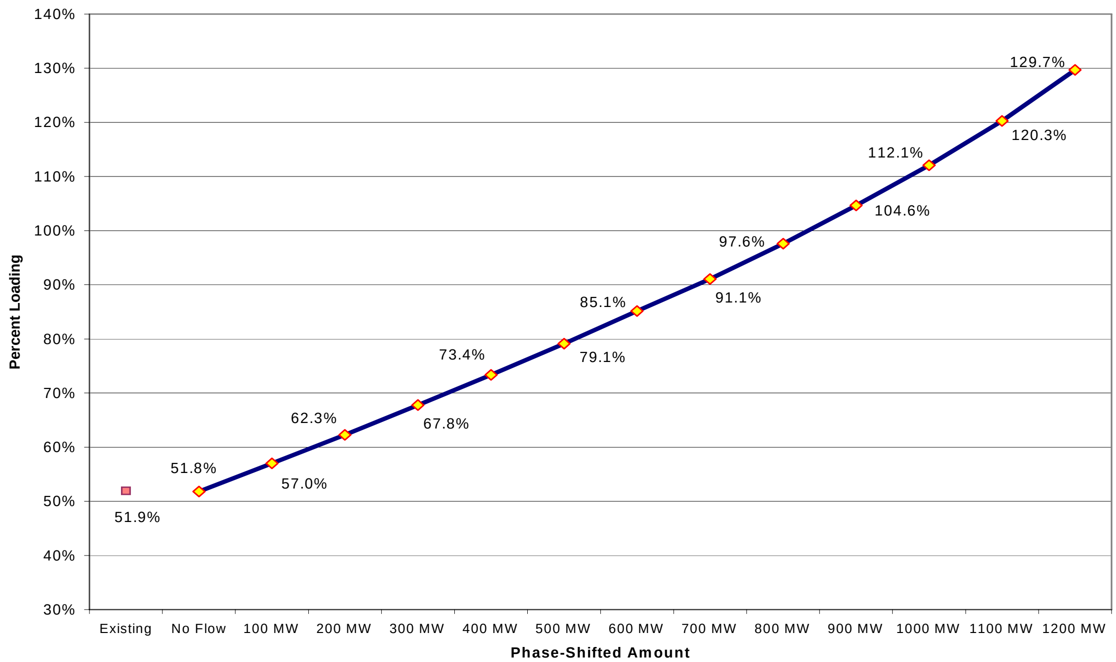
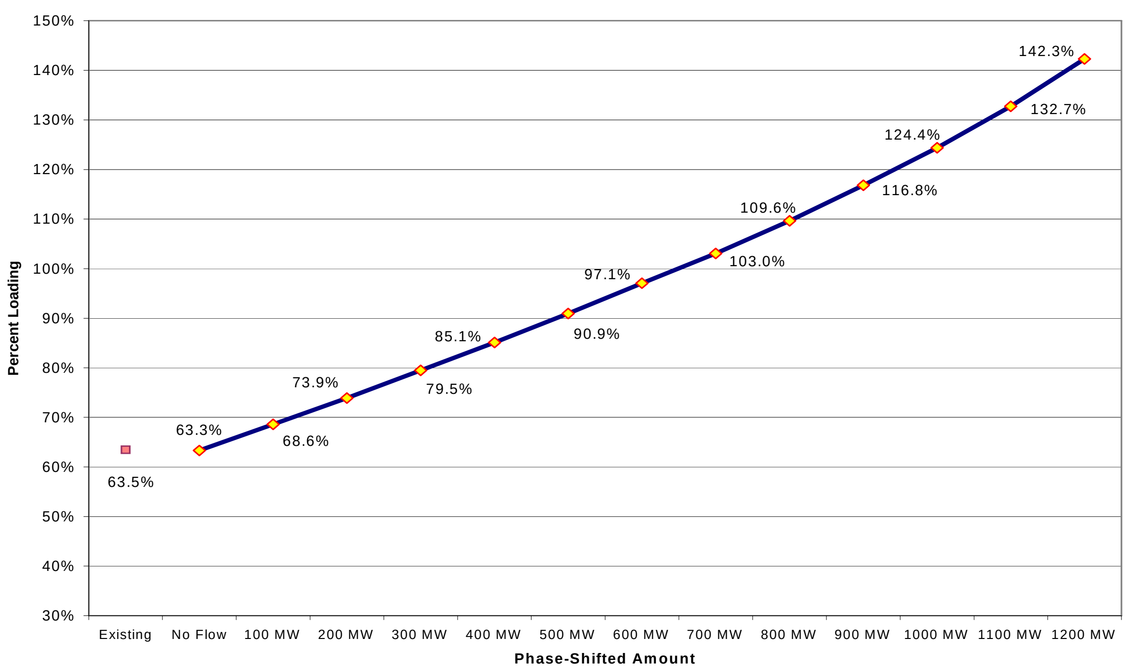


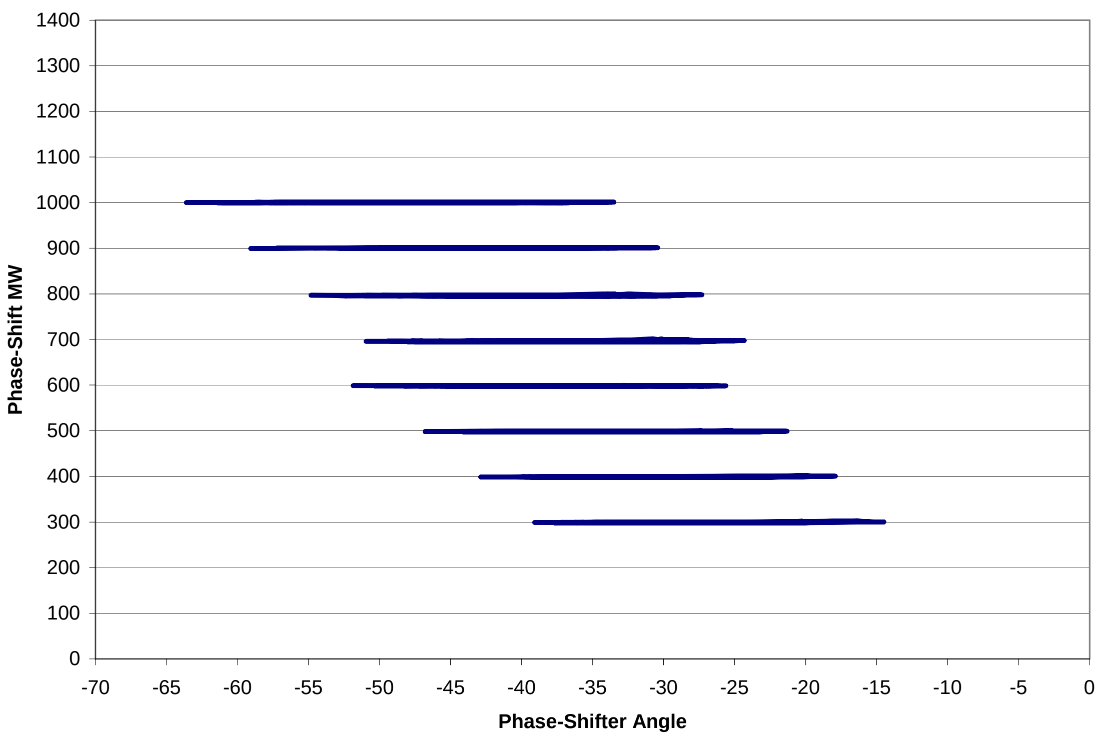
Figure 3.2.13
Both Existing Magunden-Vestal 230 kV
Line Loading with All Facilities In-Service



2.2.1.3. Phase-Shift Angle Requirements

Detailed system studies indicate a wide range of phase-shift operation in order to maintain the specified power level. Such operation is indicative of a need to install a unified power flow controller which utilizes power electronics to maintain the specified power flow instead of a traditional phase-shift transformer which cannot be manage to maintain a constant flow. The amount of phase-shift angle capability required depends on numerous factors. These factors involve SCE local area load and generation conditions (San Joaquin Valley load demand and Big Creek hydro generation output), PG&E local area load and generation conditions (Fresno area load demand and Helms operations), as well as major path flows (Pacific Intertie, Path 26, Path 15, etc.). For purposes of identifying potential angle bandwidth requirements, SCE performed parametric studies, which adjusted only the SCE local area load and generation. All other system conditions were held constant. Based on these studies, SCE determined that a phase-shift capability in excess of 60 degrees would be needed to support such a phase-shifted system tie. A summary of these findings is provided below in Figure 3.2.14.

Figure 3.2.14
Constant Power Phase-Shift Requirements



2.2.1.4. Reactive Resource Requirements

With the inclusion of the new phase-shifted system tie, loadings on the existing transmission lines are increased resulting in additional reactive losses, which adversely impact local system voltage performance. To determine the amount of additional reactive resources required under base case conditions to maintain pre-existing voltage levels, bus voltages at the Rector, Magunden and the new Fresno Tie Substations were maintained at unity by adding an assumed synchronous condenser at each location. Studies were then conducted for each hour of the year based on historical performance. The studies captured output of the synchronous condensers without the new phase-shifted system tie and with the new phase-shifted system tie so that an adequate comparison could be made. Reactive requirements identified without the addition of the new phase-shifted system tie were subtracted from the reactive requirements identified with the addition of the new phase-shifted tie in order to properly capture the incremental reactive resource required due to the addition of the new phase-shifted system tie. Study results for a 200 MW phase-shifted system tie are shown below in Figure 3.2.15. The 600 MW phase shift analysis was conducted with and without a new 230 kV transmission line from Magunden to Rector and is provided in Figure 3.2.16. As can be seen, the reactive requirements needed to support a 200 MW system tie is approximately 125 MVARs while the requirements needed to support a 600 MW system tie is approximately 500 MVARs. With the inclusion of a new line, the reactive requirement needed to support the 600 MW system tie is reduced down to approximately 200 MVARs. Additional resources may be required to maintain adequate voltages under outage conditions.

Figure 3.2.15
Reactive Requirements to Support a 200 MW Phase-Shifted System Tie

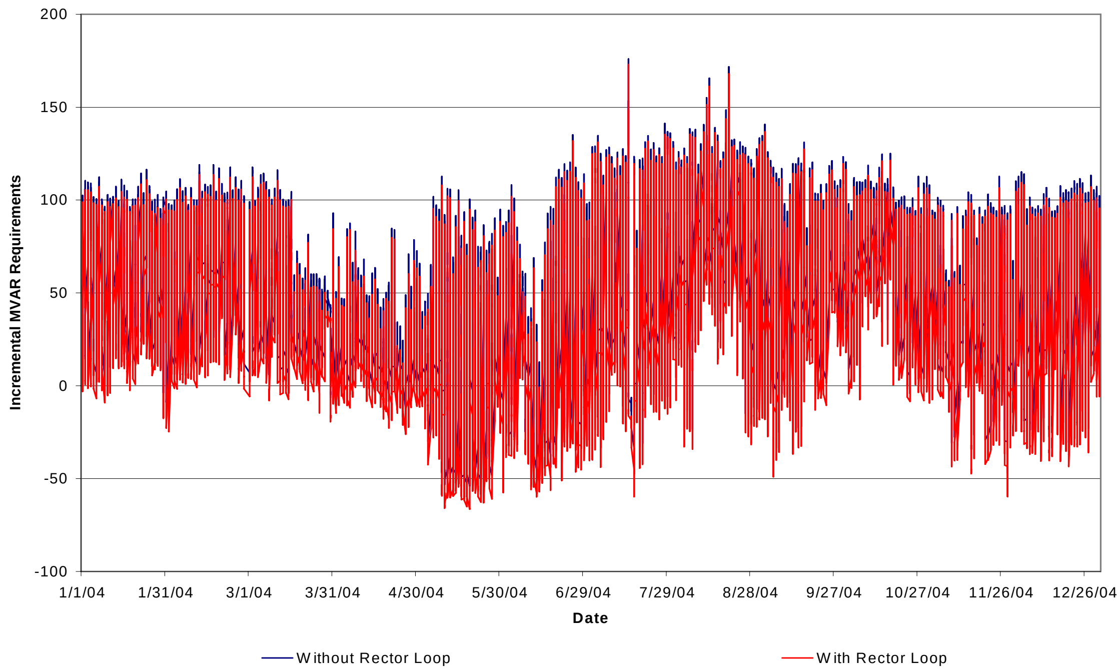
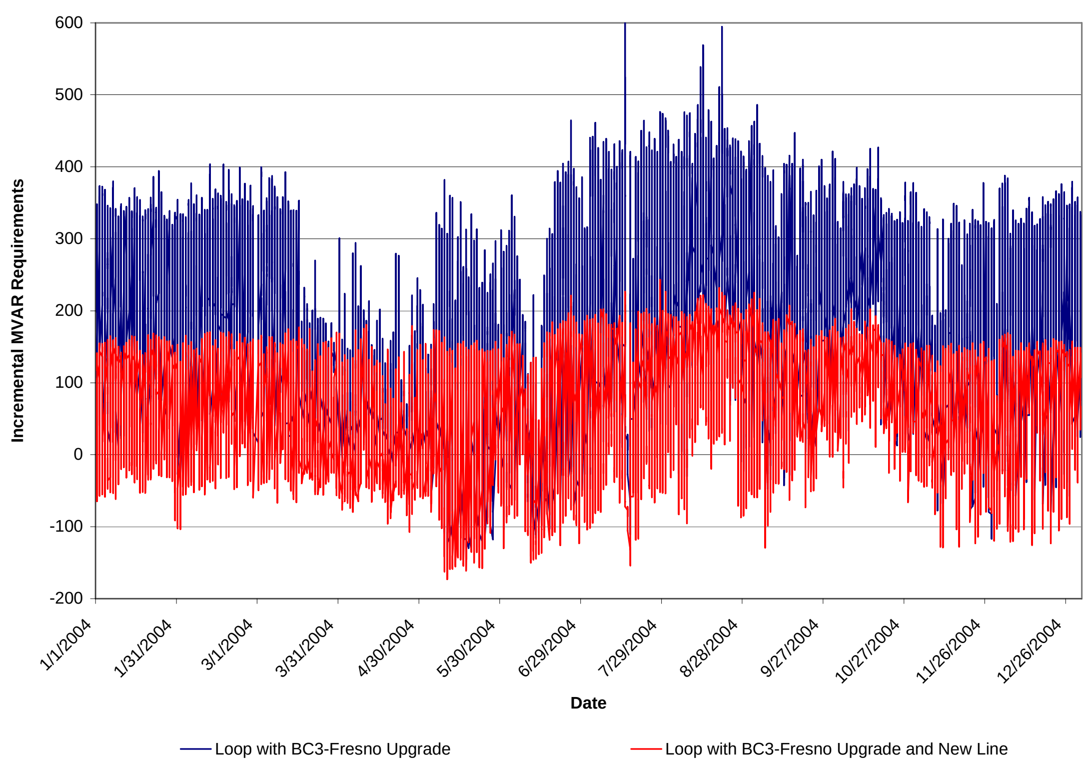


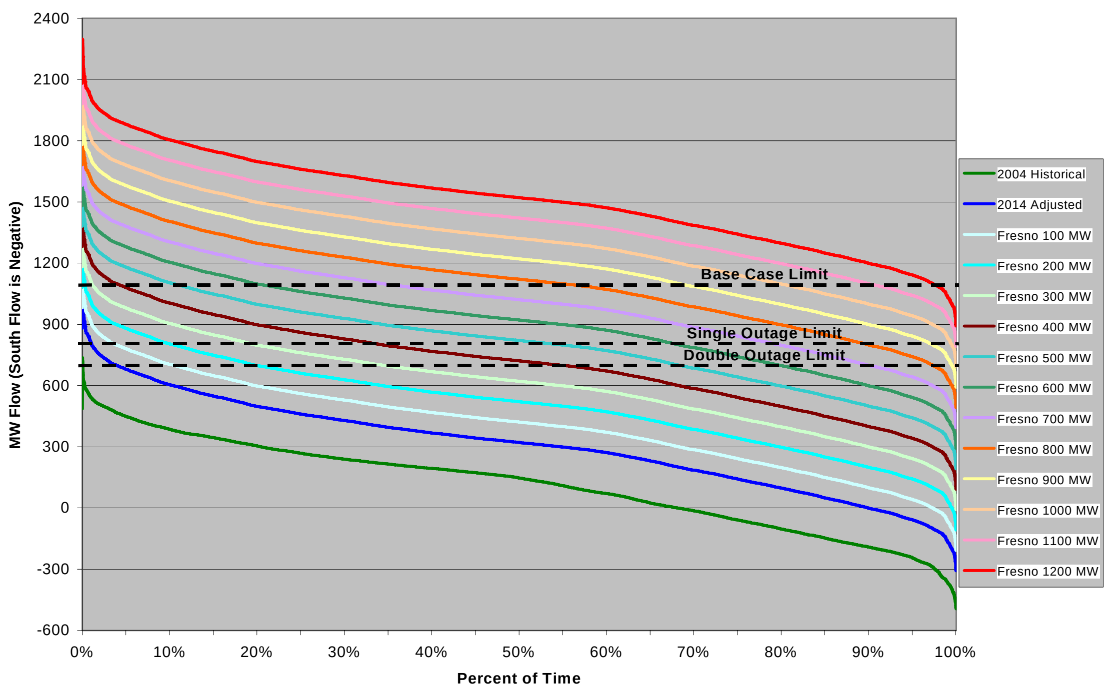
Figure 3.2.16
Reactive Requirements to Support a 600 MW Phase-Shifted System Tie



2.2.1.5. Study Results Under Loss of One Transmission Line

As previously discussed, adding a new system tie to "push" power from SCE to PG&E has the equivalent effect of increasing load in the San Joaquin Valley. With this increase in load, base case and outage conditions will result in higher thermal overload problems than are currently anticipated. Currently, the existing 230 kV transmission lines north of Magunden are anticipated to be fully utilized to support forecast load demand. Without new facilities, the existing system cannot support the new system tie at any level. Figure 3.2.17 provides the north of Magunden flow duration curves for various system tie levels and includes system limitations. As can be seen, adding a 300 MW system tie results in potentially exposing the system to thermal loading levels above the current single contingency limit for approximately 20 percent of the time. Increasing the system tie from 300 MW up to 600 MW will result in further increasing the overload exposure from 20 percent to 55 percent.

Figure 3.2.17
North of Magunden Flow Duration Curve



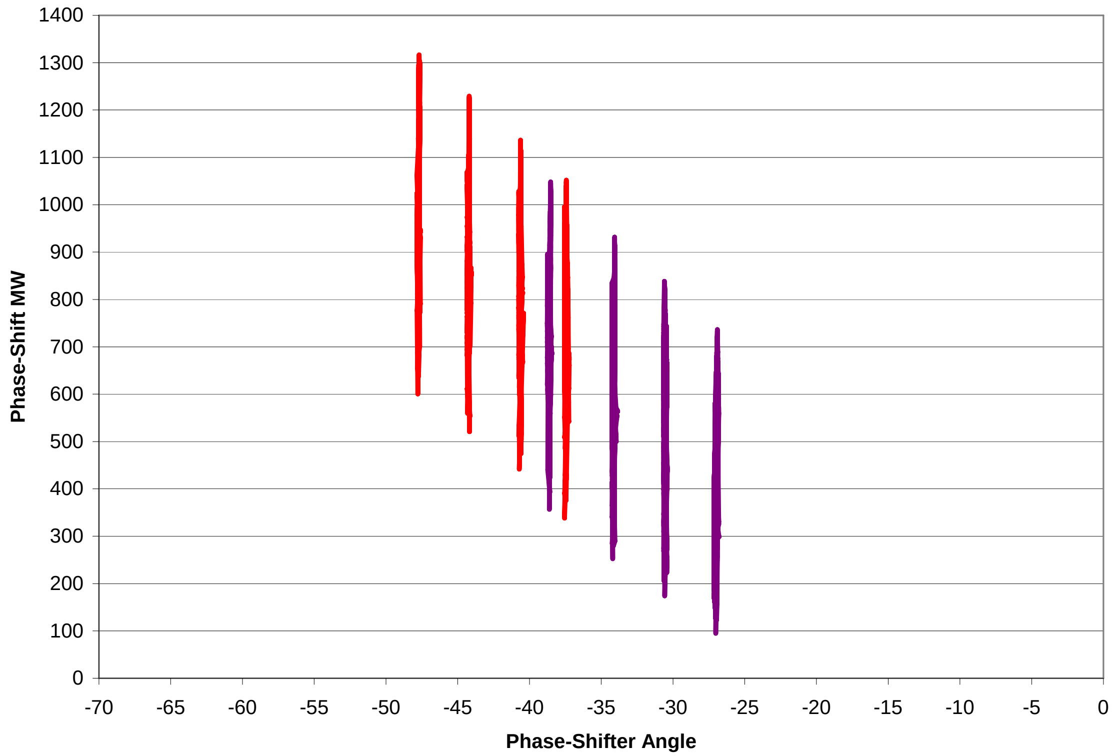
A proposed solution of opening the system tie under outage conditions may not be a workable solution. Generally, WECC supports the establishment of Operating Nomograms developed to limit the amount of power that can be scheduled through a WECC Path. In other words, the Path rating will be established based on limiting elements during outage conditions. As a result, upgrades will be required to support a new Phase-Shifted System Tie. These upgrades will involve adding a new transmission line(s) between Magunden and Big Creek. The exact amount of system tie capability that can be accommodated with this transmission in-service is unknown at this time. Detailed WECC Path Rating studies will be required to make this determination. Conceptually, SCE anticipates a maximum constrained capability (Operating Nomogram) of 400 MW with the addition of a new line. This value is derived by considering the existing base case limitation of 1,150 MW, which is expected to be the new limit under loss of the new line. The total north of Magunden flows under non-summer conditions will exceed the 1,150 MW limit when considering higher phase-shift transfer levels. The CAISO should review all other conditions where the use of the system tie could result in loadings that exceed the 1,150 MW limit. This should be done to determine if the use of congestion management (i.e. use of an Operating Nomogram) is an acceptable means for limiting flows on a system tie that is actively managed (i.e. constant power flow model).

2.2.2. Big Creek-Fresno Tie Study Results – Fixed Tap Setting Model

2.2.2.1. Impacts to Power Flows

The fixed power flow model results for each phase-shift level examined were used as the basis for conducting the fixed tap setting power flow studies. Resulting angles were examined and an average value was selected for each phase-shift capacity scenario to represent the "best" tap setting to use for that scenario. This assumption, while not perfect, captures system behavior when selecting a particular tap setting. Results of this study indicate that any given tap setting has the potential to operate within a 700 MW bandwidth as shown below in Figure 3.2-18. As an example, the curve corresponding to an angle of approximately 30 degrees can result in phase-shifting anywhere between 200 MW and 850 MW.

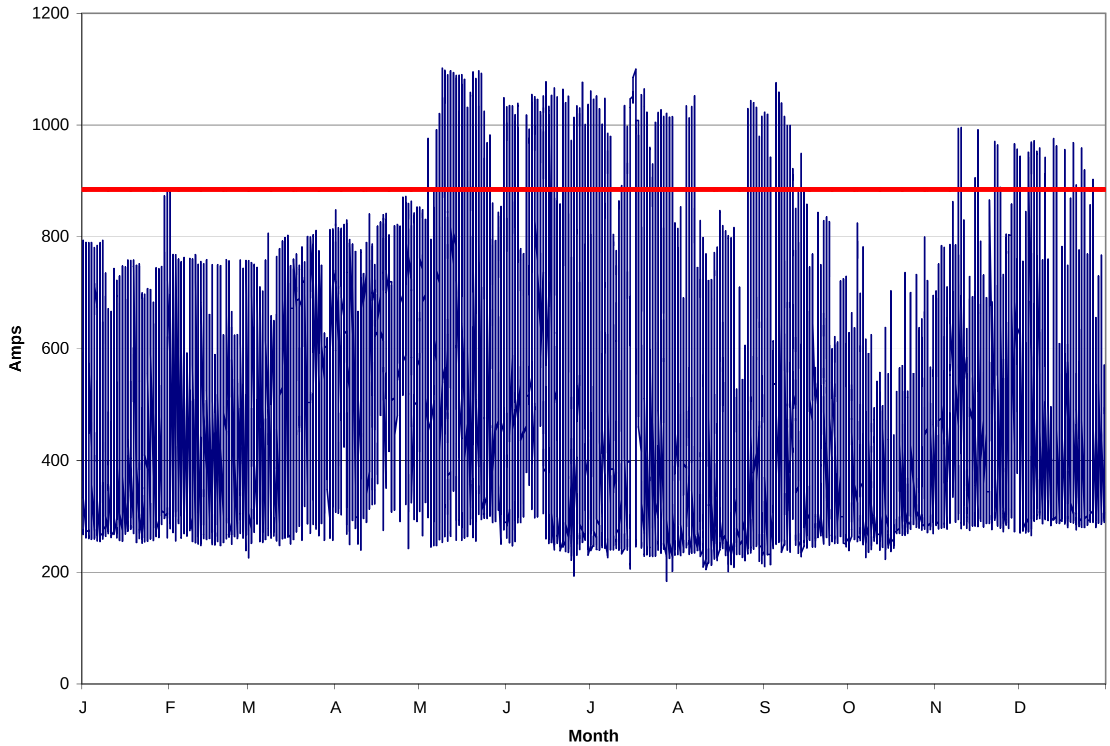
Figure 3.2.18
Fixed Angle Phase-Shifted Power



2.2.2.2. North of Magunden 230 kV Transmission Line Loadings Under Base Case Conditions

As shown below in Figure 3.2.19, loading on a section of the existing Big Creek3-Rector 230 kV line (between Big Creek and the Fresno System Tie) was identified to exceed the maximum allowable limit under base case conditions with a fixed tap setting of 30 degrees. Complete tear-down and rebuild of this transmission facility will be necessary as the current infrastructure does not support use of a larger conductor. This tear-down and rebuild will necessitate environmental review to comply with both the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA) since the line traverses the Sierra National Forest.

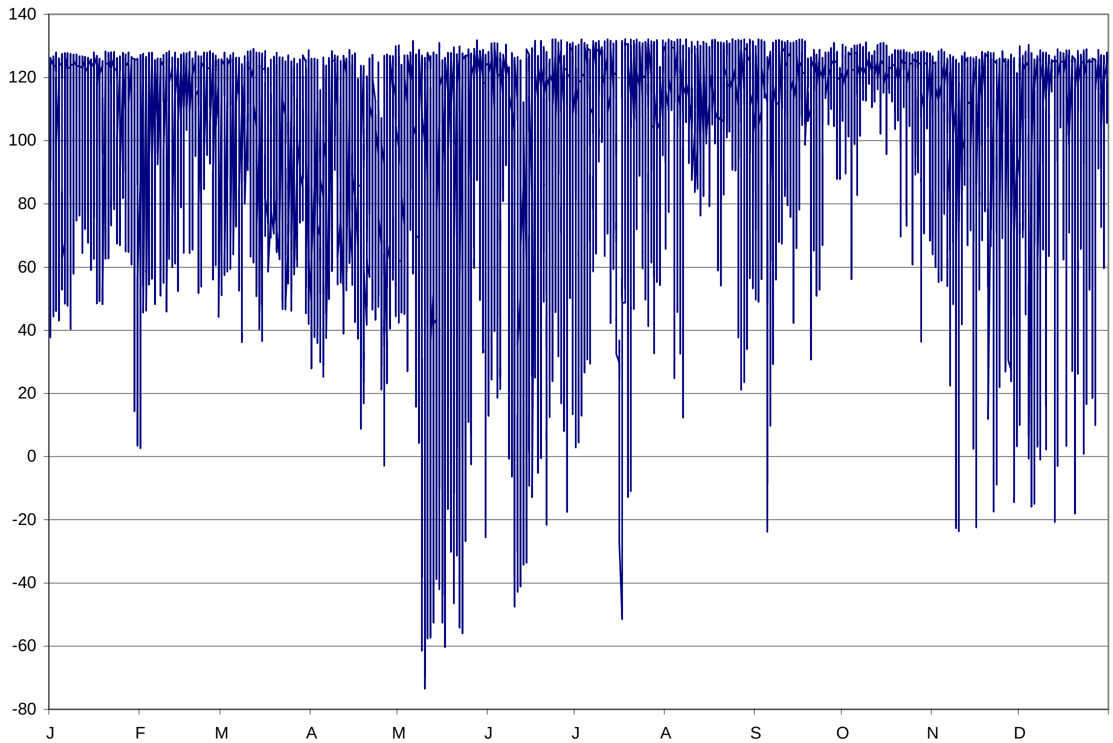
Figure 3.2.19
Loading on the Big Creek3-Rector 230 kV Transmission Line



2.2.2.3. Reactive Resource Requirements

With the inclusion of the new fixed tap phase-shifted system tie set to 30 degrees, loadings on the existing transmission lines are increased resulting in additional reactive losses, which adversely impact local system voltage performance. The same methodology utilized above for a fixed power level was used to determine the amount of additional reactive resources required under base case conditions. Study results for a fixed tap phase-shifted system tie set to 30 degrees are shown below in Figure 3.2.20. As can be seen, the reactive requirements needed to support a fixed tap phase-shifted system tie set to 30 degrees is approximately 130 MVARs. Additional resources may be required to maintain adequate voltages under outage conditions

Figure 3.2.20
Reactive Requirements to Support a Fixed Tap Phase-Shifted System Tie
Tap Setting Set to 30 Degrees



2.2.2.4. Fixed Power Flow Model Under Loss of One Transmission Line

As discussed above in the assumptions section, the fixed tap setting model does not respond well to system outage conditions. As a result, it is extremely difficult to forecast system behavior during faulted conditions. What can be said is that a surge of power through phase-shift transformer is likely due to system impedance change under the outage conditions and very slow moving load tap changers (if automated). This surge in power could lead to additional thermal overloads on the existing Big Creek 230 kV transmission lines that have not been identified under the base case conditions. System upgrades needed to support the full range of flow patterns as identified above for base case conditions should include sufficient capability to accommodate outage conditions. Detailed WECC Path Rating studies will be required to make an exact determination as to how much capacity can be made available with the addition one or more 230 kV transmission lines. Conceptually, SCE estimates that use of a fixed tap setting model will require complete upgrade of the western side of the Big Creek corridor which includes adding two new 230 kV transmission lines.

2.2.3. Big Creek-Fresno Tie Study Points of Discussion

Study Assumptions

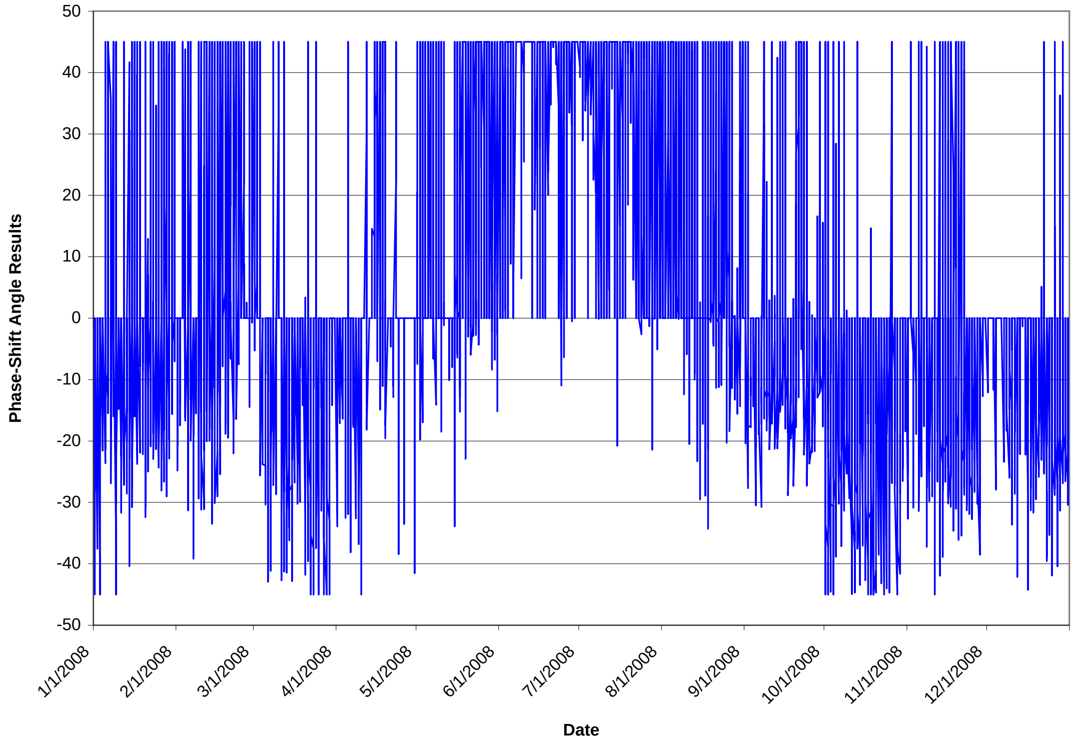
The CPUC Energy Division staff participating in the collaborative study has expressed concerns with the study assumptions implemented in performing this study. Specifically, the concerns centered on modeling of proper operating conditions for the new system tie assuming power flows could be managed. In a letter from the CPUC Energy Division to SCE dated July 9, 2005, the following was expressed:

> "From our recollection of the presentation [June 28, 2005], it consisted largely of a determination of the characteristics of a phase shifting transformer to deliver power to PG&E in a Northerly direction from the Big Creek-Rector lines under conditions of summer peak load. It is our understanding that under these conditions the flow across Path 26 is in the opposite direction, from North to South, which would explain the high angle shift required of the transformer. Forcing flow from SCE to PG&E under these conditions appears to us to be undesirable. More relevant to the study are the off-peak conditions under which the Path 26 flow is from South to North. Under off-peak conditions a phase-shifting transformer or flow controller is needed only to augment existing South to North flow in Path 26 to accommodate delivery of Tehachapi generation to the grid."

The study assumptions utilized in conducting these parametric studies included all operating conditions by simulating an entire year using historical metered data. Based on the results of the study, the phase-shift angle problems identified are not limited to summer peak conditions. With minimal flows on the new system tie, the phase-shift angle problems were also identified under spring run-off conditions (April and May) when Big Creek hydro is at maximum. With greater flows on the new system tie, the problems were found to occur year round. The reason for this is that local area loads and generation dispatch patterns play a dominant role in defining the phase-shift angle requirements necessary to deliver power from SCE to PG&E. In other words, the flow direction of the Pacific intertie does not necessarily dictate local phase-shift angle requirements.

This conclusion has been validated by the CAISO in the economic dispatch studies performed to evaluate system performance with the inclusion of a 600 MW phase-shifted system tie. SCE requested and reviewed the data supporting the study results presented by the CAISO at the September 19, 2005 Tehachapi Collaborative Study Meeting. Based on SCE's review of the data, the phase-shift angle problems identified are anticipated to occur throughout the year as shown below in Figure 3.2.21.

Figure 3.2.21
CAISO Economic Dispatch Study Results
600 MW Fresno Phase-Shift System Tie

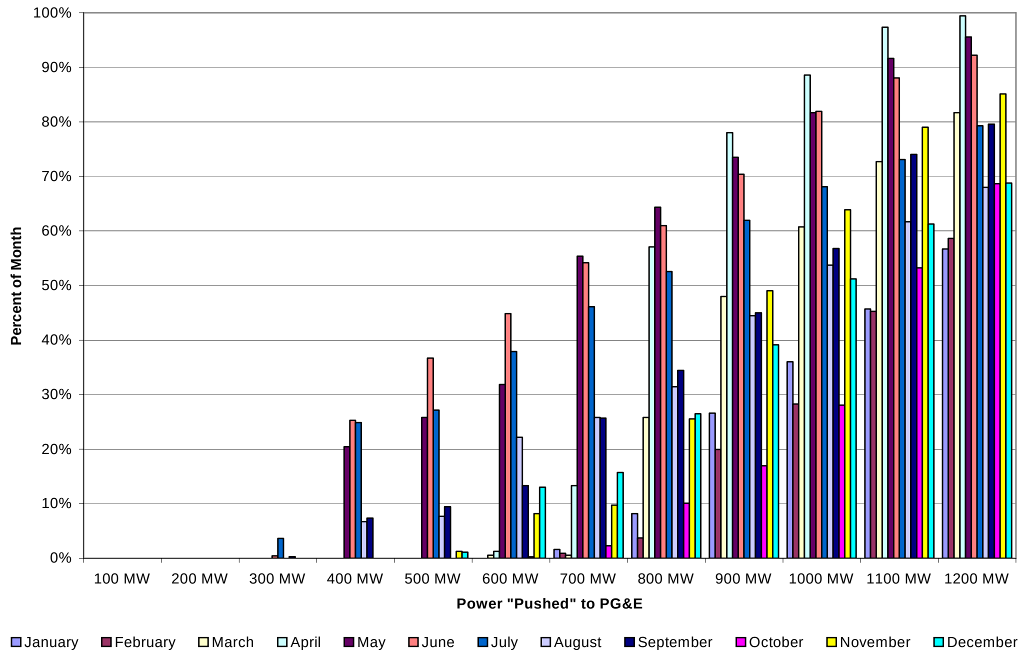


Power Flow Validation

Several of the Tehachapi Collaborative Study Group participants have expressed concerns with the study results portraying loadings that would not occur when the phase-shift transformer would be in service or would be "pushing" power from SCE to PG&E.

To determine when such overloads would occur, output data obtained from the thousands of power flow studies conducted was reviewed. The results of this data review are presented below in Figure 3.2.22. As can be seen, exposure to the thermal overload problem identified on the section of Big Creek3-Rector 230 kV transmission line between Big Creek and the Fresno system tie begin when the system tie is at 300 MW. This overload problem initially occurs during May, June and August but extends out for the entire year as the system tie is increased. Based on these results, SCE will require upgrades to mitigate this identified base case overload.

Figure 3.2.22
Section of Existing Big Creek3-Rector 230 kV (BC to Fresno Tie)
Overload Frequency



Operating Procedure to Open System Tie

Several participants suggested that an Operating Procedure be implemented to open the system tie anytime the Big Creek3-Rector 230 kV transmission section between Big Creek and the Fresno Tie is thermally overloaded.

The proposed solution of opening the system tie anytime there is an overload is not a workable solution. Since the system tie will be a new established WECC Path, the tie will need to remain in service under all normal operating conditions. A thermal overloads caused by the daily dispatch of the system does not constitute an abnormal operating condition. The CAISO has provided their comments on this subject matter in an e-mail issued on September 9, 2005. The CAISO states the following:

> "Generally, in regard to operation of a new phase-angle regulator, it would not be advisable to propose a new facility that would need to be periodically taken out-of-service to limit flows."

In addition, a Special Protection Scheme is currently in place which runs back Big Creek generation whenever either of the Big Creek-Rector 230 kV transmission lines is overloaded. Adding this system tie without upgrades can lead to unintended operation of this run-back scheme. WECC RAS Task Force requires that impacts to special protection schemes resulting from the addition of new facilities be mitigated. In this case, the mitigation would be the upgrade to the overloaded facility and operate the system within the limits of the next limiting component. Additional transmission upgrades will be necessary to accommodate a larger fixed power model.

Reasons for Power Flow Patterns

One of the participants questioned why the transmission section between Big Creek and the Fresno Tie would thermally overload.

As can be seen in Figure 3.2.1, the distance from the Big Creek 1,000 MW hydro facility to the new system tie is relatively short. "Pushing" power from SCE towards PG&E will result in increasing Big Creek hydro generation flows on the two lines from Big Creek to the Fresno Tie. The reason for this can be explained by applying Ohm's Law, which basically states that current is inversely proportional to the apparent impedance. In other words, current follows the path of least resistance (i.e. Big Creek generation is a shorter distance to the new system tie as compared to Tehachapi generation and therefore has a much smaller impedance). For this reason, the Fresno phase-shifted system tie cannot be directly linked to Tehachapi since Tehachapi power will never flow on the system tie unless the size of the tie is in excess of the total Big Creek hydro generation.

2.2.4. Big Creek-Fresno Tie Study Conclusions

Because of the complexities associated with the use of a traditional phase-shift transformer, design of a system tie with such facility, while cheaper than a FACTS device, will require significantly much more transmission line upgrades to allow for reliable operation. The use of a FACTS device on the other hand reduces the amount of transmission line upgrades required and improves overall operability of the system tie. The CAISO should be consulted as to which alternative can be supported from an operations perspective considering scheduling difficulties as well as hour-to-hour operations.

Conceptually, the study results indicate that the use of a traditional phase-shift transformer needed to "push" 200 MW needs to be designed sufficient to accommodate 850 MW. In comparison, the use of a FACTS device to "push" 200 MW requires sufficient upgrades to accommodate only 200 MW. Table 1 below summarizes the facilities needed to accommodate each type of system tie.

Table 3.1
Transmission Facilities Needed to Support New System Tie

Fixed Power System Tie FACT Device Designed for 200 MW	**Traditional Phase-Shift Transformer Fixed Tap System Tie Designed for 850 MW**
Currently Planned San Joaquin Valley Rector Loop 230 kV Project	Currently Planned San Joaquin Valley Rector Loop 230 kV Project
New 60 mile Antelope-Magunden 230 kV Transmission Line	New 60 mile Antelope-Magunden 230 kV Transmission Line
New 135 mile Magunden-Vestal-Rector-FresnoTie-Big Creek Transmission Line with connections to each of the substations	New 135 mile Magunden-Vestal-Rector-FresnoTie-Big Creek Transmission Line with connections to each of the substations
Magunden, Vestal, Rector, and Big Creek Substation Expansion	Magunden, Vestal, Rector, and Big Creek Substation Expansion
Supplemental Shunt Capacitor Banks since most dynamic supply can be provided by the FACTS device	Dynamic Reactive Resources such as SVC
	Second new 135 mile Magunden-Vestal-Rector-FresnoTie-Big Creek Transmission Line with connections to each of the substations
	Additional Magunden, Vestal, Rector, and Big Creek Substation Expansion

SCE notes that regardless of which facility is ultimately selected, much more study work is required to support establishment of an official path rating. This study work will include short-circuit duty analysis as well as transient stability review. This study should only be undertaken if this alternative appears to be cost effective when compared against other Conceptual plans and with formal approval from the CAISO Operations Group. Conceptually, the cost estimate for this new system intertie is in excess of $450 million.