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 3 of 5: Appendix 2

California Public Utilities Commission

OII 05-09-005
OII 00-11-001

April 19, 2006

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 2

Preliminary Power Flow Study Report
PG&E Area Conceptual Transmission Plan
Continuation of Tehachapi Collaborative Study

Purpose

The purpose of this continuation of the Tehachapi Collaborative Study is to formulate a plan for the transmission of 4,000MW of wind generation at Tehachapi and 500MW in the Antelope Valley to load centers in the PG&E and SCE service areas. It is assumed that half the 4,000 MW at Tehachapi will go to PG&E and half will go to SCE. The plan resulting from this study will be sufficient to initiate the preparation of Proponent's Environmental Assessments (PEAs) which would form the basis of CPCN applications for the facilities defined in the plan. The plan covers only the facilities from Tehachapi Substation 1 to the load centers and does not include the Tehachapi collector system. It is envisioned that this transmission plan will be updated in the future as each (or each group of) specific wind plant project moves through the ISO Interconnection Process and the Tehachapi collector loop beyond Tehachapi Substation 1 becomes more definitive.

Background

Pursuant to CPUC Decision 04-06-010, the Tehachapi Collaborative Study Group (TCSG) was formed to develop a comprehensive transmission development plan for the phased expansion of transmission capabilities in the Tehachapi area. The CPUC Staff coordinated the collaborative study group. As directed by the decision, TCSG completed a study that assumed there would be more than 4,000 MW of wind resources at Tehachapi Wind Area[1]. To conduct the study the TCGS further assumed that 50% of the 4,000 MW would be delivered to load centers in the transmission system North of Path 26 and the remaining 50% would be delivered to load centers in the system south of Path 26[2]. The Executive Director extended the original due date for filing the report by one week in a letter dated March 4, 2005. A report entitled, "Development Plan for the Phased Expansion of Transmission in the Tehachapi Wind Resource Area" (Report), was filed by Southern California Edison (SCE) on March 16, 2005.

As stated in that Report, the development plan prepared by the TCSG is a conceptual roadmap to the eventual Tehachapi transmission system rather than a definitive plan[3]. The Report recommended that further study be performed to select among the alternatives identified in the Report (and referred to herein with the same identification numbers as in the Report). These alternatives require further planning evaluation in order to formulate a single plan for implementation. To do this, additional studies (specific rather than generic) need to be performed and facility cost estimates refined. The final plan for the

[1] Decision 04-06-010, at 6
[2] Study Plan, date July 14, 2004, at 18
[3] Tehachapi Collaborative Study Report, at 3

Tehachapi collector system requires information concerning actual wind project locations, capacities and characteristics which are not available at this time, and therefore is not covered in the study. However, since the Tehachapi collector system and actual wind projects would impact the utilities' transmission plan, it is envisioned that the utilities' transmission systems would be updated in the future as each (or each group of) specific wind plant project moves through the ISO Interconnection Process and the Tehachapi collector loop beyond Tehachapi Substation 1 becomes more definitive. This flexible approach will allow the study to move forward at this time.

PG&E had investigated three alternatives in addition to the status quo (Alternative 1) to mitigate the impacts of scheduling and delivering 2,000 MW of Tehachapi generation (Alternatives 4 and 5) and two alternatives to mitigate the impact of scheduling and delivering 300 MW of Tehachapi area renewable generation (Alternatives 2 and 3) to PG&E. Alternative 3 to deliver 300 MW to PG&E was subsequently dropped because it could not provide the intended 300 MW of transfer capability. In this study PG&E performed further investigation on Alternatives 1, 2, 4 and 5. In addition, Alternative 2 was expanded to investigate the impact of scheduling and delivering 300 MW, 600 MW and 1,200 MW of Tehachapi area renewable generation.

Study Objective

The objective of this study is to evaluate the impact of importing 2000 MW (half of potential 4,000 MW, which is assumed to be technically available) of Tehachapi wind generation on the bulk transmission system in Northern California. This study evaluated the summer peak conditions with north-to-south transfer over Path 26 and the summer off-peak conditions with south-to-north transfer over Path 15 and Path 26.

Study Conclusion

The study conclusion is summarized in the following Tables 2-1 through 2-5. This study confirms the findings of the earlier study that determined: 1) the additional 2,000 MW of import at Midway, under system peak conditions with the Path 26 flow in the North to South direction, is not expected to require upgrades in the PG&E system (see Table 2-1); and 2) there is no spare transmission capacity for additional power import at Midway under system off-peak conditions with the Path 26 flow in the South to North direction (see Tables 2-2 and 2-3).

Table 2-1
2010 Summer Peak Base Case

Descriptions	**Existing Transfer**	**Import 2,000 MW at Midway w/o Upgrade**
Path 66 Flow (north to south)	4,793	4,503
Path 15 Flow (north to south)	-29	-1,958
Path 26 Flow (north to south)	3,394	1,397
PDCI Flow (north to south)	3,104	3,104
PG&E Area Load plus Losses	28,358	28,390
PG&E Area Generation	26,910	25,239
Fresno/Yosemite Division Loads	2,923	2,923
Helms PSP Generation	1,218	1,218
Imports from Tehachapi Generation	0	2,000
Generation Reduction in the Bay Area	0	1,700

Table 2-2
2010 Summer Off-Peak Base Case

Descriptions	Existing Transfer	Import 2,000 MW at Midway w/o Upgrade
Path 66 Flow (south to north)	3,666	3,614
Path 15 Flow (south to north)	4,999	7,005
Path 26 Flow (south to north)	1,624	3,752
PDCI Flow (south to north)	1,845	1,845
PG&E Area Load plus Losses	13,430	13,620
PG&E Area Generation	15,478	13,487
Fresno/Yosemite Division Loads	1,409	1,409
Helms PSP Generation*	-600	-600
Imports from Tehachapi Generation	0	2,000
Gen Reduction in Bay Area	0	2,000

* Note: Positive values denote operation in the generating mode. Negative values denote operations in the pumping mode

Table 2-3
2010 Summer Off-peak Base Case without Contingency

Transmission Facilities	SN Rating	Existing Transfer		Import 2,000 MW at Midway w/o Upgrade	
	(Amps)	(Amps)	(%)	(Amps)	(%)

Gates - Midway #1 500 kV line	2230	2088	93.6	3299	***147.9***
Los Banos - Midway 500 kV line	2230	1805	80.9	2814	***126.2***
Los Banos - Gates #1 500kV line	2230	1605	72	2466	***110.6***
Los Banos - Gates #3 500kV line	4332	800	18.5	1216	28.1
Gates - Panoche #1 230kV line	742	491	66.1	765	***103.1***
Gates - Panoche #2 230kV line	742	491	66.1	765	***103.1***
McCall - Henrietta tap2 230kV line	825	781	94.6	941	***114.1***
Gates - Henrietta tap1 230kV line	1600	1376	86	1642	***102.6***
Gates - Midway 230kV line	742	617	83.2	826	***111.3***
Los Banos - Westley 230 kV line	1484	783	52.7	1296	87.3

Note: Potential problems in the 115 kV and 69 kV systems are not included.

Since Path 15 does not have spare capacity for transporting additional generation from Midway to the Bay Area under certain off-peak conditions, this study evaluated several alternatives and explored potential phasing development for importing 2,000 MW of Tehachapi wind generation into PG&E. The results are summarized in Tables 2-4 and 2-5 below:

Table 2-4
Study Conclusions for PG&E Alternative 2 (Figure A2.1)

Import Level	Plan "A" (100% at Switching Station #1)	Plan "B" (50% at Switching Station #1 and 50% at Switching Station #2)
300 MW	Build Switching Station #1 with a 300 MVA phase shifter **Other Reinforcement in PG&E Area:** • Upgrade Borden-Gregg 230kV line (peak).	N/A
600 MW	Same as 300MW import level, except, with one 600MVA phase shifter and building a new 230kV line between Switching Station #1 and Gregg. **Other Reinforcement in PG&E Area:** • Upgrade Borden-Gregg 230 kV line (peak) • Upgrade Storey 1 – Gregg 230kV line (peak)	Build Switching Station #1 and #2 with a 300 MVA phase shifter at each station. **Other Reinforcement in PG&E Area:** • Upgrade Hass-McCall and Balch-McCall 230 kV lines (peak & off-peak) • Upgrade Borden-Gregg 230kV line (peak)
1200MW (Peak)	Not feasible (Due to the maximum phase angle range of +/-45 degree)	Not feasible (Due to the maximum phase angle range of +/-45 degree)
1200MW (Off-peak)	Same as 600 MW import level, except, with two 600MVA phase shifters. **Other Reinforcement in PG&E Area:** • Install 450 MVAR of voltage support. • Restrict the import level to Helms operation at 600 MW or more of pumping.	Same as 600 MW import level, except, with a 600 MVA phase shifter at each station. **Other Reinforcement in PG&E Area:** • Upgrade Hass-McCall and Balch-McCall 230 kV lines. • Restrict the import level to Helms operation at 600 MW or more of pumping.

Table 2-5
Study Conclusion for PG&E Alternatives 1, 4 and 5

Import Level	PG&E Alternative 1	PG&E Alternative 4 (Figure A2.2)	PG&E Alternative 5 (Figure A2.3)
500MW	Network upgrade not determined (see discussion above)	**Phase 4A**: Build a new Los Banos-Midway 500kV line operated at 230kV. **Other Reinforcements in PG&E Area:** None	**Phase 5A:** Build a new Gregg-Midway 500kV line operated at 230kV. **Other Reinforcements in PG&E Area:** None
1100MW	**Network upgrade not determined** (see discussion above)	**Phase 4B:** Same as 4A, except, re-connecting the new line to 500kV and installing 65% series compensation. **Other Reinforcements in PG&E Area:** Upgrade Los Banos – Westley 230 kV line and Los Banos 500/230 kV bank	**Phase 5B:** Same as 5A, except, building Gregg 500kV Substation with a 500/230kV, 1122/1350 MVA bank and re-connecting the new line. **Other Reinforcements in PG&E Area:** None
2000MW	**Network upgrade not determined** (see discussion above)	**Phase 4C:** Same as 4B, except, also building Tesla – Los Banos 500 kV line. This Phase would increase the OTC from 5000 MW to 7000 MW. However, it may ***not*** be feasible to increase Path 15 Rating to 7,400 MW from the existing Rating of 5,400 MW[4] **Other Reinforcements in PG&E Area:**	**Phase 5C:** Same as 5C, except, installing series comp on Gregg -Midway line (31%), and Tesla-Gregg line (62%). **Other Reinforcements in PG&E Area:** None

[4] The Path 15 south-to-north flow was modeled at the Operating Transfer Capability (OTC) limit of 5000 MW in the pre project base case. This alternative would be able to import additional 2000 MW of generation at Midway by tripping 4319 MW of generation/pumps/load using the Remedial Action Scheme (RAS) for the simultaneous loss of Los Banos-Midway 500 kV and the new Los Banos-Midway 500 kV line in Phases 4A and 4B). The additional import would result in the Path 15 south-to-north flow at 7000 MW. However, unlike the findings in the previous study, this alternative would not be able to increase the Path 15 south-to-north Path Rating from 5400 MW to 7400 MW without increases in load shedding via RAS. Such increases may not be acceptable.

		Install additional RAS	

PG&E Area Transmission Alternatives

This study evaluated the following four transmission alternatives:

(1) PG&E Alternative 1 (Status Quo):

This Alternative investigates the possibility of installing no or minimum transmission upgrade and instead accommodating 2,000 MW of Tehachapi wind generation through curtailment of generation under normal conditions. Power flow study to date shows overloads, ranging from 3% to 48% over the ratings (or allowable limit) of eight transmission facilities under normal (all facilities in service) operating conditions (see Table 2-3). As a result, this alternative would expand the times and conditions under which curtailment of generation would be required. It could also require installation of Remedial Action Schemes (RAS) to trip additional generation immediately after a disturbance and/or reduction in existing Path 15 transfer capability.

If existing generation in areas around Midway Substation is curtailed to allow transfer of Tehachapi power, Path 15 south to north transfer capability will have to be reduced. This is because the existing Path 15 south-to-north transfer capability under normal conditions can only be supported with operation of the Remedial Action Scheme (RAS) immediately following identified outages. If Midway area generation that is connected to the existing RAS were dispatched off-line or kept at minimum generating levels (assuming that the FERC open access rules were somehow satisfied), there would be no effective way of reducing power flow on Path 15 immediately following a double line outage and before the operator can intervene. As a result, Path 15 would have to be operated under normal conditions at a reduced level. Study shows that curtailing all Midway area generation that can be curtailed (about 2,600 MW) would reduce Path 15 south to north transfer capability from 5,000 MW to about 3,600 MW. This would enable Path 26 to load to about 2,700 MW.

Connecting Tehachapi generation to the RAS to support Path 15 is neither effective nor is it practical even assuming installation of a new type of RAS controller and other equipment so it can predict the amount of wind generation available to trip if the outage occurs. For wind turbines to be part of generation RAS to replace the Midway generation RAS, the new RAS controller would need to also arm those generators that are on-line to provide regulation for the

Tehachapi wind generation to the extent they are connected to systems south of Midway. It is also less effective because of the system configuration, a larger amount of generation from Tehachapi generators and these "regulating" generators will need to be tripped to provide the same relief on Path 15. This will in turn require tripping a higher amount of load commensurate with the increased amount of generation tripped to keep the net amount of net generation to be tripped within the allowable limit. Such a RAS would also increase by many folds the complexity of the existing Path 15 RAS and increase the probability of RAS misoperation.

In addition, Compliance with FERC Open Access rules, and agreement from the CAISO, approval from WECC, among other requirements would also be needed.

(2) PG&E Alternative 2 (Figure A2.1):

PG&E Alternative 2 is to establish a new 230 kV connection between PG&E and SCE by constructing a switching station at the crossing of PG&E-owned and SCE-owned transmission lines and installing a phase-shifting transformer to "push" power from SCE's Big Creek corridor into the PG&E system. This study investigated impacts on the PG&E system, and the possible mitigation measures for the connection. This study evaluated "pushing" 300 MW, 600 MW, and 1,200 MW by the following two Plans:

Plan A (PG&E_Alt-2A):

Establish one 230 kV tie between PG&E and SCE. Build Switching Station #1 at the crossing of PG&E's Helms – Gregg 230 kV lines and SCE's Big Creek – Rector 230 kV lines. Install one phase shifter or power flow controller to control the tie line flow.

Plan B (PG&E_Alt-2B):

Same as Plan "A", except, also building Switching Station #2 at the crossing of PG&E's Haas-McCall and Balch-McCall 230 kV lines and SCE's Big Creek – Rector 230 kV lines. Install a phase shifter or power flow controller at both switching stations to control the tie line flow.

(3) PG&E Alternative 4 (Figure A2.2):

PG&E Alternative 4 is to build a new Tesla – Los Banos 500 kV line and a new Los Banos – Midway 500 kV line. This alternative could be implemented in the following three phases:

Phase A (PG&E_Alt-4A):

Build a new Los Banos – Midway 500kV line operated at 230 kV.

Phase B (PG&E_Alt-4B):

Same as 4A, except, re-connecting the new Los Banos – Midway line to 500kV bus and installing 65% series compensation.

Phase C (PG&E_Alt-4C):

Same as 4B, except, also building a new Tesla - Los Banos 500kV line without series compensation.

(4) PG&E Alternative 5 (Figure A2.3):

PG&E Alternative 5 is to build a new Tesla – Gregg 500 kV line and a new Gregg – Midway 500 kV line. This alternative could be implemented in the following three phases:

Phase A (PG&E_Alt-5A):

Build a new Gregg - Midway 500kV line operated at 230 kV.

Phase B (PG&E_Alt-5B):

Same as 5A, except, also building a Gregg 500 kV Substation with a 500/230 kV transformer bank and re-connecting the new Gregg - Midway 500kV line.

Phase C (PG&E_Alt-5C):

Same as 5B, except, also building a new Tesla - Gregg 500kV line with 62% series compensation and installing 31% series compensation on the Gregg – Midway 500 kV line.

Power Flow Base Case Assumptions

Post-transient power flow studies for 500 kV system were based on the 2010 summer peak and 2010 summer off-peak WECC full loop system base cases developed for PG&E's 2005 Electric Transmission Grid Expansion Plan Study (a05sum2010.sav and a05sumopk2010.sav). The summer peak system base cases model 1-in-5 year load forecasts for the Northern California Area.

Contingency power flow studies for 230, 115 and 70 kV system were based on the 2010 summer peak and 2010 summer off-peak area base cases (a05sum2010_pge_a6.sav, and a05sumopk2010_pge.sav). The summer peak area base cases model 1-in-10 year load forecasts for Area 6 that includes the Yosemite, Fresno and Kern Divisions.

Since this study is to evaluate the impact of importing 2000 MW (half of potential 4,000 MW) of Tehachapi wind generation on the bulk transmission system in Northern California, only the PG&E portion of the Tehachapi wind generation (up to 2000 MW) was modeled on line and scheduled to PG&E at Midway and SCE portion of the Tehachapi wind generation was modeled off line in the study base cases. This would not impact the results of studies on system performance north of Midway since SCE's portion, which, if on line, would be scheduled to SCE would therefore not flow to PG&E.

These study base cases were reviewed and approved by CAISO and other stakeholders. Table 2-6 summarized the PG&E area loads, generation, and the major path flow assumptions modeled in the 2010 summer peak and 2010 summer off-peak system base cases. The study assumptions used for this study differs somewhat from that used in PG&E's 2005 Electric Transmission Grid Expansion Plan studies because the assumptions developed in the Grid Expansion Plan studies are meant to be starting cases, from which modifications would be made to simulate case-specific system conditions. These system conditions are indicated in Table 2-6 below.

Table 2-6
Area Loads/Generation and Major Path Flow

	Descriptions	Summer Peak System Base Case	Summer Off-peak System Base Case
1	Path 66 Flow (north_to_south)	4800	-3670
2	Path 15 flow (north_to_south)	<500	-5000
3	Path 26flow (north_to_south)	3400	-1625
4	PDCI flow (north_to_south)	3100	-1848
5	PG&E Area Loads plus Losses	28441	13402
6	PG&E Area Generation	26294	14453
7	Fresno/Yosemite Division Loads	2923	1409
8	Helms Generation	1200[5]	-900[6]

* Note: Positive values denote operation in the generating mode. Negative values denote operations in the pumping mode

Power Flow Studies for Pre-Transmission Project Conditions

Power flow studies were conducted to evaluate the potential thermal violations before the transmission alternatives for importing Tehachapi wind generation. The power flow studies were based on the 2010 summer peak area base case modeling the three Helms units on line at 1200 MW of generation, and the 2010 summer off-peak area base case modeling the three Helms units off-line. It is important to note that PG&E's 2005 Electric Transmission Grid Expansion Plan studies only model 930 MW of Helms generation in the 2010 summer peak area base case. Therefore, this study shows additional thermal overloaded facilities that were not identified in the Expansion Plan studies. The study results were summarized in Table A3-3 of Attachment 3 for summer peak conditions and in Table A4-2 of Attachment 4 for summer off-peak conditions. The study results show emergency overloads on the following facilities:

(1) 2010 Summer Peak Conditions[7]

- Herndon 230/115kV Bank-1 and Bank-2.
- Atwater Jct-Cressey Jct 115kV line

[5] The Helms generation may be outside the current Fresno Area Generation Nomogram. See CAISO Operating Procedure T-129. Helms generation was modeled at 930 MW in PG&E's 2005 Electric Transmission Grid Expansion Plan studies base case for Fresno area.

[6] In order to simulate a reasonably stressed summer off-peak conditions, Helms units were modeled off line for PG&E_Alt-2 analyses, on-line at -600MW of pumping for PG&E_Alt-4 analyses, and on-line at -900MW of pumping for PG&E_Alt-5 analyses.

[7] Most of the emergency overloads were due to Helms generation operated outside Fresno Area Generation Nomogram.

- Herndon - Woodward 115kV line
- Merced-Atwater Jct 115kV line
- Wilson A-Merced 115kV line
- Wilson B-Merced 115kV line

(2) 2010 Summer Off-peak Conditions

- Helm-McCall 230kV line
- Henrietta-GWF_HEP 115kV line
- Henrietta-McCall 230kV line

Power Flow Studies Results for PG&E Alternative 2

Power flow studies for PG&E Alternative 2 were based on the 2010 summer peak base case modeling three Helms units on-line with a total of 1200 MW generation and the 2010 summer off-peak base case modeling three Helms units off-line.

(1) 2010 Summer Peak Conditions with Helms at 1200 MW of Generation

The power flow study results for 2010 summer peak conditions were summarized in Attachment 3.

(1.1) Import 300 MW with Plan "A"

This alternative would build the Switching Station #1 and import 300 MW of generation. The study results show that the Borden – Gregg 230 kV line could load up to 108.8% of summer normal rating of 675 amperes under the summer peak conditions studied. (See Table A3-1, Attachment 3.) The import would not cause emergency overload for "B" or "C" contingencies studied. The following transmission facilities would need upgrading:

- Borden – Gregg 230 kV line

(1.2) Import 600 MW with Plan "A"

This alternative would build the Switching Station #1 and import 600 MW of generation. The existing Helms – Gregg #1 and #2 230 kV lines do not have spare capacity for importing additional 600 MW under summer peak conditions with three Helms units on line at 1200 MW of generation. This study assumes that this alternative would also build an additional 230 kV line between the proposed Switching Station #1 and Gregg Substation.

The study results show that the Borden – Gregg 230 kV line could load up to 127.7% of summer normal rating of 675 amperes. (See Table A3-1, Attachment

3.) In addition, the import could also cause emergency overload on the Storey 1 – Gregg 230 kV line for loss of the Wilson – Storey 2 – Borden 230 kV line with Melones #1 offline (Category "B" contingency; G-1/L-1). (See Case F-B213, Table A3-3, Attachment 3.) The following transmission facilities would need upgrading:

- Borden – Gregg 230 kV line, and
- Storey 1 – Gregg 230 kV line.

The following transmission facilities would be needed:

- A new 230 kV line between Switching Station #1 and Gregg,

(1.3) Import 600 MW with Plan "B"

This alternative would build both Switching Station #1 and #2, and import 300 MW of generation at each stations (total 600 MW). The study results show that the import could cause normal overload on the Borden – Gregg 230 kV line. In addition, the import could also cause normal overloads on the Haas – McCall and Balch – McCall 230 kV lines between the proposed Switching Station #2 and Mc Call Substation while the hydro power houses on Kings River were dispatched at the maximum generation of 520 MW. (See Table A3-1 and 2, Attachment 3.) The following transmission facilities would need upgrading:

- Borden – Gregg 230 kV line, and
- Haas – McCall and Balch – McCall 230 kV lines between Switching Station #2 and McCall Substation.

.
(1.4) Import 1200 MW with Plan "A" or "B"

The power transfer capability of a phase shifter is determined by the MVA rating and the maximum phase angle range. This study assumes the maximum phase angle range of +/- 45 degree, which is the same as most phase-shifters in the WECC system. The study results show that, due to the phase angle limitation, this Alternative would only be able to transfer 600 MW from SCE's Big Creek system to PG&E's Fresno area under the summer peak conditions with all three Helms units dispatched online at 1200 MW of generation.

(2) Summer Off-peak Conditions with Helms off line

The power flow study results for 2010 summer off-peak conditions were summarized in Attachment 4.

(2.1) Import 600 MW with Plan "A" or "B"

The study results show that the existing transmission system has adequate capacity for importing 600 MW of generation with either Plan "A" or "B" under 2010 summer off-peak conditions studied. The import would not cause normal or emergency overloads. (See Attachment 4.)

(2.2) Import 1200 MW with Plan "A"

This alternative would build the Switching Station #1 and import 1200 MW of generation. The power flow studies results show that the voltage at Switching Station #1 230 kV bus could be as low as 217.8 kV (0.947 pu) under the 2010 summer off-peak conditions with all facilities in service. The study results also show that the Big Creek/Fresno area could experience voltage collapse following a Midway north 500 kV double-line outage[8]. This alternative would need a 150 MVAR of shunt capacitor bank at Switching Station #1 to improve steady state bus voltage and another 300 MVAR of switchable shunt capacitors to avoid voltage collapse following a Midway north 500 kV double-line outage.

The study results show that the import could cause normal overload on the Cottle B – Warnerville 230 kV line under summer off-peak conditions studied. (See Table A4-1, Attachment 4.) The import could also cause emergency overloads on the following lines (see Table A4-2, Attachment 4):

- Borden – Gregg 230kV line,
- Storey 2 – Borden 230 kV line,
- Storey 1 – Gregg 230 kV line, and
- Wilson – Storey 1 230 kV line. .

The study results also show that the Gates – Midway 500 kV line could load up to 3598 amperes (101.2% of 30-minute emergency rating of 3556A) following the Los Banos – Midway 500 kV single line outage. (See Case OPK-B3, Table A4-3, Attachment 4.) The Los Banos – Westley 230 kV line could also load up to 2276 amperes (113.8% of emergency rating of 2000A) for the Los Banos north 500 kV double-line outage[9]. (See Case OPK-C1, Table A4-4, Attachment 4.)

There is an operational solution for the above described normal and emergency overloads. The study results show that the import of 1200 MW would not cause normal or emergency overloads if two of the three Helms units were dispatched on line with 600 MW of pumping during summer off-peak conditions studied.

[8] Simultaneous loss of Midway – Gates 500 kV line and Midway – Los Banos 500 kV line
[9] Simultaneous loss of Tesla – Los Banos 500 kV line and Tracy – Los Banos 500 kV line

The study results show the following facilities would still be needed for voltage support:

- 450 MVAR of 230 kV shunt capacitor banks.

(2.3) Import 1200 MW with Plan "B"

This alternative would build both Switching Station #1 and #2, and import 600 MW of generation at each stations (total 1200 MW). The study results show that the import could cause normal overload on the Haas – McCall and Balch – McCall 230 kV lines between the Switching Station #2 and McCall Substation under summer off-peak conditions. (See Table A4-1, Attachment 4.)

The study results also show emergency overload on the Cattle B – Warnerville 230 kV line for the Pacific DC Intertie bipolar outage (Category "B" contingency). (See Case OPK-B5, Table A4-3, Attachment 4.) The Los Banos – Westley 230 kV lines could also experience emergency overload for the Los Banos north 500 kV double-line outage with 3360 MW of RAS (Category "C" contingency). (See Case OPK-C1, Table A4-4, Attachment 4.)

The study results also show that the import would not cause the emergency overloads if two of the three Helms units were dispatched on line with 600 MW of pumping during summer off-peak conditions studied. The following transmission facilities would still need upgrading:

- Haas – McCall and Balch – McCall 230 kV lines between Switching Station #2 and McCall Substation.

Power Flow Studies Results for PG&E Alternative 4

The power flow studies were based on the 2010 summer off-peak base case modeling two Helms units on line with a total of 600 MW pumping. The preliminary power flow study results for PG&E Alternative 4 are summarized in Attachment 5. The study results show that this alternative would have adverse impact on Helms pumping operation. This alternative would increase loading on the Gates – Gregg and Gates – McCall 230 kV lines that would results in emergency overloads following a PDCI bipolar outage (Category "B" contingency). See Case B7, Table A5-2, Attachment 5.

(1) Phase A (PG&E_Alt-4A): Import 500 MW

Phase A is to build a new Los Banos – Midway 500 kV line operated at 230 kV. This alternative would increase the existing Path 15 south-to-north transfer capability by about 500 MW. The most limiting facility is the Gates – Midway

500 kV line for the Los Banos – Midway 500 kV single line outage (Category "B" contingency). (See Case B3, Table A5-2, Attachment 5.)

(2) Phase B (PG&E_Alt-4B): Import 1100 MW

Phase B is same as Phase A, except, re-connecting the new Los Banos – Midway line to the 500 kV buses and operate at 500 kV and installing 65% of series compensation on the new 500 kV line. This alternative would increase the existing Path 15 south-to-north transfer capability by about 1100 MW.

The study results show that the Los Banos – Westley 230 kV line could load up to 105.3% of its short-term emergency rating of 2000 amperes and the Los Banos 500/230 kV transformer bank could also load up to 102.2% of its 1-hour emergency rating of 1050 MVA after loss of Tesla – Los Banos and Tracy – Los Banos 500 kV lines with 3369 MW of RAS under the 2010 summer off-peak conditions studied. (See Case C1, Table A5-3, Attachment 5.)

The Gates – Henrietta section of the Gates – Gregg 230 kV line could also load up to 101.5% of its emergency rating of 1600 amperes after the PDCI bipolar outage. Helms pumping operation could be decreased to relieve the emergency overload. (See Case B7 in Table A5-2, Attachment 5.) The following transmission facilities would need upgrading:

- Los Banos – Westley 230 kV line
- Los Banos 500/230 kV transformer bank

(3) Phase C (PG&E_Alt-4C): Import 2000 MW

Phase C is same as Phase B, except, also building a new Tesla – Los Banos 500 kV line without series compensation. This alternative would increase the existing Path 15 south-to-north transfer capability by 2000 MW up to about 7000 MW. The study results show that the Gates – Midway 500 kV line could load up to 98.7% of its short-term emergency rating of 3556 amperes after loss of the existing Los Banos – Midway #1 500 kV line and the new Los Banos – Midway #2 500 kV line (Category "C" contingency) with 4319 MW of load and resources tripped through Remedial Action Scheme (RAS) under the 2010 summer off-peak conditions studied. The RAS includes 2578 MW of generation at Midway, 691 MW of pumps and 1050 MW of loads. (See Case C3 in Table A5-3, Attachment 5.) The following reinforcements would be needed:

- Install additional RAS.

The Gates – Henrietta section of the Gates – Gregg 230 kV line could also load up to 102.2% of its emergency rating of 1600 amperes after the PDCI bipolar outage

(Category "B" contingency). Helms pumping operation could be decreased to relieve the emergency overload. (See Case B7 in Table A5-2, Attachment 5.)

Power Flow Studies Results for PG&E Alternative 5

The power flow studies were based on the 2010 summer off-peak base case modeling three Helms units on line with a total of 900 MW pumping. Attachment 6 summarizes the study results. This alternative would increase the Fresno area import capability and improve Helms pumping operation.

(1) Phase A (PG&E_Alt-5A): Import 500 MW

Phase A is to build a new Gregg – Midway 500 kV line operated at 230 kV. This alternative would increase the existing Path 15 south-to-north transfer capability by about 500 MW. The most limiting facility is the Gates – Midway 500 kV line for the Los Banos – Midway 500 kV single line contingency (Category "B" contingency). (See Case B3, Table A6-2, Attachment 6.)

(2) Phase B (PG&E_Alt-5B): Import 1100 MW

Phase B is same as Phase A, except, also building a new Gregg 500 kV Substation with a 500/230 kV 1122 MVA transformer bank and re-connecting the new Gregg - Midway 500kV line to the 500 kV buses to operate at 500 kV. This alternative would increase the existing Path 15 south-to-north transfer capability by about 1100 MW. The most limiting facility is the Gregg 500/230 kV transformer bank that could load up to 99.2% of its normal rating of 1122 MVA. (See Table A6-1, Attachment 6.) Gregg 500/230 kV transformer bank would also load up to 102.5% of its emergency rating of 1260 MVA for the Gates – Midway 500 kV single line outage (Category "B" contingency). The Gregg 500/230 kV transformer bank would need the normal and emergency ratings of at least 1122 and 1350 MVA, respectively.

In addition, the Panoche – Kearney, Warnerville – Wilson, and Gates – Gregg 230 kV lines would also load above their respective emergency ratings for loss of the new Gregg – Midway 500 kV line (Category "B" contingency). (See Cases B6 at Table A6-2, Attachment 6.) Helms pumping operation could be decreased to relieve the emergency overload.

(3) Phase C (PG&E_Alt-5C): Import 2000 MW

Phase C is same as Phase B, except, also building a new Tesla - Gregg 500kV line with 62% series compensation and installing 31% series compensation on the Gregg – Midway 500 kV line. This alternative would increase the existing Path 15 south-to-north transfer capability by about 2000 MW. The most limiting facility is the Gregg 500/230 kV transformer bank that could load up to 106.4% of its emergency rating of 1260 MVA for the Tesla – Gregg 500 kV single line outage

(Category "B" contingency). (See Case B5, Table A6-2, Attachment 6.) The Gregg 500/230 kV transformer bank would need to have a normal rating of 1122 MVA and a summer emergency rating of at least 1350 MVA.

Future Studies

Additional sensitivity studies of Helms units off line need to be conducted for PG&E Alternative 4 and 5. The sensitivity studies may discover additional restrictions on the import capability for each phase of the Alternative 4 and 5.

Transient stability studies and post-transient voltage studies also need to be conducted for PG&E alternatives 1, 2, 4 and 5.

Attachment list

1. Contingency List
2. One-line Diagrams
3. 2010 Summer Peak Power Flow Study Results for PG&E Alternative 2
4. 2010 Summer Off-peak Power Flow Study Results for PG&E Alternative 2
5. Preliminary Power Flow Study Results for PG&E Alternative 4
6. Preliminary Power Flow Study Results for PG&E Alternative 5

Attachment 1
Contingency List

500 kV Contingencies

The following "B" contingencies for 500kV lines were studied:

- Tesla – Los Banos 500 kV line outage,
- Los Banos – Midway 500 kV line outage,
- Los Banos – Gates #3 500 kV line outage,
- Gates – Midway 500 kV line outage,
- PDCI Bi-pole Outage.

The following "C" contingencies for 500 kV lines were studied:

- Tesla – Los Banos and Tracy – Los Banos 500 kV double line outage (Los Banos north),
- Los Banos – Midway and Los Banos – Gates #3 500 kV double line outage (Los Banos south),
- Los Banos – Midway and Gates – Midway 500 kV double line outage (Midway north),
- Two Palo Verde generation units outage,
- Two Diablo Canyon generation units outage.

230, 115 and 70 kV Contingencies:

Additional "B" and "C" contingencies for 230, 115 and 70 kV system in the Fresno/Yosemite area were also run. Attachment 3 lists the contingencies.

Attachment 2

Figure A2.1 - PG&E Alternative 2: Fresno 230 kV Tie

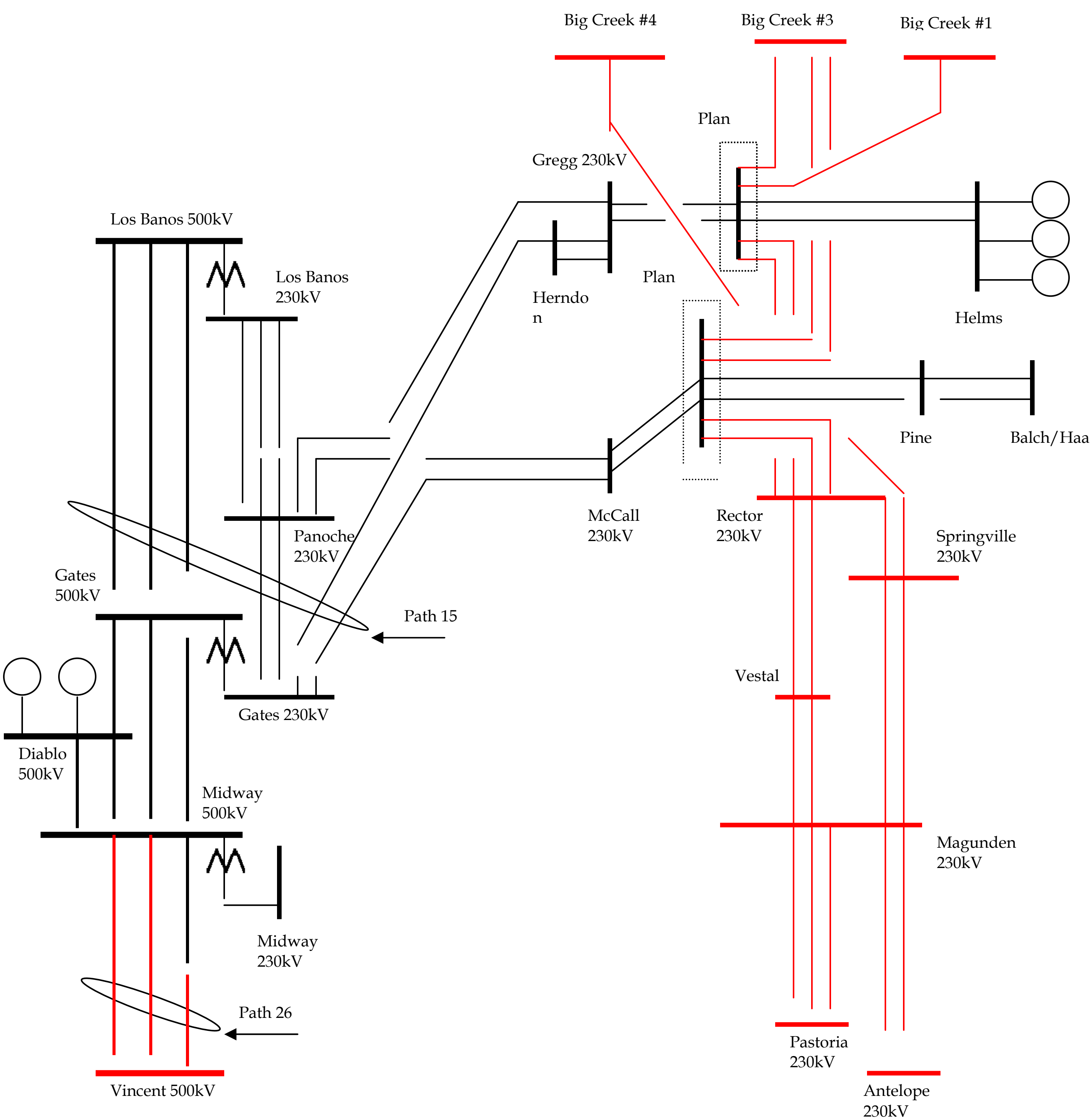


Figure A2.2 - PG&E Alternative 4: Tesla – Los Banos – Midway 500 kV line

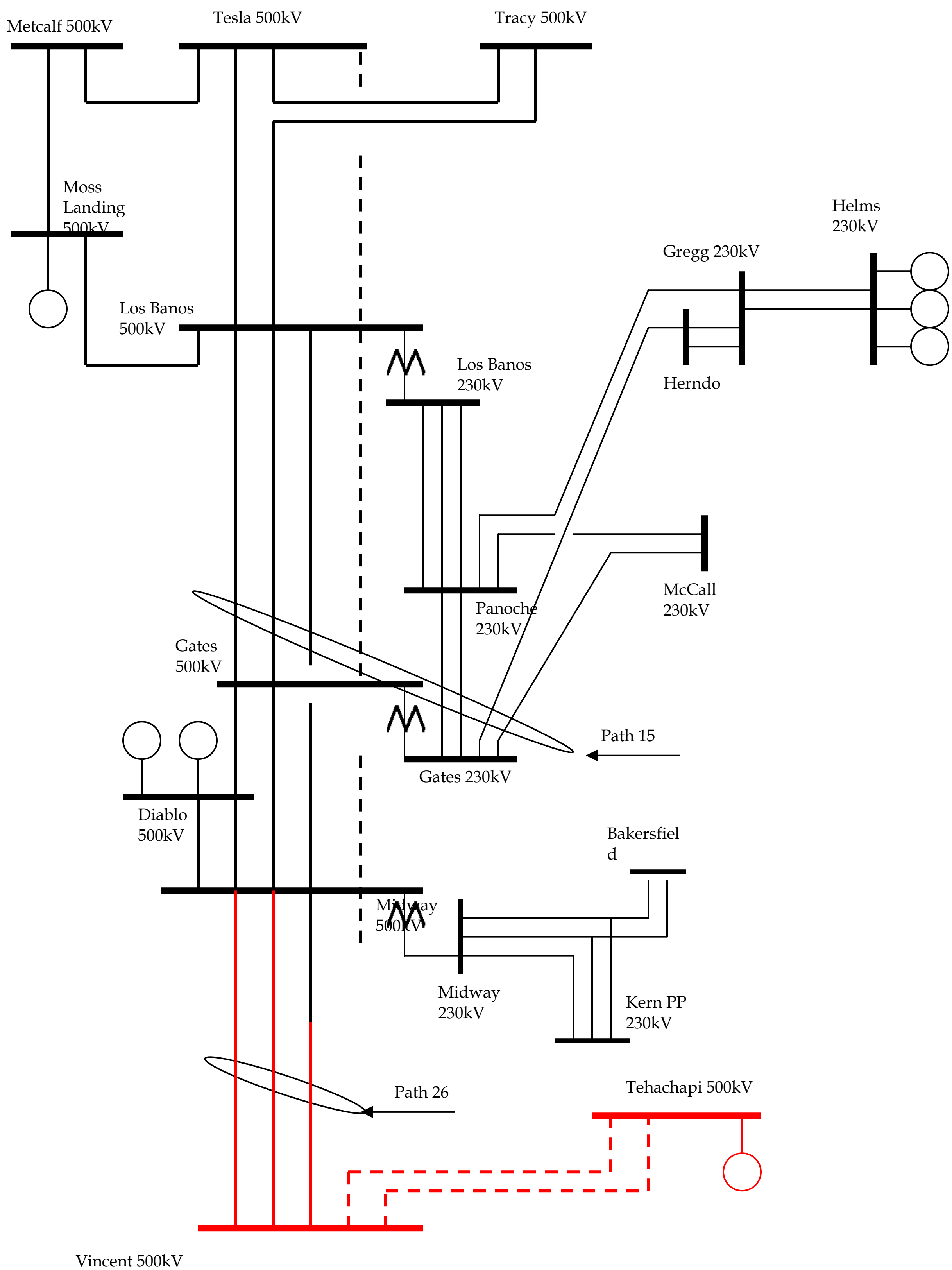
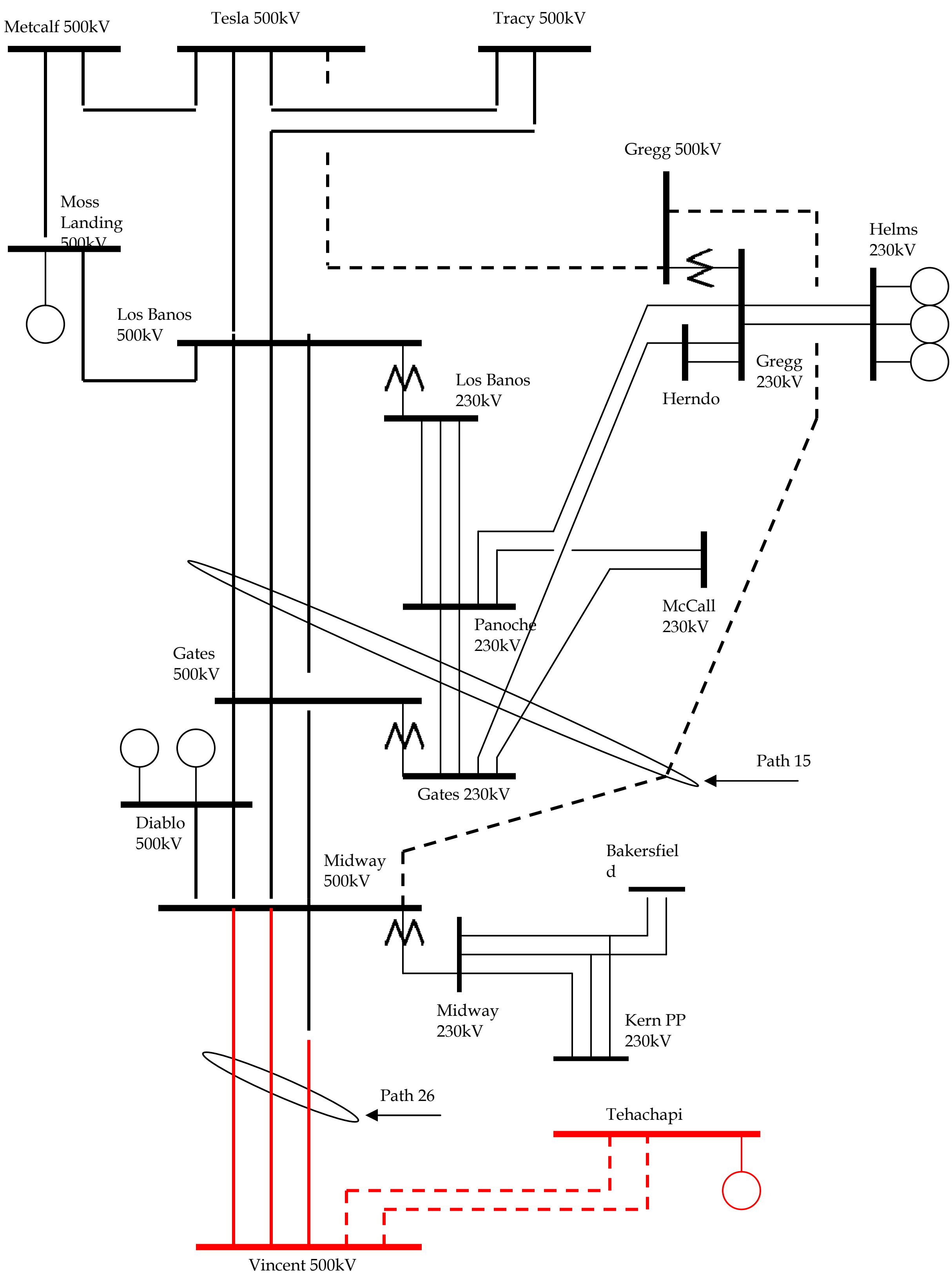


Figure A2.3 - PG&E Alternative 5: Tesla – Gregg – Midway 500 kV line



Attachment 3
Preliminary Power Flow Study Results for PG&E Alternative 2
(2010 Summer Peak conditions with Helms Generation = 1200 MW)

Table A3-1
Steady State Power Flow Study Results for PG&E Alternative 2
(2010 Summer Peak Conditions with Helms Generation = 1200 MW)

	Transmission Facilities		Base (sumpk_alt2.sav)		Alt 2A (pk_3g2a-300.sav)		Alt 2A (pk_alt2a-600.sav)		Alt 2B (pk_3g2b-600.sav)	
		SN Rating	Import = 0 MW		Import = 300 MW		Import=600MW		Import = 600 MW	
		(Amps)	(Amps)	(%)	(Amps)	(%)	(Amps)	(%)	(Amps)	(%)
1	GREGG-PGE_1_W #1 230KV LINE	1907.8	1502.4	78.8%	1879	98.5%	1512	79.3%	1889	99.0%
2	GREGG-PGE_1_W-1 #2 230KV LINE	1907.8	1502.4	78.8%	1879	98.5%	1512	79.3%	1889	99.0%
3	GREGG-PGE_1_W #3 230KV LINE (1)	1907.8	n/a	n/a	n/a	n/a	1512	79.3%	n/a	n/a
4	BORDEN - GREGG 230KV LINE	675.2	558.1	82.7%	734	**108.8%**	862	**127.7%**	779	**115.4%**
5	STOREY 1 - GREGG 230KV LINE	675.2	302.3	44.8%	n/a	<95%	673	99.6%	n/a	<95%
8	HERNDON - CHLDHOSP 115KV LINE	823.4	692.0	84.0%	n/a	<95%	n/a	<95%	n/a	<95%
9	WOODWARD - CHLDHOSP 115KV LINE	823.4	673.8	81.8%	n/a	<95%	n/a	<95%	n/a	<95%
10	MC CALL-PGE_2_W #1 230KV LINE	753.1	378.7	50.3%	n/a	<95%	n/a	<95%	740	98.2%
11	MC CALL-PGE_2_W #2 230KV LINE	753.1	378.7	50.3%	n/a	<95%	n/a	<95%	740	98.2%

(1) A new Gregg – PGE_1_W #3 230 kV line was modeled in the base case to avoid an 18.7% normal overload for Alt. 2A importing 600MW.
(2) This study assumes +/-45 degree is the maximum phase angle range for the phase shifters installed at the Fresno Switching Station that would be able to import about 600 MW from SCE to PG&E under summer peak conditions studied.

Table A3-2
Steady State Power Flow Study Results for PG&E Alternative 2
Sensitivity Study for Kings River Generation at Pmax = 520 MW
(2010 Summer Peak Conditions with Helms Generation = 1200 MW)

	Transmission Facilities	SN Rating	Base (pk_3g2b-0_kings.sav)		Alt 2B (pk_3g2b-600_kings.sav)	
			Import = 0 MW		Import = 600 MW	
	MC CALL - PGE_2_W #1 230KV LINE	753	540	71.6%	913	**121.2%**
	MC CALL - PGE_2_W #2 230KV LINE	753	540	71.6%	913	**121.2%**

Table A3-3
230 and 115 kV Contingencies for PG&E Alternative 2
(2010 Summer Peak Conditions with Helms Generation = 1200 MW)

Case #	Overloaded Transmission Facilities	Worst "B" and "C" Contingency	SE Rating	Base (sumpk_alt 2.sav)	Alt 2A (pk_3g2a-300.sav)	Alt 2A (pk_3g2a-600.sav)	Alt 2B (pk_3g2b-600.sav)
				Impor t= 0MW	Impor t= 300MW	Impor t= 600MW	Impor t= 600MW
			(Amps)	(%)	(%)	(%)	(%)
F-B214	Borden - Gregg 230kV line	Melones #1; Wilson - Storey 1 - Gregg 230kV line	793.2	<95%	<95%	**108.9%**	<95%
F-B61	Corcoran 115/70KV BK-2 (MVA)	Guernsey - Henrietta 70kV line	33.8	120.4%	120.4%	120.4%	120.4%
F-B151	Henrietta - Jacob Corner 70kV line	GWF- Hanford (lose 23 MW)	346.4	107.9%	108.0%	107.7%	107.9%
F-B123	Herndon - Woodward 115kV line	Kerckhoff #2 PH (lose 129 MW)	823.4	105.0%	110.1%	117.7%	100.3%
F-B112	Herndon 230/115kV Bk-1	Herndon 230/115kV Bk-2	462	108.8%	117.0%	128.6%	103.1%
F-B111	Herndon 230/115kV Bk-2	Herndon 230/115kV Bk-1	463.7	108.6%	116.0%	128.2%	102.4%
F-B138	McCall - Wahtoke 115kV line	Kings River PH (lose 47 MW)	492	100.6%	<95%	<95%	102.9%
F-B36	McCall - Wahtoke 115kV line	Kings River - Sanger - Reedley 115kV line	562.3	106.0%	104.2%	101.2%	107.5%
F-B106	McCall 230/115 kV Bk-1 (MVA)	McCall 230/115 kV Bk-2	133	108.3%	103.8%	97.0%	114.1%
F-B213	Storey 1 - Gregg 230kV line	Melones #1; Wilson - Storey 2 - Borden 230kV line	793.2	<95%	<95%	**105.8%**	<95%
Y-C1	Atwater Jct-Cressey Jct 115kV line	Wilson-Atwater and El Capitan-Wilson 115kV Lines	512	166.3%	166.7%	165.4%	167.0%
F-C20	Borden - Gregg 230kV line	Herndon-Kearney and Herndon-Ashlan 230kV lines	793.2	<95%	<95%	**111.9%**	<95%
F-C19	Gregg-Ashlan 230kV line	Gregg-Herndon #1 and #2 230kV lines	850	182.0%	209.3%	233.0%	195.6%
F-C3	Herndon - Woodward 115kV line	Herndon-Barton and Herndon-Manchester 115kV lines	974	106.6%	116.9%	129.9%	<95%
F-C19	Herndon-Ashlan 230kV line	Gregg-Herndon #1 and #2 230kV lines	850	115.3%	141.3%	167.1%	127.9%
F-C6	Le Grand-Chowchilla 115kV line	Kerckhoff-Clovis-Sanger #1 and #2 115kV lines	396.6	110.9%	<95%	<95%	<95%
F-C8	McCall-Wahtoke 115kV line	Kings R-Sanger-Reedley and Balch-Sanger 115kV lines	562.3	106.3%	104.6%	101.5%	107.8%
Y-C1	Merced-Atwater Jct 115kV line	Wilson-Atwater and El Capitan-Wilson 115kV Lines	738	138.2%	138.6%	137.5%	138.8%
Y-C1	Wilson A-Merced 115kV line	Wilson-Atwater and El Capitan-Wilson 115kV Lines	471.9	137.2%	137.0%	122.7%	137.0%
Y-C1	Wilson B-Merced 115kV line	Wilson-Atwater and El Capitan-Wilson 115kV Lines	471.9	124.0%	123.5%	136.2%	123.4%

Notes:

1. Case # F-B61 should be modified to reflect that Guernsey – Henrietta 70 kV line will not close circuit breaker No. 52 follow this outage. As a result, the Corcoran 115/70 kV transformer loading should reduce to within its ratings for the base alternative.

2. Case # F-B151 should use the emergency rating of the Henrietta – Jacobs Corner 70 kV line, which is 395 Amps. As a result, the Henrietta – Jacobs Corner 70 kV line will not overload for the base alternative.

3. Case # F-B123 should use the emergency rating of the Herndon – Woodward 115 kV line, which is 974 Amps. As a result, the Herndon – Woodward 115 kV line will not overload for the base alternative.

4. Cases #F-B138, F-B36 and F-C8, the Mc Call-Wahtoke 115 kV line is comprised of 1113 AAC with (SN/SE) 825/975 amps. As a result, the Mc Call-Wahtoke 115 kV line is not projected to overload for the base alternative.

5. Case #F-B106, Mc Call 230/115 kV Transformer No. 2 was re-rated for 150 MVA emergency. Therefore, Mc Call 230/115 kV Transformer No. 2 is not expected to overload for the base alternative.

6. Case #F-C19 and C6, there are existing SPS' that are in place to mitigate thermal overloads on the identified transmission lines.

Table A3-4
500 kV Contingencies for PG&E Alternative 2
(2010 Summer Peak Conditions with Helms Generation = 1200 MW)

					Base (pk_alt2-0.sav)		Alt 2A (pk_alt2a-300.sav)		Alt 2A (pk_alt2a-600.sav)		Alt 2B (pk_alt2b-600.sav)	
							IMPORT = 300 MW		IMPORT = 600 MW		IMPORT = 600 MW	
	Outages Facilities	Overloaded Facilities	RAS	SE Rating	post-outag Flow		post-outag Flow		post-outag Flow		post-outag Flow	
	Single Contingency (Category "B")		(MW)	(A)	(A)	(%)	(A)	(%)	(A)	(%)	(A)	(%)
PK-B1	Tesla-Los Banos 500kV line	Borden-Gregg 230kV line	none	793	612	77.2%	733	92.5%	868	**109.4%**	785	**99.0%**
PK-B2	Los Banos-Gates #3 500kV line	Borden-Gregg 230kV line	none	793	613	77.3%	733	92.4%	865	**109.0%**	782	98.6%
PK-B3	Los Banos-Midway 500kV Line	Borden-Gregg 230kV line	none	793	608	76.6%	725	91.4%	857	**108.1%**	775	97.7%
PK-B4	Gates-Midway #1 500kV Line	Borden-Gregg 230kV line	none	793	614	77.5%	725	91.5%	856	**107.9%**	775	97.8%
PK-B5	PDCI Bipole	Borden-Gregg 230kV line	none	793	533	67.2%	610	76.9%	735	92.7%	665	83.9%
	Double contingency (Category "C")											
PK-C1	Tesla-Los Banos, Tracy-Los Banos 500kV lines	Borden-Gregg 230kV line	none	793	608	76.6%	735	92.6%	877	**110.6%**	795	**100.3%**
PK-C2	Los Banos-Gates #3, Los Banos-Midway #1 500kV lines	Borden-Gregg 230kV line	none	793	607	76.5%	725	91.4%	859	**108.3%**	777	98.0%
PK-C3	Gates-Midway, Los Banos-Midway 500kV lines	Borden-Gregg 230kV line	none	793	611	77.0%	713	89.9%	845	**106.6%**	768	96.8%
PK-C4	Diablo Canyon G-2	Borden-Gregg 230kV line	none	793	549	69.3%	665	83.8%	794	**100.1%**	711	89.7%
PK-C5	Palo Verde G-2	Borden-Gregg 230kV line	none	793	550	69.4%	647	81.6%	777	98.0%	700	88.3%

Attachment 4
Preliminary Power Flow Study Results for PG&E Alternative 2
(2010 Summer Off-Peak Conditions with Helms off-line)

Table A4-1
Steady State Power Flow Study Results for PG&E Alternative 2
(2010 Summer Off-peak Conditions with Helms Offline)

	Transmission Facilities	SN Rating	Base (sumopk_r2.sav)		Alt 2A (opk_alt2a-600.sav)		Alt 2A (opk_alt2a-1200.sav)		Alt 2B (opk_alt2b-600.sav)		Alt 2B (opk_0p2b-1200.sav)	
			Import = 0 MW		Import = 600 MW		Import = 1200 MW		Import = 600 MW		Import = 1200 MW	
		(Amps)	(Amps)	(%)	(Amps)	(%)	(Amps)	(%)	(Amps)	(%)	(Amps)	(%)
1	WARNERVL - COTTLE B 230KV LINE	675.2	290.6	43.0%	473	70.1%	692	**102.5%**	432	63.9%	611	90.5%
2	BELLOTA - COTTLE B 230KV LINE	675.2	261.2	38.7%	444	65.7%	661	98.0%	403	59.6%	581	86.1%
3	McCall-PGE_2_W #1 230kV line	753.1	27.4	3.6%	n/a	<95%	n/a	<95%	403	53.5%	770	**102.2%**
4	McCall-PGE_2_W #1 230kV line	753.1	27.4	3.6%	n/a	<95%	n/a	<95%	403	53.5%	770	**102.2%**

Table A4-2
230 and 115 kV Contingencies for PG&E Alternative 2
(2010 Summer Off-Peak Conditions with Helms Offline)

Case #	Overloaded Transmission Facilities	Worst Contingency	SE Rating	Base (opk_op2a -0.sav)	Alt 2A (opk_0p2a -300.sav)	Alt 2A (opk_0p2a -600.sav)	Alt 2A (opk_0p2a -1200.sav)	Alt 2B (opk_0p2b -600.sav)	Alt 2B (opk_0p2b -1200.sav)
					Import = 300MW	Import = 600MW	Import = 1200MW	Import = 600MW	Import = 1200MW
			(Amps)	(%)	(%)	(%)	(%)	(%)	(%)
F-B207	Borden - Gregg 230kV line	Exchequer PH; Wilson - Storey 1 - Gregg 230kV line	793.2	<95%	<95%	<95%	**121.7%**	<95%	<95%
F-B146	Borden - Gregg 230kV line	Friant PP (22.5 MW)	675.3 (1)	<95%	<95%	<95%	**101.3%**	<95%	<95%
F-B100	Gates – Midway 230kV line	Gates 500/230kV bank	1390	<95%	<95%	<95%	<95%	<95%	<95%
F-B6	Storey 1 – Gregg 230kV line	Borden – Gregg 230kV line	793.2	<95%	<95%	<95%	**119.9%**	<95%	<95%
F-B207	Storey 2 – Borden 230kV line	Exchequer PH; Wilson – Storey 1 – Gregg 230kV line	793.2	<95%	<95%	<95%	**102.9%**	<95%	<95%
F-B6	Wilson – Storey 1 230kV line	Borden – Gregg 230kV line	851	<95%	<95%	<95%	**106.9%**	<95%	<95%
F-C12	Helm-McCall 230kV line	Gates-Gregg and Gates-McCall 230kV lines	850	**106.3%**	<95%	<95%	**138.7%**	<95%	<95%
F-C16	Henrietta-GWF_HEP 115kV line	Gates-McCall and Helm-McCall 230kV lines	743	**105.0%**	<95%	<95%	<95%	<95%	<95%
F-C13	Henrietta-McCall 230kV line	Gates-Gregg and Panoche-Kearney 230kV lines	975	**107.9%**	<95%	<95%	<95%	<95%	<95%

(1) Summer normal rating for G-1 contingency.

Table A4-3
500 kV "B" Contingencies for PG&E Alternative 2
(2010 Summer Off-Peak Conditions with Helms Offline)

					Base (sumopk_r2.sav)		Alt 2A (opk_alt2a-600.sav)		Alt 2A (opk_alt2a-00.sav)		Alt 2B (opk_alt2b-600.sav)		Alt 2B (opk_alt2b-200.sav)	
							Import=600 MW		Import =1200 MW		Import=600 MW		Import =1200 MW	
					Post-outage Flow		Post-outage Flow		Post-outage Flow		Post-outage Flow		Post-outage Flow	
	Outages Facilities	Overloaded Facilities	RAS (MW)	SE (A)	(A)	(%)	(A)	(%)	(A)	(%)	(A)	(%)	(A)	(%)
OPK-B1	Tesla-Los Banos 500kV line	Cottle B-Warnerville 230kV line	none	793	395	49.8%	596	75.2%	819	**103.2%**	555	69.9%	745	94.0%
OPK-B2	Los Banos-Gates #3 500kV line	Warnervill-Wilson 230kV line	none	793	n/a	<95%	119	15.0%	447	56.3%	70	8.8%	309	39.0%
OPK-B3	Los Banos-Midway 500kV Line	Gates-Midway 500kV Line	none	3556	3489	98.1%	3504	98.5%	3598	**101.2%**	3493	98.2%	3543	**99.6%**
OPK-B3	Los Banos-Midway 500kV Line	Gates-Midway 230kV line	none	1390	736	52.9%	684	49.2%	653	47.0%	676	48.6%	627	45.1%
OPK-B3	Los Banos-Midway 500kV Line	Arco-Midway 230kV line	none	1390	668	48.1%	627	45.1%	602	43.3%	619	44.5%	580	41.7%
OPK-B4	Gates-Midway #1 500kV Line	Los Banos-Midway 500kV Line	none	3556	2922	82.2%	2948	82.9%	3058	86.0%	2940	82.7%	3021	85.0%
OPK-B4	Gates-Midway #1 500kV Line	Gates-Midway 230kV line	none	1390	886	63.7%	819	58.9%	785	56.4%	807	58.1%	751	54.0%
OPK-B4	Gates-Midway #1 500kV Line	Arco-Midway 230kV line	none	1390	791	56.9%	737	53.0%	709	51.0%	726	52.3%	681	49.0%
OPK-B5	PDCI Bipole	Cottle B-Warnerville 230kV line	none	793	431	54.4%	675	85.1%	875	**110.4%**	630	79.4%	815	**102.8%**
OPK-B5	PDCI Bipole	Borden-Gregg 230kV line	none	793	220	27.7%	547	69.0%	836	**105.4%**	452	57.0%	637	80.3%
OPK-B5	PDCI Bipole	Storey 1-Gregg 230kV line	none	793	166	21.0%	490	61.8%	800	**100.9%**	403	50.8%	614	77.4%

Table A4-4
500 kV "C" Contingencies for PG&E Alternative 2
(2010 Summer Off-Peak Conditions with Helms Offline)

					Base (sumopk_r2.sav)		Alt 2A (opk_alt2a-00.sav)		Alt 2A (opk_alt2a-00.sav)		Alt 2B (opk_alt2b600.sav)		Alt 2B (opk_alt2b-00.sav)	
							Import=600 MW		Import =1200 MW		Import=600 MW		Import =1200 MW	
					Post-outage Flow		Post-outage Flow		Post-outage Flow		Post-outage Flow		Post-outage Flow	
	Outages Facilities	Overloaded Facilities	RAS (MW)	SE (A)	(A)	(%)	(A)	(%)	(A)	(A)	(%)	(A)	(%)	(A)
OPK -C1	TSL-LSB, TCY-LSB 500kV line	Cottle B-Warnerville 230kV line	3369	793	384	48.4%	585	73.8%	834	**105.2%**	545	68.8%	761	96.0%
OPK -C1	TSL-LSB, TCY-LSB 500kV line	Los Banos-Panoche #1 230kV line	3369	825	75	9.1%	34	4.2%	121	14.7%	50	6.1%	144	17.5%
OPK -C1	TSL-LSB, TCY-LSB 500kV line	Los Banos-Panoche #2 230kV line	3369	742	71	9.6%	34	4.6%	112	15.1%	48	6.5%	134	18.0%
OPK -C1	TSL-LSB, TCY-LSB 500kV line	Los Banos-Panoche #3 230kV line	3369	742	72	9.7%	33	4.5%	114	15.3%	48	6.5%	136	18.3%
OPK -C1	TSL-LSB, TCY-LSB 500kV line	Los Banos-Westley 230kV line	3369	2000	1731	86.6%	1926	96.3%	2276	**113.8%**	1970	98.5%	2345	**117.3%**
OPK -C1	TSL-LSB, TCY-LSB 500kV line	Los Banos 500/230kV bk	3369	1050	749	71.3%	719	68.5%	718	68.4%	722	68.8%	722	68.8%
OPK -C2	LSB-GTS #3, LSB-MDY #1 500kV lines	Los Banos-Gates #1 500kV line	1832	3556	3068	86.3%	3264	91.8%	3531	99.3%	3277	92.2%	3547	99.7%
OPK -C3	GTS-MDW, LSB-MDW #1 500kV lines	Gates-Midway 230kV line	2057	1390	1329	95.6%	1176	84.6%	1195	86.0%	1144	82.3%	1107	79.7%
OPK -C3	GTS-MDW, LSB-MDW #1 500kV lines	Arco-Midway 230kV line	2057	1390	1157	83.2%	1031	74.2%	1048	75.4%	1003	72.2%	975	70.2%
OPK -C4	Diablo Canyon G-2	None	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
OPK -C5	Palo Verde G-2	None	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Attachment 5
Preliminary Power flow Study Results for PG&E Alternative 4

Table A5-1
Steady State Power Flow Study Results for PGE Alternative 4
(2010 Summer Off-Peak Conditions with Helms = -600 MW)

	Transmission Facilities	SN Rating (1)	Base (sumopk_r1_2p.sav)		Alt 4A (opk_alt4c-500.sav)		Alt 4B (opk_alt4a-1100.sav)		Alt 4C (opk_alt4b-2k.sav)	
			Import = 0 MW		Import=500MW		Import=1100MW		Import=2000MW	
		(Amp)	(Amp)	(%)	(Amp)	(%)	(Amp)	(%)	(Amp)	(%)
1	Gates - Midway #1 500 kV line	2230	2088	93.6%	2197	**98.5%**	1844	82.7%	**2173**	**97.4%**
2	Los Banos - Midway #1 500 kV line	2230	1805	80.9%	1895	85.0%	1561	70.0%	1858	83.3%
3	Los Banos - Gates #1 500kV line	2230	1605	72.0%	1678	75.2%	1370	61.4%	1631	73.1%
4	Los Banos-Gates #3 500kV line	4332	800	18.5%	832	19.2%	690	15.9%	811	18.7%
5	Panoche-McMulln1 230kV line	825	785	95.2%	797	96.6%	816	98.9%	792	96.0%
6	McMulln1 - Kearney 230kV line	825	765	92.8%	779	94.4%	795	96.4%	771	93.4%
7	McCall - Hentap2 230kV line (1)	825	780	94.6%	777	94.2%	808	97.9%	**822**	**99.6%**
8	Los Banos - Westley 230 kV line	1484	784	52.8%	1001	67.4%	1056	71.1%	895	60.3%
9	Tesla-Los Banos #2 500kV line (new)	2230	n/a	n/a	n/a	n/a	n/a	n/a	1563	70.1%
10	LosBanos-Midway #2 500kV line (new)	2230	n/a	n/a	n/a	n/a	1802	80.8%	2134	95.7%
11	LosBanos-Midway #2 500kV line operate at 230kV (new)	2230	n/a	n/a	1723	69.5%	n/a	n/a	n/a	n/a

(1) The SN ratings are in ampere for line and MVA for transformer.

Table A5-2
500 kV Category "B" Contingencies for PG&E Alternative 4
(2010 Summer Off-Peak Conditions with Helms = -600MW)

				Base		Alt 4A		Alt 4B		Alt 4C	
				Import = 0 MW		Import=500MW		Import=1100MW		Import=2000MW	
	Outages Facilities	Overloaded Facilities	SE Rating (A)	post-outag Flow (A)	post-outag Flow (%)	post-outag Flow (A)	post-outag Flow (%)	post-outag Flow (A)	post-outag Flow (%)	post-outag Flow (A)	post-outag Flow (%)
B1	Tesla-Los Banos 500kV line	Gates-Henrietta Tap1 230kV line	1600	n/a	<95%	n/a	<95%	1564	97.7%	n/a	<95%
B2	Los Banos-Gates #3 500kV line	Gates-Henrietta Tap1 230kV line	1600	n/a	<95%	n/a	<95%	n/a	<95%	n/a	<95%
B2	Los Banos-Gates #3 500kV line	Los Banos-Midway #2 500kV Line operate at 230 kV (new)	3556	n/a	n/a	1718	48.3%	n/a	n/a	n/a	n/a
B3	Los Banos-Midway 500kV Line	Gates-Midway 500kV Line	3556	3433	96.5%	3556	**100%**	n/a	<95%	n/a	<95%
B3	Los Banos-Midway 500kV Line	Gates-Henrietta Tap1 230kV line	1600	n/a	<95%	n/a	<95%	n/a	<95%	1530	95.7%
B3	Los Banos-Midway 500kV Line	Los Banos-Midway #2 500kV Line operate at 230 kV (new)	3556	n/a	n/a	1713	48.2%	n/a	n/a	n/a	n/a
B3	Los Banos-Midway 500kV Line	Los Banos-Midway #2 500kV Line (new)	3556	n/a	n/a	n/a	n/a	n/a	<95%	n/a	n/a
B4	Gates-Midway #1 500kV Line	Los Banos-Midway 500kV Line	3556	2847	80.1%	n/a	<95%	n/a	<95%	n/a	<95%
B4	Gates-Midway #1 500kV Line	Los Banos-Midway #2 500kV Line operate at 230 kV (new)	3556	n/a	n/a	1717	48.3%	n/a	n/a	n/a	n/a
B4	Gates-Midway #1 500kV Line	Los Banos-Midway #2 500kV Line (new)	3556	n/a	n/a	n/a	n/a	n/a	<95%	n/a	<95%
B7	PDCI Bipole	Gates-Henrietta Tap1 230kV line	1600	1573	98.3%	1575	98.4%	1624	**101.5%**	**1635**	**102.2%**

Table A5-3
500 kV Category "C" Contingencies for PG&E Alternative 4
(2010 Summer Off-Peak Conditions with Helms = -600 MW)

				Base			Alt 4A			Alt 4B			Alt 4C		
				Import = 0 MW			Import=500MW			Import=1100MW			Import=2000MW		
	Outages Facilities	Overloaded Facilities	SE (A)	post-outage Flow (A)	post-outage Flow (%)	RAS (MW)				post-outage Flow (A)	post-outage Flow (%)	RAS (MW)	post-outage Flow (A)	post-outage Flow (%)	RAS (MW)
C1	Tesla-Los Banos, Tracy-Los Banos 500kV lines	Los Banos-Westley 230kV line	2000	1378	68.9%	3369	1671	83.6%	3368	2106	**105.3 % (1)**	3369	n/a	<95%	1985
C1	Tesla-Los Banos, Tracy-Los Banos 500kV lines	Los Banos 500/230kV xfr bank	1050	n/a	n/a	3369	989	94.2%	3368	1073	**102.2 % (1)**	3369	n/a	<95%	1985
C2	Los Banos-Gates #3, Los Banos-Midway #1 500kV lines	Los Banos-Gates #1 500kV line	3556	3324	93.5%	1532	3458	**97.3%**	1532	2255	63.4%	1532	n/a	<95%	1532
C3	Los Banos-Midway #1 and #2 500kV lines (Alt 4)	Gates-Midway 500kV line	3556	n/a	n/a	2648	n/a	n/a	n/a	3362	94.5%	2648	3511	**98.7%**	**4319 (2)**
C3	Los Banos-Midway #1 and #2 500kV lines (new)	Los Banos-Gates #1 500kV line	3556	n/a	n/a	2648	n/a	n/a	n/a	n/a	<95%	2648	2758	77.6%	**4319 (2)**
C4	Gates-Midway, Los Banos-Midway 500kV lines	Gates-Midway 230kV line	1390	1216	87.5%	2648	1208	86.9%	2648	707	50.9%	2648	817	58.8%	2984
C4	Gates-Midway, Los Banos-Midway 500kV lines	Los Banos-Midway #2 500kV Line (new)	3556	n/a	n/a	2648	n/a	n/a	2648	2917	82.0%	2648	3519	**99.0%**	2984
C5	Palo Verde G-2	none	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
C6	Diablo Canyon G-2	none	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

(1) Upgrade the Los Banos 500/230 kV transformer bank and the Los Banos – Westley 230 kV lines to relieve the emergency overloads.
(2) The RAS includes 2578 MW of generation, 691 MW of pumps and 1050 MW of loads. The net generation drop is 837 MW.

Attachment 6
Preliminary Power flow Study Results for PG&E Alternative 5

Table A6-1
Steady State Power Flow Study Results for PGE Alternative 5
(2010 Summer Off-Peak Conditions with Helms = -900MW)

	Transmission Facilities	SN Rating (1)	Base (sumopk_r1_2p.sav)		Alt 5A (opk_alt5a-500.sav)		Alt 5B1 (opk_alt5b1-1100.sav)		Alt 5C1 (opk_alt5c1-2k.sav)	
			Import = 0 MW Helms=-600MW		Import=500MW		Import=1100MW		Import=2000MW	
		(Amp)	(Amp)	(%)	(Amp)	(%)	(Amp)	(%)	(Amp)	(%)
1	Gates - Midway #1 500 kV line	2230	2088	93.6%	**2124**	**95.3%**	2085	93.5%	2152	96.5%
2	Los Banos - Midway #1 500 kV line	2230	1805	80.9%	1838	82.4%	1907	85.5%	1943	87.1%
3	Los Banos - Gates #1 500kV line	2230	1605	72.0%	1637	73.4%	1767	79.2%	1781	79.8%
4	Los Banos-Gates #3 500kV line	4332	800	18.5%	816	18.8%	879	20.3%	884	20.4%
5	Panoche-McMulln1 230kV line	825	785	95.2%	701	85.0%	350	42.4%	369	44.7%
6	McMulln1 - Kearney 230kV line	825	765	92.8%	680	82.4%	331	40.2%	347	42.1%
7	McCall - Hentap2 230kV line	825	780	94.6%	746	90.4%	609	73.8%	652	79.1%
8	Los Banos - Westley 230 kV line	1484	784	52.8%	806	54.3%	1036	69.8%	984	66.3%
11	Tesla-Gregg 500kV line (new)	2230	n/a	n/a	n/a	n/a	n/a	n/a	1042	46.7%
12	Gregg-Midway 500kV line (new)	2230	n/a	n/a	n/a	n/a	1238	55.5%	**2195**	**98.4%**
13	Gregg-Midway 500kV line operate at 230kV (new)	2478	n/a	n/a	1304	52.6%	n/a	n/a	n/a	n/a
14	Gregg 500/230kV Transformer (new)	1122	n/a	n/a	n/a	n/a	**1113**	**99.2%**	990	88.2%

(1) The SN ratings are in ampere for line and MVA for transformer.

Table A6-2
500 kV Category "B" Contingencies for PG&E Alternative 5
(2010 Summer Off-Peak Conditions with Helms = -900MW)

				Base		Alt 5A		Alt 5B1		Alt 5C1	
				Import = 0 MW Helms=-600MW		Import=500MW		Import=1100MW		Import=2000MW	
	Outages Facilities	Overloaded Facilities	SE Rating (A)	post-outag Flow (A)	post-outag Flow (%)	post-outag Flow (A)	post-outag Flow (%)	post-outag Flow (A)	post-outag Flow (%)	post-outag Flow (A)	post-outag Flow (%)
B1	Tesla-Los Banos 500kV line	Gates-Henrietta Tap1 230kV line	1600	n/a	<95%	1368	85.5%	n/a	<95%	n/a	<95%
		Gregg 500/230kV bank (new)	1260	n/a	<95%	n/a	n/a	1170	92.8%	n/a	<95%
		Gregg-Midway 500kV line (new)	3556	n/a	<95%	n/a	n/a	n/a	<95%	n/a	<95%
B2	Los Banos-Gates #3 500kV line	Gates-Henrietta Tap1 230kV line	1600	n/a	<95%	1331	83.2%	n/a	<95%	n/a	<95%
		Gregg 500/230kV bank (new)	1260	n/a	n/a	n/a	n/a	1134	90.0%	n/a	<95%
B3	Los Banos-Midway 500kV Line	Gates-Midway 500kV Line	3556	3433	96.5%	3457[10]	**97.2%**	3390	95.3%	3312	93.1%
		Gates-Henrietta Tap1 230kV line	1600	n/a	<95%	1374	85.9%	n/a	<95%	n/a	<95%
		Gregg 500/230kV bank (new)	1260	n/a	n/a	n/a	n/a	1259	**100.0 %**	n/a	<95%
		Tesla-Gregg 500kV line (new)	3556	n/a	n/a	n/a	n/a	n/a	<95%	n/a	<95%
		Gregg-Midway 500kV line (new)	3556	n/a	n/a	n/a	n/a	n/a	<95%	n/a	<95%
		Gregg-Midway 500kV line operate at 230kv (new)	2962	n/a	n/a	1383	46.7%	n/a	<95%	n/a	<95%

[10] A sensitivity case modeling the import of 600 MW was run. The Gates-Midway 500 kV line would load up to 3550 amperes (99.8% of SE rating of 3556A) for the Los Banos – Midway 500 kV line outage.

Table A6-2 (continue)
500 kV Category "B" Contingencies for PG&E Alternative 5
(2010 Summer Off-Peak Conditions with Helms = -900 MW)

				Base		Alt 5A		Alt 5B1		Alt 5C1	
				Import = 0 MW Helms=-600MW		Import=500MW		Import=1100MW		Import=2000MW	
	Outages Facilities	Overloaded Facilities	SE Rating (A)	post-outag Flow (A)	post-outag Flow (%)	post-outag Flow (A)	post-outag Flow (%)	post-outag Flow (A)	post-outag Flow (%)	post-outag Flow (A)	post-outag Flow (%)
B4	Gates-Midway #1 500kV Line	Los Banos-Midway 500kV Line	3556	2847	80.1%	2863	80.5%	2840	79.9%	n/a	<95%
		Gregg 500/230kV bank new)	1260	n/a	n/a	n/a	n/a	1292	102.5 %	n/a	<95%
		Gregg-Midway 500kV line (new)	3556	n/a	n/a	n/a	n/a	n/a	<95%	n/a	<95%
		Gregg-Midway 500kV line operate at 230kV (new)	2962	n/a	n/a	1403	47.4%	n/a	<95%	n/a	n/a
B5	Tesla-Gregg 500kV line	Gregg 500/230kV bank (new)	1260	n/a	n/a	n/a	n/a	n/a	n/a	1341	106.4 %
B6	Gregg-Midway 500kV line	McCall-Hentap2 230kV line	975	n/a	n/a	n/a	<95%	972	99.7%	n/a	<95%
		Panoche-McNulln1 230kV line	975	n/a	n/a	n/a	<95%	1050	107.7 %	n/a	<95%
		McMUlln1-Kearney 230kV line	975	n/a	n/a	n/a	<95%	1031	105.7 %	n/a	<95%
		Warnerville-Wilson 230kV line	793	n/a	n/a	n/a	<95%	801	101.0 %	n/a	<95%
		Gates-Henrietta Tap1 230kV line	1600	n/a	n/a	n/a	<95%	1785	111.5 %	1558	97.4%
B7	PDCI Bipole	Gates-Henrietta Tap1 230kV line	1600	1573	98.3%	1442	90.1%	n/a	<95%	n/a	<95%
		McCall-Hentap2 230kV line	975	n/a	<95%	845	86.7%	n/a	<95%	n/a	<95%
		Gregg 500/230kV bank (new)	1260	n/a	<95%	n/a	n/a	1262	100.1 %	988	78.4%

Table A6-3
500 kV Category "C" Contingencies for PG&E Alternative 5
(2010 Summer Off-Peak Conditions with Helms = -900 MW)

				Alt 5a			Atl 5b			Alt 5c		
				Import = 500 MW			Import=1100MW			Import=2000MW		
	Outages Facilities	Overloaded Facilities	SE Rating (A)	post-outag Flow (A)	post-outag Flow (%)	RAS (MW)	post-outag Flow (A)	post-outag Flow (%)	RAS (MW)	post-outag Flow (A)	post-outag Flow (%)	RAS (MW)
C1	Tesla-Los Banos, Tracy-Los Banos 500kV lines	Los Banos-Westley 230kV line	2000	1879	93.9%	1951	1815	90.8%	3369	1837	91.8%	1951
C1	Tesla-Los Banos, Tracy-Los Banos 500kV lines	Tesla-Gregg 500kV line (new)	3556	n/a	n/a	n/a	n/a	n/a	n/a	n/a	<95%	1951
C1	Tesla-Los Banos, Tracy-Los Banos 500kV lines	Gregg-Midway 500kV line (new)	3556	n/a	n/a	n/a	n/a	<95%	3369	n/a	<95%	1951
C2	Los Banos-Gates #3, Los Banos-Midway #1 500kV lines	Los Banos-Gates #1 500kV line	3556	3424	**96.3%**	1832	3276	92.1%	2948	3378	95.0%	1832
C2	Los Banos-Gates #3, Los Banos-Midway #1 500kV lines	Gates-Midway 500kV line	3556	2865	80.6%	1832	2591	72.9%	2948	n/a	<95%	1832
C2	Los Banos-Gates #3, Los Banos-Midway #1 500kV lines	Tesla-Gregg 500kV line (new)	3556	n/a	n/a	n/a	n/a	n/a	n/a	n/a	<95%	1832
C2	Los Banos-Gates #3, Los Banos-Midway #1 500kV lines	Gregg-Midway 500kV line (new)	3556	n/a	n/a	n/a	n/a	<95%	2948	n/a	<95%	1832
C4	Gates-Midway, Los Banos-Midway 500kV lines	Gates-Midway 230kV line	1390	1298	93.4%	2057	1061	76.3%	2948	1108	79.7%	2057
C4	Gates-Midway, Los Banos-Midway 500kV lines	Tesla-Gregg 500kV line (new)	3556	n/a	n/a	n/a	n/a	n/a	n/a	n/a	<95%	2057
C4	Gates-Midway, Los Banos-Midway 500kV lines	Gregg-Midway 500kV line (new)	3556	n/a	n/a	n/a	n/a	<95%	2948	3222	90.6%	2057
C4	Gates-Midway, Los Banos-Midway 500kV lines	Gregg 500/230kV bank (new)	1260	n/a	n/a	n/a	1251	**99.3%**	2948	715	56.7%	2057
C5	Palo Verde G-2	Panoche-Kearney 230kV line	975	n/a	<95%	None	n/a	<95%	None	n/a	<95%	None
C5	Palo Verde G-2	Warnerville-Wilson 230kV line	793	n/a	<95%	None	n/a	<95%	None	n/a	<95%	None
C6	Diablo Canyon G-2	Panoche-Kearney 230kV line	975	n/a	<95%	None	n/a	<95%	None	n/a	<95%	None
C6	Diablo Canyon G-2	Warnerville-Wilson 230kV line	793	n/a	<95%	none	n/a	<95%	None	n/a	<95%	None